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Enhancing Tilapia Pond Productivity Through Carrying Capacity Engineering in Turunrejo Village, Kendal Regency

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Abstract Our Community Engagement (CE) activity aimed to increase productivity in the Nile tilapia pond managed by POKDAKAN Berkah 2 in Turunrejo Village, Kendal Regency. This was achieved through carrying capacity engineering of ponds, mechanization of facilities, probiotic application, and enhancing the knowledge and skills of cultivators in managing pond water quality to meet the Indonesian National Standard (SNI) for tilapia rearing. Knowledge and skills improvement was facilitated through counseling sessions and technical assistance provided during the Nile tilapia rearing activities at Dempond Berkah 2. The community service team provided support by assisting with the procurement of two water pumps and pump holders, constructing inlet and discharge sluices, supplying 20,000 Nile tilapia fry measuring 2–3 cm, and providing factory feed. Fish stocking was conducted in the morning under optimal conditions: water salinity of 8–10 o/oo, neutral pH, and dissolved oxygen levels exceeding 3 mg/L. Factory feeding began on the 15th day after the fry were released into the pond. The results indicated that the fish grew well due to water quality management that met the standards for tilapia maintenance. This success was attributed to effective management of water and feed quality, as well as the provision of adequate cultivation facilities and infrastructure. Pond productivity exceeded the target of 1.5 tons, contributing to increased income for the farming community and improved knowledge and competence of fish farmers in Good Fish Farming Practices (CBIB).

1. INTRODUCTION

Brangsong District, Kendal Regency, especially Turunrejo and Purwokerto Villages (Figure 1), has potential for the development of salted tilapia because there are pretty large ponds in both villages. In addition, there are rice fields that cannot be grown because they have been submerged by seawater, causing the soil to become salty. Such rice fields have great potential to be developed as tilapia cultivation land (Haeruddin et al., 2023). Tilapia production from ponds in Brangsong District, Kendal Regency in 2021 reached 27.1 tons, with an area of 299.5 hectares of cultivated land (Statistics of Kendal Regency, 2021).

Before the CE activity done by Haeruddin et al. (2023), saline tilapia cultivation ponds' productivity in Kendal Regency was still very low, and some even failed to harvest. The highest yield only reaches 300 kg/planting season (MT). The failure and low productivity of ponds are caused by cultivators not paying attention to the carrying capacity of the fish pond and facilities they have, then stock the fish in denser numbers than necessary.

After the CE activities carried out by Haeruddin et al. (2023), the productivity of tilapia ponds in the pilot pond (dempond) of the Berkah 2 Fish Cultivation Group (POKDAKAN), can increase rapidly. As a result of observations by the community service team until the end

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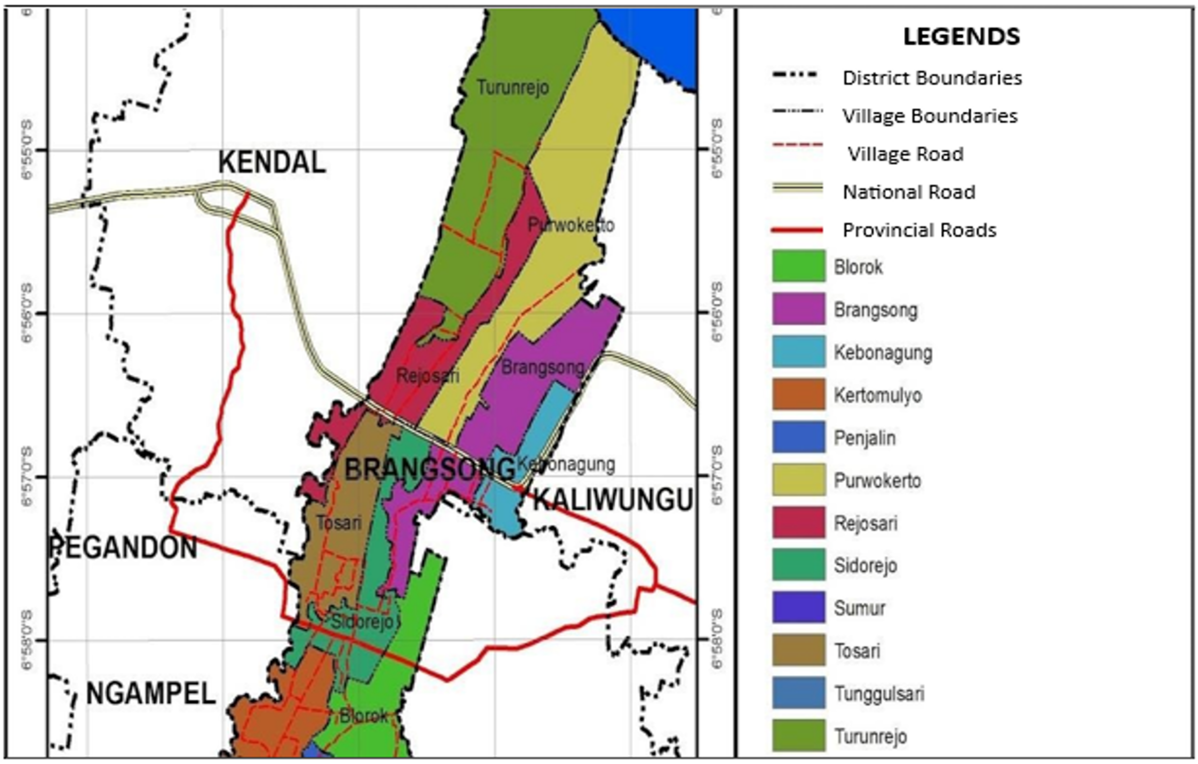

