



Priority Programs for Rungan Watershed Management: A Comprehensive and Participatory Approach

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Abstract: The watershed has a strategic role in maintaining hydrological balance, ecosystem integrity, and community welfare. However, the Rungan watershed is under threat from deforestation and ecosystem damage, therefore a study is needed that considers all related aspects as the basis for making a management strategy for the Rungan watershed. This study aims to find out the priority problems faced by the Watershed Rungan and the aspects of its causes. Furthermore, this research also seeks to formulate priority solutions that can overcome the problems faced by the Rungan watershed. Using qualitative and quantitative approaches, this study applies the Analytical Network Process (ANP) in formulating the priority strategy for the management of the Watershed. This study found that ecological problems are considered the main problem. Alternative solutions that have been successfully formulated include ecological restoration, economic recovery, and institutional strengthening and coordination between stakeholders. Zoning regulation is a priority for area management and is the main strategy for the management of the Rungan watershed by regulating various programs such as forest rehabilitation, ecotourism, and environmentally friendly land use. For these programs to be carried out in a synergistic manner, it is necessary to coordinate and synergize programs between relevant stakeholders.

Keywords: Comprehensive; Participatory approach; Priority program; Watershed room

Introduction

Most of the ecosystems in Central Kalimantan are influenced by rivers. Central Kalimantan has 11 major rivers and hundreds of tributaries that then influence and form a unique ecosystem in Central Kalimantan (Prastiwi, 2021). For example, the overflow of river water in the lowlands will form swamp forests and also peat ecosystems that have many endemic animals such as orangutans, proboscis monkeys, and hornbills (Narendra et al., 2023; Syahrani et al., 2024). Thus, watershed management in Central Kalimantan is very important.

In an ecological perspective, the Dungai Watershed Area (DAS) is an area that has important ecosystem value for providing animal habitats, maintaining

hydrological balance, and supporting efforts to improve community welfare. Nature Conservation, which has important ecological value, can support the survival of life through biodiversity conservation efforts for the welfare of the community and the quality of human life, which are designated as protected areas (Ahmad et al., 2023; Theodory & Kitole, 2024).

Watershed management must pay attention to the characteristics and uniqueness of watersheds to avoid watershed damage and trigger wider environmental damage. Based on the latest watershed concept formulated by experts, watersheds are seen not only as landscapes with topographic boundaries and hydrological unity, but also as an ecosystem units (Meierdiercks et al., 2024; Wardoyo et al., 2025). Watershed areas do not always correspond to a specific

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administrative area. Therefore, there is often overlap and conflicts of interest between various sectors. For this reason, it is necessary to carry out integrated watershed management, so that optimal conditions of the natural resources contained in it are realized, allowing these resources can provide sustainable benefits for human welfare

Watershed management is not just about managing natural resources but rather managing human activities because this will have an impact on the preservation of available natural resources. Watershed management requires integration from upstream to downstream, synergy between sectors and institutions, and involvement of parties from the community, the private sector, and the government. Community development in watershed areas can accelerate changes in the pattern of use of existing natural resources. Uses that do not pay attention to land conservation rules result in the degradation of watershed conditions. Community access to obtain, control, and regulate the use of natural resources around watersheds and the role of parties play an important role in the preservation of watershed functions and roles (Ichsan et al., 2021).

Watershed management is a human effort to regulate the reciprocal relationship between natural resources and humans in the watershed and all its activities, to realize the preservation and harmony of the ecosystem and increase the use of natural resources for humans in a sustainable manner. Watershed management is an ongoing effort, because natural and man-made factors always exist and change over time (Putra, 2017). Watershed management planning is dynamic because of the dynamics of processes that occur in watersheds, both natural, political, socio-economic, and institutional processes, and technology that continues to develop (Pertwi, 2017).

Watershed Management is a series of activities carried out in an integrated manner to improve the quality and sustainability of watersheds, as well as maintain watershed functions, such as water conservation, flood control, and ecosystem preservation (Sembiring, 2022). Watershed management involves various parties, including the government, communities, and other stakeholders, with the aim of achieving sustainable use of natural resources.

