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Sustainability analysis of the management of Lake Baru in Buluh Cina Village, Indonesia

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Abstract

Purpose – The purpose of this paper on the level of sustainability of the oxbow lake is to determine the sustainability status, leverage of attributes and driving factors in the management of the oxbow lake in Buluh Cina Village in Kampar, Riau, Indonesia.

Design/methodology/approach – The types of data collected include primary data and secondary data. The data were collected using the methods of surveys, library research, laboratory analysis and interviews. The analysis methods employed in this research were the multidimensional scaling (MDS) analysis and the prospect analysis. The sustainability analysis was undertaken using the approach of the MDS analysis with the assistance of software RapOxbow.

Findings – The current sustainability status of the management of Lake Baru ecosystems according to a number of dimensions is regarded as sustainable with a sustainability index value by 50.95. Meanwhile, analysis results of each dimension show that the sustainability index for the ecological dimension is 42.56 and the sustainability index for the economic dimension is 47.44, which means that they are less sustainable. While the sustainability index for the socio-cultural dimension is 54.81, the sustainability index for the technological dimension is 53.12 and the sustainability index for the legal-institutional dimension is 56.83, meaning that they are fairly sustainable.

Originality/value – The originality of this paper lies at the approaches of this research which are MDS analysis and a prospect analysis, and the research location in Buluh Cina Village in Kampar, Indonesia, that has not been researched before. This is one of few studies which investigate comprehensively the sustainability analysis of management, especially in ecological, economic and socio-cultural dimensions in Indonesia.

Keywords Management, Sustainability, Indonesia, Ecosystems, Resource, Multi-dimensional scaling

Paper type Research paper

1. Introduction

Kampar River is one of the important rivers in Riau Province. It is approximately 413.5 km in length. Its headstream is located in the Bukit Mountains around West Sumatra while its estuary is located in the East coast of Sumatra Island, Riau. In the headstream of the Right Kampar River, there is a dam and thus a reservoir forms and is used for power generation (Koto Panjang Hydropower Plant) with a capacity of 114 MW (Mulyadi, 2003). Prior to the establishment of this hydropower plant, Kampar River followed the annual season. In the rainy season, water in Kampar River would overflow (flood) depending on the length and intensity of the rainfall. However, since the Koto Panjang Hydropower Plant has been established, such a condition can be controlled, thus helping people along Kampar River in order to avoid the threat of flooding. Any changes will affect the physical, chemical

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and biological conditions of the waters. These conditions also affect the oxbow ecosystem located in the center of Kampar River's watershed.

Changes that occur in the headstream of Kampar River have a direct impact on the ecosystem in an oxbow lake, by causing disruption to fluctuations in water discharges making fish in the river unable to enter into the oxbow lake to spawn and vice versa. In a changing environment, organisms living therein will adapt to the environment, or else they will die. The ecosystem in the oxbow lake is not only vulnerable to direct changes such as conversion to agricultural land or settlements, but also to changes in the quality of river water that runs down to the oxbow lake. Consequently, the diversity of fish in such waters conditions is more susceptible to interference than that in another ecosystem. These will ultimately affect the lives of people whose lives depend on an oxbow lake. For the people of Kampar, the oxbow lake serves as a source of fish/livelihood, a prohibited lake (fishery sanctuary) and local tourism (Ma'auwo fish activities).

Considering the vital role of the oxbow lake for the people of Buluh Cina Village in Kampar and for conservation attempts of fish resources as well as social and economic activities, it is necessary to adopt sustainable management of the ecosystem of the oxbow lake (Lake Baru) based on the five dimensions of sustainable development, namely ecological, economic, socio-cultural, technological and legal-institutional dimensions. According the World Commission on Environment and Development (1987) report acknowledges that "growth by itself is not enough" (p. 44), it still makes a direct and inseparable connection between growth and issues of poverty alleviation, equity and income redistribution. Advocates of ecological modernization, who often present this theory as the operational tool of sustainable development in industrial societies, continue to see economic growth as a central feature for a just and equitable development (Spaargaren and Mol, 1992). However, as noted by Arrow (1996, p. 14), the link between growth and equity may not be so straightforward, especially in regions where it is needed most, namely, where "the environmental costs of economic activity are borne by the poor, by future generations, or by other countries." Redistribution and equity are, to a certain extent, contradictory with the primary objective of economic activity, being to maximize "economic efficiency" (irrespective of the initial distribution of wealth) and increase national income (which is assumed to be directly proportional to the well-being of society as a whole) (Hanley, 2000; Norgaard, 1992; Ziegler, 2009). This is intended to maintain the diversity of fish and support the prosperity of the people who depend their lives on fish resources in the oxbow lake.

There are found many small lakes in the form of horseshoe (oxbow lake) in the middle of Kampar Kanan Watershed (Tambang and Siak Hulu Sub-Districts) and Kampar Kiri Watershed in Kampar Kiri Hulu to Kampar Kiri Hilir) which are used by local communities to catch fish. Oxbow lake is a horseshoe-shaped lake, formed by the breaking down of natural streams, through sedimentation and silting. Ecologically, there has been a physical change from a flowing ecosystem (in the form of a river) to a flooded ecosystem (in the form of a lake). Physically, the river and oxbow lake have lost their relationship, but their ecological relationship can occur in the rainy season where the water of the river overflows (flooding).

There is only a small amount of ecological data of oxbow lake ecosystem in Kampar regency. Therefore, the strategy of oxbow lake water management in the area is still difficult to be properly formulated. Generally, research on oxbow lake in Kampar is limited. The research conducted is still about ecological and biological studies such as: Sediments and the abundance of macrozobenthos in Baru Lake, (Dirgahayu, 2008), Type and the abundance of Perifiton (Afriani, 2009), Temperature and dissolved oxygen (Kagawa, 2007), Diversity of fish (Wahyuni, 2013), Vertical profile of phospate (Siregar, 2013), Periphyton diversity in Eceng Gondok dan Pandan air (2014) and Vertical profile of dissolved oxygen (Andari, 2014).

Research on some oxbow lakes found in Central Kalimantan has also been conducted, such as: Productivity of Rotifera zooplankton in Batu and Sabuah Lake (Elvince *et al.*, 2006), Availability of epiphytic macroavertebrata in some types of water plants in Tundai Lake (Wulandari *et al.*, 2006). Primary production of phytoplankton in Batu Lake, an oxbow tropical lake in Central Kalimantan (Veronica and Ardianor, 2007) and The phytoplankton community in oxbow lake group around Sigi Village, Central Kalimantan (Ardianor dan Veronica, 2007).

The aims of this study on the level of sustainability of the oxbow lake is intended to determine the sustainability status, leverage of attributes and driving factors in the management of the oxbow lake in Buluh Cina Village in Kampar. The originality of this paper lies at the approaches of this research is multi-dimensional scaling (MDS) analysis and a prospect analysis, and the research location in Buluh Cina Village in Kampar, Indonesia, that has not been researched before.

This research applied some methods of analysis which were implemented comprehensively (Rap-oxbow, prospective analysis) in constructing oxbow ecosystem management design in Buluh Cina Village, Riau. In terms of research results, a new concept of oxbow ecosystem management was developed in Buluh Cina Village that integrated factors that were specific in oxbow lake management, in accordance with the socio-cultural conditions of the Kampar community, and incorporated the conservation interests of fish diversity and the importance of increasing the welfare (income) of fishermen.

2. Methodology

This research of oxbow lake to determine the sustainability status, leverage of attributes and driving factors in the management of the oxbow lake in Buluh Cina Village in Kampar was conducted from March 2014 to December 2016 in Lake Baru (oxbow lake) situated in Buluh Cina Village, Siak Hulu sub-district, Kampar. Lake Baru is one of the seven oxbow lakes situated in the area of recreation forest in Buluh Cina. This lake is located in 0°22'4"–0°22'24" in the North Latitude and 101°31'48"–101°32'8" in the East Longitude. The total area of Lake Baru is ± 5 ha, with a length of ± 1.205 m and an average width of 40 m (Figure 1). The research design of oxbow lake management was done by using survey method, literature study, laboratory analysis and interview. Field surveys were conducted to collect bio-physics data of oxbow lake and socioeconomic. Interviews were conducted to: find out the environmental issues that emerged in the management of oxbow lakes; to know the problems and opinions of stakeholders regarding the management of oxbow lake; and to know the expert or expert opinion on oxbow lake management.

