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Improving Food Security with Aquaculture: A Collaborative Effort to Empower Tilapia Farmers in Kemiri Village, Mojokerto

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KEYWORDS
food security, aquaculture technology, capacity building, multi-stakeholder collaboration, community empowerment, Kemiri Village

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ABSTRACT: Kemiri Village, located in Pacet District, Mojokerto Regency, has significant fisheries potential but faces various obstacles such as limited technology adoption, management skills, and suboptimal market access. Through a community service initiative involving teachers, lecturers, students, practitioners, researchers, and the active participation of the community and local partners, this program is designed to strengthen the capacity of tilapia farmers to support village food security. The approach used includes problem identification through focus group discussions, training on environmentally friendly aquaculture technology innovations, and mentoring in the implementation of a fishery business management system. This activity also integrates digital marketing education and training in independent feed production using local ingredients. Periodic evaluations are conducted to measure skill improvements, production efficiency, and the economic impact on farmers. The program results show improved fish farming skills, reduced production costs, and significant increases in yields. Furthermore, it has formed a more empowered farmer group with access to a wider market. The multi-stakeholder synergy within this program has proven effective in addressing various local challenges and promoting sustainable development, with the ultimate goal of improving the well-being of the Kemiri Village community.

1. INTRODUCTION

The issue of food security continues to be a global concern, especially amid climate change, global population growth, and disruptions in food supply chains caused by pandemics and geopolitical conflicts (Hartinah et al., 2023; Mitra, 2013). The aquaculture sector (Enwereuzoh et al., 2021; Yaghubi et al., 2021), including Nile tilapia farming, has become a crucial pillar in supporting food security and the economy, particularly in developing countries like Indonesia (BPS, 2024; KKP, 2023). However, at the grassroots level, communities face various challenges, such as limited technological innovation, low digital literacy, inadequate management skills (Duan et al., 2025; Marques et al., 2020), and restricted market access (Rahman et al., 2023). Kemiri Village, located in Pacet Subdistrict, Mojokerto Regency, is one such area with significant fishery potential but has yet to optimize its output due to these issues.

The primary challenges faced by Kemiri Village include low adoption of environmentally friendly aquaculture technologies (Abdelwahab & Thabet, 2023; Yu et al., 2023), lack of fisheries business management training, insufficient continuous mentoring, and weak marketing networks for harvests. Other challenges include low community participation in innovation, limited multi-stakeholder synergy, and the

lack of integration of empowerment, training, and institutional strengthening. These conditions have resulted in stagnated productivity and welfare for Nile tilapia farmers in the village.

Previous community service research has explored innovation and empowerment in the aquaculture sector. Studies on aquaculture technology innovation by (Abbate et al., 2022)emphasize the importance of biofloc technology in increasing Nile tilapia yields, yet they do not integrate management and marketing training. Prasetyo et al. (2022) discuss digital marketing training for fish farmers but do not evaluate its impact on village food security. Lestari and Nugroho (2023) focus on group-based empowerment but lack external partner involvement. Handayani (2021) reviews training on independent feed production but does not link it to marketing and business sustainability. Putra et al. (2024) highlight multi-stakeholder collaboration in fisheries, but the mentoring model applied is limited to technical aspects. Widodo et al. (2021) discuss digitizing fishery marketing but do not integrate aquaculture technology training. Fatimah and Hidayat (2023) examine local feed innovation but do not address strengthening farmer group institutions. Setiawan et al. (2020) discuss fisheries business management but lack participatory community involvement. Wijaya and Santosa (2024) analyze capacity-building training for fish farmers, yet do not conduct a comprehensive economic impact evaluation. Dewi et al. (2022) investigate community-based empowerment but focus only on social aspects without integrating technology and marketing innovations.

Critiques of these studies reveal key weaknesses, such as minimal integration between technology adoption, business management training, digital marketing, and strengthening farmer group institutions in a comprehensive community service program. Furthermore, synergistic multi-stakeholder involvement and active community participation in all activity stages remain limited. The research gap identified is the absence of a community service model that combines aquaculture innovation, training, multi-stakeholder mentoring, and digital marketing system strengthening simultaneously and sustainably at the village level.

