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Implementation of smart agrologistics for strengthening economic resilience of steamed fish enterprises in Erorejo Wadaslintang

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ABSTRACT

Steamed fish represents one of the primary processed fish products produced by fishermen in Wadaslintang. In the aftermath of the COVID-19 pandemic, the Wadaslintang Fish Craftsmen and Management KWT Rahayu faced various obstacles, particularly in securing adequate supplies of red tilapia (Oreochromis sp.) as raw material and in expanding their marketing reach. This service program aims to implement smart spatial agrologistics to increase production capacity, expand market reach, and strengthen the economic resilience of steamed fish enterprises in Erorejo Wadaslintang. Over eight months, the program targeted 15 KUB members and applied several participatory approaches, including interviews, data segregation, and georeferenced digitization, to identify reliable raw material suppliers, map potential markets, and define marketing coverage. The initiative demonstrated that green spatial agrological innovation could be successfully adapted to strengthen local fishing enterprises. As a direct outcome, membership of steamed fish businesses increased from 15 to 20 participants, while marketing areas expanded to Lampung and Banjarmasin. Furthermore, production capacity rose significantly from 60 kilograms per day to 150 kilograms per day. These results confirm that the adoption of innovative spatial-based agrological technology can enhance productivity, improve resource management, and boost the economic resilience of fishing communities in Wadaslintang.

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1. INTRODUCTION

Red tilapia *(Oreochromis sp.)* is a freshwater fish widely cultivated in reservoirs and estuaries due to its high protein content and nutritional value (Echavarría et al., 2025). Its nutritional composition includes 70–80 percent water, 16–20 percent protein, 1–5 percent fat, and 0.8–1.5 percent ash (Arias & Claudia, 2023). In general, red tilapia can be processed into a wide variety of value-added products, ranging

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from fresh whole fish sold directly to consumers, to steamed fish that highlights its delicate texture and nutritional quality, and even to salted fish that extends its shelf life while creating distinctive flavors preferred in many local markets. These diverse processing options not only increase the marketability of red tilapia but also provide flexibility for producers and fishermen to adapt their products to different consumer preferences, distribution channels, and regional demand patterns (Rehman et al., 2025; Belleggia & Osimani, 2023).

Erorejo Village in Wadaslintang District, Wonosobo Regency, is known as a center for steamed fish production, with Wadaslintang Reservoir as the source of red tilapia, the main raw material (Yusianto et al., 2024). Local women's groups, particularly the Fish Farming Group (KWT) Rahayu, are the driving force behind its processing and distribution. Before the COVID-19 pandemic, this group was able to produce around 60 kg of steamed fish daily, primarily distributed in Wonosobo and Banjarnegara. The COVID-19 pandemic has posed significant challenges for members of the KWT Rahayu in Wadaslintang, particularly in securing a supply of high-quality red tilapia as the primary raw material and in expanding market access for their processed fish products. Many members have not yet mastered the integration of red tilapia cultivation into a superior product with strong commercial appeal, a sustainable production system, and a more efficient marketing approach. These challenges highlight the urgent need for business diversification, including the development of red tilapia cultivation, which presents a promising opportunity to increase fishermen's incomes and strengthen local economic resilience.

The pandemic disrupted raw material supplies and limited market access, necessitating the need to strengthen aquaculture integration, improve marketing strategies, and diversify businesses (Aljuneidi et al., 2023; Moosavi et al., 2022). In response, the community partnership program is now focused on developing fish farming, processing, and post-harvest management to make steamed red tilapia a superior product in Wadaslintang (Hardjomidjojo et al., 2022). According to Ety Sri Mulyati, Chairperson of KWT Rahayu and producer of steamed fish under the same name on Jalan Juru Tengah, Erorejo Wadaslintang, the partner village in this program, produced an average of 60 kg of steamed fish per day before the COVID-19 pandemic, utilizing approximately 2 quintals of red tilapia per day as raw material (Figure 1).

Figure 1. Discussion of fishing partners' problems

This service program aims to implement smart spatial agrologistics to increase production capacity, expand market reach, and strengthen the economic resilience of steamed fish enterprises in Erorejo Wadaslintang.

2. METHODS

This activity involved a sample of 30 fishermen from Wadaslintang, selected through a simple random sampling technique to ensure representativeness of the wider fishing community. Data collection was conducted using a combination of in-depth discussions, structured interviews, and participatory observation to obtain comprehensive information on the challenges faced by fishermen and KWT members.