Figure 1 . Orientation map of Turunrejo Village, Brangsong District, Kendal Regency

of December 2023 (2 months of maintenance), tilapia has grown to an average length of more than 20 cm. The mortality rate is also low because based on sampling data, the survival rate is estimated at >90% (Haeruddin et al., 2023). This accomplishment has been made possible thanks to the support and guidance offered by the Undip Institute for Research and Community Service, particularly from the CE team (Haeruddin et al., 2023). Because of the success attained, numerous members of the Berkah 2 group and residents of Turunrejo Village visited the Dempond to observe and converse with the Dempond manager about strategies for achieving significant growth and successful graduation of fish.

This CE activity aimed to enhance the income of the fish farming community in Turunrejo Village by increasing the productivity of Nile tilapia ponds. This was achieved through carrying capacity engineering of the ponds, enabling a higher stocking density, reducing the mortality rate, and creating optimal environmental conditions to support healthy fish growth.

2. METHOD

This CE was conducted using the Participatory Action Research (PAR) method. PAR is an action-oriented research approach that emphasizes participation and collaboration among community members impacted by the research (Reason & Bradbury, 2008). According to Reason & Bradbury (2008), the PAR process involves a "community of inquiry and action" that develops and addresses questions and issues significant to those participating as co-researchers. In this activity, the primary stakeholders expected to benefit were the administrators and members of the Berkah 2 fish farming group.

The CE goals were achieved by the team from the Faculty of Fisheries and Marine Sciences and the Vocational School at Undip through several stages. These stages involved analyzing the situation and identifying the problems faced by the targeted community groups, formulating strategies to address these challenges, and defining clear goals and methods to accomplish the objectives of the CE activities.

The issue of low pond productivity experienced by the community was addressed through several measures. These included engineering the carrying capacity of the demonstration ponds (Dempond), constructing new water inlets and outlets, utilizing water pumps, and enhancing the ability to manage pond water quality and fish feed. These improvements ensured that the pond water quality could support the optimal growth of cultivated tilapia.

Figure 2 . Pond water intake and discharge channels

The intake and outlet sluice gates were constructed using PVC pipes, as illustrated in Figure 2. The PVC pipes were positioned vertically inside and outside the pond and connected by a PVC pipe buried slightly below the pond's bottom surface, passing through the barrier to the inlet or drainage channel. At the end of the connecting pipe, a PVC elbow joint was installed, serving as the intake/outlet channel. This elbow joint was oriented with the opening facing upwards, acting as a removable standpipe to facilitate water intake and discharge as needed.

The pumps used were two units of Alcon gasoline-fueled pumps with 4-inch inlet and outlet diameters (Figure 3 (a)). Alcon pumps were selected due to their lightweight design, making them portable and easy to move, while delivering the same water discharge capacity as other types of water pumps.The pump mount is made to prevent fuel and engine oil contamination in the soil and pond water. The mount was made of concrete with dimensions of 100 x 75 x 30 cm, providing a stable and environmentally safe base for the pumps (Figure 3 (b)).