The scope of the study reviewed include ecological, economic, socio-cultural, infrastructure and technology as well as legal and institutional aspects. Management analysis and design is conducted based on primary data and secondary data obtained from field surveys reinforced by expert or expert opinion in the field. The implementation of the study is divided into several stages (Figure 2) including:

(1) library study (desk study) by collecting research results about oxbow lake and the factors that influence it;

(2) determination of the main attributes on every ecological, economic, socio-cultural, infrastructure and technology aspects, as well as laws and institutions that affect the sustainability of oxbow lake management;

(3) conduct field surveys to collect data on biophysical, socio-economic and socio-cultural components;

(4) conducting data analysis that is biophysical analysis of lake oxbow, stakeholders needs analysis, sustainability analysis and prospective analysis;

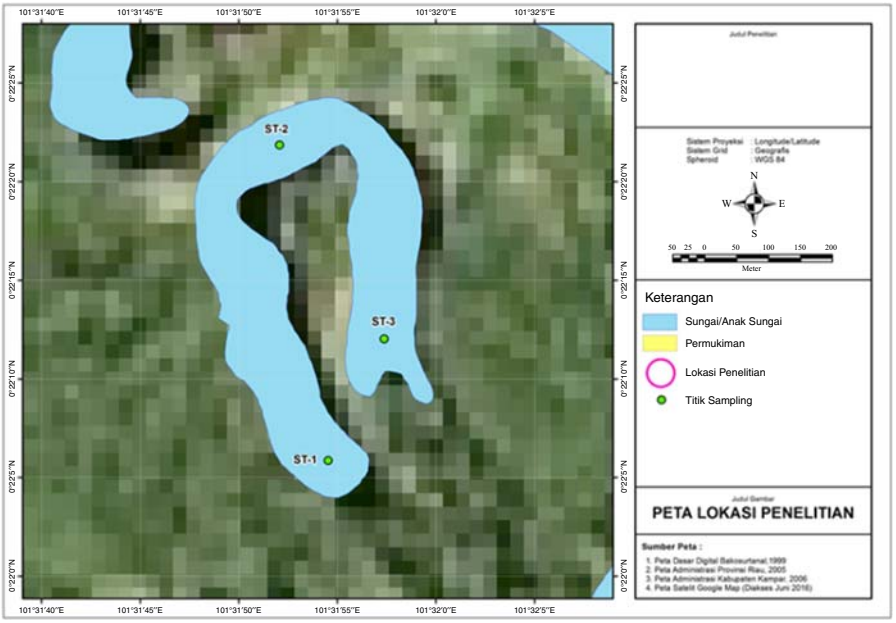

Figure 1.
Lake Baru in Buluh Cina Village

(5) develop alternative scenario of lake oxbow management strategy based on previous stage analysis result; and

(6) establish the status of the management of Lake Baru.

Data types and data collection methods

The type of data used in the oxbow lake study in Buluh China Village in Kampar includes primary and secondary data. Primary data were obtained from respondents and findings of direct observation in the research site, while secondary data were obtained from several literature and documents from several agencies related to the research into Lake Baru. Secondary data refer to data obtained from writings or documents related to the management of Lake Baru. In detail, the types and sources of data required in this study are presented in Table I.

Determination of respondents from the community is done by purposive sampling with the criteria that can represent the fishing communities and communities associated with the utilization of lake oxbow. In addition, there were also in-depth interviews with informal and formal figures as key respondents. Respondent determination for expert survey is done by purposive sampling technique (according to purpose). The selected respondents had expertise on the field under study. Some considerations in determining the respondents are: has a competent experience in accordance with the field being studied; has a reputation, position/position in its competence with the field being studied; and has a high credibility, is willing and or is in the location studied (Marimin, 2004). The method of collecting data detail in shown in Appendix 1.

Ecology focuses on populations of organizations and examines the effect that the environment, market forces, technology, natural resources and geographical locations have on organizational change and development processes. In essence, the ecological approach of diverse populations affect the rise and fall of organizations and shape the conditions that

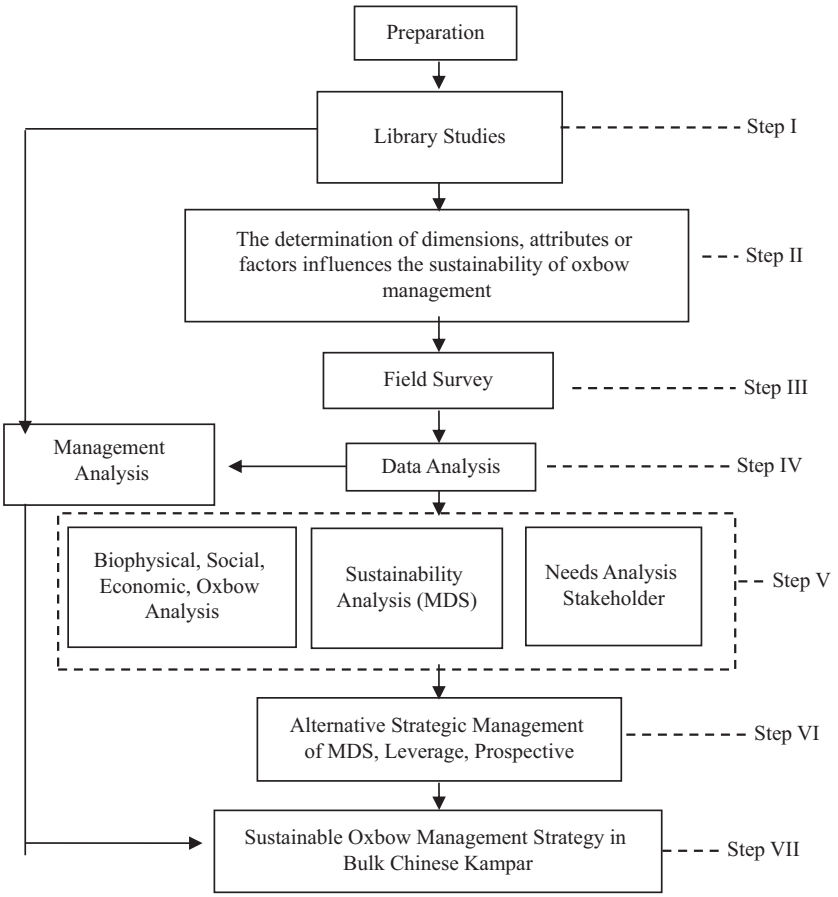

Figure 2.
Research operational framework

No.	Data type	Data source
Primary data		
1	Water quality (temperature, water clarity, depth, pH, dissolved oxygen, free CO_2, nitrate and phosphate)	*In situ* and laboratory
2	Wide lake oxbow	*In situ* and laboratory
3	The diversity of fish	*In situ* and laboratory
4	Sedimentation	*In situ* and laboratory
5	Analysis of stakeholder needs	Respondents (stakeholders)
6	Identification of strategic factors (prospective)	Respondents (expert)
7	Comparison between factors (prospective)	Respondents (expert)
Secondary data		
1	Level of exploitation	DKP
2	Total population	BPS
3	Livelihood	BPS
4	Number of fisherman	BPS
5	Frequency of conflict	DKP
6	Legislation	DKP
7	Institutional structures	DKP

Table I.
Types and sources of data required in the study

promote their mutual homogeneity, diversity, stability, change and growth (Astley, 1985, p. 114). The dimension of economic gains is strongly connected with the local environment and to the larger economy of the nation as a whole. Hence, the entire process of developing cultural tourism is not only rooted in local systems but also in the traditional ethos of a community. It plays a pivotal role in the wider interest of the nation, especially on the economic front.

The data were collected using the methods of surveys, library research, laboratory analysis and interviews. Survey method is the questionnaire technique. The questionnaire technique developed is a closed system, i.e. respondents posed questions with choices of answers that have been available. Targeted respondents are stakeholders who play a role in the management and utilization of Lake Baru. Respondent determination is based on key stakeholders and experts. Key stakeholders are respondents who have a role as a decision maker, such as: head of service, while the experts/experts are those who study science in the field of environment and natural resources. In addition, also taken are community leaders and observers of the environment and natural resources. The number of respondents is 12 people, consisting of the following: two policy makers (Fisheries and Marine Service, and Forest Service), two experts (experts), one NGO, one businessman, three community leaders and three fishermen, while the literature study method is intended to collect data in the form of previous research results related to the management of Lake Baru. Field surveys were conducted to collect biophysic and socioeconomic data on the oxbow lake. Using the MDS method, the position of sustainability points can be visualized using horizontal and vertical axes. MDS is a means of visualizing the level of similarity of individual cases of a data set. It refers to a set of related ordination techniques used in information visualization, in particular to display the information contained in a distance matrix. The purpose of MDS is to provide a visual representation of the pattern of proximities (i.e. similarities or distances) among a set of objects. Using the rotation process, the position of points can be visualized on the horizontal axis with the value of the sustainability index ranging from 0 to 100 (Table II).

3. Analysis result

Laboratory result

New Lake is a U-shaped oxbow lake where the surrounding plains are relatively high. The volume of lake water is influenced by water input from Kampar River. During the rainy season, the volume of Kampar River water increases, then there will be an abundance of water coming from Kampar River to New Lake. At this time. the water conditions in New Lake are very turbid because the mud particles carry along with the entry of water from the Kampar River. If the dry season, New Lake is relatively closed and the waters become clear because the mud particles have settled. Based on the results of research, the base substrate of New Lake is sandy mud. The results of New Lake water quality measurements during the study are presented in Table III.

