JOURNAL OF WATER AND LAND DEVELOPMENT
e-ISSN 2083-4535
Polish Academy of Sciences (PAN) Institute of Technology and Life Sciences – National Research Institute (ITP – PIB)

JOURNAL OF WATER AND LAND DEVELOPMENT
DOI: 10.24425/jwld.2024.149119
2024, No. 60 (I–III): 177–182

Socioeconomic status, lake knowledge, and community participation in the sustainable Lake Limboto management, Gorontalo Regency

Ramla H. Melo*[1)], Moch R. Pambudi[1)], Alim Niode[2)]

[1)] Universitas Negeri Gorontalo, Geography Education Study Program, Prof. Dr. Ing. B. J. Habibie Street, 96119, Gorontalo, Indonesia

[2)] Universitas Negeri Gorontalo, Department of Animal Husbandry, Prof. Dr. Ing. B. J. Habibie Street, 96119, Gorontalo, Indonesia

* Corresponding author

RECEIVED 12.10.2023 ACCEPTED 03.01.2024 AVAILABLE ONLINE 29.03.2024

Abstract: Lake Limboto, situated in Gorontalo, Indonesia, confronts severe threats jeopardizing its sustainability. Widespread deforestation in the watershed area has led to excessive sedimentation within the lake, consequently diminishing its water storage capacity and compromising its flood control function. This degradation has manifested itself in downstream droughts during the dry season and flooding during the rainy season. Historical data reveals a stark reduction in Lake Limboto's size, plummeting from approximately 3,644.5 ha in 1991 to around 2,693.9 ha in 2017. This study aims to provide comprehensive examination of the interplay between the socioeconomic status of the local community and their understanding of the lake ecosystem. Furthermore, it delves into how these factors produce synergies that shape and impact community involvement in sustainable lake management initiatives. Hypothesis testing yielded significant results, affirming the existence of a positive correlation between socioeconomic status, knowledge of the lake ecosystem, and active community participation in sustainable lake management efforts. The findings underscore the critical importance of socioeconomic factors that need to be considered when designing strategies for the preservation and sustainable management of Lake Limboto. Integrating the community into conservation initiatives is necessary, given their intrinsic relationship with the lake. By acknowledging and leveraging the nexus between socioeconomic status, ecological knowledge, and active participation, stakeholders can formulate more effective and inclusive strategies for safeguarding Lake Limboto's ecological integrity. This study contributes valuable insights for policymakers, environmentalists, and local communities alike, emphasizing the necessity of collaborative efforts to ensure the long-term resilience and vitality of Lake Limboto.

Keywords: community participation, ecosystem knowledge, environmental conservation, Lake Limboto, socio-economic status, sustainable management

INTRODUCTION

Lake is a basin that occurs due to natural events or deliberately made by humans to retain water that comes from rain, springs and/or rivers. In addition to the provision of clean water for domestic use, agricultural irrigation, and water transportation, lakes support life of various aquatic biota, and provide water management and flood control functions. Indonesian lakes, including Lake Limboto, suffer from lake siltation, pollution, eutrophication, introduction of alien species, resource exploitation, declining lake water levels, and conflicts over lake water utilisation (Stow *et al.*, 2023).

Lake Limboto currently faces serious threats to its sustainability. Deforestation in the watershed has caused increased sedimentation in the lake. It reduced water storage capacity and disrupted the flood control function, resulting in drought in the downstream area. The destruction of Lake Limboto's ecosystem has resulted in floods during the rainy season and droughts during the dry season. Historical data shows a dramatic change in the size of Lake Limboto, which in 1991 reached approximately

3,644.5 ha, reduced in 2017 to approximately 2,693.9 ha (Kusmajaya *et al*., 2023; Mahmud *et al*., 2023). The siltation of the lake is caused by continuous tree felling, erosion due to shifting cultivation activities, and overgrowth of wild plants, such as water hyacinth. These conditions disrupt the lake ecosystem, slow down the decomposition of organic matter, and accelerate sedimentation at the bottom of the lake (Yunginger *et al*., 2018). In addition, the community's habit of building structures and houses around the lake, and poor drainage management have caused domestic waste to enter the lake, degrading water quality and damaging the lake function as a source of clean water, habitat for aquatic biota, as well as water management and flood control functions.

