

Community Empowerment through Participatory Training for Sustainable Nile Tilapia Farming in Tanjung Alam, Asahan Regency

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Abstrak

Budidaya ikan nila (*Oreochromis niloticus*) merupakan inisiatif strategis untuk mendorong pengembangan akuakultur di Indonesia dan meningkatkan kesejahteraan ekonomi melalui peluang pendapatan yang berkelanjutan. Program pemberdayaan masyarakat ini dilaksanakan bersama Kelompok Pembudidaya Ikan Sudo Mina Jaya di Desa Tanjung Alam, Kabupaten Asahan, dengan pendekatan partisipatif untuk meningkatkan kapasitas dan keterampilan teknis petani ikan. Tantangan utama yang dihadapi mencakup pengelolaan kualitas air yang kurang optimal, keterbatasan pengetahuan teknik pemijahan, serta permasalahan kesehatan dan produktivitas ikan. Program ini menggunakan metode Participatory Rural Appraisal (PRA) melalui survei awal, pelatihan pembenihan berkelanjutan, manajemen kolam, produksi probiotik, serta pendampingan teknis dan sesi bimbingan interaktif. Evaluasi efektivitas dilakukan melalui pre-test dan post-test, yang menunjukkan peningkatan skor pengetahuan peserta secara signifikan dari rata-rata 54 menjadi 92 ($n = 13$), yang didukung dengan uji Wilcoxon signed-rank ($Z = 3,209$; $p = 0,001$). Pendampingan teknis lanjutan dan monitoring rutin dilakukan untuk mendukung penerapan pengetahuan. Program ini terbukti berhasil memberikan solusi terhadap tantangan di lokasi penelitian, meningkatkan keterampilan petani ikan, serta membuka peluang usaha budidaya ikan yang berkelanjutan melalui integrasi metode partisipatif dan evaluasi yang sistematis.

Kata kunci: Budidaya ikan nila; *Oreochromis niloticus*; pengembangan budidaya perairan; pemberdayaan masyarakat; budidaya ikan

Abstract

The cultivation of Nile tilapia (*Oreochromis niloticus*) is a strategic initiative to promote aquaculture development in Indonesia and to enhance economic welfare by providing sustainable income opportunities. This community empowerment program was implemented with the Sudo Mina Jaya Fish Farmers Group in Tanjung Alam Village, Asahan Regency, aiming to strengthen farmers' capacity and technical skills through a participatory approach. Key challenges identified included inadequate water quality management, limited knowledge of breeding techniques, and issues affecting fish health and productivity. The program employed the Participatory Rural Appraisal (PRA) method, comprising an initial survey, training on sustainable tilapia breeding, pond management, and probiotic production, as well as technical assistance and interactive guidance sessions. Program effectiveness was evaluated using pre-test and post-test assessments. Results showed a significant increase in participants' knowledge scores from a mean pre-test score of 54 to a post-test mean of 92 ($n = 13$), confirmed by a Wilcoxon signed-rank test ($Z = 3.209$, $p = 0.001$). Continued technical assistance and regular monitoring further supported the practical application of the knowledge gained. This program successfully provided practical solutions to local challenges, enhanced participants' aquaculture skills, and opened opportunities for sustainable fish farming businesses.

Keywords: Nile tilapia cultivation; *Oreochromis niloticus*; aquaculture development; community empowerment; fish farming

Key Messages :

- Participatory training effectively enhanced farmers' knowledge and skills, particularly in probiotic production

- and fish health management, contributing to improved aquaculture practices.
- The empowerment program strengthened the capacity of local fish farmers, addressing key challenges in water quality and fish health, and supporting the development of more sustainable and independent cultivation practices.



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Received: 20 July 2025
Accepted: 21 August 2025

DOI: <https://doi.org/10.56303/jppmi.v4i2.608>



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GRAPHICAL ABSTRACT

Community Empowerment through Participatory Training for Sustainable Nile Tilapia Farming in Tanjung Alam, Asahan Regency

Participatory training effectively enhances the knowledge and technical capacity of rural fish farmers, enabling sustainable Nile tilapia aquaculture and promoting community-based economic development.

