International Journal of Sustainable Development and Planning
Vol. 18, No. 6, June, 2023, pp. 1877-1883
Journal homepage: http://iieta.org/journals/ijsdp

Sustainability Management of Teluk Benderas Lake, Rantau Baru Village, Pangkalan Kerinci District, Riau Province

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https://doi.org/10.18280/ijsdp.180623

Received: 24 November 2022
Accepted: 23 April 2023

Keywords:
attribute, Teluk Benderas Lake, sustainability, multi-dimensional scale

ABSTRACT

Most oxbow-lakes, spreading out in the riparian of Kampar river, were ecologically unsustainable due to social and anthropological reasons including intensive agriculture in the upper land, extensive urban around the lakes. Published papers suggested that the oxbow lakes ecosystem were degraded, biodiversity of the aquatic fauna were in adversity. Those threats have social economical affect on the local community. The present paper analyzes the sustainability of Teluk Benderas Lake, an riparian oxbow lake of Kampar, Pangkalan Kerinci District, Riau. The sustainability were analyzed from the perspective of ecological, economical, sociocultural, legal-institutional and technological. Sustainability analysis was carried out using the MDS (Multidimensional Scaling) analysis approach with the help of RapOxbow software (modified Rapfish). It revealed that based on ecological, economical, technological dimensions, the lake standing were unsustainable, with sustainability index of 29.8%, 30.0%, 44.3%, respectively. Meanwhile, the sustainability index of socio-cultural and legal-institutional, appeared 65.6%, 51.3%, respectively (fairly sustainable). It is suggested that 11 the driving variables that have been identified, should be evaluated and managed holistically in order to improve and enhance the sustainability of Lake ecosystem. In short, the role of local government were of important on this matter. Accordingly, the strategy and management plan and action plan for the Teluk Benderas Lake ecosystem need to be implemented integratedly by developing (a) sustainable small scale fisheries business (b). developing of alternative income generations (c) strengthening the role of traditional leaders and institutions.

1. INTRODUCTION

Intensive agricultural practices in the upper land of the Kampar River bring about problem to most of oxbow-lakes spreading out along in the middle and downstream of the river, one of four big rivers in Riau Province, Sumatera. Since the catchment area of the lakes were highly converted to agricultural and urban, the sustainability of ecosystem was mostly degraded and polluted. The lakes were reportedly degraded in terms of hydrological regime, high sedimentation, fully vegetated and low biological diversity. The existence and the sustainability status of hundreds oxbow lakes in the riparian need to be enhanced.

Published research showed that sustainability of the lakes based on ecological, socio-economical face a problem. On the other hand, most of lakes have been used by local people for income generation by fishing, tourism.

Management plan and regulations Danau Teluk Benderas (DTB) typically included to oxbow-lake, situated in the middle part of Kampar River. Since the catchment area of the lake were highly exploitated unwisely, accordingly the dynamic equilibrium of lake ecosystem was shifted. DTB typically included to oxbow-lake, situated in the middle part of Kampar River, one of four big rivers in Riau Province, Sumatera. The sustainability of the oxbow lakes were in adversity which related to anthropogenic threats including intensive agriculture in the upper land, extensive urban around the lakes, tourism within the lakes, Rantau Baru Village is a traditional village located on the banks of the Kampar River which is located in the administrative area of Pangkalan Kerinci District, Pelalawan Regency, Riau Province.

The results of the preliminary study show the phenomenon of ecological, economic, and social pressure that is starting to be felt by the people of Rantau Baru Village, such as a lack of fish catches and a change in the environmental tone around the Kampar River. In the upstream part of the village along the Kampar River, since 2010 the people have planted oil palm, whose fertilizer waste has polluted the waters. The water quality of Teluk Bederas Lake is classified as bad due to agricultural activities and oil palm plantations that reach the lake's lips [1]. In the context of conservation, it is prohibited to catch fish with tuba and poison, cutting down trees around the lake [2].