Addressing these serious problems and restoring Lake Limboto's functional sustainability require a series of targeted actions involving the cooperation of all stakeholders. One key step is to rehabilitate forests in the watershed by replanting vegetation that has been lost. In addition, sustainable land conservation practices need to be adopted to reduce soil erosion. Controlling the growth of wild plants, such as water hyacinth, and restoring aquatic ecosystems should also be prioritised. Aside from the environmental aspect, it is important to improve drainage and domestic waste management around the lake to ensure water quality. Community empowerment in lake management and awareness of the importance of lake ecosystems must be increased through education and active involvement in conservation efforts (Long *et al*., 2022). With an integrated and sustainable approach, we may hope that Lake Limboto recovers and fulfil its important role of providing clean water, restoring a balanced living environment, and a flood control tool for the surrounding area.

While efforts to conserve Lake Limboto through the abovementioned actions have the potential to improve the lake's condition, there are several weaknesses that must be addressed. First, stronger coordination between the government, non-governmental organisations and local communities is needed (Lamangida, 2021). At times, the lack of synergy among these stakeholders can hinder the implementation of conservation programmes. Secondly, insufficient resources, including funds, personnel and technology, may be an obstacle in the implementation of a comprehensive preservation programme (Melo *et al*., 2020). In addition, the challenge of changing people's behaviour to make it more sustainable and care for the environment also need to be addressed, as this requires a change in culture and values. Unfortunately, the process may take a long time. Finally, ongoing monitoring and assessment of conservation actions are critical and require long-term commitment and continued availability of resources. In the face of these weaknesses, we need a strong commitment from all parties involved to restore the sustainability of Lake Limboto.

It is important to recognise that the socioeconomic and cultural conditions of communities surrounding Lake Limboto have a significant impact on sustainable lake management efforts. Limited awareness of the need to preserve the lake and inadequate knowledge have contributed to problems such as pollution and siltation in Lake Limboto. Therefore, immediate action is needed to protect the lake's ecosystem and its habitat. One important step is to increase public understanding of the role played by the environment, especially lake ecosystems. This can be done by disseminating information to the public, especially to those living around Lake Limboto. Out-of-school education, environmental workshops, and media exposure can be used to convey important messages about the sustainability of the lake. In addition, efforts should be made to stimulate community interest and active participation in environmental conservation and management programmes. This includes the involvement in supervision, monitoring and maintenance of the lake. By pursuing an integrated approach, promoting education, awareness and active community participation, we can expect that the communities around Lake Limboto will become strong partners in preserving the lake. This will contribute significantly to the preservation of the lake ecosystem as an important habitat for all.

The purpose of this study is to provide a holistic analysis of the relationship between the community's socioeconomic status and knowledge of the lake ecosystem, as well as how these factors interact and influence the level of community participation in the sustainable management of Lake Limboto in Gorontalo District.

MATERIALS AND METHODS

The research uses a survey method combined with correlation techniques to show how the extent of the relationship between variables. The research consists of independent variables and dependent variables. Independent variables are socioeconomic status (X_1) and lake ecosystem knowledge (X_2), whereas the dependent variable is community participation in sustainable lake management (Y).

The study used primary data. Primary data was obtained from research subjects from two sub-districts, namely Limboto and West Limboto Sub-districts. The sample population was 100 households from Limboto and Limboto Barat Sub-districts. Primary data include: a) community participation in sustainable lake management, b) socioeconomic status, and c) lake ecosystem knowledge. Research instruments and indicators can be seen in Tables 1–3.