Low productivity and limited technical capacity in Nile tilapia aquaculture among rural fish farmers



Methods:

- Participatory Rural Appraisal (PRA) Approach
- Initial Survey and Problem Identification
- Technical Training on Tilapia Breeding
- Water Quality and Pond Management
- Technical Assistance and Interactive Guidance
- Pre-test and Post-test Knowledge Evaluation

Outcomes and Recommendations:



<https://www.journalmpci.com/index.php/jppmi>

INTRODUCTION

The fisheries subsector plays a significant role in driving national economic growth. Its contributions include providing employment opportunities, increasing income for producers, and supplying high-quality animal protein with excellent nutritional value. Currently, the development of the fisheries sector is focused on strengthening a more advanced, efficient, and resilient agricultural sector, while creating balance between industrial and agricultural sectors (Sulistijowati et al., 2023). This development also aims to support rural development and improve the welfare of communities engaged in the fisheries sector.

One strategy to boost fisheries production is through aquaculture techniques using both extensification and intensification approaches in areas with high potential, such as marine waters, coastal zones, lakes, and freshwater bodies (Kurniati & Jumanto, 2017). Freshwater fish farming, such as Nile tilapia (*Oreochromis niloticus*), is highly suitable for community empowerment in Tanjung Alam Village, Asahan Regency. The local potential and natural resources in this area make freshwater aquaculture a highly promising business venture. In

addition, the role of human resources in managing aquaculture activities is crucial to achieving optimal production outcomes in line with the community's expectations (Sufi, 2021).

The cultivation of Nile tilapia (*Oreochromis niloticus*) has become one of the strategic initiatives to attract public interest in aquaculture development in Indonesia and position it as a source of income that can enhance economic well-being. Over the past few decades, Nile tilapia farming has experienced rapid growth in various regions worldwide, including Latin America (Food and Agriculture Organization, 2020). Tilapia has become one of the leading commodities in freshwater fisheries due to several advantages, such as its delicious taste, high omega content and nutritional value, fast growth rate, and its ability to adapt to diverse aquatic environmental conditions (Musadar et al., 2021). This species also possesses high reproductive capacity, omnivorous feeding habits, broad environmental adaptability, and tolerance to salinity (Robisalmi et al., 2020). In fact, Nile tilapia can grow well even under suboptimal water conditions (Herawati et al., 2015). Because of its rapid growth and excellent adaptability to less-than-ideal environments, Nile tilapia has become a popular choice for aquaculture among communities. In tilapia farming practices, it is crucial to pay attention to the management of culture environments, feed management, and the use of probiotics (Jayadi et al., 2021).

However, several challenges exist in Nile tilapia farming, such as the imbalance between feed conversion rates and fish growth. Optimal fish growth should be accompanied by a reduced feed conversion ratio. On the other hand, the accumulation of organic matter at farming sites, resulting from uneaten feed settling at the bottom, can lead to environmental problems. These issues are further exacerbated by a lack of knowledge about environmentally friendly aquaculture practices. Therefore, improvements in farming management are needed to promote more sustainable and eco-friendly Nile tilapia production (Kurniawan & Gani, 2023).

Community empowerment through aquaculture is a key strategy for enhancing economic and social well-being in rural areas. The Sudo Mina Jaya Fish Farmers Group is a community-based hatchery unit in Tanjung Alam Village, Asahan Regency, focused on fisheries. However, the significant potential for Nile tilapia farming in this area has not yet been fully realized. In fact, this region possesses various physical, social, and economic advantages that could be further developed through the application of appropriate aquaculture techniques.

The goal of empowering the community through Nile tilapia farming at the Sudo Mina Jaya Fish Farmers Group is to enhance local capacity and self-reliance in sustainable fisheries management. The program provides knowledge, skills, and eco-friendly technologies to boost productivity and economic well-being. Its main focus is on improving aquaculture techniques, strengthening community institutions, and creating new business opportunities in the fisheries sector to reduce unemployment and increase household income. Additionally, it aims to raise awareness about preserving aquatic ecosystems and environmental sustainability. In the long term, the program seeks to establish a sustainable rural economic model and position the Sudo Mina Jaya Fish Farmers Group as an innovative training center for Nile tilapia farming, serving as an example for other regions.

METHODS

Location of the Community Engagement Activity

This community empowerment program was conducted with the Sudo Mina Jaya Fish Farmers Group, located in Kongsu 6, Tanjung Alam Village, Asahan Regency, North Sumatra Province. The location of the activities is shown in Figure 1.