Based on the data presented in Table II, there is a change in water quality parameters from March 2014 to April 2015. New Lake water depths during the study ranged from 286.4 to 387.8 cm, water clarity 86.1–132.1 cm, temperature 29–31°C, pH 5.4–6.0, DO 2.64–4.18 mg/L,

Index value	Category
0.00–25.00	Bad (not sustainable)
25.01–50.00	Inadequate (less sustainable)
50.01–75.00	Fair (fairly sustainable)
75.01–100.00	Good (highly sustainable)

Source: Fauzi and Anna (2005)

Table II.
Category for the sustainability status of oxbow lake management

Table III.
Results of physical–chemical aspect measurement at new lakes March 2014–April 2015

No.	Month	Parameter water quality: Depth (cm)	Water clarity (cm)	Temperature (°C)	pH	DO (mg/l)	CO_2 (mg/l)	Phosphate (mg/l)	Nitrate (mg/l)
1	March 2014	302.0	132.1	30.2	5.9	3.07	6.49	0.0066	0.0250
2	April	322.7	119.6	29.3	5.7	3.31	7.26	0.0068	0.0308
3	May	359.1	88.8	29.0	5.6	4.11	8.96	0.0083	0.0424
4	June	328.0	99.4	29.7	5.7	3.42	7.43	0.0082	0.0350
5	July	308.6	107.4	30.0	5.8	3.10	7.04	0.0063	0.0309
6	August	293.6	114.1	30.7	5.9	2.74	6.51	0.0056	0.0287
7	September	289.8	117.7	31.0	5.9	2.64	6.40	0.0054	0.0280
8	October	292.7	114.0	30.8	5.9	2.77	6.53	0.0058	0.0289
9	November	310.4	108.1	30.0	5.9	3.08	6.98	0.0064	0.0300
10	December	387.8	86.1	29.0	5.4	4.04	9.62	0.0097	0.0392
11	January 2015	353.2	90.3	29.0	5.8	4.18	9.58	0.0089	0.0437
12	February	324.8	105.0	30.0	5.8	3.42	7.64	0.0081	0.0361
13	March	306.3	112.0	30.0	6.0	3.26	7.44	0.0069	0.0349
14	April	286.4	123.0	30.6	6.0	3.11	7.13	0.0054	0.0298
	Standard quality			Dev-3	6–9	3	25	0.2	10

CO_2 free of 6.4–9.6 mg/L, phosphate 0.0054–0.0097 mg/L and nitrate 0.0250–0.0437 mg/L. During the 14 months of the study, there were visible changes in depth, water clarity, temperature, pH, DO, CO_2 free, phosphate and nitrate. In March–May 2014, there was an increase in water level, and continued to decline until September 2014, then increase again until December 2014 and continue to decline until April 2015. The same was seen from the value of dissolved oxygen, CO_2 free, phosphate and nitrate . This condition is inversely proportional to the water clarity, temperature and pH, which, from March to May 2014, decreased, then increased until September 2014, and decreased until December 2014. In January–April 2015, the value of water clarity, temperature and pH experienced enhancement.

Sustainability status with regard to the ecological dimension

Attributes that are expected to influence the sustainable management of Lake Baru from the ecological dimension are: fish diversity, the existence of protected species, the waters' conditions, the waters' fertility, substrates of the waters' base, sedimentation and the width of forest areas.

Results of the sustainability analysis based on the ecological dimension (RapOxbow) of the management of Lake Baru (Figure 3) generate a value of the sustainability index by 42.56 or classified as less sustainable (< 50). This value indicates that Lake Baru experiences pressure from the ecological aspects. This is consistent with field observations which reveal that the environment of Lake Baru encounters a reduction in quality. For example, in the area around the lake, there is an intensive shift in the land use and activities of the community. Odum (1996) states that ecology is a study of the structure and function of an ecosystem or the nature, and humans as part of it. Thus, the impacts resulting from human activities will affect the structure and function of the ecosystem.

Based on the leverage analysis (Figure 4), there are two attributes that are sensitive to the sustainability index of the ecological dimension, they are the waters' condition (root mean square (RMS) = 8.24) and the width of forest areas (RMS = 4.83); the higher the RMS value, the greater the influence/role of the attribute on sustainability sensitivity (Kavanagh and Pitcher, 2004). These two attributes imply that the lake's condition is strongly influenced by the activities on land.

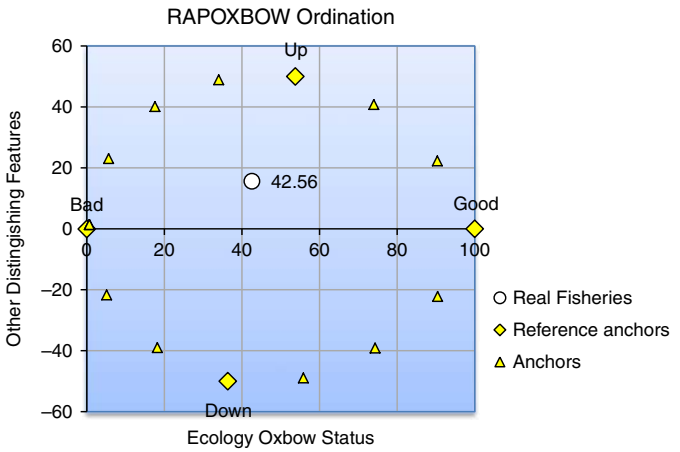

Figure 3.
The sustainability index for the ecological dimension

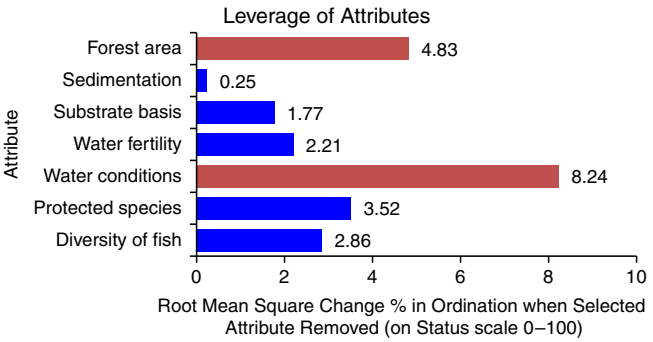

Figure 4.
Roles of each attribute of the ecological dimension stated in an RMS value (root mean square)

Sustainability status with regard to the economic dimension

Attributes that are expected to influence this dimension are: fishermen's income level, capital availability among fishermen, fishing intensity, tourism potential, local labor absorption, dependence on the fishery sector and catch marketing. Based on the RapOxbow analysis of sustainability from the economic dimension, it generates a value by 47.44, as shown in Figure 5. This value indicates that the sustainability status from the economic dimension is less sustainable (< 50) in Lake Baru management.

This value implies that Lake Baru management experiences pressure from the economical aspects. This might happen because the ability of natural resources and the environment in providing environmental benefits and services decreases as a result of high pressure from the community around the lake (oxbow). Findings from the research site indicate that the oxbow lake has waters that are open to public where access to resources is not limited, or, in other words, everyone can directly access the available resources. Such conditions provide greater opportunities for everyone to enjoy the benefits of resources. To determine attributes that are sensitive to the sustainability of Lake Baru management in connection with the economic dimension, a leverage analysis is undertaken and the results are presented in Figure 6.

Figure 6 above provides data on attributes that are sensitive to the sustainability of Lake Baru management from the economic dimension, namely, tourism potential (RMS = 8.74), fishing intensity (RMS = 7.72) and dependence on the fishery sector (RMS = 5.71). Those attributes indicate that Lake Baru has a high economic value.

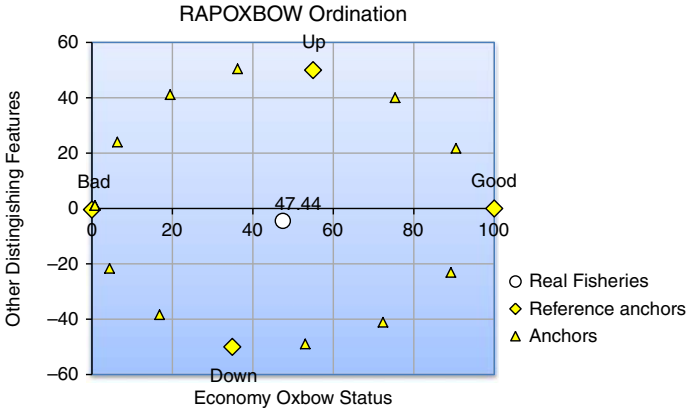

Figure 5.
The sustainability index for the economic dimension

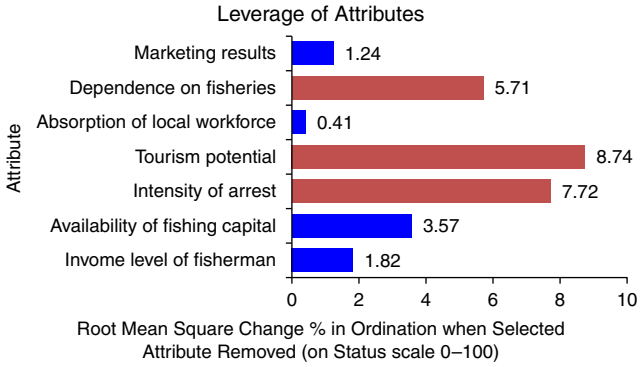

Figure 6.
Roles of each attribute of the economic dimension stated in an RMS value (root mean square)

Sustainability status with regard to the socio-cultural dimension

Attributes that are expected to affect the socio-cultural dimensions are: solidarity among fishermen, potential conflicts, the level of education, the growth of the number of fishermen, the number of households running the fishing business, having aesthetics, environmental knowledge, community empowerment and non-fishery alternative livelihoods.

Based on the analysis using MDS, the sustainability index for the socio-cultural dimension of the management of Lake Baru is presented in Figure 7. Based on Figure 7, the sustainability index value for the socio-cultural dimension is equal to 54.81, meaning that the status of this dimension is fairly sustainable (51–75). Thus, the management of Lake Baru has provided support for the development of the socio-cultural dimension. Therefore, to optimize the sustainability of the lake, it is vital to better improve the development of the socio-cultural dimension.

Based on results of the leverage analysis (Figure 8), there are three attributes that are sensitive to the sustainability index value of the socio-cultural dimension, namely, the number of households running the fishing business (RMS = 6.46), having aesthetics (RMS = 5.48) and potential conflicts (RMS = 3.69). Kavanagh and Pitcher (2004) state that an RMS value indicates the magnitude of the role of each attribute toward the sensitivity of a particular sustainability status. In other words, the higher the RMS value, the greater the influence/role of the attribute on sustainability sensitivity.

