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Sustainability Status of Mangrove Forest Ecosystem in Rawa Mekar Jaya Village, Sungai Apit District, Siak District

Status Keberlanjutan Ekosistem Hutan Mangrove Kampung Rawa Mekar Jaya Kecamatan Sungai Apit Kabupaten Siak

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Abstract

This research was conducted in October - November 2021 in Rawa Mekar Jaya Village, Sungai Apit District, Riau Province. The study area includes the mangrove forest of Rawa Mekar Jaya Village and Rawa Mekar Jaya River. Managing mangrove forests sustainably requires an integrated and sustainable management strategy; therefore an evaluation of sustainability status is carried out through 27 indicators grouped into four dimensions, namely ecology, economy, socio-culture, and institutional law. Indicators were obtained from previous research, literature studies, and field observations. Sustainability index assessment categories (1-100) can show the status of sustainability in mangrove forest ecosystem management in a multi-dimensional. Overall, the sustainability status of the multidimensional mangrove forest ecosystem of Kampung Rawa Mekar Jaya is classified as less sustainable with an average of 45.62. Socio-cultural (14.92) and economic (26.34) dimensions need improvement but the ecological and legal dimensions of the institution must be maintained.

Keywords: Rapfish, Mangrove, Multidimensional, Sungai Rawa, Sustainability dimension

Abstrak

Penelitian ini dilaksanakan pada bulan Oktober – November tahun 2021 di Kampung Rawa Mekar Jaya, Kecamatan Sungai Apit, Provinsi Riau. Wilayah kajian meliputi hutan mangrove Kampung Rawa Mekar Jaya, dan Sungai Rawa Mekar Jaya. Mengelola hutan mangrove secara berkelanjutan perlu suatu strategi pengelolaan yang terpadu dan berkelanjutan, oleh karena itu dilakukan evaluasi status keberlanjutan melalui 27 indikator yang dikelompokkan kedalam empat dimensi yaitu ekologi, ekonomi, sosial budaya dan hukum kelembagaan. Indikator diperoleh dari penelitian terdahulu, studi pustaka, serta pengamatan dilapangan. Kategori penilaian indeks keberlanjutan (1-100) dapat memperlihatkan status keberlanjutan dalam pengelolaan ekosistem hutan mangrove secara multi dimensi. Secara keseluruhan status keberlanjutan ekosistem hutan mangrove Kampung Rawa Mekar Jaya secara multidimensi tergolong dengan kategori kurang berlanjut dengan rata-rata 45,62. Pada dimensi Sosial budaya (14,92) dan ekonomi (26,34) perlu adanya perbaikan namun pada dimensi ekologi dan hukum kelembagaan harus dipertahankan.

Kata Kunci: *Rapfish*, Mangrove, Multidimensi, Sungai Rawa, Dimensi keberlanjutan

1. Introduction

Rawa Mekar Jaya is one of the villages in the Sungai Apit sub-district that has a mangrove forest with a mangrove area of ± 25 ha. The community around Kampung Rawa has managed this mangrove forest into something of economic value (Gesriantuti et al., 2016).

Mangrove damage that occurs in Riau Province is caused by excessive logging for charcoal kitchen needs, building materials, and firewood. The result will be a reduction in mangrove areas and loss of biodiversity. This has been the case in Rawa Mekar Jaya Village since 2007 when the charcoal panglong was no longer operating, but logging activities for cerocok material and firewood continued by the surrounding community. Many efforts that have been made by the community in managing mangrove ecosystems have not shown optimum results. Therefore, to prevent adverse consequences from occurring, it is important to have a methodology or administrative strategy that provides harmony between the utilization of biological, financial, social, and institutional regulations so that mangrove forest management occurs.

2. Material and Method

2.1. Time and Place of Research

This research was conducted in October - November 2021 in Rawa Mekar Jaya Village, Sungai Apit District, Riau Province. The study area includes the mangrove forest of Kampung Rawa Mekar Jaya and the Rawa Mekar Jaya River.

