



## Developing a Decision Support System for Sustainable Management of Community-Based Ecotourism: A Case Study of CMC Tiga Warna

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### ABSTRACT

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Ecotourism, aimed at appreciating and preserving biodiversity and natural ecosystems while providing economic and social benefits to local communities, faces complexity in management, requiring careful consideration to balance economic, social, and environmental aspects. Decision-making in ecotourism management involves various stakeholders, including government, NGOs, industry players, and local communities. CMC Tiga Warna in Indonesia is a highly potential ecotourism destination but poses challenges in environmental sustainability while meeting the economic and social needs of the local community. Thus, developing a decision support system (DSS) for sustainable community-based ecotourism management becomes crucial. This study aims to develop and implement a DSS based on priority actions, considering biodiversity, local community welfare, environmental and financial sustainability. Utilizing a community-based approach, the study engages local stakeholders and analyzes priority management actions across eight dimensions. Multi-criteria techniques like PROMETHEE will determine the best management actions to address challenges and opportunities for sustainable ecotourism management. The research contributes to sustainable management strategies for ecotourism in CMC Tiga Warna and provides a foundation for similar DSS development in other ecotourism contexts. It underscores the importance of holistic and sustainable ecotourism management for achieving economic development while conserving the environment, serving as a model for creating sustainable ecotourism environments worldwide.

## 1. INTRODUCTION

Ecotourism is one form of tourism aimed at appreciating and conserving biodiversity and natural ecosystems while providing economic and social benefits to local communities [1, 2]. However, the management of ecotourism is often complex and requires careful consideration in decision-making to ensure a balance between economic, social, and environmental aspects [3, 4]. In reality, decision-making regarding ecotourism management often involves various stakeholders, including governments, non-governmental organizations, industry players, and local communities.

CMC Tiga Warna, located in Indonesia, is an attractive and highly potential ecotourism destination. However, ecotourism management in this area has posed significant challenges due to its complexity [5]. One of the main challenges is maintaining environmental sustainability while meeting the economic and social needs of local communities.

Managing ecotourism at CMC Tiga Warna is a challenging task due to the various complexities involved. These complexities encompass several factors that need to be carefully considered in efforts to maintain a balance between

environmental preservation and tourism development. One of the main challenges is balancing environmental protection with the need to develop tourism infrastructure. For example, the construction of infrastructure to accommodate tourists may disrupt sensitive habitats or damage local ecosystems. Additionally, managing tourist visits is complex as it requires ensuring a sustainable number of visitors while minimizing negative impacts on the environment and local communities. This includes managing tourist flow, waste management, and resource consumption. The involvement of local communities in ecotourism activities can also lead to conflicts, as although ecotourism contributes to environmental improvements, the welfare of the local community, especially the economy, must still be considered. Moreover, navigating through regulations and government policies at the local, national, and international levels adds another layer of complexity. This includes compliance with environmental regulations, land-use policies, and obtaining permits for tourism operations.

Stakeholders involved in the decision-making process regarding ecotourism management at CMC Tiga Warna have diverse roles and often conflicting interests. Local communities, including indigenous communities, local

residents, and businesses, play a role in providing cultural insights, land access, and the potential to benefit economically from tourism. However, conflicts may arise concerning land ownership, resource use, and revenue distribution. Meanwhile, government agencies are responsible for regulating and managing natural reserves, including issuing permits, enforcing regulations, and providing infrastructure support. Conflicts may arise concerning resource allocation, differing priorities, and bureaucratic hurdles. On the other hand, tour operators are involved in organizing and managing tours, including marketing, visitor management, and ensuring safety. However, conflicts of interest may arise concerning profit maximization versus environmental conservation and sustainable practices. Furthermore, environmental NGOs act as advocates for conservation and sustainable development, providing expertise, conducting research, and monitoring environmental impacts. However, conflicts may arise concerning differing priorities, funding sources, and approaches to ecotourism. A more explicit explanation of the roles and conflicts of interest of these stakeholders underscores the need for a decision support system (DSS) in managing ecotourism at CMC Tiga Warna. A DSS can help coordinate various interests, facilitate collaboration, and identify optimal strategies considering various relevant factors.

In this context, the development of a community-based decision support system for sustainable ecotourism management in CMC Tiga Warna becomes increasingly important. This decision support system is expected to assist in addressing the complex challenges faced by stakeholders in maintaining ecotourism sustainability while ensuring that the economic and social needs of local communities are met [6, 7]. The proposed DSS presents significant differences and enhancements compared to existing systems in ecotourism management.

Firstly, the proposed DSS integrates the multi-criteria decision analysis (MCDA) technique, specifically PROMETHEE, allowing the evaluation of alternative strategies based on multiple criteria and stakeholder preferences. This enables a more comprehensive and transparent decision-making process.

Secondly, the DSS is equipped with real-time monitoring and feedback features, facilitating data collection and monitoring of key performance indicators (KPIs) related to tourist behavior, environmental indicators, and socio-economic impacts. This allows for adaptive management strategies and timely interventions to address emerging issues.

Thirdly, the DSS provides a platform for stakeholder engagement, including online forums, surveys, and collaborative decision-making modules, fostering transparency, inclusivity, and consensus-building among stakeholders, thus reducing conflicts and enhancing support for management decisions.

Finally, the DSS integrates scenario planning and risk assessment tools to simulate the potential impacts of various management strategies under different scenarios, such as changes in visitor demographics, environmental conditions, or policy frameworks. This helps managers anticipate and mitigate risks and uncertainties, enhancing the resilience of ecotourism management efforts. By outlining these differences and enhancements, this research becomes more critical as it leads to the development of a stronger and more adaptive approach to ecotourism management, ultimately contributing to the long-term sustainability of CMC Tiga Warna as an ecotourism destination. Thus, the development of

this decision support system will be a strategic step in efforts to sustain ecotourism in CMC Tiga Warna, while also benefiting local communities and the surrounding environment.

This study aims to develop and implement a decision support system based on priority action management to assist stakeholders in making decisions related to sustainable ecotourism management in CMC Tiga Warna. This decision support system will be designed considering various important aspects, including but not limited to biodiversity, local community welfare, environmental sustainability, and financial sustainability [8-10]. Through a community-based approach, this research will also involve active participation from various local stakeholders, including local governments, environmental NGOs, tourism industry players, and local communities, to ensure that the developed decision support system is truly relevant and useful for ecotourism sustainability in CMC Tiga Warna [11, 12].

Based on previous research, there are many dimensions that can influence ecotourism sustainability. For example, previous research examined the influence of community participation on ecological behavior using three main dimensions, including tourism, environment, and economy [13]. Some researchers also studied wise ecotourism management forecasting involving environmental, social, infrastructure, and economic dimensions [14, 15]. Additionally, the selection of good ecotourism policy locations based on existing potentials has also been researched [16], although this study only involved the environmental dimension and did not include other supporting dimensions, while Tseng et al. [7] studied ecotourism potentials based on tourism, infrastructure, environmental, and social dimensions. Some have also studied sustainable development strategies for ecotourism areas involving economic, social, environmental, regulatory, tourism, infrastructure, and institutional dimensions [8, 17, 18].

