

Water Resource Management Strategy for the Development of Ecotourism in Lake Seran, Banjarbaru Based on Micmac Strategic Variable Typology Analysis

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ABSTRACT

Tourism has great potential to drive economic growth and act as a catalyst for the development of other sectors, and one promising destination in Banjarbaru, South Kalimantan, is Danau Seran, a notable example of transformation from a former mining site operated by PT Galuh Cempaka into a nature-based tourist attraction offering activities such as boating, fishing, and enjoying scenic views. This study aims to formulate a sustainable water resource management strategy to support ecotourism development at Lake Seran, Banjarbaru, using a typology analysis of strategic variables through the MICMAC method. Water resource management in this area is challenging because Lake Seran was formed from a former mining area. The approach used in this study is a prospective structural analysis with in-depth interviews and MICMAC software input to analyze the relationship between variables that influence water management and ecotourism development. The results show that variables such as water quality, land status, and waste management are the main priorities in current management, while tourism policy and product development will be the focus in the future. These findings provide direction for policymakers to design management strategies that are more responsive to changing priorities and evolving dynamics. In conclusion, managing Lake Seran as a sustainable ecotourism destination requires special attention to interacting variables, with a focus on nature conservation and local community empowerment.

INTRODUCTION

Tourism has significant potential to drive economic growth and catalyze the development of other sectors such as transportation, culinary, and hospitality (Farid & Utomo, 2024; Primayesa *et al.*, 2025). Indonesia's tourism sector contributed 5.4% to GDP in 2023, with projections of continued growth as the number of domestic and international tourists increases, and plays a strategic role in diversifying an economy previously reliant on natural resource-based sectors (WTTC, 2023). Tourism development can reduce dependence on

natural resource exploitation and strengthen more sustainable economic sectors, such as tourism itself (Morakabati *et al.*, 2014; Amaliyah & Musa, 2022; Fadli *et al.*, 2024). Ecotourism in Indonesia is growing rapidly, not only providing positive economic impacts but also focusing on nature conservation and empowering local communities (McKinney, 2016). Ecotourism seeks to utilize natural resources without compromising their sustainability and providing sustainable economic benefits to surrounding communities (Kumar & Gupta, 2025; Carter & James, 2025). Effective ecotourism management can achieve a balance between economic benefits and environmental conservation. Many regions in Indonesia are now beginning to optimize their natural tourism potential, which not only has ecological value but also offers significant tourist attractions (Rahma, 2020; Gupta *et al.*, 2023).

Lake Seran in Banjarbaru, South Kalimantan, is a fascinating example of the transformation of a former mining area into a natural tourist attraction. The lake was formed by mining operations by PT. Galuh Cempaka, a coal company. The area was originally a result of mining activity, but over time, the area filled with water, forming a lake. Since 2014, the local community has begun managing the area as a natural tourist destination, offering various activities such as boating, fishing, and enjoying the surrounding natural scenery (Manik & Ulya, 2024). Despite Lake Seran's significant tourism potential, its management faces challenges, particularly in terms of water resource management, which is not yet fully sustainable.

Water resource management in Lake Seran is crucial because it is located in a former mining area, requiring special efforts to maintain water quality and quantity to prevent human activity or environmental changes. The main challenge is ensuring that water management supports the sustainability of the ecosystem and ecotourism, as well as maintaining the natural balance to support the regional economy without damaging the ecosystem (Gössling & Scott, 2012; Samal & Dash, 2023; Rahmat *et al.*, 2023; Liang & Shi, 2023). Ecotourism development in Lake Seran also faces coordination challenges between the government, local communities, and the private sector, as well as the complexities surrounding the status of the former mining area. Unclear land management authority and fragmented institutions hinder effective management, which risks harming the sustainability of the ecotourism area. Therefore, it is crucial to identify strategic variables that need to be considered in the management of this area.

One approach that can be used to formulate a sustainable water resource management strategy is to use MICMAC (Matrice d'Impacts Croisés Multiplication Appliquée à un Classement). This method uses variables that influence ecotourism and water resource management to be analyzed systematically. MICMAC allows us to identify the relationships between variables that influence the sustainability of aquatic ecosystems and ecotourism development. Previous research has shown that with MICMAC, we can map key factors, such as land use, waste management, tourist visit intensity, and water quality, which interact with each other to formulate more effective and evidence-based strategies in sustainable ecotourism and water resource management (Ariyani *et al.*, 2020). Therefore, this study aims to formulate an effective water resource management strategy in Lake Seran, by identifying variables that need to be managed more comprehensively and sustainably., the relationship between strategic variables, both direct and indirect, and developing long-term strategies. Therefore, it is hoped that the results of this study can provide direction in formulating more effective strategies in managing Lake Seran as a sustainable ecotourism destination, by paying attention to natural sustainability, empowering local communities, and clear and regulatory land use.

METHODS

Location and Time of Research

This research was conducted at Lake Seran, Landasan Ulin District, Banjarbaru City, South Kalimantan (Figure 1). Lake Seran is approximately 20 minutes from the center of Banjarbaru City with coordinates $3^{\circ}28'24.6''S$ $114^{\circ}47'20.1''E$. On the other hand, the research time is from August to September 2025.

