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SASIMI (Aquaponic System in A Circular Economy) Model with 5R Principles to address environmental pollution

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ABSTRACT

The Tanusi Farmers Group in Sumberejo Village, Batu District, faced significant challenges in waste management and limited agricultural land, which hindered their ability to adopt sustainable farming practices. To address these issues, the SASIMI (Aquaponic System in Circular Economy) initiative was implemented. The system aimed to reduce waste by applying the 5R principles. It repurposed inorganic waste, such as plastic, as planting media in aquaponics and utilized maggots as biological agents to process organic waste into compost. The methodology of SASIMI included several stages, such as preparation, education on waste management and maggot cultivation, aquaponic system preparation, training on implementation and maintenance, sustainability training, and evaluation. The implementation of SASIMI yielded significant results. Maggot cultivation was able to establish 10 cultivation sites that process up to 20 kilograms of organic waste per month, converting it into compost. Additionally, 10 aquaponics systems were established, reducing 15 kilograms of plastic waste by repurposing it as planting media. Economically, the circular economy approach contributed to reducing household expenses. The aquaponics systems provided a sustainable source of fresh produce, leading to a 22 percent reduction in monthly expenditures on vegetables for participating households.

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1. INTRODUCTION

The Tanusi Farmers Group is a farming community located in Sumberejo Village, Batu City, East Java. The community's primary sources of income are plantation agriculture and livestock farming. Additionally, the village has developed into a destination for "petik sayur" (vegetable-picking) tourism, attracting visitors who seek an agro-tourism experience. The Tanusi Farmers Group consists of agricultural farmers who have innovative ideas but face challenges in realizing them due to limited education background.

However, waste management has become a significant challenge for the Tanusi Farmers Group, particularly following the implementation of Batu City Mayor Regulation No. 66 of 2020 (Peraturan Walikota Batu, 2020). This regulation introduced changes to traditional waste processing and

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transportation systems, forcing the community to adapt. Despite repeated appeals from residents to the city government for assistance, these efforts have yet to yield significant results.

Figure 1. Piles of rubbish resulting from poor management

The lack of effective waste management after the issuance of Perwali No. 66 of 2020 has led to several problems. The community was not adequately prepared to implement the 5Rs approach (Reduce, Reuse, Recycle, Recover, Replace), resulting in waste accumulation in many areas. Whereas, prioritizing recycling and reuse can reduces the volume of waste sent to landfills (Pambudi, 2023). Many residents have complained about unpleasant odors and the emergence of skin and respiratory diseases. The negative impacts of increased waste production include environmental pollution and the depletion of natural resources (Sompotan & Sinaga, 2022).

Based on the initial discussion, several factors contribute to the failure of waste management in Sumberejo Village, Batu District, Batu City. One of the main reasons is the low utilization of organic waste. The community has limited processing capabilities for organic materials, resulting in continued reliance on manual waste collection systems. This has led to waste accumulation without proper segregation of organic and inorganic waste, which prevents the effective implementation of the 5Rs (Reduce, Reuse, Recycle, Recover, Replace). Organic waste, such as vegetable scraps, fruit peels, flowers, and other plant-based materials, could be processed into natural fertilizer to enrich the soil. However, this practice has not been fully implemented, leaving a significant opportunity for improvement in organic waste management. Another issue is the insufficient reuse of inorganic waste. Inorganic materials, such as plastics and bottles, are difficult to decompose and require extensive periods to degrade naturally. If not properly managed, they contribute to environmental pollution. Currently, most inorganic waste is discarded without consideration for reuse or recycling, and community involvement in managing this type of waste remains low. Proper reuse of inorganic waste, guided by the principles of the 5Rs, could bring substantial environmental benefits and reduce pollution. Additionally, the lack of sustainable circular economy practices in waste management has hindered progress. The waste management practices in Sumberejo Village lack a clear framework for sustainability, resulting in minimal tangible outcomes from current activities. This has discouraged community members from actively participating in waste management efforts, as they have not observed significant benefits. Innovation and new approaches are needed to establish a sustainable circular economy framework that addresses these issues while adding value to waste management processes. Lastly, limited understanding of aquaponic system maintenance and sustainability is another contributing factor. While aquaponic systems have the potential to support environmentally friendly practices and enhance economic viability, the community lacks adequate knowledge about their proper maintenance and long-term sustainability. Raising awareness and providing comprehensive training on aquaponic systems are essential for ensuring that environmentally conscious practices are adopted at the household level and scaled up across the village.

