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Ecotourism Site Suitability Using GIS and AHP: A Case Study of Ngargoyoso District in Karanganyar Regency

Martein Adigana[1] and Jawoto Sih Setyono[2]

[1]Ministry of Agrarian Affairs dan Spatial Planning/National Land Agency, North Gorontalo Regency Land Office
[2]Department of Urban and Regional Planning, Diponegoro University, Semarang

Abstract

The purpose of the Karanganyar Regency Regional Tourism Development Master Plan (RIPP) is to implement Sustainable Tourism Development (STD). Of the many concepts that are appropriate for achieving this goal, the concept of ecotourism is one of them. The growth of tourism activities in the Ngargoyoso district has accelerated. Local governments need to have instruments to help achieve STD goals in their areas. Studies related to the selection of suitable areas using GIS (Geographic Information Systems) and AHP (Analytical Hierarchy Process) based on ecotourism activities have been widely studied and applied in various regions of the world. This study aims to identify areas suitable for ecotourism as a basis for decision making for regional tourism development. The research approach is carried out by assessing expert opinion on the basis for determining policy using the AHP method. Then integrated with GIS techniques to be able to present the results of the assessment in the form of a map of the suitability of the location for ecotourism. The suitability classes in this study are divided into S1 (Very Suitable), S2 (Fairly Sufficient), S3 (Slightly Suited), and N (Not Sufficient) for the suitability of general ecotourism and S1 (Very Sufficient), S2 (Partially Sufficient) and N (Not suitable) for special ecotourism suitability. Also, this study conducted a clustering of special ecotourism (locally), namely Hiking, Tubing, and Camping. Cluster analysis is used to get a complete picture of the condition of the region to support making preliminary policy appropriately and quickly.

Keywords: ecotourism site suitability, GIS, AHP, cluster

Corresponding Author:
Martein Adigana
martein.adigana@gmail.com

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1. Introduction

The direction of tourism development in the Karanganyar Regency is sustainable tourism development and prioritizes environmentally friendly tourism development. The basis of the direction of tourism development in Karanganyar Regency is Community Based Tourism (CBT) and Sustainable Tourism Development (STD). This was stated in the Karanganyar Regency Tourism Development Master Plan (RIPP) for the 2016-2026 period. The goal to be achieved from the implementation of CBT and STD, in general,

is to preserve the natural and environmental resources, preserve the arts and culture, improve the local economy and increase the insight of sustainable development in tourism stakeholders. Then, if all those goals are adjusted and put together to become an implementation concept, the appropriate concept to achieve these objectives is the concept of ecotourism [1].

Then, the notion of ecotourism is a tourism activity that is more inclined towards conservation and environmentally sound education but still can provide increased benefits in terms of social and economic local communities [2--7]. The application of ecotourism in Indonesia is exemplified by the existence of community-based ecotourism in Batusuhunan Village, Sukabumi, which has a positive impact on the ecological aspects (environmental safeguard movement) and social aspects (cooperation among ecotourism communities) and economic aspects that increase the potential income of residents [8]. Also, there is a positive impact of ecotourism in Gunung Halimun Salak National Park in the form of increased income, cooperation and environmental insights [9].

Ngargoyoso District as part of the Karanganyar Regency already has the main capital in the form of potential natural and cultural tourism resources that can be applied to the concept of ecotourism [10--13]. If classified based on the location of the region, ecotourism that is suitable to be applied is a type of mountain ecotourism. Types of ecotourism that are popular in the Ngargoyoso District are hiking/tracking, tubing, and camping. Besides that, it was revealed that mountain ecotourism is important to be developed because it can maintain natural tourism resources (air freshness, natural scenery, plants, and wild animals) and culture (local wisdom), while increasing the community economy along with the growth of tourism activities such as in Ngargoyoso District [14]. On the other hand, Ngargoyoso District in 2017 has recorded as many as 19 of the total 45 attractions in Karanganyar Regency according to the survey results from the Karanganyar Regency Tourism Office. Also, the potential resources in the Ngargoyoso District consist of natural, cultural and human potential [15--19].