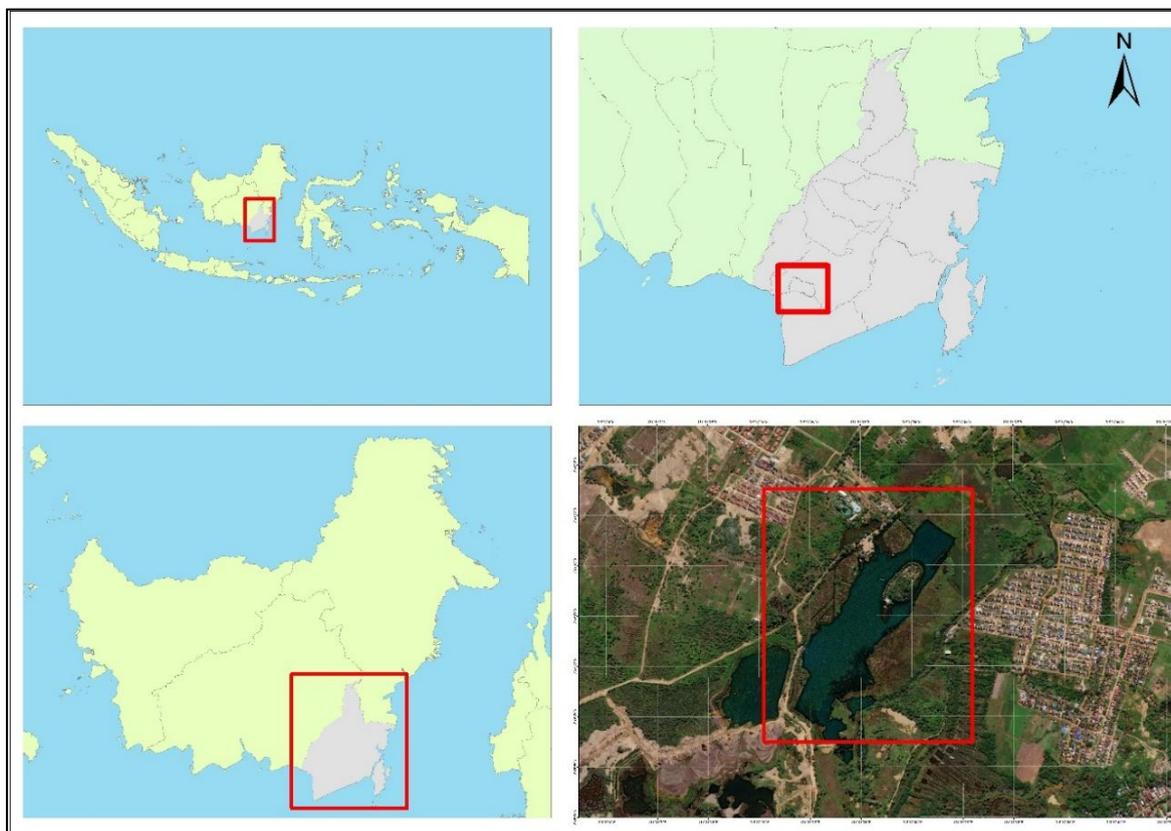


Figure 1. Research Location

Research Tools and Materials

The tools used in this research are writing tools, documentation tools, while the materials used are research instruments in the form of interview guidelines/lists (questionnaires).

Research Respondents

Respondents in this study were selected using purposive sampling, a non probability sampling technique in which participants are deliberately chosen based on specific criteria such as roles, experience, and knowledge to ensure relevant and informative data to address the research objectives (Oranga & Matere, 2023; Palinkas *et al.*, 2015). This technique is appropriate when research requires informants who truly understand the issue being studied for example, the management of Lake Seran so that researchers can dig deeper into the relationships between strategic variables (Palinkas *et al.*, 2015). Therefore, respondents in this study consisted of stakeholders in the Lake Seran area, including managers and tourists, who were selected because they were considered to have adequate knowledge and competence regarding the management and development of Lake Seran ecotourism (Etikan *et al.*, 2016; Oranga & Matere, 2023).

Research Methods

This study uses a prospective structural paradigm to explore the structure, dynamics, and interrelationship networks between variables that influence the development of the Lake Seran ecotourism area. Data collection was conducted through field studies and in-depth interviews with respondents to determine important and influential variables in water resource management and Lake Seran ecotourism development for the input of the MICMAC (Cross Impact Matrix Multiplication Applied to Classification) software used in data analysis. Interview activities used the world café method to encourage interaction, knowledge sharing, and transfer of experience between participants representing managers and tourists, as well as the local community. The variables of this study were quantified using a scale of 0 to 3 as illustrated by Godet (1994):

0 = no relationship (non-existent)

1 = weak relationship (low direct influence)

2 = equal relationship (medium direct influence)

3 = strong relationship (high direct influence)