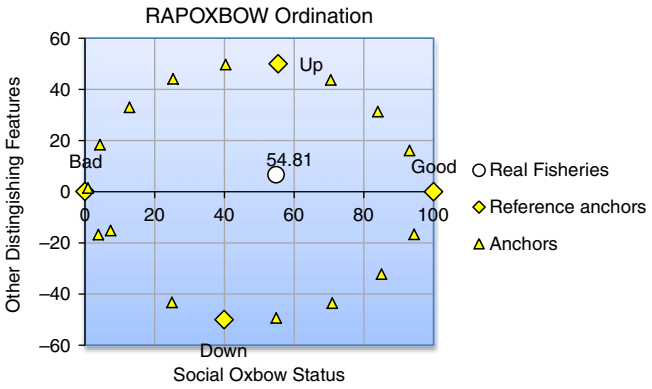

Figure 7.
The sustainability index for the socio-cultural dimension

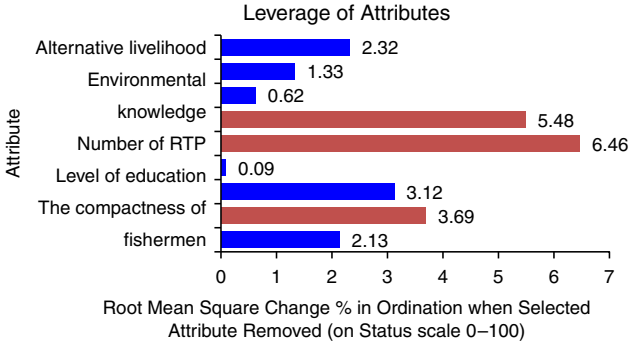

Figure 8.
Roles of each attribute of the socio-cultural dimension stated in an RMS value (root mean square)

Sustainability status with regard to the technological and infrastructure dimension

Attributes that are expected to affect the technological and infrastructure dimension are: fishing tool type; side effects of the fishing tool; selectivity of the fishing tool; facilities and infrastructure to conduct supervision; and the use of prohibited tools. Results of the analysis using MDS with regard to the technological and infrastructure dimension generate an index value by 53.12, meaning that the status of this dimension is fairly sustainable (Figure 9).

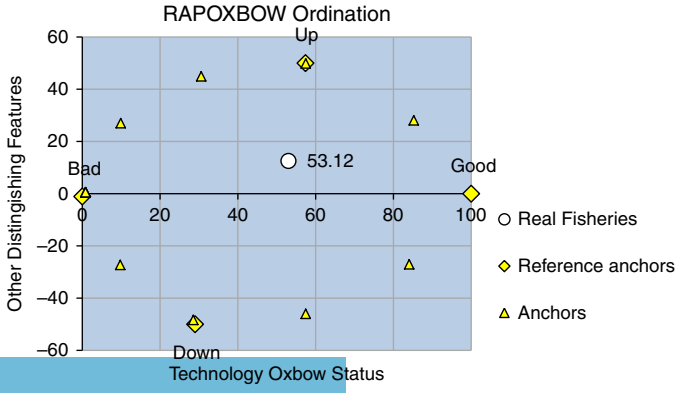

Figure 9.
The sustainability index for the technological and infrastructure dimension

The condition of the technological dimension which is fairly sustainable indicates that the management of Lake Baru has provided support for the development of the technological and infrastructure dimension. Therefore, to maximize the sustainability of the lake, the development of the technological and infrastructure dimension needs to be improved again.

Based on the leverage analysis (Figure 10), there are three attributes that are sensitive to the value of the sustainability index value for the technological and infrastructure dimension, namely, facilities and infrastructure to conduct supervision (RMS = 12.42); selectivity of the fishing tool (RMS = 7.03); and fishing tool type (RMS = 6.74). Kavanagh and Pitcher (2004) state that an RMS value indicates the magnitude of the role of each attribute to the sensitivity of the sustainability status. In other words, the higher the RMS value, the greater the influence/role of the attribute on sustainability sensitivity.

Field observations provide information that the fishing tools used by local fishermen were the traditional ones such as fishing rods, longline, fish pot + palisade trap, nets, scoop basket and gillnet. Most of the fishing tools are not selective; thus, fishes of various sizes are caught. If there is no control over the use of such tools, this will threaten the diversity of fish in the oxbow lake. Moreover, there is no facilities and infrastructure to conduct supervision in Buluh Cina Village. Therefore, it is imperative that the government provides the necessary facilities and infrastructure.

Sustainability status with regard to the legal and institutional dimension

Attributes that are considered to have an effect on the legal and institutional dimension are: customary elders; customary councils; the existence of formal regulations; delivery of information about environmental law; implementation of monitoring; the level of compliance of the community; coordination among stakeholders; and public participation. To determine the value of the sustainability index for the management of Lake Baru with regard to the legal and institutional dimension, an MDS analysis was performed (Figure 11).

Based on results of the RapOxbow analysis (Figure 11), it is revealed that the value of the sustainability index for the legal and institutional dimension is 56.83. This value explains that the sustainability of the legal and institutional dimension in the management of Lake Baru is fairly sustainable. This implies that the role of law and institutions in the management of Lake Baru is getting better. This is very important to note because law and institutions have an important role in the sustainable management of natural resources. The institutional aspect does not merely govern the natural resources of Lake Baru, but also regulates the respective roles of the stakeholders of the oxbow lake ecosystem.

Based on the leverage analysis (Figure 12), there are four attributes that have the greatest influence on the sustainability with regard to the legal and institutional dimension, namely, implementation of monitoring (RMS = 9.38); customary councils (RMS = 5.74); coordination among stakeholders (RMS = 5.50); and delivery of information about

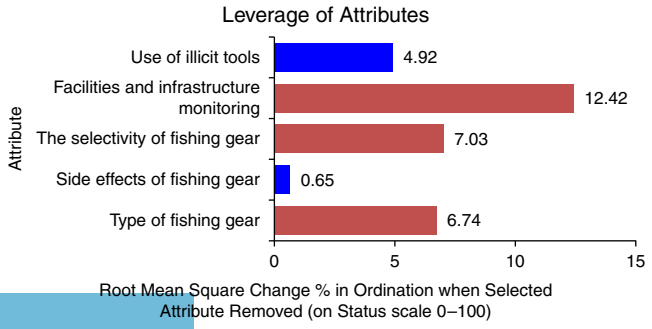

Figure 10.
Roles of each attribute of the technological and infrastructure dimension stated in an RMS value (root mean square)

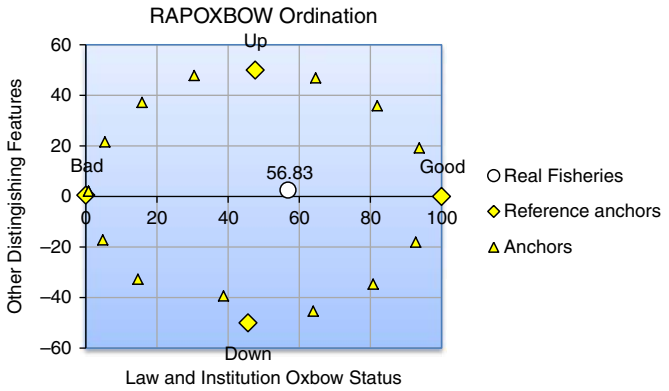

Figure 11.
The sustainability index for the legal and institutional dimension

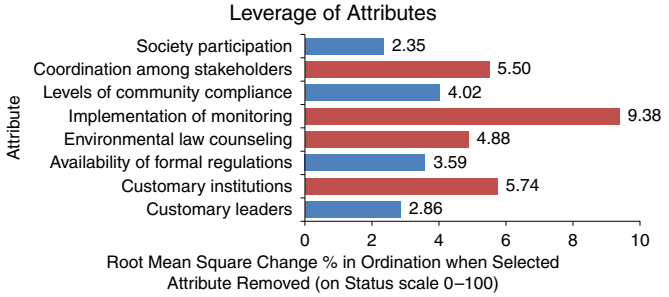

Figure 12.
Roles of each attribute of the legal and institutional dimension stated in an RMS value (root mean square)

environmental law (RMS = 4.88). Kavanagh and Pitcher (2004) state that an RMS value shows the magnitude of the role/influence of each attribute on the sensitivity of the sustainability status.

Sustainability status viewed from multi-dimensions

Results of the MDS analysis reveal that there are two dimensions with a value of the sustainability index by < 50 (less sustainable), namely, the ecological dimension by 42.56 and the economic dimension by 47.44. On the contrary, there are three dimensions regarded as fairly sustainable, namely, the socio-cultural dimension by 54.81, the legal-institutional dimension by 56.83 and the technological dimension by 53.12. The data imply that the management of oxbow lakes in Buluh Cina Village remains oriented toward the socio-cultural, legal-institutional and technological dimensions, and ignores the ecological and economic dimensions. These MDS analysis results are illustrated in the form of a kite diagram presented in Figure 13.

The values of stress and the coefficient of determination

Accuracy of the configuration of a point in reflecting the original data can be measured by looking at the stress value of the Rap-Oxbow ordination analysis results of each dimension analyzed. The ability of each attribute to explain and their contribution to the sustainability of the system under study can be determined by looking at the value of the coefficient (R^2) of determination of each dimension analyzed. The coefficient of determination and stress values of each dimension are presented in Table IV.

