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Quantifying Ecological, Economic, Social, and Governance Attributes for Urban Forest Eco-Tourism Using MDS-RAPFISH Approach

Nuryasin Abdillah[1*], Thamrin Thamrin[1], Nofrizal Nofrizal[1], Gatot Wijayanto[2]

[1] Doctoral Program in Environmental Science, Universitas Riau, Pekanbaru 28131, Indonesia
[2] Department of Management, Faculty of Economics and Business, Universitas Riau, Pekanbaru 28131, Indonesia

Corresponding Author Email: yasinabdillah10@gmail.com

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ABSTRACT

Urban forests play a crucial role in ecological conservation and environmental preservation in urban environments. Their sustainability is vital given the mounting ecological and environmental pressures they face. This study aims to identify factors influencing the sustainability of forest management in terms of ecological conservation and eco-tourism, with a focus on Dumai's urban forest. We employed a Multidimensional Scaling (MDS) approach using the RAPFISH (Rapid Assessment Technique for Fisheries) program for our analysis. The results indicate that the Dumai forest ecosystem falls into the moderate category, while its sustainability level is considered less sustainable across four dimensions: ecological, social, economic, and governance. Leverage analysis identified several sensitive attributes for the sustainability of forest management, including three ecological attributes (vegetal diversity, tree species density, animal diversity), four economic attributes (job and business opportunities, multiplier effect, non-tax revenue, community income), five social attributes (level of education, society participation, conflict, community perception, public communications), and four governance attributes (regional information database, monitoring and evaluation system, human resources, infrastructure). These findings underscore the necessity of balancing the ecological and socio-economic functions of the Dumai urban forest for ecological conservation and eco-tourism. By employing the Multidimensional Scaling (MDS) approach, this study offers new insights into the comprehensive understanding of the factors affecting the sustainability of forest management practices, and their impacts on ecological conservation and eco-tourism within an urban context.

1. INTRODUCTION

Historically, forests in Indonesia have played a major role in economic development, supporting livelihoods, helping to structure economic change, and driving sustainable growth [1, 2]. In traditional societies, forests and trees were a source of land for cultivation and settlement, building materials, fuel and energy, as well as food and nutrition [3]. The magnitude of forest benefits is a driving force for protection efforts to always be encouraged so that forest use can be carried out in a sustainable manner. Many efforts can be made to realize conservation, one of which is through ecotourism [4], which offers natural beauty as the main product and involves the people living around the forest [5]. Ecotourism as alternative tourism involves visiting natural areas to study, or carrying out environmentally friendly activities, namely tourism based on natural heritage and experiences, which enables the economic and social development of local communities [6, 7]. Ecotourism assists in engaging local communities in the ecological and biodiversity conservation of biodiversity areas in return for providing economic incentives to local communities [8]. Ecotourism contributes to the conservation of biodiversity supports the well-being of local communities, involves responsible action on the part of tourists and the tourism industry, promotes small and medium-sized tourism enterprises, requires the lowest possible consumption of natural resources, emphasizes local participation, ownership and business opportunities, especially for rural communities, and above all including learning experiences [9].

Unfortunately, the conversion of forest land to other uses causes many problems, such as decreased soil fertility, erosion, extinction of flora and fauna, flooding, drought, and even general environmental and climate changes [10-13], including in the Dumai urban forest. This problem is getting worse in line with the increasing conversion of forest land into agricultural land or oil palm cultivation in Sumatra [14]. Apart from land conversion, forest fires are also a problem in the Dumai urban forest. In 2016, urban forests were the largest contributor to forest fires in conservation areas for Riau Province, namely 2,432.02 ha of the total area of land burned in conservation areas of 3,995.40 ha [15].

These problems are caused by the diverse interests of the parties involved, so that the goals to be achieved together become biased. Therefore, effective and efficient solutions must be found regarding urban forest management. Considering that the tourism potential of the urban forest is very large, this can be a potential forum for realizing efforts to improve the urban forest. Urban forest is a complex system, there are many components that influence each other and have a causal relationship. As a first step, to provide a

comprehensive picture of the interaction of important factors that influence the existence of an urban forest, a systems approach is needed to simplify these components. Thus, a sustainable Dumai urban forest management strategy is needed. Various urban forest problems as described above, have an impact on environmental damage and pollution. Land conversion, forest fires, and suboptimal performance of management institutions are the main problems that need attention to realize urban forest sustainability. Therefore, to maintain the balance of the ecosystem and the sustainability of ecotourism, it is necessary to look for influential factors to determine sustainable urban forest management strategies in the Dumai urban forest.

The objective of this research is to evaluate the factors that influence the long-term sustainability of forest management with regards to ecological preservation and eco-tourism, in a specific forest in Dumai. The analysis was conducted utilizing the RAPFISH program, which utilizes a Multidimensional Scaling (MDS) approach. The advantage of the RAPFISH program, which utilizes a Multidimensional Scaling (MDS) approach, is that it allows for the visualization and exploration of complex ecological data. MDS reduces the dimensionality of the data, which makes it easier to interpret and communicate. The program also allows for the identification of key species and habitats that are important for maintaining a healthy ecosystem. This information can be used to guide management decisions and conservation efforts. Additionally, the program is flexible and can be adapted to a variety of ecosystems and data types, making it a valuable tool for ecological research and management.

The novelty of this paper lies in its application of the RAPFISH program, which is typically used for fisheries assessment, to the evaluation of forest management strategies. Furthermore, the use of Multidimensional Scaling (MDS) allows for a more comprehensive understanding of the attributes affecting sustainability in terms of both ecological conservation and eco-tourism. This paper offers a fresh perspective on the evaluation of forest management practices and their impacts on ecological conservation and eco-tourism with the study's focus on Dumai urban forest also providing unique insights into the sustainability of forest management in an urban setting.

This article is structured in four main sections. The first section is introduction. This section provides an overview of the importance of urban forests and eco-tourism. It also highlights the need for sustainable management practices for urban forests, which requires considering several attributes, including ecological, economic, social, and governance. The second section is research method which describes the approach used to quantify the attributes for urban forest eco-tourism by using the MDS-RAPFISH approach. The third section is results which presents the findings of the study. The results identified several leverage attributes that are crucial for the sustainability of urban forest management. They were categorized into four dimensions, namely ecological, economic, social, and governance. The last section is conclusion which summarizes the key findings of the study and highlights the importance of considering multiple dimensions for sustainable urban forest management. The findings emphasize the need for multi-stakeholder involvement to ensure that these attributes are integrated into decision-making processes. They also suggest that the MDS-RAPFISH approach can be a valuable tool for decision-makers to evaluate and prioritize different attributes.