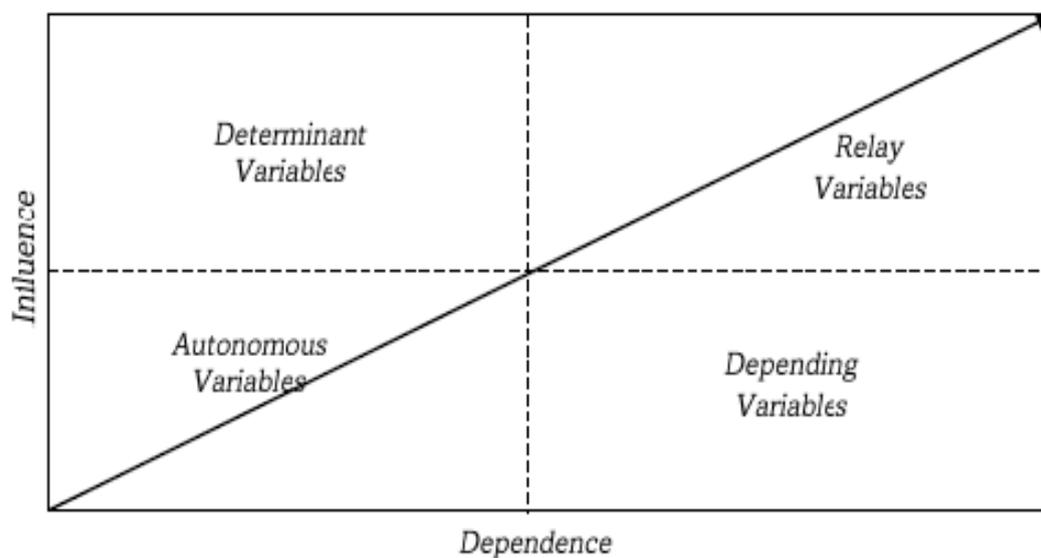


Figure 2. Variable Influence-Dependence Map (Elmsalmi & Hachicha, 2013)

Data analysis was conducted using the Micmac (Cross Impact Matrix Multiplication Applied to Classification) method, which allows for grouping and determining the hierarchy of strategic variables based on their direct, indirect, and potential influences. The influence between variables was analyzed using a quadrant map that groups variables into four typologies (Figure 2): 1) determinant (highly influential variables), 2) relay (highly influential variables that depend on other variables), 3) autonomous (variables with little influence), and 4) output (highly dependent variables) (Albala *et al.* 2009; Delgado Serrano *et al.* 2016). This method aims to identify and analyze the main variables of a system. This is important for identifying strategic variables that can help policymakers formulate effective and sustainable management strategies, and avoid management failures due to focusing on irrelevant variables (Arcade *et al.* 1999; Durance *et al.*, 2006). Thus, Micmac helps to understand the reciprocal influences between variables and provides a deep understanding of the system, which is essential for the successful development of sustainable ecotourism areas.

RESULTS

Matrix of Direct Influence (MDI)

The MDI is the original matrix that serves as input data in the Micmac method. This matrix is filled with values ranging from 0 to 3, along with the symbol P, which is used to indicate the level of intensity of direct influence and direct influence between existing variables. The process of filling in the values in the MDI then contributes to determining the position of each variable on the map of direct influence and dependency, which are then grouped into four typologies based on their influence and dependency (Table 1). The strategic variables of this study consist of ecological categories (water quality, carrying capacity, zoning, and waste management), amenities (water tourism infrastructure and K3), socioeconomic (stakeholder participation and product development), institutional (human resources and institutions), and policy (land status and regulations).

Table 1. Strategic Variables for Developing Lake Seran Ecotourism

N°	LONG LABEL	SHORT LABEL	THEME
1	Quality of lake water environment	KA	Ecology
2	Carrying capacity and capacity of lake ecotourism	DDK_T	Ecology
3	Waste and waste management in tourist areas	Rubbish	Ecology
4	Lake spatial zoning and boundary protection	Zoning	Ecology
5	Basic infrastructure and water tourism facilities	Public Facilities and Infrastructure	Amenities
6	Water tourism safety and risk mitigation	K3	Amenities
7	Institutional management and human resource capacity	HR	Institutional
8	Regulation and enforcement of rules (governance)	policy	policy
9	Land status and legality of the lake area	land	legality
10	Participation and economic benefits of local communities	action	Social
11	Tourism product development and destination marketing	product	economy

Source: MICMAC 2026 Input Results

Variable mapping based on MICMAC analysis shows that no variables are identified in the determinant quadrant, while the relay quadrant identifies land status and lake area legality. The relay quadrant represents the most important variables and requires maximum attention from policymakers. From a systems perspective, variables in this quadrant are process elements that will significantly determine output. Autonomous variables include tourism product development and destination marketing, marine tourism safety and risk mitigation, and local community participation and economic benefits. All variables are considered secondary levers because they are located far from the origin and above the diagonal line. This position means these variables still have little influence on system dynamics if handled appropriately. Therefore, although they are relatively difficult to change and can be ignored, managing these variables, if policymakers have adequate resources, will significantly support successful development (Figure 3).

