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Community Empowerment in the Aquaculture of Tilapia and Milkfish in Tanjung Rejo Village

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ABSTRACT

The fisheries sector plays a crucial role in rural development, particularly through the expansion of tilapia (*Oreochromis niloticus*) and milkfish (*Chanos chanos*) aquaculture, which contributes to community welfare and regional food security. Deli Serdang Regency, North Sumatra, has substantial aquaculture potential, with tilapia production reaching 16,257 tons in 2023. However, small-scale aquaculture in rural areas is still constrained by inadequate production management and post-harvest handling, resulting in limited economic optimization and market development. This study presents a community empowerment program implemented in Tanjung Rejo Village, Percut Sei Tuan District. The program involved structured training, technical mentoring, field-based practices, and the introduction of improved aquaculture technologies. Survey results indicated a significant improvement in community knowledge and skills, with 22% of respondents strongly agreeing and 78% agreeing that the polyculture pond training was beneficial. Furthermore, 75% of respondents strongly agreed and 25% agreed on the need for continued technical assistance in tilapia and milkfish aquaculture.
Keyword: *Oreochromis niloticus, Chanos chanos,* Community Empowerment, Aquaculture

ABSTRAK

Sektor perikanan memainkan peran penting dalam pembangunan pedesaan, terutama melalui perluasan budidaya ikan nila (Oreochromis niloticus) dan ikan bandeng (Chanos chanos), yang berkontribusi pada kesejahteraan masyarakat dan ketahanan pangan regional. Kabupaten Deli Serdang, Sumatera Utara, memiliki potensi budidaya perikanan yang besar, dengan produksi tilapia mencapai 16. 257 ton pada tahun 2023. Namun, budidaya perikanan skala kecil di daerah pedesaan masih dibatasi oleh manajemen produksi yang kurang memadai dan penanganan pasca panen, yang mengakibatkan optimalisasi ekonomi dan pengembangan pasar yang terbatas. Studi ini memaparkan program pemberdayaan masyarakat yang dilaksanakan di Desa Tanjung Rejo, Kecamatan Percut Sei Tuan. Program ini melibatkan pelatihan terstruktur, bimbingan teknis, praktik lapangan, dan pengenalan teknologi budidaya perikanan yang lebih baik. Hasil survei menunjukkan peningkatan signifikan dalam pengetahuan dan keterampilan masyarakat, dengan 22% responden sangat setuju dan 78% setuju bahwa pelatihan kolam polikultur bermanfaat. Selain itu, 75% responden sangat setuju dan 25% setuju akan kebutuhan bantuan teknis berkelanjutan dalam budidaya ikan nila dan bandeng.
Keyword: *Oreochromis niloticus*, *Chanos chanos*, Pemberdayaan masyarakat, Akuakultur

1. Introduction

The development of the agricultural and fisheries sectors in rural areas is a key strategy for improving community welfare and supporting national food security. Aquaculture plays an important role in strengthening regional food availability and economic resilience. North Sumatra has considerable aquaculture potential, with total aquaculture production reaching 367,994 tons and a production value of 10.4 trillion rupiah in 2023 [1].

The fisheries sector in Deli Serdang Regency demonstrates strong potential for aquaculture development [2] due to its proximity to the Medan City market and favorable environmental conditions [3]. Nevertheless, this potential has not been fully utilized, particularly in rural communities where aquaculture activities are still managed traditionally and lack proper production planning and post-harvest management. In the context of regional food security and economic development in North Sumatra, Deli Serdang Regency has emerged as a strategic hub for the intensification of freshwater aquaculture. Among the various commodities utilized, Nile tilapia (*Oreochromis niloticus*) and Milkfish (*Chanos chanos*) represent a primary species of interest due to its significant bio-economic potential.

One type of fish with potential for cultivation in the Deli Serdang district is tilapia. Tilapia (*Oreochromis niloticus*) is a freshwater fish with high economic value, rapid growth, and strong adaptability to various environmental conditions, making it suitable for aquaculture development in rural areas [4]. Morphologically, the species is distinguished by its compressed body and characteristic vertical banding, with distinct black pigmentation along the margins of the dorsal and pectoral fins—a trait often used in phenotypic assessment of stock quality [4]. Beyond its physical resilience, the species is characterized by high fecundity and a rapid specific growth rate (SGR), which facilitates shorter production cycles and higher turnover for local smallholders.