In the early stages of testing, data analysis techniques involve analytical requirements that test the assumptions. The assumptions used include: (1) relationship between Y with X_1, (2) relationship between Y with X_2, and (3) relationship between Y with X_1 and X_2. The requirements that must be met before the regression and correlation analyses for hypothesis testing are: (1) sample must be taken randomly and meet minimum sample requirements, (2) for each price group of predictor X, respondent Y must

Table 1. Community participation in sustainable lake management

Management aspect	Indicators of participation			total item
	utilisation	preservation	development	
	questionnaire item number			
Planning	1, 22, 23	3, 4, 20, 21	2, 13, 18, 19	11
Implementation	5, 6	7, 8, 9	10, 11, 17	8
Monitoring	11, 12, 25	14, 15, 16	–	6
Total item				**25**

Source: own elaboration.

Table 2. Socioeconomic status

Aspect	Indicator	Questionnaire item number	Total item
Social economy	education level	1, 2	2
	income level and life asset owner	3–14	12
	employment status	15–18	4
Social	position in government	19	1
	position in customary	20, 23, 24, 25	4
	position in religious organisations	21, 22	2
Total item			**25**

Source: own elaboration.

Table 3. Lake ecosystem knowledge

Knowledge indicator	Dimension of the lake ecosystem			total item
	ecosystem structure	ecosystem function	relationship between ecosystems	
	questionnaire item number			
Facts	2, 3	7, 8	13	5
Term	1, 4	9, 10	14, 15	6
Concept	5, 6	11, 12	16, 17, 18	7
Procedure	19, 20	23, 24	27, 28	6
Principles	21, 22	25, 26	29, 30	6
Total item				**30**

Source: own elaboration.

be independent and normally distributed, (3) for the price group, the variance of S_2 X must be the same. Thus, the requirements of the analysis include: representativeness test, normality test, homogeneity test, and multicollinearity test.

RESULTS AND DISCUSSION

The results of the research include the following data: a) community participation in sustainable lake management, b) socioeconomic status, and c) lake ecosystem knowledge. These three sets of data will be discussed in the following paragraphs.

Research results regarding community participation in sustainable lake management are presented in Table 4.

Data grouping is based on calculations using Sturges rule. Sturges rule used $Y_2 = a + bX_2$ and $Y - Y_2$. The following data centering values were as follows: mode = 47.90, median = 47.90, and mean = 47.61.

Presentation of research results regarding socioeconomic status data is presented in Table 5.

Data grouping is based on calculations using Sturges rule. The data centering values were as follows: mode = 54.50, median = 54.67, and mean = 54.81.

Table 4. The *Acropora* sp. growth rates reported in other studies

No.	Interval class	Absolute frequency	Relative frequency
1	34–37	5	5.56
2	38–41	9	10.00
3	42–45	16	17.78
4	46–49	25	27,78
5	50–53	19	21.11
6	54–57	14	15.56
7	58–61	2	2.22
Amount		**90**	**100.00**

Source: own study.

Table 5. Socioeconomic status score frequency distribution

No.	Interval class	Absolute frequency	Relative frequency
1	38–42	3	3.33
2	43–47	13	14.44
3	48–52	19	21.11
4	53–57	23	25.56
5	58–62	17	18.89
6	63–67	11	12.22
7	68–72	4	4.44
Amount		**90**	**100.00**

Source: own results.

Presentation of research results regarding lake ecosystem knowledge data is presented in Table 6.

Data grouping is based on calculations using Sturges rule. The data centering values were as follows: mode = 10.61, median = 10.75, and mean = 10.83.

Before hypothesis testing, a prerequisite test was conducted. Prerequisite tests include a normality test and homogeneity test.

Table 6. Frequency distribution of lake ecosystem knowledge score

No.	Interval class	Absolute frequency	Relative frequency
1	4–5	5	5.56
2	6–7	11	12.22
3	8–9	14	15.56
4	10–11	24	26.67
5	12–13	19	21.11
6	14–15	14	15.56
7	16–17	3	3.33
Amount		**90**	**100.00**

Source: own results.

The results of the two prerequisite tests are described below. Normality test results can be concluded based on $L_0 < L_{0.01}$ then the data is normally distributed. The results of the normality test can be seen in Table 7.