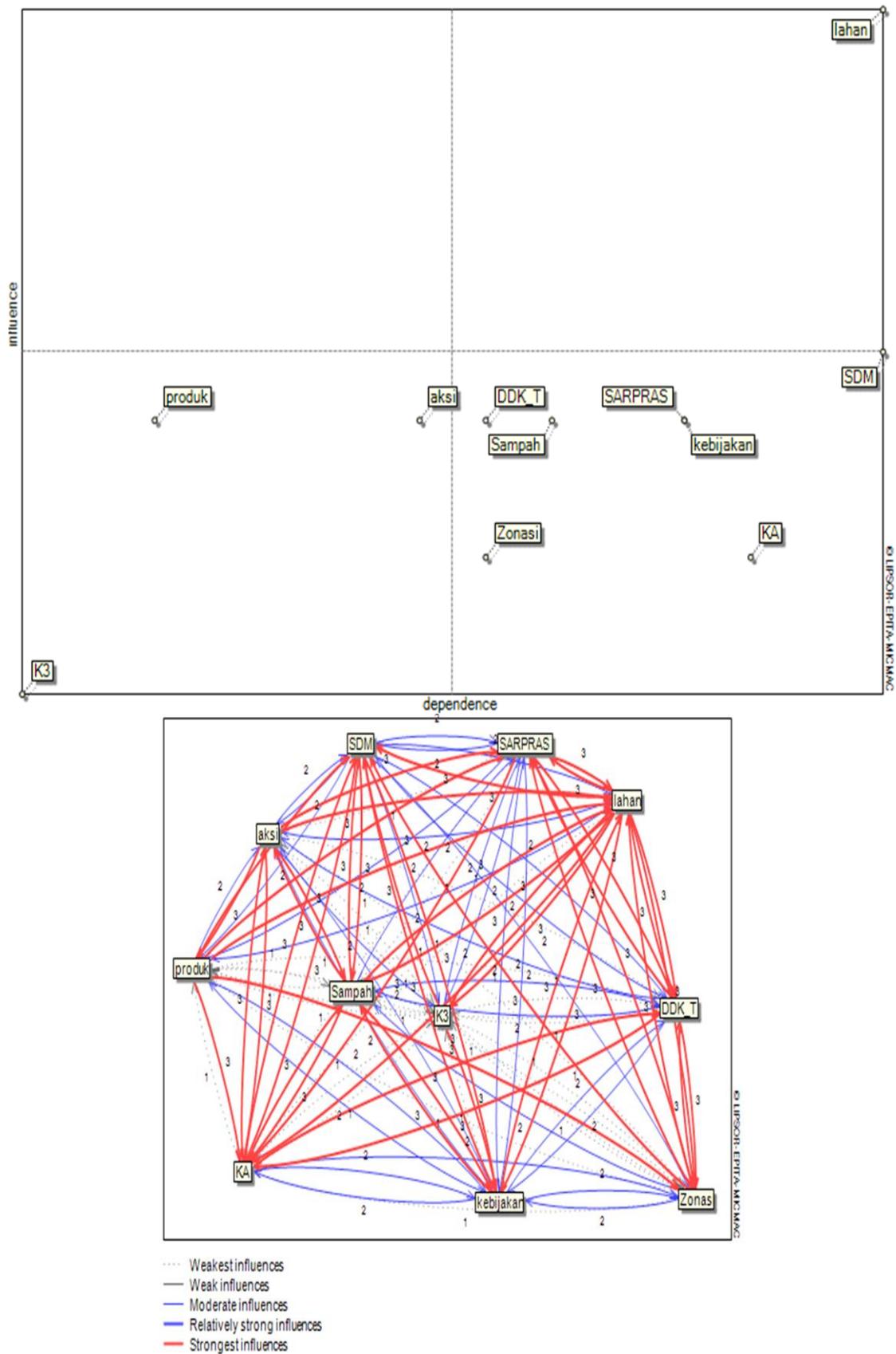


Figure 3. Maps and Graphs of Direct Influence-Dependence Interactions Between Variables
 Source: Results of MICMAC 2026 Processing

Dependent variables include, the carrying capacity and capacity of lake ecotourism, waste and waste management in the tourist area, basic infrastructure and water tourism facilities, the quality of the lake's water environment, lake spatial zoning and boundary protection, regulation and enforcement of rules (governance), management institutions and human resource capacity. These variables are the output of the development of the Lake Seran ecotourism area. The results of this analysis can be a "force" for policy makers to pay greater attention and carry out in-depth analysis of these variables, because they are a hope in the future to overcome problems, especially related to limited employment, poverty and welfare which are quite massive, especially in locations close to the Lake Seran area. The MICMAC mapping graph shows that there is an influence and dependence of variables on each other, which is indicated by arrows and colors that are connected between variables. The variables of land, infrastructure, human resources, water quality, waste, and policy are strongly influenced by other variables, while the product variable strongly influences other variables.

Information regarding the variable typology described above is crucial for policymakers in developing the Lake Seran ecotourism area. Based on the current mapping results, development policies can be focused on the variables with the greatest influence compared to others, particularly determinant and relay variables. By considering these findings, policymakers can design scenarios aimed at driving these variables and monitoring their impact on other variables. This approach will make the policies adopted more effective and can avoid potential future problems caused by inaccurate policy focus.

Matrix of Indirect Influence (MII)

The stability test for variable grouping based on direct influence is conducted by analyzing the indirect influence between variables, taking into account the dynamics of the influence map and the dependencies between variables. If there is a significant change in the position of the variables in the direct influence map, this indicates that the mapping results and the stability of the system are low.