The problem that threatens the existence of Teluk Benderas Lake is the phenomenon of ecological, economic, and social pressure faced by the people of Rantau Baru Village, such as a lack of fish catches and a change in the environmental setting (from forest to oil palm plantation) around the Kampar River

and lake. Changes in the aquatic environment can result in environmental quality not supporting fish life. If the quality of the environment does not support fish life, it will result in the erosion of fish diversity. Overfishing results in a decrease in the abundance of fish and the catch of fishermen also decreases. The next impact is that the people around Lake Oxbow whose lives depend on fish resources will lose their livelihoods which can eventually lead to social conflict. Based on the facts described above, this study aims to formulate a sustainable strategy for the management of Teluk Benderas Lake.

2. THEORY AND METHOD

2.1 Data collection and analysis

This research is qualitative research where an object is a natural object or an object that is as it is and is not manipulated where the researcher becomes an instrument that interacts with data sources through direct observation and interviews as well as a literature review. This research involved sources/informants based on the principles of suitability and adequacy. The principle of conformity selects informants based on their knowledge and according to the research topic. The principle of adequacy does not require the number of informants but the completeness of the data obtained.

Primary and secondary data were collected for this investigation. The term "primary data" refers to information gathered directly from the research field through measurements, observations, or interviews. Secondary data are data acquired by others for their own objectives, and they are categorized or classified based on their intended use. Data collection methods consist of; literature study, surveys, and interviews. Data collection in the context of filling in the good-bad scale scoring is strengthened by secondary data. in order to formulate the oxbow attribute.

Data analysis employs a standard transformation procedure (valid) to produce a result in the form of information that can be used to explain data and serve as the basis for making decisions. The employed analytical method is sustainability analysis, specifically the MDS (Multidimensional Scaling) method with Rapfish software. MDS is a statistical analysis technique that performs multidimensional transformations. This study analyzes the sustainability of Teluk Benderas Lake management using the MDS Rapid Appraisal technique for Oxbow Lake, abbreviated as Rap oxbow, which is a modification of RapFish [3-11].

The results of the analysis are in the form of values for the level of sustainability and environmental management lever attributes of the research object. The score given to each attribute will determine the position of sustainability against two reference points, namely; good-bad. The determination of management sustainability lever attributes is based on the Root Mean Square (RMS) value. One of the principles used in determining the level attribute is based on the RMS mean value.

2.2 Location of study

The Teluk Benderas Lake situated between 00”16’58.28” N and 101”46’38.31” E (Figure 1) an as apart of Rantau Baru Village, Pangkalan Kerinci District, Riau. The lake has an area of 5.21 ha with depth of 5 m. This village has an area of about 10,000 hectares which is a lowland area, swamps and peatlands with typical peat forests. Several other oxbow lake and small rivers associated with the lake including; Kampar river, boko-boko, kiyap, pebadar, seluk kuras, Badagu, and other small rivers namely Lake Sepunjung (Janda = Widow Lake) and Teluk Benderas Lake. Lakes and rivers are fishing areas for the people of Rantau Baru Village, most of whom work as fishermen (Figure 1).

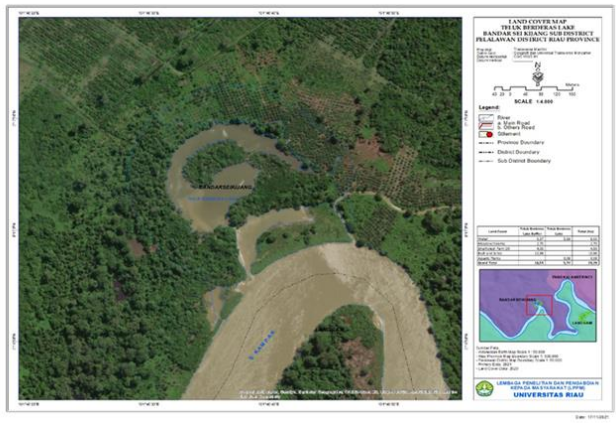

Figure 1. Map of research location (Teluk Benderas Oxbow Lake)

3. RESULTS AND DISCUSSION

3.1 Ecological sustainability

It was identified that 9 attributes influenced ecological sustainability including zoning of the lakes, forest area, protection forest, water fertility, protected species, fish diversity, conservation activities, flood frequency and water condition.