A study is needed that considers all related aspects as the basis for making a management strategy for the Rungan watershed. Previous research on Rungan watershed has focused on only a few aspects and has not considered a comprehensive and participatory approach. For example, Segah et al. (2023) focused their research on identifying flood-prone areas, Rahmat et al. (2023) focused on community empowerment around the Rungan and Kahayan watersheds, and Astoeti et al.

(2021) analyzed water quality and the environment. The research offers a more comprehensive approach by considering the ecological, economic, and socio-cultural aspects obtained by gathering opinions from relevant stakeholders. This study aims to find out the priority problems faced by the watershed Rungan and the aspects of its causes. Furthermore, this research also seeks to formulate priority solutions that can overcome the problems faced by the Rungan watershed.

Method

This research is focused around Kaja Island in the Rungan Palangka Raya Watershed River area, Central Kalimantan. This area was chosen because it has an important role for the survival of the surrounding community and because there are conservation programs that require improved strategies to overcome various obstacles faced.

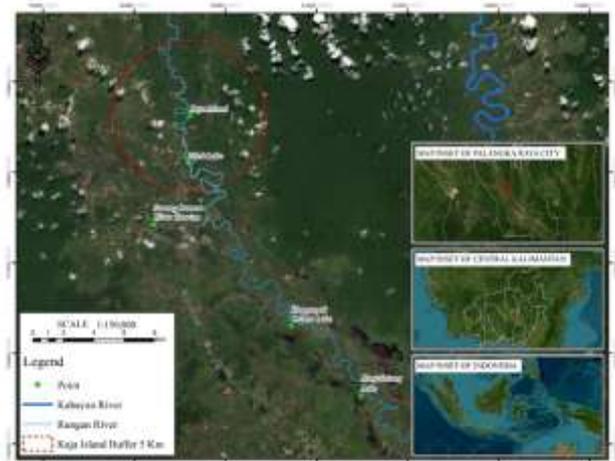


Figure 1. Map of the Research Location

This research combines qualitative and quantitative approaches in obtaining and analyzing data (Creswell & Creswell, 2018). A qualitative approach was applied in the early stages of the research, namely collecting information from local communities and related stakeholders about the problems faced by the Rungan Sub-Watershed. A quantitative approach is used to further analyze the information obtained at the initial stage to determine the priority of problems and recommendations for the management program of the Rungan Sub-Watershed.

The data collection methods in this study are Focus Group Discussion (FGD), conducted four times together with the community and related government agencies that handle the management of the Rungan Sub-Watershed. The FGDs were carried out to explore information and public opinions about potential obstacles, and recommendations for managing the

Rungan Sub-Watershed area in the future. FGDs in this study were used to assist researchers in formulating the potential and problems contained in the study area. These potentials and problems are then the basis for determining future development prospects in the Rungan River. The FGD process was carried out involving the Regional Apparatus Organizational Unit (SOPD) within the Central Kalimantan Provincial Government, the Palangka Raya City Regional Government, as well as academics and community leaders. Secondary data review was carried out to trace the data, supported by secondary data sourced from research journal articles, books, and data and information from the Regional Apparatus Organization Unit (SOPD) of the Central Kalimantan Provincial Government. Details of the data used in the research, the form of the data, the source of the data, and the relationship of the data to the analysis method can be seen in the Survey Design. Systematic observation techniques were carried out to observe the population of the Rungan Sub-Watershed in the upstream, middle, and downstream parts. In-depth interviews were conducted with environmental and development experts to assign scores on problems and alternative solutions obtained in the FGD process. The score given by the experts was then further analyzed with ANP analysis.

The ANP analysis was carried out to formulate the problems faced in the study area and the alternative solutions offered. Using Super Decisions 3.0 software, multi-criteria problems and alternative solutions were statistically analyzed to find the priority of management strategies in the Rungan Sub-Watershed (Borsboom et al., 2021; Saaty & Ozdemir, 2021). The data analysis tool used was the ANP method with the help of Super Decisions software version 2.6. The method was used to determine the relative priority scale obtained from absolute numbers based on individual assessments. Data analysis in ANP includes several stages as follows.