The indirect influence analysis is described in the MII matrix (Matrix of Indirect Influence), which is obtained from the transitivity process of the direct influence matrix (MDI). The analysis results show that there is no change in the position of variables outside the direct influence mapping quadrant (Figure 4), indicating that the system and typology of variables resulting from the direct influence analysis are stable. This finding strengthens the qualification of more adequate variables, which is crucial for accurate decision making (Stratigea & Papadopoulou, 2013).

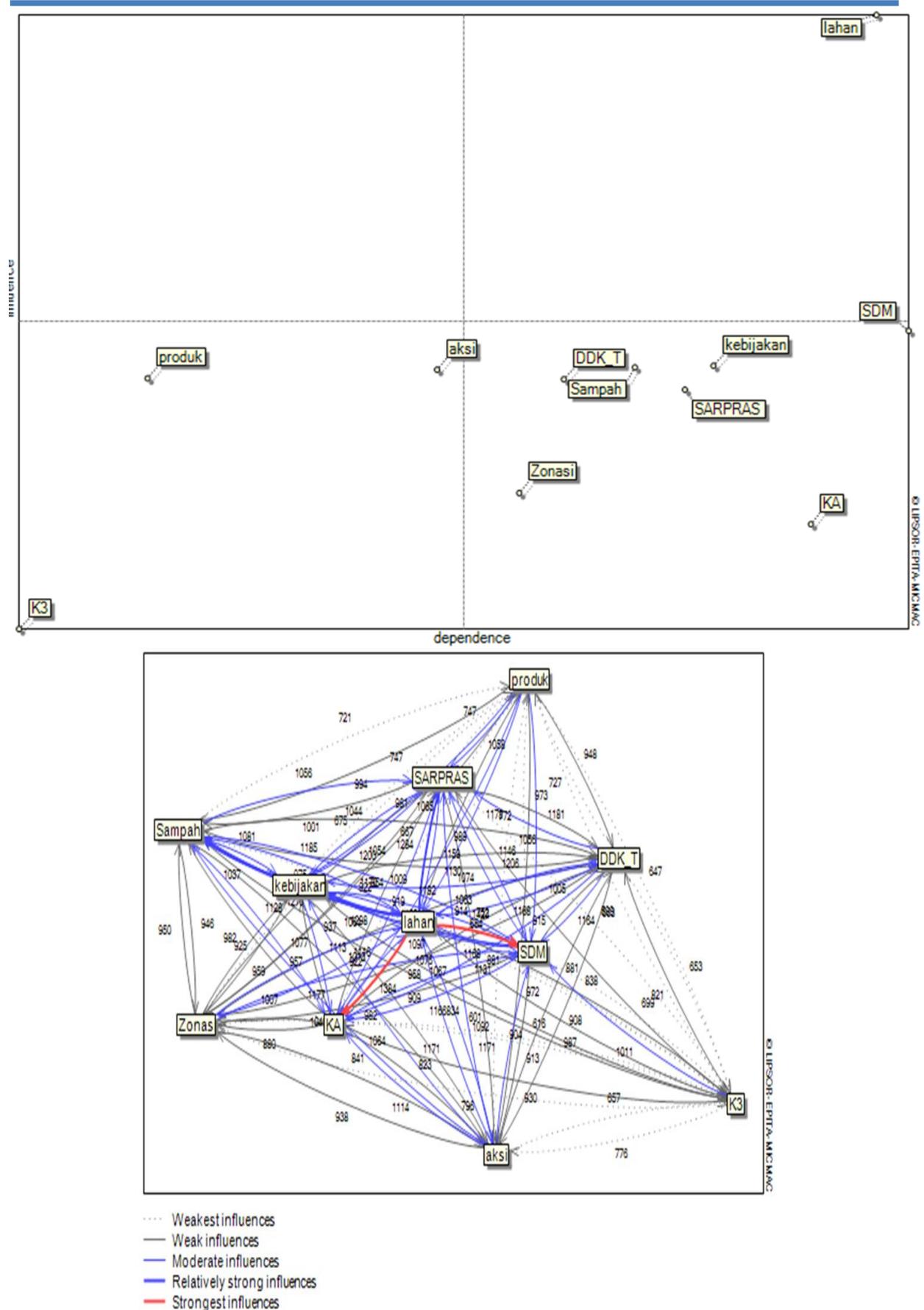


Figure 4. Maps and Graphs of Indirect Influence-Dependence Interactions Between Variables
Source: Results of MICMAC 2026 Processing

