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Economic improvement and fish farming based on Smart Aquaculture Automatized System in Segobang Village, Banyuwangi

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ABSTRACT

The fisheries and marine sector in East Java has abundant potential, one of which is Banyuwangi district. Banyuwangi Regency has potential in freshwater aquaculture because it has 324 rivers with an area of 735 km2 and swamps and reservoirs of 60 hectares. One of the villages in Banyuwangi Regency is Segobang Village, which has the potential to have abundant water sources and continuous flow. This potential can be utilized by training and assisting fish nurseries in Segobang Village by utilizing continuously flowing water and Smart Aquaculture Automatized System (SAAS) technology by utilizing biofilters and running water and aeration as a source of oxygen. The stages carried out in this community service are as follows: initial assessment of the location, infrastructure and technology development, periodic training and mentoring, implementation and monitoring of the cultivation process, and continued marketing and sales. After the training, the Segobang Village community showed a significant increase in knowledge. The average pre-test scores ranged from 30 to 51, while the post-test scores increased to 79 to 87. This improvement shows that participants better understand the SAAS and its use in fish farming. Continued training and practice can help strengthen the adoption of this technology in the community.

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1. INTRODUCTION

The fisheries and marine sector is one of the sectors with abundant natural resource potential in East Java province. The high potential of the fisheries and marine sector in East Java is proven by the area of waters reaching 208,138 km2 and a coastline reaching 1600 km^2. According to BPS data (2024), the productivity of fish farming in East Java Province in 2022 reached 1,284 tons with a value of Rp. 19,017,324,000. These results show that the potential for aquaculture in East Java province is very high.

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One of the areas in East Java province with great aquaculture potential is Banyuwangi Regency. The large potential for aquaculture in Banyuwangi Regency is proven by the number of Banyuwangi Rivers, reaching 324 rivers with a total area of 735 km2. There are also reservoirs and swamps with a total area of 60 Ha that can be used to support aquaculture activities. One of the villages in Banyuwangi Regency that has the potential for aquaculture is Segobang Village. Segobang Village is located in Banyuwangi Regency, rich in natural resource potential. One of the abundant resources in Segobang Village is the ample and continuously flowing water (Satriyo, 2020). The community can utilize the abundant water sources in fish farming (Scabra & Setyowati., 2019). The Segobang village community has done this by utilizing water for fish farming, such as tilapia, carp and koi fish on a traditional scale with minapadi in rice fields, using cages made of bamboo placed in the river flow, or in concrete or tarpaulin ponds.

The fish farming process in Segobang Village is still not optimal due to farmers' less than optimal nursery system. So, there is death, which causes failure in fish farming in Segobang Village. The fish farming phase is divided into 3, namely the seeding phase, the nursery phase and the enlargement phase. The nursery phase spreads seeds into temporary rearing ponds (Harifuzzumar et al., 2018). The fish nursery process can be carried out indoors or outdoors in several ponds, such as tarpaulin ponds, concrete ponds and earthen ponds (Andriyanto et al., 2012). Using technology for nursery ponds is an alternative solution to optimize and increase production results from fish farmers in Segobang Village.

The Smart Automated Aquaculture System (SAAS) can optimize the nursery and fish cultivation. The application of SAAS is also equipped with sensors for the cultivation process. Sensor technology is used for real-time monitoring of the pond environment, which is expected to increase production efficiency. SAAS can be controlled remotely, and an automated system can be implemented by implementing IoT, big data, artificial intelligence, 5G, cloud computing, and robotics (Vo et al., 2021). The application of SAAS in cultivation can increase efficiency in the cultivation process by reducing the labour required so that it can reduce production costs. In addition, the process of using SAAS can make it easier for cultivators to control water quality and can be done remotely (Anjali & Lutfi, 2023).

Several aspects that need to be prepared in a smart aquaculture system are collecting information through various sensors, namely temperature, DO, light and pH as a basis for managing the water quality system in the cultivation process. Furthermore, the data that has been collected will be sent to the control center for analysis and decision-making that can be done automatically for the development of an efficient and environmentally friendly cultivation system (Kaseem et al., 2021). Adding infrastructure by adding SAAS-based ponds according to the results of market needs research is also part of the solution.