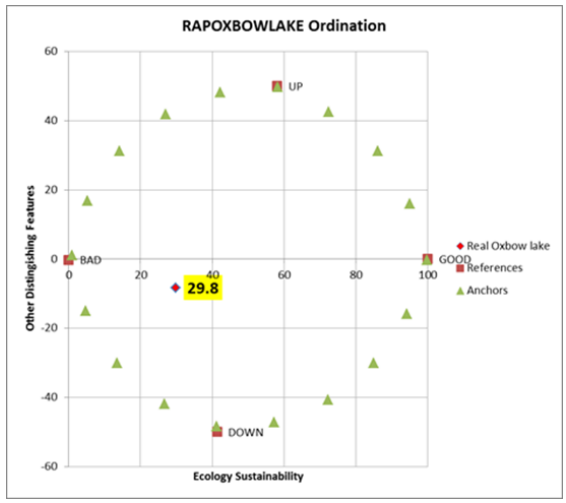

Figure 2. The sustainability index for the ecological dimension

Based on RapOxbow analysis (Figure 2) the sustainability index account for 29.8% (less sustainable). This value illustrates the condition of Teluk Benderas Lake were under pressure from an ecological aspect. Field observations proved that the water quality regime of Teluk Benderas Lake decreased, due to land conversion from forests to oil palm

plantations. All human activities will have an impact on the structure and function of ecosystems [12]. The RapOxbow analysis for the management of Lake Baru obtained a sustainability index of 46.05% or classified as less sustainable (<50). This suggest that lake experiencing pressure from the ecological aspect. In fact, it related to land use change for urban population around the lake [10].

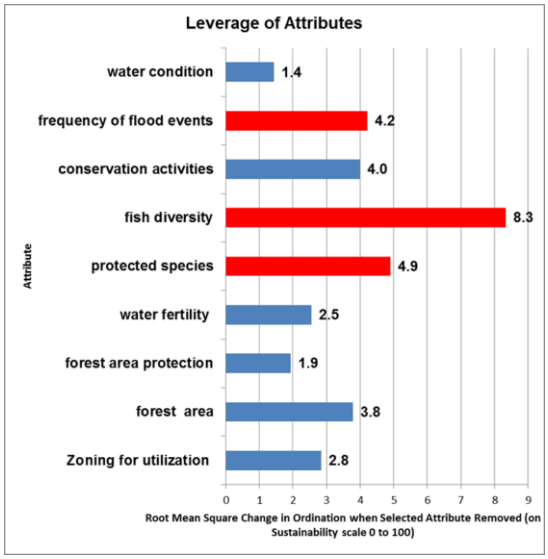

Figure 3. Ecological dimension sustainability leverage attributes

In addition to the sustainability index, RapOxbow's analysis also produces output in the form of leverage of attributes. The leverage attribute is the attribute that gives the highest percentage value in the sustainability of a management dimension. The results of the leverage analysis (Figure 3) figure out 3 attributes (sensitive) to the sustainability index value of the ecological dimension, namely, (1) fish diversity (RMS=8.3%), (2) protected species (RMS=4.9%) and frequency of flood events (RMS=4.2%). These three attributes provide direction for the interpretation that lake conditions are strongly influenced by environmental biology. The RMS value reveals the significant contribution of each characteristic to the sensitivity of sustainable status. In other words, the greater the RMS value, the greater the influence or significance of these characteristics on sustainability sensitivity.

3.2 Economic sustainability

Apparently, 9 attributes had impacts on the the long-term economic dimension of sustainability of the Lake management. Those attributes have direct influence and relevance in the utilization and management of Teluk Benderas Lake. These attributes include; Fishermen's income level, Availability of fishing capital, Fishing intensity, Tourism potential, Local labor absorption, Dependence on the fisheries sector, Marketing of fishery products, Access to resources, and Availability of tourist facilities. The following is an ordinated chart of the economic dimensions, as follows:

The results of the RapOxbow analysis for the economic dimension (economy sustainability) obtained a sustainability index of 30.0%, (Figure 4) or less sustainable (<50). This value illustrates that the management of Teluk Benderas Lake is experiencing pressure from the economic aspect. This can happen because the ability of natural resources and the environment to provide benefits and environmental services has decreased due to high pressure from the people who use the lake (the winner of the auction). Facts at the research location show that oxbows are public waters where access to resources is indeed limited but in their utilization, the winning bidder group can exploit fish resources as much as possible without any restrictions. Such conditions will result in the productivity of the lake from time to time decreasing.