2.2. Methods

This research was carried out in several stages sequentially with the stages of this research described as follows: 1) desk study by collecting research results on Mangrove Ecosystems and the factors that influence them, 2) determination of attributes in each dimension of ecological, economic, socio-cultural and institutional law that affect the sustainability of mangrove forest management in Rawa Mekar Jaya Village, 3) conduct field surveys to collect data on biophysical, economic, social and cultural components, 4) analyze data from each attribute obtained primary and secondary, and 5) develop a policy strategy for sustainable mangrove forest management in Rawa Mekar Jaya Village.

2.3. Determination of Mangrove Ecosystem Condition

Observations in the field of research areas are determined by purposive sampling by selecting areas that consider that each station can represent the condition of mangrove forests. The steps to determine it is to compare each station based on the structure of the community. The Kepmen LH (2004) sets the standard criteria for mangrove damage to determine the status of mangrove conditions classified in Table 1.

Table 1. Mangrove ecosystem damage standard criteria

No.	Condition	Criteria	Closure (100%)	Density (tree/ha)
1	Good	Very dense	≥ 75	≥ 1500
		Medium	≥ 50 < 75	≥ 1000 < 1500
2	Broken	Rare	< 50	< 1000

Source: Kepmen LH (2004)

Sustainability status cannot be separated from determining the attributes that have been conceptualized based on the ecological dimension, socio-cultural-economic dimension, and institutional legal dimension. The score of each attribute of each dimension is presented in Table 2.

Table 2. Attribute score for each dimension

No.	Attributes	Score Options	Good	Bad	Description
1	Ecological Dimension				
1.1	Mangrove density	0;1;2	2	0	(0) → Rare (1) → Medium (2) → Very dense (Kepmen LH, 2004)
1.2	Mangrove species diversity	0;1;2	2	0	(0) → Low (1) → Medium (2) → High (Kepmen LH, 2004)
1.3	Animal, fauna, and aquatic biota diversity	0;1;2	2	0	(0) → Low (1) → Medium (2) → High (Arifin, 2008)
1.4	Water quality condition	0;1	0	1	(0) → Bad (1) → Good (Kepmen LH, 2004)

1.5	Sediment Organic Matter Content	0;1;2	2	0	(0) → Low (1) → Medium (2) → high (Tech, 1984)
1.6	Substrate Type	0;1;2,3	3	0	(0) → Sand (1) → Gravel (2) → Silty Sand (3) → Mud (Buchanan et al., 1984)
2	Economic Dimension				
2.1	Dependence as a source of livelihood on mangroves	0;1;2	2	0	(0) → Low (1) → Medium (2) → High
2.2	Community income level (UMR Kab. Siak in 2020)	0;1;2	2	0	(0) → Under (1) → Same (2) → Higher
2.3	Marketing of Fishery Products	0;1;2;3	3	0	(0) → Regional Market (1) → Local Market (2) → National Market (3) → International Market
2.4	Labor absorption	0;1;2	2	0	(0) → Low (1) → Medium (2) → High
2.4	The Welfare Level of Coastal Communities	0;1;2	2	0	(0) → Low (<10%) (1) → Medium (10-20%) (2) → High (>20%) (Pitcher & Preikshot, 2001)
2.5	Accessibility of mangrove area	0;1;2	2	0	(0) → Difficult (1) → Medium (2) → Easy (Santoso, 2012)
3	Social Dimension				
3.1	Education level	0;1;2	2	0	(0) → Low (1) → Medium (2) → High (Santoso, 2012)
3.2	Community knowledge about mangroves	0;1;2	2	0	(0) → Low (1) → Medium (2) → High (Santoso, 2012
3.3	Potential land use conflicts	0;1;2	2	0	(0) → Low (1) → Medium (2) → High (Santoso, 2012)
3.4	Local wisdom	0;1	1	0	(0) →None (1) → There is
3.5	Availability of community mangrove organisations	0;1	1	0	(0) → None (1) → There is
3.6	Availability of procedures for utilisation of mangrove areas	0;1	1	0	(0) → None (1) → There is
6	Legal and Institutional Dimensions				
6.1	Availability of Formal Institutions	0;1	1	0	(0) → None (1) → There is (Arifin, 2008)
6.2	Availability of informal institutions	0;1	1	0	(0) → None (1) → There is (Arifin, 2008)
6.3	Availability of Formal Regulations	0;1	1	0	(0) → None (1) → There is (Arifin, 2008)
6.4	Availability of informal rules	0;1	1	0	(0) → None (1) → There is (Arifin, 2008)
6.5	Level of community compliance	0;1;2	2	0	(0) → Non-compliant (1) → Medium (2) → Compliant (Nikijuluw, 2002)
6.6	Involvement of Community Leaders	0;1;2	2	0	(0) → none (1) → Little (2) → Fair (Nikijuluw, 2002)
6.7	Legal and Environmental Socialisation	0;1;2	2	0	(0) → Never (1) → Rare (2) → Frequently (Nikijuluw, 2002)
6.8	Community Participation	0;1;2	2	0	(0) → Low (1) → Medium (2) → High (Nikijuluw, 2002)
6.9	Monitoring and Surveillance	0,1,2	2	0	(0) → Low (1) → Medium (2) → High (Nikijuluw, 2002)

