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Analysis of Sustainability Management of River Flow of Wae Batu Gajah City Ambon

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Abstract: ***The role of Wae Batu Gajah Watershed which has a function as water regulator and as a water source is now beginning to have a very significant change with the rate of change of forest land cover into a settlement that ultimately undermines the sustainability of ecological functions. This damage can be proved by the phenomenon of flooding, which occurs in the rainy season and dryness in the dry season. Analysis of the sustainability of Wae Batu Gajah Watershed has a goal 1). Analyze the index and sustainability status of Wae Batu Gajah Watershed from ecological, economic and social dimension. 2). Test the validity and test the accuracy of the sustainability index of Wae Batu Gajah Watershed Management. The results showed that the multidimensional sustainability index for the three dimensions of ecology, economics and social is 50.97% with fairly sustainable category. Validation test shows the difference of Monte Carlo and MDS analysis value on the 95% level of average confidence for three dimensions is 0.72%; the determination value (R^2) between 93.86% - 95.18% means the model of sustainability index estimation is good and adequate; value of stress 0.2 which means that the MDS analysis model obtained has a high accuracy (goodness of fit) to assess the index of sustainability of Wae Batu Gajah Watershed.***

Keywords: watershed, land capability, watershed characteristic, sustainability index, multidimentional scalling

1. Introduction

1.1 Background

Watersheds are often used by the forestry sector because forests are considered a function of conservation, which functions as catchment areas, whereas the term watershed is generally better known for being used by the general public. In a watershed, there are various types of land cover that have their respective functions.

The function of these watershed ecosystems will decrease as a result of human activities as well as due to naturally occurring changes. In general, the identification of watershed problems can be divided into four (4) namely hydrology, land, socio-economic and institutional. Watershed problems are observed in the land aspect caused by high erosion and sedimentation rates leading to the widening of critical land and declining land productivity. In the socio-economic aspect, the watershed problem is caused by the conversion of land with large area to increase the income of the community in the watershed. In the institutional aspect of watershed problems, it appears that the low coordination, integration, synergy (KISS) among stakeholders in watershed management resulted in conflict in its management [1].

[2] cites Munashinge (1993), Smith and Jalal (2000) that there are three main pillars of sustainable development: ecological dimension, social dimension and economic dimension. The ecological dimension means the optimization of ecological benefits should not ignore the economic and social aspects. The social dimension means not to ignore the economic and ecological aspects. While the economic dimension means not ignoring the ecological and social dimensions. Thus the three pillars must be simultaneously moved in the planning and implementation of development.
The change of watershed area in Semenajung Leitimor Ambon City has increased since entering the Year 2000an including Wae Batu Gajah Watershed area. Land use change is influenced by population growth tends to increase 1,25% in 2009 (284,809 people), social conflict that happened at the beginning of year 2000 is the main factor of acceleration of change of function of watershed area into settlement [3].

The role of Wae Batu Gajah Watershed which has a function for water regulator and as a water source is now beginning to undergo a very significant change with the rate of change of forest land cover into a settlement that ultimately undermines the sustainability of ecological functions. This damage can be proved by the phenomenon of flooding and which occurs in the rainy season and dryness in the dry season.
The sustainability of a Watershed needs to be known so that it can be known to what extent its sustainability index value and what handling steps need to be followed up.

1.2 The Aims

Taking into account the changing conditions occurring in the Wae Batu Gajah Watershed, this study was conducted with the aim of:

1) Analyze the index and sustainability status of Wae Batu Gajah Watershed from ecological, economic and social dimension.
2) Test the validity and test the accuracy of sustainability index of Wae Batu Gajah Watershed Management.

2. Research Methodology

2.1 Research Sites

This field research was conducted in Wae Batu Gajah Watershed; Ambon City with Wae Batu Gajah Watershed is 549.55 ha, with consideration of WaeBatu Gajah Watershed is one of the locations of raw water source and is currently experiencing the conversion of forest into a very high settlement.