Strategic analysis of ecotourism area management variables has been conducted [19]. In that study, six dimensions were used to test strategic variables, including environmental, social, economic, infrastructure, institutional, and tourism dimensions. Additionally, researchers also conducted similar research using dimensions such as environment, social, economic, infrastructure, technology, regulation, institutional, and tourism [20, 21].

Several other studies also use the same dimensions as those used by other researchers as explained in the previous paragraph. However, in studies focusing on ecotourism management models like research by Lola et al. [22], examining management models from environmental, social, economic, infrastructure, and tourism dimensions, Sadikin et al. [9] used environmental, social, economic, infrastructure, and regulatory dimensions, while Mai and Smith [23] used infrastructure, economic, and environmental dimensions. In the assessment of ecotourism sustainability status, research by Fattah et al. [24] used environmental, social, economic, and regulatory dimensions. Meanwhile, Sukuryadi et al. [25] used environmental, social, economic, and institutional dimensions. Other studies related to ecotourism management have been conducted by many researchers with different topics [26], which examined the multi-stakeholder perspective, and studies on ecotourism competitiveness [27], involving social and environmental dimensions. Research on ecotourism criteria has been conducted [28], while the link between ecotourism and sustainable development goals (SDGs) has been studied [29].

Although previous studies have provided valuable insights into the dimensions influencing ecotourism sustainability, several shortcomings have been identified. One of them is the lack of comprehensive integration among the various dimensions studied. Some studies tend to narrow their focus on one or a few specific dimensions, without considering the complex relationships and interactions among these dimensions. Additionally, in some cases, research may overlook contextual aspects or external factors that can affect the implementation or success of ecotourism management strategies. Furthermore, most studies tend to focus on descriptive analysis rather than deeper analytical approaches, which may limit the ability to critically evaluate the effectiveness of existing management strategies or to identify areas that require further attention. Moreover, some studies may experience limitations in the methodology or conceptual framework used, which can affect the validity and generalizability of their findings. By identifying these shortcomings, new research can fill existing knowledge gaps and contribute to the development of a more holistic and in-depth understanding of sustainable ecotourism management. This research aims to collaborate the dimensions used by previous researchers into eight dimensions, namely environmental, social, economic, infrastructure, institutional, technology, regulation, and conservation. Thus, this research is expected to make a significant contribution to the development of sustainable management strategies for ecotourism in CMC Tiga Warna, as well as to provide methodological and practical foundations for the development of similar decision support systems in other ecotourism contexts.

## 2. METHODOLOGY

### 2.1 Research location

This research focuses on ecotourism at CMC Tiga Warna, with a focus on 6 observation points, namely: Clungup Beach, Gatra Beach, Watu Pecah Beach, Sapana Beach, Mini Beach, and Tiga Warna Beach (Figure 1).



Figure 1. Research location

### 2.2 Population and sample

The population in this study consists of stakeholders involved in the management of ecotourism at CMC Tiga

Warna, with sample selection using purposive sampling criteria targeting stakeholders with expertise in ecotourism management. The criteria for selecting experts are as follows: experts with authority in policy decision-making such as ecotourism area management, experts with authority in the development of ecotourism area management sectors, experts affected by ecotourism area management activities, experts crucial for the success of ecotourism area management sectors, and experts with competence in ecotourism area management sectors. The stakeholders involved include the Department of Marine Affairs and Fisheries, the Department of Tourism and Culture, the Department of Forestry, the Department of Environment, academics, managers of CMC Tiga Warna, village officials, local communities, economic actors, and visitors.

### 2.3 Research design

This research involves the identification and analysis of management actions emphasizing simulation of alternative management decisions to determine the best management priority actions. The operational framework of the research is outlined in the following diagram (Figure 2):

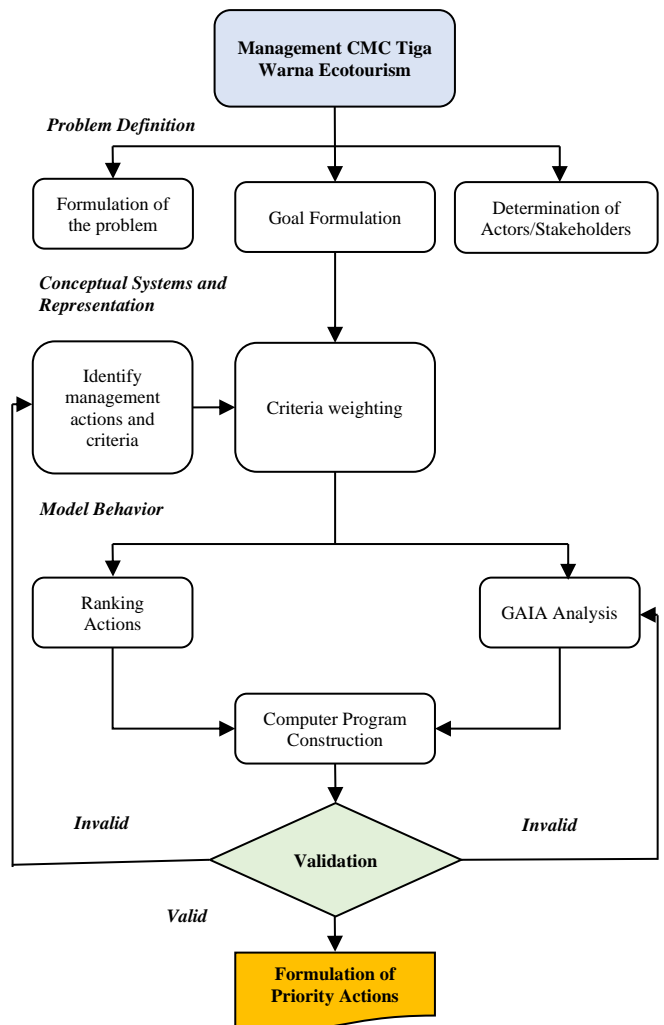


Figure 2. Research operational framework

The data in the analysis of community-based ecotourism management decision support systems are sourced from the environmental dimension, social dimension, economic dimension, infrastructure dimension, institutional dimension,

conservation dimension, technology dimension, and regulatory dimension (Table 1). Data collection is conducted using surveys with a questionnaire instrument. Each questionnaire will contain management actions which will then be evaluated based on a scale of 1-5 (very unimportant –

very important) with six assessment criteria including effectiveness, efficiency, adequacy, benefits, responsiveness, and accuracy. The following is the identification of management actions from each study:

**Table 1.** Dimension and action management

| Dimension      | Action   | Code | Description  |  |
|----------------|--|------|--|--|
| Environmental  | Environmental protection and management planning*                                      | A1   | Planning includes environmental inventory, conservation area designation, and environmental education.   |  |
|                | Utilization of natural resources in accordance with environmental capacity*            | A2   | Implementation of natural resource utilization based on environmental capacity and carrying capacity, utilization such as turning mangroves into mangrove tea. | *Law no. 32 of 2009, article 4   |
|                | Pollution control and/or environmental damage control*                                 | A3   | Environmental control includes prevention, mitigation, and restoration.  | **Law no. 27 of 2007, article 3  |
|                | Environmental sustainability**   | A4   | Ecological integrity remains intact.   | ***Minister of Home Affairs Regulation No. 33 of 2009, article 3 [19, 30]      |
|                | Consistency in environmental quality**   | A5   | The environment is not damaged or tends to improve.  |  |
|                | Tourism suitability***   | A6   | Considering that tourism activities should not disrupt the conservation area's functions caused by inappropriate utilization.                                  |  |
|                | Natural beauty**   | A7   | Natural beauty includes beach beauty, mangrove walks, coral reef beauty, and seagrass meadows.   |  |
|                | Cleanliness of tourist attractions**   | A8   | Tourist areas are free of litter, with monitoring of visitor waste.  |  |
|                | Carrying Capacity**  | A9   | Emphasizing the maximum area usage limit based on its capacity.  |  |
|                | Community participation*   | A10  | Local communities are involved in ecotourism management and support ecotourism management activities.  |  |
| Social         | Respect for the social, cultural, and religious values of communities around the area* | A11  | Ecotourism management is inseparable from social, cultural, and religious values.  | *Law No. 5 of 1990, articles 3, 6, 20  |
|                | Community empowerment*   | A12  | Ecotourism management has an impact on empowering local communities such as training in natural resource utilization in ecotourism areas.                      | **Law No. 27 of 2007, article 6  |
|                | Local business opportunities**   | A13  | Opening opportunities for business sectors such as homestays, restaurants, fish vendors, souvenirs, etc.   | ***Law No. 23 of 2004, articles 12, 25, 31, 258                                |
|                | Employment opportunities in the tourism sector   | A14  | Opening opportunities for community members to become ecotourism workers such as tour guides, parking attendants, ticket vendors, etc.                         | ****Minister of Home Affairs Regulation No. 33 of 2009, articles 1, 3 [19, 30] |
|                | Community welfare****  | A15  | Improving community welfare.   |  |
|                | Social conflict***   | A16  | Existence of stakeholder issues during ecotourism management implementation.   |  |
|                | Community knowledge****  | A17  | Community understanding of the importance of ecotourism.   |  |
|                | Harmony among stakeholders***  | A18  | Level of synergy among stakeholders in management implementation.  |  |
|                | Driving regional economic development*   | A19  | Increasing regional economic development.  | *Minister of Home Affairs Regulation No. 33 of 2009, article 3                 |
|                | Accelerated economic development**   | A20  | The presence of ecotourism helps improve other economic sectors such as fish markets.  | **Law No. 27 of 2007, articles 29, 36  |
| Economic       | Local revenue (PAD)**  | A21  | Contributing to increased local revenue (PAD).   | ***Law No. 10 of 2010, article 28 [19, 30]                                     |
|                | Sustainable ecotourism efforts*  | A22  | Ecotourism is expected to remain consistent.   |  |
|                | Ecotourism industry growth*  | A23  | Increasing the number of environmentally-focused tourism businesses.   |  |
|                | Ecotourism industry profits  | A24  | Ecotourism benefits the industry.  |  |
|                | Conservation budget***   | A25  | There is a conservation budget.  |  |
|                | Facility budget***   | A26  | There is a budget for facility improvement.  |  |
|                | Corporate social responsibility (CSR) by managers***                                   | A27  | Issuing CSR for community benefits.  |  |
|                | Public facilities*   | A28  | Availability of public facilities such as toilets, trash bins, electricity, telecommunications, etc.   | *Law No. 10 of 2010, article 33, paragraph 2c [9, 19, 21, 22]                  |
| Infrastructure | Health facilities*   | A29  | Availability of medical equipment and health teams for visitors.   |  |
|                | Worship facilities*  | A30  | Availability of decent places of worship.  |  |

| Dimension   | Action  | Code                                  | Description   |   |
|---|---|---------------------------------------|---|---|
| <b>Institutional</b>  | Public transportation to tourist locations*             | A31                                   | Public transportation to ecotourism areas is available.   |   |
|   | Access roads to ecotourism sites*                       | A32                                   | Easy access roads when traveling to ecotourism areas.   |   |
|   | Travel routes*  | A33                                   | There are directional signs.  |   |
|   | Number of attractions*                                  | A34                                   | A variety of attractions offered to attract visitors.   |   |
|   | Attraction appeal*                                      | A35                                   | Tourist destinations require a unique level of uniqueness to attract tourists to visit. This uniqueness includes similarity of type, quality, condition, and impression.                            |   |
|   | Availability of land*                                   | A36                                   | Specially provided areas by tourist attractions for visitors to relax and enjoy the provided attractions. Land availability includes seating, playing, exercising, and taking photos.               |   |
|   | Role of NGOs*   | A37                                   | NGOs are able to embrace and nurture communities to manage existing tourist potentials around the communities.  |   |
|   | Institutional activity*                                 | A38                                   | Supporting institutions actively support ecotourism activities.   |   |
|   | Growth of institutions/community groups*                | A39                                   | Increasing the number of institutions or community groups supporting ecotourism.  |   |
|   | Division of tasks*                                      | A40                                   | Explaining the division of tasks and responsibilities among institutions involved in ecotourism management, such as local governments, conservation agencies, and the private sector.               |   |
|   | Decision-making authority*                              | A41                                   | Determining the level of authority held by relevant institutions in making strategic decisions related to ecotourism management.  | *Law No. 10 of 2010, article 5, paragraph 76 [19, 30]                                   |
|   | Education and information*                              | A42                                   | Determining the responsibilities of institutions in providing education and information to local communities and visitors regarding ecosystems, conservation, and responsible ecotourism practices. |   |
|   | Coordination among managers*                            | A43                                   | Regularly conducting internal coordination through daily, weekly, or incidental meetings.   |   |
|   | Coordination between managers and relevant authorities* | A44                                   | Regularly coordinating with relevant agencies for optimal ecotourism management.  |   |
|   | Governance system*                                      | A45                                   | Having an organizational structure that facilitates management tasks.   |   |
|   | <b>Conservation</b>                                     | Preservation of natural capabilities* | A46   | Restoring the function of mangrove ecosystems, coral reefs, and seagrass meadows.       |
| Balanced utilization of nature*   |   | A47                                   | Avoiding over-exploitation of natural resources.  |   |
| Preservation of ecological processes*                                     |   | A48                                   | Not damaging the life support systems.  |   |
| Continuous rehabilitation efforts*  |   | A49                                   | Conducting mangrove and coral reef rehabilitation activities.   | *Law No. 5 of 1990 Article 2, 7, 10, 12, 13, 28   |
| Maintaining the integrity of the area according to the natural landscape* |   | A50                                   | Not damaging the natural landscape for economic needs.  | **Minister of Home Affairs Regulation No. 33 of 2009 Chapter II Article 3b [16, 19, 22] |
| Avoiding the danger of extinction*  |   | A51                                   | Initiating seagrass conservation efforts.   |   |
| Considering the potential and carrying capacity of the area*              |   | A52                                   | Implementing area carrying capacity systems.  |   |
| Ecosystem protection**  |   | A53                                   | Protecting ecosystems by creating conservation zones and visitation time limits.  |   |
| Biodiversity conservation**   |   | A54                                   | Protecting flora and fauna by providing habitats for breeding.  |   |
| Level of mastery of marketing technology*                                 |   | A55                                   | Management has the ability to conduct online marketing.   |   |
| <b>Teknologi</b>  | Ability to implement eco-friendly technology*           | A56                                   | Management has the ability to implement environmentally friendly technologies such as solar panels.   |   |
|   | Database technology development capability*             | A57                                   | Management has the ability to input databases.  | *Law No. 10 of 2010, Articles 36-49 [21, 30]  |
|   | Ease of ecotourism information*                         | A58                                   | Information about ecotourism is easily accessible.  |   |
|   | Online ecotourism marketing*                            | A59                                   | Conducting ecotourism marketing through websites and social media.  |   |
|   | Digital advertising*                                    | A60                                   | Marketing through mass media such as news, radio, or posters.   |   |
|   | Institutional database*                                 | A61                                   | Having databases related to organizational structures, working partners, MoUs, certificates, etc.   |   |

