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Priority Analysis of Mangrove Guraping Ecotourism Development Based on Spatial Data Using Process Hierarchy Analysis

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Abstract

This article aims to analyze the development priorities of Guraping mangrove ecotourism based on spatial data using process hierarchy analysis (AHP). The research process is divided into three stages: the pre-processing stage, processing stage, analyzing and reporting phase. In the processing stage, the spatial data used is Landsat 8 OLI in the Guraping mangrove ecotourism area from 2013-2021 with the Coordinate Reference System World Geodetic System (WGS) 84 or Universal Transverse Mercator (UTM) Zone 52N. In the Processing stage, raster data for each zone in the Guraping mangrove ecotourism area will be calculated using the Normalized Difference Vegetation Index (NDVI) algorithm to determine the maximum, average, and minimum values value. The analyzing and reporting phase contains an idea of NDVI calculations result related to the Decree of the Minister of State for the environment in 2004. The findings of this study indicate that the ranking system in the Analytical Hierarchy Process (AHP) algorithm can be used to analyze the priority of the Guraping mangrove ecotourism development program. In AHP Calculation, the programs consist of rehabilitation, restoration, reclamation, and conservation. In addition, the alternatives are zone 1, zone 2, and zone 3. The ranking results show that the program relevant to the NDVI calculation of the Guraping mangrove ecotourism context is the rehabilitation program. Furthermore, the alternative ranking results show that Zone 1 is the priority zone for the rehabilitation program.

Keywords: Ecotourism; Mangrove; Guraping; NDVI; AHP

1. INTRODUCTION

To establish the priority of mangrove ecotourism development, changes in vegetation index values need to be considered as the basis for decision making. There have not been many studies that show spatial data considerations in decision making to set the priorities of tourism development programs in Indonesia, especially mangrove ecotourism development programs using the Process

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Hierarchy Analysis (AHP) approach. This study offers the idea of considering the results of spatial data calculated using a remote sensing approach based on the Normalized Difference Vegetation Index (NDVI) algorithm in the mangrove ecotourism area of Guraping, North Oba, Tidore Islands Regency, North Maluku Province. Specifically, the results of NDVI calculations on Landsat 8 OLI (WGS 84/UTM 52N) data can be adjusted to mangrove forest damage criteria based on the Decree of the Minister of State for environment No. 201 of 2004 on Standard Criteria and Guidelines for Determining Mangrove Damage. Furthermore, the AHP approach is used to obtain program criteria that need to be prioritized based on the index value of guraping mangrove areas, both rehabilitation, restoration, reclamation and conservation programs. Thus, the development of mangrove ecotourism Guraping not only considers the perspective of stakeholders based on the characteristics of the ecotourism development program but also the existing conditions of mangrove ecology in each zone.

In the context of mangrove ecotourism, a remote sensing approach can be used to analyze monitoring the distribution and condition of mangrove forests. Remote sensing facilitates the process of controlling mangrove conditions with a wide range of areas by utilizing Landsat 8 OLI satellite imagery data using the Normalized Difference Vegetation Index (NDVI) algorithm[1]. The NDVI algorithm is used to calculate bands five and band 4 of Landsat 8 OLI based on the specified time so that it can be interpreted various events that cause a decrease or increase in the value of the mangrove vegetation index in various regions[2]. Thus, an analysis of mangrove health in various regions can be conducted based on mangrove forest damage criteria based on the Decree of the Minister of Environment No. 201 of 2004 on Standard Criteria and Guidelines for Determining Mangrove Damage [3]. The ecological condition of mangrove forests needs to be monitored periodically to identify density levels as a reflection of mangrove forest health. Mangrove forest areas that experience a decrease in index value and decrease in density level as a decree of the Minister of Environment No. 201 of 2004, reflect the condition of damaged mangroves so that it needs to be rehabilitated, restored, conserved and even allows for reclamation. Therefore, mangrove ecotourism development strategies are needed using the AHP approach to set priority programs in accordance with criteria and alternatives in achieving mangrove ecotourism development goals.