3. Result and Discussion

3.1. Mangrove Vegetation and Density

The results of observations and analysis of mangrove vegetation found in the three research stations in Kampung Rawa Mekar Jaya found 6 species of mangrove species. For a more complete classification of mangrove species can be seen in Table 3.

Table 3. Classification of mangrove species found in Rawa Mekar Jaya Village

Family	Genus	Species	Regional Name
Rhizophoraceae	Rhizophora	*Rhizophora apiculata*	Bakau puteh
		Rhizophora mucronata	Bangka black
	Bruguiera	*Bruguiera Sexangula*	Tumu
Arecaceae	Nypa	*Nypa fruticans*	Nipah
	Cantlleya	*Cantleya corniculata*	Bedaru
Lythraceae	Sonneratia	*Seonneratia ovata*	Kedabu

In general, the composition of mangrove species at each station is almost the same and growth is not much different. The types of mangroves found in several areas in the Siak district are relatively the same as the mangroves found in Kampung Rawa Mekar Jaya. As the results of research by Efriyeldi et al. (2020) get almost the same type and the results of research from Sitinjak (2019) in Mengkapan Village, Sungai Apit District, Siak Regency also get results that are not much different in Kampung Rawa Mekar Jaya. When viewed from the number of mangrove species found, Kampung Rawa Mekar Jaya is low when compared to other areas such as Efriyeldi (1997) found 11 types of mangrove species, while the results of Sintinjak (2017) found 10 types of mangrove species. The effect of the difference in the number of mangrove species occurs due to differences in substrate types.

The density of mangrove ecosystems in Rawa Mekar Jaya Village is included in the good criteria with a dense category. With an average value of 1545.55 trees/ha from the three observation stations. A more detailed density value can be seen in Table 4.

Table 4. Mangrove species density at each station

Species name	Station 1		Station 2		Station 3	
	Total	Density (ind/ha)	Total	Density (ind/ha)	Total	density(ind/ha)
R. apiculata	26	866,667	24	800	41	1366,67
R. mucronata	6	200	6	200	8	266,667
B. Sexangula	4	133,333	6	200	7	233,333
Nypa fruticans	1	33,3333	0	0	0	0
Cantleya corniculata	4	133,333	0	0	0	0
Sonneratia ovata	0	0	7	233,333	0	0
Total	41	1336,67	43	1433,33	56	1866,67

Based on Table 4, it can be seen that several species have the lowest to the highest density levels. Station 1 has the lowest density value with a value of 1336.67 trees/ha, station 2 has a density of 1433.33 trees/ha, and station 3 is the highest density with a value of 1866.67 trees/ha. Referring to KepMen L.H. No. 201 the year 2004 that Rawa Mekar Jaya Village is included in the good criteria with a dense category while the standard criteria regarding mangrove forest damage are classified as good, namely the range of 1000-1500 trees/ha.

3.2. Water Quality

Water quality measurements in Kampung Rawa Mekar Jaya were conducted during high tide. The parameters measured in this study are temperature, pH, salinity, and turbidity. The results of parameter measurements can be seen in Table 5.