Compiling a construction model

All information obtained from FGDs, observations, and interviews was then classified and arranged in a hierarchy starting from the goals to be achieved, the main clusters (aspects), and the parameters of the constituent sub-clusters. The construction model makes it possible to see the main problems faced by the Rungan Sub-Watershed as well as the factors that affect it, as well as the alternative solutions offered. Weighting by experts, i.e., clusters that have been arranged are then compared in a super matrix using the expert weighting method to compare one cluster with another.

The synthesis of ANP was carried out by entering the scoring value into the Super Decisions software to be

processed to produce an output in the form of a super-matrix and then synthesized into priority. The results of each respondent were input into their own ANP network. As for the synthesis and analysis of data, this stage is divided into two.

Geometric Mean was carried out to find out the results of individual assessments from experts and determine the results of opinions in one group by calculating the geometric mean value. Questions in the form of pairwise comparisons from respondents were combined to form a consensus. Geometric mean is a type of average calculation that shows a certain tendency or value and is determined by the following formula. Geometric mean calculation was carried out to provide a better average approach because it can eliminate the deviation that occurs in the data obtained from the respondents' assessments in the questionnaire. The synthesis in the calculation of the ANP method was carried out using rater agreement, which is a measure that shows the level of conformity (agreement) of the respondents (R1-Rn) to a problem in a cluster. The tool used to measure rater agreement is Kendall's Coefficient of Concordance (W; $0 < W \leq 1$). The stages to calculate Kendall's coefficient (W) are:

Calculate the total number of rankings per cluster as represented by Formula 1.

$$Xa = (R1 + R2 + \dots + Rn) \tag{1}$$

Note:

Xa = Total number of ranks per cluster
R = Number of Ranks of Each Cluster

Calculate the average (U) of the total ranks of each cluster as represented by Formula 2.

$$U = \frac{Xa+Xb+\dots+Xn}{n} \tag{2}$$

Note:

U = Average total ranking
Xa = Total number of cluster rankings a
n = Number of clusters

Calculating the value of the sum of the squares of the deviation (S), calculated by the Formula 3.

$$S = (R1 - u)^2 + (R2 - u)^2 + \dots + (Rn - u)^2 \tag{3}$$

Note:

S = Number of quadrant deviations
(R1 - u) = Cluster deviation quadrant 1

Calculating the maximum value of the square deviation (Max S), calculated by the Formula 4.

$$\text{Max S} = (n - u)^2 + (2n - u)^2 + \dots + (Zn - u)^2 \quad (4)$$

Note:

Max S = Maximum value squared of foreign currency
 $(n - u)^2$ = the square value of the deviation of the n cluster

The last step is to determine the value of Kendall's W in the calculation of the Rater of Agreement, which is with Formula 5.

$$W = \frac{S}{\text{Max S}} \quad (5)$$

Note:

W = rater of agreement
 S = Number of quadrant deviations
 Max S = Maximum value of the deviation quadrant

Result and Discussion

Overview of Watershed Rooms

Rungan watershed is a lowland swamp forest ecosystem that is influenced by the hydrological cycle of Sungai Rungan River. The 2024 land cover analysis shows that the dominant types of land cover are oil palm plantations and industrial plantation forests, which are 35% and 26%, respectively. This indicates that natural forests have been heavily deforested into gardens and other uses. Natural forest cover in the form of peat swamp forests remains at approximately 10%, and lowland forests are less than 7%. Shrubs, which are land cover that occurs after deforestation occurs, have a significant area, which is approximately 10% of the total area.

Table 1. Land use in the Rungan sub-watershed

Land Use	Wide	Percentage %
Rivers	940	0.30
Non-residential buildings	43	0.01
Residential Buildings	919	0.30
Lowland Forest	21,698	6.97
Peat Swamp Forest	32,884	10.57
Plantation Forest	81,231	26.10
Garden and Mixed Crops	23,545	7.57
Other Natural Open Land	560	0.18
Open Land Cultivated	7,458	2.40
Oil Palm Plantation	111,901	35.96
Inland Swamp	188	0.06
Bushes and Bushes	29,852	9.59
Total	311,219	100.00

Most of the people who live in the Rungan watershed depend on natural resources for their livelihoods. In general, people have livelihoods as farmers, gardeners, collectors of forest products, and traditional fishers. Most of the proceeds from gardening and fishing are used to meet their own needs, and the surplus is sold to bring in income. Traditional gardens are mostly mixed gardens between rubber plants, fruit, and vegetable plants.