This research uses the Process Hierarchy Analysis (AHP) approach with the following considerations: first, the AHP approach can be used as a flexible decision support system as well as considering the subjectivity of stakeholders in the tourism sector[4]; second, the AHP approach can be integrated with tourism village planning and development strategies to establish the priority of tourism village development programs based on the availability of significant potential. It excels in each region[5]; third, the AHP approach selectively performs the role of

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criteria with contextual alternatives based on value weights that are in accordance with the perspectives of stakeholders in a tourism destination. Based on these three considerations, the AHP approach is needed to consider the existing conditions of social, economic, ecological, institutional and infrastructure in the tourism sector[6]. In addition to the AHP approach, there are analytical approaches and decision support systems relevant to the tourism context, such as Value Chain, Politic Economic Social and Technology (PEST) and Strenght Weakness Opportunities and Threat (SWOT) to Balanced Scorecard[7] . However, the use of the approach needs to adjust to the context of Dodola Island tourist destinations by considering the subjectivity of stakeholders in the early stages of mangrove ecotourism destination development. Stakeholders need an AHP approach to establish ecotourism development strategies based on value weights and a system that suits the needs and subjectiveness of stakeholders in setting criteria and alternatives that need to be prioritized, taking into account the budget year. Through priority programs, consideration of social, cultural, economic, ecological, institutional, and infrastructure dimensions can be described in detail on operational aspects to become applicable, effective and efficient.

Previous research has shown that remote sensing is very effectively used to optimize monitoring vast mangrove forests. The Normalized Difference Vegetation Index (NDVI) technique can also collaborate with the Soil Adjusted Vegetation Index (SAVI) to identify mangrove forest density, while the Normalized Difference Water Index (NDWI) is used to identify moisture levels in mangrove forest areas.[8] . Based on the NDVI index's value, the density of mangrove forests based on the criteria is very rare, rare, medium, dense, or very close [9]. In addition, NDVI can also be adjusted to the Leaf Area Index (LAI) to identify mangrove canopy density criteria that are rare, medium, dense, and very dense. The higher the NDVI value, the higher the LAI value [10]. However, research on remote sensing in mangrove forest areas is still limited to the classification of canopy density levels and the identification of humidity levels. There have not been many studies that show the benefits of mangrove forest density classification in the NDVI-based mangrove ecotourism development strategy and Process Hierarchy Analysis (AHP)." Research that examines the AHP decision support system in the tourism sector is more dominant on criteria and alternatives that are not directly related to spatial data. The integration of decision support systems with spatial data is more dominant in the study of development planning, land suitability or management risk[11]. Considering the gaps in previous studies, this study was conducted to analyze the priority of mangrove ecotourism development based on spatial data using NDVI and AHP techniques.

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2. METHOD

The approach used in this study is the remote sensing approach using the Normalized Difference Vegetation Index (NDVI) and the decision support system using Process Hierarchy Analysis (AHP). The instrument used in this study was QGIS 3.20. This research is divided into three stages, as Figure 1.