2. RESEARCH METHODS

The research was conducted in an urban forest with a total area of ± 1.68 km^2 which is in the Dumai urban forest area, Dumai City, Riau Province (Figure 1; Figure 2). In terms of forestry administration, Dumai urban forest is under the supervision of the Riau Natural Resources Conservation Center.

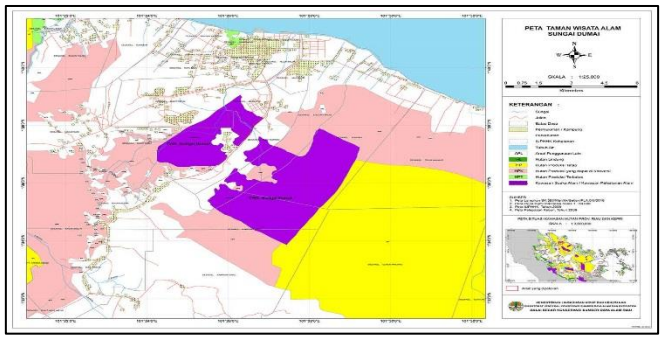

Figure 1. Map of Dumai urban forest [16]

(a) (b) (c)

Figure 2. Dumai urban forest

The primary data collected includes ecological data. Ecological data includes vegetation and animals which are the main components in the urban forest ecosystem. Moreover, to collect economic, social and governance data, secondary data was utilized with the data obtained from related agencies in the Central Government, Riau Province and City of Dumai such as the Ministry of Environment and Forestry, Bappeda, Environment and Forestry Service, Natural Resources Conservation Center (BBKSDA), Central Statistics Agency (BPS), districts and villages within the City of Dumai. In addition, secondary data was also obtained from universities, research institutions and non-governmental organizations such as Riau University, Bogor Agricultural Institute, and WWF Indonesia. This study collect 28 data with divided into each category of sustainability, namely ecological sustainability (3 data), economic sustainability (7 data), social sustainability (8 data), and governance sustainability (10 data).

The analytical technique for analyzing the sustainability status of urban forest management is carried out using the Multi-Dimensional Scaling (MDS) approach, which is an approach with the RAPFISH (Rapid Assessment Technique for Fisheries) program developed by the Fisheries Center, University of British Columbia [17, 18] (Figure 3). The RAPFISH program is being utilized to assess forest management techniques. Additionally, the implementation of Multidimensional Scaling (MDS) provides a more extensive comprehension of the elements that impact sustainability, encompassing ecological preservation and eco-tourism. Even though RAPFISH was designed for sustainability analysis in the fisheries sector, the essence of sustainability being developed can essentially also apply to other sectors by first fully understanding the nature of sustainability analysis in it. RAPFISH is widely used for analyzing the sustainability of environmental management, including those related to tourism,

such as Nurhayati et al. [19] who analyzed sustainability of tourism villages in Malang. Parmawati and Hardyansah [20] analyzed sustainability of mangrove tourism objects in Probolinggo. Moreover, Ario et al. [21] who analyzed the level of sustainability of Bunaken ecotourism.

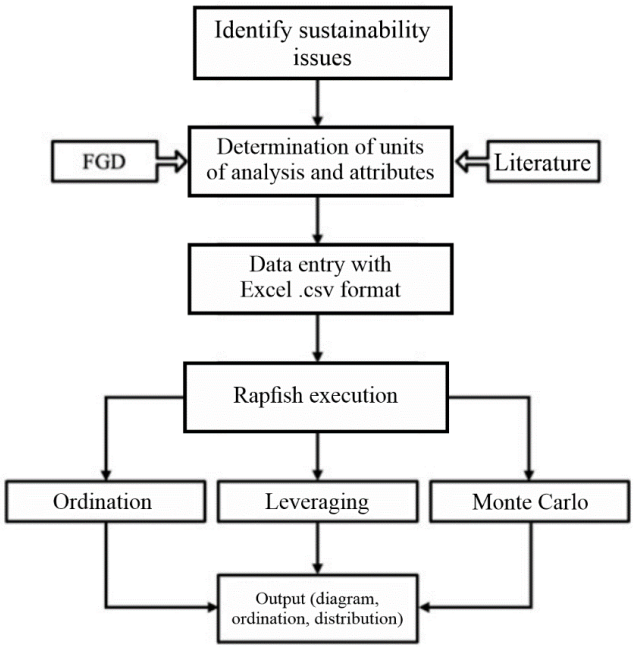

Figure 3. Stages of RAPFISH/MDS analysis

In this study, sustainability analysis of ecotourism forest management in Dumai through several stages as presented in Figure 8, including (1) identification of sustainable issues; (2) determination of sustainable management analysis and attributes for each dimension (ecology, economy, social, and governance); (3) attribute assessment on an ordinal scale based on the sustainability criteria for each factor and analysis of ordination based on multidimensional scaling (MDS) methods; (4) preparation of index and sustainable status of urban forest management. The ordination process employed RAPFISH software [17] (Table 1).

Table 1. Categories of urban forest management sustainability status

Index	Category	Sustainability Status
00.00 – 20.00	Bad	Unsustainable
20.01 – 50.00	Low	Less Sustainable
50.01 – 75,00	Medium	Relatively Sustainable
75,01 – 100.00	High	Sustainable

Source: [17]

Next, a sensitivity analysis was carried out to see which attributes are most sensitive in contributing to the sustainability of the urban forest. The effect of each attribute is seen in the form of changes in the Root Mean Square (RMS) ordination, especially on the X-axis or on the accountability scale. The greater the value of the RMS change due to the loss of a particular attribute, the greater the role of the attribute in establishing the sustainability value, or the more sensitive the attribute is in urban forest management.

To evaluate the effect of random error on the process of estimating the ordination value of urban forest management, Monte Carlo analysis was used. According to Kavanagh and Pitcher [22] states that Monte Carlo analysis is useful for studying the following: (1) the effect of errors in scoring attributes caused by an imperfect understanding of the conditions of the research location or an misunderstanding of the attributes or the method of scoring attributes; (2) the effect of variations in scoring due to different opinions or assessments by different researchers; (3) the stability of the MDS analysis process which is repeated (iteration); (4) data entry errors or missing data; (5) high value of "stress" analysis result (stress value is acceptable if < 25%). In addition, Monte Carlo analysis was used to estimate the effect of the error at the 95% confidence interval. This Monte Carlo index value is compared with the MDS index. The stress value and termination coefficient (R2) serve to determine whether or not additional attributes are needed and reflect the accuracy of the dimensions studied with the actual situation.