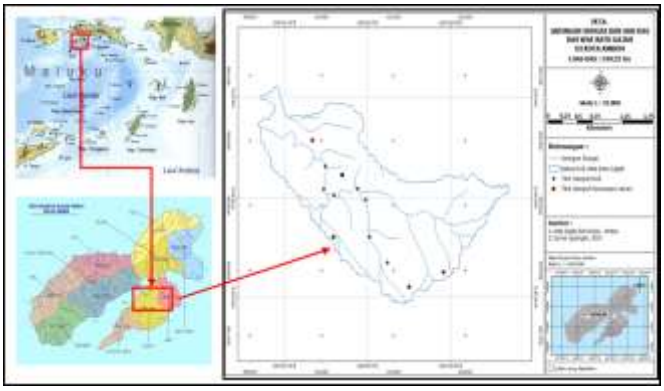


Figure 1: Map of Research Locations

2.2 Types and Data Sources

The data collected are primary data in the form of attributes related to the three dimensions of watershed sustainability management. The data were obtained by interviewing various respondents and selected experts, as well as the results of field measurements and observations. While secondary data comes from related institutions, and some library sources.

2.3 Method of Collecting Data

Types of data collected in this study are primary data and secondary data. Primary data collected in the field is the position of the observation point according to the type of land cover taken at random. Secondary data collected include land cover map from Development Planning Agency at Sub-National Level (Bappeda) Ambon City.

2.4 Data Analysis

Analysis of the sustainability of Wae Batu Gajah Watershed management is done by Multi-Dimensional Scaling (MDS) approach method. This analysis is done through several stages, those are:

- Determination of sustainable attributes of Watershed Management covering five dimensions: ecology, economy, socio-culture, infrastructure / technology and institutions.
- Assessment of each attribute on an ordinal scale based on the sustainability criteria of each dimension.
- Each attribute in each dimension is given a score based on the scientific judgment of the scorers. The range of scores ranges from 0-3 or depends on the state of each attribute, which means from bad to good.

The scores of each attribute are analyzed by multi-dimensional scaling to determine one or more points reflecting the sustainability of sustainable management development of the two reference points of good and bad points. The estimated score of each dimension is expressed on the worst (bad) scale 0% to the best (good) 100%. Score value which is the value of sustainability index of each dimension can be seen in Table 1 below:

Table 1: Category of sustainability status of Wae Batu Gajah Watershed management

Index value	Category of sustainability
0,00 -25,00	Bad
25,01 -50,00	Less
50,01 -75,00	Sufficient
75,01 - 100,00	Good

Through the MDS method, the sustainability point position can be visualized in the form of kite diagrams shown in Figure 1 below:

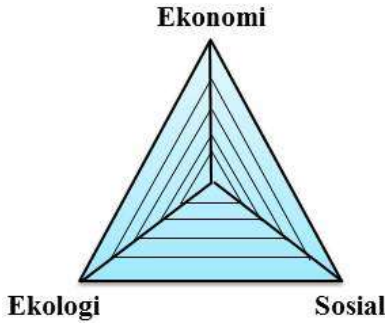


Figure 2: Illustration of multidimensional sustainability index

3. Results and Discussion

3.1 Characteristic of Wae Batu Gajah Watershed

The rapid development of Ambon City in recent years requires a vast land area. This is evidenced by the change in land use is quite large lately. Wae Batu Gajah Watershed as part of urban area also experience land use change that leads to open area / vacant land to be built area. The results of data processing using spatial analysis showed a change of land use that occurred in Wae Batu Gajah Watershed. The per area of land use per year is presented in Figure 2.

Table 2: Changes in Land Use Year 2009-2014

Watershed	Land cover	Year 2009 (Ha)	Percentage (%)	Year 2014 (Ha)	Percentage (%)	Change (Ha)	Percentage of change (%)
WaeBatu Gajah	Secondary Dryland Forests	299.95	54.58	268.61	48.88	-31	-5.7
	Shrubs	193.21	35.16	253.44	46.12	60	11.0
	Settlement	56.39	10.26	27.50	5.00	-29	-5.3
Total		549.55	100.00	549.55	100.00		

Source: Research Data.

Description:% change 2009/2014 = (Area 2014-Area 2009) / area of watershed x 100%.