Table 5. Water quality measurement values

Water Quality Parameters	Station I	Station II	Station III
Salinity (‰)	14	14	16
Turbidity (NTU)	41,7	37,2	31,8
Temperature (°C)	32,3	34,1	32,3
pH	3,5	3,63	3,11

Based on Table 5, it can be seen that the salinity in the waters of Kampung Rawa Mekar Jaya ranges from 14-16 ppt. According to Saparinto (2007), mangrove life depends on seawater, and silt as a source of nutrients. One of the environmental factors that affect the existence of mangrove species is salinity (Kustanti, 2011). Begen (2004) states that one of the characteristics of mangrove habitat is brackish salinity water with values

between 2 - 22‰. Based on the Decree of the Minister of Environment Number: 51 the year 2004 salinity waters of Kampung Rawa Mekar Jaya are still classified as normal.

The temperature ranged from 32.3-34.1°C. According to Gilman et al. (2008), the optimal temperature range for mangrove photosynthesis is 28-32°C. While Muhamaze (2008) states that the average temperature that supports mangrove growth is a maximum of 32°C during the day and a minimum of 23°C at night. The degree of acidity (pH) of the mangrove ecosystem of Kampung Rawa Mekar Jaya is in the range of 3.5 - 3.6. The difference in pH values at each station is influenced by the oceanographic and geomorphological characteristics of the area. Open waters tend to have a higher pH, and vice versa (Schaduw, 2018). The turbidity value of the waters in Rawa Mekar Jaya Village ranges from 31.8 - 41.7 NTU. Turbidity is caused by suspended material in the form of colloids and fine particles (Wardhana, 2004). The high turbidity value is related to the substrate of the mangrove ecosystem which is dominated by mud and material input from the land (Schaduw, 2018).

3.3. Mangrove Ecosystem Sustainability Analysis

3.3.1. Ecological Dimension

The results of Rapfish Ordination to 6 attributes that affect the sustainability status of the Mangrove ecosystem of Kampung Rawa Mekar Jaya can be seen in Figure 1.

Based on the *Rapfish ordination* analysis contained in Figure 1, it can be explained that the sustainability status of the mangrove ecosystem in the ecological dimension of Kampung Rawa Mekar Jaya has a value of 75.67 with a fairly sustainable status. This is following Susilo's (2003) statement that the score value with a range of 50.1 - 75.00 based on the condition or status of sustainability can be said to be quite sustainable. In Adriman (2012) on the design of sustainable management of coral reef ecosystems in the East Bintan Marine Protected Area of Riau Islands, it can be seen that the status of sustainability in the ecological dimension shows 61.00 (Figure 2)