Traditional gold mining is also rampant in parts of the Rungan watershed. This results in water flows coming from the Kahayan River and several lakes around the Rungan River becoming polluted. As a result, the habitat of the water ecosystem is damaged, so that many types of fish are difficult to get due to the incompatibility with the murky water conditions of the river (Moyle & Leidy, 1992). The results of water quality measurements during the research in the Rungan River, Petuk Katim Village, showed that the water quality of the Rungan River is still in accordance with the Class III water quality standard based on Government Regulation No. 82 of 2001 concerning Water Quality Management and Water Pollution Control.

People have for generations depended on fishing in rivers and swamps. Fish that are commonly caught include jellyfish, baung, harwan, and patin. The fish catch is sold in fresh form or processed into salted fish, but there is no further processing to provide added value. Besides the Rungan Sub-Watershed, many fish are found in lakes and swamps around this area. From interviews with the community, it is known that currently the number of fish catches is decreasing, the size of fish is getting smaller, and some types of fish are increasingly difficult to find.

For the people of Petuk Katimpun, the Rungan River cannot be separated from their daily activities in life. One of the activities of the community that is in direct contact with the river is in the fisheries sector as the main livelihood. In carrying out their activities as fishermen, most people still use traditional fishing gear such as rengge, hidas, beje, salambau, and rempa.

Sei Gohong Village was designated as a tourist village based on the 2015 Regional Regulation of Palangka Raya City concerning the determination of Sei Gohong Village as a tourist village in Palangka Raya City. Sei Gohong Village has local potential that can be explored and developed to attract tourists because of the condition of the village that is still natural, has the Batu River and the Rungan River which can be used as tourist attractions, has Dayak traditional buildings, and there is cultivation of Dayak onions as a local commodity. Research by Fitriana et al. (2019) stated that the results of the SWOT analysis for tourism in Sei Gohong Village showed that the most appropriate strategy for

ecotourism development is the WO strategy, which is a strategy that utilizes all opportunities to minimize weaknesses.

The WO strategy consists of adding various facilities to attract visitors; managing river tourism well; developing a variety of attractive tour packages; providing training for tour guides, security officers, and methods to increase the added value of Dayak onions for the surrounding community; and improving management capacity for Pokdarwis (tourism awareness groups).

The traditional agroforestry system is quite developed with commodities such as rubber, durian, cempedak, langsung, and rattan. Traditional agroforestry gardens provide various products to meet the subsistence needs of the community such as fruits, vegetables, cooking spices, medicinal plants, firewood, and wood construction materials for houses, bridges, and boats (Viswanath & Lubina, 2018; Wana et al., 2023). Some communities have also started to plant oil palm on a small scale. Only communities with sufficient capital capacity can develop small-scale oil palm plantations because oil palm cultivation requires relatively large capital and intensive maintenance compared to traditional plantations such as rubber and fruits.

Main Problems of Rungan Watershed

The results of interviews, secondary data analysis, and field observations indicate that there are three groups of problems in the study area, namely ecological problems, economic problems, and institutional problems. The problems included in the ecological cluster are problems that threaten the integrity of the Rungan sub-watershed ecosystem. These ecological problems are mostly caused by anthropogenic activities such as forest logging, forest land conversion, illegal mining, and natural resource use practices that do not pay attention to forest preservation aspects. Ecological problems identified in the research process can be grouped into three groups, namely deforestation, destruction of river ecosystems, and destruction of fish habitats (Chen et al., 2009; Islam & Wahab, 2005).