Wae Batu Gajah River watershed Network is a series of Main riverwith branches of a tributary. The upstream of Wae Batu Gajah watershed is located in Soya village, the central part is around Soya village to Batu Gajah village and the downstream area is in the Honipopu to Ahusensub district and then up to Waihaong beach.

Wae Batu Gajah watershed is a Main river where many tributaries flow with river flow patterns include dendritic patterns. The shape and size of the longitudinal watershed area and relatively narrow that can describe the level of drainage density in the watershed area.

Wae Batu Gajah Watershed in Ambon City has slopes divided into 4 (four) grade slopes i.e. 8-15%, 15-30%, 30-45%, and> 45%. The result of Hydrology Response Unit formation is formed the slope condition is flat to steep as it represents the slope of 8-15% to> 45%.

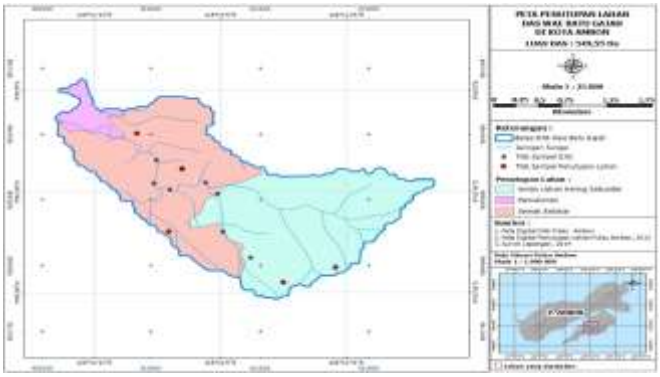


Figure 3: Map of Wae Batu Gajah River watershed Year 2014.

The slopes of Wae Batu Gajah watershed are dominated by steep slopes (15-30%) with an area of 121.16 ha, steep slope (8-15%) with 45.32 ha, steep (30-45%) on 362.06 ha and very steep (> 45%) with an area of 21 ha. It can be said that the Wae Batu Gajah Watershed is located in an area with steep slopes (mountainous).

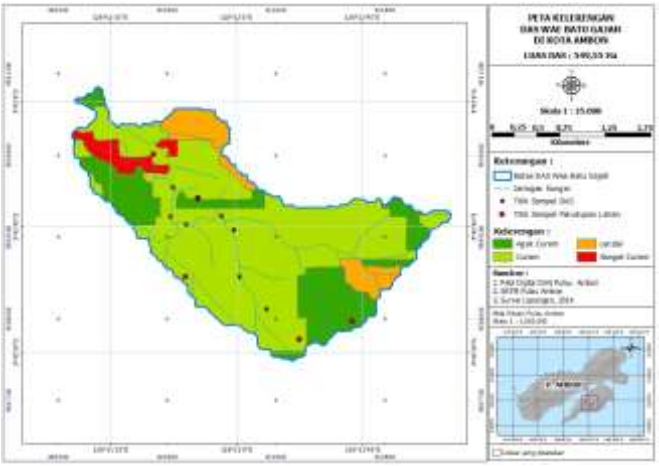


Figure 4: Class Map of Wae Batu Gajah Watershed.

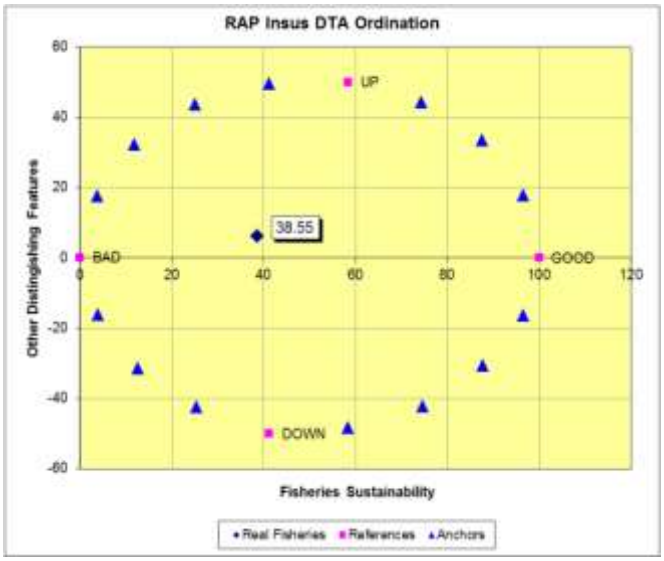
Table 3: The slope conditions in the watershed in Ambon City