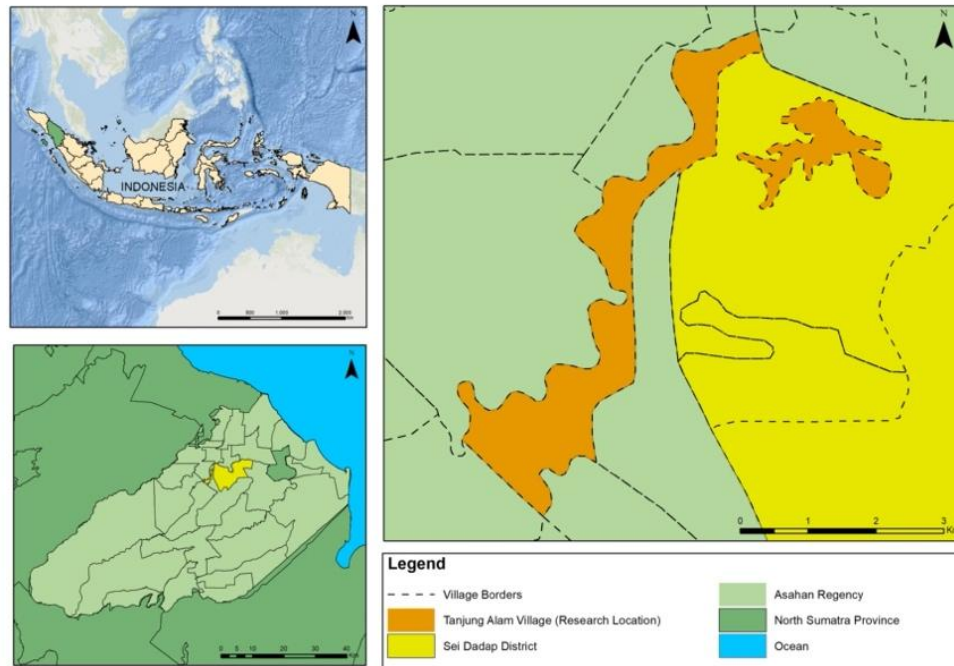


Figure 1 Research Site

Participants

The participants consisted of 13 fish farmers from the Sudo Mina Jaya Fish Farmers Group. They were aged between 35 and 41 years and included 3 women and 10 men. This farmer group was selected as the target partner due to its strategic location and untapped potential in Nile tilapia (*Oreochromis niloticus*) farming. Although the region has considerable physical, social, and economic advantages—such as access to freshwater sources, community interest in aquaculture, and existing group organization—its capacity for Nile tilapia cultivation had not yet been fully optimized. The group’s active status, organizational readiness, and willingness to participate made it an ideal partner for implementing sustainable aquaculture training using a participatory approach.

Activities and Procedure

The program used the Participatory Rural Appraisal (PRA) approach, which emphasizes active community participation. According to (Lestari et al., 2020), PRA is an evolution of the Rapid Rural Appraisal (RRA) method and involves the community as researchers, planners, and implementers, ensuring they are not merely objects of intervention but active contributors (Hudayana et al., 2019). The PRA activities consisted of several stages, as shown in Table 1.

Table 1. PRA Activities

Activity Input	Activity Process
Initial Survey and Problem Identification	An initial survey and problem identification were carried out using the PRA approach, which emphasizes active community participation. In this approach, the fish farmers’ group was directly involved in discussions about various issues related to Nile tilapia production processes.
Outreach and Business Strengthening Activities	This activity was conducted alongside meetings between the community empowerment team and the partner group. During these meetings, the empowerment team served as resource persons, presenting information on various issues faced by the partners in Nile tilapia farming.

Training Activities	In this stage, the partner group received knowledge and training on Nile tilapia spawning techniques, including pond preparation, broodstock selection, and water quality management.
Technical Assistance and Guidance Activities	This mentoring activity focused on providing guidance to the partner group on the maintenance and management of Nile tilapia farming.
Monitoring and Evaluation	Evaluation was conducted to assess whether the objectives of the activities had been achieved. The success of the activities was measured based on improvements in the partners' knowledge and skills.
Implementation	

Instrument and Data Collection

Knowledge assessments were conducted using a questionnaire consisting of ten multiple-choice questions (options a, b, and c). The questionnaire covered four main indicators: optimal environmental conditions, broodstock selection and spawning readiness, hatchery and fry management, and pond preparation and biosecurity. The questionnaire was adapted from previous research and, therefore, no additional validity or reliability testing was performed. Table 2 shows the questionnaire used in this study.