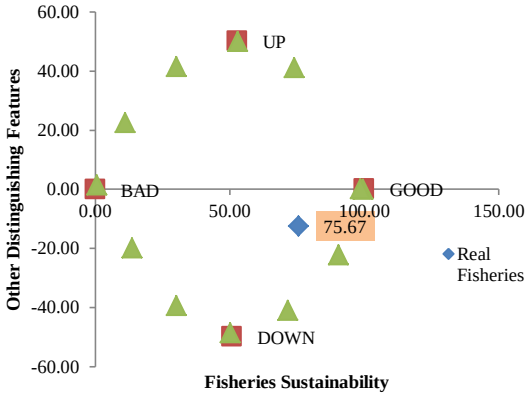

Figure 1. Sustainability status of the ecological dimension

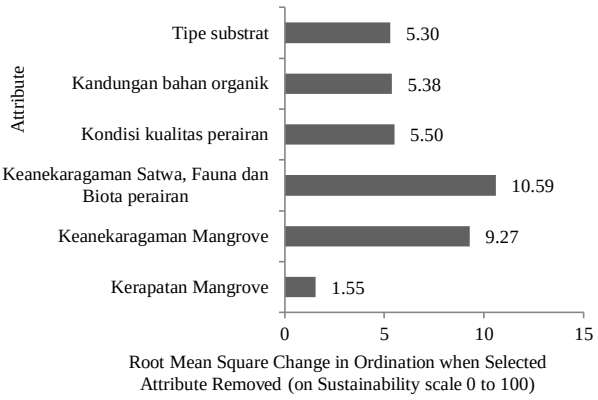

Figure 2. Results of the ecological dimension leverage analysis

Based on Figure 2 The results of the leverage analysis 2 attributes provide the most sensitive influence on the sustainability of mangrove ecosystems in Rawa Mekar Jaya Village, namely: diversity of animal species, fauna, and aquatic biota with Root Mean Square (RMS) 10.59, mangrove diversity with RMS 9.27. This can be interpreted that the attributes of animal species diversity, fauna and aquatic biota, and mangrove diversity have an influence on the status of sustainability in the ecological dimension. From the field results obtained that the level of mangrove species diversity can be used as an indicator of damage to the mangrove ecosystem in Rawa Mekar Jaya Village. Following the statement of Nybakken (2003) that the diversity of mangrove species can be used as an indicator of environmental damage such as the process of sedimentation, logging, reclamation, and environmental pollution. Efforts to establish mangrove ecosystem reserve areas have a very good impact on the mangrove ecosystem. In addition to increasing mangrove density, the diversity of animal species, fauna, and aquatic biota will also be saved with a note that the rules regarding the mangrove ecosystem reserve area are still obeyed by the surrounding community.

3.3.2. Economic Dimension

The results of the Rapfish Ordination analysis contained in Figure 3 can explain the sustainability status of the mangrove ecosystem in the economic dimension has a value of 26.34 with a less sustainable status. This is following the statement of Susilo (2003) which states that if the assessed dimension is below the value of 50% then the dimension of the system can be said to be less sustainable, and if the interval is 0.25% down it can be said to be bad. Of the 6 attributes, 2 attributes have the most influence on the sustainability status of the mangrove ecosystem of Kampung Rawa Mekar Jaya, namely the attribute of employment and the level of community welfare. Leverage analysis in the ecological dimension can be seen in Figure 4.

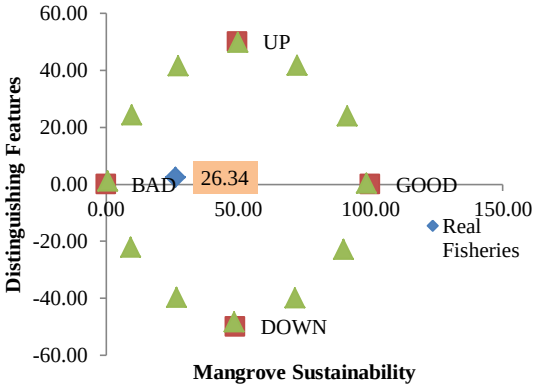

Figure 3. Sustainability status of the economic dimension

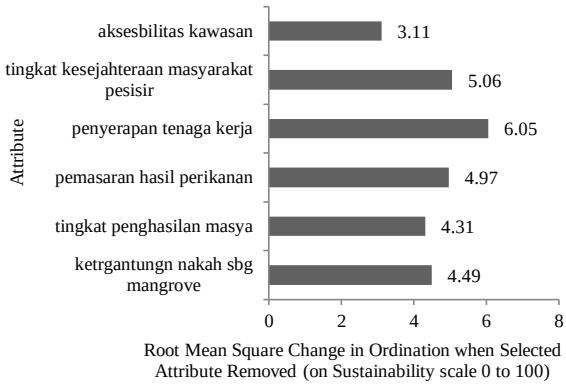

Figure 4. Results of economic dimension leverage analysis

3.3.3. Socio-Cultural Dimension

In determining the score of the socio-cultural dimension obtained from interviews with respondents who have been determined to include data on the level of education of community knowledge about mangroves, potential land conflicts, local wisdom, the availability of mangrove care communities, and the availability of procedures for utilizing mangrove areas. The results of Rapfish Ordination on 6 attributes of the socio-cultural dimension of the sustainability status of mangrove ecosystems in the influential Kampung Rawa Mekar Jaya can be seen in Figure 5.