Priority

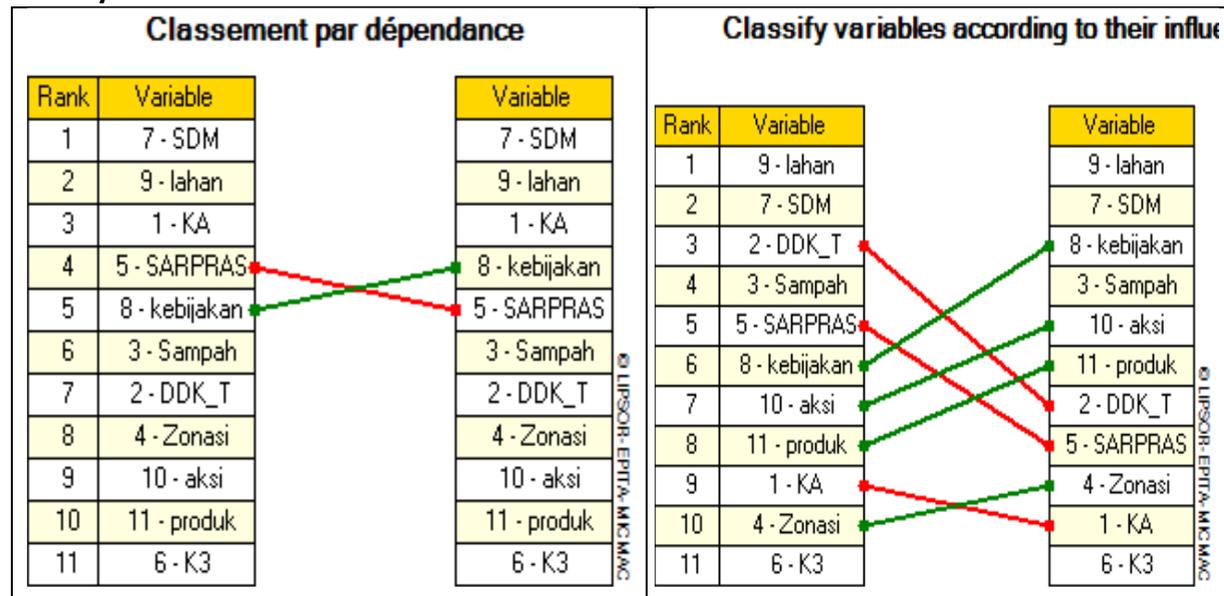


Figure 5. Classification of Changes in the Ranking of MDI Variables to MII Based on the Level of Influence and Dependence

Source: Results of MICMAC 2026 Processing

MICMAC projects changes in variable priorities related to influence and dependency, where the SARPRAS variable will experience a decrease in dependency priority, while policy will increase. In terms of influence, the priority of the DDK_T, SARPRAS, and water quality variables is predicted to decrease, while policy, action, zoning, and product will become top priorities in the future (Figure 5). These results provide guidance for policymakers to anticipate changes in variable priorities, so that policies are more targeted.

Displacement Map

Changes in the position of variables on the influence/dependence map from MDI to MII can be seen through the displacement map shown in Figure 6. This map depicts variables that experience increases, decreases, or remain constant over the long term. Most changes in the position of variables on the displacement map occur within the same quadrant, from MDI to MII.