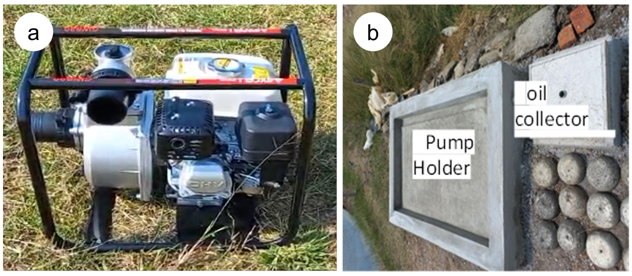

Figure 3 . The water pumps and pump mounts

Improving water quality, in addition to water changes, was achieved through the use of probiotics. Probiotics help enhance water quality, boost the immunity of farmed fish against stress, and improve the quality of fish meat. The probiotics used in this study were previously researched by Fatchiyyah et al. (2021), Haeruddin et al. (2019), and Tyas et al. (2020). These probiotics consist of various microorganisms that play critical roles in degrading organic matter, producing essential nutrients, and naturally combating pests and diseases. The probiotics were prepared in-house using a combination of lactic acid bacteria, yeast, photosynthetic bacteria, bran, banana peel, and molasses. The lactic acid bacteria, yeast, photosynthetic bacteria, and molasses were purchased from chemical suppliers, while bran was sourced from rice mills, and banana peels were collected from street vendors selling fried bananas (molen). The probiotic liquid was prepared with a ratio of 1:10 and then evenly distributed in the pond water to ensure its effectiveness in maintaining optimal water quality.

The implementation of the facilities and infrastructure introduced during the CE activities is expected to increase pond productivity from 300 kg/season (MT) to over 1,500 kg/season. This productivity target assumes a survival rate (SR) of 60% from the initial stocking of 20,000 fish and an average harvest weight of 200 grams per individual.

In addition to providing counseling on tilapia cultivation techniques and probiotic production, field assistance was conducted to support tilapia farming operations at the POKDAKAN Berkah 2 Dempond. This assistance was provided by both lecturers and students. Lecturers offered consultations to administrators and group members, while students collected water quality data by measuring key parameters such as temperature, water clarity, salinity, pH, dissolved oxygen concentration, ammonia, nitrite, and hydrogen sulfide (H_2S).

Temperature, salinity, pH, and dissolved oxygen concentration were measured in situ using a Water Quality Checker, while ammonia, nitrite, and H_2S were analyzed in the laboratory using a visible spectrophotometer. These water quality measurements were essential to evaluate the suitability of the pond water against established quality standards for tilapia cultivation.

The improvement in cultivators' knowledge and competence was assessed through a questionnaire distributed to them at the beginning and near the conclusion of the CE activity. The questionnaire included questions covering key aspects of tilapia farming, such as pond preparation, selection of quality seeds, seed dispersal, feed management, and pond water quality. The comparison of responses from the two time points provided insight into the effectiveness of the CE activity in enhancing the skills and understanding of the cultivators.

3. RESULT AND DISCUSSION

3.1 Results

The activity commenced in early July 2024. Data on pond productivity and the competence of cultivators who are members of POKDAKAN Berkah 2 are summarized in Table 1.

Table 1 . Pond productivity and competence of POKDAKAN Berkah 2 cultivators before CE activity

Observed Variables	Values
Pond Productivirty (kg/Season)	300
Land Drainage	Sometimes
Eradication of Wild Fish	Sometimes
Calcification	Not done
Fertilization	Not done
Water Change	Not done
Water qualiry management	Not done
Fish feed management	Not done

The data in Table 1 is basis for compiling CE programs. It addressed all aspects of cultivation activities, including land preparation (pond bottom drainage, eradication of wild fish, fertilization, water replenishment, and water quality conditioning for fish stocking), as well as fish growth and harvesting. The program emphasized the use of quality seeds, proper feeding practices with high-quality feed, and effective water quality management. These practices were applied to the demonstration pond (Dempond) to provide the fish farming community with a learning platform and to facilitate technology transfer based on the tilapia farming practices demonstrated in the Dempond.

