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The Aquaponic Cultivation of Catfish in Barrels (Budikdamber) on Internet of Things (IoT) and Fish Pellets from Water Hyacinth as a Food Security Strategy for the Tugu Village Community, Sayung District, Demak

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Abstract. Tugu Village in Demak Regency frequently experiences disasters such as coastal erosion and inundation due to tidal activities and the reclamation of Marina Beach in Semarang, which borders Sayung District. These conditions negatively impact the local economy, necessitating a solution to enhance food self-sufficiency. One approach taken is the cultivation of catfish in barrels (budikdamber) using an aquaponic system to grow water spinach, supported by the Internet of Things (IoT). The target audience for this community service activity is the women in Tugu Village affected by flooding. The program was implemented in five stages: observation and coordination, socialization, training, technology application, mentoring, and evaluation. Evaluation was conducted using pre-test and post-test instruments. Before the program, participants' understanding of aquaponic budikdamber was only 32.5%, but after the program, it increased sharply to 95%. Participants' understanding of pellet-making also saw a significant increase, from 10% before the program to 90% afterward. This data indicates that the program implementation successfully improved participants' understanding.

Keywords: budikdamber aquaponics, water hyacinth, IoT, fish pellets

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INTRODUCTION

Tugu Village is one of the villages located in Sayung District, Demak Regency with a length of 8 km from west to east and 16 km from north to south. Sayung District has an area of 78.8 km (Amin, 2024). Sayung District consists of 20 villages, 101 hamlets, and 105 RW and 484 RT. There are 4 villages in Sayung District located on the coast of the Java Sea, one of which is Tugu Village (Yanti et al., 2024). Tugu Village often faces problems of abrasion and tidal flooding due to tidal activity and reclamation of Marina Beach in Semarang which directly borders Sayung District (Munawaroh & Setyaningsih, 2021). Rainfall in Demak Regency ranges from 1000-2000 mm and between 2000-3000 mm per year (Suprapti et al., 2024). Especially in Sayung District, the intensity of rainfall reached 1,731 mm with a total of 75 days of rain (Gustiar et al., 2024). This has caused the impact of climate change to be felt in Sayung District, Demak Regency, including water crisis, flooding, and rob or abrasion. In early 2024, floods hit Tugu Village and peaked in March 2024, the flood spread due to high rainfall, resulting in an overflow of river water and the collapse of the Wulan River embankment (Editorial Team, 2024). This flood not only inundated people's homes, but also destroyed their main sources of livelihood, such as agricultural land and ponds so that land became limited and could cause relatively large economic losses. In the midst of this crisis situation, effective utilization of environmental resources is very important to achieve welfare and food security. Food security, which is defined as the ability to ensure the availability of sufficient, safe, and nutritious food for community members, is a top priority for Tugu villagers. However, increasingly uncertain geographical and climatic

conditions require innovative and adaptive solutions (Afifah et al., 2024). Another challenge for residents of Tugu Village and its surroundings is the very large and increasing population of water hyacinth but has not been utilized properly. Water hyacinth is a type of aquatic weed that can have a negative impact on aquatic ecosystems due to its invasive ability (Midhun et al., 2023). If water hyacinth is left alone, it can certainly have negative impacts such as covering the water surface, reducing light penetration, and reducing the dissolved oxygen content in the water (Kasim et al., 2020). However, water hyacinth has beneficial nutritional content such as crude protein of 9.8-12.0%, ash of 11.9-12.9%, crude fat of 1.1-3.3% and fiber content of 16.8-24.6% (Yuvita et al., 2020). However, the high fiber content can make water hyacinth difficult to digest (Indriyani et al., 2021). To overcome this, the fermentation method can be used in making water hyacinth-based fish feed. This is proven in research (Widaryati, 2023) which states that fermentation treatment can increase protein content by 19.63%, carbohydrates by 50.07%, and reduce crude fiber content to 12.35%. With a higher protein content, water hyacinth has the potential to be used as a highly nutritious fish feed (Silaban et al., 2021).

In response to the problems currently occurring in Tugu Village, a solution that can be applied to overcome land limitations and increase food security for Tugu Village residents is to implement catfish cultivation in buckets *(budikdamber)* combined with an aquaponic system. Budikdamber is a fish cultivation technique in a limited container such as a bucket combined with aquaponic vegetable planting. The volume of the bucket used is 60 liters which can accommodate the cultivation of up to 50 catfish (Holilah et al., 2023).

According to Suryana et al., (2021), *budikdamber* has several advantages such as a relatively easy manufacturing process, requires a small area of land, and of course requires affordable capital. However, additional technology is needed that can be used for this aquaponic budikdamber to make it easier to apply. Internet of Things (IoT) technology can be integrated into the budikdamber system to enable real-time monitoring and management of cultivation. The application of IoT will increase the efficiency, productivity, and sustainability of the cultivation system.

