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Empowering Bulota Village Communities through Lake Limboto Water Quality Monitoring

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Abstract

Lake Limboto is a strategic freshwater ecosystem in Gorontalo Province whose declining water quality, driven by sedimentation, water hyacinth proliferation, and domestic waste, threatens fisheries productivity and the welfare of surrounding communities, particularly in Bulota Village, Telaga Jaya District. Coastal residents in this area have limited knowledge and technical capacity to monitor water quality independently. This community engagement program therefore aimed to build local capacity for participatory water quality monitoring and to strengthen blue economy literacy. Activities included a preliminary field survey, coordination with the village government, technical training and field practice in measuring pH, Total Dissolved Solids (TDS), and Dissolved Oxygen (DO), formation of a village monitoring group, and development of manual and digital logbooks. Measurements at three observation stations around Lake Limboto showed pH, TDS, and DO values within the Class III water quality standard for fisheries. Participants gained the ability to operate simple monitoring instruments and record data systematically, and a village-based monitoring group was established as an institutional foundation for continued, community-driven monitoring. Community empowerment through participatory water quality monitoring and blue economy literacy is therefore an effective strategy for supporting the long-term sustainability of Lake Limboto and the welfare of its coastal communities.

Keywords: *Lake Limboto; Water Quality; Coastal Communities; Monitoring; Blue Economy.*

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INTRODUCTION

Lake Limboto is a strategic lake in Gorontalo Province that provides essential ecological, social, and economic functions for

surrounding communities, supplying livelihoods for local fishers, water for agriculture, and regulating the regional hydrological system (Krismono et al., 2017). Coastal villages around the lake, including Bulota Village, Telaga Jaya District, depend heavily on capture fisheries, small-scale aquaculture, and fish processing, so the sustainability of the lake's water quality is directly tied to local livelihoods and welfare.

Like many inland lakes in Indonesia, Lake Limboto faces mounting pressure from sedimentation, eutrophication, and pollution from domestic and agricultural waste (Yuningsih & Ngabito, 2018). Soil erosion and land-use change in the watershed accelerate sediment inflow (Asri et al., 2025), while nutrient loading from fertilizers and household waste fuels the rapid growth of water hyacinth and other aquatic weeds, reducing dissolved oxygen and disrupting aquatic life (Supu et al., 2026). Left unaddressed, these pressures reduce fish populations and, in turn, the income of households that depend on the lake.

The residents of Bulota Village exemplify this vulnerability. A preliminary field survey conducted by the implementation team found that most households depend on a single source of income from capture fisheries or small-scale aquaculture, that water hyacinth cover and sedimentation along the village shoreline have visibly increased in recent years, and that residents have no established means of measuring basic water quality parameters or linking them to declining catches. Without access to simple monitoring tools and skills, the community remains a passive observer of environmental change rather than an active participant in managing it (Dominguez-Rendón et al.,

2024), and local groups such as fishers' associations have not yet been engaged as partners in environmental stewardship.

Water quality monitoring is therefore a fundamental instrument for the sustainable management of Lake Limboto, enabling the early detection of environmental change before it becomes more severe (Batina & Krtalić, 2024). Training coastal communities to conduct this monitoring themselves is a practical response, focusing on parameters that are both meaningful for fisheries productivity and feasible for community-based measurement (Sholihah & Gharesifard, 2025): it builds locally owned knowledge of water sampling, instrument use, and data recording, consistent with the principle of participatory monitoring.

This community engagement program therefore aimed to: (1) improve community understanding of water quality parameters and train residents in practical water sampling and measurement using simple equipment; (2) strengthen community capacity to systematically record, process, and interpret water quality monitoring data; and (3) increase community participation in the environmental management of Lake Limboto through a participatory monitoring approach.

METHODS

This program was designed to empower the coastal community of Lake Limboto through an integrated approach encompassing education, technical training, mentoring, and institutional strengthening grounded in the principles of the blue economy. The implementation strategy was systematically and participatively developed to address the challenges faced by the partner community, particularly those related to fisheries production, data management, blue economy literacy, and community

institutional development. Each stage of the program was directed toward generating practical and sustainable solutions that could be independently implemented by the coastal community of Bulota Village, Telaga Jaya District, Gorontalo Regency.