Tilapia has high nutritional content and great economic value, with demand for fry and fish for consumption continuing to increase along with the development of aquaculture [5]. In addition, this fish has advantages such as good breeding ability, rapid growth, tolerance to various environmental conditions, and ease of cultivation [6]. It also has high adaptability to various environmental conditions, grows quickly, and has a wide market. This fish is one of the freshwater fish species that has a higher level of cultivation compared to other freshwater fish species. This fish is very popular among the public as a source of consumption because it has a relatively high price and wide market demand [7]. The total production of tilapia in the Deli Serdang reached 16,257 tons in 2023 [1], where tilapia farming production in this region has great potential.

Tilapia is known to have a fairly rapid growth rate, especially in shallow waters. Male tilapia grows faster than females, especially when they are raised separately [8]. Once tilapia reach a weight of 200 grams, their growth rate begins to slow down. Therefore, many farmers choose to harvest tilapia when they reach 200 grams, as this size meets the standard for consumption [9]. Tilapia habitat is in freshwater with temperatures between 14°C and 38°C, with an optimal temperature between 25°C and 30°C [10]. Tilapia can also grow well in salinity (salt content) ranges between 0 and 15 ppt. The natural habitat of tilapia is usually in shallow waters with moderate currents. Although tilapia do not particularly like fast-flowing waters, they can still adapt and grow well in flowing waters if adjustments are made to the environment [11]. Tilapia have better nutritional content than other freshwater fish, such as catfish. Tilapia contains 43.76% protein, 79.44% water, 7.01% fat, and 6.80% ash per 100 g of fish weight, while catfish contains 40.28% protein, 11.28% fat, and 5.52% ash [12].

Milkfish (Chanos chanos) has long served as a foundational species for aquaculture across the Indo-Pacific, particularly within the Philippines, Indonesia, and Taiwan [13]. For centuries, this euryhaline teleost has been cultivated in traditional brackish water ponds (tambak) and fish pens, representing a critical intersection of cultural heritage and modern food systems [14]. Today, Indonesia and the Philippines remain the global leaders in production, leveraging extensive coastal resources to sustain a sector that is deeply embedded in the socioeconomic fabric of Southeast Asian coastal communities [15]. In Indonesia specifically, tambak aquaculture has underpinned rural economies and food security since at least the 15th century, providing a stable source of employment and affordable animal protein for millions [16].

From a biological and technical perspective, *C. chanos* is an ideal candidate for diversified aquaculture due to its remarkable physiological plasticity. The species demonstrates an extraordinary tolerance to fluctuating environmental parameters, maintaining homeostasis across a salinity gradient ranging from 0 to 15 ppt [17]

and enduring thermal stresses from 8.5°C to nearly 42.7°C [18]. This resilience, coupled with a rapid growth rate, allows for high-yield production cycles that often facilitate two harvests per annum, optimizing the land-use efficiency of coastal pond systems [19].

Beyond its hardiness in cultivation, the nutritional profile of milkfish positions it as a "superfood" within the freshwater and brackish water categories. Recent biochemical analyses indicate that *C. chanos* possesses a higher omega-3 fatty acid content relative to more expensive marine counterparts such as salmon, tuna, and sardines [20]. It is a rich source of essential amino acids, vitamins, and minerals, making it a vital tool in combating regional malnutrition [21]. To capitalize on this nutritional density and increase market penetration, the industry is increasingly moving toward product diversification—transforming raw biomass into value-added preparations that move beyond traditional whole-fish sales to meet the demands of modern consumers.

Tilapia and milkfish is considered as a lucrative commodity and being the backbone of aquaculture industry in North Sumatra, particularly in Medan and Deli Serdang. In Deli Serdang regency, one village with potential for tilapia farming development is Tanjung Rejo Village, Percut Sei Tuan District, Deli Serdang Regency. However, most of the people in Tanjung Rejo Village have not maximized the potential of tilapia and milkfish farming. Tilapia production in Tanjung Rejo Village is still only carried out by a few residents using traditional ponds using polyculture technique [22]. In addition, there are no farmer groups and no tilapia and milkfish farming production management system in place, making it difficult to calculate profits and supply to the market. Post-harvest management standards for farmed products have also not been implemented, so the quality of tilapia and milkfish produced has not reached market standards. Hence, the community service program was aimed to educate the farmers regarding to best aquaculture practice for tilapia and milkfish farming, including pond preparation and cultivating live feed, as well as providing fish fry to boost production.