Figure 2. Agricultural Land in Sumberejo Village

Other than waste management issues, the Sanusi Farmers Group also faces the challenge of limited agricultural land, which has significant implications for the community. The scarcity of arable land has often led to competition among residents, resulting in social conflicts. The limited agricultural land also hampers the ability of the farmers to achieve optimal yields, thereby affecting their economic stability. With less land available for cultivation, farmers struggle to diversify crops or implement innovative agricultural techniques that require more space.

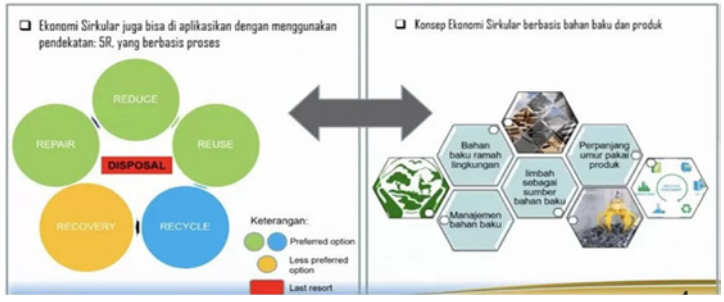

Figure 3. Circular economy concept - 5R (Reuse, Reduce, Recycle, Recovery, Repair)

However, the long-term sustainability initiative need to be fully realized (Ridwan, 2015). The implementation of the 5Rs is crucial for advancing towards a circular economy (Yuana, 2023). By adopting these practices, communities can achieve better economic sustainability, protect the environment, and create further economic value (Agung, 2015). The Sumberejo area has yet to fully leverage its natural resources due to limited human resources, necessitating outreach programs to support regional and environmental advancement.

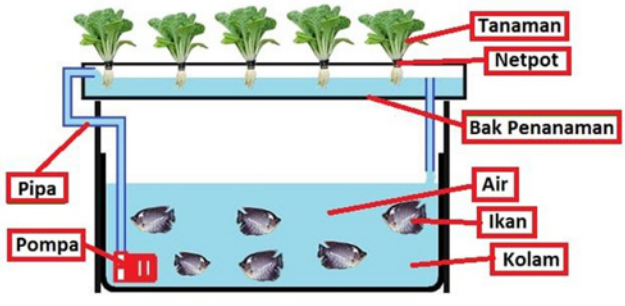

Figure 4. Aquaponics design

One potential solution for addressing waste management and environmental sustainability is the cultivation of an Aquaponics program, which integrates plant cultivation with fish farming (Nawawi, et al., 2018). Previous community service initiatives have explored innovative approaches to enhance economic self-reliance and environmental sustainability. Sartika & Cahyani (2023) provided education and assistance in hydroponic plant cultivation, emphasizing sustainable agricultural practices to strengthen self-reliant economies. Wibowo et al. (2023) implemented automation technology and the Internet of Things (IoT) in greenhouse systems through the SLiCE program, enabling efficient and productive cultivation processes. Similarly, Rusdianto et al. (2023) developed fish pellets by utilizing by-products of BSF (Black Soldier Fly) maggot organic fertilizer, contributing to economic growth through sustainable waste management and aquaculture innovations. Our community service program, SASIMI (*Sistem Akuaponik dalam Sirkular Ekonomi* or Aquaponic System in A Circular Economy) represents an innovative approach to integrating technological advancements with eco-friendly practices. Through this community service program, the implementation team aims to provide education and training to the residents of Sumberejo Village on waste management practices, focusing on the recycling of both organic and inorganic waste. Additionally, the team will offer guidance on effective and efficient land management. These efforts are intended to promote a healthy environment and prevent environmental degradation.

This community service initiative aims to implement the SASIMI system within the community of Sumberejo Village, Batu City, to introduce sustainable waste management for both organic and inorganic waste, as well as to implement a circular economy within the community. By integrating aquaponic systems, the initiative aims to improve land productivity, reduce social tensions related to land scarcity, and enhance community welfare by creating new opportunities for sustainable income. In addition to addressing waste management issues through the implementation of SASIMI, the program not only offers an innovative solution for waste management but also provides an alternative approach to optimize limited land resources.