The program commenced with a preparatory phase. During this stage, the implementation team conducted a field survey to obtain an initial understanding of community conditions, the lake's coastal environment, fisheries activities, and the challenges encountered by the partner community. Based on the needs assessment conducted in the field, the team subsequently determined the implementation site and target participants. Coordination was also undertaken with the Government of Bulota Village, Telaga Jaya District, Gorontalo Regency, to secure institutional support and ensure that the program was implemented in accordance with local social conditions. In addition, the team prepared all supporting facilities and equipment required for the activities, including water quality monitoring instruments, training materials, educational modules, and field practice equipment. During this phase, the structure of the training and mentoring activities to be delivered to the coastal community was also developed.

The program was implemented in Bulota Village, Telaga Jaya District, Gorontalo Regency, and involved coastal residents directly engaged in capturing fisheries, small-scale aquaculture, and fish processing, together with representatives of the village government and local youth. Water quality monitoring was carried out at three observation stations representing the stretch of Lake Limboto adjacent to Bulota, Hutadaa, and Buhu villages, using a portable multiparameter

water quality meter to measure pH, Total Dissolved Solids (TDS), and Dissolved Oxygen (DO).

The implementation strategy for the economic-sector partner focused on two primary aspects: production and management. Within the production aspect, the principal challenge faced by the community was declining fisheries productivity. Consequently, the program began with the identification of production-related issues through a preliminary survey examining fish species cultured or harvested, catch volumes, and constraints associated with water quality. These baseline data served as the foundation for designing technical interventions tailored to community needs.

Following the initial assessment, community members participated in technical training on water quality. The training introduced key water quality parameters, including pH, dissolved oxygen (DO), temperature, and turbidity. Participants also received hands-on instruction in conducting field measurements using simple portable water quality meters. Through this practical training, community members were expected to develop a clear understanding of the relationship between water quality conditions and fisheries productivity, enabling them to conduct independent monitoring activities.

The subsequent stage involved production monitoring and evaluation. During this phase, community members were assisted in recording fish catches or aquaculture yields throughout the initial monitoring period. These data were then subjected to a simple analysis to examine the relationship between water quality conditions and fish productivity. The analysis served as the basis for developing production improvement plans. Recommended interventions included mitigation

measures such as aeration, water hyacinth management, domestic waste reduction, and initiatives to maintain the cleanliness of the lake's aquatic environment.

Within the management component, the program addressed the limited capacity of the community in data recording and management. Activities included the establishment of a monitoring group with a simple organizational structure comprising a coordinator, a field monitoring team, and data recording personnel. The formation of this group was intended to ensure that water quality monitoring and fisheries production data collection could be carried out in an organized and sustainable manner. Through a clear division of responsibilities, community members were expected to implement monitoring activities more effectively over the long term.

Community members were subsequently introduced to a data recording system using both a manual logbook and a simple digital recording format. The logbook was designed to document water quality parameters as well as fish catch and aquaculture production volumes. Participants also received training in data management, including the preparation of trend graphs and basic interpretation of the data collected. The recorded data and analytical results were then discussed during periodic community evaluation forums. These forums provided a collaborative platform for assessing environmental conditions, evaluating fisheries productivity, and formulating collective decisions regarding production management.

In addition to targeting the economic-sector partner, the program also involved the broader community. Activities related to environmental education and blue economy literacy were conducted through

environmental and blue economy literacy workshops. The training materials addressed the influence of water quality on fisheries productivity, household income, and the sustainability of the lake ecosystem. To reinforce community understanding, educational infographics carrying the key message, "Healthy Water = Healthy Fish = Higher Income," were provided. These educational materials were intended to help community members recognize the close relationship between environmental quality and economic well-being.

The literacy program was further complemented by a simple economic simulation. During this activity, participants were invited to estimate household income before and after the implementation of water quality monitoring practices. The simulation was designed to demonstrate the potential economic benefits of improved environmental management. Consequently, community members gained not only an understanding of the ecological dimensions of the program but also a practical appreciation of its potential contribution to increased household income and family welfare.

