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Enhancing Family Nutrition and Economy by Cultivating Catfish in Aquaponic Systems to Optimise Narrow Land Space

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Abstract

The MMD 1000 Village Strategic Community Service Grant Program aims to address the issues that the village community is currently facing, such as the low level of community participation in PKK activities, the need to improve the nutrition of low-income families, and the underutilization of narrow yards. So that through the MMD 1000 Village Strategic Community Service Grant Programme activities, will offer solutions to these problems, including outreach and demonstration plots along with the assistance of aquaponic cultivation systems. The methods that will be applied to this activity include the following: 1) providing understanding to community leaders and target audiences, especially activity partners; 2). Counseling and training to increase knowledge about the implementation of an appropriate aquaponic cultivation system, 3). Direct practice or application of the aquaponic cultivation system, including assembling the design of aquaponics tools, setting tools and tanks, water preparation and monitoring water quality, stocking fish seeds, planting vegetable seeds, and raising fish and vegetables together 4). Evaluation to monitor success in implementing activities, 5). Evaluate the impact of activities directly on increasing fish and vegetable consumption and the impact on the family economy through fish and vegetable production. This activity increases the community's ability to manage narrow land by implementing an aquaponic system, which has an impact on improving family nutritional welfare and increasing economic income It is expected to be implemented by the wider community in Dawuhan Village and other villages in Malang Regency.

Keywords: *Aquaponics, Narrow Land, Family Nutrition, Catfish Cultivation, Village Empowerment.*

INTRODUCTION

Dawuhan is a village located in the Poncokusumo subdistrict of Malang Regency, which is situated in the province of East Java. The majority of the Dawuhan Village region consists of undulating woodland, interspersed with a limited number of low-lying areas. This results in a significant amount of time being required to travel both from the village to nearby towns and between different hamlets within the village. The population of Dawuhan Village is around 7,115, and it covers an area of 77.95 km2. The primary occupation of the villagers is farming, as this village is situated in an agropolitan region. Dawuhan Village is comprised of five distinct hamlets, namely Lesti, Dawuhan, Dompyong, Duren, and Ngandeng hamlets. The five hamlets are dispersed over various places, with some hamlets being fairly far apart (Pemerintah Desa Dawuhan, 2022).

Typically, the yard land in Dawuhan Village is not efficiently utilized and is mostly dedicated to agricultural activities, such as rice cultivation and plantations. Indeed, the utilization of tiny parcels of land is a crucial approach to enhancing productivity and well-being in urban or rural settings that have restricted land availability (Herawati *et al.,* 2023). Optimizing the utilization of a limited garden area can yield significant benefits such as increased food output, enhanced nutrition, economic advancement, and even bolstered food security and self-sufficiency (Rahayu *et al.,* 2022). Moreover, Indonesia continues to face significant nutritional challenges, particularly in relation to stunting, which predominantly affects toddlers during their crucial growth period. Stunting is a disorder in which toddlers have a failure to grow, resulting in reduced height and impaired growth (Ulum *et al.,* 2023).

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.The prevalence of stunting in Malang Regency remains suboptimal. Out of the total of 150,442 toddlers measured in February 2023, 10,128 toddlers had insufficient height, 10,423 toddlers had insufficient weight, and 7,306 toddlers were malnourished. Furthermore, the Malang District Health Service documented 1,034 infants who failed to satisfy the criteria for height, weight, and nutritional adequacy (KEMENKES RI, 2023). To effectively address this issue, it is crucial to implement extensive optimisation of community empowerment initiatives through the Family Empowerment and Welfare (PKK) programme. Through this initiative, the PKM Team aims to address the issue by introducing an aquaponics system that includes socialisation, counselling, training, and demonstration plots. Additionally, the team will provide two aquaponics sets to assist the PKK group in enhancing their skills and knowledge. The ultimate goal is to improve family nutrition by utilising limited urban space effectively. With the aim of enhancing the economy and well-being of the Dawuhan Village community.