Table 2. Knowledge Questionnaire for Nile Tilapia Cultivation

Aspect	Question (Item Content)	Options	No. Item
Optimal Environmental Conditions	The optimal temperature range to support natural spawning of Nile tilapia in ponds is:	a. 20–24°C b. 24–28°C c. 30–34°C	1
	The ideal pH level for successful Nile tilapia breeding is:	a. 4.5–5.5 b. 6.5–8.5 c. 8.5–9.5	4
	The ideal dissolved oxygen (DO) level for Nile tilapia breeding ponds is:	a. 2–3 mg/L b. 4–7 mg/L c. Above 10 mg/L	8
Broodstock Selection and Spawning Readiness	Selecting high-quality male broodstock for Nile tilapia farming should consider the following characteristics, except:	a. No physical deformities and active b. Has been used for spawning more than 10 times without selection c. Bright body color and proportional body shape	2
	Female Nile tilapia are considered ready to spawn when they exhibit the following characteristics:	a. Dull body color and inactive b. Soft, enlarged abdomen and reddish urogenital papilla c. Increased appetite and reddish gills	3
	In controlled spawning systems in concrete ponds, the ideal ratio of male to female broodstock is:	a. 1:1 b. 1:2 c. 1:3	10
Hatchery and Fry Management	One of the main causes of seed (larvae) mortality during the larval stage is:	a. Overfeeding from the first day b. Fluctuating temperature and unstable water quality c. Very low stocking density	5
	Why is grading of fry important in Nile tilapia farming?	a. To enhance fry body color b. To achieve uniform growth and reduce cannibalism	6

		c. To increase competitiveness against predators	
	What is one of the initial treatments for fry after being transferred from the spawning pond to the nursery tarpaulin pond?	a. Directly stocking into the nursery pond without acclimatization b. Gradual acclimatization of temperature and pH for 30–60 minutes c. Administering high doses of antibiotics to all fry	9
Pond Preparation and Biosecurity	During pond preparation, drying the pond bottom is done to:	a. Lower water pH levels b. Kill microorganisms, parasites, and pest eggs c. Accelerate oxygen circulation in water	7

Data Analysis

Descriptive statistics were used to summarize participants' pre-test and post-test scores. To determine whether the differences in knowledge scores before and after the intervention were statistically significant, the Wilcoxon signed-rank test was performed, as the data were paired and not assumed to be normally distributed. A significance threshold of $p < 0.05$ was used to indicate statistical significance.

RESULTS

Initial Survey and Partner Problem Identification

An initial survey and problem identification were carried out using the PRA approach, which emphasizes active community involvement. During this stage, the community engagement team conducted direct visits to the Sudo Mina Jaya Fish Farmers Group. The purpose of these visits was to gain an understanding of the group's current activities, gather information about the challenges they face in fish farming, and evaluate the group's potential and opportunities for development.

This stage also included socialization of the planned community engagement program. Activities related to the initial survey and partner problem identification are shown in Figure 2.



Figure 2 Initial Survey

During the initial stage, a preliminary evaluation was conducted to assess the condition of the partner group and identify the challenges faced in Nile tilapia farming. The survey results revealed several key issues, as summarized in Table 3.

Table 3. Identified Problems in Nile Tilapia Farming (Initial Survey Findings)

No.	Problem Area	Description of Findings
1	Pond Infrastructure	Many ponds have issues with water circulation and waste disposal systems, affecting water quality and fish health. Infrastructure improvements are needed to support effective farming operations.
2	Knowledge and Skills	Farmers have limited knowledge of efficient spawning techniques and optimal management of natural feed, indicating a knowledge gap that may hinder farming development.
3	Water Quality Management	Many ponds lack adequate monitoring systems for parameters like pH, dissolved oxygen, and temperature, posing risks to fish growth and health.
4	Feed Management	Farmers face challenges in accessing quality feed and producing natural feed efficiently, relying heavily on costly commercial feed instead of utilizing natural feed sources.

The series of activities planned to be carried out by the implementation team together with the partner group aims to address and mitigate the problems faced by the partners. Based on the issues identified, the research team has developed several steps designed to resolve these challenges. The details of these steps are summarized in Table 4.