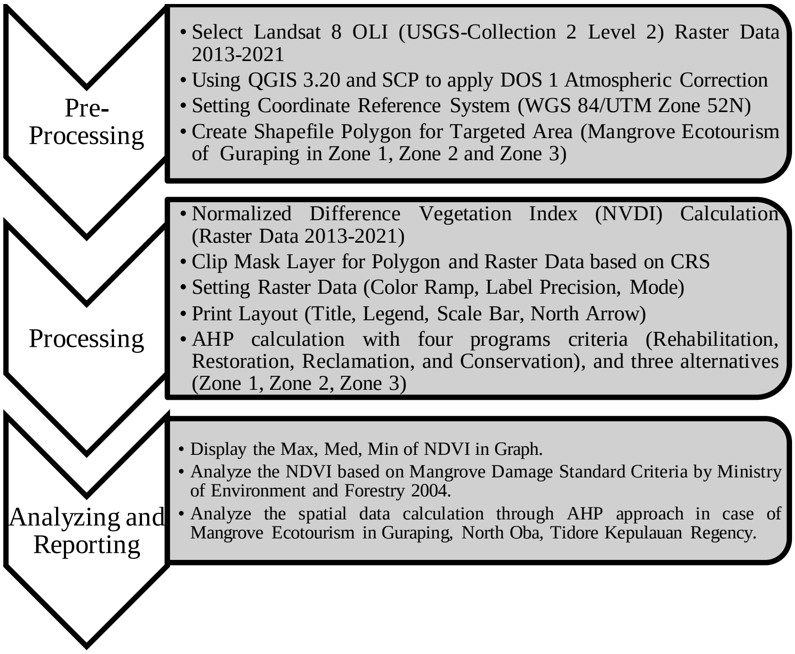

Figure 1. Research Stage

Figure 1 shows that at the pre-processing stage, Landsat 8 OLI raster data in 2013-2021 was downloaded from USGS-Collection 2 level 2 in accordance with Coordinate Reference System WGS 84/UTM Zone 52N. Furthermore, raster data is processed through Semi-Automatic Classification Plugins (SCP) for DOS 1 Atmospheric Correction using QGIS 3.20. Meanwhile, a polygon shapefile for each zone in the Guraping mangrove ecotourism area is designed for the processing stage. At the processing stage, raster data is calculated using the NDVI algorithm, and then the clip mask layer process is carried out on polygon shapefile in zone 1, zone 2, and zone 3 of guraping mangrove ecotourism area. The raster data masking results are arranged based on design colour, exactly label 2, and the quantile model is then visualized in map form. Furthermore, the role is carried out based on the level of interest of the development program in zone 1, zone 2, and zone 3 of the Guraping mangrove ecotourism area. Meanwhile, the program in question is a program of rehabilitation, restoration, reclamation, and

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conservation. At the analyzing and reporting stage, the NDVI calculation data is converted into table format according to a minimum, medium, and maximum data and then analyzed in accordance with the Decree of the Minister of Environment No. 201 of 2004 on Standard Criteria and Guidelines for Determining Mangrove Damage. Furthermore, the results of AHP calculations are analyzed based on the existing conditions of mangrove areas based on NDVI so that priority programs are obtained in the development strategy of Mangrove Guraping ecotourism.

3. RESULT AND DISCUSSION

3.1 Analysis of Spatial Data Vegetation Index Using NDVI

The development of mangrove ecotourism in Guraping is inseparable from the development of tourism supporting infrastructure in the form of amenities. The intention of local governments to adopt a community-based ecotourism approach in the optimization of mangrove forests is not limited to the goal of achieving ecological sustainability but also to improving the social and economic well-being of the surrounding communities. Mangrove conditions in Guraping and Lake Gurua Marasi have changed vegetation index and density levels due to the presence of individuals who do mangrove tree felling of commercial interests [12]. In addition, the construction of tourism supporting facilities and infrastructure in Guraping also led to changes in the landscape of inauthentic mangrove areas [13]. Based on the results of NDVI calculations in guraping mangrove areas, it can be known that there was a change in vegetation index from 2013 to 2021, as shown in Figure 2.

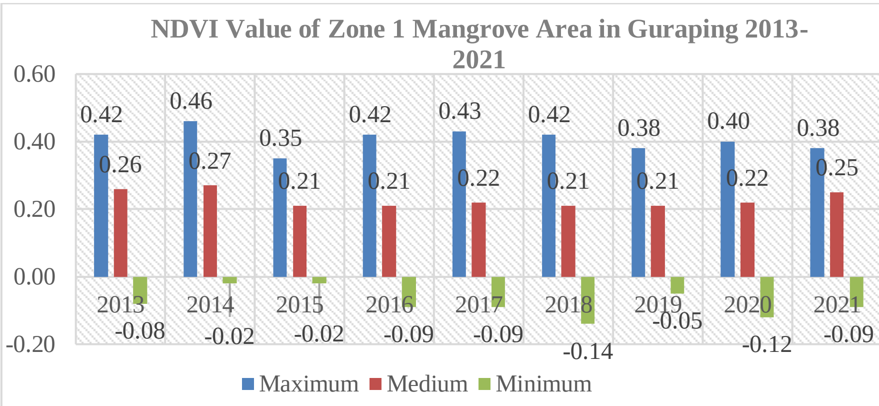

Figure 2. Results of Calculation of NDVI Zone 1 Mangrove Guraping Ecotourism Area 2013-2021