2. Methods

This community service program was conducted in Tanjung Rejo Village, Percut Sei Tuan District, Deli Serdang Regency. The program applied a participatory community empowerment approach involving active collaboration between the implementation team and community partners.

The activities included problem identification through surveys and discussions, training and education on good aquaculture practices, technical mentoring, monitoring and evaluation, and the introduction of tilapia and milkfish fry suitable for local water conditions. The community service activity was executed using a participatory community empowerment approach divided into four main stages:

1. Survey and analysis of problems faced by community partners. Interactive discussions and surveys were conducted with community members to identify specific challenges, which revealed issues like long cultivation cycles, high fish mortality rates, and unregulated traditional polyculture systems

2. Education and training on tilapia and milkfish cultivation techniques were conducted after formulating the materials from the survey results. The implementation team provided structured training on technical culture standards, synergetic species relationships, optimal biomass density, and natural feed management. Field-based practices were carried out, which included introducing brackish water–tolerant tilapia and milkfish fry alongside practical training on proper acclimatization and preparation before putting them into cultivation ponds.

3. Monitoring and evaluation of aquaculture with a post-activity evaluation were conducted after adding the fish fry to the pont. The evaluation was conducted where community partners filled out questionnaires to assess improvements in their knowledge and skills, followed by tracking the eventual harvest yields after 4 months of growing period.

The training session was attended by 28 people from the Tanjung Rejo Village community, consisted of 20 males and 8 females. Among the male participant, 8 people were high school diploma, 8 people were middle school graduate. Most participants (20 people) were members from the fish cultivation community group, with age ranging from 23 to 56 years old. Most female participants were wives and members of PKK (family welfare education program).

The primary instrument used to collect evaluation data in this program was a questionnaire survey distributed to the community members after the educational and training sessions. Program evaluation was conducted after the implementation of activities to assess the achievement of objectives related to improving community knowledge and skills. The evaluation indicators and benchmarks used in this program are presented in Table 1.

Two methods of analysis were employed to measure the program's success. The first was quantitative survey perception analysis. The surveys were analyzed quantitatively with distribution of questionanaires as pre-test before the workshop and as post-test after the workshop. The pre-test questions measured their initial knowledge regarding to the technical aspect of fish cultivation, while the post-test questions measured the respondent's feedback about the materials presented, as well as their opinion regarding to environment-friendly cultivation practices and willingness to engage in post-harvest steps to ensure the quality of their harvested fish. The second assessment was analyzing the total production of tilapia and milkfish fry after four months of cultivation.

Table 1. Evaluation design for community service in cultivation tilapia and milkfish for community in Tanjung Rejo Village

Criteria	Indicators of Goal Achievement	Benchmarks
Tilapia and milkfish cultivation training	Partners' understanding and skills in tilapia and milkfish cultivation	Partners understand the techniques and tips for tilapia and milkfish cultivation.

3. Results and Discussion

The community empowerment activities through tilapia and milkfish aquaculture in Tanjung Rejo Village were implemented according to the planned stages. Community partners successfully completed pond preparation, stocking, feeding, and harvesting processes.

3.1. Survey and Problem Analysis (Diagnostic Phase)

Initial activities involved interactive discussions with community members to identify challenges in tilapia and milkfish cultivation. The main problems identified included long cultivation cycles, high fish mortality rates, and pest and disease disturbances in ponds. These findings served as the basis for designing training materials tailored to community needs.

Initial field surveys and interactive diagnostic discussions carried out with the community members revealed that local aquaculture operations are overwhelmingly small-scale, disorganized, and managed traditionally. Notably, there are no established farmer groups or integrated production management systems in place within the village, making it exceptionally difficult for local smallholders to calculate operational profits, stabilize supply chains, or consistently meet standard market criteria.

The diagnostic phase successfully isolated several primary technical barriers hindering aquaculture optimization in the region:

(1) Farmers experienced heavily extended production timelines before fish reached standard weights.

(2) Ponds suffered from high fish mortality, severely reducing overall yield and economic efficiency.

(3) Persistent pest and disease disturbances frequently disrupted the health and stability of the pond ecosystems.

(4) Difficulty in obtaining new fish fry to support the following production cycle, making the cultivation process not sustainable.