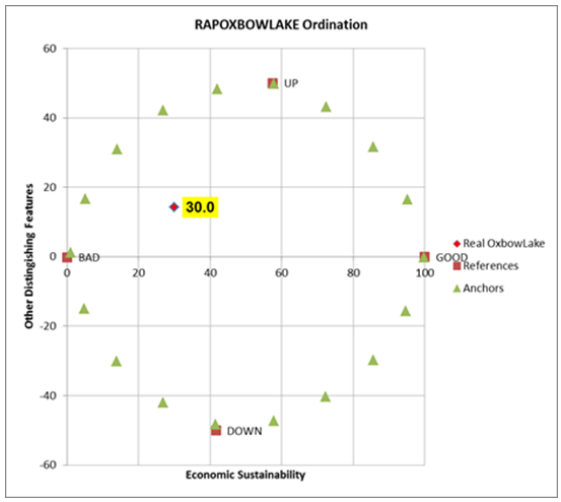

Figure 4. The Sustainability index for the economic dimension

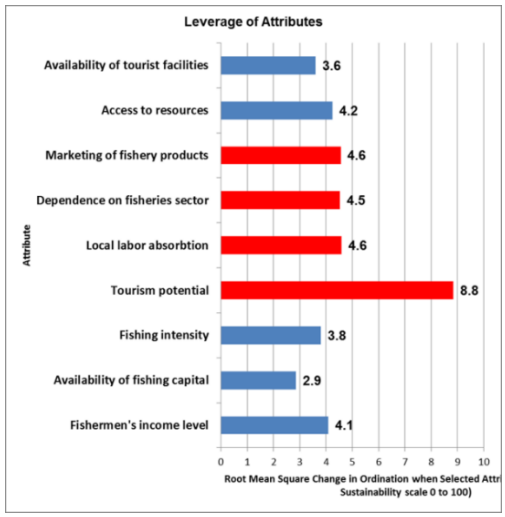

Figure 5. Economic dimension sustainability leverage attributes

RapOxbow's analysis also produces output in the form of leverage of attributes. It revealed that 4 attributes of the economic dimension that have the most influence on the sustainability of Teluk Benderas Lake (Figure 5), including tourism potential (RMS=8.8%), local labor absorption (RMS=4.6%), marketing of fishery products (RMS=4.6%) and dependence on fisheries sector (4.5%). These attributes provide direction for the interpretation that Teluk Benderas Lake. has high economic value.

The tourism potential of the lake is classified as having a fairly high sensitivity. This attribute is very important to be managed through the development of good Teluk Benderas Lake tourism. This is in line with the existing conditions that Rantau Baru Village has been made a fishing tourism village on the Kampar River. Therefore, Teluk Benderas Lake has the

opportunity to develop aquatic ecotourism objects (rowing boats, fishing boats, typical village culinary delights) which can be used to develop alternative economic sources for the lake, so as to reduce ecological pressure caused by fishing activities. This means that the economic dimension of the lake can be developed, one of which is through the management of the ecotourism sector. Therefore the infrastructure to develop lake ecotourism as an economic resource needs to be prepared.

The development of Teluk Benderas Lake Ecotourism will have a positive effect on the economy of rural communities, where job opportunities for local workers are fulfilled and facilitate the marketing of fishery products, which in turn will reduce people's dependence on the lake. The development of these tourist objects can be used to develop alternative economic sources for the community, so that they can reduce ecological pressure caused by fishing activities. This means that the economic dimension of the lake can be developed, one of which is through the management of the tourism sector. Thus the high economic intensity of the Danau Baru fishery in the future can be controlled by optimizing the potential of oxbow ecotourism [10].