Table 7. Normality test results

Estimation error	L_0	L_t $\alpha = 0.01$	Distribution
$Y - \hat{Y}_1$	0.0483	0.1087	normal
$Y - \hat{Y}_2$	0.0809	0.1087	normal

Explanations: L_0 = Lilliefors test result, L_t = table Lilliefors.
Source: own study.

Table 7 shows that the price of L_0 estimated error data 1 ($Y - \hat{Y}_1$) by 0.0483 and L_0 estimated error data 2 ($Y - \hat{Y}_2$) by 0.0809. These two calculation results show that $L_0 < L_t$ at $\alpha = 0.1$ by 0.1087. Thus, it can be concluded that the error data 1 ($Y - \hat{Y}_1$) dan 2 ($Y - \hat{Y}_2$). normally distributed.

The results of the homogeneity test can be found in Table 8.

Table 8. Homogeneity test results

Variance	*df*	X^2_{cal}	X^2_{tab} $\alpha = 0.01$	Conclusion
Y over X_1	64	24.1122	44.3	homogeneous
Y over X_2	76	24.4479	27.76	homogeneous

Explanations: *df* = degrees of freedom.
Source: own study.

Based on the homogeneity testing table, it can be concluded that the variation of Y (community participation in sustainable lake management) on X_1 (socioeconomic status) and the variation of Y on X_2 (knowledge of lake ecosystem) are homogeneous.

According to the results, the two prerequisite tests have been met. Thus, the requirements for using parametric statistics to test the research hypothesis have been met as well. The hypothesis test used in this study is a multiple regression test. The results of the hypothesis test regarding the relationship between a socioeconomic status and lake ecosystem knowledge with community participation in sustainable lake management are as follows: $df = 2/87$, $r = 0.59$, $R^2 = 0.3472$, $F_{cal} = 23.13$, F_{tab} (at $\alpha = 0.01$) = 4.88, and F_{tab} (at $\alpha = 0.05$) = 3.44.

Thus, the relationship between the socioeconomic status and lake ecosystem knowledge with community participation in sustainable lake management is highly significant. So the null hypothesis is rejected, meaning that there is a significant relationship between the socioeconomic status and lake ecosystem knowledge with community participation in sustainable lake management.

Based on the regression equation $Y = 25.56 + 0.261X + 0.731X_2$, it can be seen that knowledge of the lake ecosystem (0.731) has a higher significance than the socioeconomic status (0.261) in determining the level of community participation in sustainable lake management. An increase in the lake ecosystem knowledge score has a greater impact on community participation than an increase in the socioeconomic status score. This understanding is important in evaluating the influence of independent variables on community participation, which can be taken into consideration in developing sustainable lake management policies. The importance of community participation indicators in lake management is not only determined by socioeconomic factors and ecosystem knowledge, but also by abiotic and biotic components. Factors such as climate change also play an important role in influencing the level of community participation. Therefore, in considering the sustainability of lake management, it is necessary to consider the influence of these environmental factors. In addition, in the context of equation 25.56, further explanation is needed regarding the indicators and their relevance to the variables they indicate. Further investigation into the factors expressed in the regression equation may provide a deeper understanding of the role of the independent variables in determining community participation in sustainable lake management.

The socioeconomic status is a concept that refers to the position of a person or a group of people in society. The factors that form the basis for determining socioeconomic status include social aspects, such as level of education, type of work, position in an organisation, and level of health. In addition, economic factors also play an important role in determining the socioeconomic status, such as the level of income, home ownership, type and size of house, and the ownership of other goods and facilities (Melo *et al.*, 2019; Ab Manaf *et al.*, 2023). All these factors together form a comprehensive picture of the socioeconomic status of a person or a group in society. By understanding this concept, we can analyse and understand various important aspects in research related to socioeconomic status and its impact in a broader social and economic context (Firyal Akbar, Alkatiri and Tuli, 2022; Han *et al.*, 2023). A better socioeconomic level is expected to support development efforts and activities, especially sustainable lake management.