The success of the technology transfer was evaluated by measuring improvements in the knowledge and competence of the fish farming community targeted by the activity. This

Table 2 . Knowledge and competence of the fish farming community at the beginning and near the end of the CE activities

Assessed Knowledge and Skills (%)	Before		After		Improvement of knowledge and competence (%)
	Do not know (%)	Know but don't apply (%)	Don't know and don't apply (%)	Know and apply (%)	
Draining the bottom of the pond	80	20	0	100	80
Eradication of wild fish	50	50	0	100	50
Calcification	80	20	0	100	80
Fertilization	60	40	0	100	60
Water change	0	100	0	100	0
Water quality management	100	0	0	100	100
Fish feed management	100	0	0	100	100

Table 3 . Water quality of tilapia farming ponds during CE activities

No	Variables	Lowest	Highest	Criterion
1.	Temperature (°C)	31.8	32.3	25 - 32[a]
2.	Total Dissolved Solid (mg/l)	5.64	6.9	1.000
3.	Conductivity (mS/cm)	11.59	13.68	-
4.	Salinity (o/oo)	7	8.2	<25
5.	Dissolved oxygen (mg/l)	3.75	4.28	>3[a]
6.	pH	7.62	7.59	6.5 - 8.5[a]
7.	Ammonia (mg/l)	not detected	0.012	0.02[a]
8.	Nitrite (mg/l)	0.035	0.046	0.06[b]
9.	Hydrigen Sulfide (mg/l)	not detected	0.001	0.002[b]

[a] Based on National Standardization Agency of Indonesia (2009)
[b] Based on Ministry of State Secretariat (2021)

was assessed through a questionnaire that included questions about key activities in tilapia farming. The results of the questionnaire analysis are presented in Table 2.

The success of the pond carrying capacity engineering was evaluated based on fish growth indicators during the CE activities and the maintenance of water quality within the standards required for fish farming, particularly for tilapia. The growth performance of the cultivated tilapia is illustrated in Figure 4. The water quality of Nile tilapia ponds during CE activities is presented in Table 3.

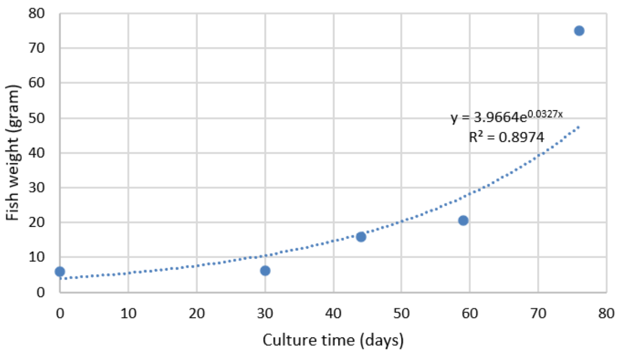

Figure 4 . The growth of cultivated Nile tilapia

3.2 Discussion

A comparison of the data in Table 1 and Table 2 demonstrates that the CE activities significantly improved the knowledge and competence of fish farmers who are members of POKDAKAN Berkah 2. The smallest improvement, observed in the aspect of water management (0%), was attributed to the fact that cultivators already understood the importance of water changes in fish farming to maintain fish health and prevent disease-related mortality. However, due to limitations in cultivation facilities, the application of water management practices could not be fully optimized.

Competence in the eradication of wild fish and the fertilization of the pond bottom and water showed an improvement of 50–60%. Almost half of the surveyed cultivators had learned proper procedures, including eradicating wild fish by fertilizing the pond bottom with compost and fertilizing pond water using urea and TSP fertilizers. The most significant improvements, reaching 100%, were in the areas of water quality management for pond cultivation and feed management. These aspects were entirely new to the cultivators and represented substantial advancements in their knowledge and competence as a result of the CE activity.

Tilapia farming activities, as described by Salsabila & Suprapto (2019), encompass several key processes, including pond preparation, seed dispersal, feeding, water quality management, pest and disease control, and harvesting. Pond preparation involves soil drainage, soil reversal, liming, and water replenishment to create an optimal environment for fish cultivation. Referring to the National Standardization Agency of Indonesia (2015) regarding Good Fish Farming Practices (CBIB) outlined in the Indonesian National Standard (SNI) 7550:2015, the knowledge and competencies required for tilapia farmers have been successfully achieved by members of POKDAKAN Berkah 2. This indicates that the farmers are now equipped to implement tilapia farming practices that align with national standards, ensuring both sustainability and productivity.