2. METHODS

The community service was conducted in Sumberejo Village, Batu City, with the active participation of 15 members from the Tanusi farmers group. The facilities used during the socialization session included the community conference hall and presentation equipment. Meanwhile, the facilities used for the training session included a home yard, used buckets, used pipes, used plastic cups, and patchwork materials. Additionally, vegetable seeds such as spinach and cabbage were also utilized during the training.

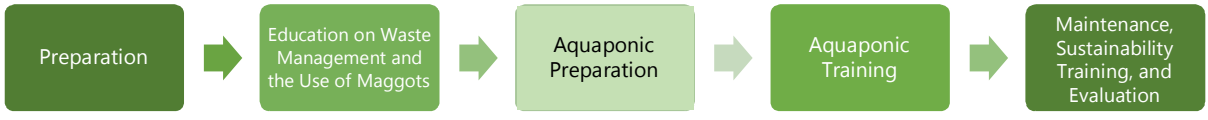

Figure 5. Community service method

The implementation of the community service program consisted of several stages. The first stage was preparation, which involved conducting a site survey to understand the environmental conditions and community needs. Materials and tools such as presentation media, educational materials, plant seeds, maggots, and equipment for aquaponic systems were prepared. The next stage was education on waste management and the use of maggots for organic waste processing, where participants were introduced to methods for separating and processing organic and inorganic waste. Organic waste was

processed with maggots, while inorganic waste was prepared for recycling into aquaponic growing media. This was followed by aquaponic preparation, during which materials for constructing the system were arranged and made available. Subsequently, participants underwent aquaponic training, where they were taught how to build and operate the system using recycled materials. The next step was maintenance and sustainability training for the SASIMI program, focusing on maintaining the aquaponic system and ensuring its long-term use. Finally, an evaluation was conducted to assess the program's effectiveness, measuring participants' understanding, engagement, and the adoption of sustainable practices.

Table 1. Success Indicator of SASIMI

Indicator	
Organic Waste Processing	The percentage of people who burned waste, left it to rot, or reprocessed it into compost before and after the SASIMI program
Inorganic Waste Management	The percentage of people who allowed garbage to pollute the environment versus those who recycled it before and after the SASIMI program
Understanding Aquaponics Care	The percentage of people who understood the benefits of aquaponics and how to maintain the system before and after the SASIMI program (pre-test and post-test based)
Community Awareness and Participation	The percentage of people who rated environmental hygiene as "really important," "important," "somewhat important," or "not important" before and after the SASIMI program
Circular Economy	The percentage of participants with an understanding of the circular economy before and after the SASIMI program (pre-test and post-test based)

As for community service schedule, we planned to implement the program in 5 activity which following details:

Table 2. Series of activity SASIMI program

1st Activity	**Initial Survey**	**Time**
Activities	Discussion with the Tanusi farmers group and initial problem survey	May 4th
Goals	To understand the main problem and community needs, so the program would run right on target	
2nd Activity	**Organic Waste Management**	**Time**
Activities	First socialization about waste separation and how to use maggot as organic decomposer	May 28th - June 14th
Goals	To educate community about waste separation and organic waste management	
3rd Activity	**Preparation for Inorganic Waste Management**	**Time**
Activities	Collection of supporting materials, facilities, and purchase of plant and catfish seeds	July 18th
Goals	To prepare the training of anorganic waste management with Aquaponic system	
4th Activity	**Inorganic Waste Management**	**Time**
Activities	Together with Tanusi Farmer Group, construct aquaponic system with anorganic waste	July 21st
Goals	To realize anorganic waste management which is valuable and profitable for community	
5th Activity	**Evaluation**	**Time**
Activities	Second socialization about aquaponic maintenance and program sustainability and evaluation	July 28th
Goals	To make sure SASIMI Program Impact last long for the community and understand the improvement needed	

However, we provided substantial education to the Tanusi Farmers Group, which focusing on a few key topics. The first topic was waste separation. The initial activity emphasized segregating organic and inorganic waste. Organic household waste was processed with the assistance of maggots, while inorganic waste was recycled into growing media for aquaponics. The second topic was aquaponics setup. This phase involved engaging community service partners in practical sessions to construct aquaponic systems using recycled inorganic waste materials. This hands-on approach aimed to demonstrate the practical application of waste materials in sustainable aquaponic systems. To evaluate this program we give a questionaire to Tanusi Farmer Group. There are five indicators we use to evaluate: two of them involve pretests and post-tests, while the other three focus on participants' reflections and self-assessments. Few indicators we used to measure the success of this community service program presented in Table 1.