One of the important components in *budikdamber* is water spinach, an aquaponic vegetable that is commonly cultivated with catfish. Water spinach was chosen because the seeds are easy to obtain, the price is relatively cheap, and the maintenance is simple. Water spinach is also very easy to process into various types of ready-to-eat foods such as *urap* or stir-fry. In addition, catfish, which is another part of the budikdamber system, is also relatively easy to cultivate, only requiring pellet feed. This pellet feed can be produced independently by utilizing the abundant water hyacinth in Tugu Village and its surroundings. This not only reduces production costs, but also utilizes abundant local resources that are often a problem for the environment. By utilizing IoT-based aquaponic budikdamber and fish feed from water hyacinth, the people of Tugu Village can overcome the constraints of limited land and clean water that are often faced by coastal areas. This solution provides effective and efficient benefits, while also helping to improve food security and community welfare in Tugu Village.

The purpose of community service is to increase food independence through fish farming in buckets so that it does not require a large area, just a yard at home. In addition to fish farming, there is also aquaponic planting of kale which aims to fulfill family nutrition through vegetables.

METHODS

Location and Time

Community service in the form of socialization and training in making IoT-based aquaponic budikdamber and fish pellets from water hyacinth, which was carried out in Tugu Village, Sayung District, Demak Regency, Central Java Province. The implementation was carried out from May to September 2024 with a total of 20 participants from the Family Empowerment and Welfare (PKK) Mothers.

Procedure

The implementation of community service is carried out through 5 stages, namely preparation, socialization, training, application of technology, mentoring and evaluation as well as program sustainability.

Preparation stage, in this activity, offline partner observations are carried out to find out the conditions in Tugu Village. After that, coordination is carried out to arrange the timeline of the event that will take place later.

Socialization activity stage, this activity aims to provide an initial overview of the program plan to the partner community and increase partner understanding of the potential of water hyacinth which can be processed into fish feed pellets in catfish and kale cultivation with IoT-based

aquaponic budikdamber techniques to partner communities which are carried out offline.

Training activity stage, in this activity, guidance and teaching are carried out on making water hyacinth pellets, installing aquaponic budikdamber media, how to seed catfish and kale fiber care with aquaponic budikdamber techniques, and processing catfish and kale into food products.

Technology implementation stages, this activity is carried out designing a budikdamber equipped with a DS18B20 temperature sensor, ATMega328P microcontroller, relay, and equipped with a 16x2 LCD. The DSB18B20 sensor is equipped with an aluminum cover to provide protection in the water, preventing the risk of electrical interference or danger to catfish in the budikdamber. The DS18B20 sensor is often used in electronic and IoT applications because it can measure temperature with high accuracy and is easy to integrate with microcontrollers and electronic devices.

Mentoring and evaluation stages, the mentoring stage aims to provide a theoretical understanding to partners to carry out the practice of making water hyacinth pellets as feed for catfish and kale cultivation using IoT-based aquaponic budikdamber techniques. The evaluation is carried out with the aim of providing solutions to the problems faced by the partner community in the process of making water hyacinth pellets to processing catfish and kale. This stage is measured through the success of making water hyacinth pellets as fish feed in catfish and kale cultivation using the aquaponic budikdamber technique, as well as being able to process the obtained catfish and kale into food products using the methods and skills that we provide during community service activities.

Fish Pellet Making Process from Water Hyacinth

The first stage is the collection and sorting of water hyacinth to ensure that the water hyacinth is suitable for use. After sorting, the water hyacinth is cleaned using running water and cut into small pieces like dice to speed up the soaking and fermentation process. The initial soaking is done using water for 25 hours to soften the plant tissue and reduce unwanted substances. Furthermore, the water hyacinth is soaked using EM4 for 24 hours which aims to increase the nutritional content, especially the protein content and reduce the crude fiber content (Widiarti, 2023). After fermentation, the water hyacinth is dried in the sun until dry to reduce the water content, prevent the growth of fungi, and facilitate the grinding process.

The dried water hyacinth is then ground into a fine powder like flour. In the next stage, other ingredients such as soybean flour, fish flour, pollard flour, and water hyacinth flour are weighed according to the specified measurements. All these ingredients are transferred into one container and stirred until evenly mixed. Next, tapioca flour is transferred into a separate container and mixed with hot water to produce a natural adhesive that can help the pellets stay intact when used. This tapioca flour mixture is then mixed into the main ingredient mixture and stirred until evenly mixed. When it is evenly mixed, the mixture is ready to be molded using a pellet molding machine that has the right size, shape, and density for fish consumption. The resulting fish pellets have optimal nutritional content, are affordable, and empower the use of local resources.

RESULTS AND DISCUSSION

In this community service program, the number of participants who attended was 20 PKK mothers from Tugu Village, Sayung District, Demak Regency. This number reached 100% of the previously set target participants. This full attendance showed the high enthusiasm and commitment of the local community towards the program being held. This activity also received full support from the Village Head and Secretary of Tugu Village who were also present to provide a speech and motivation to the participants so that they could utilize the aquaponic budikdamber technology optimally.

