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Assessing Sustainability in Indonesia Fisheries through Local Wisdom Empowerment

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Abstract. This research assessing the sustainability of Indonesian fisheries by utilizing local knowledge and identifying the key factors that significantly contribute to the economic, technological, social, ethical, and governance dimensions through Multidimensional Scaling (MDS) with the RAPFISH application and Participatory Prospective Analysis (PPA). The analysis reveals a sustainability score of 49.67, indicating poor sustainability performance. Furthermore, this research indicates that sustainability can be enhanced by taking into account factors beyond the economic aspect. One way to achieve this is by utilizing resources that are already available within these communities but have not yet been utilized. This research emphasizes the significance of local knowledge and the necessity to mitigate ecosystem damage. It adds to existing knowledge by demonstrating that utilizing local wisdom is crucial to achieving sustainability. The study highlights the importance of local knowledge as a valuable resource for conserving fisheries. To achieve sustainability, it is crucial to empower local wisdom and strengthen customary rules.

Keywords: Multidimensional Sustainability Analysis, RAPFISH, PPA Analysis, Sustainability analysis, Sustainability scenarios, West Pasaman's Local Wisdom.

1. INTRODUCTION

Although the fisheries sector in Indonesia has become a commercial enterprise, it has not been fully relied upon to boost the national economy. Indonesia lags behind other countries in the world that have achieved economic progress through the development of fisheries. This situation should motivate all parties to take concrete steps to manage and empower the fisheries sector to achieve optimal results. The fisheries sector faces a dilemma due to externalities. The main economic challenge in developing aquaculture fisheries is to minimize these externalities. There are two types of externalities to consider: those arising from actions that create unfavourable circumstances for others, such as pollution or the destructive impact of human activities, and their uncompensated externalities; and those resulting from competition for limited resources, and their uncompensated externalities, which cause economic inefficiencies.

The fisheries sector is highly susceptible to externalities resulting from fishing activities, as the fish resources in the fisheries environment are public goods that are freely available to all. This creates a dilemma where economic needs and demands must be balanced with the need to preserve the natural resources that support these activities. Externalities contribute significantly to overfishing as efforts are made to meet the demand (Klis, A. A., & Melstrom, R. T., 2020). While fishery resources are highly profitable, they are associated with environmental. Fisheries Assessment and Sustainable Utilisation (FRASU) is an issue of global concern. Although fishery resources are highly profitable, they are associated with environmental and socio-economic problems. In the context of increasing demands for sustainability in fisheries, assessment of fishery resources is essential to support scientific management of fishery resources (Xu, P., et.al., 2021) and socio-economic issues. Long-term overexploitation can lead to a decline in fish populations and damage to fishery biota (Bennett, N. J., et.all, 2021; Ael Teff-Seker, et.al, 2022).

The fishing industry is confronted with major challenges, such as declining catches, increasing environmental degradation, and overcapacity. Therefore, an integrated management approach is necessary. To effectively address these challenges, it is essential to preserve and conserve the fishing environment. Additionally, the welfare of fishing communities can be improved by adopting an approach that goes beyond the economic aspect. One way to achieve this is by using resources that these communities already have but have not yet utilized. Previous research has demonstrated that households based in fisheries have the potential to make a positive contribution to the local economy (Nilsson, J. A., et.al, 2019; Ng'onga, M., et.al, 2019). Aquaculture and related sectors hold significant potential for the rural economy Wang, Y., & Wang, N., 2021). However, the fishing community has not been able to prosper. It is necessary to empower the attributes that already exist but have been ignored.

Previous research has focused solely on the environmental dimension of sustainable fisheries, disregarding other crucial dimensions. According to Taylor, I. G et.al, 2021; Steven Greenland, 2022), sustainability and sustainable growth are multifaceted concepts that can only be achieved through a social-ecological system. This system must consider the pillars of social, economic, and ecological growth, including culture, institutions, and governance. This cultural capacity is used to balance the potential for use, capture and processing, and is an important aspect for local populations in the exploitation of resources to create sustainable fisheries, the management of fisheries has become more complex due to the pursuit of economic, community, and ecological

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sustainability, known as the triple bottom line (Nathan J. Bennett, 2021). Concerns about environmental sustainability have steadily increased, particularly in recent decades. Previous research has examined the sustainability of the fisheries sector, but only from an ecological perspective (Anderson JL, et.al, 2015; Kusdiantoro, Fahrudin, A., et.al 2020). Progress towards environmental sustainability only occurs in countries with slow or negative socio-economic trends, such as developing countries like Indonesia (Tranter, S. N.,et.al, 2022).

Traditionally, sustainability in fisheries has been evaluated through stock assessment models that focus solely on biological and ecological aspects (Hametner, M.,2022; Cope, J. M.,2024; Maunder, M. N., et.al, 2020). Humanity's interactions with natural resources are complex and require consideration of environmental, conservation, social, and economic factors. However, this approach overlooks the various dimensions of fisheries and the wider perspective of sustainability, including social-ecological aspects. There is a growing recognition that ecosystems are in fact 'socio-ecological', i.e. ecosystems encompass not only the ecology of species (the ecological dimension) but also the human context (the social and economic dimensions), further analyses are needed to complement the proxy stock data that has been conducted to calculate the previous stock (Peng, D., 2023; Alvarez, A. M. (2021).