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Figure 2 shows that in zone 1 of the Guraping mangrove ecotourism area, there was a change in the average value of the vegetation index from 2013-to 2021. The average value of NDVI's calculation results in 2013 was 0.26, which increased to 0.27 in 2014. Despite this, there was a decline in 2014 to 0.21. In addition, the average value of the mangrove vegetation index in Zone 1 is only in the range of 0.21-0.22 from 2015 to 2020. The increase again occurred in 2021, which is 0.25. In addition to the average value of the vegetation index, the minimum value of the vegetation index in the Guraping mangrove ecotourism area zone 1 in 2014 was -0.14, and in 2020 it was at 0.12. Similarly, in 2021 where the minimum value of the vegetation index is in 2021. This suggests that rehabilitation and restoration programs are needed to address gaps in density levels based on minimum index values. Several studies on the development of ecotourism in Guraping show the logging of mangrove forests by the surrounding community [12] as well as the result of land conversion for the benefit of tourism infrastructure development [13]. Unlike the condition of mangroves in zone 2 which shows the average value of the mangrove area vegetation index, the results of NDVI calculation above 0.34 as shown in figure 3.

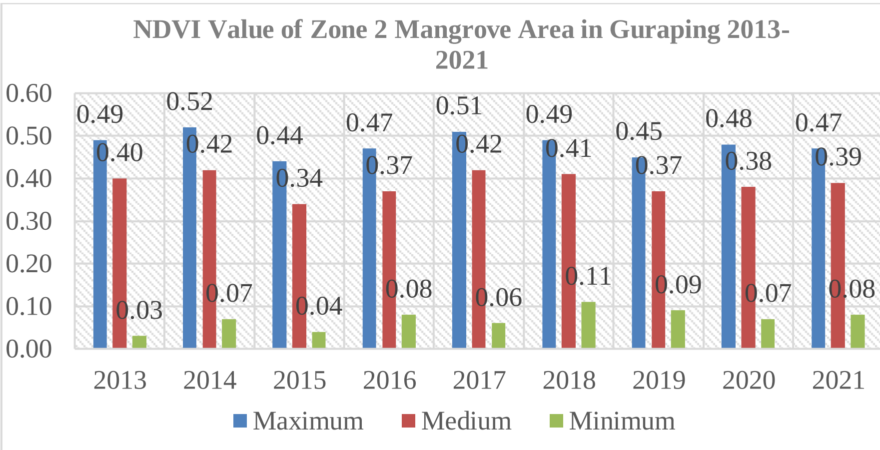

Figure 3. Results of NDVI Calculation Zone 2 Mangrove Guraping Ecotourism Area 2013-2021

Figure 3 shows that the average value of the guraping mangrove area vegetation index in zone 2 based on the results of NDVI calculations ranges from 0.34-0.42. In 2013, the average value of the vegetation index of guraping mangrove ecotourism area in zone 2 was 0.40, which increased in 2015 to 0.34. The average value of the vegetation index of guraping mangrove ecotourism area in zone 2 began to increase in 2016 to 0.37 and continued to increase to 0.42 in 2017. Nevertheless, the average value of the vegetation index of the Guraping zone 2 mangrove ecotourism area decreased in 2018 to 0.41 and 0.37 in 2019. The

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development of the average value of the vegetation index of the Guraping zone 2 mangrove ecotourism area slowly increased in 2020 to 0.38 and 0.39 in 2021.