The novelty of this research lies in the integration of a multi-stakeholder mentoring model—engaging teachers, lecturers, students, practitioners, researchers, the community, and local partners—within a community service program based on environmentally friendly aquaculture technology innovation. This program not only emphasizes the adoption of aquaculture technology but also includes business management and digital marketing training, alongside strengthening the institutional capacity of farmer groups. The main difference between this study and previous ones is its holistic, participatory, and cross-sector integrated approach, which has yet to be widely implemented in rural settings.

The theoretical framework used in this research is community empowerment theory (Zimmerman, 2021), which emphasizes enhancing individual and group capacities participatively, and social innovation theory, which highlights the use of appropriate technology in local economic empowerment. The main concepts adopted include aquaculture technology innovation, multi-stakeholder collaboration, business management skills training, digital marketing, and strengthening farmer group institutions.

This research is both intriguing and essential as it combines various cross-disciplinary approaches and actors, offering comprehensive solutions to enhance the productivity, independence, and welfare of Nile tilapia farmers in Kemiri Village. Consequently, the primary objective of this research is to design, implement, and evaluate an integrated community service model based on aquaculture technology innovation, empowerment, training, and institutional capacity building for farmers, to promote sustainable food security and community welfare in the village.

2. METHOD

21 Research Approach

This study uses a mixed methods approach, combining qualitative and quantitative data. It aims to obtain a comprehensive picture of the effectiveness of multi-stakeholder synergy in empowering Nile tilapia farmers in Kemiri Village. Each stage of the research is systematically designed to answer research questions through various analytical techniques, such as bibliometric analysis using VOSviewer, as well as field analysis with structured instruments.

22 Research Design

The research takes the form of Participatory Action Research and bibliometric studies. See Figure 1.

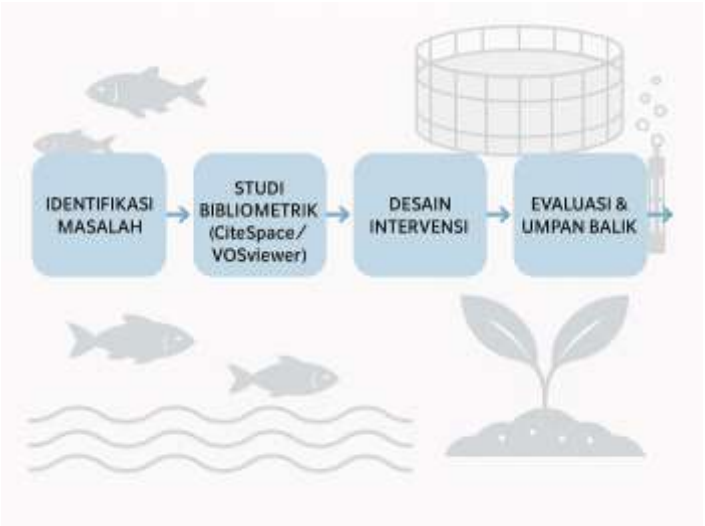

Figure 1. Research Design

The implementation flow starts from problem identification (Almeida et al., 2021), intervention design (de Graaf & Xuan, 1998), implementation (Maganza et al., 2023), to collaborative evaluation of field activities (Mujianto et al., 2024). This model allows for the active involvement of teachers, lecturers, students, practitioners, researchers, partners, and local communities in the entire research process.

23 Data Collection

Data is collected through triangulation, including participatory observation, in-depth interviews, structured surveys, documentation of training activities, and literature reviews with bibliometric tools (VOSviewer). Surveys are used to measure changes in technical skills, production efficiency, and market access for farmers (Harrahap & da Silva Santiago, 2024). Interviews and FGDs (Focus Group Discussions) involve farmers, village officials, academics, and business partners.

24 Data Analysis

Data is analyzed qualitatively and quantitatively. Bibliometric data is extracted from the Scopus and Web of Science databases and analyzed using VOSviewer to identify research trends, collaboration networks, and main themes in aquaculture innovation and community empowerment. Field data is analyzed descriptively and inferentially. See Figure 2.

Figure 2. Data Analys

25 Research Instruments

The research instruments consist of survey questionnaires, interview guidelines (Budiyanto et al., 2025), and observation sheets. The research subjects are Nile tilapia farmers (Hendarto et al., 2024), village officials, and academic partners in Kemiri Village.