3. RESULTS AND DISCUSSION

Results

The first step was preparation. During this phase, the community service team conducted discussions and observations in Sumberejo Village, Batu District, Batu City, which was identified as having significant potential for environmental development. The team began by collecting data on the environmental conditions, including waste management practices and current efforts related to introducing a circular economy. The main problems of waste management in Sumberejo Village were identified as follows: (1) Low utilization of organic waste; (2) The insufficient reuse of inorganic waste; (3) The lack of sustainable circular economy practice; (4) Limited understanding of aquaponic system maintenance and sustainability.

Figure 6. Initial discussion

The second step is socialization abut waste management and the benefit of maggot as natural decomposer. This activity utilizes maggots as biological agents to decompose food scraps and other organic materials. Maggots play a crucial role in the decomposition process due to their ability to consume vegetable and fruit waste rapidly (Raihan, 2022). Their efficiency in breaking down organic waste is well-documented, and they are used by the community to produce odorless compost or organic fertilizer (Juliawati & Reniawaty, 2020).

Organic waste, which has the potential to cause environmental pollution, is collected and managed separately from inorganic waste. Maggots are placed in specialized containers containing the organic waste. During this process, maggots rapidly decompose the organic material into nutrient-rich compost, significantly reducing the waste volume. This compost can be used as organic fertilizer for agriculture or gardening, thereby creating a sustainable environmental cycle. This approach not only addresses the waste management issue but also adds economic value by converting waste into valuable organic fertilizer.

Figure 7. Maggot cultivation

Figure 8. Equipment preparation

The next step was aquaponics preparation. During this phase, we collected various materials and equipment needed for the aquaponics system. These included used buckets, pipes, cups, patchwork materials, and seeds. The use of recycled items demonstrated an effort to promote sustainability and cost-efficiency in system construction. By utilizing these materials, we aimed to showcase how waste could be repurposed effectively into functional components of an aquaponics setup. Additionally, the seeds selected for this project, such as spinach and cabbage, were chosen for their adaptability and nutritional value, aligning with the community's agricultural potential. This practice aligns with the 5R principles (Reduce, Reuse, Recycle, Recover, and Replace), which advocate for transforming waste that initially lacks utility into resources that benefit both the environment and the local economy (Nisak et al., 2019). The process begins with sorting inorganic waste, particularly plastic cups that can still be used. These cups are then processed and arranged to serve as planting media within an aquaponic system.

Figure 9. Aquaponic development proccess

The fourth step is aquaponic training. This activity is using recycled materials as we prepared, such as used buckets, pipes, and patchwork materials, to construct the aquaponic setup. Some individuals are working on setting up the aquaponics tank, while others are preparing the growing media and planting vegetable seeds like spinach and cabbage. The atmosphere is educational and hands-on, with the villagers learning and working together to build a sustainable and functional system. In addition, the creation of an aquaponic system presents an innovative solution to support economic sustainability within the framework of the circular economy. Aquaponics, which integrates aquaculture (the cultivation of fish) with hydroponics (the cultivation of plants in water), offers an effective and efficient cultivation method, particularly advantageous for urban communities with limited land. This system enables residents to utilize confined spaces, such as small yards or unused corners of their homes, to grow a variety of plants while simultaneously raising freshwater fish (Handayani, 2018). Implementing an aquaponic system allows households to address their food needs independently while contributing to the reduction of carbon footprints and the sustainable management of resources (Muhtarom, 2023).