| Dimension | Action   | Code | Description  |
|-----------|--|------|--|
| Regulasi  | Tourism database*  | A62  | Having databases related to existing tourism facilities and attractions.                               |
|           | Ecosystem database*  | A63  | Having databases on the area of management and conservation, flora and fauna, and existing ecosystems. |
|           | Availability of legal instruments                              | A64  | In ecotourism management, there are management permits and legal regulations governing them.           |
|           | Regional regulations for ecotourism management                 | A65  | There are regional regulations regarding conservation area and ecotourism management.                  |
|           | Transparency in policies                                       | A66  | Every policy is known to the wider community.  |
|           | Availability of legal supervision                              | A67  | There are supervisors who maintain the ecotourism environment.   |
|           | Number of local security personnel                             | A68  | The number of local security personnel is adequate.  |
|           | Legal counseling on natural resource management                | A69  | Legal counseling activities on natural resource management for managers.                               |
|           | Harmonization of policies                                      | A70  | There is no overlap between applicable regulations.  |
|           | Compliance with tourism management documents                   | A71  | Every stakeholder complies with management documents.  |
|           | Implementation of management according to management documents | A72  | Ecotourism management is in accordance with management documents.                                      |

[9, 21, 24]

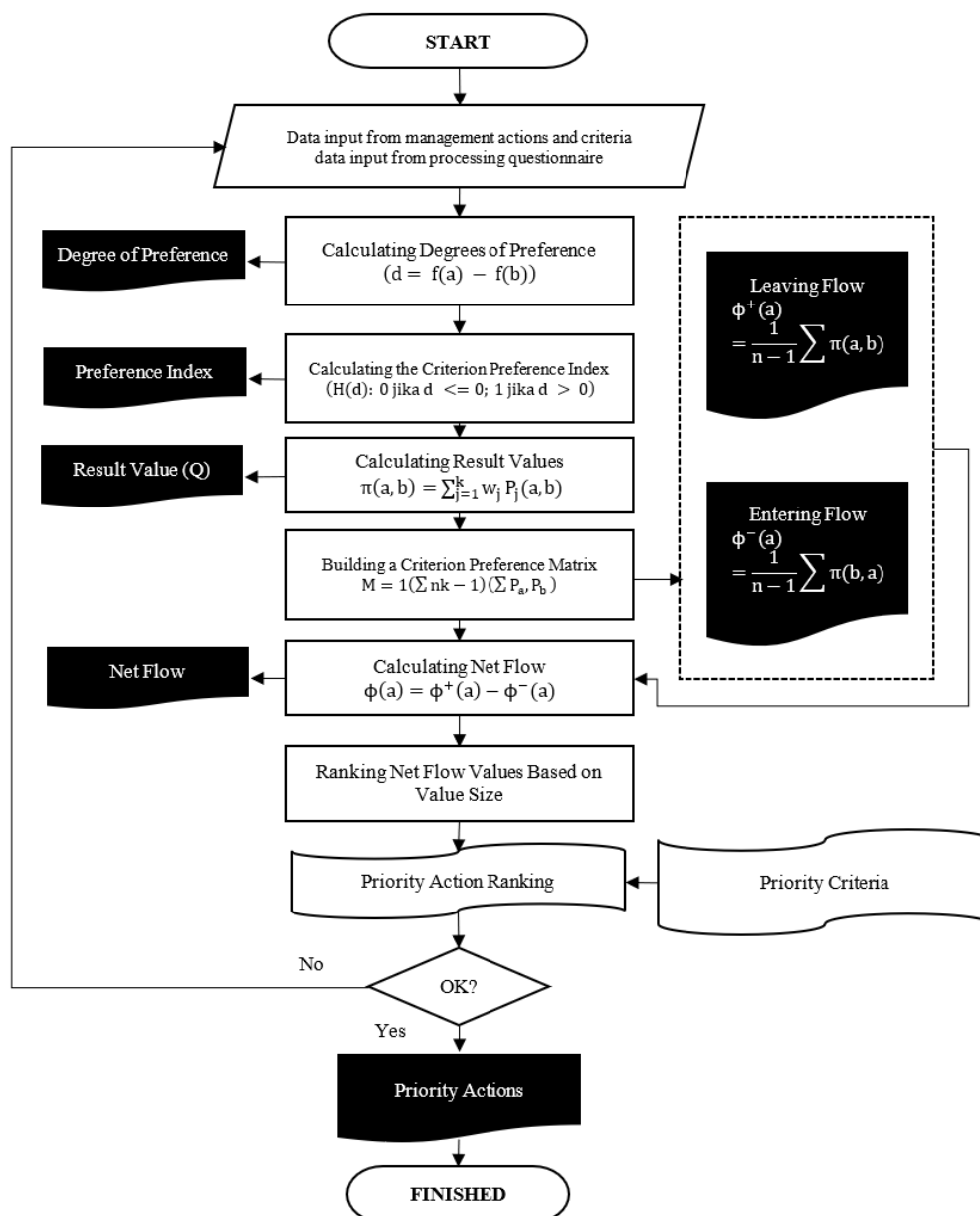


Figure 3. Data analysis framework

## 2.4 Data analysis

The use of multi-criteria techniques to determine the best decisions in managing tourist destinations has been suggested in previous literature. Thus, according to Lopes et al. [27], it is proposed to use a combination of multi-criteria methodology (entropy to obtain weights and TOPSIS for ranking) for the tourism and travel competitiveness index. PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) is also included in the group of outranking methods. Regarding tourist destinations, the PROMETHEE method has been used to measure destination performance in several studies. In terms of assessing the accuracy of priority actions arranged in the management of ecotourism areas, the indicators used for verifying and validating priority actions according to van Noordwijk [3], consist of effectiveness, efficiency, adequacy, benefits, responsiveness, and accuracy of priority actions. Data analysis is performed using PROMETHEE analysis to determine the best management actions. The data analysis framework can be seen in (Figure 3).

## 3. RESULT AND DISCUSSION

Tourism development relies on commercial, economic, and logistical issues such as product quality, accessibility, destination infrastructure, and skills availability [31]. Therefore, priorities in tourism development must be considered. Priority actions in the context of ecotourism management refer to a series of high-priority actions that must be implemented to achieve specific goals in nature conservation and destination management. In the context of priority actions for managing CMC Tiga Warna Ecotourism, this includes specific steps that need to be taken to protect biodiversity, preserve environmental authenticity, and ensure the economic benefits of tourism remain sustainable.