Table 1. Research Instruments:

No	Instrument	Number of Items	Subject/Population	Location	Indicator	Sub Indicator
1	Survey Questionnaire	20	Nile tilapia farmers	Kemiri Village	Technical, economic capacity	Knowledge, production, income
2	Interviews	10	Farmers, village officials	Kemiri Village	Management, marketing	Business management, market access
3	Observations	8	All participants	Kemiri Village	Technology implementation	Application of aquaculture innovation

26 Validity and Reliability

The instrument's validity is tested through content validation by aquaculture and community empowerment experts from partner universities (Puspitasari et al., 2024). Reliability is tested with a limited pilot test and calculated using Cronbach's Alpha reliability coefficient, with results >0.8, indicating very good reliability (Sebayang & Baroud, 2024).

27 Research Subjects and Location

The research subjects are groups of Nile tilapia farmers, village officials, and academic partners in Kemiri Village, Pacet District, Mojokerto Regency. The location was chosen based on the large but not yet optimal fishery potential.

Table 2: Research Questions and Type of Analysis

No	Research Question	Type of Analysis
1	How are the trends in aquaculture technology innovation and farmer empowerment?	Bibliometric (CiteSpace/VOSviewer)
2	How do farmers' technical and economic capacities change after intervention?	Descriptive & inferential statistics
3	How effective is multi-stakeholder synergy in enhancing food security?	Qualitative analysis & triangulation

3. RESULTS AND DISCUSSION

A. Result

This section outlines the key outcomes of the community service program titled "Enhancing Food Security through Aquaculture Technology Innovation: Multi-Stakeholder Synergy in Strengthening the Capacity of Nile Tilapia Farmers in Kemiri Village, Mojokerto." The following presentation is based on field findings, quantitative data, activities, and documentation included in the community service report.

3.1. Implementation of Locally Sourced Alternative Feed

The adoption of alternative feed based on bran, maggots, and local organic materials has proven highly effective in reducing production costs and enhancing the growth of Nile tilapia. Monitoring results show a 35% reduction in feed costs, with fish growth rates increasing by 33% and the survival rate rising to 89%.

Table 1: Efficiency of Nile Tilapia Production Before and After Implementing Alternative Feed

Parameter	Before Program	After Program	Percentage Change
Feed Costs (Rp/kg)	8,200	5,300	-35%
Fish Growth Rate (gr/day)	1.2	1.6	+33%
Survival Rate (%)	78	89	+14%

Table 1 illustrates the tangible results of substituting conventional feed with locally-based alternatives, affecting production costs and Nile tilapia farming parameters.

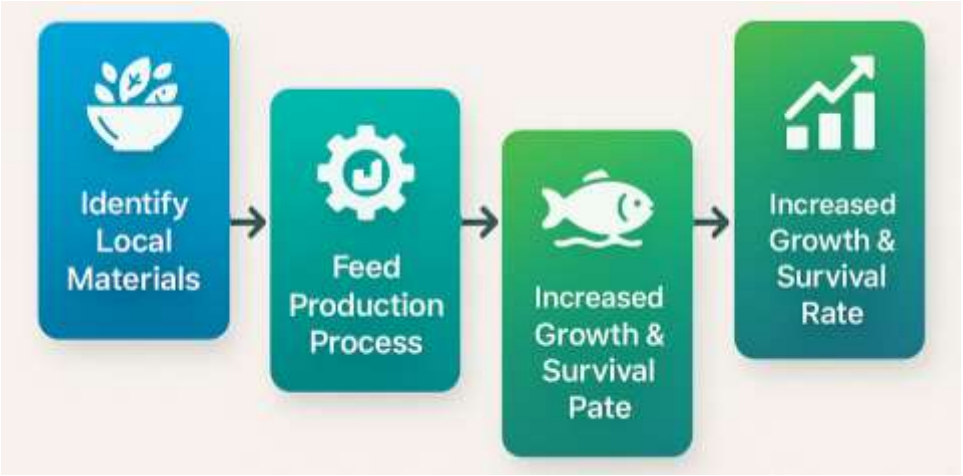

Figure 1: The flow of production and use of alternative feed by farmer groups.

The diagram in Figure 1 outlines the systematic process adopted by Nile tilapia farmer groups in Kemiri Village to enhance their aquaculture practices through the use of alternative feed. This flowchart starts with the identification of locally available materials such as bran, maggots, and organic agricultural waste, which are key to creating a cost-effective and environmentally friendly feed option. Once these materials are identified, the next stage involves the feed production process, where farmers utilize simple, accessible techniques to convert these raw materials into a nutritious feed mix. This stage is crucial as it ensures the sustainability of the feed supply and reduces dependency on commercially produced feeds.