In addition to the application of sensor and automation systems, the fish nursery process can utilize biofilters and aeration to support the cultivation process. Biofilters themselves can function as decomposers of cultivation waste so that they can reduce ammonia values (Suriasni et al., 2023). Biofilters utilize microorganisms to reduce the value of ammonia and dissolved organic matter in water by forming colonies called biofilms so that the water quality in the cultivation pond is maintained (Roakvalm et al., 2020). In addition, the use of sufficient aeration can also maintain water quality by increasing the DO value so that it has an optimal value for fish farming (Nguyen et al., 2024). Effective management is needed for fish/shrimp farming to monitor the system and anticipate a decrease in water quality (Teja et al., 2020).

The purpose of this activity is to increase insight into cultivation technology for farmers and to increase the production results of fish farming carried out in Segobang Village, Banyuwangi Regency.

2. METHODS

In general, community service is implemented using the Participatory Rural Appraisal (PRA) concept. PRA has the same meaning as Understanding Rural Conditions Participatory, which is an approach to formulating planning and policies in rural areas by involving the community as effectively as possible. PRA allows rural communities to share, improve, and analyze their knowledge about village conditions and life and make plans and actions in a participatory manner.

The main objective of implementing PRA is to empower communities to articulate and analyze reality, design actions to be taken, and evaluate the results of programs that have been carried out. In other words, PRA aims to enable local communities to play a key role in all aspects of the development projects they participate in (Karini, 2023).

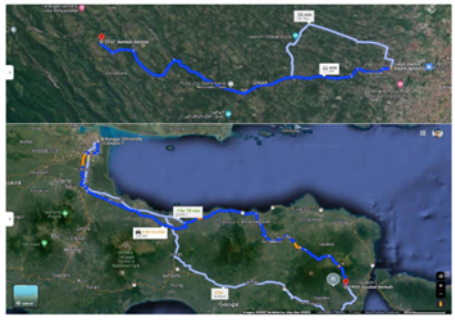

Figure 1. Location on community service

This activity was carried out in January - July 2024 in Segobang Village, Licin District, Banyuwangi Regency. This community service has several stages, according to (Figure 2).

Initial Location Assessment Stage

This activity involves a comprehensive assessment of water quality, including measuring key parameters to ensure suitability for cultivation. Additionally, it includes inspecting water sources and evaluating access to water to determine its availability and sustainability for agricultural use. Furthermore, the activity involves identifying specific ponds or rice fields that will be utilized for cultivation, ensuring that the selected areas meet the necessary environmental and hydrological conditions. Based on these evaluations, the most suitable commodities for cultivation can be determined, optimizing the potential yield and sustainability of the agricultural practices.

Infrastructure and Technology Development Stage

This stage is carried out by making four tarpaulin ponds with a diameter of 2 meters and a height of 1 meter, installing an effective water circulation system and implementing an aeration and bio filter system. This stage begins with identifying the need for tools and materials and continues ordering the components used for the cultivation process. After that, the pond assembly process is carried out with SAAS technology, as per the provided guidebook, and initial trials are carried out before being used in the cultivation process.

Training and Mentoring Stage

This stage is carried out by training farmers on feed management, disease control, water quality control, and using SAAS-based technology, as well as holding regular seminars for farmers. This training

process begins with a pre-test to measure members' initial understanding of the cultivation process to be carried out. After the pre-test process is complete, the cultivators spread seeds and continue mentoring and consulting. The Transfer of Technology (ToT) method is used during the training period.