To promote sustainability in the fishing industry, it is important to gain a comprehensive understanding of the sustainability status of fisheries. Although several studies have been carried out to assess the sustainability of the fishery, including research in Indonesia (Liu, S., 2023; Donna Dimarchopoulou, 2021; Mehnwon Wuor & Leslie Mabon 2022; Ho Geun Jang, 2020, Xavier Basurto, 2013) no one has yet examined the sustainability of fisheries from a multi-dimensional perspective. To achieve sustainability, it is crucial to integrate social dimensions such as culture, economy, institutions, governance, ecology, and growth. This integration is necessary for achieving long-term sustainability goals. Currently, there is no way to measure the sustainability of fisheries activities in West Pasaman Regency, West Sumatra Province, Indonesia. Additionally, no research has been conducted on other attributes that could contribute to achieving sustainable fisheries.

Based on the above points, it is clear that improving the welfare of communities and fisheries sustainability requires an approach beyond economic perspectives. One potential aspect that has yet to be utilised is the use of indigenous knowledge, commonly known as 'local wisdom'. From a cultural perspective, utilizing indigenous knowledge can safeguard a society's cultural heritage. Local knowledge, which has been passed down by the community as a cultural heritage, can be utilised to achieve sustainable development, particularly in the fisheries sector. Traditional practices instil specific values and behavioural norms, which imply continuity with the past and are linked to the growth of sustainable fisheries.

Previous research suggests that improving the well-being of communities requires an approach that goes beyond economic perspectives. One potential aspect that has yet to be explored is the use of indigenous knowledge, also known as 'local wisdom'. From a cultural perspective, utilizing indigenous knowledge can help preserve a society's cultural heritage. Local knowledge, passed down by the community as a cultural heritage, can contribute to achieving sustainable development, particularly in the fisheries sector. Traditional practices convey specific values and behavioural norms that imply continuity with the past and are linked to the growth of sustainable development.

The main challenge for the economic development of fisheries is the need to reduce these externalities. Previous research has been carried out on environmental protection efforts. It is crucial to explain. If the sustainability of natural resources is determined, then using them in accordance with the local wisdom values and cultural practices of the community can improve the welfare of the community while ensuring environmental sustainability. The research assesses the sustainability of fisheries using RAPFISH and PPA analysis as a sustainability assessment tool. Furthermore, there are several other attributes of fisheries that have not been studied for their utilization. In addition, no assessment of the status of sustainability in various dimensions has been carried out in West Pasaman, Regency, West Sumatra Province, Indonesia.

This study aims to examine the current sustainability status of fisheries in West Pasaman Regency, West Sumatra Province, Indonesia, by applying local wisdom. The main attributes that make a dominant contribution to the status of sustainable fisheries will be identified, and scenarios will be formulated to achieve sustainable fisheries based on the implementation of local wisdom. Once the sustainability of this scenario has been determined, local wisdom values, as a cultural aspect of the local community, can be applied to the management of natural resources while preserving their continuity.

2. LITERATURE REVIEW

Local Knowledge Patterns and Cultural Empowerment are considered important factors in achieving fisheries sustainability. This includes knowledge and technology systems, religion, traditions, and social capital such as ethics, environmental wisdom, norms, and legal institutions. These cultural capacities are used to balance harvesting and exploitation, and to process potential resources. It is important for local communities to consider these factors when using resources. The community of Pasaman Barat possesses local wisdom based on long-standing practices within their society. A previous study examined the impact of culture on natural resource use. The results show that local wisdom influences individual and group behaviour towards the environment and natural resource management. Local wisdom also aids in developing environmentally friendly socio-political

systems and making decisions and policies affecting the environment and natural resources (Eoin Grealis, et.al, 2017). Local wisdom is essential in managing freshwater aquaculture resources sustainably, meeting current needs without compromising the ability of future generations to meet their own. It is crucial to acknowledge the cultural element inherent in local wisdom (Garibaldi, A., & Turner, N. ,2004; Kakoty, S. 2018; Vitasurya, V. R. , 2016).

From a cultural perspective, the use of local knowledge is a form of cultural preservation that has been passed down from generation to generation. The results suggest that local knowledge plays a role in shaping attitudes towards the environment and in efforts to manage natural resources, both individually and collectively. In addition, local knowledge can aid in the development of socio-political systems that are environmentally friendly and in the formulation of decisions and policies that impact natural resources and the environment (Widodo, J., 2012; Sultana Razia, Siti Hajar Abu Bakar Ah. (2023); Ambarini, N. S. B., et.al., 2019; Garibaldi, A., & Turner, N., 2004).

Sustainable development is a development approach that aims to meet the present needs without compromising the ability of future generations to meet their own needs. The concept of sustainable development is focused on meeting the current human needs without hindering the ability of the next generation to meet their own needs. This principle is also applicable to the fisheries sector. The theory of the triple bottom line (TBL) focuses on the economic, social, technological, and governance aspects. The sustainable paradigm aims to balance these dimensions while also considering social values. The idea of the Triple Bottom Line (BTL) concept focuses on three types of resources: economic, social and environmental [16,17,18], (A. Murillas, R, et.al, 2008; Żak, A. 2015; Archibald, D. W., et.al, 2021), where the sustainable economic paradigm is based on the balance between these dimensions. There is a dimension that has long existed in West Pasaman Regency, West Sumatra Province, Indonesia, namely local wisdom but has not been empowered to achieve fisheries sustainability, so far only the economic dimension has been developed but still cannot improve economic welfare. The economic development that is achieved also has a negative impact on environmental sustainability so that the idea of the concept of local wisdom can be utilised.