Based on the results of the Rapfish Ordination analysis contained in Figure 5, it can be explained that the sustainability status of the mangrove ecosystem in the socio-cultural dimension in Rawa Mekar Jaya Village has a weighted value of 14.92 with a very unsustainable status. Some of the factors that influence this sustainability index in a negative direction are low levels of education which of course will affect people's understanding of the importance of mangrove forests both directly and indirectly. By data from BPS (2019), there is only education at the level of preschool or kindergarten and elementary school in Rawa Mekar Jaya Village. While the results of interviews with 30 respondents in the research area that 63.3% of respondents graduated from elementary school, 20.0% graduated from junior high school and 16.6% graduated from senior high school.

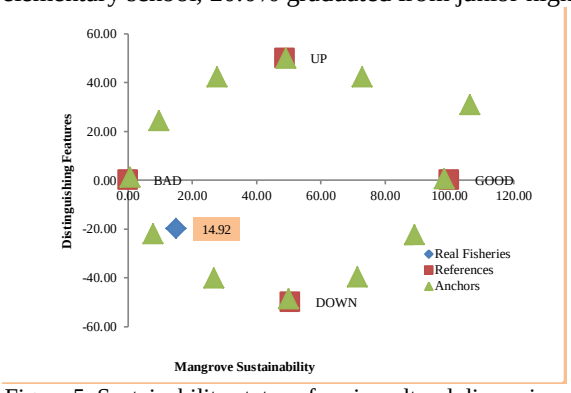

Figure 5. Sustainability status of socio-cultural dimension

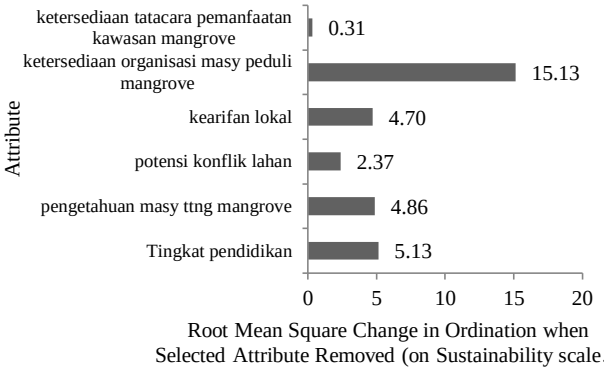

Figure 6. Results of leverage analysis of socio-cultural dimension

From the results of the leverage analysis in Figure 6, there is one attribute that is very prominent with the others, namely the availability of mangrove care communities. It can be said that this attribute has the greatest influence on the status of sustainability in the social dimension. The status of sustainability in the socio-cultural dimension is determined by the key indicators that have the most influence, meaning that the availability of basic tourism group organizations or POKDARIS in Rawa Mekar Jaya Village has a positive impact on the sustainability of mangrove ecosystems both in terms of ecology and economy.

3.3.4. Legal and Institutional Dimension

Determination of attribute scores in the Legal and Institutional dimensions to determine the sustainability status of mangrove ecosystems obtained from interview data to respondents. The results of the Rapfish Ordination of the 9 influential attributes of the legal and institutional dimensions can be seen in Figure 7.

Based on Figure 7 the results of the Rapfish Ordination analysis have a weighted value of 65.56. It can be concluded that in general the sustainability status of the mangrove ecosystem of Kampung Rawa Mekar Jaya in the legal and institutional dimensions can be said to be sustainable. This happens because each attribute in the legal and institutional dimensions is going well but not yet optimal in several aspects such as legal and

environmental socialization, community participation, and monitoring and supervision by the authorities. Good coordination between institutions and communities will have a positive effect on mangrove management