Figure 10. Training process

The last step is maintenance, sustainability training, and evaluation of SASIMI Program. To enhance community understanding of the use and maintenance of the aquaponic system, the service team conducted training sessions aimed at solidifying user knowledge. This training is crucial for ensuring the sustainability of the established aquaponic system, which addresses waste management issues and promotes the implementation of a circular economy in a sustainable manner. The training sessions were held with local residents, consisting of one meeting with Sumberejo community. We also doing the evaluation to improve SASIMI Program in the future and to make sure SASIMI Program give a long term impact.

Implementation of 5R Principles in SASIMI

The implementation of the 5R principles (Reduce, Reuse, Recycle, Recover, Replace) in SASIMI applied in Sumberejo Village, Batu District, Batu City, exemplifies a successful circular economy model at the community scale. This approach aims to create a sustainable agricultural model that optimally utilizes resources and minimizes waste while delivering positive impacts on both the environment and the local economy. Each stage of the 5R process involves the Kelompok Tani Tanusi group, ensuring a participatory approach that effectively enhances community understanding.

The first principle, Reduce, focuses on minimizing the use of materials that are difficult to recycle and have the potential to pollute the environment in Sumberejo Village. In the aquaponic system, the use of chemical fertilizers and pesticides is minimized, replaced by natural nutrients produced from fish waste within the system. Additionally, the community reduces reliance on single-use plastics by promoting the use of more environmentally friendly materials in daily activities.

The reuse principle is applied by repurposing inorganic waste materials that can still be used, such as plastic bottles, cups, and old buckets. These items are processed and utilized as planting media or containers within the aquaponic system, transforming waste that was previously considered valueless into functional components of the economic cycle. This approach not only reduces the volume of waste disposed of in the environment but also creates solutions that support sustainability through the circular economy.

Figure 11. Reduce, reuse and recyle principle implementation by using inorganic waste as aquaponic material

Through recycle, the community service team ensures that materials that are no longer usable are processed into new, useful products. For example, plastic cups that can no longer be used are transformed into materials for SASIMI. This process helps reduce carbon footprints and decreases the need for new materials. In the long term, it supports environmental sustainability.

Figure 12. Recover and replave principle implementation by fish waste as fertilizer

Recover in this context means optimizing the use of available resources to create SASIMI. The nutrients produced from fish waste in the water are extracted and used to fertilize plants within the system, creating an efficient and low-waste cycle. In this way, the aquaponic system not only produces vegetables and fish but also recovers and utilizes resources that would otherwise be wasted. This activity aligns with the circular economy concept, which aims to leave minimal residue or waste in economic activities.

Finally, replace is applied by substituting non-environmentally friendly materials with more sustainable alternatives. In this case, the community service team replaces conventional materials that harm the environment with SASIMI innovations that support the circular economy concept in Sumberejo Village. This process also replaces conventional growing media used by the Kelompok Tani Tanusi group. Additionally, SASIMI addresses the issue of limited land in Sumberejo Village.

The implementation of the 5R principles in SASIMI in Sumberejo Village not only contributes to environmental preservation but also empowers the community through education and active participation in maintaining economic and environmental sustainability. These small community-level steps can spark broader changes, particularly in reducing waste pollution in Sumberejo Village. This demonstrates that circular economy principles can be effectively integrated into daily life to create a sustainable positive impact.

Evaluation of Results

The first indicator is organic waste management. Before the program, the majority of organic waste, about 55 percent, was left to rot, while 30 percent was burned and only 15 percent was decomposed. After the program, there was a notable shift in waste management practices. A larger portion of organic waste, 45 percent, is now decomposed, showing an improvement in sustainable waste processing. Additionally, the percentage of waste left to rot decreased to 35 percent, while the percentage of waste burned reduced to 20 percent. This shift reflects a positive change towards more environmentally-friendly waste management practices following the SASIMI program. The second indicator is inorganic waste management. Before the program, a significant portion of inorganic waste, 65 percent, was left to pollute the environment, while only 35 percent was recycled. After the program, there was a positive shift, with 55 percent of the inorganic waste being recycled. This data indicating an improvement in sustainable waste management practices. The third indicator is understanding about aquaponic care. Before the program, 48 percent of the participants had a good understanding of aquaponic care, while 52 percent had limited knowledge. After the program, the percentage of participants with an improved understanding increased to 52 percent, while the number of those with limited knowledge decreased to 48 percent. This indicates that the SASIMI program successfully enhanced participants' understanding of aquaponic care. The fourth indicator is community awareness. Before the SASIMI program, community awareness regarding environmental cleanliness was quite varied. Only 37 percent of participants considered have high awareness of environmental cleanliness. After the SASIMI program, there was a noticeable improvement in community awareness. The percentage of community awareness increased to 55 percent. The last indicator is understanding about circular economy. Before the SASIMI program, the understanding of the circular economy was relatively low, with only 30 percent of the community having an awareness of the concept. However, after the SASIMI program, there was a significant improvement, with 45 percent of the community members now understanding the principles of the circular economy.