Table 4. Proposed Solutions to Identified Problems

Identified Problem	Proposed Solution	Planned Activities
Limited knowledge among participants regarding Nile tilapia farming techniques.	Outreach and education on sustainable tilapia spawning techniques.	Technical mentoring focused on mastering effective methods for producing high-quality tilapia fingerlings.
Difficulty in monitoring water quality, and controlling pests and diseases. In addition, monitoring fish growth remains a challenge.	Training in probiotic production.	Assistance in producing probiotics to maintain water quality and control pests and diseases.

Outreach and Business Strengthening Activities

This activity involved interactions between the community engagement implementation team and the Sudo Mina Jaya Fish Farmers Group. In this activity, the team served as resource persons, providing knowledge on how to improve Nile tilapia farming practices. Efforts to enhance farming operations were carried out by offering solutions to various problems faced by the partners.

The methods used in this activity included lectures and discussions, serving as a platform for interactive information exchange between the engagement team and the fish farmers' group. Through these methods, it was expected that the Sudo Mina Jaya Fish Farmers Group would gain deeper knowledge and understanding of effective and proper Nile tilapia spawning techniques.



Figure 3 Outreach and Business Strengthening Activities

Figure 3 shows the process of the outreach and business strengthening activities. Based on the results, there was an increase in the partners' understanding and capabilities in several important aspects of fish farming, such as water quality management and efficient spawning techniques.

Training Activities

During the training activities, the partner group received in-depth instruction on Nile tilapia spawning techniques, covering several important aspects: pond preparation, water quality management, and broodstock selection.

The ponds used for broodstock maintenance consisted of two square concrete ponds, each measuring 400 m². The pond preparation process began with drying the pond for 2 to 3 days to oxidize organic materials into minerals or nutrients beneficial to the fish (Prihatini, 2014). After drying was completed, the ponds were filled with water. Figure 4 shows the pond preparation activities.



Figure 4 Pond Preparation

Water quality management was emphasized as a crucial part of successful fish farming. The water quality in the broodstock ponds was monitored regularly by measuring key parameters such as temperature, pH (water acidity), and dissolved oxygen (DO) levels to ensure they remained within optimal ranges for fish health and spawning performance. Maintaining stable water quality is essential to prevent stress and disease in the broodstock, which can negatively affect reproduction and fry survival rates.

The broodstock were selected from the existing stock owned by the Sudo Mina Jaya Fish Farmers Group. According to Sumarni (2018), the purpose of broodstock selection is to choose high-quality fish for spawning in order to produce eggs of good quality and quantity. The selection process was carried out manually by observing visual differences in body shape, genital organs, and body coloration between male and female fish, as well as by examining the health of the selected broodstock.



Figure 5 Broodstock Selection Activities

Male and female Nile tilapia exhibit distinct morphological differences (Figure 6), such as body size, the number of openings near the anus, and body coloration. Males generally have larger, rounder bodies, brighter coloration, a genital organ shaped like a small pointed protrusion, and a wider mouth. In contrast, females tend to have smaller, elongated bodies, paler coloration, a concave genital organ, and a smaller mouth (Iskandar et al.,

2021). During the maintenance period, the broodstock were fed artificial floating pellets with a diameter of 3–4 mm and a protein content of 32–34% (Apriani et al., 2019).

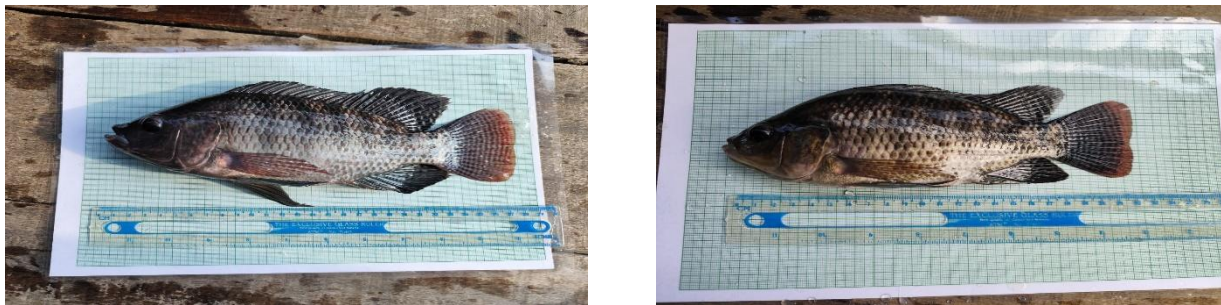


Figure 6 Male (left) and female (right) Nile tilapia.