Aquaponic technology integrates aquaculture, which involves the production of fish, with hydroponic techniques for growing plants, all in a single location. Aquaponics operates on the principle of water recirculation, where pond water is reused by employing hydroponic components as a biofilter. Additionally, it uses fish waste and fish food waste as a nutrient source for plants (Rahmadhani *et al.,* 2020). The aquaponic cultivation system has the ability to mitigate water pollution resulting from fish farming, conserve water resources and cultivation areas, enhance operational efficiency by utilising nutrients from residual feed and fish metabolism, and boost overall production capacity in catfish farming (Farida *et al.,* 2017). The primary aspiration is for aquaponics-derived products, including vegetables and fish, to enhance community nutrition, address issues of stunting and malnutrition, and, if the aquaponic system is effectively managed, enable the sale of aquaponic products to bolster the local economy. The objective of this community service initiative is to offer instruction and implement technology for utilising small areas of land while also promoting food security and self-sufficiency in rural communities. This will be achieved by empowering the community's economy through the implementation of aquaponic cultivation activities, with the aim of addressing prevalent issues related to stunting and malnutrition.

MATERIAL AND METHOD

Study Area

Activities for utilising narrow land through the implementation of aquaponic technology in the context of the MMD 1000 Village Strategic Community Grant programme at Brawijaya University were carried out in Dawuhan Village, District. Poncokusumo, Kab. Malang, from July to August 2023. Figure 1 displays a map indicating the precise location of Community Grant programme.

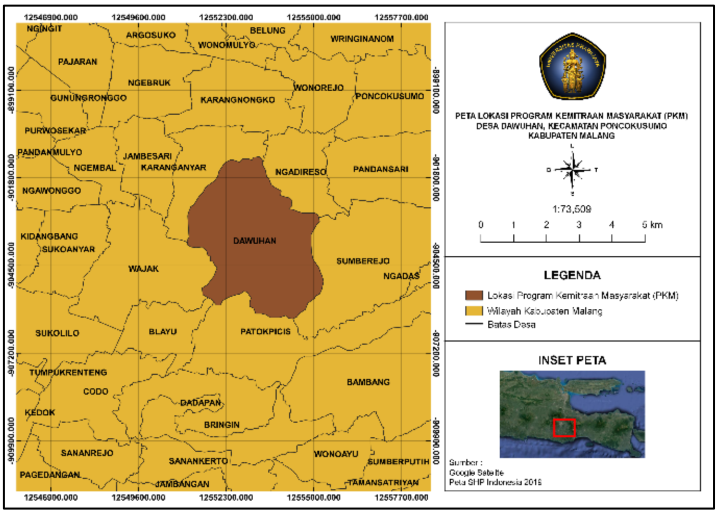

Figure 1. Map of locations for community service activities

Equipment and Materials

The equipment utilised in aquaponics technology comprises drills, grinders, measuring tape, screwdrivers, scissors, and various other tools. The materials utilised include tarpaulin pools of 3 metres in diameter, galvalum, perforated hydroponic pipes, bolts, UV roofing, wires, hoses, netpots, rockwool, flannel, kangkong seeds, and catfish. In addition, this aquaponics system is equipped with a water pump apparatus to convey water from the cultivation pond to the aquaponics circuit, along with an electrical power source to operate the water pump.

Aquaponics Technology Design

Aquaponics technology is a straightforward technique that offers remarkable advantages when done well and in a sustainable manner. The dimensions of this aquaponic technology's structure are 2.5 meters in length, 1 meter in width, and approximately 2 meters in height. Utilizing a hydroponic conduit of 4 cm in diameter and spanning a length of 2.5 m, there are a total of 6 conduits, each capable of accommodating 9 units of planting media. The filter tank has dimensions of 0.8 m x 1 m x 0.5 m and is filled with a mixture of coral, charcoal, palm fiber, and gravel as filter media. The upper part of the structure features a translucent ultraviolet (UV) roof, which serves to shield the hydroponic pipe from any debris that may descend from the overhead area. The tarpaulin pond, which serves as a habitat for fish, has a diameter of 3 meters. The aquaponic technology design utilized in this endeavor is seen in Figure 2.

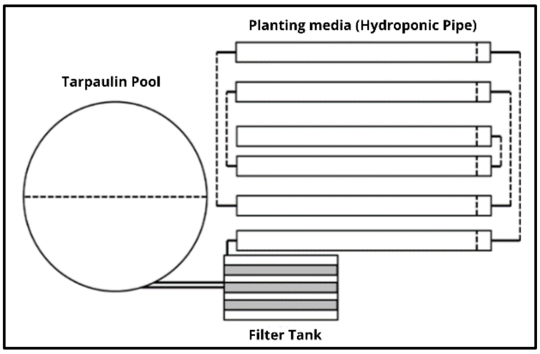

Figure 2. Aquaponics Technology Design

Methodology

The strategic service grant program utilizes a participatory approach method called Participatory Rural Appraisal (PRA) for execution. PRA, or Participatory Rural Appraisal, is an approach used to examine rural circumstances and livelihoods through active involvement and collaboration with local populations. Essentially, this approach emphasizes the participation of the community in all aspect of the activities, spanning from initiation to completion (Hudayana *et al.,* 2019). The strategy is very appropriate for implementation as village communities have transitioned from solely accepting programs from higher authorities (top-down) to actively participating in the development process by designing programs from within (bottom-up). They will play an active role in the planning process, deciding on the scale of program priorities, implementation, and usage of the produced outcomes (Mardjana *et al.,* 2020). This activity is implemented through a series of distinct stages, which include introduction, process, and evaluation.