Deforestation in the study area, based on the analysis of land cover changes and interviews with the community, found that the change of forest land to non-forest land was caused by the conversion of forest to oil palm plantations, tree felling, and land conversion to traditional plantations. Deforestation, furthermore, is one of the causes of damage to the Rungan Sub-Watershed ecosystem that supports biodiversity and specifically fish habitats. Land cover in the riverbank area plays an important role in maintaining the integrity of the Rungan Sub Watershed ecosystem by preventing erosion and siltation of the river. Reducing land cover in

the form of forests also has the potential to reduce and even eliminate biodiversity that supports various types of environmental services. This is in line with the research of Hou et al. (2023) who found that river hydrology systems are sensitive to deforestation, further stating that deforestation affects the protection of water stability and aquatic properties. Likewise, research by Ngwane (2024) in his research in Cameroon, provides empirical evidence that deforestation increases sedimentation, increases water pollution levels, and increases the risk of waterborne diseases.

People in the study area, most of whom work as fishers, specifically mentioned that the habitat where fish breed has been damaged. They stated that the potential for fish in the Rungan Sub-Watershed is decreasing. Twenty years ago, large types of jellyfish, patin, and harwan were still often found; now, the existence of these fish is increasingly rare. The community observed that the river water has become more turbid, the river water overflows and causes flooding during the rainy season and becomes shallow and dries up during the dry season. The community also observes that the existence of forests is important for providing fish food sources. Many fish eat insects and other small animals that live in the forest. The waters surrounded by forests are ideal habitats for fish to spawn, live, and breed. This information from the community is in line with the results of research from Cantera et al. (2023) which found that deforestation affects the diversity of river fish species.

The information obtained from interviews, FGDs, and secondary data analysis was then compiled into a model construction, which is the basis for the *analysis of the Analytical Network Process (ANP)* as seen in the following chart.



Figure 2. Construction Design Problems and alternative solutions for the watershed room

ANP analysis shows that ecological problems are considered as the most influential problem in the management of the Rungan Sub-Watershed with a value of 0.20. The second most important problems are economic (0.16) and institutional (0.13) problems. However, the *rater agreement* (W) value of the most influential choice of problems is relatively small, which is 0.1, which indicates that the opinion of experts is not focused on one of the choices.

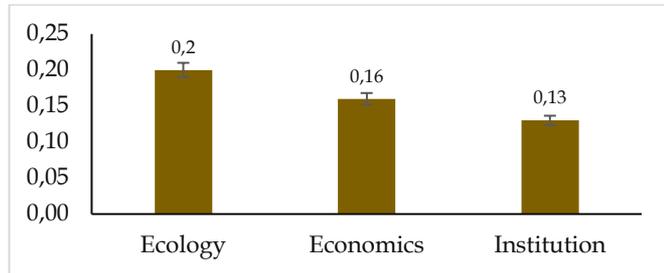


Figure 3. The priority of the problems that most determine the management of the Rungan Sub-Watershed

Alternative solutions formulated from the results of the interviews and FGDs are ecological improvement, economic recovery, and improved institutions and coordination. The ANP analysis resulted in a calculation showing that alternative solutions to improve the community's economy are a priority with a value of 0.35. Capacity building and cooperation between parties are considered the second most important, followed by ecological improvements in the third position. The *rater agreement* value of the solution cluster is 0.08, which indicates that there is a tendency for the three solutions to be considered equally important.