Increased tourism activities in Ngargoyoso District encourage land conversion. Uncontrolled land use/land cover changes (LUCC) can lead to a reduction in the potential of existing ecotourism resources, namely in the form of natural and cultural tourism resources [20, 21]. The reasons for land-use change because the economic benefits of wildland conversion are often considered to be greater than the costs of environmental protection, and often the benefits of ecosystem/environmental services are not included in the assessment of cost-benefit analysis in planning [7]. The overlapping of land use can reduce the potential quality of ecotourism that already exists

in the Ngargoyoso District. The overlap that occurs is due to the lack of determination of the area following the concept of ecotourism. Because there is no reference in determining the specific area for ecotourism activities, it will make it difficult to make decisions regarding the promotion, planning, governance, control and regulation of ecotourism policies in the Ngargoyoso District. If this happens, it will negatively affect the development of the economic potential of the tourism sector in Karanganyar Regency, which currently has not significantly affected the increase in PAD (Regional Revenue) [10, 11].

Not applying the concept of ecotourism in areas with potential ecotourism can cause negative impacts in the future, one of which is the occurrence of uncontrolled land-use change. Uncontrolled land use/land cover changes (LUCC) can lead to a decrease in the potential of natural tourism resources [20, 21]. In addition to natural factors, changes in land use due to uncontrolled tourism activities can increase the potential for disasters such as landslides and environmental damage [22]. The importance of this research is to utilize the momentum of tourism growth, safeguard the main potential of ecotourism, and manage it all to increase contributions to the Regional Government, local communities and the environment in which tourism activities are located.

To achieve these objectives, this study determines the potential/suitable site for general ecotourism activities in Ngargoyoso District using GIS and AHP techniques and was equipped with additional cluster analysis for special/local ecotourism activities such as Hiking, Tubing and Camping. This is very important for policymakers to determine control policies and structuring land use. So that it can prevent the problem of decreasing quality and optimize existing ecotourism resources by determining the appropriate site for ecotourism activities. The approach to determining ecotourism activities uses GIS (Geographic Information System) and AHP (Analytical Hierarchy Process) based instruments. Furthermore, the potential site for ecotourism is assessed based on the concept of ecotourism which is divided into physical and environmental aspects with its criteria in the form of landscape, wildlife, topography and socio-economic aspects with criteria such as accessibility and community characteristics [23, 24].

2. Experimental Method

This research is quantitative research with a focus on site suitability for ecotourism activities in the Ngargoyoso District. And the analysis approach was using GIS (Geographic Information System) technology and AHP (Analytic Hierarchy Process) techniques. Related data and information are collected from available resources through

agency surveys and the utilization of satellite imagery. Maps and satellite imagery are needed for spatial descriptions and analysis of environmental conditions in the study area. Spatial data includes Land use/land cover changes (LUCC) in the Ngargoyoso District in 2008 and 2018. Interpretation of high-resolution satellite imagery combined with field surveys to analyze LUCC is processed with the help of Geographic Information System tools. The suitability analysis of ecotourism locations and AHP analysis was carried out on all layers according to the research variables obtained. In conducting conformity analysis, the main device used is the integration of ArcGIS and Expert Choice software. The data needs can be seen in Table 1. And, the flow chart of the research framework can be seen in Figure 1.

Table 1: Research Data.

No.	Data Needs	Data Type	Sources
1.	AHP questionnaire Statistics on ecotourism development (Direction of Regency tourism policy) (RIPP Karanganyar Regency 2016-2026) (RTRW or Spatial Plan Karanganyar Regency 2013-2032)	Primer and Secondary	Baperlitbangda and Disparpora Karanganyar Regency Google Earth, Google Maps, Field Survey
2.	High Resolution Google Earth Satellite Imagery in 2008 and 2018	Secondary	Baperlitbangda and Disparpora Karanganyar Regency Google Earth, Google Maps,, Field Survey
3.	Map of the earth or Rupa Bumi Indonesia (RBI) in Karanganyar Regency	Secondary	Geospatial Information Agency
4.	Criteria and variables determining site suitability for types of ecotourism activities	Secondary	Research journals, articles, publications, books
5.	Digital Elevation Model National for study location (DEMNAS)	Secondary	Geospatial Information Agency