RESULT AND DISCUSSION

Stage of Survey and Socialization

The first stage of the MMD 1000 Village Strategic Community Service Grant Program involves conducting a survey and engaging with the community. The primary challenges encountered by partners include limited engagement of the community in PKK initiatives, inadequate nutrition among impoverished families, and little utilization of small land adjacent to households. Based on the findings of the conducted identification, the PKM Team proposes appropriate technology as a solution to enhance food security and self-sufficiency among disadvantaged families, particularly in the domains of agriculture and fisheries, specifically for the utilization of limited land areas.

Stage of Counseling and Training

The initial action done was to introduce the partner group to aquaponics technology, based on the problem identification conducted in the previous stage. Aquaponics is an advancement of the bio-integrated farming method, which combines aquaculture (fish cultivation) with hydroponics (agricultural production techniques). Aquaponics aims to utilize nutrients derived from residual food and fish waste to cultivate plants, ensuring that the presence of nutrients in the growing medium does not hinder fish growth (Apriliani *et al.,* 2020). This cultivation system offers the benefit of eliminating the need for plant fertilizer, as the necessary nutrients for plants are derived from the water flow resulting from the decomposition of fish metabolic waste and feed waste. Additionally, it requires less maintenance, generates dual profits, and provides sufficient nutrition for the family by producing both catfish and vegetables (Zulfanita *et al.,* 2021). The aquaponic culture technique offers an optimal resolution to the challenge of acquiring water sources suited for fish farming, particularly in limited yard spaces (Hakim & Hariadi, 2021).

Figure 3. Counseling & Training on Aquaponic Systems

Following the provision of counseling on the advantages of aquaponic technology, a grant was subsequently awarded for two sets of aquaponic growing systems. The PKM students provided assistance during the aquaponics circuit assembly training, which involved tasks such as laying tarpaulin ponds, assembling the aquaponics frame, sowing vegetable seeds, learning about vegetable care, understanding fish cultivation techniques, and maintaining the aquaponics system with the Dawuhan Village PKK Group. Figures 3 display education and training activities, while aquaponics set grant shown in the Figure 4.

Figure 4. Aquaponics Set Grant

Aquaponics Efficiency Value

The development of aquaponic technology is highly feasible and has the potential for widespread adoption within the broader community. The aquaponics system's efficiency is derived from its utilization of limited land space, which presents a potential to enhance community nutrition by boosting the PKK program. In addition, this cultivation system presents the potential to augment revenue, so positively influencing the economic and nutritional well-being of the family. The specific information regarding the financial advantages of aquaponic agriculture is as outlined:

1. The aquaponics system, designed to specific proportions, can accommodate a total of 1,875 catfish with a stocking density of 500 m^2.
2. If the survival rate is 80%, the number of catfish at harvest time will be 1.500, which is equivalent to 150 kg. The cost per kilogram of catfish is IDR 23.000. The catfish generates a gross income of IDR 3.450.000.
3. The Food Conversion Ratio (FCR) value in the aquaponic growing system is 1:1, indicating that 150 kg of feed is required for one production cycle. The current price for one production cycle is IDR 11.000 x 150 kg = IDR 1.650.000.
4. Another benefit of this farming plan is the ability to harvest vegetables in three consecutive cycles. Each production cycle yields 8-10 kg of organic veggies, valued at IDR 150.000 each cycle (with each cycle lasting one month). The monthly profit generated via aquaponics, taking into account the production of catfish and vegetables, amounts to IDR 750.000. The breakdown of this computation is as follows:

$$Total = \left(\frac{3.450.000 - 1.650.000}{3}\right) + 150.000$$

$$= \text{IDR } 750.000/\text{Months}$$

Water Quality

The catfish farming method is intricately linked to the quality of water. Water quality refers to the degree to which water conditions are suitable for certain uses, including fish farming activities. Water quality is assessed by analyzing various characteristics related to its chemistry, physics, and biological (Setyowati, 2015). Tables 1 display the findings of regular water quality assessments conducted in cultivation ponds on a daily and weekly basis.