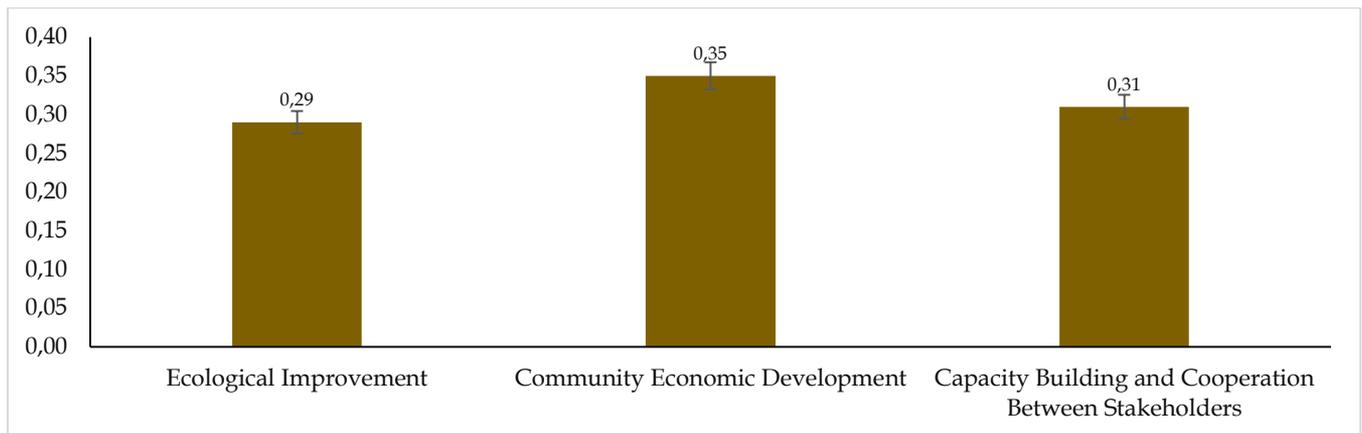


Figure 4. The priority of the solution that most determines the management of the Rungan Sub Watershed

Analyzing further ecological problems, there are three problems that are considered to affect the management of the Rungan Sub-Watershed, namely deforestation, destruction of river ecosystems, and destruction of fish and other animal habitats. The ranking of scores through the ANP process obtained the result that deforestation is an ecological problem that has the most influence on the management of the Rungan Sub-Watershed (0.197). The second most important problem is the destruction of river ecosystems (0.17), and the third is the destruction of fish habitats (0.12). The three options did not show a significant difference, which was confirmed by the *rater agreement* value of 0.5.

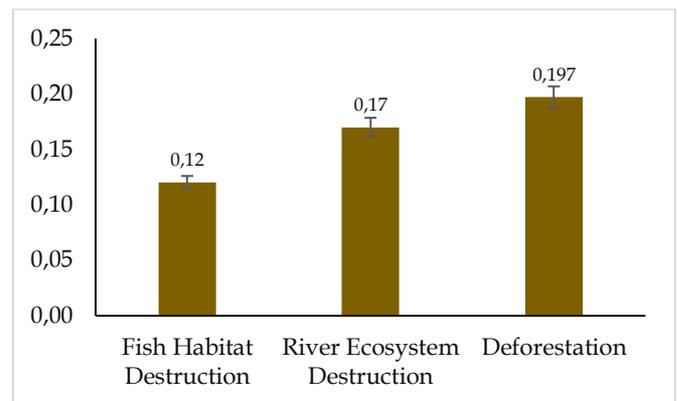


Figure 5. Ecological problems that most determine the management of the Rungan Sub-Watershed

Economic problems have three criteria, namely gold mining, lack of fish marketing, and lack of sustainable livelihoods. Of the three problems, gold mining is considered the most influential problem for the

management efforts of the Rungan Sub-Watershed with a geometric mean (geomean) value of 0.230. The second problem that is considered almost as significant is the lack of sustainable livelihoods with a value of 0.210. The lack of fish marketing is considered a less important problem with a score of 0.156. The *rater agreement* value, which indicates unanimity among the respondents, resulted in a value of 0.7.

The institutional aspect is one of the important problems that affect the management of the Rungan Sub-Watershed, which includes the lack of community capacity and the lack of coordination and cooperation between various parties. Experts consider that the problem of weak coordination and cooperation between various parties is the most important obstacle to the institutional aspect. Currently, each party has its own program without any synergy and integration. For example, the orangutan rehabilitation center on Kaja Island, which is run by *the Borneo Orangutan Survival Foundation*, does not yet have a joint program with the Tourism Office and the local community. Similarly, the Cooperatives and SMEs Office does not yet have a program that supports ecotourism activities in this region.