These priority actions may include monitoring and protecting rare species, implementing strict rules and regulations to control human access and activities in the area, developing environmentally friendly infrastructure, and environmental education programs to raise awareness among communities and visitors about the need for nature conservation and conservation. Conservation typically involves complementary goals of preserving biodiversity and ecosystem functions [32]. By prioritizing these actions, the goal of ecotourism management is to achieve a balance between preserving natural ecosystems and providing a positive experience for visitors while having a positive impact on the local economy. This also includes sustainable development strategies to ensure ecotourism revenue supports environmental preservation and restoration. The following is an explanation of the results of the priority action analysis for managing CMC Tiga Warna Ecotourism.

### 3.1 GAIA analysis test

GAIA analysis is one of the methods used in PROMETHEE analysis (Preference Ranking Organization Method for Enrichment Evaluations). PROMETHEE is a method used for multi-criteria decision-making that considers preferences and weights of given criteria. The function of GAIA analysis in PROMETHEE analysis is to integrate preferences and weights of given criteria in multi-criteria decision-making. GAIA analysis helps in calculating the final value for each evaluated

alternative, considering subjective preferences and weights given to each criterion. In general, GAIA analysis in PROMETHEE analysis functions to simplify the multi-criteria decision-making process by combining preferences and weights of criteria into a final value that can be used for ranking and selecting the best alternative. In this case, if the GAIA analysis value  $>70\%$ , it can be considered valid [33].

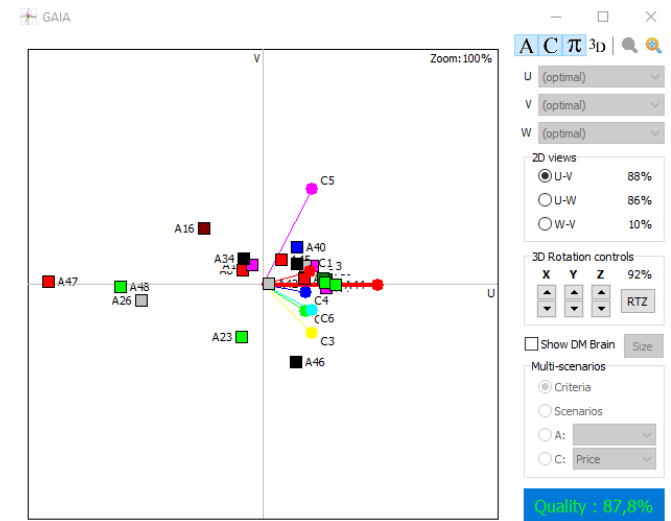
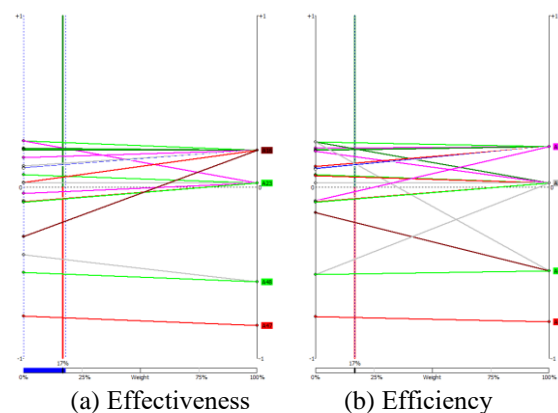


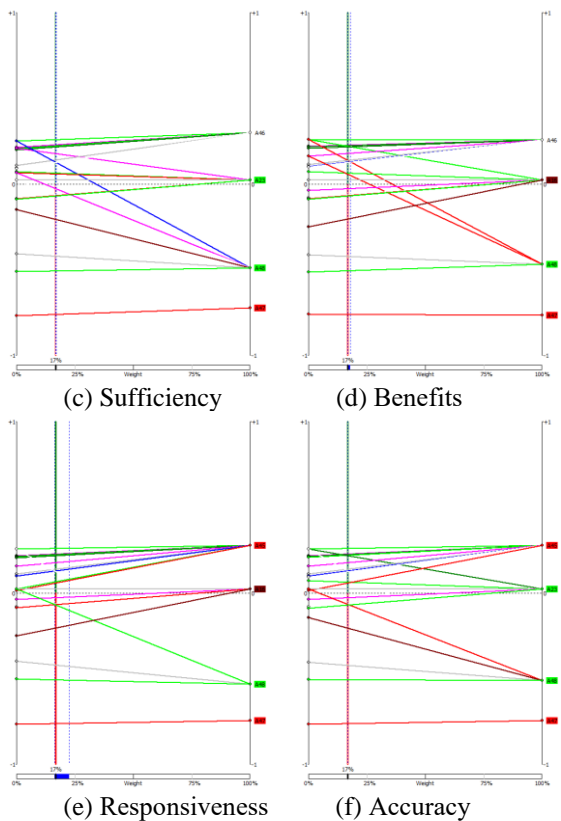
Figure 4. GAIA analysis

From Figure 4, it can be concluded that the GAIA analysis test shows a quality value of 87.80%. This verifies that the tested data is reliable and valid as it has a percentage value of more than 70% [33]. Therefore, it can be inferred that the quality level of GAIA analysis representation is excellent, thus considered capable of interpreting results in the decision-making process of priority actions for managing CMC Tiga Warna Ecotourism. This indicates that the GAIA analysis results used in this analysis can be trusted and effective in assisting decision-making related to the management of CMC Tiga Warna Ecotourism.

### 3.2 Stability interval test

Sensitivity analysis is used to assess the sensitivity of each management action, in case of slight changes in assessment (uncertainty). This sensitivity analysis can also be used to predict conditions in the event of significant changes, such as changes in weights or changes in the sequence of priority actions due to changes in policy. In this study, sensitivity analysis was conducted through the stability interval test. The results of the stability interval test are as follows:





**Figure 5.** Stability interval test

From the results of the stability interval test in Figure 5, it can be seen that overall, the level of sensitivity is not high, only 17% because the value is less than 50% [33], it can be concluded that the level of sensitivity is low. This indicates that the influence of changes in the weights of management actions on evaluation results is not very significant overall. However, although the overall sensitivity level is not high, the results of the stability interval test show that for each criterion, there is a sensitivity level to changes in each weight of management action. This means that although changes in the weights of management actions may not have a significant overall impact, each criterion in the evaluation remains responsive to these weight changes [10]. This underscores the importance of considering the sensitivity of each criterion in the evaluation and decision-making process, even though the overall impact may be limited. By considering this sensitivity, decision-makers can better understand how changes in the weights of management actions can affect evaluation results, thus making more accurate and responsive decisions to various factors involved in ecotourism management.

From the sensitivity analysis results, it can be observed that in terms of effectiveness criteria, changes in weights result in an increase in the position of decision-making authority actions, while environmental sustainability actions experience a decrease in position to a lower level. This effectiveness criterion measures the extent to which an action or policy successfully achieves the set goals [34]. In this context, the increase in weight on decision-making authority indicates an increased focus on making effective and strategic decisions in ecotourism management. Strong decision-making authority allows for more effective and timely policy implementation, which in turn can enhance overall performance in achieving set goals [35]. Conversely, the decrease in weight on environmental sustainability actions indicates that environmental sustainability may no longer be considered a

top priority in decision-making. This could be due to a shift in focus or greater emphasis on economic or social aspects, resulting in a decrease in the position of environmental sustainability in the effectiveness criterion [36].