Further evaluation of these diagnostic findings indicated that these barriers were systemic symptoms of unregulated "passive polyculture" practices. Traditionally, local farmers stocked Nile tilapia (*Oreochromis niloticus*) and milkfish (*Chanos chanos*) simultaneously without calculating the specific carrying capacity of the ponds or accounting for the distinct trophic niches of each species. This management deficit induced severe interspecific competition for essential resources, including dissolved oxygen and low level of live feed available in the ponds, which ultimately stagnated fish growth rates and induced lethal stocking shock.

3.2. Education and Training

In the next stage, the service implementation team provided education on good technical practices in tilapia and milkfish farming (Figure 1). This education played an important role in broadening the community's knowledge of good technical practices in tilapia and milkfish farming, as the community currently farms tilapia and milkfish conventionally using a polyculture system without considering feed competition and fish population balance. This education is expected to increase knowledge about good polyculture farming of tilapia and milkfish, thereby supporting production optimization.

Previous studies have highlighted similar issues in traditional aquaculture systems. Romana-Eguia et al. [23] reported that conventional tilapia farming often lacks scientific guidance on appropriate stocking density and feeding management, resulting in suboptimal production. The authors further emphasized that higher yields and shorter rearing periods can be achieved through the application of efficient husbandry techniques. Likewise, the FAO technical document [24] underscores the importance of training farmers in feed formulation, feeding strategies, and managing feed competition in Nile tilapia and milkfish polyculture systems. Improved feeding practices can reduce feed wastage and water pollution while enhancing fish growth performance.

Furthermore, Moncawe [25] reported that the National Fisheries Research and Development Institute (NFRDI), through the Freshwater Fisheries Research and Development Center (FFRDC), implemented capacity-building programs on technology packages (POTs) for tilapia and milkfish hatchery and nursery production. Following the training, participating farmers achieved a 12% increase in tilapia production and a 22% increase in profit, while milkfish fry production exceeded the target by 2.7 million fries with survival rates ranging from 21% to 26%.

Figure 1. Educating the community about the technical culture of tilapia and milkfish polyculture farming

In order to improve the effectiveness of education related to the technical culture of tilapia and milkfish farming, the implementation team also conducted practical training on the preparation and distribution of tilapia and milkfish fry as the initial stage in the technical culture of fish farming. The community participated enthusiastically and actively in this activity (Figure 2).

Figure 2. Practical activities on the preparation and distribution of tilapia and milkfish fry.

This educational and training activity was concluded with the community filling out a questionnaire. The purpose of this questionnaire was to assess the achievement of the program objectives in improving the knowledge and skills of the Tanjung Rejo Village community in good polyculture tilapia and milkfish

farming. Based on the results of monitoring and evaluation of the educational and training activities that had been carried out, it was found that the community in Tanjung Rejo Village had increased their knowledge and skills regarding polyculture, natural feed management in polyculture ponds, and the importance of maintaining fish population balance in polyculture systems. The community also felt the need for further assistance regarding tilapia and milkfish farming.

The implementation of improved aquaculture techniques resulted in harvest weights of approximately 200 g per tilapia and 250 g per milkfish after a maintenance period of four months (August – November). These results demonstrate that proper management of polyculture systems can enhance productivity and support sustainable aquaculture development at the community level.

The initial diagnostic phase in Tanjung Rejo Village revealed that the primary barriers to productivity such as long cultivation cycles and high mortality, were symptomatic of unregulated polyculture systems. Conventionally, farmers in the region practiced "passive polyculture," where tilapia (*Oreochromis niloticus*) and milkfish (*Chanos chanos*) were stocked without calculating the carrying capacity of the pond or the specific trophic niches of each species. This lack of management often leads to interspecific competition for dissolved oxygen and supplemental feed, ultimately stagnating growth rates. Passive polyculture that relies heavily on live feed often induces severe interspecific competition for natural benthic resources and natural feed reserves, which severely stagnates fish growth when stocking densities are not balanced against the pond's natural carrying capacity [26]. Hence, knowledge about pond preparations, fry handling, and live feed management in the pond is crucial for the sustainability of the fish production [27].

The intervention shifted this paradigm toward optimized polyculture. By introducing technical culture standards, the community was educated on the synergetic relationship between these two species. Tilapia, which primarily occupy the mid-to-upper water column and consume periphyton, complement milkfish, which are efficient grazers of algae mass or “klekap”. This spatial and dietary separation reduces competition and maximizes the utilization of the pond’s natural energy flow.