Communities in this region have limited skills and knowledge in terms of more diverse and sustainable livelihood development. The community's main livelihoods are fishing, gold mining, and other crops. Fishermen do not yet have the skills to process the fish they catch. Fish are only sold in fresh form or processed into salted fish. Furthermore, the community also does not have the skills to make handicrafts or typical souvenirs that can support ecotourism activities in this area.

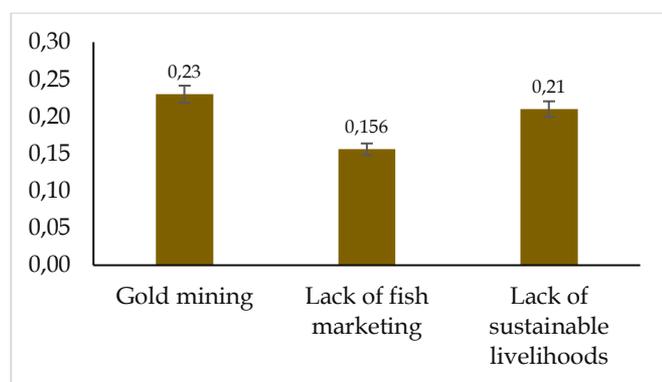


Figure 6. The economic problems that determine the management of the Rungan Sub-Watershed

The experts' assessment of the institutional aspect concluded that lack of coordination was the most important problem with a score of 0.286 and a lack of community capacity with a score of 0.205. The *rater agreement* value of the assessment of the two problems is

0.44, which indicates a relative divergence of experts' opinions.

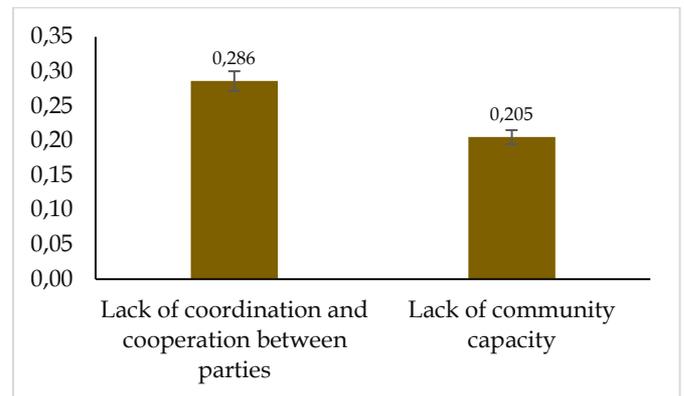


Figure 7. Institutional Problems that Determine the Management of the Rungan Sub-Watershed

The next stage in the ANP process is to analyze alternative solutions related to the problems formulated in the previous stage. There are three alternative solutions offered, which include ecological restoration, economic recovery, and institutional improvement and coordination. An assessment of the three alternative solutions will provide the output of the most important and priority solution recommendations to be carried out.

The highest score on alternative solutions for ecological restoration aspects is held by management zoning regulation (0.462), followed by watershed rehabilitation (0.281), and conservation of fish and other animal habitats (0.252). The value of *the three alternative ecological aspects of the rater agreement* was calculated at 0.77, indicating that the value of agreement among experts was relatively large.

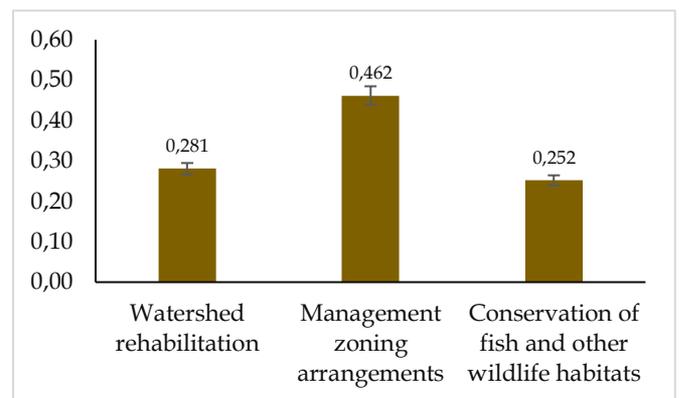


Figure 8. Alternative solutions for ecological aspects that most determine the success of the management of the Rungan Sub-Watershed

Zoning arrangements based on the characteristics, problems, potentials, and strategic values of the area will produce clear guidelines for the development of strategies and management programs for the Rungan

Sub-Watershed in the future. Utilization zoning arrangements can be seen as an effort to accommodate a variety of different interests. The determination of forest rehabilitation zoning will be able to reduce the level of ecological damage and improve the health of the ecosystem. Zoning for the use and development of productive businesses will provide space for the community, the government, and development partners to encourage sustainable livelihoods.