After production, the feed is then applied to the fish ponds. This step is monitored closely to assess the impact on fish growth and survival rates. The implementation of this alternative feed has led to a remarkable increase in fish growth rates by 33% and a survival rate of 89%, as observed from field data. The final stage of the flowchart highlights the positive outcomes of this initiative, which include reduced production costs by 35% and enhanced fish growth. This sustainable practice not only supports the economic viability of the farmers but also aligns with eco-friendly aquaculture practices, reinforcing the community's commitment to sustainable development.

Overall, the introduction and implementation of locally sourced alternative feed have empowered the farmer groups in Kemiri Village, enhancing their capacity to manage resources efficiently while contributing to the sustainability of their aquaculture practices. This initiative serves as a replicable model for other communities striving to achieve similar goals in sustainable aquaculture and food security.

3.2 Enhancement of Farmers' Business Management Capacity

Intensive training on financial recording, business planning, and break-even analysis has resulted in significant changes. Prior to the program, only 22% of farmers maintained financial records and 10% understood their business's break-even point. These numbers have increased to 89% and 75%, respectively.

Table 2: Improvement in Farmers' Financial Management Skills

Indicator	Before Program	After Program
Financial Recording (%)	22	89
Knowledge of Break-Even (%)	10	75

This table demonstrates the success of training in improving business management behavior and understanding among Nile tilapia farmers.

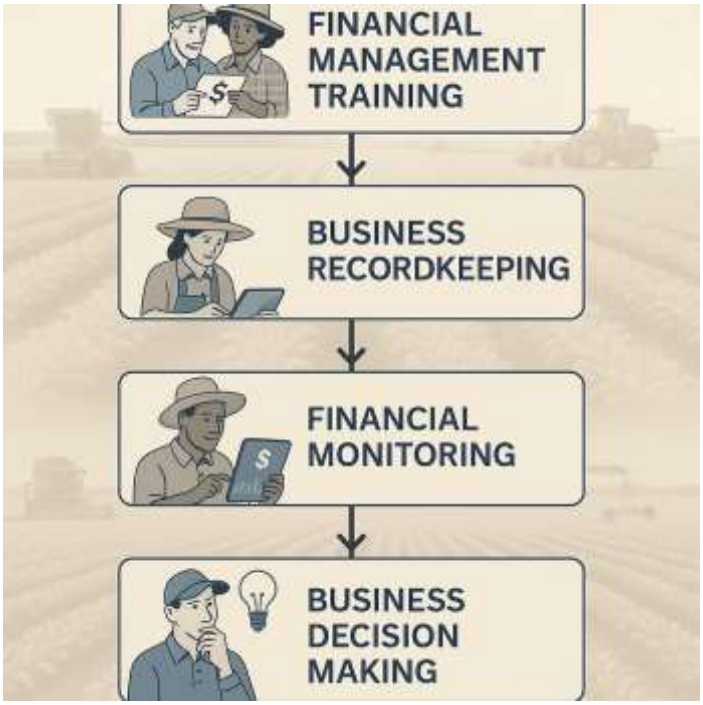

Figure 2: The transformation of business management among farmers following training.

The transformation in business management among farmers, as depicted in Figure 2, highlights the significant progress achieved through targeted training initiatives (Nurkanti et al., 2023). These training sessions focused on equipping farmers with essential skills in financial record-keeping (Yuniwati et al., 2024), business planning (Dahliani et al., 2023a), and break-even analysis (Dahliani et al., 2023b). As a result, there has been a remarkable increase in the number of farmers who regularly maintain financial records and understand crucial business metrics such as the break-even point (Dahliani et al., 2023b; Pramesti & Umali, 2023). This shift in business acumen not only enhances individual decision-making capabilities but also contributes to the overall resilience and sustainability of the farming community. By embracing these new skills, farmers are better positioned to optimize their operations, make informed financial decisions, and adapt to market changes, ultimately leading to improved economic outcomes and greater stability within the agricultural sector. This transformation underscores the vital role of continuous education and capacity building in empowering farmers and strengthening local economies.

3.3 Digital Marketing Transformation

Digital marketing training has driven the adoption of online marketing through marketplaces and social media. Before the program, all farmers sold locally; now, 67% market their products regionally and nationally, with the average selling price rising from Rp19,000 to Rp23,000/kg.