To strengthen the validity of findings, qualitative data from interviews and observations were systematically coded, while quantitative responses were analyzed using descriptive statistics to identify trends in production capacity, market access, and resource availability. In addition, segregation analysis with the Geo Segregation Analyzer was applied to generate statistical insights based on spatial data, allowing the team to map the distribution of reliable suppliers of red tilapia, identify potential market segments, and determine marketing coverage strategies (Essamlali et al., 2024).

Through this mixed-method approach, the analysis not only highlighted the key constraints in raw material procurement and market penetration but also quantified the extent of business disruptions during the COVID-19 pandemic.

The statistical outcomes were then integrated into the design of a decision support system in the form of a smart green spatial database. This system is intended to assist KWT members in Wadaslintang in planning and developing sustainable businesses by providing valid and integrated data for decision-making. At present, the KWT has not yet adopted any information system to enhance sales transactions, and its production capacity remains relatively low—only one processing cycle per day, with a maximum of 60 kg, relying on 2 quintals of red tilapia as raw material. Most KWT members also have limited knowledge of integrated steamed fish production systems, which encompass cultivation, production, post-harvest handling, distribution, and marketing. Therefore, this program incorporates training and technology-based interventions to address these knowledge and capacity gaps, aiming to improve both production efficiency and competitiveness in the steamed fish business in Wadaslintang.

Figure 2. Activities of craftsmen and fish managers in Erorejo

Post-harvest processing in Wadaslintang has considerable potential for optimization through the application of modern techniques and technology-based systems. The introduction of vacuum packaging is expected to extend product shelf life by 30–40 percent, while the implementation of clear and standardized product labeling can increase consumer trust by at least 25 percent. In addition, the development of database-driven marketing systems, particularly those that leverage rapidly expanding online platforms, is projected to broaden market reach by 50 percent within the first year. To support these initiatives, the Wonosobo Regency Government, in collaboration with the local administration of Wadaslintang, has allocated approximately IDR 150 million annually, which includes funding for at least four training sessions and two counseling activities each year for fishermen and KWT members.

Despite these efforts, the role of KWT in disseminating productivity programs has not yet been fully optimized to position steamed fish as a flagship commodity. For this reason, it is necessary to increase production capacity through the use of an intelligent decision support system based on a spatial database. This system encompasses the mapping of cultivator distribution (estimated at 120 active farmers), access to high-quality red tilapia raw materials (targeting 5–6 tons per month), identification of potential market segments (10 new district-level buyers), and expansion of marketing coverage (at least 5 regencies in Central Java within two years).

In line with the Industrial Revolution 4.0 era, this program seeks to develop a smart green spatial agro-logistics system supported by an intelligent decision support platform. The ultimate purpose is to implement several KWT business development initiatives through a new integrated steamed fish business model, supported by data-driven decision-making. This approach is expected to increase sales transactions by at least 40 percent within two years and build a productive and resilient fishing community, with 75 percent of KWT members actively adopting the system. The methods and stages of this program's implementation are presented in Figure 3.