Slopes Class (%)	wide (Ha)	Percentage (%)	Information
8 – 15	45,32	8,25	Sloping
15 – 30	121,15	22,04	Rather steep
30 – 45	362,07	65,88	steep
>45	21,03	3,83	Very steep
TOTAL	549,57	100	

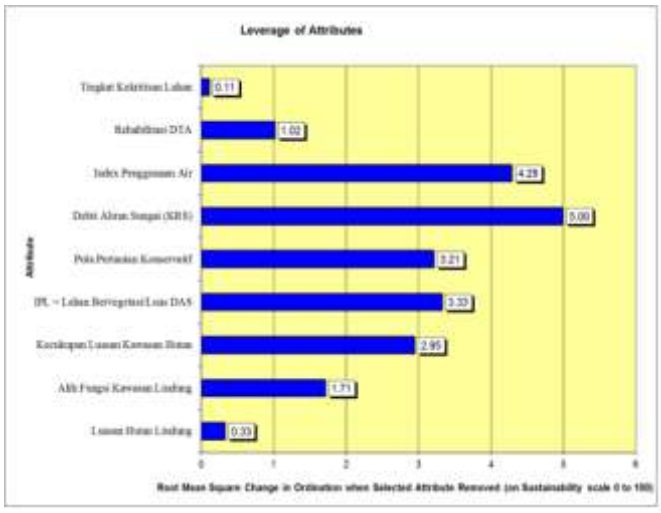
Source: Research Data.

3.2 Status of Sustainability Ecological Dimension

The results of Wae Batu Gajah Rap-watershed analysis found that the index value of sustainability level on the ecology dimension of 38.55% means less sustainable. This sustained index of less than 50% indicates the worsening ecological conditions of the Wae Batu Gajah Watershed region. The ecological capacity of the region to support activities in the region is decreasing. If this ecological carrying capacity is allowed then it affects the sustainability of other dimensions so that the management of the Wae Batu Gajah Watershed is increasingly unsustainable. The results of the ecological dimension sustainability analysis are presented in Figure 5 (A).



(A)
The value of ecological sustainability index of WaeBatu Gajah watershed



(B)
The result of attribute leverage analysis on the ecological dimension

Figure 5: The value of sustainability index and leverage analysis results.

Analysis of leverage to ecological attributes obtained 5 attributes that are sensitive to the level of sustainability of the ecological dimension are (1) River Flow Debit; (2) Water /

Science Usage Index; (3) Vegetation index IPL = Restricted Area / Area of Watershed; (4) Conservative Agricultural Patterns; and (5) Adequacy of Forest Area Area. Changes to these 5 leverage factors will easily affect the increase or decrease of the ecological dimension sustainability index value. The results of leverage analysis are presented in Figure 5 (B).

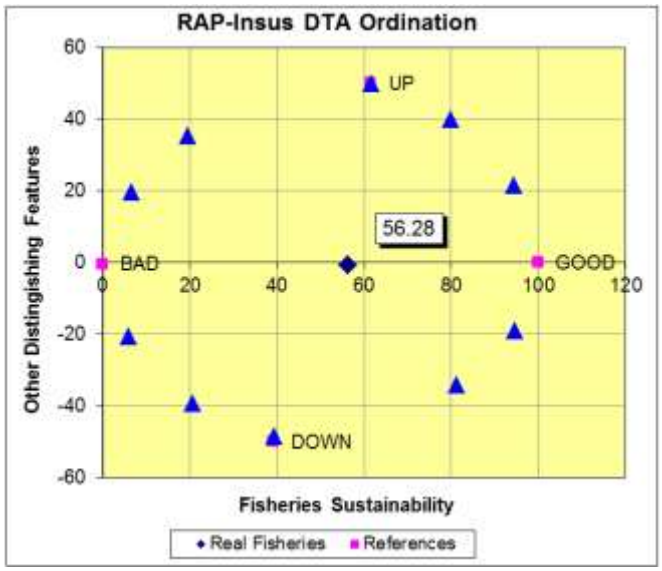
To increase the sustainability index of the ecological dimension, it is necessary to have policy interventions, among others: a) It is necessary to increase the extent of vegetation cover and reduce the rate of conversion of vegetated soil to settlement so as to reduce the flow of river flow; b) Good utilization of water in domestic water needs, good water production management by PDAMs, increasing water production by utilizing new water source potentials; c). Maintaining a conservative farming system of planted crops is mixed and long-lived, using organic fertilizers, without pesticides by communities living in the upper reaches of DTA; d). This vegetation covered land needs to be maintained and should be increased area. With the increase of vegetated land it will increase the amount of forest land cover the function of forest area can become water catchment area, because forest has hydrologic function as water regulator.