Table 1. Water Quality Measurement Results

Parameter	Average	Quality standards
Temperature	28.3 ºC	25-32 ºC
pH	7,6	6,5-8,5
DO	5.8 mg/L	>3 mg/L
Ammonia	0.23 mg/L	<1 mg/L
Nitrate	0,33 mg/L	< 5 mg/L
Orthophosphate	0.052 mg/L	0,05–0,07 mg/L

The average temperature obtained when cultivating catfish is 28.3 ºC, which is included in the optimal temperature for cultivating catfish. The optimum temperature range for catfish growth is between 25-32°C (Azhar *et al.,* 2017). So the temperature during cultivation with an aquaponic system is very suitable for the survival and growth of catfish.

Measuring the degree of acidity (pH) obtained an average value of 7.6. This value is classified as optimal and normal to support the survival and growth of catfish. The optimum pH range suitable for catfish growth is 6.5 – 9 (Qalit *et al.,* 2017).

The average value of Dissolved Oxygen (DO) levels obtained in aquaponic cultivation is 5.8 mg/L. The DO value obtained is very supportive for the survival of catfish. Good oxygen levels for catfish cultivation should not be less than 3 mg/L (Zidni *et al.,* 2019).

The ammonia content obtained during the research had an average value of 0.23 mg/l. Good ammonia levels in cultivation are less than 1 ppm (Sahetapy *et al.,* 2021). Ammonia levels that are too high will be toxic in the water. The higher the ammonia level, the more oxygen supply will decrease.

The average nitrate value obtained was 0.33 mg/L. Meanwhile, the normal limit for nitrate levels in cultivation waters for the growth of catfish is <5 mg/L (Pratama *et al.,* 2017). High nitrate content can cause eutrophication and accelerate the growth of phytoplankton, which can cause blooming.

Orthophosphate is a soluble inorganic compound that is used directly by plants and fish as a compound. essential for the growth of aquatic organisms. The average orthophosphate value obtained was 0.052 mg/L. A good orthophosphate level for cultivating freshwater fish, especially catfish, is 0.2-1 mg/L. Meanwhile, the optimum orthophosphate level for catfish growth is around 0.05–0.07 mg/L (Effendi *et al.,* 2015).

Based on measurements of several water quality parameters in cultivation ponds with an aquaponic system, the results were still within the optimal range to support the growth of cultivated fish. The water quality is always in optimal condition because it undergoes a filtering process in the hydroponic pipe which is used as nutrition for the vegetables contained in it.

Monitoring and evaluation

Monitoring and evaluation activities continue to be carried out by the PKM Team to achieve the planned success indicators. The activities carried out include monitoring the ability and seriousness of the community and women who are members of the Dawuhan Village PKK group in implementing the aquaponics system independently once a week. Then monitor the improvement in nutrition, in this case increasing consumption of fish and vegetables and improving the family economy after implementing activities in the community through the Dawuhan Village PKK group.

IMPACT OF ACTIVITIES

Lack of community insight regarding the potential for utilizing small plots of land, lack of attention to community nutrition and improving the economy of underprivileged families, are the main problems faced by service activity partners, namely the Dawuhan Village PKK group. With the implementation of the MMD 1000 Village Strategic Community Service Grant activities, several impacts were obtained, including:

1. Increasing the community's ability to manage small areas of land by implementing an aquaponic system.
2. Increasing the level of welfare of citizens based on adequate consumption of protein and vegetables.
3. Economic increase in additional income from the sale of vegetables and catfish produced by cultivation through an aquaponics system.
4. The quality of the water used in the aquaponics system is within the optimal range for the growth and development of fish and cultivated vegetables.
5. Fish and vegetables cultivated through the aquaponics system have good quality and grow rapidly because they are cultivated organically without pesticides and chemical

fertilizers. So the results produced by the aquaponic system have better quality, are safe to consume and have a larger size.

CONCLUSION

By implementing strategic community service grant activities and utilizing narrow land through the application of aquaponic technology in Dawuhan Village, it is evident that this initiative contributes to enhancing knowledge and skills and positively impacts community welfare and family economy through the cultivation of disease-resistant catfish. Ensuring the preservation of water quality and supplying essential nutrients to plants leads to the simultaneous achievement of dual profitability. In addition, individuals obtain their nutritional requirements from aquaponics products, namely fresh vegetables, and catfish, which are rich in protein.

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