In previous studies, the mangrove families identified in the Ecotourism Area of Guraping zone 2 mangroves are Rhizophoraceae, Sonneratiaceae, Meliaceae, Rubiaceae, Sterculiaceae, with the following local species and terms: Bruguiera gymnorrhiza (Dau); Ceriops decandra (Ting); Rhizophora apiculate (Soki-soki); Rhizophora mucronata (Soki-soki); Sonneratia alba (Posi-posi); Xylocrapus granatum (Approximately); Scyphiphora Hydrophyllaceae (Vine); Heritiera littoralis (Kolot Kambing) [14]. The decrease in the value of the mangrove vegetation index based on the results of NDVI calculations shows the existence of factors that cause changes in density that threaten the sustainability of the ecosystem of guraping mangrove ecotourism area in zone 2. Therefore, local governments as development catalysts need to establish tourism development approaches that are relevant to the socio-cultural, socio-economic, the socio-ecological context of the surrounding community. In addition to zone 1 and zone 2, zone 3 shows an average value of vegetation index that is better than zone 1, but zone 3 has a minimum value that needs to be taken seriously so as not to threaten the sustainability of mangroves ecotourism in zone 3 as figure 4.

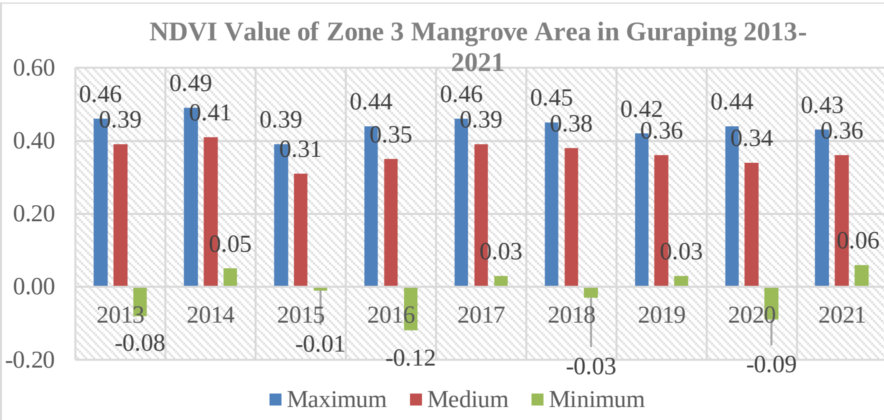

Figure 4. Results of NDVI Calculation Zone 3 Mangrove Guraping Ecotourism Area 2013-2021

Figure 4 shows that the average value of the vegetation index of the guraping mangrove ecotourism area in 2013 was 0.39, with a minimum value of -0.08. The increase in the index value in 2014 to 0.41 also increased the minimum value to 0.05. Nonetheless, in 2015 there was a decrease in the average value of the Guraping mangrove vegetation index in zone 3 to 0.31. In addition, there was a decrease in the minimum value in 2016 to -0.12. The same thing happened in 2020,

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where the minimum value is at -0.09. As an anticipatory step to reduce maximum, average, and minimum value in zone 3, local governments need to design community-based ecotourism programs as a form of participatory development to collaborate with guraping communities in rehabilitation, restoration, reclamation, and conservation programs of mangrove ecotourism areas.

The approach of developing community-based or community-based mangrove ecotourism becomes relevant to the context of Guraping communities that tend to be communal and able to improve social and economic welfare for livelihood sustainability[15]. Based on spatial data from NDVI calculations in zone 1, zone 2, and zone 3 of Guraping mangrove ecotourism areas in 2013-2021, it can be known that the decrease in vegetation index value illustrates changes in mangrove forest density levels caused by various factors such as mangrove conversion for settlement expansion and logging of mangrove forests for commercial purposes. Therefore, spatial data from NDVI calculations in the Guraping mangrove ecotourism area need to be used as a consideration for the determination of priority programs to optimize contextual ecotourism development. Meanwhile, the change in the value of NDVI 2013-2022 can be seen in figure 5.