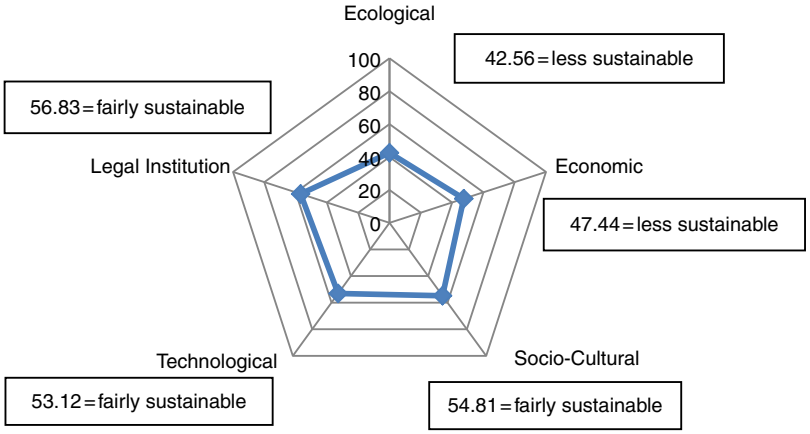

Figure 13.
The kite diagram for the analysis of the index and sustainability status of the management of Lake Baru in Buluh Cina Village

Dimension	Sustainability index	Stress	R^2
Ecological	42.56	0.13	0.95
Economic	47.44	0.13	0.95
Socio-cultural	54.81	0.14	0.94
Technological	53.12	0.14	0.94
Legal-institutional	56.83	0.14	0.94

Notes: *An index value between 25.01 and 50.00 falls into the "less sustainable" category; an index value between 50.01 and 75.00 falls into the "fairly sustainable" category; **a stress value < 0.25 indicates goodness of fit; ***an R^2 value $> 80\%$ or approaches 100%: very good contribution

Table IV.
Multi-dimensional coefficient of determination and stress values

Table II shows that the average stress value of the dimensions is equal to 0.14 while the average R^2 value is equal to 0.94. In Rapfish, the stress value is said to be good if it is smaller than 0.25 (Malhotra, 2006), which means that the value of goodness of fit in MDS, which indicates the stress value which approaches zero, then the resulting output is getting increasingly similar to the actual condition, or, in other words, the lower the stress value, the better/more suitable the model. Conversely, the higher the stress value, the less suitable the model. Kavanagh (2001) states that the stress value which can be tolerated is < 20 percent; thus, the model is accepted with a stress value by 14 percent.

Results of the goodness of fit test also reveal that the model to estimate the sustainability index can be used, where the squared correlation (R^2) value generated is equal to 0.94 or approaches 1. The R^2 value approcahing 1 means that the existing data are getting increasingly perfectly mapped. This value indicates that more than 94 percent of the model can be well explained, and the remaining 6 percent is explained by other factors. Kavanagh (2001) argues that the value of squared correlation (R^2) greater than 80 percent indicates that the model to estimate the sustainability index is good and adequate to be used.

The effect of errors

The evaluation of the effect of random errors using the Monte Carlo analysis aims to determine: the effect of attribute scoring errors; the effect of score variation; stability of repetitive MDS analysis processes; and errors in the process of inputting data or those resulting from missing data. The Monte Carlo analysis results for all dimensions are presented in Table V.

4. Discussion

Sustainability status with regard to the ecological dimension

The attributes of the waters' conditions and the width of forest areas have high sensitivity as a result of a shift in land use such as a decrease in forest areas. On the other hand, Lihawa (2009) asserts that forest has the best ability to reduce erosion. It is because in forest areas, water energy does not directly hit the soil surface, but it is captured by canopies, trunks and twigs of the vegetation. Moreover, in the event water exists on the soil surface, it does not directly change into runoff, but settles on the surface soil as a result of the existence of vegetation and humus allowing groundwater augmentation. These will affect conditions of the waters. The above description illustrates that the condition of Lake Baru's ecosystem is not influenced by the activities undertaken in the lake only, but also by the activities undertaken in its surrounding environment. This is in line with Haryani (2002) who states that the lake ecosystem and the landscape constitute an integral part. According to Suhardi (2005) and Kumurur (2001), activities undertaken in the catchment area of a particular lake will affect the ecosystem of the lake's waters. Consequently, in order to improve the sustainability status for the ecological dimension of Lake Baru management, it is necessary to consider insensitive attributes, in addition to the sensitive ones.

Sustainability status with regard to the economic dimension

The RapOxbow analysis of sustainability from the economic dimension, it generates a value by 47.44, which indicates that the sustainability status from the economic dimension is less sustainable (< 50) in Lake Baru management. As for the attribute of the lake's tourism sector, it is classified as having fairly high sensitivity. It is very important to manage this attribute by developing the lake's tourism sector properly. This is in line with existing conditions that Lake Baru is one of the seven lakes situated in Buluh Cina Tourist Village. Development of this attraction can be used to develop alternative sources of livelihoods offered by the lake, thereby reducing ecological pressure arising from fishery activities. This means that the economic dimension of the lake can be developed among others through management of the tourism sector. Hence, the high economic intensity of Lake Baru's fishery sector can be controlled in the future by making use of the ecotourism potential of oxbow lakes. Therefore, infrastructure and suprastructure to develop lake ecotourism as an economic resource need to be prepared. The limited attention of the government to the tourism sector of Lake Baru in Buluh Cina Village is among the factors that contribute to the low economic value of oxbow lake tourism.

The attributes of fishing intensity and dependence on the fishery sector have sufficient scores, but they have high sensitivity as well. This means that these attributes have a vital role in the sustainable management of the oxbow lake. If the fishing intensity and public dependence on the oxbow lake are not taken seriously, the existence of biological resources in the oxbow lake will be threatened. Consequently, it is necessary to improve the management of fishery business in order to be more efficient. Furthermore, it is expected to

Dimension	Sustainability index (MDS)	Monte Carlo analysis[a]	Difference (MDS–MC)
Ecological	42.56	43.08	0.52
Economic	47.44	46.69	0.75
Socio-cultural	54.81	54.24	0.57
Technological	53.12	51.39	1.73
Legal-institutional	56.83	56.23	0.60

Note: [a]Error at the 95% confidence level

Table V. Multidimensional analysis results using the Monte Carlo analysis

provide stimulus to encourage a more optimal economic dimension with regard to the sustainability of oxbow lake management.

Public dependence on the oxbow lake is significantly high viewed from the socio-cultural aspects. People consider their life as inseparable from waters (rivers and oxbow lakes). They believe that the ecosystems of rivers and oxbow lakes are part of their living system that have formed a bond with their socio-cultural system, making it impossible for them to be separated from the environment. Thus, there is a proverb saying "Oxbow palansai hutang."

Based on the foregoing, to improve the sustainability of the economic dimension of the management of Lake Baru, it is important to undertake development of better sensitive attributes and integrate them in a plan so as to provide a more optimal impact. The attribute of socio-cultural dependence on the lake can serve as the social capital to encourage the public to participate in sustainable management of the lake.

Sustainability status with regard to the socio-cultural dimension

Field observations provide information that the majority of residents in Buluh Cina Village are fishermen, who depend their lives on rivers and the oxbow lakes. The potential conflicts is getting increasingly greater considering that the area of the lake will not increase, while economic activities in the fishery sector continue to grow. Conflicts exist due to limited natural resources, and, on the other hand, the lake's natural resources belong to common property resources, resulting in open access; consequently, such a condition might potentially lead to the tragedy of the common. Therefore, sources of a conflict must be handled appropriately in order to prevent a greater negative effect on the management of the lake. Therefore, community empowerment activities need to be considered and implemented.

Based on the above explanation, in order to improve the sustainability of the socio-cultural dimension of Lake Baru's management, it is necessary to pay serious attention to sensitive attributes. However, other attributes such as the level of education of the community need to be taken into account as well.

Sustainability status with regard to the technological and infrastructure dimension

The technological and infrastructure dimension generate an index value by 53.12, meaning that the status of this dimension is fairly sustainable. The condition of the technological dimension which is fairly sustainable indicates that the management of Lake Baru has provided support for the development of the technological and infrastructure dimension. Therefore, to maximize the sustainability of the lake, the development of the technological and infrastructure dimension needs to be improved again.

Based on the foregoing, to improve the sustainability of the management of Lake Baru with regard to the technological and infrastructure dimension, it is necessary to pay serious attention to sensitive attributes. Moreover, it is also necessary to pay attention to other attributes such as the use of forbidden equipment (catching fish using electricity and derris).

Sustainability status with regard to the legal and institutional dimension

The value of the sustainability index for the management of Lake Baru with regard to the legal and institutional dimension, an MDS analysis was performed. There are customary councils in Buluh Cina Village, where indigenous leaders have a vital role in social life. In this village, there are two tribes, namely, Malay and Domo tribes. The Malay tribe is led by three *pucuk*, namely, Datuk Mojolelo, Datuk Sangg and Datuk Jelo Sutan, who are assisted by two *dubalang*, namely, Dubalang Monti and Dubalang Kayo, while the Domo tribe is led by three *pucuk*, namely, Datuk Tumenggung, Datuk Bagindak and Datuk Kuto Marajo, who are assisted by three people.

Generally, the community of Buluh Cina village understands the importance of rivers, lakes and forests. They remain upholding customary rules, where customary property (forests, lakes and gulfs), which exists, belongs to public property rather than private property. It is evident from the existence of joint regulations between the local government and the community known as "Ten Prohibited Things in Buluh Cina Village." Of the ten prohibited things in Buluh Cina Village, six of them are directly related to the environment. The community of Buluh Cina have been aware the importance of the environment for their survival. Based on the interviews, the community generally knows the rules or restrictions that apply in the village; however, some of them remain committing violations.

Those who commit violations are subject to sanctions set out in the Deliberation Decision of the Community of Buluh Cina Number 35/NET/SH/2006, which reads "For those who have and/or destroyed recreation forest (the flora and fauna) and for those who refuse to participate in village activities, such as never taking part in mutual cooperation or refusing to comply with the rules set out by the village for the common good shall be subject to sanctions."