The analysis produces a value, where this value is the value of the sustainability index of the system under study. This ordination analysis can also be used to analyze how far the sustainability status for each dimension is depicted in the kite diagram. The sustainability index value for each dimension can be visualized in the form of a kite diagram as shown in Figure 4.

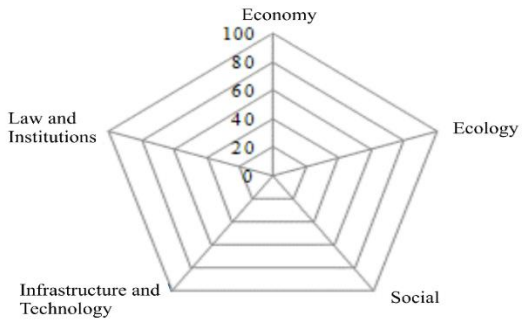

Figure 4. Illustration of a sustainability index kite diagram

3. RESULTS

3.1 Description of Dumai urban forest

The Dumai River Tourism Forest Area has an area of 3,567.62 hectares in Dumai City, Riau Province. In general, urban forest forest ecosystem types are included in dry swamp forest and lowland forest ecosystem types. The general condition of the ecosystem in the urban forest location is partly influenced by sea tides, especially for areas to the west of the area. In addition to the type of swamp ecosystem in this urban forest area, there is also a peat ecosystem. The urban forest area is in the City of Dumai, Riau Province. Geographically, the location of this conservation urban forest area is at 1031'-1038' North Latitude and 100031'- 101028' East longitude.

Topographically, the urban forest has a flat-sloping class, the area that is located lower has a sloping topography with a little hill and has a height of 0-3 meters above sea level. urban forest has a wet tropical climate and is included in climate type A according to Schmidth and Ferguson. Wet tropical climates have a dry month to wet month ratio <14.3 so this area tends to be very wet and the forest is a tropical rain forest with an average rainfall of 1,731 mm/year. The highest rainfall was recorded in August with 499 mm with a total of 18 rainy days. While the lowest rainfall was recorded in June 49 mm with a total of 7 rainy days. The dominant soil type in the urban forest

area is organosol soil (peat) with a thickness of more than 3 meters, the maturity level varies from sapric to hemofibric in the upper layers and hemofibric in the lower layers. Meanwhile, the geological conditions of the urban forest are Quarter formations consisting of young surface deposits (Qh) dominated by organic matter in the form of peat domes, only a small portion is formed from clay and silt and there are no rocks on the ground surface.

The influence of the existence of urban forests on regional economic conditions can also be seen from the multiplier effect analysis through two multiplier values, namely: (1) Keynesian local income multiplier which shows the magnitude of the impact of tourist spending on increasing local community income, and (2) Ratio income multiplier which shows the magnitude of the direct impact of tourist spending on the overall local economy. In addition to the direct impact, the income multiplier ratio also measures indirect and induced impacts (Table 2).

Table 2. The value of the multiplier effect in the urban forest

Criteria	Score	Information
Keynesian local income multiplier	0.02	Tourism activities have a very small economic impact because the Keynesian income multiplier value obtained is less than 1 (<1)
Type I income multiplier ratio	0.84	The economic impact is said to have had a very small impact because the value of the type I income multiplier ratio and type II income multiplier ratio is smaller or equal to one (<1)
Ratio income multiplier type II	1.14	

The Keynesian local income multiplier value in the urban forest from the analysis results is 0.02. This value means that every tourist expenditure of IDR 10,000 will have an impact on increasing the income of local people by IDR 200.00. Meanwhile, the value of the type I income multiplier ratio in urban forests is 0.84. This value means that for every tourist expenditure of IDR 10,000.00. there was an increase in business unit income of IDR 8,400.00 in total community income which includes direct and indirect impacts (in the form of income for business unit owners and local workers). The value of the type II income multiplier ratio in the urban forest is 1.14. This value means that every tourist expenditure of Rp. 10,000.00 will increase people's income by Rp. 11,400.00 which includes direct, indirect and induced impacts. The economic impact of tourism can benefit people who live near tourist areas and contribute to regional economic growth, as found by Chidakel et al. [23] in Zambia and Sangpikul [24] in Thailand, where the multiplier effect of tourist spending, has the potential to encourage regional tourism business growth. This is also in line with Kim et al. [25] demonstrating the effect of ecotourism on community livelihood and participation in Cambodia.

3.2 Multidimensional Scaling (MDS) validity and accuracy test

Validity test was performed using Monte Carlo analysis to estimate the effect of error (uncertainty) in MDS. The results of the Monte Carlo analysis show a 95% confidence level if there is not much difference for each dimension (the difference is relatively small), then this situation indicates that the simulation using MDS has a high level of confidence. The comparison (difference) of the sustainability index between MDS and Monte Carlo in urban forests can be seen in Table 3.

Table 3. Differences in urban forest sustainability index with Monte Carlo analysis

No	Dimensions	Sustainability Index		
		MDS	Monte Carlo	Difference
1	Ecology	41.52	42.51	0.99
2	Economy	20.60	21.77	1.17
3	Social	23.25	23.38	0.13
4	Governance	39.98	40.36	0.38

The difference or difference between the MDS and Monte Carlo sustainability indices is relatively small, namely 0.13 – 1.17. This shows that the 4-dimensional analysis of urban forest management has a high level of confidence, namely 95%. This indicates that: (1) errors in scoring each attribute are relatively small, (2) the variety of scoring due to differences in opinion is relatively small, (3) the analysis process is carried out repeatedly stable, and (4) errors in data entry or lost data can be avoided and (5) the system under study has a high level of trust.

The accuracy test of the MDS analysis in urban forest can be seen based on the stress value and the coefficient of determination (R2) to find out that the results obtained are quite accurate with the actual situation and can be accounted for. Sustainability index, stress value and urban forest determination coefficient can be seen in Table 4.