Previous research has investigated the role of culture as a social dimension in natural resource utilization (Sultana Razia, Siti Hajar Abu Bakar Ah., 2023). The local knowledge passed down for generations has resulted in successful fishery practices that can be further strengthened by their interesting principles. In West Pasaman Regency, West Sumatra Province, Indonesia, these practices are still valued solely for their uniqueness and cultural significance, making them ideal for preservation and cultural tourism. Local knowledge and wisdom are concepts, beliefs, and opinions that are specific to a particular community. They are valued for their intelligence and positive significance. It is important to note that local wisdom is deeply embedded within and supports its members. It cannot be completely replaced.

Previous research has demonstrated that successful fisheries management with Sustainable Fisheries Development Indicator System (SFDIS) in India (Bavinck, M., & Verrips, J. ,2020)., requires more than just a focus on resource conditions. However, when using sustainability tools, it is important to consider the limitations in terms of time and processing requirements. This is especially true when solving more complex problems, such as those with numerous objective functions or requiring multiple Monte Carlo simulations. It is likely that future research will require even more resources for these types of analyses (C. Lloyd Chrispin, et.al, 2022). Stakeholders and managers require an understanding of the model results. Therefore, they need intuitive visualization tools to inform the range of management options and decide which measures to take (Aikaterini Forouli, et.al, 2020).

Previous research has shown that inadequate fisheries management and failure to achieve sustainability principles can be attributed to insufficient data on the status of fisheries sustainability. This study supports the idea that a comprehensive approach is necessary to achieve sustainable fisheries. The multidimensional nature of sustainable fisheries provides crucial information, revealing the key attributes that impact sustainability.

3. METHODS AND DATA COLLECTIONS

To answer the research questions and purposes, a mixed method with a concurrent embedded strategy model was used. Quantitative research methods were employed to analyse the sustainability status and identify sustainability attributes. Qualitative research methods were used to conduct a deeper exploration of the sustainability attributes and formulate sustainability scenarios.

3.1. Sampling Location

West Pasaman Regency is located in West Sumatra, Indonesia, between 00° 33' north latitude and 00° 11' south latitude and 99° 10' to 100° 04' east longitude. It was formed from the division of Pasaman Regency based on Law No. 38 of 2003 concerning the establishment of Dharmasraya, South Solok and West Pasaman Regencies dated 18 December 2003. The capital of West Pasaman Regency is Simpang Ampek District. The West Pasaman Regency is located in the West Sumatra Province and covers an area of 3,864.02 Km^2. The population density is 110 people/Km^2, with a total population of 436,298 people as of 2021. The government administration covers 11 sub-districts.

3.2. Data

The research problems were addressed by analysing primary and secondary data. Primary data was collected by conducting in-depth interviews with community leaders and resource persons from the Office of Maritime Affairs and Fisheries in West Pasaman Regency, West Sumatra Province, Indonesia. Structured questions were used to evaluate sustainability and identify attributes that significantly contribute to the economic, technological, social, ethical, and governance dimensions. Resource persons were selected based on their expertise in the field, knowledge of the object under study, and familiarity with the research topic. The respondents consisted of at least 30 community members or 3-7 experts, or a combination of both Rayhan Dudayev, et.al., 2023; Groenen, P.J.F, & van de Velden, M., 2004). The research was conducted with 100 respondents from 11 sub-districts in West Pasaman Regency, West Sumatra Province, Indonesia.

Qualitative data was collected through interviews, observation, documentation, and Focus Group Discussions (FGDs) using relevant interview guidelines. The guided interview technique was employed to ensure consistency and structure in the interview process. The researcher conducted the interviews in a deep and thorough manner. FGDs were conducted to gather in-depth information. A meeting or discussion is held where a group of respondents or informants are interviewed together. The study used content analysis to extract data and information from interview transcripts. The analysis for this research is based on the diverse perspectives and knowledge obtained from the interviews. The secondary data was obtained through a literature review and examination of related policies and regulations. These aspects were examined in several documents, including statistical reports and sustainability reports published by relevant stakeholders or governmental agencies.

3.3. Analysis

3.3.1. Sustainability Analysis

The RAPFISH analysis is a useful tool for assessing sustainability. It involves conducting interviews with respondents and using the RAPFISH program to determine the attributes that have the greatest influence on the sustainability index value. The results are presented which compare the performance of each dimension (Groenen, P.J.F, & van de Velden, M., 2004).

The analysis results are interpreted into four groups that describe the condition of sustainability. A score of 0-25 points indicates poor (unsustainable), 25.01-50 points indicates poor (less sustainable), 51-75 points indicates fair (moderately sustainable), and 76-100 points indicates good (highly sustainable) (Peng, D., 2023; Rayhan Dudayev, 2023).

Aspects of sustainability Indicators examined for each dimension for the economic aspects of sustainability included economic value of fishery products, fisheries marketing distribution, market concern for sustainability, dependence on the fisheries sector, advantages of business, income relative to regional minimum wage, labor absorption and business alternative. Social aspects included number of actors, knowledge of environmental sustainability, conflict level, cultural/ethical impact on fishing communities, level of socialization of environmental conservation and fisheries household involvement in fisheries policy.Tehnology aspects included number of fish ponds, fish pond size, fishing gear, risks of using fishing gear, harvest handling and access to fisheries technology. Ethics and governance aspects included number of regulations, regulatory violation rate, regulations for resource limitations, ecosystem damage mitigation, traditional rules and local wisdom and the role of fisheries actors in policy making.