The response to the practical training on fry preparation and distribution (Figure 2) highlights a critical shift in community agency. Proper acclimatization protocols consisted of adjusting fry to the temperature and salinity of the recipient pond, are vital for reducing initial "stocking shock," which is a major contributor to the high mortality rates previously identified by the partners. Identifying these baseline production constraints is critical, as operational risks such as elevated mortality rates and unmanaged disease outbreaks represent the primary drivers of financial instability in rural, small-scale aquaculture operations [29]. We conducted pre-test and post-test to measure the participant’s understanding from the education and workshop activity. The percentage of survey results for several of these points is presented in Figures 3–5.

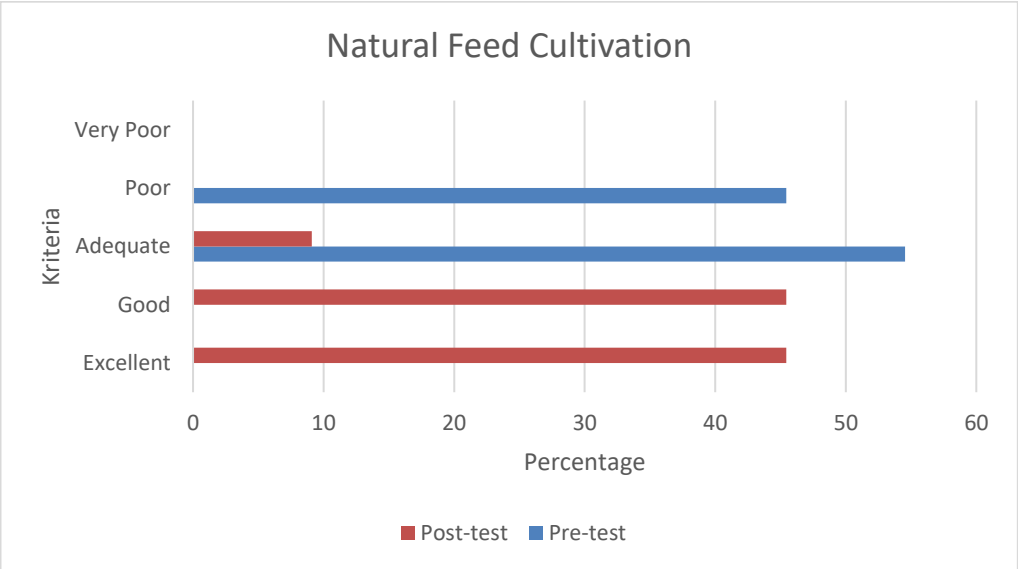

Figure 3. Results of pre-test and post-test regarding to natural feed cultivation

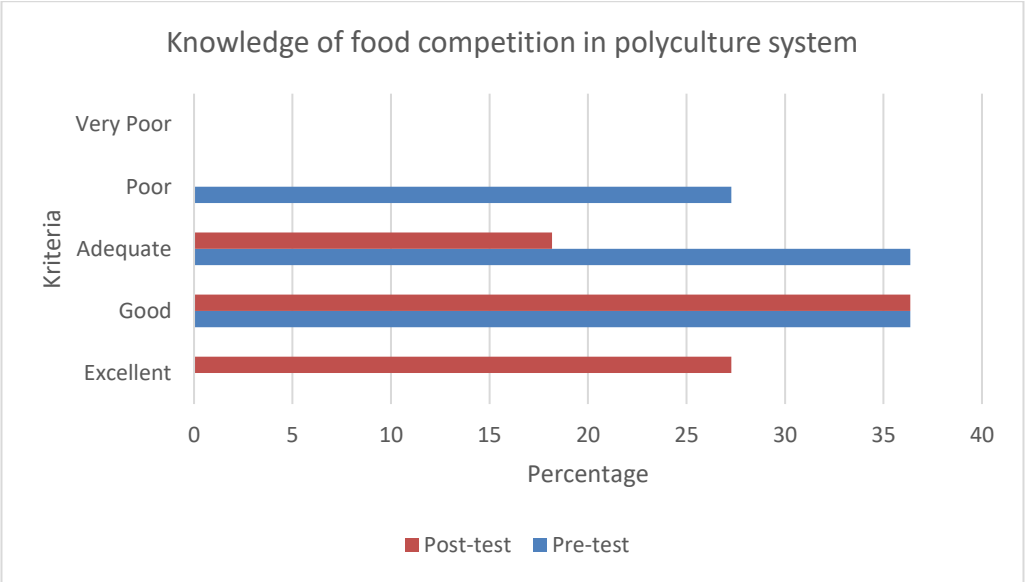

Figure 4. Results of pre-test and post-test regarding to knowledge of food competition in polyculture system