Table 4. Sustainability index, stress value and R2 urban forest

No	Dimensions	Index Value	Category	Stress	R^2
1	Ecology	41.52	Less sustainable	0.18	0.91
2	Economy	20.60	Relatively sustainable	0.14	0.94
3	Social	23.25	Less sustainable	0.14	0.94
4	Governance	39.98	Less sustainable	0.14	0.94

Based on Table 4, the resulting stress value is between 0.14-0.18, which is smaller than the requirement (<0.25), the smaller than 0.25 the better. While the coefficient of determination (R2) in each dimension and multidimensional is quite high, namely: 91% - 94% (close to 1). These two statistical parameters show that all the attributes used in each dimension are good enough to explain the sustainability of urban forest management. Thus, the model for estimating the sustainability index is sufficient to use [26].

3.3 Factorial analysis affecting urban forest sustainability

The first analysis is to examine ecological dimension. The sustainability of the ecological dimension is described in 3 attributes, namely diversity of vegetation, diversity of animals, and density of tree species. The results of measuring ecological parameters in the urban forest are then analyzed to obtain important attributes which are thought to influence the sustainability of the ecological dimension. The results of the MDS analysis on the ecological dimension can be seen in Figure 5. The MDS analysis on the attributes of the ecological

dimension shows an index value of 41.52 and is included in the less sustainable status category. The sustainability index value indicates the unfavorable condition of the urban forest from an ecological point of view.

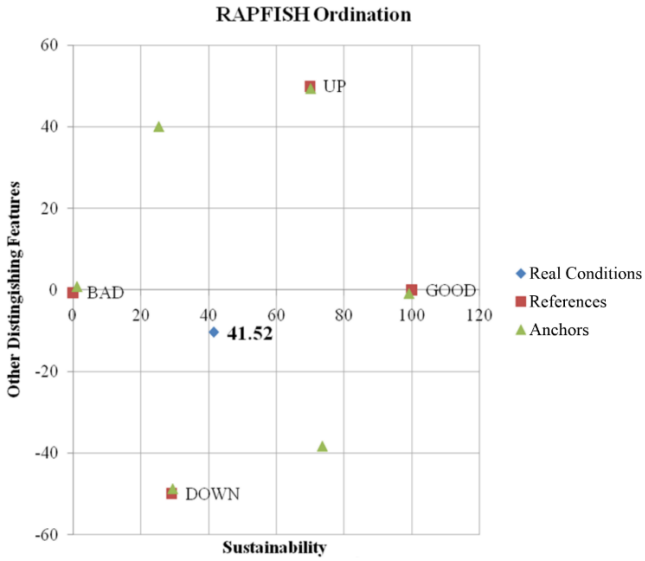

Figure 5. Ecological dimension sustainability index in urban forest

Based on current conditions, the value of vegetation density in urban forests is 515.63 ind/ha. This shows that the density in the urban forest is included in the sparse category. Ikhsani [27] found the fact that the decline in forest cover was due to rampant encroachment on the forest which was exacerbated by forest and land fires in 2016. In addition, the driving factor and trigger for encroachment and deforestation was accessibility into the forest, so that everyone could carry out activities there. inside. The diversity index in the urban forest is 2.50. This diversity value indicates a moderate level of diversity.

Each attribute on the ecological dimension has its own role which was assessed through leverage analysis. This analysis aims to determine the attributes that are sensitive in contributing to the sustainability of the ecological dimension. The results of this leverage analysis were obtained from the root mean square (RMS) value for each attribute. Determination of sensitive attributes that affect the sustainability of ecological dimensions uses a combination of leverage analysis and Pareto analysis [28, 29]. Pareto analysis is carried out by sorting the RMS value resulting from the leverage analysis from the largest to the smallest value then weighted in percentages and cumulative up to a maximum cumulative value limit of 75%. The percentage of RMS values for determining sensitive attributes on the ecological dimension can be seen in Table 5.

Table 5. RMS values for determining sensitive attributes

No	Attribute	RMS Value	Percentage
1	Vegetal diversity	8.98	36.30
2	Tree species density	8.20	33.14
3	Animal diversity	7.56	30.56
	Total	24.74	100.00

The RMS value indicates the level of influence of the attribute on the sustainability index value. The attribute that has the greatest influence is indicated by the largest RMS value and vice versa, the attribute with the smallest RMS value also has a small effect on the sustainability index value [30]. This means that in formulating policies to improve the sustainability status of the ecological dimension, it is necessary to pay attention to and consider these three attributes. In the ecological dimension, 3 sensitive attributes are obtained that affect the sustainability of urban forest management. Those sensitive attributes are: (1) diversity of vegetation; (2) tree species density; (3) diversity of vegetation. These three attributes of the ecological dimension were considered for the next step in developing a sustainable urban forest management strategy. The success of sustainable urban forest management, one of which is determined by the diversity of vegetation and animals. Biodiversity is important for most aspects of our lives, including intrinsic value, anthropocentric, aesthetic, mitigation and compensation, market valuation, political value, and scientific value [31].

The second analysis is to examine economic dimension. The economic dimension is described in 7 attributes, namely (1) economic access for the community; (2) multiplier effect; (3) work and business opportunities; (4) community income; (5) non-tax state revenue; (6) tourism products; (7) non-timber forest resources. The results of the MDS analysis for the economic dimension show that the urban forest sustainability index is 20.60. This index value is included in the less sustainable category (Figure 6).

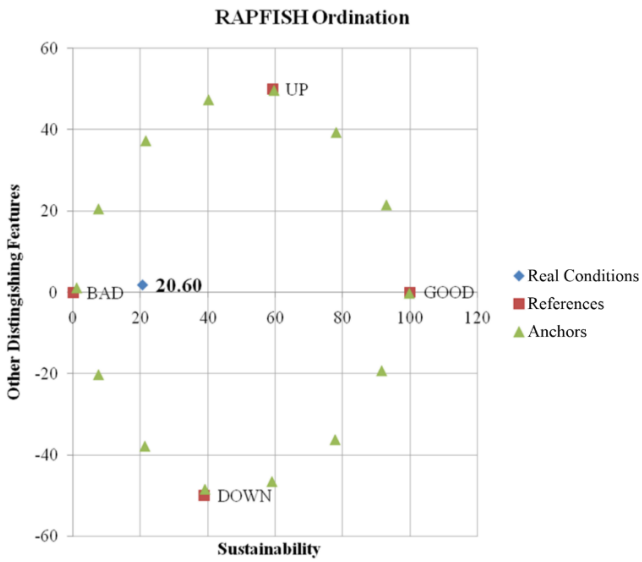

Figure 6. Economic dimension sustainability index in urban forest

Table 6. RMS value to determine sensitive attributes

No	Attribute	RMS Value	Percentage
1	Job and business opportunities	5.58	21.03
2	Multiplier effect	4.74	17.87
3	Non-tax revenue	4.20	15.83
4	Community income	4.10	15.45
	Total Percentage		70.18
5	Tourism product	3.47	13.08
6	Non-timber forest resources	2.54	9.57
7	Economic access for the community	1.90	7.16
	Total	4.90	100.00

The role of each attribute in the economic dimension, then analyzed with leverage analysis aims to see sensitive attributes in contributing to the sustainability of the economic dimension. The results of the leverage analysis, obtained from the root mean square (RMS) value for each attribute. The percentage of RMS values for determining sensitive attributes on the economic dimension can be seen in Table 6.