Table 1. Knowledge questions on pre-test and post-test

Questions about land preparation
1. The main criteria in selecting land for fish farming include water quality, distance to water sources and land topography 2. The potential for natural disasters in land selection can be evaluated by considering flood factors, landslides and earthquakes or volcanic eruptions 3. Environmental factors that need to be considered in land selection include environmental temperature and water quality, including water pH and organic content 4. Evaluation of water quality is carried out by testing water quality parameters, including physical, chemical and biological parameters 5. Determining the ideal land size includes the type of fish to be cultivated, density and water quality in the environment
Questions about pool construction
1. Pond construction aims to create an ideal environment for growth, health and the process of fish cultivation 2. Types of materials that are widely used in the process of making ponds are tarpaulin, soil, concrete and HDPE plastic 3. A good fish pond has drainage in the construction system to facilitate the process of changing water 4. The security of the cultivation pond against predator attacks can be achieved by installing nets on the edge of the pond to support the biosecurity process 5. Routine pond maintenance is carried out by washing the pond after harvest and checking for leaks in the pond to prevent potential crop failure
Questions about production aspects
1. Fish farming production is a fish farming process that includes seeding to enlargement 2. Factors that affect the farming process are seed quality, water quality, feed quality and feed management 3. Selection of the right feed based on the type of fish, age of the fish and nutritional content of the feed 4. Good pond management can be done by monitoring water quality, changing water regularly and removing leftover feed and feces 5. Fish health during the farming process can be maintained by testing water quality regularly and checking the physical condition and behavior of the fish
Questions about the harvest process
1. Harvesting is taking fish from ponds or cultivation containers to be sold or consumed 2. The right time to harvest fish is when they reach the desired size 3. Effective fish harvesting can be done by reducing the water and continuing with the use of nets and carried out in the morning or evening 4. The harvesting process can be carried out by preparing several tools, such as nets and scales 5. The harvesting process needs to be weighed to determine the biomass of the harvested fish
Questions about post-harvest
1. Post-harvest is the process of handling, processing and marketing after the cultivation process is carried out 2. Post-harvest aims to maintain fish quality, increase added value and meet consumer needs 3. Post-harvest handling is carried out by putting fish in clean water or containers for further distribution and sales 4. Marketing of fish after harvest is carried out by selling directly to consumers or through fish shops both offline and online 5. Evaluation of fish quality after harvest can be done by checking the physical condition of the fish and monitoring the quality of the fish to be marketed

Implementation and Monitoring Stage

This stage is carried out with daily management, routine monitoring, periodic evaluation, and adjustments to cultivation strategies independently by the community under the supervision of the mentoring team. This stage also carries out supervision and discussion to evaluate the community's understanding of the training and mentoring that has been carried out.

During the implementation process in the field, participants are given a pre-test before the event starts and continue implementing a post-test after the event. The pre-test and post-test each include five questions covering five aspects of cultivation, including land preparation, construction, production, harvesting and post-harvest (Table 1). After the post-test is complete, it is continued with an evaluation of the implementation of activities based on the increase in pre-test and post-test values , with the benchmark for success being an increase in the community's pre-test and post-test values of 75% of the total respondents (Rini & Sari, 2020).

Marketing and Sales

This stage is carried out by preparing the tools and materials that will be used for harvesting, including the number of workers. It is continued by identifying local and regional markets for marketing, creating branding to increase attractiveness and selling value, and using mass media to promote products.

Figure 2. Community service planning flow

3. RESULTS AND DISCUSSION

Results

Implementation of activities

The implementation of community service activities in Segobang Village, Banyuwangi Regency, aims to increase insight into technology for cultivation, one of which is the application of Smart Automated Aquaculture System (SAAS) technology and to improve the productivity of cultivation results. This community service process is carried out for 7 months, starting in January and ending in July 2024. This community service has several stages of activities, namely initial location selection, infrastructure and technology development, training and mentoring, implementation and monitoring, and marketing and sales.

Initial location selection

This community service activity has several stages, namely, initial location assessment. The initial location assessment contains several aspects that can be considered: the quality of cultivation water, access to cultivation water, and the location of ponds and rice fields that will be used in the cultivation process. There are several problems at this stage, one of which is limited water due to the absence of direct water channels to the cultivation ponds. This problem can be overcome by directly making water channels from the water source to the pond to facilitate fish cultivation (Figure 3).

Figure 3. Documentation of the implementation of location selection in Segobang village

In addition, measurements of water quality were taken. The water quality values are in Table 2 based on the measurement results.