3.3 Social sustainability

The social-cultural dimension describes how the social aspects in the management of Teluk Benderas Lake affect the sustainability of resources and the environment in the long term. The social-cultural dimension has 9 attributes including; level of community participation, fisherman cohesiveness (social networking), conflict potential, education level, environmental knowledge, alternative non-fishery livelihoods, community empowerment, aesthetics, and local wisdom.

Based on the MDS analysis, the social and cultural dimension index is 65.6% (Figure 6). This number indicates that the sustainability of this dimension is between 51 and 75%. Thus, the management of Lake Teluk Benderas has contributed to the growth of its social and cultural dimension. Therefore, to maximize the lake's sustainability, it is essential to boost the growth of its social and cultural dimension.

The results of the leverage analysis (Figure 7) obtained five attributes that are sensitive to the value of the social and cultural dimensions of the sustainability index, namely: (1) Knowledge of the environment (RMS=6.1%), (2) Potential conflicts (RMS=4.2%), (3) Alternative non-fishery livelihoods (RMS=4.2%), (4) Community empowerment (3.5%) and (5) Fisherman cohesiveness (social networking) (RMS=3.3%). The RMS value reveals the significant contribution of each characteristic to the sensitivity of the sustainability status. In other words, the greater the RMS value, the greater the influence or significance of these traits on the sensitivity to sustainability [13, 14].

Noting the level of education of the community is of equal importance. The development of human resources through formal education policies must be enhanced in order to raise the level of formal education in the community. In addition, human resource development can be accomplished by enhancing counseling, training, and non-formal education in order to increase environmental awareness among the general people. There is a positive relationship between the level of education and environmental sustainability behavior. A high level of education will provide positive behavior toward environmental sustainability behavior, and vice versa [15].

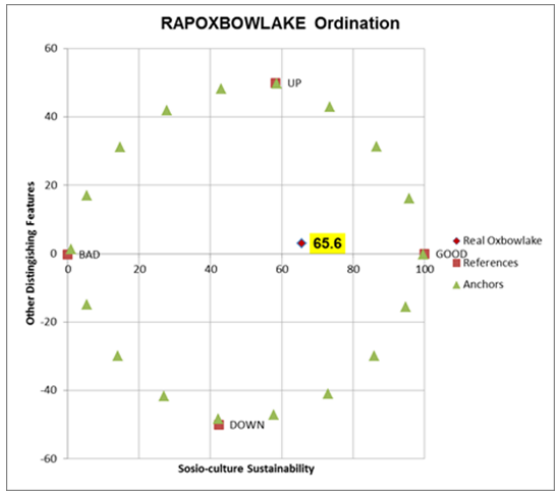

Figure 6. The sustainability index for the socio-cultural dimension

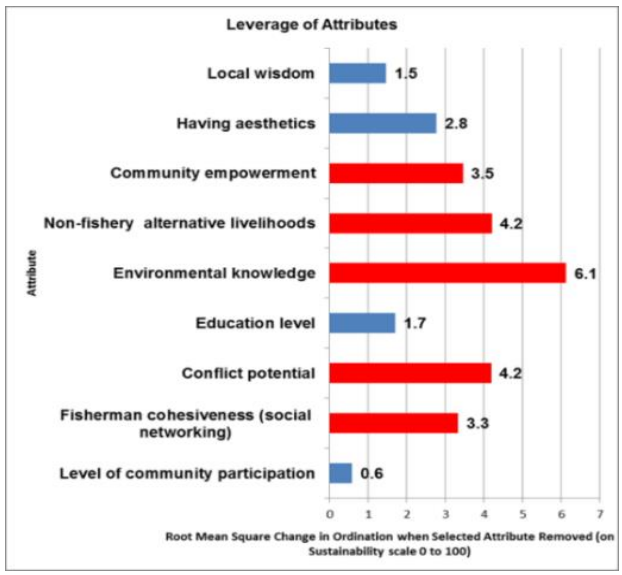

Figure 7. Socio-Cultural dimension sustainability leverage attributes

Given that the lake's water area is not growing while the economic activity of fisheries is growing, the possibility of conflict is growing. The conflict was precipitated by limited natural resources; nevertheless, the lake's natural resources are categorized as common property resources, which have consequences for open access, and therefore have the potential to result in a tragedy of the commons. Therefore, the conflict sources must be appropriately addressed so as not to exacerbate the negative effects on lake management. Therefore, it is necessary to consider and implement community empowerment activities so that alternative non-fishing livelihoods are formed and fishermen's social networks are always preserved.