In the economic dimension, there are 4 sensitive attributes that affect the sustainability of urban forest management. Sensitive attributes are obtained from the cumulative percentage of the RMS value, which is 70.18%. These sensitive attributes are: (1) work and business opportunities; (2) multiplier effect; (3) non-tax state revenue; (4) community income. These four attributes of the economic dimension were considered for the next step in developing a sustainable urban forest management strategy. Muhumuza and Balkwill [32] in their research to identify the factors that influence the success of biodiversity conservation in National Parks in Africa. The study found that conservation efforts are influenced by various interrelated factors. However, the most dominant factors are economic and cultural factors, because these are related to the existence of communities around conservation areas.

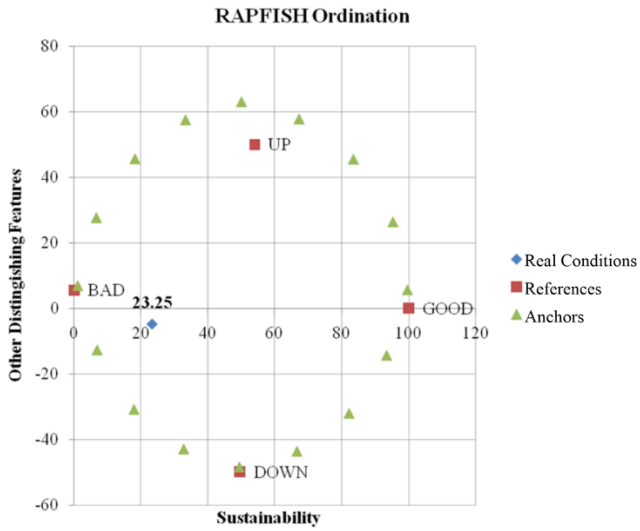

Figure 7. Social dimension sustainability index in urban forest

Next, the social dimension explains how the social aspects of urban forest management affect natural resources, especially forests in the future. The social dimension consists of eight attributes, namely local people's access to forests, dependence on forests, public communication, conflict, community participation, community empowerment, community perceptions, and level of education. The social dimension sustainability index can be seen in Figure 7.

The results of the MDS analysis for the social dimension show that the urban forest sustainability index is 23.25. The social dimension sustainability index value is included in the less sustainable category. This shows that the existence of the urban forest has not been good enough to be felt and used by the community as a vehicle for tourism. The role of each attribute in the social dimension, then analyzed with leverage analysis aims to see the sensitive attributes in contributing to the sustainability of the social dimension. The percentage of RMS values for determining sensitive attributes on the social dimension can be seen in Table 7.

Table 7. RMS values for determining sensitive attributes

No	Attribute	RMS Value	Percentage
1	Level of education	4.54	16.44
2	Society participation	4.13	14.96
3	Conflict	4.03	14.60
4	Community perception	3.70	13.40
5	Public communications	3.63	13.15
	Total Percentage		*72.54*
6	Community empowerment	3.47	12.57
7	Dependence on forests	2.62	9.49
8	Community access to forests	1.49	5.40
	Total	27.61	100.00

On the social dimension, 5 sensitive attributes are obtained that affect the sustainability of urban forest management. Sensitive attributes are obtained from the cumulative percentage of the RMS value, which is 72.54%. Those sensitive attributes are: (1) level of education; (2) community participation; (3) conflict; (4) public perception; (5) public communication. These five attributes of the social dimension were considered for the next step in developing a sustainable urban forest management strategy. This is in line with Sanesi et al. [33], Steenberg et al. [34], Bacon et al. [35] presenting that social factor between the local community and the park manager is considered important in managing the sustainability of urban forests.

Lastly, the analysis to examine governance dimension was performed. The governance dimension explains the roles of the parties in urban forest management. The governance dimension consists of ten attributes, namely budget allocation, accessibility, area information database, management organization, community participation, law enforcement, management plan, infrastructure, monitoring and evaluation system, human resources. The results of the MDS analysis for the dimensions of governance are 39.98. Therefore, the dimensions of governance in urban forests are considered less sustainable (Figure 8).

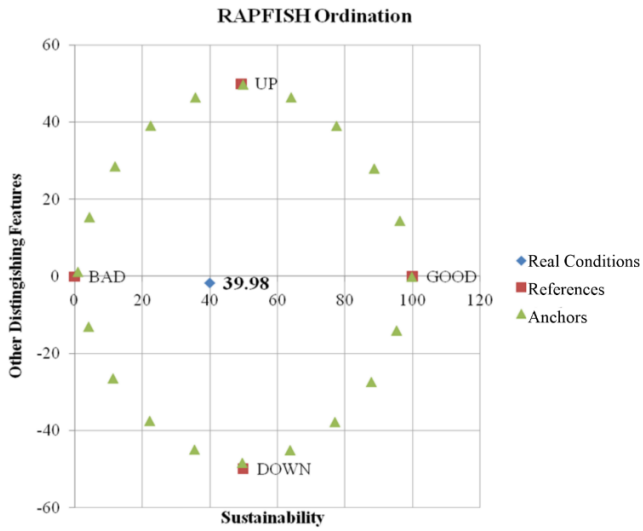

Figure 8. Governance dimension sustainability index in urban forest

The attribute that provides the highest leverage is the regional information database. This is related to the certainty of regional boundaries, which is the main trigger for conflicts. In general, this does not only occur in urban forests, but in all areas designated as forest areas in Indonesia. According to

Mariyam and Setiyowati [36], human resources and technology along with the government need to carry out the establishment of forest sustainability on a macro basis. Azwar and Mulyadi [37] in analysing the sustainability level of Rumbio customary forest showed that governance dimensions such as institutional and personnel capacity, involvement of social institutions, availability of management provisions, and legal status of customary forests are influential attributes for sustainable forest management. Laclau et al. [38] emphasized the importance of an emphasis on budget, human resources, and institutional capacity in the level of forest sustainability.