3.3.2. Leverage Analysis

Sensitivity analysis (leverage analysis) was conducted to assess the accuracy of the sustainability dimension attributes measured by MDS analysis, the stress value is less than 0.25 points or 25%, and a coefficient of determination (R2) close to 1 indicates high accuracy of the analysis results (Rayhan Dudayev, 2023). Leverage analysis is an analysis used to identify leverage factors in each sustainability dimension, so that it can be seen that the aspect that has the largest value is the aspect that has the largest leverage factor on the sustainability status of a dimension or in other words is the determining factor for the sustainability of the fisheries sector in that dimension.

3.3.3. Monte Carlo Analysis

Monte Carlo analysis is utilised to evaluate the extent of error factors in sustainability analyses arising from variances in respondents' ratings of features, data entry errors, and incomplete or absent data. Monte Carlo analysis is a technique used to test the results of the ordination analysis. This is necessary because errors may occur in the RAPFISH method due to scoring errors, variations in scoring caused by differences in judgement, or errors in data input. If the difference between the Monte Carlo sustainability index and the MDS sustainability index is less than 1, it indicates a small influence of error in the analysis (Rayhan Dudayev, 2023).

3.3.4. PPA Analysis

To analyse the current condition of fisheries sustainability, a Participatory Prospective Analysis was conducted. This analysis aims to examine various possibilities for sustainable fisheries management in the future.

Scenario development was carried out through Focus Group Discussions (FGDs). During the FGDs, stakeholders were asked to estimate future conditions of each determining variable. These estimates are subjective and reflect stakeholders' interests. Scenarios can be developed based on future estimates of these variables (Tony J Pitcher & David Preikshot (2001).

4. RESULTS AND DISCUSSION

4.1. RESULT

4.1.1. Location of Sampling

Geographically, West Pasaman Regency is located between 00° 33' North Latitude and 00° 11' South Latitude and 99° 10' to 100° 04' East Longitude. West Pasaman is one of the districts in the Province of West Sumatra, Indonesia. This area was formed from the division of the Pasaman Regency based on Law Number 38 of 2003 concerning the Establishment of Dharmasraya, South Solok, and West Pasaman Regencies dated December 18, 2003, with the capital city of Simpang Ampek district. The regional map of West Pasaman Regency, West Sumatra Province, is shown in Figure 1.



Figure 1: Study Area of West Pasaman Regency, West Sumatra Province, Indonesia.

4.1.2. Sustainability Status

The sustainability status of freshwater aquaculture in West Pasaman Regency, West Sumatra Province was determined using RAPFISH analysis based on four dimensions: economic, social, technological, and ethical and governance. The research conducted on the sustainability of freshwater aquaculture in West Pasaman Regency, West Sumatra Province (Tables 1,2,3) has shown that the results obtained from the RAPFISH output are accurate. The stress value, which indicates the level of sustainability, is low and falls within the desired range of less than 25%. The coefficient of determination (R2), which measures the model's accuracy, has an average value of 95%, implying a high level of confidence in each dimension. A lower stress value signifies a better fit within the highest limit, as indicated by the literature. This research confirms the effectiveness of the RAPFISH model in assessing the sustainability status of freshwater aquaculture.

Table 1. Sustainability Analysis on Each Dimension.

No.	Dimension	Value	Sustainability Status
1.	Economy	32.61	Less Sustainable
2.	Social	47.69	Less Sustainable
3.	Technology	69.16	Sufficiently Sustainable
4.	Ethics and Governance	49.20	Less Sustainable

Source: RAPFISH.

Table 2: Leverage Analysis on Each Dimension of Sustainability in West Pasaman Regency, West Sumatra, Indonesia.

No.	Dimension	Atribut	Value
1.	Economy	Dependence on Fishing Sectors	5,55
2.	Social	Knowledge of Environmental Sustainability	5,80
3.	Technology	Harvest Handling	10,26
4.	Ethical and Governance	Customary Rules and Local Wisdom	6,33

Source: RAPFISH.

Table 3: Multidimensional Value of Aquaculture Fisheries in West Pasaman Regency, West Sumatra, Indonesia.

No.	Dimension	Stress	r-Squared	MDS	Monte Carlo	Difference
1.	Economy	0.140	94.64	32.61	31.72	0.89
2.	Social	0.151	94.02	47.69	49.51	1.82
3.	Technology	0.143	94.01	69.16	72.24	3.08
4.	Ethics and Governance	0.149	94.02	49.20	52.56	3.36

Source: RAPFISH.

The RAPFISH ordination yielded a score of 32.61 in the less sustainable category for the economic dimension. The stress value calculation in the economic dimension ordination is 0.140 with an R2 value of 94.64. According to the provisions, if the stress value is less than 0.20 and the R2 value is close to 1, the model is considered good and can explain the sustainability of fisheries.

The result of RAPFISH ordination on the social dimension is 47.69 with the category of less sustainable. The stress value calculation for the social dimension ordination is 0.151 with an R2 of 94.02. As per the provisions, a stress value of <0.20 and an R2 value close to 1 indicate a good model that can explain the sustainability of fisheries.

The RAPFISH ordination yielded a result of 69.16 in the technology dimension, indicating a fairly sustainable category. The stress value calculation for the technology dimension ordination is 0.143 with an R2 of 94.01. As per the provisions, a stress value of less than 0.20 and an R2 value close to 1 indicate a good model that can explain the sustainability of fisheries.

The result of the RAPFISH ordination on the ethics and governance dimension is 49.20 in the less sustainable category. The calculation of the stress value in the ordination of the ethics and governance dimension is 0.149 with R2 of 94.02. According to the rules, if the stress value is <0.20 and the R2 value is close to 1, the model is considered to be good in explaining the sustainability of fisheries. Multidimensionally, the sustainability index value of freshwater aquaculture in West Pasaman Regency, West Sumatra Province is 49.67 or in a less sustainable status.