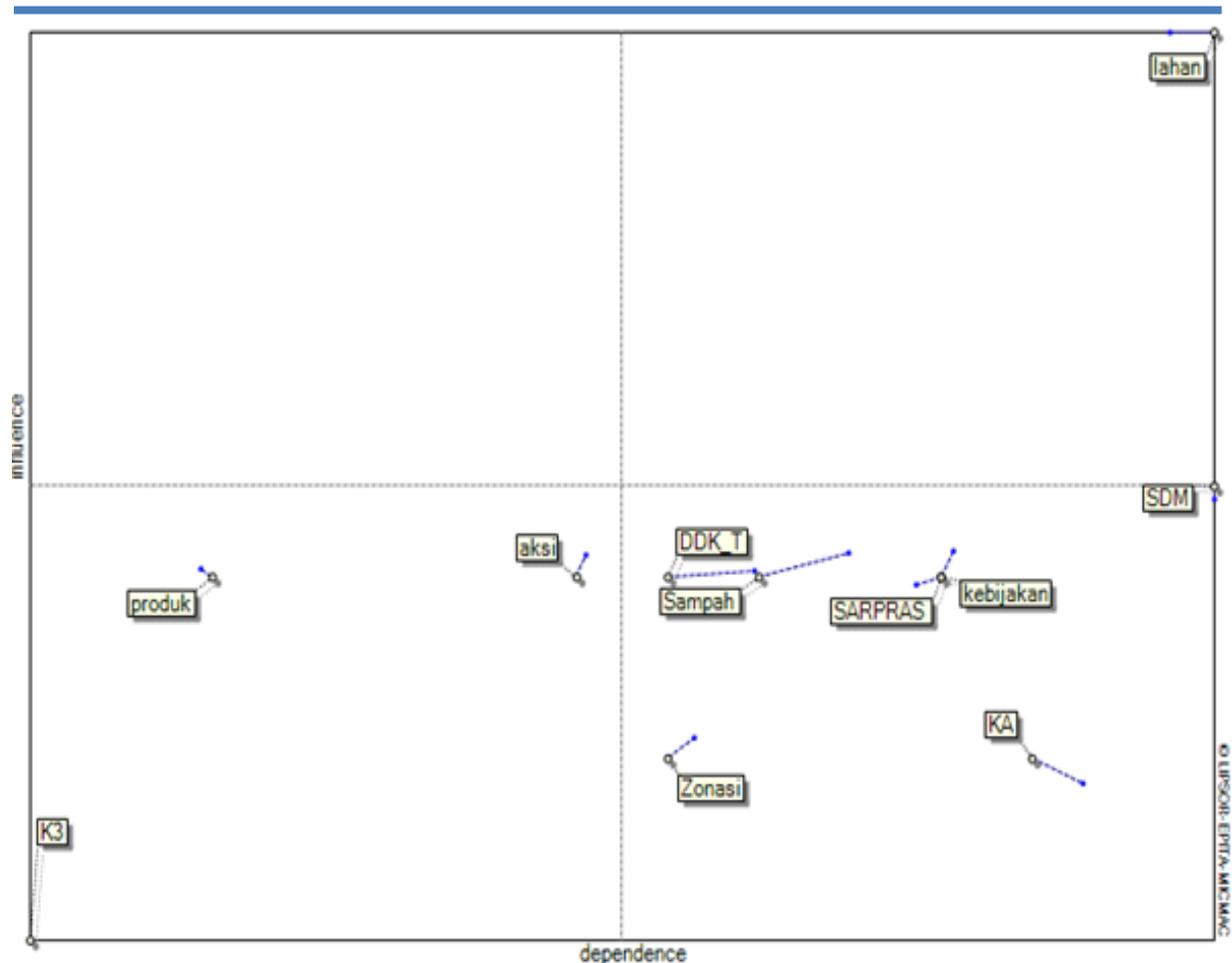


Figure 6. Displacement Map of Direct and Indirect Dependent Influence Variables

Source: Results of MICMAC 2026 Processing

Based on the MICMAC analysis, the Lake Seran ecotourism management and development strategy must focus on managing variables that have a high influence and dependency on the area's sustainability, while adapting to changing priorities in the future. The following table illustrates the variables that require special attention and prioritization in management:

Table 2. Level of Urgency of Strategic Variables for Developing Lake Seran Ecotourism

No	Variables	Current Priorities	Future Priorities
1	Quality of aquatic environment	Tall	Tall
2	Carrying capacity and carrying capacity	Tall	Decrease
3	Waste and waste management	Tall	Decrease
4	Space zoning and protection	Intermediate	Decrease
5	Basic infrastructure and SARPRAS	Intermediate	Decrease
6	Water tourism safety	Intermediate	Decrease
7	Management institutions and human resources	Intermediate	Decrease
8	Regulation and enforcement of rules	Intermediate	Decrease
9	Land status and legality	Tall	Tall
10	Participation and economic benefits	Intermediate	Decrease
11	Tourism product development	Intermediate	Tall

DISCUSSION

The MICMAC analysis reveals that the position of variables in the influence-dependence map can change over time, reflecting the dynamics of the Seran Lake ecotourism system, which requires careful management. Variables such as SARPRAS, water quality, and waste management are strongly influenced by other factors, demonstrating the importance of careful management to maintain the sustainability of the ecosystem and tourism destination. Conversely, variables such as policies, tourism products, and actions have a dominant influence on other variables, making them key elements in ecotourism development and the local economy. Variables in the relay quadrant, such as land status and area legality, require more attention due to their significant impact on area development outcomes. Analysis of indirect influences in the MII matrix confirms that the Seran Lake ecotourism system is relatively stable, thus policies developed based on this mapping are reliable for sustainable management. Projected changes in variable priorities indicate that SARPRAS will decline in priority, while policies will become increasingly important in the future. This mapping provides clear guidance for policymakers to adjust strategic steps according to evolving dynamics, so that implemented policies are more effective in supporting environmentally friendly ecotourism development while benefiting the local economy.

Currently, Lake Seran ecotourism management needs to focus on high-priority variables, such as water quality, land status and area legality, and waste and sewage management. Therefore, policies supporting water quality conservation and sustainable waste management must be strengthened. Furthermore, the management of basic infrastructure and water tourism facilities (SARPRAS) also needs to be improved to support visitor comfort and mitigate negative environmental impacts. Enforcing regulations and empowering management institutions are also key to maintaining the sustainability of ecotourism areas, as stated by Gössling & Scott (2012), who emphasized the importance of collaboration between the public and private sectors in effective ecotourism area management. Sustainability-based area management can minimize negative environmental impacts while increasing social and economic benefits for local communities (Samal & Dash., 2023).

In the future, the primary focus of Lake Seran ecotourism management will shift to variables related to tourism policy and product development, such as policies related to spatial zoning and boundary protection, as well as the development of more sustainable tourism products. SARPRAS (Regional Strategic Plan for Public Works and Public Housing), water quality, and waste management are expected to experience a decline in priority, making it crucial to ensure that existing management policies remain functional. For reference, Liang & Shi (2023) stated that effective ecotourism management relies not only on infrastructure but also on strengthening policies and strategies that support the long-term sustainability of tourism products. Furthermore, developing tourism products that involve local community participation and more effective destination promotion will significantly support local economic growth without damaging the environment. Therefore, anticipating this shift in priorities is crucial to ensure that ecotourism areas continue to develop sustainably and provide optimal economic benefits to local communities (Rahmat *et al.*, 2023).

CONCLUSION

Based on the analysis using the MICMAC method, the management and development of Lake Seran ecotourism must consider the dynamics of changes in the influence and

dependencies between variables in the long term. High-priority variables, such as aquatic environmental quality and land status, need to be managed sustainably to ensure ecosystem sustainability and support local economic development. Meanwhile, variables related to tourism policy and product development are predicted to become increasingly important in the future. Therefore, ecotourism management strategies must be adaptive and responsive to changing dynamics, emphasizing collaboration between the government, local communities, and the private sector to create environmentally friendly and economically viable ecotourism. However, for further research, it is recommended to conduct FGSs with various parties in a comprehensive manner, especially the government, mining parties and village parties.