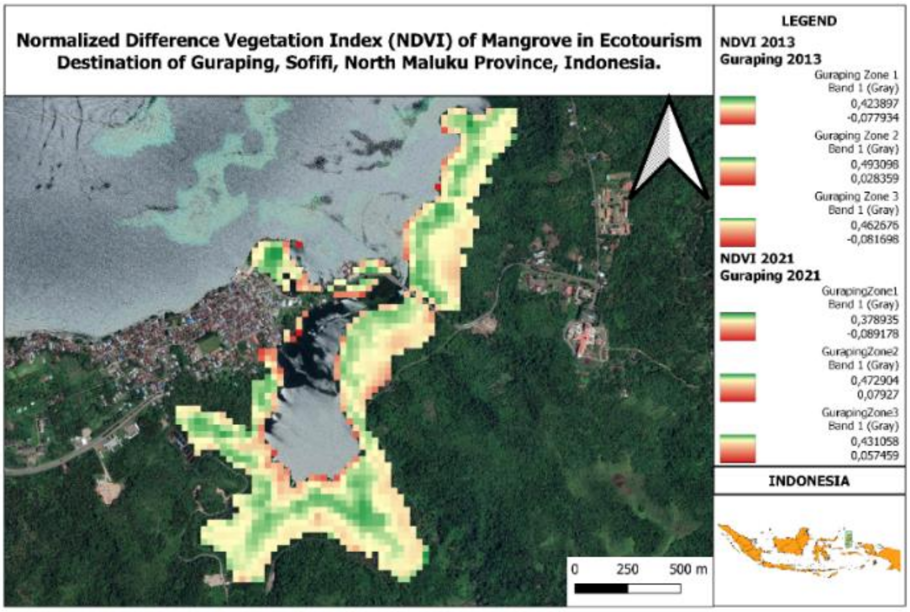

Figure 5. Results of NDVI Calculation of Mangrove Guraping Ecotourism Area 2013-2021

Figure 5 shows that the results of NDVI calculations in the Guraping mangrove ecotourism area in 2013-2021 need to be taken into consideration in planning contextual mangrove ecotourism development. In tourism planning, spatial data visualization of NDVI calculation results can be used as an instrument to monitor mangrove development periodically while controlling the economic growth of local communities through programs that are in accordance with the needs of guraping communities. The existing condition of mangrove ecosystems in Guraping has an influence on the potential of seagrass resources as a support for ecotourism [16]. However, the decrease in the average value of the vegetation index of guraping mangrove ecotourism areas in zones 1, zone 2, and zone 3 requires different handling programs based on mangrove forest damage criteria as the Decree of the Minister of State for environment Number 201 of 2004 in table 1.

Table 1. Average Value of NDVI Zone 1, Zone 2, and Zone 3 in Guraping Mangrove Ecotourism Area in 2021

Criterion		Nappe (%)	Density	NDVI	Average value Zone 1 (2021)	Average value Zone (2021)	Average value Zone (2021)
Health	Dense	≥75	>1500	0,43 ≤1,00	-	-	-
	Medium	≥50 - <75	≥1000 - <1500	0,33≤0,42	-	0,39	0,36
Broken	Rarely	<50	<1000	-1,00≤0,32	0,25	-	-

Table 1 shows that the average value of vegetation index in guraping mangrove ecotourism area in 2021 in Zone 1 is 0.25, which belongs to the category of damage, while the average value of vegetation index in guraping mangrove ecotourism area in 2021 in Zone 2 and zone 3 is classified as moderate with values of 0.39 and 0.36. This shows that the handling of guraping mangrove forest damage needs to be adjusted to the existing mangrove conditions in each zone. In addition, the characteristics of the program that can be implemented are rehabilitation, restoration, reclamation, or conservation programs. Each mangrove human damage management program has different levels of operational difficulties in terms of implementing aspects budget availability to the final goal to be achieved. Therefore, a decision support system is needed to obtain an overview of priority programs relevant to the context of guraping society. In the context of this research, the AHP approach is used to analyze zone stage processes and priority programs.