4.1.3. Leverage Analysis

Leverage analysis is a method used to identify leverage factors in each dimension of sustainability. The largest value in an aspect indicates the largest leverage factor on the sustainability status of a dimension. In other words, it is the determining factor for the sustainability of the fisheries sector in that dimension. The leverage analysis in the economic dimension reveals that the dependence on the fisheries sector has the most significant impact on sustainability, with a value of 5.55. The analysis results indicate that the leverage factor, which attributes dependence on freshwater aquaculture sector, has the greatest influence on the sustainability status in the economic dimension.

Based on the results of the leverage analysis in the social dimension, it can be seen that the aspect that has the most determining leverage value for the sustainability of fisheries in the social dimension is the attribute of knowledge about environmental sustainability with a value of 5.80. The results of the analysis show that the leverage factor of knowledge about environmental sustainability has the greatest influence on the status of sustainability in the social dimension.

Based on the leverage analysis results in the technology dimension, it is evident that the harvest handling attribute has the highest determining leverage value for the sustainability of fisheries in this dimension, with a value of 10.26. The analysis indicates that the harvest handling leverage factor has the greatest impact on the sustainability status in the technological dimension. The leverage analysis in the ethics and governance dimension reveals that the attribute of customary rules and local wisdom has the most determining leverage value for fisheries sustainability, with a value of 6.33. The analysis results indicate that the leverage factors of customary rules and local wisdom have the greatest influence on the sustainability status in the dimensions of ethics and governance. Thus, based on the calculation, any intervention in the attribute of dependence on the fishing sector will affect the value of the sustainability index in the future.

4.1.4. Monte Carlo Analysis

To determine the ordination of the sustainability status of freshwater aquaculture in West Pasaman Regency, West Sumatra Province, Indonesia, based on the assessment of attributes, the accuracy of which is reinforced by Monte Carlo simulation, which generates sensitivity values for each attribute. Based on the Monte Carlo analysis, which was conducted by performing 25 repetitions with a 95% confidence level, the economic dimension has a value of 31.72, the social dimension has a value of 49.51, the technological dimension has a value of 70.24, and the ethics and governance dimension has a value of 50.56. The comparison between the ordination results and the Monte Carlo value shows only a slight or insignificant difference. Monte Carlo analysis is employed to evaluate the impact of calculation errors and misjudgement of attributes by respondents. If the difference between the Monte Carlo sustainability index and the MDS sustainability index is less than 1, it indicates that the influence of errors in the analysis is negligible (Kavanagh, 2001). Therefore, it can be concluded that the ordination model that has been executed is reliable because the error that occurs in the ordination determination process is minimal.

Based on the calculation, it is evident that fish farming activities in West Pasaman Regency, West Sumatra, Indonesia have become a commercial business and a source of community economy. However, progress has not been fully reliable in lifting the community economy, as indicated by its less sustainable status. The research reveals that the community applied efforts to preserve the environment to the handling of the harvest as indicated on technology dimensio. However, they did not maximise these efforts to maintain the sustainability of the fishing environment.

In terms of ethics and governance, this research demonstrates that successful development must be accompanied by environmental preservation. Therefore, the government should empower the community to engage in various activities in the fisheries sector, including cultural empowerment through local wisdom. On this basis, by strengthening the cultural assets in the form of local wisdom that have existed in the community for a long time, while still prioritizing the conservation of the natural environment, the people's economy can strive to survive and continue to contribute to the economy as one of the main sources of income for households.

4.1.5. Participatory Prospective Analysis (PPA)

Based on the results of the sustainability analysis with the RAPFISH application, 10 (ten) key components were obtained that had a strong influence on the fisheries management scenario (Table 4), dependence on the fisheries sector, profitability of aquaculture business, market concern for sustainability, distribution of fisheries marketing, knowledge of environmental sustainability, level of socialisation of environmental conservation efforts, harvest handling, pond size, customary rules and local wisdom, mitigation of ecosystem damage. These key components are preliminary analyses conducted to identify key components and scenarios to achieve sustainable fisheries in West Pasaman Regency, West Sumatra Province, Indonesia as needed for policy formulation by stakeholders. The variables were discussed in a focus group discussion (FGD).

Table 4: Key Components in Developing a Sustainable Fishery Scenario in West Pasaman Regency, West Sumatra, Indonesia.

No.	Key Component	Value
1.	Dependence on the Fisheries Sector	1.01
2.	Profit of Aquaculture Business	0.13
3.	Market Concern for Sustainability	-
4.	Fisheries Marketing and Distribution	-
5.	Knowledge of Environmental Sustainability	-
6.	Level of Socialization of Environmental Conservation Efforts	-
7.	Harvest Handling	-
8.	Pool Size	-
9.	Customary rules and local wisdom	1.95
10.	Ecosystem Damage Mitigation	0.91

Source: RAPFISH.

For each district, 10 key informants were involved. Stakeholder participation was integrated into the prospective analysis through the representation of key informants, including community leaders and religious scholars who possess expertise and knowledge regarding aquaculture and local wisdom. This involvement enabled the identification of important planning variables, the definition of variable conditions in the future, the development of planning scenarios, and the preparation of strategic implications and anticipatory actions for effective fisheries management. To ensure a focused discussion, this analysis first establishes the specific area of concern as the West Pasaman Regency in the West Sumatra Province of Indonesia. The analysis will consider the next 20 years in accordance with Law No. 26 of 2007 on spatial planning. The system variables were identified through brainstorming, starting with variables that influenced the composition and evolution of the system from a participant perspective. The key variables were defined through structured discussions on the importance of each previously agreed variable. The interview results were then analysed with PPA software. The Figure 2 shows the scenario analyzed with PPA software and its key components.