3. Result and Discussion

Image data classification is an activity to determine the classes contained in image data. The classes show the characteristics of the land and are based on the colors, hues and patterns that appear in the image data. Classification is done by grouping the same interpretation results into images into certain classes. Classification activities are divided into two stages, namely direct image classification (digitization on screen) and sampling (field survey). The classes defined indicate the types of land cover and use in the field can be seen in Figure 2 and TABLE 2. And within a period of 10 years, from 2008 to 2018 through the interpretation and digitization of the Google Earth Satellite

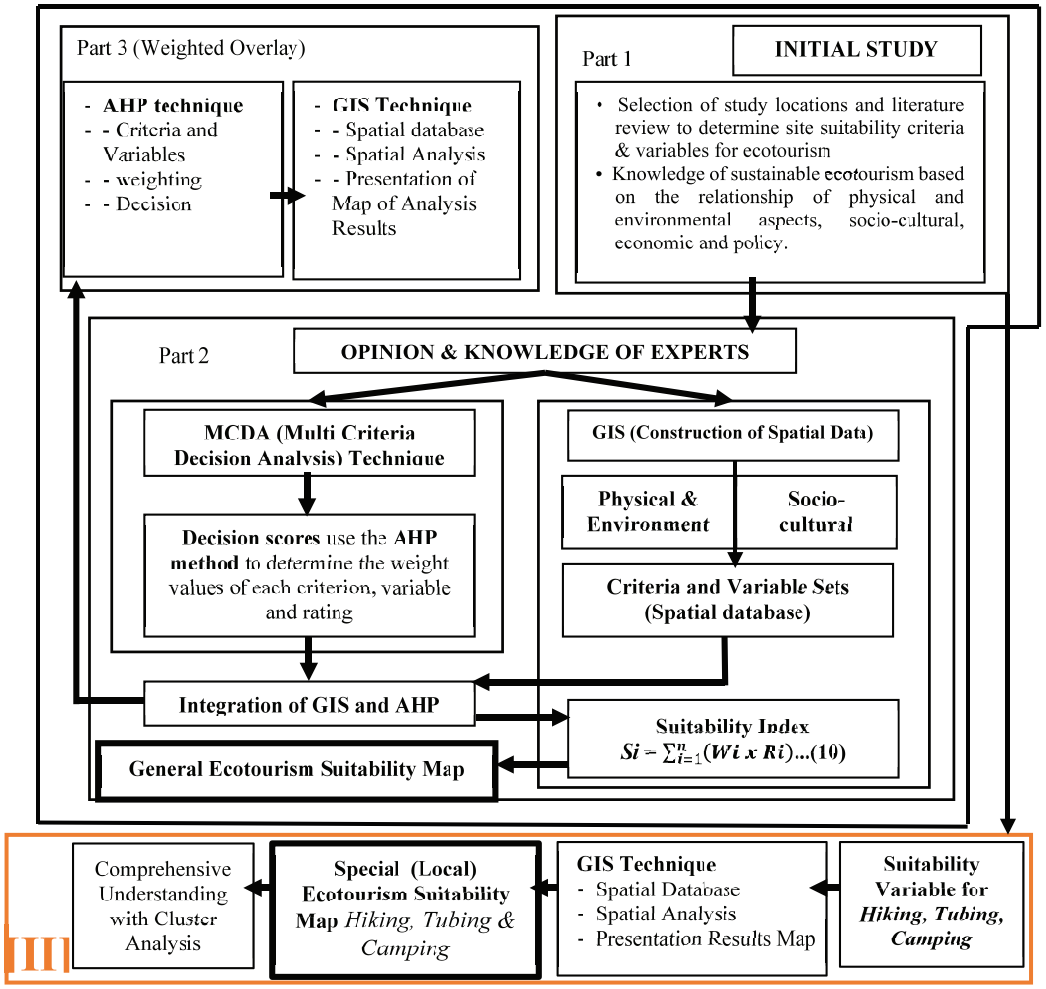

Figure 1: Is the flow chart of the research framework. In the schematic diagram this research is divided into three main phase.