3.2 Priority Analysis of Mangrove Guraping Ecotourism Development Program Using Process Hierarchy Analysis (AHP) Approach

The decision support system that has been widely used by stakeholders to identify priorities through the degree of interest of a development program is Process Hierarchy Analysis (AHP).[17] indicate that the AHP approach is used to evaluate

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the functional aspects of hotels. Meanwhile, [18] argue that the AHP approach is adopted in various aspects to facilitate the decision-making process, including in the field of entrepreneurship. Voudrias[19] suggests that the AHP approach can also be used as a decision support system for selecting the right technology in the management of medical waste. The AHP approach can also be used to select the pilot candidate who best fits the criteria of the airline company[20].
[21] show that the stages in the AHP process can be done by evaluating the weighting of evaluation indicators, namely the determination of criteria and sub-criteria and the weighting of values on each criterion. Next, a paired comparison is made according to the scale of the level of importance, calculating the value of Eigen and testing its consistency. Furthermore, Akyuz [22] points out that the AHP approach is favoured through four stages as follows: the first stage, describing program criteria and alternatives; the second stage, giving weighting values based on the scale of importance; the third stage, summing the weight of criteria to obtain priority determinants of success; the fourth stage, identifying the consistency ratio (consistency ratio).) and the eigenvalue (eigenvalue). The equation used is as follows:

a. Calculation of Criterion Weights $$Wi = \frac{1}{n}\sum_{j=0}^{n}\frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \quad (1)$$

b. Consistency Ratio Calculation $$CI = \frac{\lambda_{max} - n}{n-1} \quad (2)$$

c. Maximum Eigenvalues $$\sum_{j=i}^{n} a_{ij} w_j = \lambda_{max} w_i \quad (3)$$

d. Consistency Ratio $$CR = \frac{CI}{RI} \quad (4)$$

[23] It also shows that the Consistency Ratio (CR) value can be obtained from the results of the division of consistency index (CI) with random index (RI) value. If the CR value is equal to or less than 0.10 as stated in the following table, then the level of consistency is considered satisfactory.

Table 2. Random Index Value

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Table 2 is a Random Index Value table based on the number of criteria (n) developed by [24] to identify the degree of importance of a criterion. Some previous researchers have shown that the AHP approach is very effectively used in spatial planning as well as in the field of infrastructure development [25], [26].

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In the context of tourism, the AHP approach can also be combined with the Geography Information System (GIS) to analyze the suitability and vulnerability of natural tourism in an area[27]. In addition, the AHP approach can be used to identify indicators of festival tourism sustainability, viewed from the perspective of tourists, residents, Government Agencies, Business Owners [28]. On the other hand, [29] showed that the AHP approach could be used to identify travellers' interest in bicycle destinations based on the dimensions of Tourism Resources, Accessibility, Amenities, and Complementary Services. This shows that the AHP approach can be used to measure the degree of interest of a program as well as assist the decision-making process in establishing sustainable tourism. Based on the results of AHP calculations, it can be known that the Guraping mangrove forest handling program based on mangrove forest damage criteria as the Decree of the Minister of State for Environment No. 201 of 2004 can be seen in Figure 6.

