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Application of hydroponic technology and processing variations to enhance food security and prevent stunting

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ABSTRACT

Hydroponics is a modern plant cultivation system without soil to produce clean, healthy, and fresh vegetables. The availability of fresh, healthy food is a key factor in preventing stunting. This community service activity aims to increase food security and prevent stunting through vegetable cultivation using hydroponic technology. Methods used include socialization, training, practice, mentoring, monitoring, and evaluation of hydroponic technology and its processing. Results show that partners experienced increased empowerment, with knowledge of hydroponics and it's processing improving by >30 percent. Partner skills in producing hydroponic vegetable products significantly improved, transitioning from no prior experience to being skilled at hydroponic cultivation, with increased production. This activity also yielded various vegetables (water spinach, spinach, bok choy, and Chinese kale) grown using hydroponic systems. Additionally, DFT hydroponic system facilities with a capacity of 200 plants per installation (4 installations) and processing tools were provided, enabling the community to access fresh, nutritious food and support stunting prevention.

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1. INTRODUCTION

Cibalung Village is a stunting-prone area in Bogor Regency, striving to become stunting-free. In 2022, the village government implemented various measures to reduce stunting rates, which led to a decrease in 2023. However, the village has not entirely eradicated stunting, with the current stunting rate standing at 12 percent, according to the village head. The stunting issue in Cibalung Village is closely related to suboptimal food production. Cibalung Village has potential in human resources, with over 50 percent of its population being farmers. However, their educational levels are low, with most having only reached junior high school. This low education level affects their knowledge and ability to produce healthy and nutritious food.

To improve food security and prevent stunting, the Cibalung Village government has established community groups, namely the Family Empowerment and Welfare group (PKK) and the Women Farmers Group (KWT). The PKK group plays a strategic role in addressing and preventing stunting. The group

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consists of 15 members with an average education level of junior high school, aged 25-70 years. Their routine activities include weighing babies, monitoring pregnant women, and conducting family health check-ups. The PKK group is also active in conventional gardening, though it faces challenges with limited and infertile land. The PKK leader hopes to equip members with additional skills, especially in producing healthy, fresh, and nutritious food options.

Similarly, the KWT plays an essential role in maintaining food security at the village level. The group consists of 15 members managing a 78 m^2 plot of land. They grow vegetables conventionally, but production is limited in both quantity and variety due to infertile soil and limited time for maintenance. For instance, a 1.5x4 meter plot of water spinach yields only 5 kg per harvest. Hydroponic vegetable farming can significantly increase productivity on their limited land.

Hydroponics is a modern plant cultivation technology (Izzany et al., 2023; Alviani, 2015) that does not use soil (Jones, 2014; Roidah, 2024) and is suitable for narrow and infertile areas (Siswadi, 2018). This system allows for year-round vegetable production (Yulianti et al., 2021). The results are some cleaner and healthier crops (Herwibowo & Budiana, 2014; Hidayat et al., 2018), making it ideal to consumed by society who diagnosed stunting and also ideal for stunting prevention.

Stunting is a condition characterized by impaired growth in children due to prolonged malnutrition, resulting in shorter stature and delayed cognitive development (Anjani et al., 2024; Astriany et al., 2024). This problem is prevalent in areas with unhealthy environments and limited access to nutritious food. Vegetables are rich in fiber, vitamins, and minerals, essential for maintaining body health. Consuming a variety of vegetables can help improve nutritional intake and prevent stunting in children (Qodir et al., 2024). Apart from consuming fresh vegetables directly, to increase food security and prevent stunting can also be carried out through processing vegetable products (Sari & Astriana, 2023). Vegetables can also be processed into products like vegetable biscuits to increase variety and appeal, especially for those who dislike fresh vegetables. This community service program aims to improve food security and prevent stunting by implementing hydroponic vegetable farming technology.

2. METHODS

This community service activity was conducted in Cibalung Village, Bogor Regency, involving two target partners: the PKK group with 20 members and the KWT group with 15 members. The stages of community empowerment carried out by students included several methods: program socialization and preparation, hydroponic installation provision, training and practice, assistance, monitoring, and evaluation.

The activity began with socialization involving village government partners, target partners, higher education partners, and students. This phase introduced the program team and outlined the planned community service activities. Subsequently, four DFT hydroponic installations were provided and assembled at the partners' locations.

Training and practice sessions on hydroponic vegetable cultivation and its processed products were conducted by delivering training materials, facilitating discussions, and providing hands-on practice at the partners' sites. Assistance was provided throughout the hydroponic vegetable cultivation process, from seeding to harvesting, including processing the produce into cookies. Monitoring and evaluation were carried out through pre- and post-tests administered to partners before and after implementing the community service program. The detailed stages of the activities are in Table 1.