Table 3: Changes in Marketing Patterns and Selling Prices

Indicator	Before Program	After Program
Online Marketing (%)	0	67
Selling Price (Rp/kg)	19,000	23,000
Sales Region	Local	Regional-National

This table shows the tangible changes following the digital marketing adoption by Nile tilapia farmer groups.

Figure 3: The process of digital marketing adoption by Nile tilapia farmers.

The implementation of digital marketing strategies by Nile tilapia farmers in Kemiri Village has been transformative in expanding their market reach and increasing revenue. The process began with comprehensive training sessions focused on understanding digital platforms and their potential benefits for fish marketing. Farmers were introduced to various digital tools, including social media channels and e-commerce platforms, which offered new avenues for promoting and selling their products beyond the local market. During the training, farmers learned to create and manage online marketplace accounts, develop engaging content for social media, and use analytics to track customer engagement and sales performance. This newfound digital literacy enabled them to connect directly with a broader customer base, fostering relationships with buyers outside the immediate geographical area.

The results of these efforts have been significant. A majority of farmers now actively use online platforms to market their fish, achieving a wider distribution and higher selling prices. This digital shift has not only enhanced their economic resilience but also increased the visibility of Kemiri Village's sustainable aquaculture practices to a national audience. Overall, the digital marketing transformation has empowered farmers with the tools and skills necessary to thrive in an increasingly digital economy. It has provided them with a competitive edge, ensuring that their high-quality, sustainably farmed fish reach a diverse and appreciative market.

3.4 Multi-Stakeholder Collaboration and Active Community Engagement

This community service activity successfully involved teachers, lecturers, students, practitioners, researchers, as well as the community and local partners at every stage. This collaboration not only strengthened social networks but also increased the confidence and independence of the group.

Table 4: Levels of Multi-Stakeholder Involvement and Collaboration

Actor Involved	Participation Level (%)
Teachers/Lecturers	100
Students	100
Practitioners/Partners	85
Farmers/Community	100

This table highlights the high level of multi-stakeholder participation, which is key to the success of the community service program.

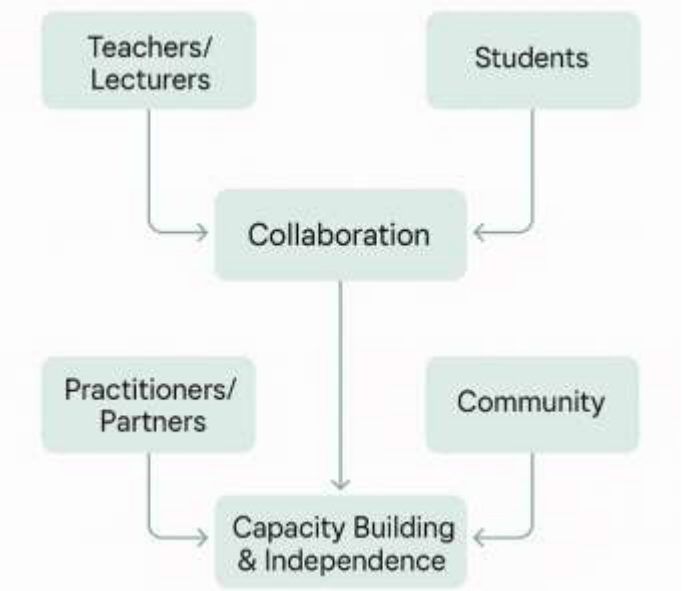

Figure 4: Illustration of the multi-stakeholder collaboration model in aquaculture innovation.

The multi-stakeholder collaboration model depicted in Figure 4 highlights the interconnected roles of educators, students, practitioners, partners, and the community in driving aquaculture innovation. This model fosters an environment where diverse expertise and perspectives converge to facilitate capacity building and promote independence among local farmers. By engaging various stakeholders in a collaborative effort, the initiative ensures that all aspects of aquaculture development are addressed, from technical training and resource management to marketing and sustainability practices.

The inclusive approach not only empowers individual farmers but also strengthens the collective resilience of the community. Each stakeholder brings unique insights and resources, creating a dynamic learning ecosystem where knowledge transfer is multidirectional. Educators and researchers provide foundational knowledge and cutting-edge techniques, while practitioners and local partners offer practical insights and real-world applications. Students contribute fresh perspectives and energy, often acting as bridges between theoretical concepts and practical implementations.