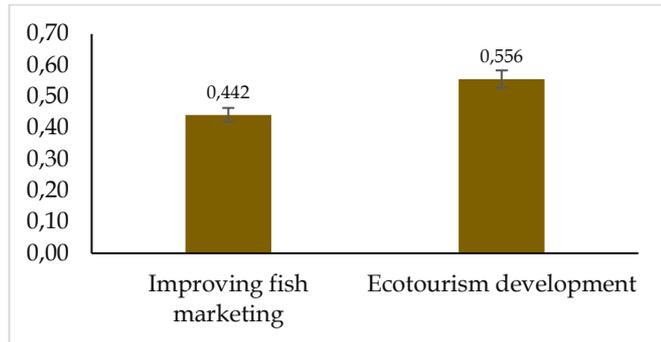


Figure 9. Alternative solutions to economic aspects that determine the success of the management of the Rungan Sub-Watershed

Alternative solutions to economic aspects seek to answer the challenges of the lack of sustainable livelihoods and limited marketing of fish, which are the main commodities in this region. There are two alternative solutions offered, namely the development of ecotourism and an increase in fish marketing. Between the two, the development of ecotourism received the highest score with a score of 0.556, while an increase in fish marketing obtained a score of 0.442. The *value of the rater agreement* chosen by the experts is 0.44.

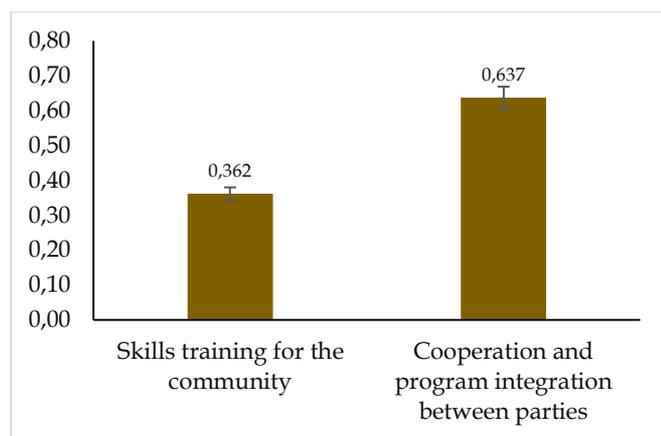


Figure 10. Alternative solutions to institutional aspects that most determine the success of the management of the Ruang Sub Watershed

Experts argue that institutional problems can be adjusted to two alternative programs, namely skills training for the community and cooperation and

integration of programs between parties. Analysis of the scores given by experts indicates that increasing cooperation and program integration is a priority program in the institutional aspect with a score of 0.637. Skills improvement gets a score of 0.362. The rater agreement value is 1, which indicates the unity of opinion from the experts to make cooperation and program integration a viable alternative solution.

Conclusion

Watershed areas face complex problems that can be classified into three main clusters, namely ecological, socio-economic, and institutional problems. Of the three clusters, ecological problems are considered the main problem. Alternative solutions that have been successfully formulated include ecological restoration, economic recovery, and institutional strengthening and coordination between stakeholders. The zoning arrangement of area management is the main strategy for the management of the watershed by regulating various programs such as forest rehabilitation, ecotourism, and environmentally friendly land use. To be carried out in a synergistic manner, it is necessary to coordinate and synergize programs between relevant stakeholders.

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Author Contributions

S.M.R.M.: Conceptualization, methodology, original draft preparation, formal analysis, investigation, visualization, and writing—review and editing. P.P. & A.H.: Validation, supervision, and resources. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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