Technical Assistance and Guidance Activities

The technical assistance activities were designed to provide intensive, hands-on support to the partner group, particularly the fish farmers, in maintaining Nile tilapia farming operations. The main focus of this assistance was to ensure that the partners acquired practical and technical knowledge related to tilapia aquaculture, covering crucial aspects such as water quality management, appropriate feed use, and effective spawning techniques. During these activities, the support team acted as facilitators, helping the partners understand and apply improved aquaculture techniques. The partners received explanations about the importance of water quality management in fish farming ponds. Water quality is a key factor influencing the health and growth of Nile tilapia (Sudirman et al., 2023). Parameters such as pH, temperature, and dissolved oxygen levels were monitored regularly to ensure optimal environmental conditions for the fish. Partners were also trained in the use of probiotics, which can improve water quality and support fish health (Nathanailides et al., 2021).

The guidance activities focused on equipping the partners with the correct spawning techniques, from pond preparation and broodstock selection to feed management and larval care (Sumarni, 2018). These techniques are crucial for ensuring successful reproduction in Nile tilapia, thereby enhancing productivity and the quality of aquaculture yields. The support team provided direct demonstrations and interactive discussions to ensure a thorough understanding among the partners of these essential techniques.

Monitoring and Evaluation Implementation

Monitoring and evaluation are the most crucial stages in an empowerment program, as they assess the effectiveness and achievement of the established objectives. Regular monitoring is conducted to ensure that activities proceed according to plan and to identify any challenges or obstacles faced by the partners. In this program, monitoring was carried out through routine field visits to the site of the Sudo Mina Jaya Fish Farmers Group. During these visits, the implementation team observed the practices applied by the partners and provided feedback and recommendations for improvement.

Meanwhile, evaluation was conducted to measure the extent to which the activities improved the knowledge and skills of the target group, namely the fish farmers. The evaluation process was carried out systematically using pre-test and post-test questionnaires administered to the participants before and after the program activities. This method aimed to assess the increase in participants' understanding and skills regarding various aspects of Nile tilapia farming, including spawning techniques, water quality management, as well as the use of feed and effective probiotics. The use of pre- and post-tests is an effective approach to evaluate changes in participants' knowledge and skills.

The results of the pre-test and post-test are shown in Figure 7. The evaluation results indicated a significant improvement in participants' understanding of better aquaculture techniques. Data obtained from the

post-test (score of 92) showed an increase compared to the pre-test (score of 54), reflecting an improvement in participants' knowledge and skills following the guidance and training provided. This improvement was statistically significant, as indicated by the Wilcoxon signed-rank test presented in Table 5, where the p-value was 0.001 (which is lower than the significance threshold of 0.05). This result indicates that the training had a significant effect on enhancing participants' knowledge in Nile tilapia aquaculture.

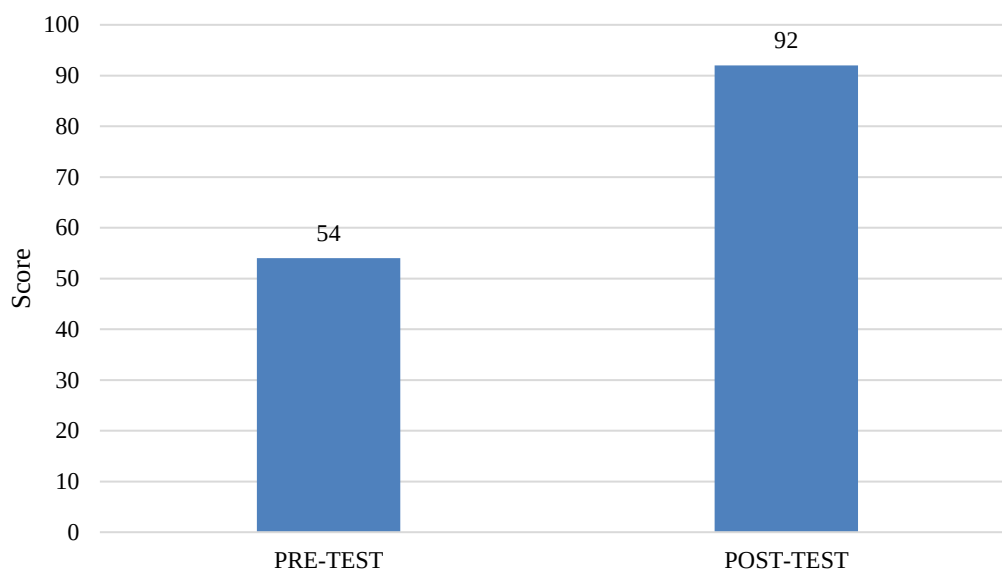


Figure 7 Mean results of pre-test and post-test (N = 13)