Secondly, in terms of efficiency criteria, changes in weights lead to an increase in the position of public facility authority actions and ecotourism information accessibility actions. The efficiency criterion measures how efficient an action or policy is in achieving goals with the available resources [37]. The increase in weight on public facility authority actions indicates an increased focus on providing adequate infrastructure and public facilities for visitors and local communities, which can improve the efficiency of destination management [7]. Similarly, the increase in weight on ecotourism information accessibility actions indicates an increased importance of information accessibility for visitors and stakeholders to improve efficiency in decision-making and policy implementation related to ecotourism [38].

Thirdly, in terms of sufficiency criteria, changes in weights result in an increase in the position of compliance actions in implementing ecotourism area management documents and environmental sustainability actions. The sufficiency criterion measures the extent to which available resources are sufficient to achieve the set goals [39]. The increase in weight on compliance actions in implementing ecotourism area management documents indicates an increased focus on the availability and fulfillment of established management regulations and procedures, which can enhance the overall effectiveness of ecotourism management [40]. Meanwhile, the increase in weight on environmental sustainability actions indicates an increased awareness of the importance of maintaining environmental sustainability in destination management [41, 42].

Fourthly, in terms of benefits criteria, changes in weights lead to an increase in the position of compliance actions in implementing ecotourism area management documents, while natural beauty actions experience a decrease in position to a lower level. The benefits criterion measures the positive impact generated by an action or policy [26]. The increase in weight on compliance actions in implementing ecotourism area management documents indicates an increased recognition of the benefits of compliance with established management regulations and procedures, which can improve the effectiveness and transparency of ecotourism management [18]. Furthermore, the increase in weight on decision-making authority actions indicates an increased recognition of the importance of making effective and strategic decisions in achieving ecotourism management goals [1].

Fifthly, in terms of responsiveness criteria, changes in weights result in an increase in the position of local revenue actions and decision-making authority actions. The responsiveness criterion measures how responsive an action or policy is in addressing emerging changes and challenges [43]. The increase in weight on local revenue actions indicates an increased recognition of the importance of additional revenue for the local area from the tourism industry, which can stimulate responsive actions to increase such revenue [44]. Meanwhile, the increase in weight on decision-making authority actions indicates an increased recognition of the importance of adaptive and responsive decision-making in addressing environmental changes or community needs [1].

Lastly, in terms of accuracy criteria, changes in weights result in an increase in the position of compliance actions in implementing ecotourism area management documents, while



natural beauty actions experience a decrease in position to a lower level. The accuracy criterion measures how accurate or suitable an action or policy is in achieving the set goals [45]. The increase in weight on compliance actions in implementing ecotourism area management documents indicates an increased focus on meeting established regulations and procedures, which can improve accuracy and precision in ecotourism management [46]. Conversely, the decrease in weight on natural beauty actions indicates a decreased focus on natural beauty aspects in decision-making or policy implementation related to ecotourism, which can lead to a decreased priority for preserving natural beauty. This is due to various complex factors. Firstly, economic pressures prioritize economic aspects of tourism, such as income and industry growth, over nature conservation. Secondly, rapid infrastructure development and tourism industry growth can put significant pressure on the natural environment, leading to sacrifices in nature conservation for economic development interests. Thirdly, a lack of awareness of the importance of nature conservation and natural beauty in the long term can lead to low priorities for these aspects in decision-making. Lastly, weak government policies related to nature conservation and ineffective law enforcement can also contribute to decreased priorities for preserving natural beauty in CMC Tiga Warna [19, 47, 48]. Therefore, there is a need for greater awareness of the importance of maintaining a balance between economic development and environmental preservation in making decisions related to ecotourism to ensure that the natural beauty of CMC Tiga Warna remains preserved for future generations.

### 3.3 Priority actions for the management of CMC Tiga Warna Ecotourism

CMC Tiga Warna Ecotourism is a natural area rich in biodiversity and stunning natural beauty. Amidst its captivating natural charm, the challenges in ecotourism management become increasingly pressing. In order to preserve the environment and provide maximum benefits for the local community, priority actions for the management of CMC Tiga Warna Ecotourism are initiated as a strategic step to address various emerging issues. Through an approach focused on urgent and strategic actions, this program aims to create a harmonious balance between environmental preservation, sustainable ecotourism development, and empowerment of the local community. In this context, analysis of the implementation and outcomes of priority actions for the management of CMC Tiga Warna Ecotourism becomes important to explore and evaluate in depth. From the analysis conducted, the sequence of priority actions for the management of CMC Tiga Warna Ecotourism is as follows (Figure 6):

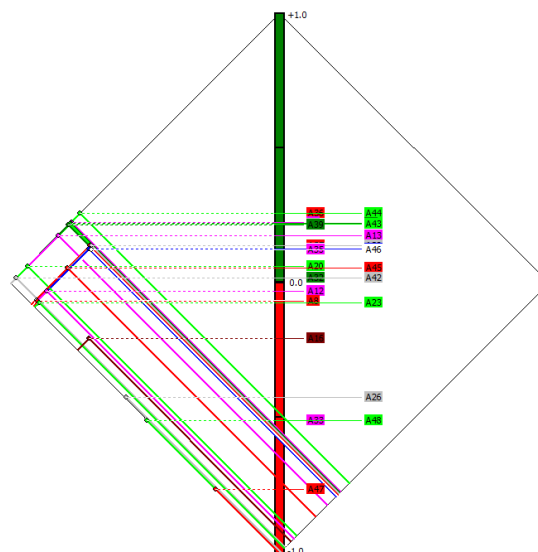


Figure 6. Action priority

From the analysis results in Table 2, it is known that the priority action for managing the CMC Tiga Warna Ecotourism emphasizes the importance of community welfare aspects as the main foundation in every decision and action taken. This is due to the recognition of the direct impact that the local community has on environmental balance and overall ecotourism sustainability [49]. These efforts aim not only to provide economic benefits to the local community but also to improve their quality of life through job opportunities provided in the tourism sector [50]. By providing appropriate training and support, the local community can actively engage in the tourism industry, increase their income, and enhance economic independence. Furthermore, this action plan emphasizes sustainable environmental rehabilitation efforts, including natural habitat restoration and monitoring of the conservation of local flora and fauna [31, 51]. The implementation of environmentally friendly technology is key to maintaining the balance between ecotourism development and environmental preservation. By utilizing the right technology, such as efficient energy and waste management systems, managers can minimize negative impacts on the surrounding environment [52]. Consistency in maintaining environmental quality is also a priority in this action plan, emphasizing sustainability in natural resource management and ensuring that the natural beauty and biodiversity of the CMC Tiga Warna Ecotourism are well preserved [38]. By considering these aspects holistically, this action plan aims to create sustainable positive impacts for the local community while ensuring the necessary environmental sustainability to preserve this valuable natural heritage for future generations.