The sanctions imposed consist of: sanctions from the village government, namely, losing access to any kind of assistance from the government such as rice allowance for the poor, house construction assistance, kerosene and direct cash assistance, and so on; sanctions with regard to religious affairs, where religious officials will not proceed documents required for the arrangements of marriage, divorce or reconciliation and not attending the funeral in the event their family member dies; and sanctions related to customary affairs, *Ninik Mamak*, and the community will not attend any events held by their family. The customary sanctions imposed on those committing violations are in the form of fines, confiscation of tools and being ostracized by the indigenous people. Confiscated equipment/tools will be returned if the punishment and fine is completed. The purpose of returning the tools is to help make a living, not to destroy or cut down trees. In addition to being subject to sanctions by village government, religious sanctions and customary sanctions, perpetrators who have caused damage will also be reported to the police to be prosecuted according to the law.

Saam (2014) and Nurhidayah and Saam (2016) state that the community have their own local wisdom to maintain the environment such as forest, rivers, soil, lakes, hills and slopes. For example is the prohibited forest where the community are not allowed to cut down and take the wood except for daily necessities such as for firewood. Another example of such local wisdom is the prohibited pond where the community are allowed to catch fish only at a particular time. The value of this local wisdom is useful for maintaining the existing natural resources.

Based on the interviews with some residents, it is also revealed that the community are generally afraid of committing violations because of severe sanctions. But, as time passes and socio-economic issues increase, the local wisdom owned by the Buluh Cina community begins to fade away. This is indicated by violations against the existing regulations such as cutting down trees in indigenous forests and the opening of oil palm plantations around the (oxbow) lake.

To overcome those issues, environmental monitoring is required and it is expected that the village government work in conjunction with the local government to establish an agency in charge of monitoring conditions of the environment in Buluh Cina Village, especially oxbow lakes as well as preparing the necessary facilities and infrastructure. Later, this agency can also provide education relating to environmental law to the public. The successful implementation of this activity certainly cannot be separated from the cooperation between stakeholders, both the village community, the government and other related parties.

Based on the above description, to improve the sustainability status of the management of Lake Baru with regard to the legal and institutional dimension, it is necessary to seriously take into account the sensitive attributes above. It is vital for the government to establish policies to establish an agency in charge of the management of Lake Baru in order that

mechanisms of the respective parties are clearly defined. It is because the agency in charge of natural resource does not merely regulate issues related to natural resources, but also the ways the parties should undertake their own roles and clear rules regarding the management of Lake Baru. The development of the roles of local leaders and public participation in the management of Lake Baru will have a major contribution to improving the sustainability of the legal and institutional dimension.

Sustainability status viewed from multi-dimensions

The data imply that the management of oxbow lakes in Buluh Cina Village remains oriented toward the socio-cultural, legal-institutional and technological dimensions, and ignores the ecological and economic dimensions. There is no significant difference in the value of the MDS index, certain that scoring errors, the effect of score variation, stability of the repetitive MDS analysis processes as well as errors in the process of inputting data or those resulting from missing data have no effect. According to Kavanagh and Pitcher (2004), the Monte Carlo analysis can be used as a simulation method to evaluate the effects arising from random errors in the statistical analysis performed on all dimensions. Similarly, Fauzi and Anna (2005) point out that Monte Carlo analysis can be used as an indicator for errors caused by scoring in each attribute, multidimensional scoring variations due to different opinions, repetitive data analysis processes and errors in the process of inputting data or those resulting from missing data.

Those RapOxbow analysis results can be accepted as the validation results generate a differential in the value of the sustainability index with a Monte Carlo value ranging from 0.52 to 1.73, meaning that the differential is extremeli small, namely, by 1.73 or less than 5. This value indicates that the effect of random errors or the effect arising from scoring errors is relatively small. Thus, the RapOxbow model for the management of Lake Baru is considered adequate to serve as an indicator of the value of the sustainability index. According to Kavanagh and Pitcher (2004), if the value of differences in the two analyses results. Results of the Monte Carlo Analysis minus results of the RapOxbow Analysis > 5 percent mean that the analysis results are considered insufficient to estimate the value of the sustainability index, and if the value of differences in the two analyses results.

5. Conclusions and recommendation

Conclusions

Based on the analysis result show that, first, the current sustainability status of the management of Lake Baru ecosystems according to a number of dimensions is regarded as sustainable with a sustainability index value by 50.95. Meanwhile, analysis results of each dimension show that the sustainability index for the ecological dimension is 42.56 and the sustainability index for the economic dimension is 47.44, which means that they are less sustainable. While the sustainability index for the socio-cultural dimension is 54.81, the sustainability index for the technological dimension is 53.12, and the sustainability index for the legal-institutional dimension is 56.83, meaning that they are fairly sustainable. Second, there are 15 attributes of the sustainability of Lake Baru management, namely, 2 attributes from the ecological dimension (the waters' conditions and the width of forest areas), 3 attributes from the economic dimension (fishing intensity, tourism potential and dependence on the fishery sector), 3 attributes from the socio-cultural dimension (potential conflicts, the number of households running the fishing business and having aesthetic), 3 attributes from the technological dimension (facilities and infrastructure to conduct monitoring, selectivity of the fishing tool, fishing tool type) and from the legal-institutional dimension (customary councils, delivery of information about environmental law, implementation of monitoring, coordination among stakeholders). Third, it is revealed that there are five attributes that affect the management of Lake Baru, namely, the waters' conditions, tourism potential, fishing intensity, dependence on the fishery sector and the width of forest areas.

Recommendation

Based on conclusion above, the recommendations for this study are as follows: first, improvements in the sustainability dimensions with an inadequate sustainability index, namely, ecological and economic dimensions, need to get priority. Second, in order that the two dimensions become sustainable, it is necessary to pay attention to the five attributes determining the sustainability of the management of Lake Baru. Third, further more in-depth research into the design of oxbow lakes in Buluh Cina Village needs to be conducted.

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Appendix 1. Method of collecting data

Determination of ecological conditions (physics, chemistry, water biology)

Water quality data obtained from primary data and secondary data. Measurement of primary water quality data aims to determine the current status of water conditions in the study sites. Therefore, the water samples were taken at three established observation stations, i.e. St1 (0°22'6 "LU and 101°31'54" BT), St2 (0°22'22 "LU and 101°31'52" BT) and St3 (0°22 "12 "LU and 101°31'57" BT). Measurements are done once a month in two seasons (rainy and dry season). Water quality parameters measured include physical and chemical parameters of water. Method of taking and method of water quality analysis refers to SNI. Parameters measured directly (*in situ*) include: temperature, brightness, depth and

dissolved oxygen, while the parameters measured in the laboratory are BOD, nitrate (NO3) and phosphate (PO4).

To determine the amount of sediment coming from the mainland into Baru Lake, measurements were made by calculating the suspended load. The measurement of sedimentation rate in oxbow lake is done by sediment trap. The sediment trap tube used is a PVC pipe with a diameter of 4 inches and a height of 25 cm, at the top has barriers cover. Sediment trap tube mounted on a 12 mm diameter iron pole at a height of 20 cm from the bottom of the water (Rifardi, 2008). Each station is installed three sediment traps, the distance between sediment traps ranging from 1 to 5 m. Sediment trap was installed for 20 days, the collected sediment was then dried in an oven at 60°C for 24 hours. Further, measurement of dry weight of sediment in milligram units was made with an analytic scale. Sedimentation rates are expressed in units of mg/cm^2/day (Rogers *et al.*, 2008).

The data of fish diversity are obtained by survey method (primary data). Primary data are obtained by catching fish using various tools such as bubu, fishing line, fishing nets and electrophishing, besides also interviewing people living around the river. Specimens of captured fish were placed into plastic bags, labeled and included ice box and brought to the Laboratory of Aquatic Biology, Faculty of Fisheries and Marine Sciences, University of Riau, arriving at the fish laboratory identified. Identification was done using Saanin (1968) and Kottelat *et al.* (1993).

To determine the diversity of fish, Shannon Wiener's diversity index in Odum (1996) was used as follows:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i,$$

where H' = Variance Indeks, $p_i = n_i/N$, n_i = number of individual types to–I, N = total number of individuals, by criterion, $H' < 1$: Low, meaning low diversity with uneven individual distribution and low community stability, $1 \leqslant H' \leqslant 3$: moderate, mean medium diversity with moderate individual distribution and moderate community stability.

$H' > 3$: High, meaning high diversity with high individual distribution and high community stability.

To see if there are any dominant species, it can be calculated using Simpson's dominant index (in Odum, 1996), as follows:

$$C = \sum_{i=1}^{s} p_i^2,$$

where C = index of dominance type, n_i = number of individuals to I, N = total number of individuals, $Pi = n_i/N$ = the proportion of type I, with index criteria. If C approaches 0 (zero), it means no dominating type; if C approaches 1 (one), it means there is a type that dominates.

Calculation of sedimentation rate is done through the following equation:

$$LS = \frac{\text{BS}}{\text{Number of days} \times \pi r^2}.$$

Description: LS = sedimentation rate (mg/cm^2/day); BS = dry weight of sediment (mg); π = constant (3.14); and r = ring radius of sediment trap (cm).

The economic, socio-cultural and technological dimensions data obtained were analyzed descriptively and compared with Rapfish (Tesfamichael and Pitcher, 2006), while legal and institutional dimension data obtained were analyzed descriptively and compared with Nikijuluw (2002).

Analysis of sustainability of oxbow management

The data needed are primary data in the form of attributes related to the five dimensions of development sustainability, namely, ecological, economic, socio-cultural, institutional and technological dimensions. Primary data came from the respondents, and the results of direct observation are in the study sites, while secondary data obtained from several sources of literature and

documents from several agencies related to the research. The dimensions and attributes of oxbow lake management in Buluh Cina Kampar Village are presented in Tables AI–AV.