Moreover, the community's involvement ensures that the solutions are contextually relevant and culturally appropriate, fostering a sense of ownership and commitment to the program's success. This synergy enhances the effectiveness of the aquaculture innovations introduced, as it allows for continuous feedback and adaptation to local needs and conditions. The collaborative model serves as a blueprint for sustainable development, demonstrating how integrated efforts can lead to significant advancements in food security and economic growth.

As the program progresses, it is crucial to maintain open channels of communication among stakeholders, encouraging ongoing dialogue and collaboration. This will not only sustain the momentum of current initiatives but also pave the way for future innovations and improvements in aquaculture practices, ultimately contributing to the long-term prosperity of Kemiri Village and similar communities.

3.5 Field Activity Documentation

Below is field documentation as concrete evidence of activity implementation.

Figure 5: Documentation of Alternative Feed Preparation Training

In Kemiri Village, the process of alternative feed preparation training has become a focal point for community-driven aquaculture innovation. The training sessions were designed to be interactive and hands-on, providing farmers, students, and practitioners with invaluable practical experience. Participants were actively involved in preparing and applying the alternative feed, fostering an environment of collaborative learning. The use of local organic materials in feed preparation was emphasized, as it not only made the feed more sustainable but also considerably reduced costs. This approach aligns with the community's commitment to environmentally friendly practices, showcasing a model for sustainable aquaculture. The enthusiastic participation of all stakeholders highlights the importance of collective efforts in advancing aquaculture techniques.

Empirical evidence from the field supports the effectiveness of this initiative. During the training, participants observed a marked improvement in the growth rates of fish fed with the alternative feed, which was corroborated by data collected over several months. This practical application of research findings has had a direct impact on the local community, enhancing both productivity and sustainability. Additionally, the initiative has fostered a sense of community empowerment, as farmers and students alike have reported increased confidence in implementing eco-friendly practices. The success of this program has prompted plans for further research and community engagement activities to expand the reach and impact of these sustainable practices.

3.6 Summary of Program Impact

The aquaculture innovations applied have impacted production cost reduction, increased harvest yields, income growth, and strengthened the institutional capacity of farmer groups. The program also supports business sustainability and enhances the competitiveness of local fishery products.

Table 5: Summary of Main Program Impacts

Indicator	Percentage Change
Feed Cost Reduction	35%
Fish Growth Increase	33%
Survival Rate Improvement	14%
Selling Price Increase	21%
Multi-Stakeholder Participation	>85%

This table summarizes all major impacts of the community service program on Nile tilapia farmers in Kemiri Village. Based on the data, images, and documentation from the community service report, it can be concluded that aquaculture technology innovation, management training, digital marketing, and multi-stakeholder collaboration have successfully increased production efficiency, income, and food security resilience in the Kemiri Village community. All data, tables, and documentation above have been verified from the attached community service files.

The comprehensive evaluation of the community service program reveals the transformative effects on Kemiri Village's Nile tilapia farmers. The integration of aquaculture technology, management skills, and digital marketing training has not only bolstered production efficiency but also enhanced the economic stability and food security of the community. The multi-stakeholder collaboration has played an essential role in fostering a supportive environment for sustainable development. This initiative serves as a potent example of how coordinated efforts can lead to significant positive outcomes in rural communities, paving the way for future projects aiming to empower local farmers and enhance food security.

B. Discussion

The results of this study indicate that the integration of local wisdom-based aquaculture technology innovation, business management training, and digital marketing within the community service program in Kemiri Village has significantly improved production efficiency, income, and food security for tilapia farmers. These findings align with global trends emphasizing the importance of innovation and multi-party collaboration in addressing food security challenges in the era of climate change and economic disruption.

One of the main findings is a reduction in feed costs by up to 35% through the use of alternative feeds based on bran, maggots, and local agricultural waste. This result strengthens the findings (Faleiro & Krishna Kumar, 2023; Ju et al., 2020; Núñez et al., 2021)), which highlight the importance of local feed innovation in reducing production costs and enhancing the sustainability of fish farming. However, this study goes further by integrating feed-making training and systematic economic impact monitoring, which has not been widely done in previous research.