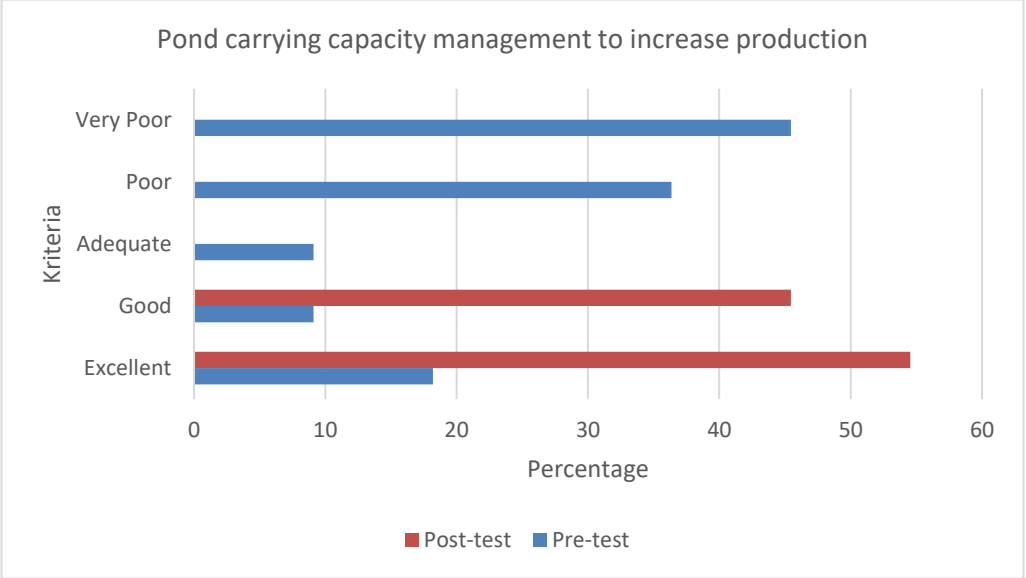

Figure 5. Results of pre-test and post-test regarding to Pond carrying capacity management to increase production

The post-training evaluation (Figures 3-5) confirms a significant quantitative increase in knowledge regarding natural feed management. Specifically in natural feed cultivation the community was trained to view "klekap" not merely as wild growth, but as complex microphytobenthos aggregates, which is a biological matrix composed of benthic diatoms (such as Navicula and Nitzschia spp.), filamentous cyanobacteria, and organic detritus that coat the pond bottom [30]. These aggregates are highly nutritious, providing a balanced profile of essential fatty acids and amino acids that perfectly match the dietary requirements of grazing milkfish and juvenile tilapia. By mastering the cultivation of “klekap” and phytoplankton through controlled fertilization, farmers can reduce their dependency on expensive commercial pellets.

Crucially, the post-training survey data also reflects a substantial surge in the participants' understanding of interspecific food competition and ecological niche partitioning within a polyculture system. Previously, the farmers suffered from poor yields due to random stocking that forced both species to compete for the same immediate resources. Through the educational modules, the community learned to strategically manage the distinct behavioral and dietary traits of each species—positioning tilapia to utilize the upper water column and artificial feeds while milkfish efficiently graze on the bottom benthic aggregates. This

heightened awareness allows the farmers to actively suppress competition, ensuring that neither species stunts the growth of the other.

Furthermore, this mastery directly translates into advanced management of the pond's physical carrying capacity. By understanding how to calculate biomass density thresholds in relation to natural food availability and dissolved oxygen levels, the community is now equipped to maximize stocking formulas without exceeding ecological limits [30]. This optimization is fully supported by aquaculture frameworks demonstrating that milkfish–tilapia polyculture exhibits no food competition while yielding a substantially higher aggregate production and better resource-utilization efficiency than monoculture systems. This is supported by research showing that urea and triple superphosphate fertilizers significantly boost klekap standing crop and chlorophyll content [31], that milkfish–tilapia polyculture exhibits no food competition while yielding higher production than monoculture [32], and that local feed formulations can achieve up to 40% cost efficiency compared to commercial pellets [33]. This also supports the other issue such as food competition and pond carrying capacity.