3.3. Status of Sustainability Economic Dimension

The result of Rap-Insuswatershed Ambon City analysis obtained the value of sustainability index from economic dimension of 56.28% means with sustainable enough status. This means that economically, Wae Batu Gajah Watershed still provides support for sustainable management. The result of economic sustainability dimension analysis is presented in Figure 6 (A).

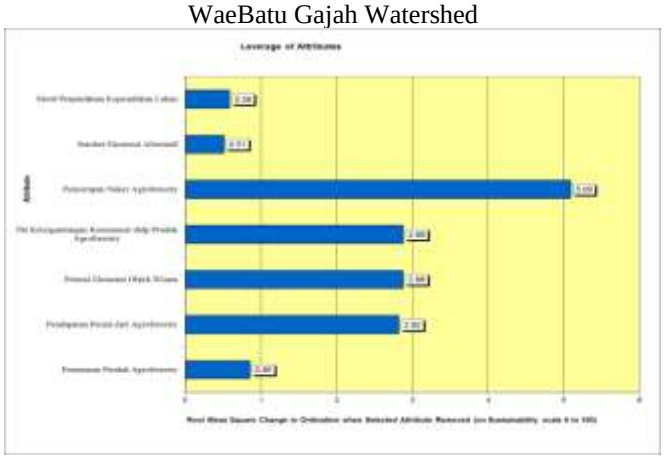
Based on the results of leverage analysis presented in Figure 3 (B), obtained 4 (two) attributes whose changes affect sensitivity to the value of economic sustainability index, namely (1) Absorption of Agroforestry Labor; and (2) Consumer Dependency on Agroforestry Products; (3) Potential of Tourist Attraction; and (4) Farmer's Income from Agroforestry.

To maintain and improve the sustainability index of the economic dimension, there should be policy intervention, among others: a). Absorption of Naker Agroforestry, in this case is an economic activity that is not based on agroforestry system of high economic value compared with seasonal crops, so it can absorb labor to manage agroforestry roduction; b). Need for post-harvest handling of agroforestry products coming from the upper watershed of Ambon City, considering the people's dependence on the product is very high; c). Utilization and management of areas that have good tourism potential so as to attract many visitors, thus the potential of this attraction can be an alternative source of income for the community around the location of the tourist attraction; d). There needs to be an increase in other sources of income other than agroforestry such as services, handicrafts, and others.



(A)

The value of sustainability index economic dimension of WaeBatu Gajah Watershed



(B)

The result of attribute leverage analysis on economic dimension

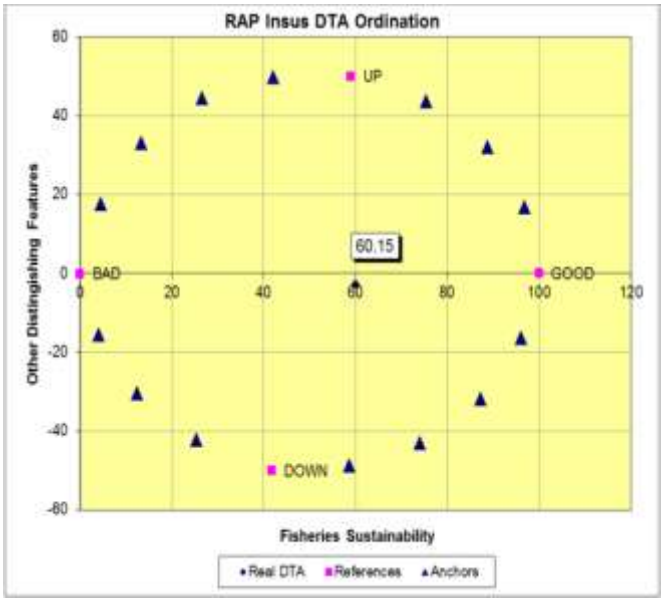
Figure 6: The value of sustainability index and leveraged economic dimension analysis