Determination of sensitive attributes that affect the sustainability of governance dimensions employed a combination of leverage analysis and Pareto analysis [28, 29]. Pareto analysis was carried out by sorting the RMS value resulting from the leverage analysis from the largest to the smallest value then weighted in percentages and cumulative up to a maximum cumulative value limit of 75 percent, with the results of RMS value was shown in Table 8.

In the institutional dimension, there are 4 sensitive attributes that affect the sustainability of urban forest management. Sensitive attributes are obtained from the cumulative percentage of the RMS value, which is 77.70%. Those sensitive attributes are: (1) regional information database; (2) monitoring and evaluation system; (3) human resources; (4) infrastructure. Data and information are important factors in the decision-making process. Data presents facts, while information is the result of data analysis arranged according to its purpose [39]. Information systems as data and information management develop along with technological developments. Organizations use information in all aspects such as planning, controlling, managing, and decision making. Therefore, information becomes an important resource for organizations [40]. Forest resource information systems have been known for many years because of their importance for forest resource management. Over the past 2 decades, many new methods have been developed for forest measurement and processing of forest management information, optimizing forest design and forestry planning, and creating forest resource information systems [41].

Table 8. RMS values for determining sensitive attributes on the governance dimension

No	Attributes	RMS Value	Percentage
1	Regional information database	2.72	50.56
2	Monitoring and evaluation system	0.53	9.85
3	Human Resources	0.50	9.29
4	Infrastructure	0.43	7.99
	Total Percentage		*77.70*
5	Management plan	0.36	6.69
6	Law enforcement	0.32	5.95
7	Society participation	0.23	4.28
8	Management organization	0.16	2.97
9	Accessibility	0.13	2.42
10	Budget allocation	0.00	0.00
	Total	*5.38*	*100.00*

4. DISCUSSION: MULTIDIMENSIONAL SUSTAINABILITY STATUS OF DUMAI CITY FOREST

The results of the MDS analysis show that the urban forest sustainability index for the ecological dimension is 41.52 (less sustainable), the economic dimension is 20.60 (less sustainable), the social dimension is 23.25 (less sustainable), and the management dimension is 39. 98 (less sustainable). The multidimensional sustainability status of an urban forest can be described with a kite diagram which can be seen in Figure 9.

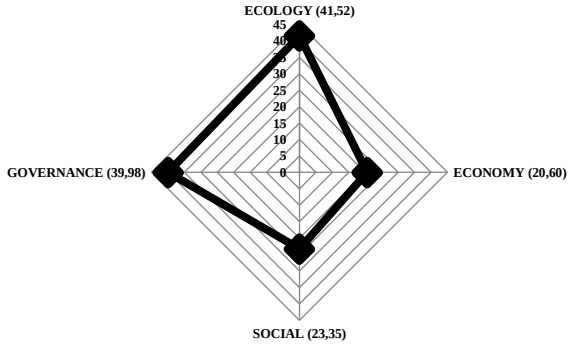

Figure 9. Diagram of urban forest sustainability status

In general, the status of multidimensional sustainability indicates that the urban forest is in a less sustainable status, thus indicating that the urban forest still requires further sustainable management. In the future, the attributes of the current conditions on each sensitive dimension need intervention or improvement.

Table 9. Key factors or attributes that affect the urban forest sustainability index

No	Dimensions	Key Attributes	Leverage
1	Ecology	Vegetal diversity	8.98
		Tree species density	8.20
		Animal diversity	7.56
2	Economy	Job and business opportunities	5.58
		Multiplier effect	4.74
		Non-tax revenue	4.20
		Community income	4.10
3	Social	Level of education	4.54
		Society participation	4.13
		Conflict	4.03
		Community perception	3.70
		Public communications	3.63
4	Governance	Regional information database	2.72
		Monitoring and evaluation system	0.53
		Human Resources	0.50
		Infrastructure	0.43

On the ecological dimension, it is known that the density of vegetation in urban forests is included in the sparse category caused by forest encroachment to forest and land fires, resulting in a decrease in vegetation density. The existence of high accessibility in the forest can encourage and trigger people to change forest and land use to trigger deforestation. The lowest sustainability status is found in the economic dimension. This is because the urban forest has not maximally provided economic access for the community, as well as low opportunities for work and business, which in turn has led to a low multiplier effect value for the urban forest. In this regard, the collection of ecotourism development funds is needed to improve the infrastructure of mangrove forest ecotourism. Azwar and Mulyadi [37] in analyzing the attributes of the

Rumbio customary forest, found that the economic dimension has not made a significant contribution to the index of sustainability of forest area management.

Sustainable urban forest management is a combination of the various attributes of each dimension. However, not all attributes have a significant effect. Therefore, the selected attributes are key attributes that affect the level of urban forest sustainability obtained from the results of the leverage analysis (Table 9).

Based on Table 9, there are 16 out of 28 key attributes on the dimensions of ecology, social economy, and governance that affect the level of sustainability of urban forests. These key attributes were used as material for consideration in determining the steps for developing a sustainable urban forest management strategy.

5. CONCLUSION

The findings show that the condition of the Dumai urban forest ecosystem is in the moderate category, both from the vegetation and animal aspects. The vegetation found was dominated by the *Dipterocarpaceae* family. Meanwhile, the types of animals found were from the class of mammals, reptiles and aves. The current level of sustainability of urban forest management is categorized in the less sustainable status. Likewise, with the four dimensions of ecological, social, economic and governance sustainability, each dimension is categorized less sustainable status. A number of leverage attributes that are considered sensitive for the sustainability of urban forest management are on the ecological dimension with three attributes (vegetal diversity, tree species density, animal diversity), economic dimension with four attributes (job and business opportunities, multiplier effect, non-tax revenue, community income), social dimension with five attributes (level of education, society participation, conflict, community perception, public communications), and governance dimension with four attributes (regional information database, monitoring and evaluation system, human resources, infrastructure).