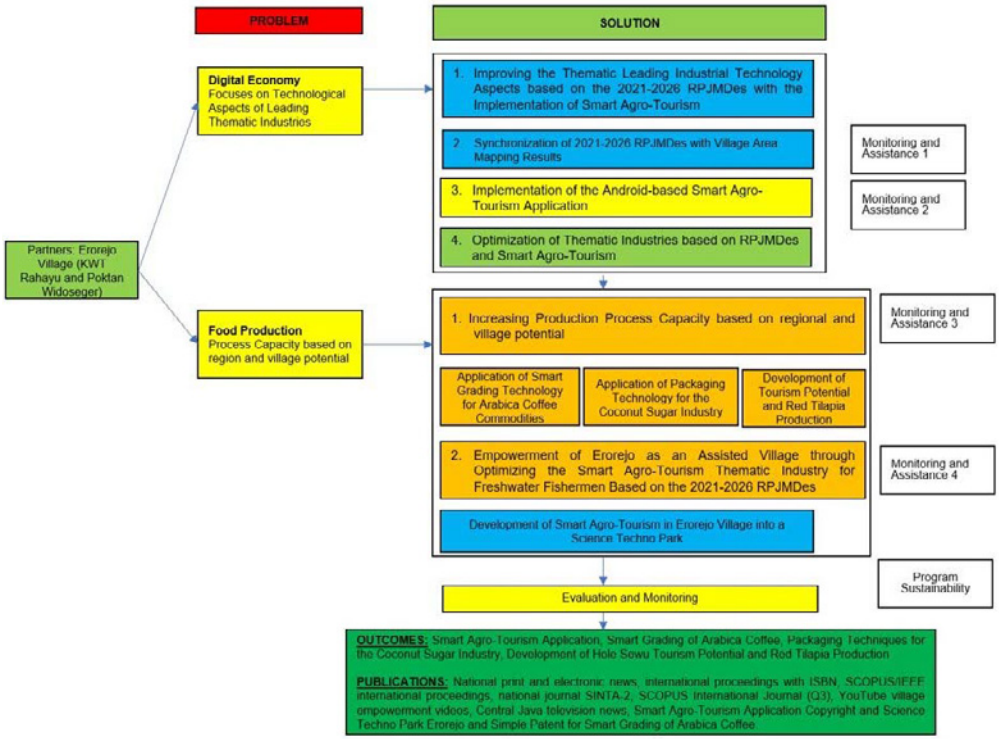

Figure 3. Stages of activity implementation

In this activity, the analysis and processing of steaming were carried out through direct observation and field studies of several red tilapia processing artisans in Wadaslintang. The steaming process begins with the careful preparation and selection of raw materials, ensuring that only high-quality fish are used as the basis for production (Figure 4).

Figure 4. Red tilapia fish raw materials and steamed red tilapia

The steaming process, based on interviews and field studies with steamed fish artisans in Wadaslintang, is as follows (Figure 5).

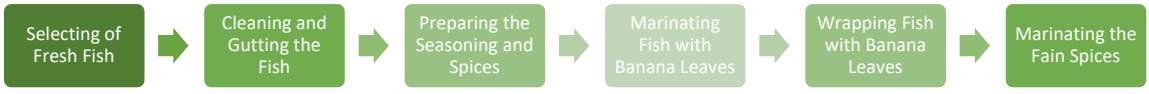

Figure 5. Stages of steamed fish

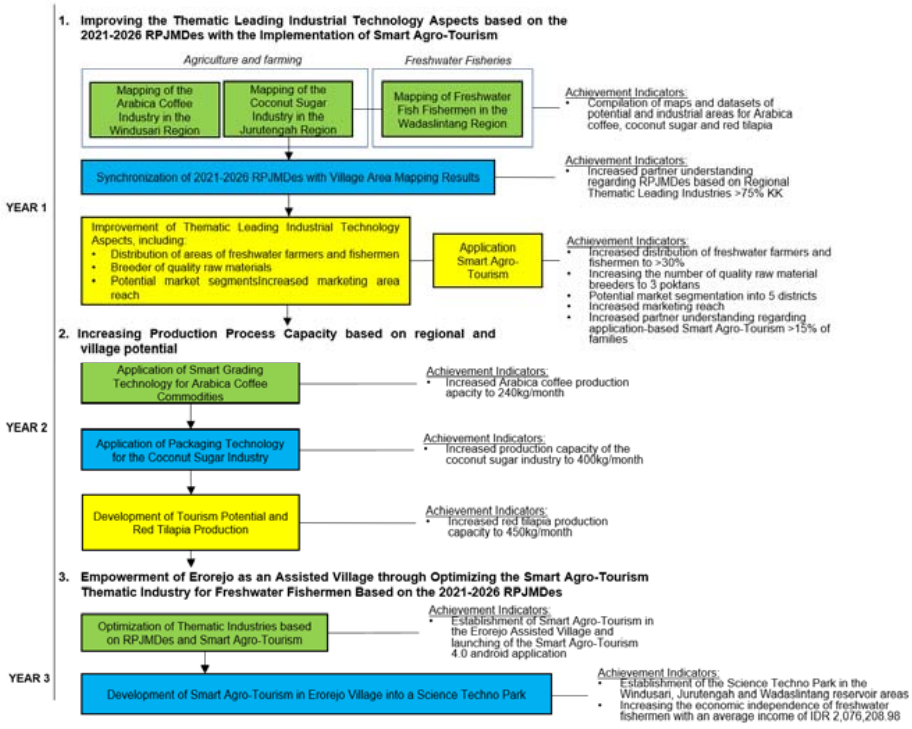

Figure 6. Chart of achievement indicators

In order to ensure that the community service activities carried out in this program are not only well-documented but also objectively measured in terms of their effectiveness and impact, it is necessary to establish clear indicators that can serve as benchmarks for evaluation. By presenting well-defined activity indicators, the program can demonstrate accountability, provide a basis for comparison with similar initiatives, and generate insights that are useful for continuous improvement as well as policy recommendations (Figure 6).