Knowledge of lake ecosystems includes an understanding of the complex dynamics involving interactions between various components of the ecosystem. This includes the relationships between the biotic components (living organisms) and abiotic components (non-living factors) within the lake. This knowledge is crucial, as it allows us to understand how these interactions impact the survival of various organisms that inhabit the lake (Ebner, Schirpke and Tappeiner, 2022; Velie, Poulos and Green, 2023). In addition, understanding the function of lake ecosystems is also crucial, as they play an important role in carrying out ecological functions that support life around them (Desta, 2021; McGregor *et al.*, 2023). Thus, lake ecosystem knowledge is not only the understanding of the structure and components of the ecosystem itself, but also the understanding of the role and contribution of ecosystems in maintaining the ecological balance and sustainability of the surrounding environment.

Community participation in sustainable lake management has great significance. It integrates the communities involved in the management of the Limboto Lake, both directly and indirectly. With this involvement, it is expected that the status of Lake Limboto will be sustainable. The community

participation in the maintenance of the lake is a key to ensure that benefits provided by the lake can be enjoyed sustainably by current and future generations (Zhong *et al*., 2022). Thus, active community participation in sustainable lake management is a determining factor for the preservation of the lake and ensuring that the lake resources will continue to provide sustainable benefits for the entire community (Melo and Samatowa, 2023).

Based on the considerations presented earlier, it was found that an improvement in the socioeconomic status of the community could potentially influence the level of knowledge regarding the lake ecosystem (Yu *et al*., 2023). In other words, people who have a better socioeconomic status tend to have deeper understanding of the lake ecosystem. Therefore, it can be anticipated that the higher a person's socioeconomic status, the more likely they are to engage in activities that support lake conservation, thus supporting the goal of sustainable management of Lake Limboto.

CONCLUSIONS

There is a positive relationship between socioeconomic status and lake ecosystem knowledge, as well as community participation in sustainable lake management. The existence of this relationship means that the higher the socioeconomic status and lake ecosystem knowledge, the higher the community participation in sustainable lake management. Conversely, the lower the socioeconomic status and lake ecosystem knowledge, the lower the community participation in sustainable lake management. In other words, the higher a person's socioeconomic status and the better the knowledge of the lake ecosystem, the wiser and better the community participation in sustainable lake management.

CONFLICT OF INTERESTS

All authors declare that they have no conflict of interests.

REFERENCES

Ab Manaf, N. *et al*. (2023) "Assessing wellbeing: Profiling and socioeconomic status of Kenyir Lake side community, Malaysia," *Heliyon*, 9(6), e16399. Available at: https://doi.org/10.1016/J.HELIYON.2023.E16399.

Desta, H. (2021) "Local perceptions of ecosystem services and human-induced degradation of lake Ziway in the Rift Valley region of Ethiopia," *Ecological Indicators*, 127, 107786. Available at: https://doi.org/10.1016/J.ECOLIND.2021.107786.

Ebner, M., Schirpke, U. and Tappeiner, U. (2022) "Combining multiple socio-cultural approaches – Deeper insights into cultural ecosystem services of mountain lakes?," *Landscape and Urban Planning*, 228, 104549. Available at: https://doi.org/10.1016/J.LANDURBPLAN.2022.104549.

Firyal Akbar, M., Alkatiri, R. and Tuli, Z. (2022) "Socio-economic aspects of community in Limboto Lake management in Telaga Biru District, Gorontalo Regency," *Journal La Bisecoman*, 3(2), pp. 59–64. Available at: https://doi.org/10.37899/JOURNAL-LABISECOMAN.V3I2.590.

Han, W. *et al*. (2023) "Anthropogenic activities altering the ecosystem in Lake Yamzhog Yumco, southern Qinghai-Tibetan Plateau," *Science of The Total Environment*, 904, 166715. Available at: https://doi.org/10.1016/J.SCITOTENV.2023.166715.

Kusmajaya, F. *et al*. (2023) "Assessment of the condition of Limboto Lake as a flood control storage," *Journal of Hunan University Natural Sciences*, 50(7). Available at: https://doi.org/10.55463/ISSN.1674-2974.50.7.15.