Table 2. Water quality of cultivation location

Parameter	Water Quality	Optimum Range (Tatangidatu et al., 2013)
Temperature (°C)	27.5 - 29.9	28 – 32
pH	7.0 - 7.9	6 - 9
Dissolved oxygen (mg.L^{-1})	4 – 6	>5
Ammonia (mg.L^{-1})	0 - 0.1	<1

Infrastructure and technology development

The infrastructure and technology development of the Smart Automated Aquaculture System (SAAS) is used to automatically control water quality. The use of SAAS technology involves several components, namely temperature sensors, microcontrollers, feed valves, pumps, pH sensors, water level sensors, and real-time clocks (RTC), as shown in Figure 4. SAAS technology is installed in each cultivation pond to facilitate and increase cultivation productivity.

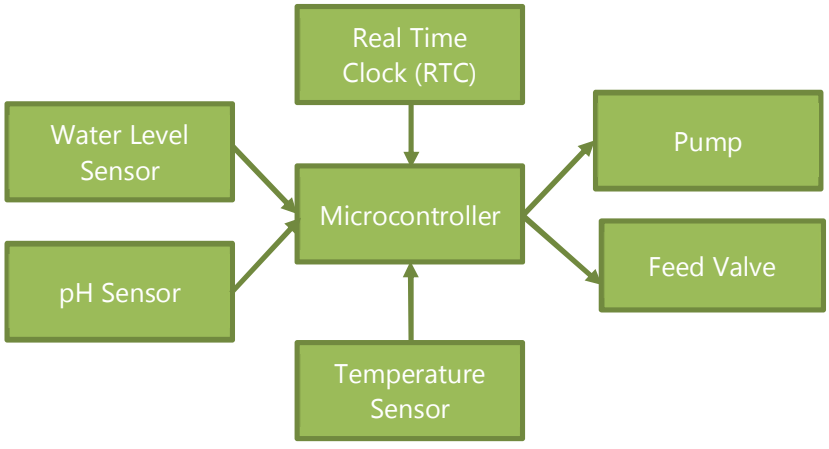

Figure 4. SAAS hardware block diagram

Training and development

The technology development process can be carried out using the Transfer of Technology (ToT) method. This process is carried out periodically during evaluations with the mentoring team and at the beginning and end of community service (Figure 5). The ToT method is used to facilitate discussions with farmers and problem solving that occurs during the cultivation period. The results of the ToT show that active community participation is carried out in the discussion material. In addition, increasing community knowledge of the cultivation process is indicated by an increase in post-test scores (Table 3).

Figure 5. Training process in Segobang Village

Table 3. Average pre-test and post-test scores

Cultivation Aspects	Value	
	Pre Test	Post Test
Land Preparation	51 ± 26.34	80 ± 19.47
Pond Construction	39 ± 23.82	79 ± 27.12
Production Aspects	36 ± 17.89	83 ± 19.76
Harvest Process	38 ± 23.30	84 ± 23.03
Post-Harvest	30 ± 20	87 ± 16.25

Implementation and monitoring

The implementation process of community service includes routine monitoring of water quality and the cultivation process and periodic evaluation of the cultivation process. Monitoring of farmers is carried out directly at the farmer's location and is continued with consultation with the implementing team. The consultation materials include problems during the cultivation period and materials regarding diseases that attack fish and how to handle them to minimize losses due to fish deaths. In addition, monitoring is also carried out in the process of implementing technology, including overcoming obstacles faced during the cultivation period (Figure 6).

Pre-test and post-test values

This community service process needs to be evaluated to measure community knowledge before and after this service is carried out. Based on the results of the pretest and posttest in Table 3 and Table 4, which have been implemented, the pretest results are shown namely the participants had pretest scores ranging from 30 - 51 with dominant values in the range of 26 - 50. These results indicate that the community still does not know much about the Smart Aquaculture Automated System (SAAS). These

results suggest the need for further assistance regarding the Smart Aquaculture Automated System (SAAS) to the wider community. After the training, there was a rapid increase in the results of the posttest that had been carried out. The posttest results from the participants showed an increase, with scores ranging from 79 to 87. In addition, the distribution of post-test scores (Table 4) showed an increase in scores, so the post-test scores were dominated by scores ranging from 76 to 100. This increase indicates that the training and community service are very effective in increasing community knowledge regarding Smart Aquaculture Automated System (SAAS) technology.