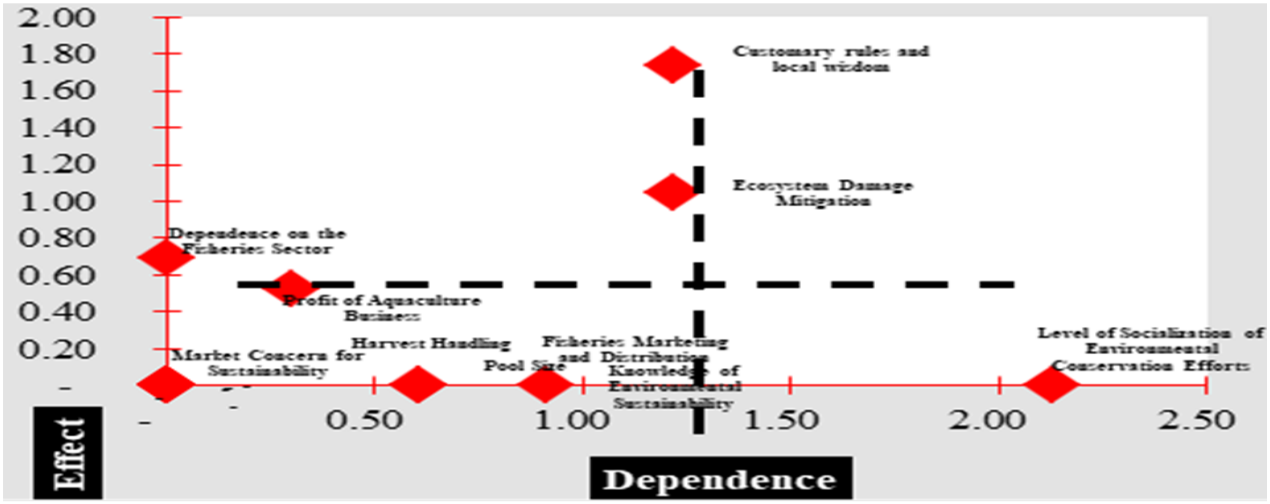


Figure 2: Result of Prospective Analysis of Sustainable Scenarios in West Pasaman Regency, West Sumatra, Indonesia.

Based on PPA analysis, the scenario for sustainability is ranked as follows: the conservative-optimistic scenario is ranked 1, the moderate-optimistic scenario is ranked 2, and the progressive-optimistic scenario is

ranked 3. Therefore, the conservative-optimistic scenario is considered the most likely scheme to be implemented in the management of fisheries. The scenario involves repairing key components at a minimum level. The cost-efficiency of improvements is taken into consideration in the improvement efforts there are scenario to achieve moderate dependence on the fisheries sector, moderate profitability of aquaculture business, moderate market concern for sustainability, moderate distribution of fisheries marketing, moderate knowledge of environmental sustainability, moderate level of socialisation of environmental conservation efforts, high harvest handling, moderate pond size, high application of customary rules and local wisdom and high mitigation of ecosystem damage with final result to achieve sustainable fisheries in the future.

The use of Participatory Prospective Analysis (PPA) revealed that achieving sustainability requires consideration of customary rules, local wisdom, and mitigation of ecosystem damage. This analysis demonstrates the importance of customary rules and local wisdom in achieving sustainability. The results demonstrate the strengthening of sustainability analysis through the use of RAPFISH software in the leverage analysis. Furthermore, the significance of customary rules and local wisdom is emphasised. The community has implemented local wisdom to conserve fishery resources, which is an embodiment of the principles of natural resource conservation. Traditional resource-conserving communities have specific rules to prevent over-exploitation, such as strict control over the harvesting process and prohibitions on hunting or harvesting in certain areas. Thus, the analysis finaly suggests that the conservative-pessimistic scenario is the most likely to be implemented immediately. This scenario involves making minimum improvements to key components while considering the efficiency of repair costs.

4.2. Discussion

4.2.1. Freshwater Aquaculture Sustainability Scenario in West Pasaman District, West Sumatra Province, Indonesia

The research discovered that the fisheries sector in West Pasaman Regency, West Sumatra Province, Indonesia has poor sustainability, with a sustainability index of 49.67 points. This study supports previous research, the management of fisheries always deals with the fundamental issue of the human dimension. In this case, local communities as users directly related to fisheries resources. In the past, fisheries resources were often seen as open access and common property. This view meant that anyone could enter and extract resources with any equipment and in unlimited quantities (the tragedy of the commons), This explains why fisheries resources are depleted. The common property status of the resource is thought to be the cause.

This study also supports previous research (Bourgeois, Robin & Jesus, Franck, 2004; Arthur, R. I. 2020), resources that are commonly owned can be exploited by individuals or actors in the fisheries sector, even though the number of catches is decreasing. In other words, despite the decreasing number of catches, actors in the fisheries sector will not reduce their efforts to catch fish, hindering the recovery of resources. Instead, they will continue to increase their efforts, even though profits continue to decrease. Although this may seem rational at an individual level, such actions are a tragedy at the community or collective level and are not in line with the concept of sustainable fisheries

This study demonstrates that managing fisheries as common property cannot be separated into three dimensions that are interdependent: those related to fisheries resources and their ecosystems, those related to the exploitation of fisheries resources for the socio-economic interests of the community, and those related to fisheries policy itself. Fisheries ecosystems require water as a major component. Water is highly valued as a source of life for the community.