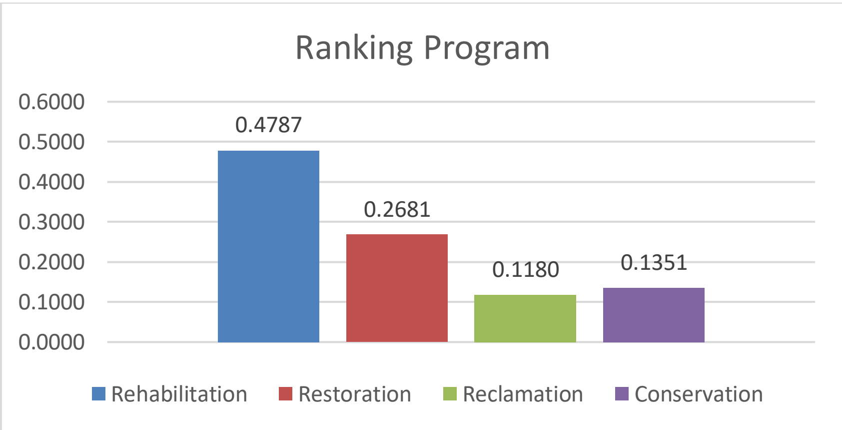

Figure 6. Program Results Using AHP

Figure 6 shows that the program priority for the development of Guraping mangrove ecotourism that needs to be prioritized is a rehabilitation program. Mangrove area rehabilitation program that is in accordance with socio-cultural conditions of the community is community-based ecotourism or local communities. Studies on the success of mangrove rehabilitation programs in North Maluku Province show that the characteristics of communal communities as well as local community cultures in the form of traditional traditions or rituals can be integrated with mangrove forest rehabilitation programs. Specifically, mangrove area rehabilitation programs can be carried out gradually from socialization, the formation of cultural-based groups or tourism observer communities, training and mentoring of bedeng making, fruit harvesting and

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treatment, breeding, planting and maintenance [31]. Furthermore, the results of the role of zones that need to be prioritized can be seen in Figure 7.

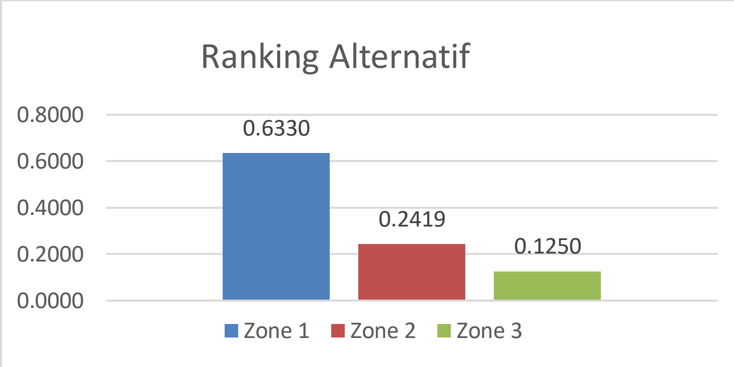

Figure 7. Results of Rehabilitation Zones Using AHP

Figure 7 is the result of the role of rehabilitation zones that need to be prioritized in the conservation of Guraping mangrove ecotourism. Zone 1 becomes a priority zone that needs to be considered by stakeholders by organizing mangrove rehabilitation programs that are economically and socially beneficial. Based on the results of AHP calculations, it can be known that in the context of the development of mangrove ecotourism Guraping, the program that needs to be prioritized is the rehabilitation program, while the zone that needs to be prioritized is zone 1. Thus, the local government can work with the Guraping youth community and the local village government to jointly protect the mangrove ecosystem from various vandalism behaviours, including the behaviour of individuals who negatively affect the environment, such as removing micro-waste and household waste in the Guraping mangrove area. Through priority programs, development concentration is more optimal, effective and efficient in measuring the success rate of tourism development periodically.

4. CONCLUSION

The results of this study show that spatial data can be used as a decision support instrument in establishing priority programs for the development of mangrove ecotourism Guraping, North Oba, Tidore Islands Regency, North Maluku Province, Indonesia. Through a remote sensing approach using the Normalized Difference Vegetation Index (NDVI) algorithm as well as a decision support system based on Process Hierarchy Analysis (AHP), it can be known that the destruction of Guraping mangrove forests in zone 1 is classified as rarely damaged, while guraping mangrove forest damage in zone 2 and zone 3 includes moderate-damage criteria, as the Decree of the Minister of Environment No. 201 of 2004.

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Furthermore, based on the results of program and priority zones, it can be known that rehabilitation programs in zone 1 need to be prioritized. So, the guraping mangrove ecotourism development program becomes concentrated in efforts to achieve sustainability.

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