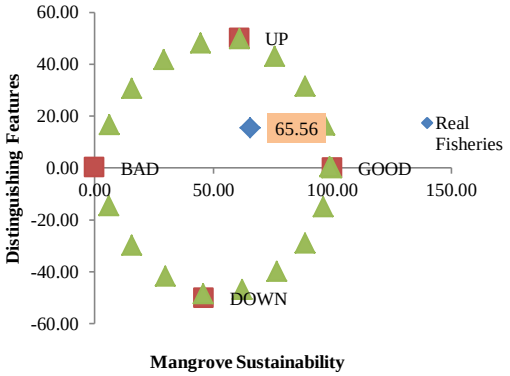

Figure 7. Sustainability status of the legal and institutional dimension

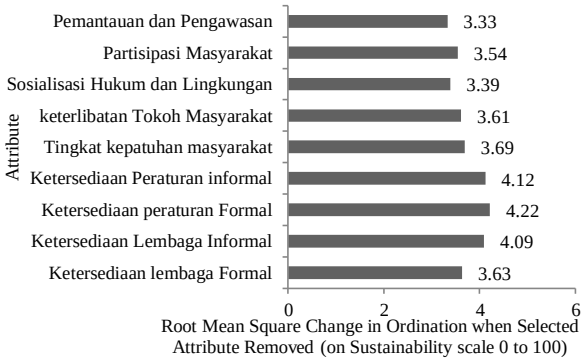

Figure 8. Results of leverage analysis of Legal and institutional dimensions

Based on the results of the leverage analysis in Figure 8, three attributes have a major influence on the sustainability of the mangrove ecosystem, namely the availability of formal regulations with an RMS of 4.22 then the availability of informal regulations with an RMS of 4.12 and the availability of informal institutions. In the legal and institutional dimensions, although the status of mangrove forest sustainability is included in the fairly sustainable category with an index value of 65.56, it cannot be said to be safe in supporting the sustainability of mangrove forests in Rawa Mekar Jaya Village.

3.4. Index Value and Status of Multidimensional Sustainability

The value of the sustainability status of the mangrove ecosystem of Kampung Rawa Mekar Jaya is simulated in 27 attributes consisting of 4 dimensions, namely, ecological dimensions, economic dimensions, social dimensions, and institutional legal dimensions. The index value in the ecological dimension is 75.67, the economic dimension is 26.34, the social dimension is 14.92, and the institutional legal dimension is 65.56. The index value and sustainability status can be seen in Figure 9

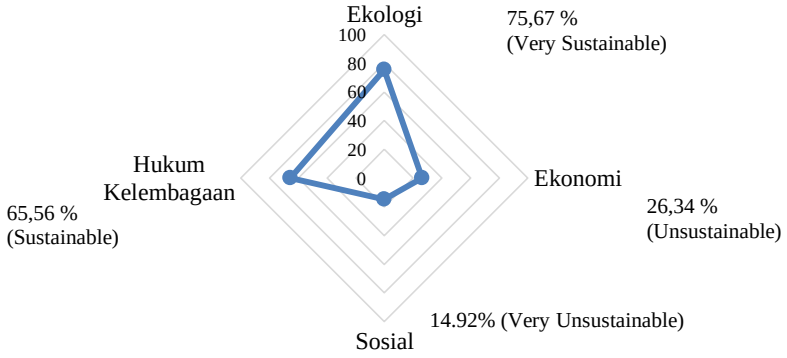

Figure 9. Diagram of sustainability analysis and sustainability index value of mangrove ecosystem of Rawa Mekar Jaya Village

Rapfish analysis shows IKP < 50, which is less sustainable with an index value of 45.62. This means that dimensions that are not yet sustainable need to be improved and dimensions that are already sustainable must be maintained. Based on the results of interviews with the community and key informants, the results of the sustainability index obtained the following conditions in the field.

4. Conclusions

The condition of the mangrove ecosystem in Rawa Mekar Jaya Village is classified as in good condition. The results of observations of mangrove vegetation conditions at the 4 research stations are still classified as good with an average mangrove density ranging from 1336.67 - 1866.67 trees/ha. The sustainability status of the mangrove ecosystem in Rawa Mekar Jaya Village in the dimensions of ecology, economy, socio-culture, and institutional law is classified as less sustainable in multidimensional with an average sustainability index value of 45.62. Strategic direction or policy recommendations that can be done to increase the value of sustainability is to increase coordination and communication between stakeholders and mangrove managers which includes supervision and enforcement of laws that have been established by the central government as well as local and

village governments. In addition, training and coaching counseling in the field of mangrove ecosystem sustainability and the field of fisheries are important factors to be considered by related parties and marketing of fishery products and mangrove forests is also a concern.

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