Image, it was found that LUCC occurred in the Ngargoyoso can be seen in Table 4 & Table 5

TABLE 2: Land Use/Land Cover Class Description.

No.	Label	Classification	Description
1	AC (Crop Land)	Rice fields, fields / fields	Main Food Field
2	AO (Orchad Land)	Garden	Mixed Gardens
3	AP (Plantation Land)	Tea Plantation, Plantation	Plantation Land
4	F/DF (Forest)	Forest	Dense Forest
5	FO (Open Forest)	Community Forest	Open Forest
6	M (Miscellaneous)	Open land, Camping ground	Mixed land
7	U (Urban Land)	Settlement, Temple, Road, TPU, Built land, tourism infrastructure.	Built Land
8	W (Water Body)	River, Reservoir/Lake	Water Body

This research is divided into three stages of analysis including the general eco-tourism suitability analysis using 5 criteria and 10 variables can be seen in Table 4,

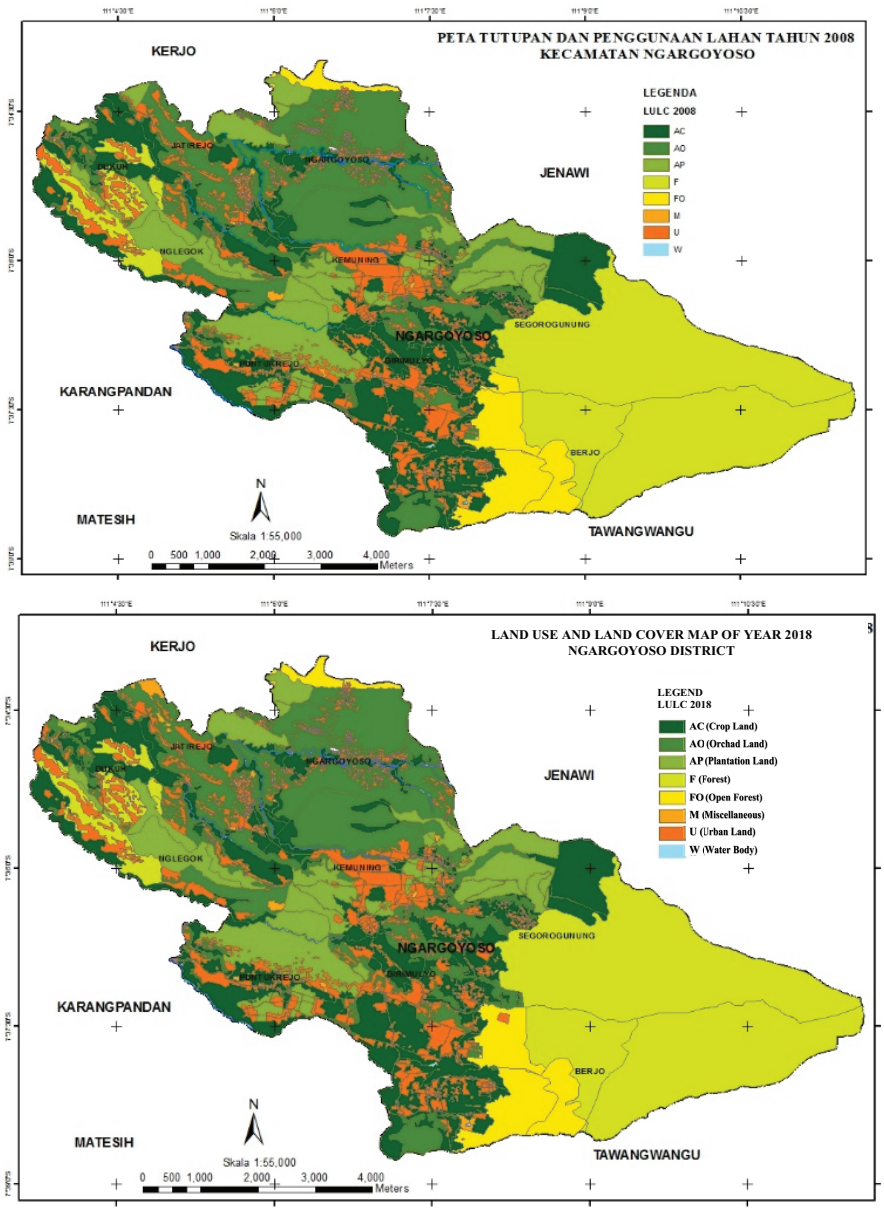

Figure 2: Is the result of LULC in 2008 and 2018 from digitation from Google Satellite Imagery and classified into 8 classes.

the special/local ecotourism suitability analysis for Hiking, Tubing and Camping using 6 variables can be seen in TABLE 5, and the cluster analysis of special/local ecotourism activities with 4 cluster (HTC, HT, HC, TC).

Questionnaire results for 5 (five) experts consisting of three officials at the Baperlitbangda and two two officials at the Disparpora. Respondents were selected for recommendations obtained from the results of surveys in the Agency related to the reason that these people were considered experts and were speakers in many activities related to determining regional tourism policies. Then the primary data taken is done by processing and archiving data using Expert Choice program to quickly find out the

Table 3: Detection Of Lucc In The Ngargoyoso District (2008-2018).

LULC	2008 (ha)	2018 (ha)	Wide Difference (ha)	Percentage