Figure 1. Handover of Aquaponic Budikdamber Tools and Guidebooks to PKK of Tugu Village

During the activity, the Tugu Village community received various assistance to support the implementation of aquaponic budikdamber technology. Each participant was given a complete set of aquaponic budikdamber tools, a manual containing technical information and practical

guidance, as well as kale seeds and catfish seeds (Gustiar et al., 2024). The provision of these tools and materials aims to enable participants to implement the aquaponic budikdamber system independently in their respective homes. The following is documentation of the activity which can be seen in Figure 1.

This program is implemented in the period from May to September 2024 with a total of 5 meetings. This series of activities includes 3 meetings focused on observation and preparation of partners, 1 meeting for socialization and training of aquaponic budikdamber technology, and 1 meeting focused on monitoring and evaluation sessions to assess the success of the program.

Figure 2. Socialization and Training Program

The speakers involved in this activity consist of Chemical Engineering lecturers who have expertise in food technology, Electrical Engineering lecturers who are experts in designing temperature detector systems in aquaponic budikdamber or intelligent systems, and Chemical Education lecturers who focus on food processing. Meanwhile, the students involved in this activity serve as companions for the training participants. Their role is very important because they not only provide direct guidance during the training session but also help participants understand and apply aquaponic budikdamber technology more effectively (Silaban et al., 2021). In addition, they are also tasked with answering questions and providing technical support during the training process. The following is a training session that can be seen in Figure 2.

To measure the effectiveness of the training, participants were asked to complete a pre-test before the training began and a post-test after the training ended. The pre-test aims to determine the level of participants' initial understanding of the aquaponic budikdamber material. Meanwhile, the post-test was conducted to evaluate the increase in participants' understanding after participating in the entire series of training and mentoring. Thus, the results of the pre-test and post-test can be used to assess the extent to which this training has succeeded in improving participants' knowledge and skills in implementing aquaponic budikdamber technology in Tugu Village. The following are the results of the pre-test and post-test which can be seen in Figure 3.

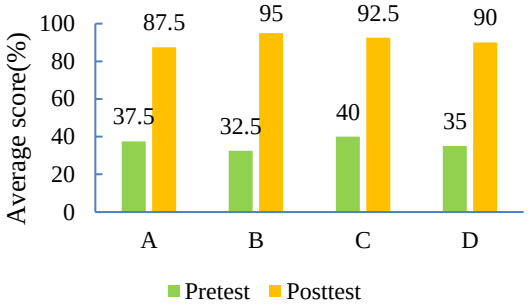

Figure 3. Pre-test and Post-test Graph Results of Participants

Figure 3 shows a graph showing an increase in the level of understanding of participants after participating in the IoT-based aquaponic budikdamer training program and fish pellets from water hyacinth. This increase was measured by the team through pre-test and post-test instruments. Before the program was implemented, the level of understanding of participants regarding the concept of aquaponic budikdamber (A) was 37.5% and increased after the program was implemented to 87.5%. The level of understanding of the procedure for using aquaponic budikdamber (B) increased from 32.5% to 95% after the program was implemented. The level of understanding of material selection (C) increased from 40% to 92.5% after the program was implemented. The level of understanding of making pellets (D) from 35% to 90% after the program was implemented. These data show that the program that has been implemented has succeeded in increasing the knowledge and skills of the Tugu Village community so that it can be concluded that this community service program was successful in its implementation. The training participants were then asked to fill out a post-training questionnaire with the aim of evaluating their interest in aquaponic budikdamber cultivation. This questionnaire also aims to follow the potential sustainability of the program that has been implemented and to collect impressions and messages from participants during the activity (Suryana, Dewanti, and Andhikawati, 2021). The results of the questionnaire showed that as many as 95% of training participants were very interested in cultivating aquaponic budikdamber after the

implementation of this program. While as many as 5% stated that they were interested, and none stated that they were less interested in this cultivation. This shows that the program that was carried out was successful, especially in terms of increasing the interest of participants, especially mothers, to continue cultivating aquaponic budikdamber in the future.

CONCLUSION

The community service program in the form of IoT-based aquaponic budikdamber and fish pellets from water hyacinth has succeeded in providing a positive impact on PKK mothers in Tugu Village. The participants showed high enthusiasm and were active in every stage of the activity, starting from the pellet making process, installation of the IoT-based aquaponic budikdamber system to maintaining water spinach and catfish cultivation. In addition, it can also provide real benefits in improving community welfare. The participants felt that this program had helped them in cultivating water spinach and catfish. With consistent support and guidance from the team, the participants felt supported in their efforts in implementing aquaponic budikdamber. Thus, this program is not only a community service activity but also a foundation for long-term efforts in building food independence and the welfare of the Tugu Village community in a sustainable manner.

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