Looking at the development of fish cultivated in the pond, it can be predicted that the pond productivity target will be achieved at harvest time. However, the growth of the fish is slower compared to the 2023 CE activity. In the 2023 CE activity, fish raised in the pond reached an average size of 10.5 cm at 35 days of maintenance. This difference is attributed to the 2023 activity providing more natural feed in the form of klekap that floated to the surface (Haeruddin et al., 2023). Despite the slower initial growth, the fish in the current activity exhibited faster growth after 45 days, surpassing the results reported by Haeruddin et al. (2023). Additionally, the growth rate exceeded that documented by Adi & Suryana (2023), who reported a growth rate of 0.83 mm/day in tilapia raised in nursery ponds.

Fish growth is affected by several factors, comprising (1) seed quality, quality seeds will grow faster than poor quality seeds; (2) the quality and quantity of feed, quality feed with sufficient and balanced nutritional content, will trigger a high growth rate; (3) environmental quality, good environmental quality and suitable for optimal fish life and growth, will encourage a faster growth rate, because the energy obtained from feed, more is transformed into fish biomass weight, rather than for adaptation to unfavorable environmental conditions.

Observation of fish growth up to 75 days of age indicates that selective harvesting – harvesting fish that have reached market size – can begin when the fish are 105 days old. With an estimated survival rate (SR) of 60% and an average harvested fish weight of 200 grams per fish, the total harvest is projected to reach 1,500 kg. At a market price of IDR25,000.00 per kilogram, the farmers' income could amount to IDR37,500,000.00. According to Nurchayatie et al. (2021), tilapia ponds in Tayu District, Pati, typically yield 3 tons per hectare per season. The productivity of the tilapia pond in the Dempond has surpassed this benchmark, despite its smaller scale. This higher productivity is attributed to strict water quality management and controlled feed provision, which optimize the growth and health of the fish.

Table 2 indicates that the water quality of the fish farming media in the Dempond aligns with the optimal criteria for fish rearing. According to National Standardization Agency of Indonesia (2009), concerning the production of tilapia in calm water ponds, the recommended water temperature for rearing ranges from 25°C to 32°C, with a pH of 6.5 to 8.5 and dissolved oxygen levels above 3 ppm. It is noted by Sucipto & Prihantoro (2007) that dissolved oxygen concentrations of 3 mg/L can negatively affect fish growth. Additionally, high levels of suspended solids can impair the breathing activity of tilapia (Haeruddin et al., 2023). Tilapia is a euryhaline species capable of growing in brackish water, as stated by Dewi et al. (2018). Arifin (2016) further noted that tilapia can survive and reproduce in waters with salinity levels ranging from 0 to 28 ppt. However, as tilapia is a freshwater species, optimal salinity should not exceed 10 o/oo to ensure ideal growth conditions (Haeruddin et al., 2023). These findings underscore the importance of maintaining water quality parameters within the specified ranges to support healthy tilapia cultivation.

Based on the requirements outlined in National Standardization Agency of Indonesia (2009), the maximum allowable ammonia (NH_3) concentration for fish farming activities is <0.02 mg/L. Ammonia becomes toxic to commercially farmed fish at concentrations exceeding 1.5 mg/L, and in some cases, the acceptable concentration is as low as 0.025 mg/L (Chen et al., 2006). In the Dempond, the concentration of nitrite in the fish farming medium remained below the river water quality standard for aquatic biota (<0.06 mg/L), as set by Ministry of State Secretariat (2021). The highest recorded nitrite concentration in the cultivation medium was 0.046 mg/L. Similarly, the concentration of hydrogen sulfide (H_2S) also stayed within acceptable limits for aquatic biota (<0.002 mg/L), with the highest recorded H_2S concentration in the Dempond being 0.002 mg/L. Ammonia, nitrite, and H_2S concentrations exceeding these quality standards can cause health issues in fish and, in severe cases, result in mortality. The consistent maintenance of ammonia, nitrite, and H_2S levels below the quality standards demonstrates effective water quality and feed management in the Dempond. This success is attributed to the strict regulation of feed quantity, ensuring that fish are fed only according to their actual needs, minimizing waste accumulation in the pond and preventing water quality deterioration.

4. CONCLUSION

Our CE activity was conducted in Turunrejo Village from July 2024 to the end of November 2024. All service goals are expected to be fully achieved by the conclusion of the program. Pond productivity is anticipated to exceed the target of 1.5 tons per season, driven by successful water and feed quality management, as well as the provision of essential cultivation facilities and infrastructure, including water pumps, new water intake systems, old water disposal gates, and the application of probiotics. The activity has demonstrated its potential to increase the farming community's income while enhancing fish farmers' knowledge and competence in Good Fish Farming Practices (CBIB).

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest

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