To strengthen the sustainability of the social and cultural components of Teluk Benderas Lake management, it is vital to pay close attention to sensitive characteristics, based on this description. However, it is also important to consider other characteristics, such as the level of community education.

3.4 Technological sustainability

The technological dimension describes the role/influence of technology in Teluk Benderas Lake's sustainable management. The technological dimension is comprised of six attributes: types of fishing gear, use of forbidden gear, negative effects of fishing gear, selectivity of fishing gear, monitoring facilities and infrastructure, and information accessibility.

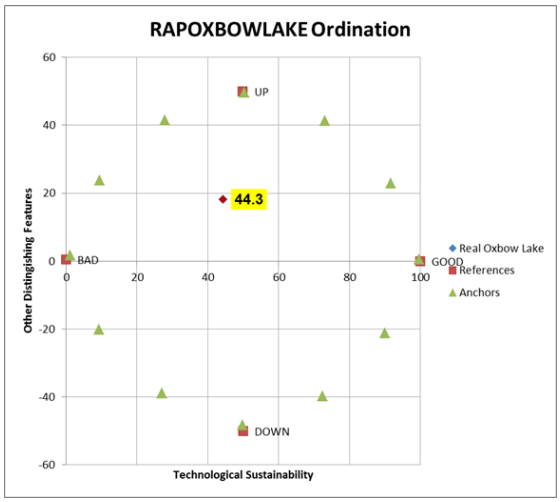

Figure 8. The sustainability index for the technology dimension

Based on the MDS analysis, the Technology dimension index is 44.3% (Figure 8). This value means that the Technology dimension in the management of Teluk Benderas Lake is less sustainable. This condition illustrates that in the sustainable management of Teluk Benderas Lake the Technology dimension is not optimally considered. This is in accordance with field observations which illustrate that in utilizing fish resources, the auction winner uses trawl fishing gear.

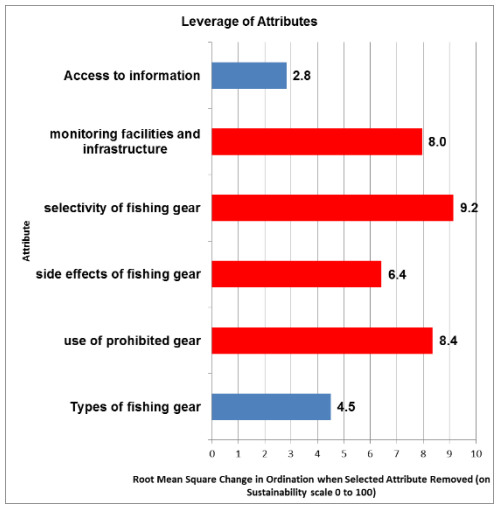

Figure 9. Technology dimension sustainability leverage attributes

The results of the leverage analysis (Figure 9) obtained four attributes that are sensitive to the value of the technology dimension sustainability index, namely, (1) Selectivity of fishing gear (RMS=9.2%), (2) Use of prohibited gear (RMS=8.4%), (3) Monitoring facilities and infrastructure (RMS=8.0%), and (4) Side effects of fishing gear (RMS=6.4%). The RMS value indicates the large role each attribute plays in the sensitivity of sustainability status. In other words, the higher the RMS value, the greater the influence or role of these attributes on sustainability sensitivity [14].

Field observations provide information that the fishing gear used by the fishermen group is not ecologically friendship, since the gear is less selective, so that fish of various sizes are also caught. If the operation of this tool is not regulated, the diversity of fish in Teluk Benderas Lake will be disrupted. Meanwhile, supervision facilities and infrastructure in Rantau Baru Village also do not exist. For this reason, the role of government is needed in preparing the necessary facilities and infrastructure.