Lamangida, T. (2021) "Design model management of Limboto Lake based on Good Society Governance (Gsg) Indonesia," *Turkish Online Journal of Qualitative Inquiry*, 12(3), pp. 3831–3844. Available at: https://www.tojqi.net/index.php/journal/article/view/1871 (Accessed: Febuary 8, 2024).

Long, X. *et al*. (2022) "Evaluation and analysis of ecosystem service value based on land use/cover change in Dongting Lake wetland," *Ecological Indicators*, 136, 108619. Available at: https://doi.org/10.1016/J.ECOLIND.2022.108619.

Mahmud, M. *et al*. (2023) "An analysis of water quality of Lake Perintis and Lake Limboto as irrigation water sources in Gorontalo Province," *Advances in Science and Technology*, 128, pp. 63–71. Available at: https://doi.org/10.4028/P-L3RP7I.

McGregor, D. *et al*. (2023) "Towards meaningful research and engagement: Indigenous knowledge systems and Great Lakes governance," *Journal of Great Lakes Research*, 49, pp. S22–S31. Available at: https://doi.org/10.1016/J.JGLR.2023.02.009.

Melo, R.H. *et al*. (2019) "A stakeholder analysis of sustainable mangrove management in Kwandang, Sub-district of North, Gorontalo District," *IOP Conference Series: Earth and Environmental Science*, 399(1). Available at: https://doi.org/10.1088/1755-1315/399/1/012071.

Melo, R.H. *et al*. (2020) "Short communication: Mangrove forest management based on multi dimension scalling (RAP-Mforest) in Kwandang Sub-district, North Gorontalo District, Indonesia," *Biodiversitas Journal of Biological Diversity*, 21(4), pp. 1352–1357. Available at: https://doi.org/10.13057/BIODIV/D210411.

Melo, R.H. and Samatowa, L. (2023) "Analisis vegetasi mangrove di desa Katialada, Bulalo, Leboto, Botungobungo, Kecamatan Kwandang Gorontalo Utara [Analysis of mangrove vegetation in Katialada, Bulalo, Leboto, Botungobungo villages, Kwandang District, North Gorontalo]," *Normalita (Jurnal Pendidikan)*, 11(2), pp. 375–381. Available at: https://ejurnal.pps.ung.ac.id/index.php/JN/article/view/2145 (Accessed: February 8, 2024).

Santhanam, H. and Majumdar, R. (2022) "Quantification of green-blue ratios, impervious surface area and pace of urbanisation for sustainable management of urban lake – land zones in India – A case study from Bengaluru city," *Journal of Urban Management*, 11(3), pp. 310–320. Available at: https://doi.org/10.1016/J.JUM.2022.03.001.

Stow, C.A. *et al*. (2023) "Lake Erie hypoxia spatial and temporal dynamics present challenges for assessing progress toward water quality goals," *Journal of Great Lakes Research*, 49(5), pp. 981–992. Available at: https://doi.org/10.1016/J.JGLR.2023.02.008.

Velie, R.E., Poulos, H.M. and Green, J.M. (2023) "Exploring lake user and manager knowledge of aquatic invasive species in New Hampshire freshwater lake systems, USA. *Journal for Nature Conservation*, 73, 126405. Available at: https://doi.org/10.1016/J.JNC.2023.126405.

Yu, J. *et al*. (2023) "Spatiotemporal dynamic impacts of Lake Victoria water volume variations on sustainable economic development," *International Journal of Applied Earth Observation and Geoinformation*, 123, 103475. Available at: https://doi.org/10.1016/J.JAG.2023.103475.

Yunginger, R. *et al.* (2018) "Lithogenic and anthropogenic components in surface sediments from Lake Limboto as shown by magnetic mineral characteristics, trace metals, and REE geochemistry," *Geosciences*, 8(4), 116. Available at: https://doi.org/10.3390/GEOSCIENCES8040116.

Zhong, S. *et al.* (2022) "Sustainability assessment in the anthropocentric watershed based on emergy and decomposition methods: A case study of Erhai Lake Basin, southwest China," *Ecological Indicators*, 139, 108932. Available at: https://doi.org/10.1016/J.ECOLIND.2022.108932.