Table 2. Priority actions for the management of CMC Tiga Warna Ecotourism

| Rank | Action  | Phi    | Phi+   | Phi- |
|------|---|--------|--------|------|
| 1    | Community welfare                               | 0.2589 | 0.2589 | 0    |
| 2    | Employment opportunities in the tourism sector  | 0.2589 | 0.2589 | 0    |
| 3    | Continuous rehabilitation efforts               | 0.2589 | 0.2589 | 0    |
| 4    | Ability to implement eco-friendly technology    | 0.2589 | 0.2589 | 0    |
| 5    | Consistency in environmental quality            | 0.2589 | 0.2589 | 0    |
| 6    | Legal counseling on natural resource management | 0.2589 | 0.2589 | 0    |
| 7    | Local business opportunities                    | 0.2589 | 0.2589 | 0    |
| 8    | Community participation                         | 0.2589 | 0.2589 | 0    |
| 9    | Coordination among managers                     | 0.2589 | 0.2589 | 0    |

| Rank | Action   | Phi     | Phi+   | Phi-   |
|------|--|---------|--------|--------|
| 10   | Coordination between managers and relevant authorities                   | 0.2589  | 0.2589 | 0      |
| 11   | Governance system  | 0.2589  | 0.2589 | 0      |
| 12   | Conservation budget  | 0.2589  | 0.2589 | 0      |
| 13   | Cleanliness of tourist attractions                                       | 0.2589  | 0.2589 | 0      |
| 14   | Worship facilities   | 0.227   | 0.227  | 0      |
| 15   | Avoiding the danger of extinction  | 0.2234  | 0.2234 | 0      |
| 16   | Level of mastery of marketing technology                                 | 0.2199  | 0.2199 | 0      |
| 17   | Carrying capacity  | 0.2199  | 0.2199 | 0      |
| 18   | Balanced utilization of nature   | 0.2163  | 0.2163 | 0      |
| 19   | Health facilities  | 0.1773  | 0.1773 | 0      |
| 20   | Facility budget  | 0.1383  | 0.2163 | 0.0780 |
| 21   | Institutional database   | 0.1383  | 0.2199 | 0.0816 |
| 22   | Harmonization of policies  | 0.1277  | 0.2128 | 0.0851 |
| 23   | Social conflict  | 0.1277  | 0.2092 | 0.0816 |
| 24   | Access roads to ecotourism sites   | 0.1241  | 0.2128 | 0.0887 |
| 25   | Compliance with ecotourism management documents                          | 0.1241  | 0.2128 | 0.0887 |
| 26   | Tourism suitability  | 0.0638  | 0.0638 | 0      |
| 27   | Local revenue (PAD)  | 0.0567  | 0.1348 | 0.078  |
| 28   | Availability of legal supervision  | 0.0213  | 0.0213 | 0      |
| 29   | Database technology development capability                               | 0.0213  | 0.0213 | 0      |
| 30   | Ecosystem protection   | 0.0213  | 0.0213 | 0      |
| 31   | Pollution and/or environmental damage control                            | 0.0213  | 0.0213 | 0      |
| 32   | Biodiversity conservation  | 0.0213  | 0.0213 | 0      |
| 33   | Ecosystem database   | 0.0213  | 0.0213 | 0      |
| 34   | Public facilities  | -0.0284 | 0.0532 | 0.0816 |
| 35   | Transparency in policies   | -0.0638 | 0.0177 | 0.0816 |
| 36   | Sustainable ecotourism efforts   | -0.0674 | 0.0177 | 0.0851 |
| 37   | Environmental sustainability   | -0.0709 | 0.0177 | 0.0887 |
| 38   | Decision-making authority  | -0.2057 | 0.0426 | 0.2482 |
| 39   | Ease of ecotourism information   | -0.422  | 0.0035 | 0.4255 |
| 40   | Education and information  | -0.5071 | 0      | 0.5071 |
| 41   | Maintaining the integrity of the area according to the natural landscape | -0.5071 | 0      | 0.5071 |
| 42   | Ecotourism industry growth   | -0.5071 | 0      | 0.5071 |
| 43   | Ecotourism industry profits  | -0.5071 | 0      | 0.5071 |
| 44   | Division of tasks  | -0.5071 | 0      | 0.5071 |
| 45   | Number of local security personnel                                       | -0.5071 | 0      | 0.5071 |
| 46   | Travel routes  | -0.5071 | 0      | 0.5071 |
| 47   | Natural beauty   | -0.5071 | 0      | 0.5071 |
| 48   | Accelerated economic development   | -0.7624 | 0      | 0.7624 |

The priority action for managing the CMC Tiga Warna Ecotourism also emphasizes the importance of legal education on natural resource management (NRM) as a key step in maintaining environmental sustainability and ensuring that ecotourism activities comply with applicable legal frameworks. By providing comprehensive legal education to managers, local communities, and other relevant parties, this action plan aims to enhance understanding of regulations governing NRM, including habitat protection and conservation efforts [46]. Additionally, this action plan also focuses on local business opportunities by involving the local community in the development of sustainable economic initiatives. By empowering local entrepreneurs to participate in the ecotourism industry, this action plan creates opportunities for them to develop unique and supportive products and services, which in turn can increase income and welfare for the local community [53]. Active community participation is also a focus in this action plan, by encouraging their participation in decision-making processes and ecotourism management program implementation. By involving the community directly, this action plan can ensure that policies and actions taken into account the needs and aspirations of the local community [54, 55]. Furthermore, coordination among managers and coordination with relevant agencies are considered important in ensuring the effectiveness and efficiency of implementing this action plan. By enhancing collaboration and communication among

various stakeholders, this action plan can better address complex challenges in ecotourism management and ensure that resources and efforts are optimally coordinated to achieve set goals [56, 57]. Thus, this action plan creates a robust framework for managing the CMC Tiga Warna Ecotourism while considering the important aspects of legality, community participation, and stakeholder coordination.

The priority action for managing the CMC Tiga Warna Ecotourism also emphasizes several crucial aspects that support the success of ecotourism management in the area. Firstly, an effective governance system is a critical foundation to ensure that every decision and activity related to ecotourism is carried out in accordance with sustainability principles and environmental preservation. By having a strong governance system, managers can efficiently manage natural resources and implement policies that support conservation goals [58]. Furthermore, adequate conservation budgets are key to supporting ecosystem conservation efforts and biodiversity in the CMC Tiga Warna Ecotourism. With sufficient funding, managers can conduct routine monitoring, habitat maintenance, and restoration efforts necessary to maintain ecosystem balance [59]. Tourism site cleanliness and the availability of facilities also take priority, as this ensures visitor comfort and satisfaction, while supporting diversity and inclusion principles in ecotourism management [7, 60]. Avoiding extinction hazards is an important goal in this action plan, involving the identification and mitigation of potential

threats to local flora and fauna and their habitats [61]. These actions include conservation area development, strict enforcement of habitat-damaging activities, and public awareness campaigns about the importance of ecosystem balance.