Sustainability analysis is intended to obtain a picture of the level/sustainability status of each dimension in Baru Lake. Sustainability analysis is done with MDS analysis approach with the help of RapOxbow software (Rapfish modification). According to Pitcher and Preikshot (2001), Rapfish stands for Rapid Appraisal for Fisheries is a Non-Parametric MDS (Kruskal and Wish, 1978; Schiffman *et al.*, 1981; Preikshot *et al.*, 1998) with ordination techniques (Clarke, 1993) based on the principle multi-criteria analysis by relaying on algorithms called MDS algorithms (Fauzi and Anna, 2005), while Young (2001) stated that MDS analysis is used to present similarity/dissimilarity between individual pairs and characters/variables.

RapOxbow analysis is done through several stages, among others:

(1) determination of sustainable attributes of oxbow management covering five dimensions, namely, ecological, economic, socio-cultural, institutional and technological dimensions;

(2) provide a bad–good rating on each attribute on an ordinal scale based on the sustainability criteria of each dimension;

(3) enter the value/score of assessment results from each attribute into RapOxbow software, and run RapOxbow; and

(4) preparation of index and sustainability status.

Each attribute in each dimension is given a score based on the scientific judgment of the scorers. The range of scores ranges from 0 to 3 or depends on the state of each attribute, which means from bad to good. The scores of each attribute are analyzed by multi-dimensional to determine one or

Table AI.
Ecological dimensions and attributes of sustainability of oxbow lake management in Buluh Cina Kampar Village

No.	Attribute	Ecological attributes and dimensions Skor	Baik	Buruk	Information
1	The diversity of fish	0, 1, 2			Low ($H' < 1$) Moderate ($H' = 1$) High ($H' > 1$)
2	Has a protected species	0, 1			No Yes
3	Conditions of water	0, 1			> Baku mutu < Baku mutu
4	Water fertility (N and P)	0, 1, 2, 3			Nitrat Low Moderate High (Effendi, 2003) Phospate: Low Moderate Good Very good (Goldman and Horne, 1983)
5	Substrates bottom of water	0, 1, 2, 3			(0) Mud (1) Muddy sand (2) Fine sand (3) Rough sand
6	Sedimentation	0, 1, 2			(0) Light to moderate 1–10 mg/cm^2/day (1) Moderate to 10–50 mg/cm^2/day (2) Very heavy to catastrophic > 50 mg/cm^2/day
7	Forest area	0, 1, 2			(0) Not whole, < 30% (1) In part, 30% (2) Whole > 30%

No.	Attribute	Atribut dan Dimensi Ekonomi Skor	Baik	Buruk	Keterangan
1	Fisherman's income level: (based on the poverty line of Kab. Kampar	0, 1, 2			Low, < UMR Moderate, UMR High, > UMR
2	Availability of fishing capital	0, 1, 2, 3			(0) Average do not have capital (1) Average lack of capital (2) Average enough capital (3) No problem with capita
3	The fishing effort, based on the intensity of the capture	0, 1, 2, 3			(0) Very high: full time (1) Height: seasonal (2) Medium: part time (3) Low: attendance
4	Tourism potential	0, 1			No Yes
5	Absorption of local workforce	0, 1, 2			Low Moderate High
6	Dependency on fisheries as a source of livelihood	0, 1, 2			(0) Low: slightly dependent < 50% (1) Medium: depends (50–80%) (2) Height: highly dependent > 80%
7	Marketing of fishery products	0, 1, 2			(0) Local market (1) The national market (2) International market

Table AII.
Economic dimensions and attributes of sustainability of oxbow lake management in Buluh Cina Kampar Village

more points reflecting the sustainability position of sustainable management development that is studied relative to two reference points, i.e. good and bad points. The definitive score is the mode value, which is analyzed to determine the points reflecting the sustainability position of the system studied relative to the good and bad points with MDS statistical ordination techniques. The estimated score of each dimension is expressed on the worst (bad) scale 0 percent to the best (good) 100 percent. The score value which is the value of sustainability index of each dimension can be seen in the Table AVI.

Through the MDS method, the sustainability point position can be visualized through the horizontal axis and the vertical axis. With the rotation process, the position of the point can be visualized on the horizontal axis with the value of the sustainability index scored 0 percent (bad) to 100 percent (good). The illustrated ordination result of the sustainability index value is shown in Figure A1.

In addition, the sustainability index value of each dimension can be visualized together in the form of kite diagrams (kite diagrams). The kite diagram is simitrisnya determined by the index of each dimension (ecology, economics, socio-culture, policy and technology). In addition, the index value of each dimension can be raised in the diagram. The sustainability kite diagram is shown in Figure A2.

The analysis to look at the most sensitive attributes contributes to the sustainability index and then analyzes the sensitivity by looking at the shape of the root mean square (RMS) change of ordination on the *X*-axis. The larger the RMS value, the greater the role of attribute to the sensitivity of sustainability status (Kavanagh and Pitcher, 2004), to evaluate the effect of error on the process to estimate the ordinate value of lake oxbow management using Monte Carlo analysis. This analysis is intended to see the effect of error, in an effort to increase confidence in the results of the analysis. The difference in the results of a small Monte Carlo analysis of RapOxbow analysis results indicates that the impact of the scoring error is relatively small. If the value of the difference between the two analyzes Monte Carlo Analysis−RapOxbow Analysis > 5 percent, then the analysis result is not sufficient as a predictor of sustainability index value, and if the value of the second difference analysis Monte Carlo Analysis−RapOxbow Analysis < 5 percent, then the analysis result is considered sufficient to estimate the value of the sustainability index.

No.	Attribute	Attributes and social and cultural dimensions Skor	Good	Bad	Information
1	The cohesiveness of fishermen (social networking)	0, 1, 2			(0) Low, fisherman is not compact (1) Medium, sometimes compact (2) High, always compact
2	Potential conflicts of utilization	0, 1, 2, 3			Based on the number of conflicts that occur within a year (0) High, > 10 times (1) Medium, 6–10 times (2) Low, 1–5 times (3) No complications
3	Level of education	0, 1, 2, 3			(0) Not finished primary school (1) Graduated from elementary and junior high school (2) High school graduation (3) Graduated from SD-S1
4	Growing number of fishermen	0, 1, 2, 3			(0) Very high > 30% (1) Height: 20-30% (2) Medium: 10–20% (3) Low < 10%
5	Number of fishery households	0, 1, 2			(0) Many > 30% (1) Average: 10–30% (2) Little < 10%
6	It has aesthetics	0, 1, 2			(0) Low: if there is one natural tourist attraction (1) Medium: if there are 2–3 natural attractions (2) Height: if there are ⩾4 natural attractions
7	Environmental knowledge	0, 1, 2, 3			(0) None (1) A little, 1–2 times (2) Enough, 3–4 times (3) Many⩽5 times
8	Community empowerment	0, 1, 2			(0) None (1) There is not yet optimal (2) Optimal
9	Non-fisheries alternative livelihoods	0, 1, 2			Low Medium, there is one Many, more than one

Table AIII.
Socio-cultural dimensions and attributes of sustainability of oxbow lake management in Buluh Cina Kampar Village

According to Kavanagh (2001), the "Monte Carlo" analysis is also useful for studying the following:

(1) influence of attribute scoring error caused by understanding the condition of the research location is not perfect or misunderstanding of attribute or way of making attribute score;

(2) the effect of scoring variation due to different opinions or assessments by different researchers;

(3) stability of MDS process repeatedly (iteration);

(4) error of data entry or missing data; and

(5) the high value of "stress" Rap-oxbow analysis results (the value of stress can be accepted if < 25 percent).

In a complete, modified Rap-Oxbow application process chart from Adler (2000) and Fauzi and Anna (2005) can be seen in Figure A3.

Analysis of determinants of oxbow management

To obtain determinants (dominant factors) in the determination of sustainable management of oxbow in BuluhCina Kampar, prospective analysis is used. A prospective analysis is used to predict

No.	Atribut dan Dimensi Teknologi Attribute	Skor	Good	Bad	Keterangan
1	Type of fishing gear	0, 1, 2			(0) The majority is active (1) Balanced between active and passive (2) Passive majority
2	Side effects of fishing gear	0, 1, 2, 3			(0) Many, causing habitat destruction over large areas (1) Moderate, causing destruction of habitat in narrow areas (2) Slightly, causing partial destruction of habitat in narrow areas (3) None, safe for habit
3	Selectivity of fishing gear	0, 1, 2			(0) Less selective, catching tool≥3 species of different size (1) Somewhat selective, catching tools≥3 species of approximately the same size (2) Very selective, a single species capture device of approximately the same size
4	Monitoring facilities and infrastructure	0, 1, 2			(0) None (1) There is, not yet optimal (2) Optimal
5	Use of illicit tools	0, 1, 2, 3			(0) Many, > 3 tools (1) Medium, 2–3 tools (2) Few/rare, one tool (3) None

Table AIV. Technological dimensions and attributes of sustainability of oxbow lake management in Buluh Cina Kampar Village

future possibilities. The prospective analysis is not the same as forecasting because the prospective analysis can predict future alternatives that are either positive (desirable) or negative (undesirable). The usefulness of prospective analysis is to: prepare for strategic action that needs to be done; and to see if changes are needed in the future. Appropriate prospective analysis is used for policy strategy design. From the prospective analysis, it is known that information on key factors and the oxbow management scenario in Buluh Cina Kampar is in line with stakeholders' needs.

Stakeholder needs analysis was undertaken to acquire influential components and play an important role in the management of oxbow lakes from all stakeholders involved. After obtaining supporting data for the determination of basic needs obtained based on stakeholders needs analysis, the needs of each stakeholder are determined.