Theoretically, the holistic approach offered by this study by conducting a comprehensive study is expected to be able to provide integrative outputs. Thus, theoretical research offers a model of a sustainable urban forest management strategy, which can become the basis for developing an urban tourism forest. As a practical implementation, it is necessary to pay attention to activities on the social dimension, such as forming communities, holding routine activities, providing public communication facilities and infrastructure, and increasing community participation to maintain, develop and discuss forest area issues. The operationalization of this scenario is formulated by involving all relevant stakeholders, with a discussion of factors that must be considered, challenges and opportunities as well as implementation strategies for the success of urban forest management efforts. In addition, it is necessary to make efforts to increase the sustainability of urban forest management by looking at the sensitive attributes in this study as a driving factor for urban forest sustainability. In addition, the government and policy makers need to increase the institutional role and organization of urban forests, so that government policies can be immediately adapted to the needs of the public. Economic and social factors are sticking out as dimensional factors inhibiting urban forest sustainability in this study. Therefore, it is necessary to carry out operational steps to increase the sustainability index of Dumai urban forest management.

The study was conducted in a single urban forest, which may not be representative of other urban forests in different locations, making generalization difficult. Moreover, the study did not take into account the effects of climate change on the sustainability of the Dumai urban forest ecosystem. The study also did not quantify the actual benefits of ecotourism to the local community. Lastly, with the data collected using the RAPFISH program, which is primarily used for fisheries assessment, further analysis may be necessary to determine the suitability of RAPFISH for evaluating the sustainability of urban forests. Thus, future research could focus on conducting a comparative analysis of the sustainability of urban forests in different locations to identify factors contributing to sustainability. Moreover, future research could incorporate the effects of climate change on the sustainability of urban forests, making it more comprehensive and reflective of the real situations. A cost-benefit analysis of ecotourism to determine the actual benefits to the local community was also suggested to be examined in future studies. Lastly, future research could develop a new assessment tool that is specifically designed for assessing the sustainability of urban forests, which can be more practical for future studies.

REFERENCES

[1] Barr, C., Resosudarmo, I.A., Dermawan, A., McCarthy, J., Moeliono, M., Setiono, B. (2006). Decentralization of forest administration in Indonesia: Implications for forest sustainability, economic development and community livelihoods. Bogor: CIFOR. https://doi.org/10.17528/cifor/002113

[2] Brockhaus, M., Obidzinski, K., Dermawan, A., Laumonier, Y., Luttrell, C. (2012). An overview of forest and land allocation policies in Indonesia: Is the current framework sufficient to meet the needs of REDD+? Forest Policy and Economics, 18: 30-37. https://doi.org/10.1016/j.forpol.2011.09.004

[3] Balée, W. (2013). Cultural Forests of the Amazon: A Historical Ecology of People and Their Landscapes. University of Alabama Press.

[4] Zoysa, M.D. (2022). Forest-based ecotourism in Sri Lanka: A review on state of governance, livelihoods, and forest conservation outcomes. Journal of Sustainable Forestry, 41(3-5): 413-439. https://doi.org/10.1080/10549811.2021.1943450

[5] Fennell, D.A. (2009). Ecotourism, in Rob Kitchin, and Nigel Thrift (Eds), International Encyclopedia of Human Geography. Amsterdam: Elsevier.

[6] Santarém, F., Saarinen, J., Brito, J.C. (2020). Desert Conservation and Management: Ecotourism. in Michael I. Goldstein and Dominick A. DellaSala (Eds), Encyclopedia of the World's Biomes, pp. 259-273. Amsterdam: Elsevier.

[7] Hammar, R.K.R. (2019). Proses dan bentuk penataan ruang masyarakat hukum adat arfak papua barat dalam perspektif penataan ruang nasional. Lex Publica, 6(1): 41-51. https://doi.org/10.58829/lp.6.1.2019.41-51

[8] Abidin, Z., Setiawan, B., Muhaimin, A.W., Shinta, A. (2021). The role of coastal biodiversity conservation on sustainability and environmental awareness in mangrove ecosystem of southern Malang, Indonesia. Biodiversitas