Table 5. Wilcoxon Test Results for Knowledge Score Improvement

Related-Samples Wilcoxon Signed Rank Test Summary	
Statistics	Value
Total N	13
Test Statistic	91.000
Standard Error	14.177
Standardized Test Statistic	3.209
Asymptotic Sig.(2-sided test)	.001

DISCUSSION

The results of the empowerment activities showed that participants were able to apply new techniques taught during the training, including the production of probiotics. This improvement in skills is significant, as probiotics play a vital role in maintaining water quality and fish health. According to the FAO/WHO, probiotics are live microorganisms which, when administered in adequate amounts, confer health benefits to the host. In aquaculture, probiotics include microorganisms that not only enhance feed digestion but also improve water quality conditions (Nathanailides et al., 2021). The successful application of probiotics observed in this study aligns with Rahmayanti (2020), who found that probiotic use can effectively enhance aquatic environments, making it an attractive option for modern fish farmers. By adopting these techniques, the participants are expected to maintain healthier pond ecosystems, potentially leading to higher productivity and lower fish mortality rates.

A significant finding in this study was the increase in participants' knowledge scores from a pre-test average of 54 to a post-test average of 92. This result, confirmed as statistically significant by the Wilcoxon signed-rank test ($p = 0.001$), demonstrates that the training effectively enhanced the participants' understanding of Nile tilapia aquaculture practices. Such knowledge gains are consistent with previous studies, such as Jayadi et al.

(2021), who reported substantial improvements in farmers' skills following participatory training sessions in aquaculture.

The use of participatory methods proved to be an effective approach in this program. As emphasized by Hidayana et al. (2019), effective community empowerment should involve active participation from the target groups in all stages of learning. This participatory approach ensured that the training was relevant and tailored to the specific challenges faced by the Sudo Mina Jaya Fish Farmers Group. Furthermore, proper evaluation, as noted by Rahmayanti (2020), provides a clear picture of the program's success in enhancing the partners' capacities.

The practical implications of this program are substantial. The adoption of probiotic techniques and improved pond management could reduce the dependence on expensive commercial feeds and decrease disease outbreaks, leading to increased profitability and sustainability for small-scale fish farmers. Additionally, participants who have gained new skills may serve as local resources for further training within their community, promoting broader knowledge dissemination and fostering sustainable rural economic development.

However, despite these positive outcomes, several challenges remain. While participants demonstrated increased knowledge and skills, implementing these practices consistently may be hindered by financial limitations, the cost of necessary materials for probiotic production, and limited access to reliable inputs and equipment. Ongoing support and technical assistance will be crucial to ensure the sustainability of the improvements achieved through this program.

CONCLUSION

This community empowerment program effectively enhanced the knowledge and skills of the Sudo Mina Jaya Fish Farmers Group in Nile tilapia aquaculture. Participants showed significant improvement, with average knowledge scores increasing from 54 on the pre-test to 92 on the post-test. This difference was statistically significant, as indicated by the Wilcoxon signed-rank test result ($Z = 3.209$, $p = 0.001$), demonstrating the success of the training intervention. The program's combination of participatory approaches and practical technical assistance proved effective in addressing key challenges such as pond preparation, broodstock selection, water quality management, and probiotic production. However, challenges remain regarding consistent implementation due to financial constraints and access to resources. Continued support, follow-up monitoring, and additional training will be critical to sustaining these gains and translating improved knowledge into lasting practice changes. In summary, this program highlights that participatory and practical training approaches are valuable strategies for empowering small-scale fish farmers and fostering sustainable aquaculture development.

ACKNOWLEDGMENT

The authors wish to express sincere gratitude to the Ministry of Research, Technology, and Higher Education (Ristekdikti) and the Higher Education Service Institution for Region 1 for providing funding support for this community service program under contract number 123/E5/PG.02.00/PM.BARU/2024. Special thanks are also extended to the Research and Community Service Institute of Universitas Asahan, as well as to Mr. Sugiatno and the Sudo Mina Jaya Fish Farmers Group for their valuable cooperation and assistance.

CONFLICT OF INTEREST

The authors state there is no conflict of interest

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