Figure 6. Implementation and monitoring process in Segobang Village

Table 4. Distribution of pre-test and post-test scores

Cultivation Aspects	Pre Test value (%)				Post Test Value (%)			
	0 - 25	26 - 50	51 - 75	76 - 100	0 - 25	26 - 50	51 - 75	76 - 100
Land Preparation	20	30	30	20	0	15	0	85
Pond Construction	30	40	20	10	5	10	10	75
Production Aspects	30	50	20	0	0	10	10	80
Harvest Process	25	45	25	5	5	5	20	70
Post-Harvest	45	40	15	0	0	0	20	80

Discussion

The community service program in Segobang village, Banyuwangi, with the theme of implementing SAAS technology, is running well. The application of technology in the cultivation process is important to increase the productivity of cultivation results. This community service process was carried out for 7 months, including initial location selection, infrastructure and technology development, training and mentoring, implementation and monitoring, and marketing and sales. The first stage is determining the initial location, which includes making a water channel sourced from the nearest water source with direct access to the cultivation pond and measuring the water quality. Based on the measurement results, the temperature value ranges between 27.5-29.9 °C, the pH and DO values have respective values of 7-7.9 and 4-6 ppm and the ammonia value ranges between 0 - 0.1. This value is the optimal value for use in cultivation according to Tatangidatu et al. (2013), which states that the optimal temperature in the cultivation process ranges between 28-32 °C, the pH and DO values are 6-9 and > 5ppm and the ammonia value <1 ppm.

After site selection, infrastructure and technology development is carried out. The technology used is the Smart Automated Aquaculture System (SAAS). The aquaculture process allows fish to be raised in a controlled environment. The controlled fish farming process requires the application of technology

to support the cultivation process, increase productivity, and reduce the potential for environmental pollution caused by the cultivation process (Bernal-Higuita et al., 2023). The SAAS is an appropriate technology that integrates the Internet of Things (IoT) and artificial intelligence (AI) to increase efficiency and productivity in aquaculture. This system includes automatic feeding, automatic water changes, water quality monitoring, problem solving through AI, and automatic disease detection (Vo et al., 2021). This technology has several main components: automatic water filling, automatic water draining, automatic feeding, temperature monitoring, water level monitoring and pH monitoring. The automatic check result data will be stored on the microcontroller. According to Sitohang et al. (2018), the microcontroller has several functions, namely scanning the keypad, adjusting the output voltage based on user input, reading the output voltage and current and displaying the results of the voltage and current readings on the LCD.

The microcontroller is responsible for controlling all input outputs on SAAS. The water level sensor will measure the water level in the fish pond so that if the water level sensor indicates that water needs to be added, the microcontroller will command the pump to add water or turn the pump on. The temperature sensor will be used to measure the temperature in the fish pond, and if the temperature is not as expected, the pump will flow water that can adjust the water temperature. The pH sensor is used to measure the pH of the water. Realtime Clock (RTC) will be used to schedule animal feed. Furthermore, the Internet of Things will be integrated to make it easier for fish farmers to monitor in real time and command SAAS remotely.

The next process is training and development. The training and development process uses the ToT method. The ToT method can be used effectively when knowledge can be transferred to potential farmers. In addition, the application of technology is also influenced by the characteristics and suitability of the technology to the needs of farmers (Kumar et al., 2018). Transferring knowledge for technology development in community service is carried out by conducting training, mentoring and monitoring. Applying training directly to the community can reduce the negative impacts arising from the complexity of technology (Joffre et al., 2017). This time, the technology applied in community service uses circulation with SAAS technology with biofilters and aeration. Biofilters can reduce dissolved waste through biochemical reactions during bacterial metabolism (Mnyoro et al., 2022). This statement is supported by Roakvalm et al. (2020), who state that the use of biofilters can reduce the value of ammonia and dissolved organic matter found in water by microorganisms that colonize the biofilter, hereinafter referred to as biofilms. In addition, aeration can also increase the DO value in waters to increase the productivity of cultivation results (Dewanto & Gusprastomo, 2022). Applying this ToT method positively impacts the community, as indicated by an increase in the pretest value, which ranges from 30-51 to 79-87 (Table 3).