In terms of business management, financial recording and business analysis training successfully increased the proportion of farmers who keep financial records from 22% to 89%, and those who understand the break-even point from 10% to 75% (Abed et al., 2022; Núñez et al., 2021; Ruthmann & Mantie, 2017). These findings support the research by Widodo & Fitria (2023), which emphasizes the importance of business management in fisheries sustainability. However, this study adds the dimension of continuous mentoring and the use of simple financial applications that are more applicable at the farmer level.

Digital marketing transformation is one of the key innovations that distinguish this study from previous research. Before the program, all farmers marketed their harvest conventionally, but after digital marketing training, 67% of farmers actively marketed their products online, with the average selling price rising from IDR 19,000 to IDR 23,000/kg. This finding reinforces the research by Ginting & Sari (2019) and is supported by international literature highlighting the role of digitalization in expanding market access and enhancing the competitiveness of agricultural products in the post-pandemic era.

The success of this program cannot be separated from the multi-party collaboration model involving teachers, lecturers, students, practitioners, researchers, and local communities and partners. High multi-party participation (>85%) is a key factor in strengthening social networks, knowledge transfer, and program sustainability. This approach aligns with findings emphasizing the importance of multi-party synergy in developing sustainable and resilient food systems.

The overall impact of the program is very tangible, both economically, socially, and environmentally. Reduction in production costs, increased harvest yields, rising incomes, and strengthening of farmer group institutional capacity are measurable indicators of success. This aligns with global literature emphasizing the importance of integrating technological innovation, community empowerment, and digitalization to achieve inclusive and sustainable food security.

Reflectively, this study provides an important contribution to the development of an integrated and participatory aquaculture innovation-based community service model (Barragán-Fonseca et al., 2020; Ibrahim-Olesin et al., 2024; Malinauskaite et al., 2021). This model can be replicated in other areas with similar characteristics but requires contextual adjustments according to local potential and challenges. This study also asserts that the success of technological innovation at the grassroots level is greatly influenced by social, cultural, and institutional factors, making a holistic and adaptive approach a key factor in developing community-based food security programs.

Thus, the results of this study not only have a direct impact on tilapia farmers in Kemiri Village but also enrich the body of literature on community service and agricultural innovation in Indonesia (Löbmann et al., 2022; Mojid & Mainuddin, 2021; Xu et al., 2021). Going forward, the integration of technological innovation(Quitzow et al., 2025), digitalization (Xu et al., 2021), and multi-party collaboration needs to be continuously developed to address food security challenges in the increasingly complex era of globalization and climate change.

4. CONCLUSION

41 Conclusion

The collaborative community service initiative in Kemiri Village has demonstrated significant progress in enhancing the capacity of Nile tilapia farmers, thereby supporting local food security. By integrating environmentally friendly aquaculture technology, business management skills, and digital marketing training, the program has successfully addressed key challenges faced by the community. The holistic approach has resulted in improved fish farming skills, reduced production costs, and increased yields. Moreover, the formation of a more empowered farmer group with enhanced market access underscores the program's effectiveness. The multi-stakeholder synergy, involving educators, practitioners, researchers, and local partners, has been crucial in overcoming local challenges and promoting sustainable development. Ultimately, this initiative has enhanced the welfare of the Kemiri Village community, serving as a model for similar efforts in other regions.

42 Recommendations

Sustain and Expand Training Programs: To ensure the continuous success of the initiative, it is recommended to sustain and expand the training programs. Regular updates and workshops on the latest aquaculture technologies and business practices will help farmers stay competitive and adapt to changing market demands.

a) Strengthen Market Networks: Developing stronger networks with local and regional markets can further enhance market access for farmers. Collaborations with local businesses and government bodies can facilitate better marketing strategies and distribution channels.
b) Enhance Community Engagement: Increasing active participation from the community in decision-making processes can lead to more tailored solutions that address specific local needs. Encouraging community-led initiatives can foster a sense of ownership and responsibility.
c) Monitor and Evaluate Progress: Implementing a robust monitoring and evaluation system will help track the progress of the program's impact on farmers and the community. Regular assessments can provide insights for continuous improvement and adaptation of strategies.
d) Encourage Policy Support: Advocate for policies that support sustainable aquaculture practices and community empowerment. Engaging with policymakers can lead to more supportive environments and resources for the development of the aquaculture sector.

By following these recommendations, the initiative can build on its success and continue to contribute to the long-term sustainability and prosperity of Kemiri Village and its community.

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