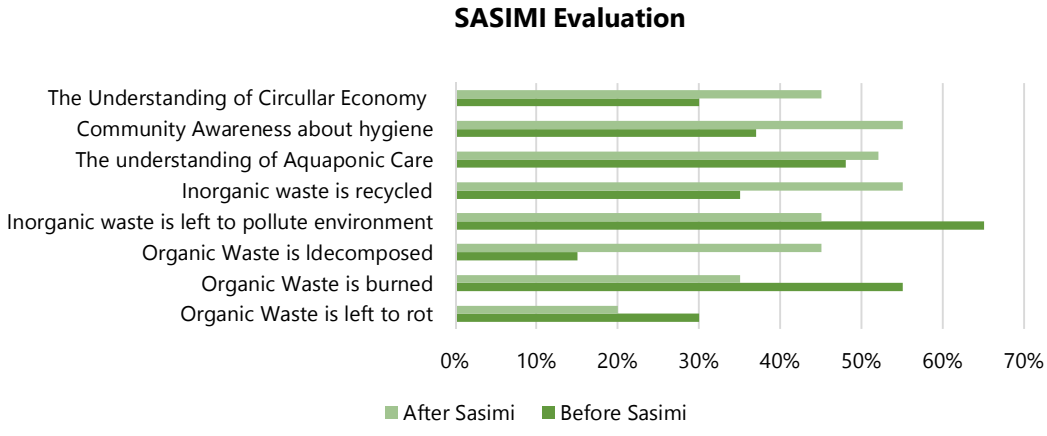

Figure 13. SASIMI evaluation results

Despite the ongoing challenges that need to be addressed, this activity has successfully shifted the community's mindset and behavior towards better waste management and sustainable circular economy practices. Continued efforts in education and training are required to enhance the community's understanding of aquaponic system maintenance and to develop more effective strategies for managing both organic and inorganic waste. With these ongoing improvements, Sumberejo Village is expected to serve as a successful example of circular economy implementation at the local level, potentially inspiring other communities in broader regions.

Discussion

This community service initiative aims to implement the SASIMI system in Sumberejo Village, Batu City, as a comprehensive solution for sustainable waste management and the promotion of a circular economy. The program effectively addressed both organic and inorganic waste challenges by introducing innovative practices tailored to the community's needs. Organic waste was processed using maggot cultivation, reducing 20 kilograms of waste per month, while inorganic waste, such as plastic, was repurposed as planting media in aquaponics systems, reducing 15 kilograms of plastic waste. These efforts not only minimized environmental pollution but also optimized resource use within the community. Additionally, the integration of aquaponics systems yielded tangible economic benefits, including the production of 20 kilograms of vegetables per month, which contributed to a 22 percent reduction in household vegetable expenses. This initiative also tackled the issue of limited agricultural land by providing sustainable farming solutions that maximized productivity within small areas.

In comparison, Atem et al. (2024) focused on strengthening food security and women's economic empowerment through aquaponics in Bahu Palawa Village. The program recorded an increase in partner knowledge and skills scores from 48.4 percent to 83.7 percent and engaged 38 active members in managing the aquaponic system. Unlike SASIMI, which emphasizes harvest outcomes and circular economy impacts, Atem's program focused more on human resource capacity building.

The program conducted by Yulianyahya (2024) resulted in one aquaponic system installation through a partnership with Pokdakan Karya Mandiri, aiming to enhance the community's independence in aquaponics. While the focus on partnerships is similar to SASIMI, SASIMI's outcomes are more measurable in terms of environmental and economic impacts, such as waste reduction and household expense savings.