In addition to that, there are several indicators, among others: (1) Improvement of Marketing Technology Aspects with the Development of an Information System Based on an Intelligent Decision Support System Using a Spatial Database. This activity introduces an integrated business model starting from 30 red tilapia suppliers in Wadaslintang, covering the production process, post-harvest handling, and database-based marketing systems, including the use of online marketing platforms projected to reach a 60 percent wider customer base within one year. The developed database also considers the spatial environment to map at least 120 registered suppliers, 15 production centers, and 10 district-level market coverage areas more accurately. This application is expected to strengthen the self-reliance of KWT members by providing an appropriate technology development program, including 4 technical training sessions and 2 digital marketing workshops per year. Through this program, members will gain the knowledge and skills needed to manage production more effectively using a data-driven system. By adopting this approach, production capacity is expected to increase from the original 2 quintals (200 kg) of raw red tilapia per day to 5 quintals (500 kg) per day, while also improving marketing efficiency by 30 percent and enhancing product quality standards to achieve at least 85 percent compliance with food safety and labeling requirements; and (2) Database-based activities to increase Production Capacity and Marketing Reach. With an information system based on intelligent decision-making using a spatial database in the form of the distribution of quality raw material suppliers, potential market segments, and marketing area coverage, the production capacity will increase to 150kg/day. The marketing reach is expanding to include all areas in Central Java and outside the island, namely Lampung and Banjarmasin.

3. RESULTS AND DISCUSSION

The activities carried out in Wadaslintang demonstrated measurable improvements in marketing, distribution, and production technology among members of the Wadaslintang Fish Craftsmen and Managers KUB. In the aspect of marketing and distribution, KWT members successfully adopted smart green spatial agro-logistics applications based on mobile platforms equipped with interactive spatial maps. Target achievement indicators include the ability to integrate data on red tilapia suppliers, production capacity, post-harvest handling, and marketing coverage into a single intelligent system.

In terms of business development, the number of new steamed fish ventures increased from 15 artisanal fishing groups to 25 KWT members, accompanied by an expansion of marketing reach from the local area to broader coverage across Central Java and even outside the island, including Lampung and Banjarmasin. For technological capacity, the application of an intelligent decision support system supported by a distribution database of suppliers and market segments enabled KWT members to increase production from 60 kg/day to at least 150 kg/day.

Area-based activities

The implementation of this system was further supported by segregation analysis using the Geo Segregation Analyzer and digitized georeferencing with ArcMap, which provided accurate spatial data and statistical information for decision-making. The area-based activities implemented in this program are carefully designed to consider the spatial environment and the unique characteristics of each location (Figure 7).

Figure 7. Area-based activities

Through this program, KWT members are equipped with the knowledge and practical skills needed to manage high-quality production by utilizing a database-driven system. This database-based approach allows them to monitor and control every stage of the process more effectively, enabling production to increase from an initial capacity of 2 quintals of raw materials per day to as much as 5 quintals per day. Among all stages of the operation, the smoking process remains the most crucial step, as it determines the final quality, flavor, and market competitiveness of the steamed red tilapia products produced.

Spatial area mapping

The Smart Green Spatial Agro-Logistics application, which has been developed through detailed spatial area mapping (Figure 8), is expected to significantly enhance the self-reliance and capacity of KWT members. By integrating spatial data into the design, this application enables more accurate planning, better resource allocation, and improved decision-making at every stage of production and marketing. The adoption of this technology development program will help KWT to optimize its operations, strengthen its competitive edge, and gradually transition towards more sustainable and efficient business practices.

These outcomes mark the first phase of introducing an integrated business model, beginning with the cultivation of tilapia fish, followed by post-harvest handling, production processes, and marketing through online platforms supported by a database system.