3.4 Status of Sustainability Social Dimension

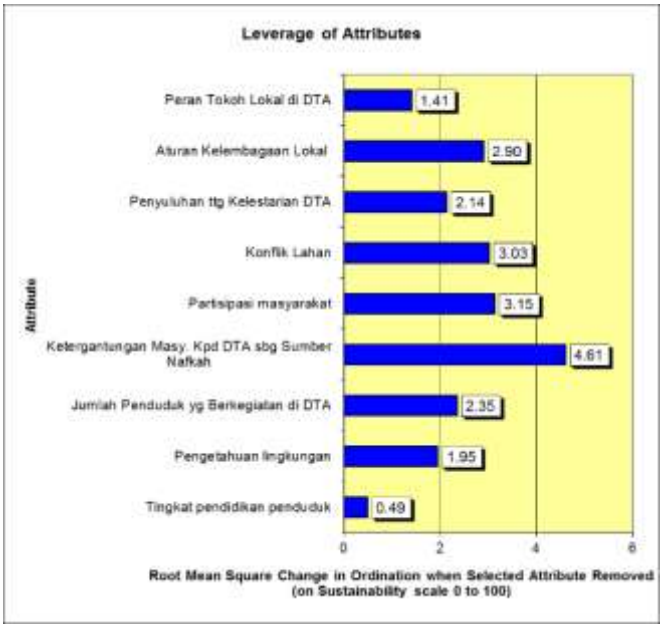
The result of sustainability analysis resulted in index value at social dimension of 60.15% means that it is quite sustainable. The results of the social dimension sustainability analysis are presented in Figure 4 (A). Based on the results of leverage analysis obtained 4 (five) attributes that are sensitive to social and cultural sustainability index, namely (1) dependence of the community on the watershed as a source of livelihood; (2) Community participation level; (3) Land Conflict; (4) Local institutional rules. The result of leverage analysis to social dimension is shown in Figure 7 (B).

In order to maintain and improve the value of the sustainability index of the social dimension, it is necessary to have policy interventions, among others: a). Increasing the sincerity of the upland communities on the importance of watersheds so that the dependency of the community to the watershed as a source of income will be efficient if the land area corresponds to the number of farmers as it relates to the carrying capacity of the land; b). Involve the community

jointly in various DTA management activities, c). The role of the government as a policymaker may be a bridge in the case of settling the conflicting land tenure status, so that the conflicting parties may end up; d). Maintaining the local institutional rules (sasi) that apply to Ambon City generally and Wae Batu Gajah Watershed area in particular is still good and there are rules that are not written and there are institutional customs that take care of the prohibition or postponement of harvest on certain types of plants. This institutional regulation is still running until today, so it needs to be maintained in order to conserve natural resources in general and watershed in particular.



(A)
The value of sustainability index of social dimension of WaeBatu Gajah Watershed



(B)
The result of attribute leverage analysis on social dimension
Figure 7: The value of sustainability index and leverage analysis of social dimension

3.5. Sustainability Status Multidimensional Management of WaeBatu Gajah Watershed

The results of multi-dimensional Rap-Insus analysis of sustainability of Wae Batu Gajah Watershed management resulted in 50,97 sustainability index value as quite sustainable. This value is obtained based on the assessment of 25 attributes that include ecological, economic and social dimensions. The results of Rap-InsuswatershedWaeBatu Gajah Wash analysis are presented in Figure 8 below.