A cornerstone of the program's success was the emphasis on fish population balance. In traditional systems, overstocking often leads to stunted growth due to metabolic waste accumulation (ammonia and nitrites). The training provided a framework for maintaining optimal biomass density, which was directly reflected in the harvest results. Reaching a harvest weight of 200 g for tilapia and 250 g for milkfish within a four-month period is a significant benchmark for community-based aquaculture [8,9]. This growth trajectory indicates that the metabolic demands of both species were met through improved technical culture.

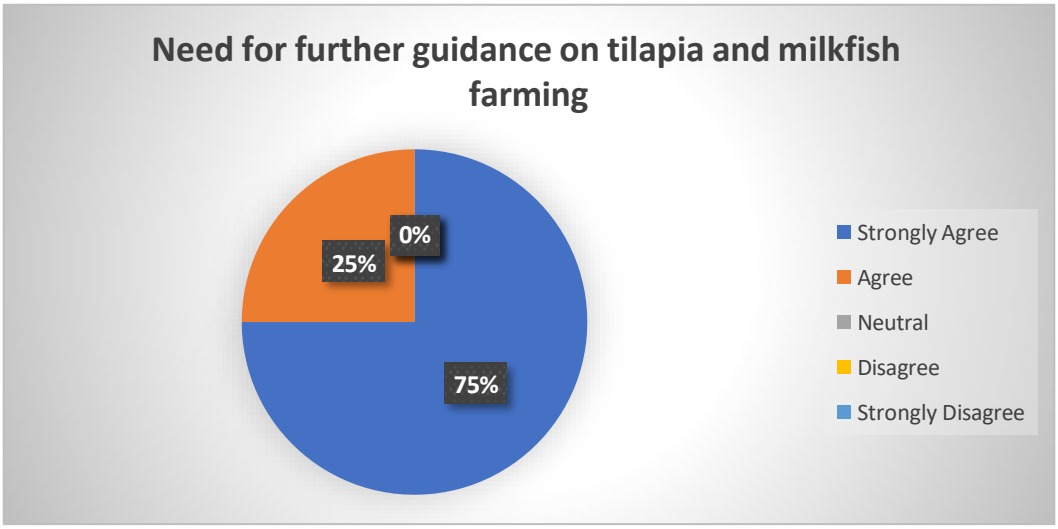

Figure 6. Need for further guidance on tilapia and milkfish farming

The survey results in Figure 6 indicate the community's expressed need for "further assistance". This suggests that the program has entered a consolidation phase, where continued guidance is necessary to ensure the long-term adoption of introduced practices. In particular, the regular monitoring of water quality parameters, including pH, salinity, and dissolved oxygen, remains a technical challenge that requires sustained mentoring and capacity building.

To maintain and strengthen the program's outcomes, future interventions should focus on three strategic aspects: (1) establishing local aquaculture cooperatives to facilitate resource sharing, improve access to capital, and stabilize market prices; (2) promoting product diversification by developing and marketing value-added fish products; and (3) providing affordable environmental monitoring tools to enable routine water quality assessments and reduce the risk of mass fish mortality during seasonal transitions. According to Weningtias [34], fish product diversification training can transform unsold or low-value catches into marketable products with extended shelf life, thereby improving income stability, increasing sales, and enhancing the competitiveness of small-scale fisheries, particularly in communities where fishing constitutes the primary livelihood for most households. Furthermore, Lestari and Purwanto [35] emphasized that Indonesia's aquaculture sector faces significant sustainability challenges and that cooperative models

play a crucial role in improving access to financial resources, stabilizing markets, and supporting environmental protection within the country's strategic marine development sector.

4. Conclusion

The results of this community service program indicate that the application of good aquaculture practices in polyculture systems enables pond farmers in Tanjung Rejo Village to achieve harvest weights of approximately 200 g per tilapia and 250 g per milkfish within a four-month cultivation period. Training and practical activities significantly improved community knowledge and skills related to polyculture management, natural feed utilization, and fish population balance. Furthermore, the community expressed a strong need for continued technical assistance to ensure the sustainability and further development of tilapia and milkfish aquaculture. Ongoing mentoring and capacity-building programs are therefore recommended to strengthen local aquaculture production and improve community welfare.

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