AC	1291.946	1240.616	-51.33	-3.97%
AO	1189.306	1252.651	63.345	5.33%
AP	780.529	766.695	-13.834	-1.77%
F	1736.221	1735.107	-1.114	-0.06%
FO	334.828	315.213	-19.615	-5.86%
M	19.689	33.326	13.637	69.26%
U	748.959	757.576	8.617	1.15%
W	20.009	20.301	0.294	1.46%
Total	6121.487	6121.485		

CR value of each respondent. From the results of each respondent, the calculation is then combined to obtain a CR value for the entire data. From the results of calculations and data processing, the CR value for the criteria is 0.03 and the CR value for the ecotourism site suitability variable/factor is 0.09. This shows that the data requirements for calculating weights and ratings have been reached so that they can be continued for the next stage. The CR value is still in tolerance, namely CR < 0.1. Then the process of calculating the weight values which is carried out for each criterion, factor/variable and rating value Table 6. The weight value will be used for GIS analysis using ArcGIS software.

The following steps to produce weight results from AHP questionnaire were devided into 11 part. They are will be shown by several equation for each steps.

Step 1 is normalize the Pairwise Comparison Matrix value for each criterion and variable by the steps:

1. Add up the values for each matrix column

$$\begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \end{bmatrix} \qquad C_{ij} = \sum_{i}^{n} 1C_{ij} \tag{1}$$

2. Dividing each matrix element by the total value of its column to produce a Normalized Pairwise Matrix

$$X_{ij} = \frac{C_{ij}}{\sum_{i}^{n} = 1C_{ij}} \begin{bmatrix} X_{11} & X_{12} & X_{13} \\ X_{21} & X_{22} & X_{23} \\ X_{31} & X_{32} & X_{33} \end{bmatrix} \tag{2}$$

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TABLE 4: General Ecotourism Suitability Criteria and Variables.