A high level of marketing technology mastery is essential to expand the reach of promotion for the CMC Tiga Warna Ecotourism and increase tourist visits with a sustainable approach [62]. Furthermore, considering the carrying capacity or environmental support capacity is essential to prevent ecosystem damage due to increased visits [63]. Balanced natural resource utilization is a key principle in maintaining environmental resource sustainability, considering the needs of the local community and environmental protection [1]. Adequate healthcare facilities and allocation of adequate facility budgets are also primary concerns, to ensure visitor well-being and the availability of essential services in supporting tourism activities [7]. Thus, this action plan encompasses several important aspects that support holistic and sustainable management of the CMC Tiga Warna Ecotourism.

In the context of managing the CMC Tiga Warna Ecotourism, some priority actions have lower priorities for certain reasons relevant to the management conditions and goals. Firstly, maintaining area integrity according to natural characteristics may have a lower priority because the CMC Tiga Warna Ecotourism area already has strong protection status or has established regulations to ensure environmental conservation. Secondly, ecotourism industry growth and profits may be of lower priority because ecotourism management focuses more on environmental sustainability than on increasing profitability. Thirdly, task allocation, local security personnel numbers, and travel routes may have lower priorities because there may already be established organizational structures and management systems in place, and the need to improve security and route arrangements may be considered as routine responsibilities performed sustainably. Fourthly, natural beauty may have lower priorities because its presence as a major attraction is already recognized, and the focus is more on maintaining and strengthening ecotourism infrastructure. Lastly, accelerating economic development may have lower priorities because ecotourism management is more oriented towards sustainable economic development rather than rapid economic growth that could potentially harm the environment. Thus, while these actions remain important, their priorities in the context of managing the CMC Tiga Warna Ecotourism may be lower compared to other actions that are more urgent and strategic for achieving conservation and sustainable ecotourism development goals.

Overall, it can be observed that the priority actions for managing the CMC Tiga Warna Ecotourism are primarily social in nature. This is quite intriguing considering that CMC Tiga Warna Ecotourism is a community-based tourism area, yet social activities are still relatively low, indicating a need for prioritized actions. Based on field observations, it is evident that not all local communities support the initiatives for managing the CMC Tiga Warna Ecotourism. Some communities feel they do not directly benefit from these management efforts, either due to restricted access imposed by the management or lack of perceived benefits. This has triggered social conflicts in the CMC Tiga Warna Ecotourism area.

According to the research findings [5, 64], the level of

community participation in the vicinity is still suboptimal due to inadequate business arrangements and incentive schemes to attract community interest in managing this ecotourism destination. This underscores an important note in ecotourism management everywhere, that engaging communities requires compelling incentives, one of which is the opportunity to earn additional income and improve community welfare. Therefore, community education and participation become the main focus, while it is also important to address and resolve any issues or dissatisfaction that may arise among the local communities, thus achieving a balance between environmental conservation and community interests.

There is a need for greater focus on the social dimension in managing CMC Tiga Warna Ecotourism. Priority actions originating from the social dimension, such as community welfare, employment opportunities in the tourism sector, local business opportunities, community participation, and reduction of social conflicts, dominate the management priorities. This indicates that the social dimension has a low sustainability status and requires greater attention compared to other dimensions. Additionally, the regulatory and technological dimensions also need further attention to enhance the effectiveness of ecotourism management. However, even actions with lower priorities still contribute to achieving the goals of conservation and sustainable ecotourism development, as well as strengthening local communities and visitor satisfaction. Therefore, it is important to consider all management actions while also providing additional focus on the social dimension and efforts to improve regulatory and technological dimensions to enhance the overall effectiveness of managing CMC Tiga Warna Ecotourism.

#### 4. CONCLUSIONS AND RECOMMENDATIONS

The research findings indicate that the action plan for managing CMC Tiga Warna Ecotourism emphasizes the importance of prioritizing community welfare as the primary basis for decision-making and actions. This includes efforts to enhance the income and economic independence of local communities through training, support, and active participation in the tourism industry. Additionally, the action plan emphasizes sustainable environmental rehabilitation by utilizing eco-friendly technology to maintain a balance between ecotourism development and environmental preservation. Consistency in maintaining environmental quality and sustainability in natural resource management is also a priority. The action plan aims to create sustainable positive impacts for local communities while ensuring the environmental sustainability necessary to preserve the natural heritage for future generations. In the context of managing CMC Tiga Warna ecotourism, some priority actions have lower priority due to specific reasons relevant to the conditions and goals of the management. However, it is important to remember that all actions in the action plan still make significant contributions to achieving the goals of sustainable ecotourism conservation and development. Therefore, the implementation of this action plan is expected to enhance the sustainability of CMC Tiga Warna ecotourism, strengthen the welfare of local communities, and ensure the preservation of valuable natural environments for the future. In conclusion, these findings affirm that a holistic approach to ecotourism management can create sustainable positive impacts for local

communities and the environment, while preserving this valuable natural heritage for future generations.

Recommendations based on these findings underscore the importance of prioritizing active community participation in decision-making and implementing ecotourism management programs. This can be achieved through the provision of comprehensive legal education, involvement in the development of local economic initiatives, and efforts to enhance accessibility and comfort for visitors. Furthermore, policy harmonization, routine environmental monitoring, and the utilization of environmentally friendly technology are also crucial steps to consider in implementing this action plan.

The implications of this study emphasize the need for a holistic and sustainable approach to ecotourism management to achieve a balance between economic development and environmental conservation. By integrating aspects such as community participation, policy harmonization, and the application of environmentally friendly technology, the management of CMC Tiga Warna Ecotourism could serve as an example for other tourist destinations in creating sustainable ecotourism environments that positively impact local communities and valuable natural heritage.

While this research provides valuable insights, several limitations need to be acknowledged to enhance the reliability of the findings. One of them is the limitation in data collection methods, where the use of surveys with questionnaires may limit the depth of analysis. To address this, future research could consider using more diverse data collection methods, such as in-depth interviews or direct observations, to gain a more comprehensive understanding of the phenomena under study. Additionally, limitations in sample coverage also need to be considered, as this study may only cover a small portion of the relevant population. To address these limitations, further research can expand the sample coverage or use more representative sampling techniques. Furthermore, limitations in generalizing the findings also need to be acknowledged, as this research may be limited to specific contexts or populations. To address this, future research can adopt a more holistic approach and integrate broader contexts into their analyses. By identifying these limitations, further research is expected to enhance the reliability and validity of the findings and make a more significant contribution to understanding in the field studied.

To build upon the findings obtained in this research, several directions for future research can be proposed to deepen understanding and its impact in the field studied. Firstly, further research can delve deeper into the use of environmentally friendly technology in ecotourism management, as well as its effectiveness in maintaining the balance between development and environmental preservation. This may involve research on the application of specific technologies in specific ecotourism situations and an analysis of their impact on the environment and local communities. Furthermore, research on community participation in ecotourism management can be expanded to better understand the roles and contributions that various community groups can play in the development and preservation of tourist destinations. This research may include further analysis of factors influencing the level of community participation and strategies to increase their involvement in decision-making processes. Additionally, future research can focus on further evaluating the economic sustainability of the proposed ecotourism management model, including an analysis of its impact on the local economy, job creation, and

income distribution. By continuing in these research directions, it is hoped that there will be a greater contribution to the development of sustainable ecotourism and positive impacts on the environment and local communities.

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