Journal of Biological Diversity, 22(2). https://doi.org/10.13057/biodiv/d220217
[9] Shoo, R.A., Songorwa, A.N. (2013). Contribution of eco-tourism to nature conservation and improvement of livelihoods around Amani nature reserve, Tanzania. Journal of Ecotourism, 12(2): 75-89. https://doi.org/10.1080/14724049.2013.818679
[10] Buizer, M., Humphreys, D., de Jong, W. (2014). Climate change and deforestation: The evolution of an intersecting policy domain. Environmental Science & Policy, 35: 1-11. https://doi.org/10.1016/j.envsci.2013.06.001
[11] Chowdhury, A., Hossain, M.B. (2021). Role of environmental law and international conventions in mitigating climate change effects on food system and livestock production. Lex Publica, 8(2): 14-28. https://doi.org/10.58829/lp.8.2.2021.14-28
[12] De la Barrera, F., Barraza, F., Favier, P., Ruiz, V., Quense, J. (2018). Megafires in Chile 2017: Monitoring multiscale environmental impacts of burned ecosystems. Science of the Total Environment, 637-638: 1526-1536. https://doi.org/10.1016/j.scitotenv.2018.05.119
[13] Reddington, C.L., Yoshioka, M., Balasubramanian, R., Ridley, D., Toh, Y.Y., Arnold, S.R., Spracklen, D.V. (2014). Contribution of vegetation and peat fires to particulate air pollution in Southeast Asia. Environmental Research Letters, 9(9): 094006. http://dx.doi.org/10.1088/1748-9326/9/9/094006
[14] Berkelmann, D., Schneider, D., Engelhaupt, M., Heinemann, M., Christel, S., Wijayanti, M., Meryandini, A., Daniel, R. (2018). How rainforest conversion to agricultural systems in Sumatra (Indonesia) affects active soil bacterial communities. Frontiers in Microbiology, 9: 2381. https://doi.org/10.3389/fmicb.2018.02381
[15] Direktorat Jenderal KSDAE. (2018). Laporan Kinerja Direktorat Jenderal KSDAE. Direktorat Jenderal KSDAE, Jakarta. [Indonesia].
[16] 16BBKSDA Riau. (2018). Taman Wisata Alam (TWA) Sungai Dumai. https://bbksda-riau.id/index.php?r=post&id01=4&id02=23&id03=53&token=a7be0d5d09ce83bd1bdfb19963c3183f. [Indonesia].
[17] Kavanagh, P., Pitcher, T.J. (2001). Rapid appraisal of fisheries (RAPFISH) Project. Fisheries Centre Research University of British Columbia, Canada.
[18] Fauzi, A., Anna, S. (2005). Pemodelan sumberdaya perikanan dan kelautan untuk analisis kebijakan. Gramedia Pustaka, Jakarta. [Indonesia].
[19] Nurhayati, Y., Pudjihardjo, P., Susilo, S., Ekawaty, M. (2021). The status of tourism village sustainability in indonesia: multi-dimensional scaling rapfish approach. International Journal of Social Science Research, 3(1): 20-33.
[20] Parmawati, R., Hardyansah, R. (2020). Sustainable tourism study on beejay bakau resort probolinggo: An analysis of RAPFISH-MDS. ECSOFiM (Economic and Social of Fisheries and Marine Journal), 7(2): 184-196. https://doi.org/10.21776/ub.ecsofim.2020.007.02.05
[21] Ario, D., Karuniasa, M., Patria, M.P., Roeroe, K.A. (2021). Assessment of Bunaken Island for sustainable tourism destination using the rapid appraisal for fisheries. In IOP Conference Series: Earth and Environmental Science, 716(1): 012094. https://doi.org/10.1088/1755-1315/716/1/012094
[22] Kavanagh, P., Pitcher, T.J. (2004). Implementing Microsoft Excel software for Rapfish: A technique for the rapid appraisal of fisheries status. Fisheries Centre Research University of British Columbia, Canada. https://dx.doi.org/10.14288/1.0074801
[23] Chidakel, A., Child, B., Muyengwa, S. (2021). Evaluating the economics of park-tourism from the ground-up: Leakage, multiplier effects, and the enabling environment at South Luangwa National Park, Zambia. Ecological Economics, 182: 106960. https://doi.org/10.1016/j.ecolecon.2021.106960
[24] Sangpikul, A. (2017). Ecotourism impacts on the economy, society and environment of Thailand. Journal of Reviews on Global Economics, 6: 302-312. https://doi.org/10.6000/1929-7092.2017.06.30
[25] Kim, M., Xie, Y., Cirella, G.T. (2019). Sustainable transformative economy: Community-based ecotourism. Sustainability, 11(18): 4977. https://doi.org/10.3390/su11184977
[26] Pitcher, T.J., Lam, M.E., Ainsworth, C., Martindale, A., Nakamura, K., Perry, R.I., Ward, T. (2013). Improvements to Rapfish: A rapid evaluation technique for fisheries integrating ecological and human dimensionsa. Journal of Fish Biology, 83(4): 865-889. https://doi.org/10.1111/jfb.12122
[27] Ikhsani, H. (2021). Analisis Vegetasi di Taman Wisata Alam (TWA) Sungai Dumai, Riau. Wahana Forestra: Jurnal Kehutanan, 16(1): 25-36. https://doi.org/10.31849/forestra.v16i1.5720
[28] Destry, E., Purnaweni, H., Syafrudin, S. (2015). Evaluation on sustainability of technological dimension biopore absorption hole management for soil water conservation in Semarang City. Sains Tanah-J. Soil Sci. Agroclimatol, 12(1): 1-9. http://dx.doi.org/10.15608%2Fstjssa.v12i1.249
[29] Handayani, H., Anggoro, S., Hendrarto, B., Mudzakir, A.K. (2016). Policy on fishery extension in local marine conservation area Mayalibit Bay in Raja Ampat Regency, West Papua Province. Aquaculture, Aquarium, Conservation & Legislation-International Journal of the Bioflux Society, 9(1): 20-33.
[30] Wibowo, A. B., Anggoro, S., & Yulianto, B. (2015). Status keberlanjutan dimensi ekologi dalam pengembangan kawasan minapolitan berkelanjutan berbasis perikanan budidaya air tawar di Kabupaten Magelang. Saintek Perikanan: Indonesian Journal of Fisheries Science and Technology, 10(2): 107-113. https://doi.org/10.14710/ijfst.10.2.107-113
[31] Ehrlich, P.R., Ehrlich, A.H. (1997). The value of biodiversity. The Economics of Transnational Commons, 97-117. https://doi.org/10.1590/s1519-69842008000500018
[32] Muhumuza, M., Balkwill, K. (2013). Factors affecting the success of conserving biodiversity in national parks: A review of case studies from Africa. International Journal of Biodiversity, 2013: 798101. https://doi.org/10.1155/2013/798101
[33] Sanesi, G., Lafortezza, R., Bonnes, M., Carrus, G. (2006). Comparison of two different approaches for assessing the psychological and social dimensions of green spaces. Urban Forestry & Urban Greening, 5(3): 121-129. https://doi.org/10.1016/j.ufug.2006.06.001
[34] Steenberg, J.W., Millward, A.A., Nowak, D.J., Robinson, P.J. (2017). A conceptual framework of urban forest

ecosystem vulnerability. Environmental Reviews, 25(1): 115-126. https://doi.org/10.1139/er-2016-0022
[35] Bacon, C.M., Getz, C., Kraus, S., Montenegro, M., Holland, K. (2012). The social dimensions of sustainability and change in diversified farming systems. Ecology and Society, 17(4): 41. http://dx.doi.org/10.5751/ES-05226-170441
[36] Mariyam, S., Setiyowati, S. (2021). Legality of Artificial Intelligence (AI) technology in public service transformation: Possibilities and challenges. Lex Publica, 8(2): 75-88. https://doi.org/10.58829/lp.8.2.2021.75-88
[37] Azwar, B., Mulyadi, A. (2020). Index and management sustainability condition of Kenegerian Rumbio customary forest, Riau Province-Indonesia. International Journal of Environmental Science, 5: 241-202.
[38] Laclau, P., Meza, A., Garrido Soares de Lima, J., Linser, S. (2019). Criteria and indicators for sustainable forest management: Lessons learned in the Southern Cone. International Forestry Review, 21(3): 315-323. https://doi.org/10.1505/146554819827293196
[39] Pearlson, K.E., Saunders, C.S. (2010). Managing and Using Information Systems: A Strategic Approach. John Wiley & Sons, Inc, Danvers.
[40] Walsham, G. (2009). Interpreting Information System in Organizations. Blackwell, Chichester.
[41] Atroshchenko, O.A. (2013). Forest stand growth forecast models. Proceeding of BSTU, 2013(1): 3-5.