According to Hardjomidjodjo (2004), the stages in the prospective analysis are as follows:

(1) Definition of the objectives of the system under study: the objectives of the system studied need to be specific and understandable by all the experts to be consulted. This is done so that the expert understands the scope and study of the shared views about the system being studied.

(2) Identify the factors that influence the achievement of these objectives, which are usually the needs of stakeholders of the system studied: based on the purpose of study to be achieved, experts are asked to identify the factors that influence in achieving these goals. Experts are expected to represent the stakeholders of the system studied so that all the interests of the system elements can be represented. At this stage, the definitions of each factor must be clear and specific. Expert opinion integration is implemented by taking the mode values.

(3) Assessment of direct influence between factors: all identified factors will be assessed for the direct influence of factors as presented in Tables AVII and AVIII.

In this study, a prospective analysis is used to identify the dominant factors (key factors) by looking at the direct influence between factors on the system or research object. The prospective analysis is conducted through three stages, namely, the first stage, the determination of the key factors in the existing condition of the MDS result; the second phase, determining the key factors needed by the needs analysis (needs analysis) of stakeholders; and the third phase; the determination of the key

No.	Attribute	Attributes and legal/ institutional dimensions Skor	Good	Bad	Information
1	Adat leaders	0, 1, 2			(0) None (1) Few, 1–5 people (2) Enough, > 5 people
2	Customary institutions	0, 1, 2			(0) None (1) There is, not yet optimal run (one adat institution) (2) Optimal, many customary institutions
3	Availability of formal management regulations	0, 1, 2			(0) None (1) There is, not yet optimal running (2) Optimal
4	Environmental law education	0, 1, 2			Based on the number of fishermen who follow the counseling (0) Never (1) Rarely, below average (2) Often, above average (0) Low, never monitoring (1) Moderate, sometimes monitored (2) High, scheduled monitoring
5	Implementation of monitoring, supervision	0, 1, 2			(0) Low, never monitoring (1) Moderate, sometimes monitored (2) High, scheduled monitoring
6	Levels of community compliance	0, 1, 2			(0) Non-compliance (1) medium (2) Obedient
7	Coordination among stakeholders	0, 1, 2			(0) Bad, never (1) Average, unscheduled (2) Good, unscheduled
8	Society participation	0, 1, 2			(0) Low, nothing (1) Medium, when there is time (2) Fine, fully supportive

Table AV.
Legal dimensions – institutional and attribute sustainability of oxbow lake management in Buluh Cina Village Kampar

Nilai Indeks	Kategori
0.00–25.00	Bad (unsustainable)
25.01–50.00	Less (less sustainable)
50.01–75.00	Enough (fairly sustainable)
75.01–100.00	Good (very sustainable)

Source: Sumber: Fauzi and Anna (2005)

Table AVI.
Category of sustainability status of oxbow lake management

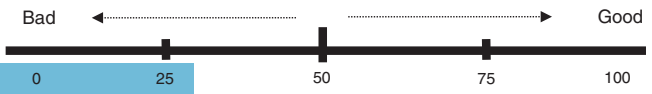


Figure A1.
Illustration of sustainability index values on an ordination scale

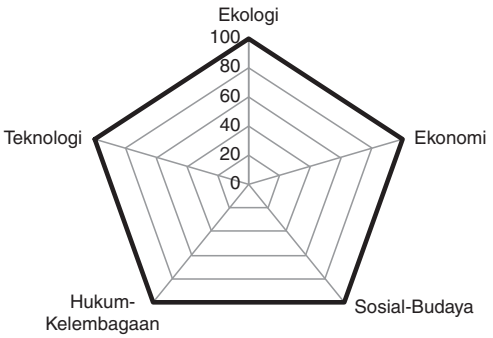
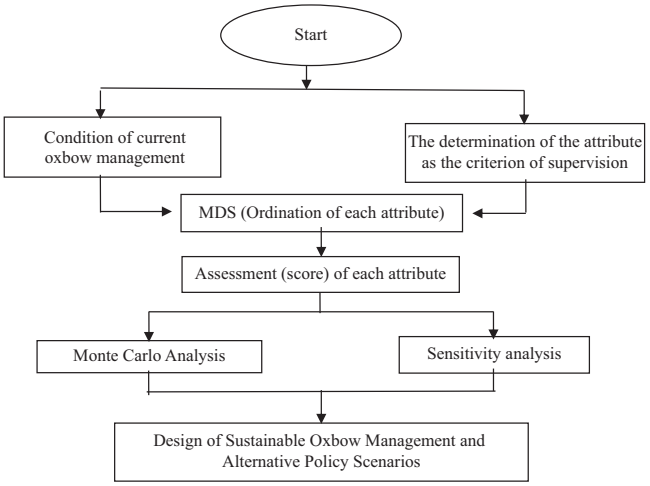


Figure A2.
Illustration of the sustainability index of each dimension



Sources: Modified from Adler (2000) and Fauzi and Anna (2005)

Figure A3.
The Rap-Oxb application process chart

Skor	Information
0	No effect
1	Has little effect
2	Medium effect
3	Influence is very strong

Table AVII.
Guidelines for the assessment of prospective analyzes

factors of the combined analysis results between the first and second stage results or a combination of existing conditions and need analysis.

The filling mechanism of Table AVIII is to give a score of 3 if the direct influence between factors is very strong; score 2 if the direct influence between the medium factor; score 1 if direct influence between small factor; and score 0 if there is no direct influence between factors. After obtaining the key factors from Table AIX, we analyze the influence and dependency matrix to see the position of each factor in the system using prospective analysis software, with the appearance shown in Figure A4.

Each quadrant in the diagram has the characteristics of different factors (Bourgeois and Jesus, 2004) as follows:

(1) The first quadrant of the driving variables: contains factors that have a strong influence but are less strongly dependent. Factors in this quadrant are the determinants or drivers that fall into the strongest category of factors in the system under study.

(2) Quadrant of two leverage factors: shows factors that have strong influence and strong dependence between factors; the factors in this quadrant are partly considered as strong factors or variables.

(3) Quadrant of three dependent factors (output variables): represents the output factor, where the effect is small but the dependence is high.

(4) Quadrant of four marginal variables: a marginal factor whose influence is small and the level of dependence is also low, so this factor is free in the system.

Table AVIII.
Direct influence between factors in sustainable management of sludge lake

	A	B	C	D	E	F	G
A							
B							
C							
D							
E							
F							
G							

Source: Sumber: Godet (1999) in Marhayudi (2006)

Table AIX.
Key factors and possible situations in the future

Factor	Possible circumstances		
1	1A	1B	1C
2	2A	2B	2C
3	3A	3B	3C
…	……	…	…
n	nA	nB	nC

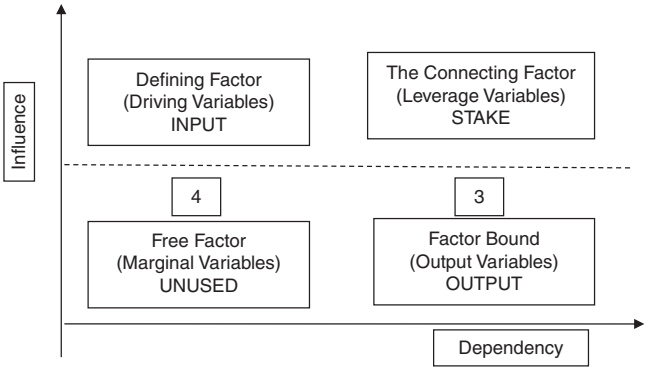


Figure A4.
Level of influence and interdependence among factors in the system

Source: Bourgeois and Jesus (2004)

Brourgeois further states that there are two types of variable distribution in the influence and dependence graphs: first, the type of distribution that tends to accumulate in the quadrant diagonal four to the second quadrant. This type indicates that the built system is unstable because most of the resulting variables include marginal variables or levarage variables. This makes it difficult to construct strategic scenarios for the future, and, second, the type of distribution that crosses one quadrant to the third quadrant, as an indication that the system is built stable because it shows a strong relationship, in which the variable of the force sets the output variable strongly. With this type, the strategic scenario can be built more easily and efficiently. The next stage of prospective analysis is a morphological analysis with the aim of acquiring future possible domains in order to achieve consistent, relevant and credible strategic scenarios. This stage is done by defining some of the likely future situations of all selected key factors. Key factors with some possible future circumstances are then included in Table AIX.

Morphological analysis is followed by consistency analysis to reduce the combined dimensions of key factors in formulating future scenarios through the identification of incompatibilities between incompatibility factors. Implementation of this stage by including conditions that cannot or very unlikely occur simultaneously results in an unsuitable pair.

The final stage of the prospective analysis is to construct a design scenario of oxbow lake management in Buluh Cina. This scenario is a combination of several key factors that may occur in the future minus a combination of circumstances that may not occur simultaneously. In general, the selected scenario consists of three scenarios that are grouping similar scenarios into one group of scenarios. Based on possible future occurrences, the scenarios are grouped into pessimistic scenario clusters (I), moderate (II) scenario clusters and optimistic scenarios (III), as listed in Table AX.

The resulting management design is an instrument of decision support tool that can be used by various parties, especially planners and policy makers, to determine the right policy priority in realizing sustainable management of oxbow lake in Buluh Cina. All that can be realized by merging the results of analysis of MDS, leverage and prospective.

Table AX.
The results of the oxbow lake management scenario analysis in Buluh Cina Village

Scenario	Description	Sequence of factor
1	Perform minimal improvements in less sustainable attributes	
2	Perform improvements on all attributes and performed optimally	
3	Perform maximal improvements to all attributes thoroughly and integrated	

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