In terms of community welfare and institutional strengthening, the program facilitated the establishment of an environmental management group. This group functions as a community-based environmental stewardship organization responsible for monitoring water quality, maintaining environmental cleanliness, and encouraging community participation in the sustainable management of Lake Limboto. In addition, the implementation team collaborated with community members to develop a draft empowerment model integrating science and technology with blue economy principles. This model is expected to

serve as a reference for the implementation of similar programs in other lake coastal areas.

To ensure program sustainability, a follow-up action plan was also developed in collaboration with the village government and relevant stakeholders. This plan includes the preparation of a draft memorandum of understanding or a cooperation agreement with the Government of Bulota Village. Such collaboration is essential to ensure that water quality monitoring, data management, and community economic empowerment activities continue after the completion of the program. With institutional support from the village government, the initiative is expected to evolve beyond a short-term training program into a sustainable community-driven environmental movement.

The participation of both the funding partner and the target community constituted a critical factor in the program's success. The funding partner provided financial support, water quality monitoring equipment, training modules, and other supporting facilities. In addition, the funding partner monitored program implementation through weekly progress reports prepared by the implementation team. Meanwhile, the target beneficiaries—the coastal community of Lake Limboto—actively participated in training sessions, field practices, monitoring group management, and data recording activities. Community members also contributed valuable feedback regarding field conditions and the challenges they encountered, enabling the program to be continuously adapted to local needs.

Program evaluation was conducted to assess the effectiveness of the implemented activities using four indicators: (1) participants' knowledge of water quality concepts and parameters, (2) their technical

skill in operating monitoring instruments, (3) the consistency and completeness of recorded monitoring data, and (4) the level of community participation in monitoring and group activities. Data on the first two indicators were collected through pre- and post-training questionnaires and interviews and compared descriptively to identify changes before and after the program, while the latter two indicators were assessed through field observation and a review of the logbooks and databases developed by the community. The evaluation findings served as the basis for refining the program, formulating recommendations, and strengthening the long-term sustainability of community empowerment initiatives for the coastal communities of Lake Limboto.

RESULTS AND DISCUSSION

The implementation of the coastal community empowerment program for water quality monitoring in Lake Limboto adopted a participatory approach that integrated environmental education, technical capacity building, institutional strengthening, and blue economy development. The program focused on the residents of Bulota Village, the primary target group, whose livelihoods depend heavily on the natural resources of Lake Limboto to meet household economic needs. Activities commenced with technical training on the fundamental concepts of water quality and the introduction of key parameters influencing the sustainability of aquatic ecosystems, namely temperature, pH, dissolved oxygen (DO), and turbidity. The training was delivered through lectures, equipment demonstrations, group discussions, and hands-on field practice.

Community participation throughout the program was high, reflected in consistent attendance across the training and field-practice sessions and active involvement in discussions on the relationship between water quality and fisheries productivity, which constitutes participants' primary source of livelihood. This response suggests that the community has a substantial need for practical knowledge and technical skills that can be directly applied to their daily activities (Starkey et al., 2024).

Based on pre and post training questionnaires and interviews, participants' understanding of the importance of water quality monitoring as a community-based environmental management tool improved after the training. Prior to the program, most participants reported limited knowledge of the functions of individual water quality parameters and their relationship to fish health; following the training and field practice, participants were able to operate simple water quality monitoring instruments, collect water samples, and systematically record measurement results, as verified through direct observation of their field practice. These findings suggest that a practice-oriented training approach is more effective than conventional extension methods, and that hands-on experience helped build participants' confidence in independently conducting water quality monitoring.

The subsequent phase involved monitoring water quality at several observation stations representing the aquatic conditions of Lake Limboto surrounding Bulota Village. This activity was conducted collaboratively by community members, university students, and the implementation team. The monitoring process provided participants with an opportunity to apply the knowledge and skills acquired during the

training. Community members measured water quality parameters using portable monitoring equipment and recorded the results using standardized data collection forms. Three monitoring stations were established: Station I (Bulota Village), Station II (Hutadaa Village), and Station III (Buhu Village). The parameters measured were pH, Total Dissolved Solids (TDS), and Dissolved Oxygen (DO), as presented in Table 1.