The findings of this study support previous research (Ostrom, E., 2016; Arif Satria, Yoshiaki Matsuda, 2004), that highlighted the importance of water as a basic human need, especially for the fisheries sector. Water resources are critical to human survival and must be managed effectively to prevent depletion and drought. It is important to prioritise management and conservation efforts to ensure the sustainability of these resources in the future. This study supports previous research Ortega-Gaucin, D., et.al., 2018; Topchiy, I., Fatkullina, A. et.al., (2021), that the most effective approach to managing drought is to start with a vulnerability assessment. These assessments serve several purposes, including prioritising the implementation of prevention and mitigation measures, identifying areas to improve adaptive capacity, reducing exposure and vulnerability, optimising resource allocation, and supporting better water management. This is also measured through the sustainability analysis.

The study found that managing fisheries to meet social, economic, and environmental objectives is a fundamental problem in fisheries management worldwide, involving a complex set of national and sub-national policy arrangements. These results support the investigation. The shift in societal objectives from maximizing yield to a greater emphasis on ecosystem protection has led to major conflicts in the courts and in policy-making. Although conflict may appear unavoidable, there is a growing convergence in several areas between those advocating greater ecosystem protection and consumptive users seeking profitability and stability.

The investigation (Mahler, R.L.,2022; Mahler, R.L., & Ghimire, N. 2023) supports these results, indicating a positive correlation between economic performance and both environmental and community performance. The local government aims to manage the fishery to provide a source of income and food for community members.

This can be achieved through two broad approaches: helping fishers become more effective harvesters and improving the quality of the fishery through local wisdom empowerment. This condition could also be applied in West Pasaman District, West Pasaman Province, Indonesia, to improve the economic impact while empowering the socio-cultural aspects. This study reinforces previous research (Mahler, R.L.,2022; Mahler, R.L., & Ghimire, N. 2023) and may assist the government in developing water resource conservation policies. Community participation in environmental activities is moderate. To increase awareness of the diverse interests of social groups, the government should replace economic pressures with economic benefits and promote ecological lifestyles through the media and public education. This will generate public interest in the implementation of environmental programmes to achieve sustainable fisheries in the future.

This research highlights the importance of local knowledge as a valuable resource for conserving fisheries. The people of West Pasaman Regency, West Sumatra Province, Indonesia have adopted a culture of water conservation, particularly for fishing. Fishing according to local wisdom values is ecologically beneficial as it allows fish to grow and reproduce properly. Additionally, fish can be harvested when they reach a certain size, thus protecting them from extinction. The community has implemented a participatory, adaptive, and sustainable management system based on local wisdom to conserve fishery resources, particularly local fish. In West Pasaman Regency, West Sumatra Province, Indonesia, forbidden fishing areas are designated for the preservation of fish that cannot be caught, and the fish that are allowed to be kept are those with economic value, local freshwater fish species such as Gabus (channa striata) and Baung (mystus nemurus) are prohibited from being fished. These fish are mostly cultivated in rivers and have significant economic value. There are several locally farmed fish species in each subdistrict. These fish species have economic value and, if developed, can have a positive impact on the surrounding community's economy, as well as on nature in terms of economic, social, and socio-cultural impacts.

The study This study also supports previous research Ebele Chinelo Amaechina, et.al., (2021) that investigates the impact of restrictions on the Sundarbans, which were imposed to protect its biodiversity, on the fishing resources of the local fishermen. Local wisdom is often expressed through taboos and prohibitions that are followed by the community, including restricted fishing areas. The study also examines the response of the local community to these restrictions in order to maintain their way of life. It has been found that the adoption of conservation as a global ideology without considering the local context has created new complexities that have alienated local communities and made the future even more uncertain. To ensure success in development, particularly in the fisheries sector, it is crucial to integrate development programmes, involve the whole community, develop fishing communities, and strengthen local wisdom.

Therefore, the management of natural resources in various sectors is considered to be closely linked to local culture. Local culture, which is derived from community culture, is believed to offer numerous solutions in development because it is the outcome of 'learning' from local communities in dealing with the environmental changes they encounter. The local wisdom of a community comprises its values and norms, which are essential for managing natural resources and the environment. This study also supports previous research (Vitasurya, V. R.. 2016). Community-based economic empowerment through fisheries management is crucial for economic progress and improving the welfare of society, as well as sustainable technology in fisheries (Siddique, M. R. H.et.al,. 2023).

Previous research has shown that applying local wisdom to regulations and policies increases the income of local communities (Tiyaningsih, T., et.al., 2020). This research demonstrates that empowering customary rules and local wisdom and knowledge of environmental sustainability is crucial for mitigating ecosystem damage and achieving sustainability. The community has implemented these measures, but they have not been fully empowered. The improvement of management form and the establishment of regulations and incentives are necessary to encourage the community. From an economic and cultural perspective, this has the potential to improve the welfare of the community. Local wisdom values and participatory, adaptive, and sustainable community wisdom can enhance the local economy and achieve sustainability. Local knowledge is a vital but underutilised resource in the community for conserving fisheries resources. This research highlights the inefficacy of the current fisheries environmental mitigation system, despite its significance in the fishing industry.