Based on this description, in order to increase the sustainability of the technological dimensions of the management of Teluk Benderas Lake, it is necessary to pay serious attention to the selectivity attributes of fishing gear, prohibit the use of prohibited equipment (catching using electricity and poison/tuba) and preparing monitoring infrastructure (facilities and village regulations regarding the use of rivers, inlets and oxbow lakes).

3.5 Legal and institutional sustainability

The legal and institutional dimension describes the role/influence of law and institutions in the sustainable management of Teluk Benderas Lake. Legal and institutional dimensions are explored into eight main attributes namely; Local community access to oxbow resources, local cultural practices in preserving the oxbow, availability of community organizations in oxbow management, coordination among stakeholders, completeness of rules, environmental law education, implementation of monitoring and supervision, and enforcement of penalties.

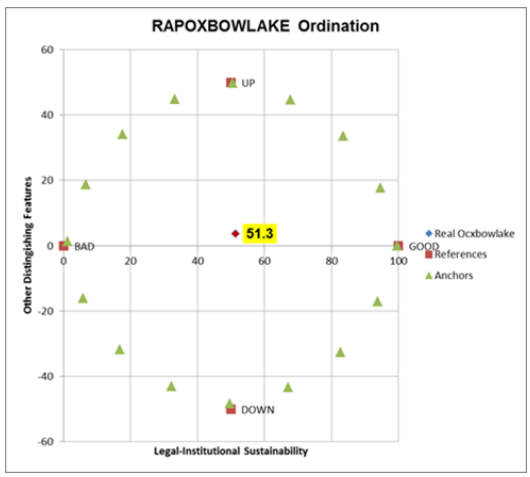

Figure 10. The sustainability index for the legal and institutional dimension

In accordance with the findings of the MDS analysis, the legal-institutional dimension index is 51.3% (Figure 10). This rating indicates that the legal-institutional aspect of the management of Teluk Benderas Lake is quite sustainable. These conditions indicate that the legal and institutional responsibilities in the Teluk Benderas Lake's sustainable management are beginning to improve. It is crucial to pay close attention to this since laws and institutions play a crucial

role in the sustainable management of natural resources. The institutional aspect regulates not just the natural resources of Teluk Benderas Lake, but also the functions of parties with an interest in the ecosystem of the oxbow lake.

Based on the leverage analysis for the legal and institutional dimensions (Figure 11), demonstrate that the attributes that most influence the legal and institutional dimensions' sustainability are: (1) Access of local communities to oxbow resources (RMS=1.4%) and (2) Enforcement of punishments (RMS=0.8%). The RMS value illustrates the significance of each attribute's function or influence on the sensitivity of the sustainability status [14].

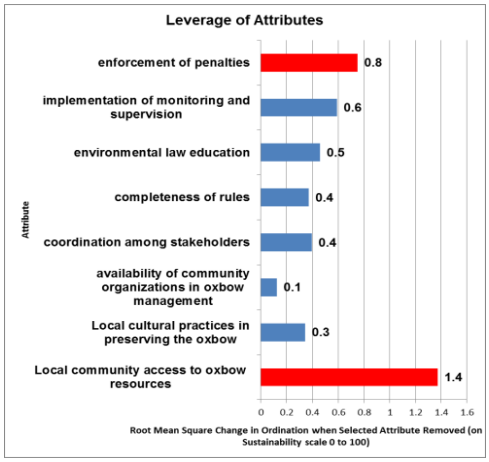

Figure 11. Legal and Institutional dimension sustainability leverage attributes

Basically, the people of Rantau Baru Village really understand the importance of rivers, lakes, and forests. The community still adheres to customary provisions, in which existing customary assets (forests and lakes) are collective property, not private. Besides that, traditional institutions in Rantau Baru Village already exist, where traditional leaders have a very important role in social life. Developing the role of local leaders and community participation in river and lake management will have a major contribution to increasing the sustainability of the legal and institutional dimensions.

3.6 Determinants of the sustainability of Teluk Benderas Lake management

The preparation of the Teluk Benderas Lake management strategy is carried out by determining the determinants that influence system performance. Getting the dominant factor in compiling the model is done by looking at the sensitive attributes. There are eleven determining factors that need to be considered to improve the sustainability status of Teluk Benderas Lake, namely fishing gear selectivity, tourism potential, use of prohibited gear, fish diversity, monitoring facilities and infrastructure, side effects of fishing gear, environmental knowledge, protected species, local workforce, marketing fishery products, and dependence on fisheries as a source of livelihood.