By integrating cultivation, post-harvest, and marketing into a single spatially supported framework, this approach provides a holistic model for improving efficiency and competitiveness in the fisheries sector. When compared with similar initiatives, such as the spatial database integration for aquaculture businesses reported by Lauva et al. (2025) and the application of smart logistics systems for fishery cooperatives in Southeast Asia (Ayisi et al., 2024), this program demonstrates comparable benefits in improving supply chain transparency and production efficiency. However, unlike those studies, which focused mainly on production optimization, the present program integrates spatial mapping with online marketing and decision support, making it more comprehensive in addressing both supply and demand-side challenges.

Intelligent Spatial Decision Support System (ISDSS)

The final output of this program is the development of a smart decision support system in the form of Smart Green Spatial Agro-Logistics, designed as a comprehensive platform to assist KWT members in

initiating and managing an integrated fish smoking business. The system is constructed using valid and verifiable spatial database sources, ensuring that every stage of production and marketing is grounded in accurate, location-specific information. Results from the program show that a complete spatial database has been collected and organized, including data on the distribution of smoked fish artisans, suppliers of high-quality raw materials, potential market segments, and the extent of marketing coverage areas. In addition, a spatial database architecture has been designed, multi-layer mapping has been arranged, and an Android-based application has been developed (Figure 9).

Figure 8. Spatial area mapping activities

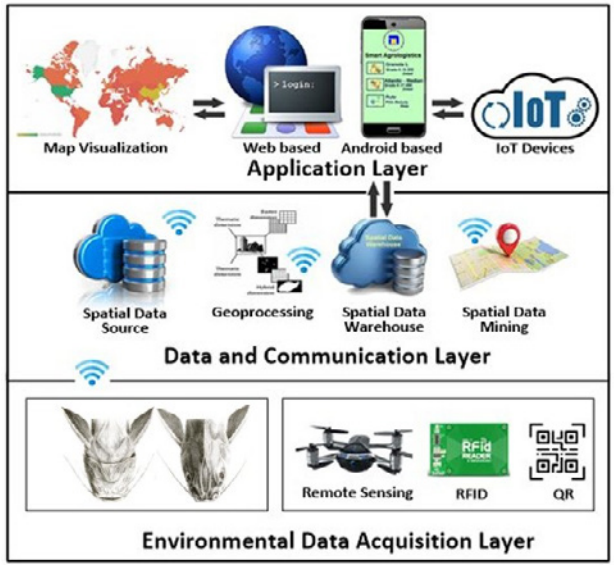

Figure 9. The created application layers

The technology introduced to partners is a smart decision support system for the new business of integrated fish steaming, designed to strengthen the development of a productive fishing community in Wadaslintang. This decision support system is designed based on identified needs to ensure the sustainability of the program. The Android-based system consists of three main modules: User Management, Intelligent Spatial Decision Support System (ISDSS), and Interface. A sample mock-up of the application is shown in Figure 10.

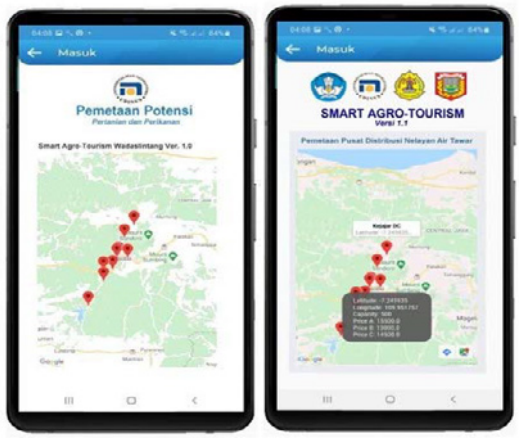

Figure 10, The initial page of the application

Enhancing member participation

In addition, the implementation of this activity was supported by PT. Indonesia Power, which collaborated to include financial literacy materials. This ensured that the technology provided to the partners became more comprehensive by adding an economic perspective. Through the initial stages of program implementation, such as discussions, in-depth interviews, and socialization, the interest and participation of KWT members of the Steamed Fish Artisans and Managers in Wadaslintang increased significantly. The following figure illustrates the readiness level of KWT members before and after the program was implemented.