The results demonstrated that community members were able to independently implement monitoring procedures with a satisfactory level of accuracy. The water quality monitoring data for Lake Limboto is presented in Table 1.

Tabel 1
Water Quality of Lake Limboto

Parameter	Class III Water Quality Standard (Government Regulation No. 21 of 2021)	Measured value			Description
		St. I	St. II	St. III	
pH	6-9	6,73	6,70	6,70	Meets the Class III water quality standard
TDS (mg/L)	≤ 1000	258	274	257	Meets the Class III water quality standard
DO (mg/L)	≥ 3	5,81	6,50	6,57	Meets the Class III water quality standard

Source: Primer Data, 2026

These findings provide baseline information regarding the current water quality status of Lake Limboto that can serve as a reference for future periodic monitoring. The measured values of pH, TDS, and DO at all three monitoring stations complied with the Class III water quality standards, which designate water suitable for fisheries and aquaculture

activities. Nevertheless, the long-term decline in environmental quality over the past decade cannot be overlooked. According to Lihawa & Mahmud (2017), previous measurements reported pH values ranging from 7.7 to 8.0 and a dissolved oxygen concentration of approximately 7 mg/L.

The availability of monitoring data is strategically important because it can function as an early warning system for detecting potential environmental degradation. Regular monitoring enables the community to identify changes in aquatic conditions at an early stage, allowing mitigation measures to be implemented before more severe impacts on fisheries activities occur (Nair & Nayak, 2023).

The establishment of a village-based monitoring group constituted one of the program's major achievements. The group was formed through consultations involving community members and the village government while ensuring representation from coastal residents, fishers, and village youth. The monitoring group adopted a simple organizational structure consisting of a coordinator, a field monitoring team, and data recording personnel. This division of responsibilities was intended to ensure the continuity of monitoring activities after the completion of the community engagement program.

The establishment of the monitoring group generated positive outcomes in strengthening community institutions. Rather than serving merely as recipients of development programs, community members assumed the role of primary actors in managing the lake environment (Warner et al., 2024). This approach aligns with the principles of Community-Based Natural Resource Management (CBNRM), which

emphasize active community participation in natural resource governance.

The program also produced a water quality data recording system consisting of a manual logbook and a simple digital recording format. The system was designed to be user-friendly and accessible to community members with diverse educational backgrounds. Training in data management enabled participants to systematically record, store, and perform basic interpretation of monitoring results. As a result, community members increasingly recognized the importance of reliable data as a basis for informed environmental management decisions.

The implementation of this data recording system represents an initial step toward evidence-based natural resource management. The availability of systematically documented monitoring data can assist the village government in designing more targeted and effective environmental management programs.

Environmental and blue economy literacy activities were conducted through workshops and group discussions focusing on the interrelationships among water quality, fisheries productivity, and community welfare. The workshop featured Dr. Arfiani Rizki Paramata, S.Pi., M.Si., an expert in fisheries management, as the invited resource person. Post-activity discussions and interviews indicated an improvement in community understanding of the ecological and economic consequences of declining water quality. Participants came to recognize that environmental quality and fisheries productivity are inseparable components of sustainable livelihoods. This increased awareness represents valuable social capital for supporting future lake conservation initiatives. Collective community awareness plays a

fundamental role in maintaining the sustainability of aquatic resources while fostering the development of a blue economy based on the sustainable utilization of natural resources.

CONCLUSION

This community empowerment program produced several concrete outputs for Bulota Village: a village-based water quality monitoring group with a defined organizational structure; a manual and digital logbook system for recording pH, TDS, and DO data; a baseline dataset of water quality at three observation stations, all within the Class III standard for fisheries; and a community that is able to operate simple monitoring instruments and record data independently. Together with the technical training, field practice, and blue economy literacy activities that produced them, these outputs indicate an improvement in community knowledge, technical skill, and participation in the sustainable management of the lake environment.

Sustaining these outputs, particularly the continued activity of the monitoring group and regular use of the logbook system, is expected to support more effective management of Lake Limboto, promote the sustainability of fisheries resources, and contribute to improving the welfare of coastal communities through a blue economy approach.

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