3.7 The management strategy for the Teluk Benderas Lake ecosystem

Sustainable Fisheries Business Development. It can be started with environmentally friendly fishing activities and the development of fishery reserves. This requires regulation: the use of fishing gear sizes; tool operation; season, time, and area of fishing; quantity and type of fish caught; permitted types of fishing gear; and the use of environmentally friendly fishing gear. Indicators of environmentally friendly fishing gear, namely: 1) Not catching in restricted areas; 2) Does not endanger fishermen; 3) Not catching protected species; 4) Maintaining biodiversity; 5) Does not damage the physical environment of the waters; 6) High-quality catch; 7) Low bycatch; 8) High selectivity; if the mesh size used and the size of the type of catch match the purpose and target of the catch [16]. Regulation of fishing in public waters is an aspect of preserving fisheries' germplasm resources [17]. In this effort, there are several aspects of catching that are very important to pay attention to, namely: (1) fishing regulations related to the size of fishing gear, (2) fishing gear operations, (3) fishing areas, (4) catching with prohibited tools or materials, and (5) regulation of the amount of fishing effort state that the establishment of asylums in several places in the waters is urgently needed to maintain the sustainability of fishery resources [18].

Development of Alternative Livelihoods. This condition can be done by developing oxbow ecotourism. One good way to eliminate community dependence on fish resources is to reduce fishing intensity. Changing the business of fishing from the main livelihood to a sideline livelihood, and carrying out restocking activities means entering fish species that previously existed in lake waters. For this reason, it is necessary to have other business opportunities as alternative livelihoods (e.g., river/oxbow ecotourism and fish farming). To realize an ecotourism development program, it is necessary: 1) Procurement of facilities and infrastructure to support tourism activities. (Availability of roads leading to the area, clean water infrastructure, electricity, telecommunications, health, restaurants, and entertainment), 2) Increasing the capacity of the community around Oxbow, 3) Availability of Tourism Program Operational Costs. which has an impact on improving the community's economy, 4) Establish rules/policies on river/lake management, as well as carry out supervision and plans for the development of tourist areas so as not to deny the principles of sustainability, for example by setting product standards, being environmentally friendly, and standard facilities in accordance with the natural character and potential. In addition, the development of fish farming in floating net cages (KJA) is a form of cultivation that allows it to be realized in a sustainable manner.

Strengthening Traditional Leaders and Institutions. Some programs that can be implemented are: 1) The village government, traditional leaders together with the community must carry out continuous monitoring regarding damage to forests, rivers, inlets, and lakes carried out by certain people/individuals. Furthermore, information is provided electronically (SMS, WhatsApp), so that even if there is damage, appropriate steps can be taken immediately, 2) The government must involve the community in order to increase forest conservation and utilization. Counseling/informing the local community is very important in order to assist in preserving aquatic ecosystems. As well as motivating the community to be responsible for the environment in order to remain sustainable, and 3) Firm law enforcement by the village government, and traditional leaders of law enforcement officers (police) for people/persons who damage the environment.

4. CONCLUSIONS

The level of multi-dimension sustainability of Teluk Benderas Lake is currently classified as less sustainable, with an index of ecological, economical, sociocultural, tyechnological and legal institutional dimension 49.20%, 29.8%, 30.0%, 65.6%, 44.3% and 51.3%, respectively.

The driving variables for the sustainability of Teluk Benderas Lake consist of 11 attributes namely; selectivity of fishing gear, tourism potential, illegal gear, fish diversity, monitoring facilities and infrastructure, side effects of fishing gear, environmental knowledge, protected species, local workforce, marketing of fishery products, and dependence on fisheries as a source of livelihood.

The management strategy for the Teluk Benderas Lake ecosystem should integratedly implement a). Sustainable Fisheries Business Development b). Development of Alternative Livelihoods c). Strengthening Traditional Leaders and Institutions.

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