Criteria	Variable	Unit	Suitability Rating				Source Modification
			S1	S2	S3	N	
Landscape (C1)	**Visibility (V1)**	Visibility unit	7-15	4-6	0-3	0	(Bunruamkaew, 2012)
	LULC (V2)	Class	DF	OF,O,W	P,C	U,M	(Bunruamkaew, 2012)
Wildlife (C2)	**Conservation (V3)**	Class	Forest	Tahura	LP2B	APL	(Bunruamkaew, 2012)
Topographic (C3)	**Slope (V4)**	°	0-5°	5-25°	25-35°	>35°	(Bunruamkaew, 2012)
	Elevation (V5)	Meter	800-1800m	1800-2300m	>2300m	0-800m	(Bunruamkaew, 2012)
Accessibility (C4)	**Distance from Road (V6)**	Kilometer	Outside Buffer	0-0.1km 3^{rd} road type	0-0.5km 2^{nd} road type	0-1.5km from main road	(Molaei, et. al, 2018)
	Distance from the Cultural Center (V7)	Meter	300 m	750 m	2000 m	>2000 m	(Molaei, et. al, 2018)
	Distance from River / Lake (V8)	Meter	50 m	300 m	750 m	>750 m	(Molaei, et. al, 2018)
	Distance from Settlements (V9)	Meter	Outside Buffer	2000 m	750 m	≤300 m	(Molaei, et. al, 2018)
Community Characteristics (C5)	**Settlement Size (V10)**	People Density	0 People/km^2	1-150 People/km^2	151-400 People/km^2	>400 People/km^2	(Bunruamkaew, 2012)

Table 5: Special/Local Ecotourism Suitability Factors/Variables.

Hiking	F1 Elevation	F2 Slope	F3 Visibility	F4 Distance from the Natural and Cultural Center	F5 Distance from river/lake	Source Modification
S1	800-2000m	0-25%	>6	0-1500m	0-500m	Ahmadi, et. al (2015) & Shahrak, et. al (2015)
S2	There are 1 to 4 corresponding factors					
N	There are no corresponding factors at all					

Tubing	F1 Elevation	F2 Slope	F3 Visibility	F4 Distance from the Natural and Cultural Center	F5 Distance from river/lake	Source Modification
S1	800-1600m	0-25%	>6	0-500 m	0-100m	Ahmadi, et. al (2015) & Shahrak, et. al (2015)
S2	There are 1 to 4 corresponding factors					
N	There are no corresponding factors at all					

Camping	F1 Elevation	F2 Slope	F3 Visibility	F4 Distance from the Natural and Cultural Center	F5 Distance from river/lake	F6 LULC	Source Modification
S1	1200-1600m	0-25%	>6	0-500m	0-500m	Hutan, Kebun teh, Lahan terbuka, *camping ground,* lapangan dan hutan terbuka	Ahmadi, et. al (2015) & Shahrak, et. al (2015)
S2	There are 1 to 4 corresponding factors						
N	There are no corresponding factors at all						

3. Divide the total number of normalized pairwise matrix lines by the number of criteria / variables (n) to produce a weighted matrix

$$W_{ij} = \frac{\sum_{i}^{n} = 1 X_{ij}}{n} \begin{bmatrix} W_{11} \\ W_{21} \\ W_{31} \end{bmatrix} \quad (3)$$

Step 2 is consistency Analysis uses the formula flow numbers (4) to (8) to find out the value of CR per respondent and the CR results in total combinations for each criterion and variable with the condition CR <0.1

$$\begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \end{bmatrix} * \begin{bmatrix} W_{11} \\ W_{21} \\ W_{31} \end{bmatrix} = \begin{bmatrix} CV_{11} \\ CV_{21} \\ CV_{31} \end{bmatrix} \tag{4}$$

$$CV_{11} = \frac{1}{W_{11}} \left[C_{11}W_{11} + C_{12}W_{21} + C_{13}W_{31} \right]$$

$$CV_{21} = \frac{1}{W_{21}} \left[C_{21}W_{11} + C_{22}W_{21} + C_{23}W_{31} \right]$$

$$CV_{31} = \frac{1}{W_{31}} \left[C_{31}W_{11} + C_{32}W_{21} + C_{33}W_{31} \right] \tag{5}$$

$$\lambda = \sum_{i}^{n} =1 \; CV_{ij} \tag{6}$$

$$CI = \frac{\lambda \; maksimum - n}{n - 1} \tag{7}$$

$$CR = \frac{CI}{RI} \tag{8}$$

Step 3 is calculate the rating factor for each variable by classification P1, P2, P3 and N per respondent and combination by:

1. Make a pairwise comparison matrix rating for each variable
2. Calculate the factor rating value by the formula:

$$X'_{ij} = \frac{X_{ij}}{X_{ij\ max}} \tag{9}$$

X'_{ij} is a standardized value of the order of the object to "i" and attribute to "j"

X_{ij} is the raw value of the rating weights

$X_{j\ max}$ is the maximum value of the "j" attribute

Step 4 is calculate the value of a combination of the results of the calculation of the 5 respondents then the results are displayed in the Table of Criteria Weights, Variables and Conformance Ratings General Ecotourism can be seen in TABLE 6.

Furthermore, an overlay analysis of the maps of each variable is made into a result map, namely a location suitability map for ecotourism activities in Ngargoyoso District can be seen in Figure 3.

Table 6: Weight of Criteria, Variable and Value of Site Suitability Rating Ecotourism.

Criteria	Weight	Factor/Variable (Sub Category)	Weight	Total Conformity Value	Rating			
					P1	P2	P3	N
Landscape	0.38	Visibility	0.19	0.074	1.00	0.41	0.25	0.11
		LULC	0.81	0.306	1.00	0.41	0.24	0.11
Wildlife	0.31	Conservation / Protection	1.00	0.305	1.00	0.43	0.26	0.11
Topographic	0.10	Slope	0.59	0.058	1.00	0.44	0.25	0.11
		Altitude	0.41	0.041	1.00	0.41	0.27	0.11
Accessibility	0.14	Distance from road	0.25	0.036	1.00	0.46	0.27	0.12
		Distance from the Cultural Center	0.28	0.039	1.00	0.40	0.29	0.12
		Distance from River / Lake	0.35	0.050	1.00	0.43	0.26	0.11
		Distance from Settlements	0.12	0.016	1.00	0.38	0.27	0.11
Community Characteristics	0.07	Settlement Size	1.00	0.074	1.00	0.41	0.28	0.11

From the results of the map overlay, the results were in the form of an ecotourism site suitability map in the Ngargoyoso District. So that it can be seen that the Area S1 is 1073,631 ha or 17.54%; S2 covers 711,656 ha (11.62%); S3 is 2419,709 ha (39.52%) and N is 1917,205 ha (31.32%). This shows that 68.68% of the Ngargoyoso District area has the potential to become a leading Travel Destination (DW) especially those carrying the concept of ecotourism.

After we know where is the suitable location for general ecotourism, we must know where is the suitable area for Hiking, Tubing and Camping. After we know where is area which suitable for Hiking, Tubing and Camping we can make cluster analysis. Each cluster divided into 4 levels of suitability as the basis, among others: S1, S2; S1; S2; N. For S1, S2 means that the village besides having a special ecotourism area with a S1 value (Very Appropriate) also has an area with a S2 value (Partially appropriate). For S1 or S2 alone, this means that only one type of value is available in the village. Whereas N means that in the village there were no clusters formed and this village needed another village to collaborate on planning, development and ecotourism development.