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REFERENCES

- Albala, M. A., Lozano, M. J. M., & Hernández, P. P. P. (2009). *Prospective Structural Analysis: An Application to Rural Development Strategies*. In *83rd Annual Conference of the Agricultural Economics Society* (pp. 1–17).
- Amaliyah, M., & Musa, S. (2022). Sektor Pariwisata, Pengangguran, dan Pertumbuhan Ekonomi di Indonesia. *Al-Iqtishad Journal*, *18*(1), 100–112.
- Arcade, J., Godet, M., Meunier, F., & Roubelat, F. (1999). Structural Analysis with the MICMAC Method & Actor's Strategy with the MACTOR Method. In *Futures Research Methodology* (pp. 1–69). American Council for the United Nations University: The Millennium Project.
- Carter, P., & James, A. (2025). The Transformative Power of Ecotourism: Social, Economic, and Environmental Impacts. *MDPI*. <https://mdpi.com>.
- Delgado-Serrano, M. M., Ambrosio-Albalá, M., & Francisco, A. (2015). Exploration de l'analyse Structurale Prospective Pour évaluer l'importance du Développement Rural Territorial en Espagne et Nicaragua. *Cuadernos de Desarrollo Rural*, *12*(76), 35–56. <https://doi.org/10.11144/Javeriana.cdr12-76.epsa>.
- Delgado-Serrano, M. M., Vanwildemeersch, P., London, S., Ortiz-Guerrero, C. E., Semerena, R. E., & Rojas, M. (2016). Adapting Prospective Structural Analysis to Strengthen Sustainable Management and Capacity Building in Community-based Natural Resource Management Contexts. *Ecology and Society*, *21*(2). <https://doi.org/10.5751/ES-08505-210236>.
- Durance, P., Gerber, A., Bassaler, N., Menant, I., Monti, R., & Richou, S. (2006). *Strategic foresight: La prospective—Problems and methods*. Cahiers du LIPSOR.
- Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1–4. <https://doi.org/10.11648/j.ajtas.20160501.11>.

- Farid, M. H. M., & Utomo, Y. P. (2024). Pengaruh Perkembangan Sektor Pariwisata dan PAD Sektor Pariwisata Terhadap Pertumbuhan Ekonomi di Provinsi Bali Tahun 2016-2022 (Studi Kasus: 9 Kabupaten/Kota). Muhammadiyah University of Surakarta.
- Gössling, S., & Scott, D. (2012). *Tourism and Water: Interactions, Impacts and Challenges*. Channel View Publications.
- Gupta, R., Kumar, S., & Patel, A. (2023). Economic Impact of Nature-based Tourism. *PLOS ONE*. <https://doi.org/10.1371/journal.pone.0282912>.
- Kumar, S., & Gupta, R. (2025). Ecotourism and Economic Sustainable Development of Local Communities from the Lens of Technological Innovation: The Synergistic Role of Green Industry and Social Capital. *ScienceDirect*. <https://sciencedirect.com>.
- Liang, X., & Shi, Y. (2023). Rational Utilization of Water Resources to Promote Sustainable Ecotourism Development. *Water Science and Technology*. <https://doi.org/10.2166/ws.2023.229>.
- Oranga, J., Matere, A. (2023). Qualitative Research: Essence, Types and Advantages. *Open Access Library Journal*.
- Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. *Administration and Policy in Mental Health and Mental Health Services Research*, 42(5), 533–544. <https://doi.org/10.1007/s10488-013-0528-y>.
- Primayesa, E., Widodo, W., & Sugiyanto, F. X. (2025). *Tourism Spatial Spillover Effect and Economic Growth in Indonesia*. Diponegoro University.
- Rahma, A. A. (2020). Potensi Sumber Daya Alam Dalam Mengembangkan Sektor Pariwisata di Indonesia. *National Journal of Tourism*. https://journal.ugm.ac.id/tourism_pariwisata/article/view/52178.
- Rahmat, A. F., El Archi, Y., Putra, M. A., Benbba, B., Mominov, S., & Dávid, L. D. (2023). Pivotal Issues of Water-based Tourism in Worldwide Literature. *Water*, 15(16), 2886.
- Rahmat, F., Ali, S., & Rani, S. (2023). Assesing Tourism Object Management Towards Sustainable Tourism Development Strategy: A SWOT Analysis. *International Journal of Sustainable Development and Planning*, 15(2), 50–62.
- Samal, R., & Dash, M., (2023). Ecotourism, Biodiversity Conservation and Livelihoods: Understanding the Convergence and Divergence. *International Journal of Geoheritage and Parks* 11 (2023)1-20.
- World Travel & Tourism Council. (2025). *Reporting on the Significant Contribution of the Travel & Tourism Sector to the Global Economy and Employment*. <https://wttc.org>.
- Zhang, S., Wu, Y., & Xu, B. (2023). Rational Utilization of Water Resources to Promote Sustainable Development of Rural Ecotourism. *Water Supply*, 23(9), 3844–3855.