In conclusion, this research suggests that empowering customary rules and local wisdom can mitigate the impact of externalities on the fisheries sector. Local wisdom aids in the development of an environmentally friendly socio-political system for decision-making and policy formulation that affects the environment and natural resources of fisheries, this is because it is based on knowledge that has been passed down in the community. The results suggest that the restoration or recovery of shared resources will be particularly challenging. Decentralization and local participatory arrangement are essential for successful fisheries governance. It is recommended that the government develops policies for environmental mitigation in the fishing industry in the future. Indonesian fisheries law and policy are currently dominated by hierarchical or centralized governance models, which have numerous shortcomings compared to participatory governance. The implementation of participatory governance in policy-making, with a focus on empowering social values, could be beneficial in the future (Etelepta, J. M. S., et.al., 2016; Seishiro Sakita, 2021; Ostrom, E. , 2016, Anna A. Klis &Richard T. Melstrom (2020).

5. CONCLUSION

This research evaluates the sustainability of Indonesian fisheries by utilizing local knowledge and identifying the key factors that significantly contribute to the economic, technological, social, ethical, and governance dimensions The research found the sustainability of the fisheries sector in West Pasaman Regency, West Sumatra Province, Indonesia. The sustainability index was 49.67 points, indicating a poor status emphasises the significance of local knowledge as a valuable resource for conserving fisheries.

To achieve sustainability, it is crucial to empower local wisdom and strengthen customary rules. The study identified the primary factors necessary for achieving sustainable fisheries, which depend on customary rules, local wisdom, and ecosystem damage mitigation.This research demonstrates that local knowledge, a concept long present in society, has direct or indirect economic impacts. It has contributed to the conservation of the environment and the prevention of environmental degradation. The ultimate goal is to achieve sustainable fisheries. However, the abundance of fisheries resources has not yet lifted the welfare of the community. Therefore, it is necessary to empower existing resources. This can be seen from a multi-dimensional perspective. The research indicates that local wisdom, which has been passed down through generations, is a forgotten factor that can be utilised to achieve sustainable fisheries.

The most likely strategy for managing sustainable fisheries is the conservative-optimistic scenario. However, analysis via RAPFISH suggests that the conservative-pessimistic scenario is more probable due to its cost-efficient approach in enhancing essential components. Therefore, efforts must be made to improve the key components involved in order to increase the sustainability of fisheries management. The research findings contribute to the existing body of knowledge by demonstrating that reinforcing traditional regulations and indigenous knowledge, as well as reducing harm to ecosystems, is crucial for achieving sustainable fisheries. Empowering customary rules and local wisdom can help reduce the impact of external factors on the fisheries sector, according to this research. Local wisdom assists in developing an environmentally friendly socio-political system for decision-making and policy formulation that affects the environment and natural resources of fisheries. This is because it is based on knowledge that has been passed down in the community.

The study results demonstrate the suitability of the area for Minapolitan development. With its character, economic activity in West Pasaman Regency, West Sumatra Province, Indonesia, is dominated by activities related to fishing Therefore can be said that the fisheries sector is a valuable potential for the economy. West Pasaman Regency is known for its unique application of the culture of prohibited fishing, making it a potential Minapolitan area in West Sumatra. The Regulation of the Minister of Marine Affairs and Fisheries No. 12 of 2010 outlines Minapolitan, an initiative to develop areas that utilize existing land and potential to address issues in managing and structuring space for activities that utilize abundant fishery products.

Therefore, it is recommended that the government develops policies for environmental mitigation in the fishing industry in the future. The current Indonesian fisheries law and policy are dominated by hierarchical or centralized governance models, which have numerous shortcomings compared to participatory governance. The management implications of this research suggest that the development of strategies based on ecosystem conservation and social empowerment, especially local wisdom, is necessary for the sustainable management of fisheries resources. Conservation activities are linked to specific areas, defined by Law No. 32 of 2009 as areas primarily intended for protection or management. Conservation involves regular maintenance and protection to prevent damage and destruction through conservation. Conservation can be considered from an economic, social and environmental perspective. Economically, conservation refers to the sustainable use of natural resources. Socially, conservation involves preserving and empowering local wisdom to improve the economy. Ecologically, conservation involves the allocation of natural resources for present and future use, so that fisheries management can be carried out with this in mind in order to achieve sustainable fisheries.

Further research is also needed to analyse the condition of the fisheries sector in West Pasaman Regency, West Sumatra Province, Indonesia with the aim of analysing the strengths, weaknesses, opportunities and challenges of the fisheries sector, especially from an ecological perspective so that appropriate risk mitigation can be determined. Furthermore, although it is beyond the scope of this article, it may be valuable to build on this study by conducting further research using more dimensions and comparing the results with findings from similar research in other provinces in Indonesia and other countries in order to find suitable managerial fisheries policy in achieving sustainable fisheries.

6. HIGHLIGHTS

West Pasaman Regency, West Sumatra Province, Indonesia, as one of the regencies that is unique in implementing forbidden fishing culture, can be considered a Minapolitan area in accordance with the Regulation of the Minister of Maritime Affairs and Fisheries Number 12 of 2010 concerning Minapolitan, where Minapolitan is the concept of area-based fisheries economic development based on the principles of integration, efficiency, quality, and acceleration by empowering local wisdom. The Minapolitan concept is based on three principles: democratization of the pro-people fishery economy, community empowerment, and strengthening regional potential.

Author's Contribution

First Author: Conceptualization, Data Curation, Formal Analysis, Investigation, Writing draft
Second Author: Methodology, Writing -review and editing
Third Author: Methodology, Writing -review and editing

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