Kadir et al. (2023), in their research in Sidrap Regency, South Sulawesi, successfully harvested tilapia along with several types of vegetables, such as mustard greens, water spinach, spinach, and pak choy, using a solar-powered aquaponics system. Their program stood out in achieving product diversification and energy efficiency, while SASIMI emphasized circular approaches by utilizing waste and maggots as biological agents.

Finally, Sugianto et al. (2022) managed to harvest 100 pots of water spinach, totaling 18 kilograms, in less than one month after seeding. Additional benefits included healthier fish and better uniformity in size. Compared to SASIMI, their program focused more on horticultural yields, whereas SASIMI adopted a holistic approach with additional components, such as organic waste management through maggots.

This community service initiative brings significant benefits, including enhancing community awareness and participation in addressing the growing challenges of both organic and inorganic waste. It tackles the waste management issues that have long been a concern within the community, offering a solution that not only mitigates environmental impact but also empowers local citizens. SASIMI Program reduced 20 kilograms of organic waste and 15 kilograms of inorganic waste. Furthermore, the initiative

plays a crucial role in strengthening the involvement of academics in addressing pressing social issues, fostering collaboration between educational institutions and communities to create sustainable solutions.

For the partners, the positive impacts are far-reaching. The development of new farming areas in a community facing land limitations has provided an innovative means of overcoming these challenges, enabling them to cultivate crops in confined spaces. There are 20 kilograms vegetable that can be harvested per month. In addition, the initiative has helped reduce household expenses related to basic food needs by providing a reliable source of vegetables through aquaponics, lowering the cost of purchasing fresh produce. The partners also benefit from enhanced technical knowledge in waste management, as well as the skills required to create and maintain aquaponic systems, improving both their agricultural practices and environmental stewardship.

Furthermore, the initiative promotes the development and application of technology and innovation for the broader community. By introducing cutting-edge technologies for managing waste through aquaponic systems, it contributes to a greater understanding of sustainable agricultural practices. The program not only fosters awareness of the principles of a circular economy but also facilitates the transfer of critical knowledge about innovations in agriculture that support long-term sustainability. This knowledge is practical and can be applied in daily life, ensuring the community remains resilient in the face of environmental and economic challenges while fostering a culture of sustainability and innovation.

4. CONCLUSION AND RECOMMENDATIONS

The implementation of SASIMI (Aquaponic System in Circular Economy) in Sumberejo Village aimed to enhance community awareness, waste management practices, and food security while fostering a green economy. This program successfully implements maggot cultivation to decompose organic waste, an aquaponic system to recycle inorganic waste, and utilizes organic compost from fish waste to create a circular economy. Currently, Sumberejo Village has 10 cultivation sites dedicated to maggot cultivation that reduced 20 kilograms organic waste per month. Other than that, there are 10 hydroponic systems in operation that reduced 15 kilograms inorganic waste. This program also decrease 22 percent of houshold spending on basic needs with 20 kilograms per month of vegetable harvest. Besides, the program achieved significant improvements across several indicators. For organic waste processing, the percentage of waste being burned decreased from 55 percent to 35 percent, while composting increased from 15 percent to 45 percent, showing a 30 percent improvement due to the introduction of maggot-based compost production. In terms of inorganic waste processing, recycling efforts increased from 35 percent to 55 percent, while waste left to pollute the environment dropped from 65 percent to 45 percent, reflecting a 20 percent improvement in managing inorganic materials. Community awareness of environmental cleanliness also showed notable progress. Before SASIMI, only 12 percent of residents considered cleanliness "very important," and 33 percent viewed it as "not important." After the program, those who considered it "very important" increased to 20 percent, while those viewing it as "not important" fell to 15 percent, indicating a positive shift in attitudes. Additionally, understanding of aquaponic utilization and maintenance improved slightly from 48 percent to 52 percent, suggesting the need for continued mentoring to strengthen practical knowledge. Finally, the community's understanding of the circular economy increased from 30 percent to 45 percent, demonstrating a 15 percent improvement in awareness of sustainable economic practices. Overall, the SASIMI program successfully reduced waste, improved recycling rates, enhanced environmental awareness, and introduced sustainable solutions such as aquaponics and composting.

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