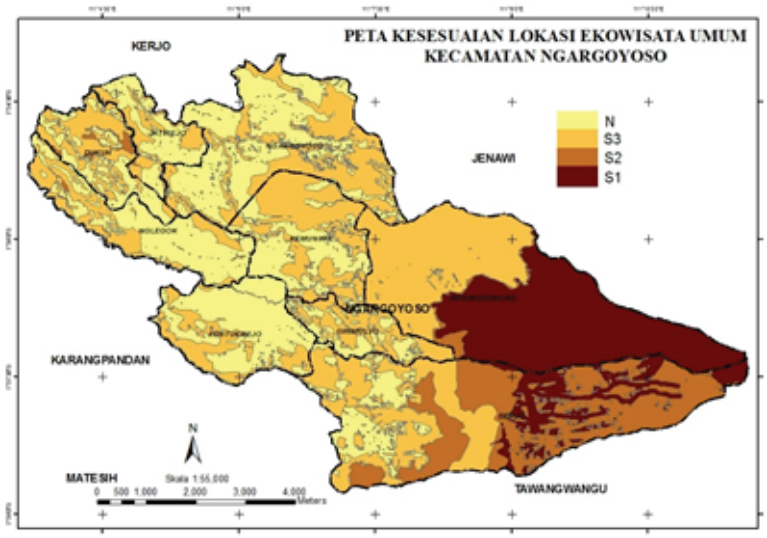

Figure 3: Is the result of weighted overlay from all variables layer and criteria. This is the final form from Ecotourism Site Suitability Map in the Ngargoyoso District of Karanganyar Regency.

TABLE 7: Extensive Results of Site Suitability Analysis For Ecotourism Activities In The Ngargoyoso District.

No.	Village					Total (ha)	Suitable Proportion %
		N	S1	S2	S3		
1	BERJO	181.322	271.953	660.979	444.592	1558.846	22.5
2	DUKUH	128.573	0	15.488	161.131	305.192	2.88
3	GIRIMULYO	84.067	0	0	149.901	233.968	2.45
4	JATIREJO	144.704	0	0.833	85.719	231.256	1.41
5	KEMUNING	222.323	0	0	314.599	536.922	5.14
6	NGARGOYOS	516.316	0	0	390.475	906.791	6.38
7	NGLEGOK	296.795	0	3.464	153.331	453.59	2.56
8	PUNTUKREJC	341.022	0	0	150.342	491.364	2.46
9	SEGOROGUN	2.083	801.678	30.892	569.619	1404.272	22.9
Total		1917.205	1073.631	711.656	2419.709	6122.201	68.68
Proportion %		31.32	17.54	11.62	39.52	100.00	

4. Conclusion

The growth of the tourism industry in Ngargoyoso District has the potential to threaten the sustainability of ecotourism principles as evidenced by the results of the 2008 and 2018 LUCC analyzes that have changed. From 2008 to 2018 there was a change of function from staple food and forest land to mixed gardens and built-up land which was quite large. Changes also occur in areas that have become a natural tourist attraction, mainly namely tea plantations in Kemuning Village and Segorogunung Village. As a result of the site suitability analysis that is suitable for ecotourism activities, the

Table 8: Special Ecowisata Area Cluster.

No. Code	Desa	*Hiking*			*Tubing*			*Camping*		
		S1	S2	N	S1	S2	N	S1	S2	N
1	Ngargoyoso	√	√	√		√	√	√	√	√
2	Jatirejo		√	√			√			√
3	Dukuh		√	√		√	√		√	√
4	Nglegok		√	√		√	√		√	√
5	Kemuning	√	√	√	√		√	√	√	√
6	Segorogunung	√	√	√	√	√	√	√	√	√
7	Girimulyo	√	√	√	√	√	√			√
8	Berjo	√	√	√		√	√		√	√
9	Puntukrejo	√	√	√		√	√		√	√

results of the broad S1 are 1073,631 ha or (17.54%); S2 covers 711,656 ha (11.62%); S3 is 2419,709 ha (39.52%) and N is 1917,205 ha (31.32%). It shows that 68.68% of the area has the potential to apply the concept of ecotourism. When viewed in more detail, several villages have the greatest ecotourism potential, namely Segorogunung Village at 22.94%, Berjo Village at 22.5%, Ngargoyoso Village at 6.38% and Kemuning Village at 5.14%. Actually, from the results of a survey that has been carried out, it is known that considerable tourism development already exists in Kemuning Village and Segorogunung Village. This happens because there are many natural and cultural attractions in the place. This study recommends that villages with large ecotourism resource potential to be more monitored, supported and evaluated in terms of the application of the concept of ecotourism in order to achieve the Karanganyar Regency tourism direction in accordance with the RIPP mandate, namely through the CBT and STD approach which is an elaboration of the concept of ecotourism.

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