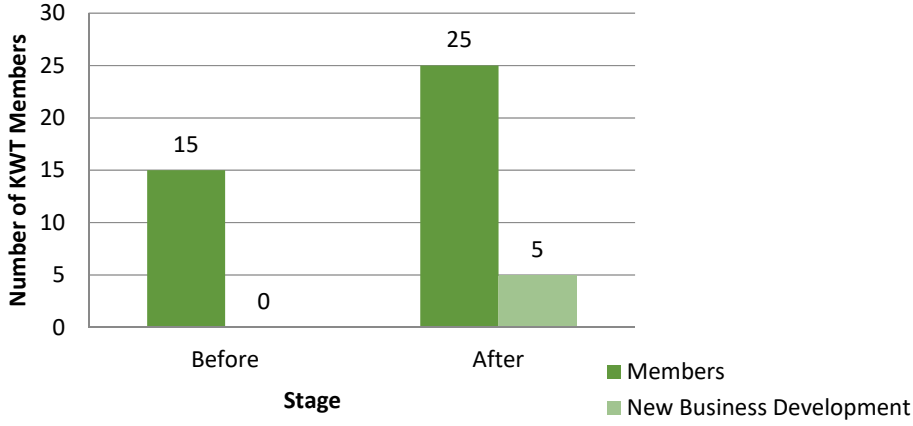

Figure 11. Readiness of KWT members

Based on the initial interviews, out of 15 KWT members in Wadaslintang, five members were already prepared to adopt and use the smart application. The remaining members were still focusing on strengthening their marketing strategies. As a result of the program, the marketing reach has begun to expand beyond Central Java to other regions such as Lampung and Banjarmasin.

Interpretation and comparative discussion

These findings highlight the effectiveness of integrating smart green spatial agro-logistics into small-scale fisheries enterprises. The improvement in production capacity (an increase of more than 150 percent) and market expansion demonstrates the potential of spatially based intelligent systems to enhance both efficiency and competitiveness in community-driven agribusiness (Chen et al., 2025; Molina et al., 2023). Compared with similar studies, such as Essamlali et al. (2024), who reported that spatial-based decision support systems in aquaculture improved supply chain efficiency by 35 percent, the Wadaslintang case shows even greater relative progress (Li & Sun, 2025). Likewise, Heiß et al. (2025) demonstrated the role of spatial mapping in supporting agricultural commodity logistics, which is consistent with the findings here that spatial databases and segregation analysis significantly improve data-driven decision-making. Overall, the Wadaslintang case contributes new empirical evidence that combining mobile-based GIS applications with intelligent decision support systems can accelerate the transformation of traditional artisanal fishing groups into more professional and competitive business units. This approach not only strengthens the independence of local fishermen but also provides a replicable model for other regions seeking to develop integrated, sustainable, and market-oriented fisheries enterprises.

This comparative perspective highlights that while Smart Green Spatial Agro-Logistics shares common objectives with previous studies—such as sustainability and market efficiency—it offers added value through its emphasis on localized spatial mapping and the development of an Android-based platform. This innovation contributes not only to the productivity of individual KWT members but also to building a more resilient and competitive fisheries community in Wadaslintang.

4. CONCLUSION AND RECOMMENDATIONS

In conclusion, the Implementation of Smart Agrologistics for Strengthening Economic Resilience of Steamed Fish Enterprises in Erorejo Wadaslintang has successfully demonstrated that smart green spatial agro-logistics technology can serve as an effective framework to enhance the entire value chain, from raw material procurement and production to post-harvest handling and marketing, through data-driven decision-making supported by a spatial database. The program not only increased the number of business ventures from 15 to 20 KWT members but also expanded the marketing reach beyond Central Java to Lampung and Banjarmasin, while significantly improving production capacity from 60 kg/day to 150 kg/day. These achievements highlight that the integration of smart agrologistics directly contributes to empowering fishermen, improving operational efficiency, and strengthening the economic resilience and competitiveness of steamed fish enterprises in Wadaslintang.

Based on the outcomes of this program, it is recommended that the implementation of smart agrologistics be further strengthened through continuous training for KWT members, particularly in database management, digital marketing, and sustainable production practices. Local government and related stakeholders should provide policy and financial support to expand the application of this system to other fisheries commodities, thereby increasing its scalability and long-term impact. In addition, partnerships with universities and technology providers are essential to integrate advanced tools such

as IoT and AI into the spatial database, ensuring real-time monitoring, more accurate decision-making, and broader market access. By adopting these strategies, the program can not only sustain but also amplify its role in enhancing economic resilience and competitiveness of the fishing community in Erorejo Wadaslintang.

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