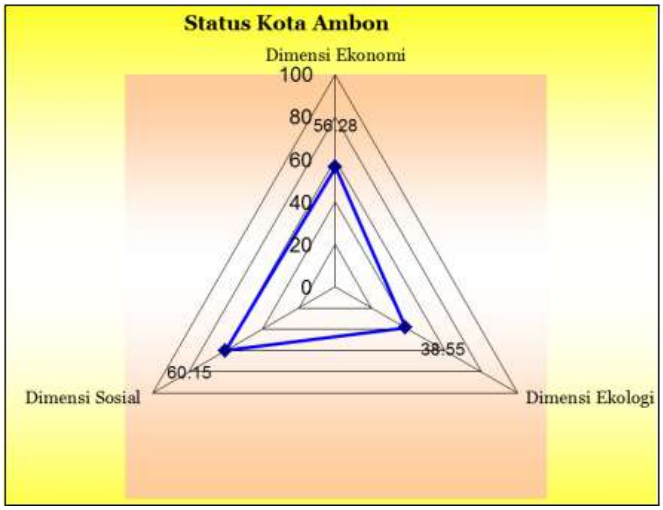


Figure 8: Sustainability index of multidimensional sustainability of Wae Batu Gajah Watershed.

3.6 Test Validity and Accuracy Test of MDS

Validation test pointed to Monte Carlo analysis result and MDS analysis at 95% confidence level obtained that the value of sustainability index of Wae Batu Gajah Watershed management showed that the difference of value of both analyzes is very small (see Table 3). This means that the resulting MDS analysis model is **adequate** to estimate the sustainability index value of the Wae Batu Gajah Watershed. The small differences in the results of these two analyzes show that: 1) errors in the analysis process can be minimized or avoided. The error that the error in scoring in attributes is relatively small; 2). Multi-dimensional scoring variations due to different opinions are relatively small; 3). the process of data analysis performed repeatedly relatively stable; 4). errors in input data and lost data can be avoided.

Table 4: Differences of MDS sustainability index value and Monte Carlo analysis

Dimensi	Nilai Indeks Keberlanjutan (%)			
	MDS	Monte Carlo (MC)	Perbedaan (MDS-MC)	Perbedaan (MDS-MC) %
Ekologi	38,55	38,48	0,07	0,18
Ekonomi	56,28	57,16	0,88	1,56
Sosial	60,15	60,30	0,15	0,25
Rata-rata	51,66	51,98	0,37	0,72

The analysis of Rap-Insus watershed Wae Batu Gajah obtained the coefficient of determination (R^2) between 93.86% - 95.18% or greater than 80% or close to 100% means the model of sustainability index estimation is **good and adequate** use [4]. The value of stress between 0.14 to

0.16 or the difference in stress value of 0.2. The value of determination is close to 95-100% and the stress value is 0.2 smaller than 0.25 or 25% so that the MDS analysis model obtained has a goodness of fit to assess the sustainability index of Wae Batu Gajah [4]. The value of stress, determination coefficient of Rap-Insus watershed Wae Batu Gajah, is presented in Table 5 below.

Table 5: Value of stress and determination value (R^2) result of Rap-watershedWaeBatu Gajah

Parameter	Dimension of Ecology	Dimension of Economy	Dimension of Social
Stress Value	0,14	0,16	0,14
Value R^2	95,18	93,86	95,12

4. Conclusions and Recommendations

4.1. Conclusion

1. The ecological sustainability index of 38.55% is categorized as unsustainable, the economic sustainability index of 56.28% is categorized as sustainable; social sustainability index of 60.15% with fairly sustainable category; the multidimensional sustainability index for all three ecological, economic and social dimensions of 50.97% with fairly sustainable categories.

2. The result of the validation test shows the difference of Monte Carlo and MDS analysis value on the 95% confidence level average for the three dimensions is 0.72%; with the determination value (R^2) between 93.86% - 95.18% or greater than 80% or close to 100% means the model of sustainability index estimation is good and adequate; with a stress value of 0.2 less than 0.25 or 25% so that the MDS analysis model obtained has a goodness of fit to assess the sustainability index of Wae Batu Gajah Watershed

4.2. Suggestion

It is necessary to have policies related to the management of Ambon City Watershed by considering the sensitive attributes to the management of the Ambon River watershed, and the need to coordinate with the stakeholders, so that the layout planning will be run in accordance with the existing land function.

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