After that, it continued with implementation and monitoring, which included routine monitoring of water quality and the cultivation process and periodic evaluation of the cultivation process. According to Pramana (2018), monitoring and monitoring are needed to support the success of the cultivation process. The implementation and monitoring stages include several things discussed, problems during the cultivation period, fish health and the SAAS technology implementation process. The implementation of SAAS technology in the community includes several things, namely automatic water filling, automatic water draining, automatic feeding, temperature monitoring and water level monitoring. Automatic water filling can run automatically to fill water when the water condition drops below the minimum limit (<100%). This is done during the cultivation cycle and when the water replacement schedule is scheduled. A motorized valve regulates the inflow of water into the cultivation container. After that, there is automatic water drainage with a mechanism. Namely, when the water level exceeds the

maximum limit (> 100%), the system automatically drains the water by opening the motorized valve to remove the water. Draining is also carried out according to the water replacement schedule to maintain water quality. In addition, automatic feeding is carried out automatically according to a predetermined schedule. The motorized valve is opened to feed into the cultivation container at a time previously set in the application. Automatic feeding technology can increase farmers' efficiency in meeting fish feed needs by reducing labour and production costs. Applying this technology can also reduce the amount of feed wasted to minimize water quality damage (Nafisyah et al., 2024).

The next SAAS implementation is automatic water level sensor testing to detect water levels in real time. The data obtained is used to regulate water filling and draining automatically and uploaded to the database for further monitoring. Next, a temperature sensor can detect water temperature in real time. This temperature data is uploaded to the database and displayed on the application so that users can accurately monitor the cultivated water's temperature. Real-time temperature value testing is important because water temperature can affect the viscosity level in water, the concentration of dissolved oxygen in water, the oxygen consumption of aquatic animals and the distribution of water minerals (Suwito & Rivai, 2018). Changes in water temperature in fish ponds are very important for cultivators to know because water temperature greatly affects fish growth, affecting the survival of the fish we cultivate (Muarif, 2016). Another implementation is an automatic water pH sensor that detects pH in real time. The data obtained is uploaded to the database for further monitoring. Temperature and pH are very important factors in the fish farming process, fluctuations in temperature and pH can cause delays in fish growth and can cause mass mortality in fish (Maryam, 2023).

The implementation of community service ended with a post-test activity. Based on the results, there was an increase in pre-test and post-test scores. Before community service, the pre-test scores were dominated by the range of 26-50, with a pre-test score range of 30-51. However, there was an increase in the score in the post-test, with a score range of 79-87 and a score dominated by 76-100. According to Kristiyanti et al. (2024), pre-test and post-test assessments can measure participants' knowledge before and after the training was carried out.

4. CONCLUSION AND RECOMMENDATIONS

Community service activities in Segobang Village have successfully increased awareness and understanding of technology use in fish farming through the implementation of the Smart Automated Aquaculture System (SAAS). The impact of these activities is reflected in the improvement of participants' knowledge, as indicated by the increase in post-test scores. The initial pre-test scores ranged from 30 to 51, while the post-test scores improved significantly to 79 to 87. This increase demonstrates the effectiveness of the training in enhancing the community's understanding of fish farming using the SAAS system.

The regular training on applying the Smart Automated Aquaculture System (SaaS) for fish farmers in Banyumas Regency faces several challenges. These include limited technology infrastructure, low digital literacy among farmers, and insufficient funding for system implementation and maintenance. Additionally, adopting new technology is often difficult due to resistance to change and limited access to supporting devices. To address these challenges, a support program is needed to help fish farmers understand the benefits of the Smart Automated Aquaculture System. The government should provide regular training and easy-to-access technical guidelines for farmers in Banyumas Regency and beyond. Collaboration with the private sector and academia is also important to ensure the necessary infrastructure and resources for the program's success.

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