Table 1. Stages of program implementation

Activity 1	**Socialization and Program Preparation**	**Time**
Activities	- Socialization of activities carried out together with partners, both village government partners and target partners and university partners and students. Introduction between the entire proposing team, both lecturers and students, with target partners and the village government to be closer and support the smooth running of the program. - Preparation of the activity program is also carried out, including by conducting nurseries and surveys of locations that will be occupied by students during the activity.	7th July 2024 1st - 5th August 2024
Objectives	This activity aims to introduce the team, program and prepare the activity location.	
Activity 2	**Provision of hydroponic installations**	
Activities	Providing DFT hydroponic installations, materials and facilities for cultivating vegetable plants	28th July - 5th August
Objectives	Preparing hydroponic installations at partner locations and providing explanations to partners regarding the use and maintenance of hydroponic installations	
Activity 3	**Training and Practice**	
Activities	Practice of sowing leafy vegetable plants with hydroponic system	3rd August 2024, in partner's garden
Objectives	The sowing practice activity aims to provide skills to partners related to the technique of sowing leafy vegetables with a hydroponic system.	
Activities	Training and practice of plant cultivation with hydroponic system	9th August 2024, in partner's garden
Objectives	The training activity aims to improve partner knowledge related to vegetable cultivation with hydroponic system, starting from moving plants, nutrient management and plant care. In addition, the practical activity also aims to improve partner skills related to vegetable cultivation with hydroponic system.	
Activities	Training and practice related to the variation of hydroponic harvest processing based on vegetables. This training is conducted through lectures, discussions and also practices related to the processing of hydroponic vegetables	18th August 2024, in partner's garden
Objectives	Training on packaging fresh vegetable products and hydroponic vegetable processed products	
Activities	Harvesting and packaging of fresh vegetable products and hydroponic vegetable products	7th September 2024, in partner's garden
Objectives	This activity aims to provide skills in harvesting and packaging hydroponic vegetables.	
Activity 4	**Assistance**	
Activities	Assistance in cultivation with hydroponic system and processing of results	1st August – 31st August 2024
Objectives	This activity aims to assist partners in cultivating vegetables with hydroponic system and processing them until successful.	
Activity 5	**Monitoring and Evaluation**	
Activities	Monitoring and Evaluation of mentoring and training activities for cultivation with a hydroponic system and processing of results	1st August 2024 – 30th November 2024, once a week
Objectives	Monitoring and evaluation aims to evaluate and monitor the results of mentoring and training.	

3. RESULTS AND DISCUSSION

Results

Socialization and program preparation

The socialization of this activity was carried out to the target community, both from the village government, PKK groups and women's farmer groups. Land checks were carried out for the placement of the 1.5m x 4m DFT hydroponic system installation. Vegetable planting activities that were usually carried out by partners before this community service activity were planting plants using soil media or conventionally. Socialization and land checking activities can be seen in Figure 1.

Figure 1. (a) Socialization of community service activities; (b) Land checking

Provision of hydroponic installations

The outcomes of this community service activity include the provision of four DFT hydroponic system installations for the partners. These installations use frames made of lightweight steel, with dimensions of 4 meters in length, 1.2 meters in width, and 1.5 meters in height. The installations are equipped with transparent fiber roofing to protect the plants and nutrient solution from rainwater.

The plant containers consist of 2.5-inch PVC pipes, each 4 meters long, equipped with a 60-liter nutrient reservoir. The planting distance is set at 15 cm between planting holes, allowing each pipe to accommodate 25 planting holes. Each installation uses 8 PVC pipes arranged vertically, as illustrated in Figure 2. The partners received four hydroponic installations, each capable of producing 200 plants per cycle, resulting in a total of 800 plants per planting period. The implementation of hydroponic technology provided partners with skills in nutrient management, plant maintenance, and seedling preparation to ensure uniformity and quality.

Figure 2. Installation of DFT vertical hydroponic system

Training and practice

Practice of sowing leafy vegetable plants using a hydroponic system.

The seedling practice activities were carried out by both the partners and the students assisting in the program. This activity began with selecting quality vegetable seeds, which involved soaking the seeds in warm water. Seeds that sank were identified as good and suitable for planting, while seeds that floated were deemed suboptimal. The growing medium used for seedling was rockwool, cut into 3x3 cm cube sizes. The process and results of the seedling activities are illustrated in Figure 3.

Figure 3. (a) Seeding activity; (b) Results of seeding 7-day-old seedlings

Training and practice of plant cultivation using hydroponic systems

The training activities were conducted through lectures, discussions, and hands-on practice related to hydroponic vegetable cultivation. The materials covered included an introduction to the hydroponic system, various types of hydroponic systems, selecting quality vegetable seeds, vegetable seedling techniques, preparing and applying hydroponic nutrients, transplanting, and maintenance (https://drive.google.com/file/d/1W8fD3z3hBxfvgSRqTtMzEx8M98CpunyR/view?usp=sharing). Some of the materials were accompanied by direct practice, such as nutrient preparation, vegetable seeding, and transplanting. The training and practical planting activities are illustrated in Figure 4.

Figure 4. (a) Training activities; (b) Practice of transplanting vegetable seedlings to the installation

Training and practice related to variations in hydroponic processed crops made from vegetables

This training is conducted through lectures, discussions and also practices related to the processing of hydroponic vegetables with the following training material links (https://drive.google.com/file/d/129Bwr7Mu6qO0wzwsvZ4lu0dVbfo46Frz/view?usp=sharing). The processing of vegetables made is spinach cookies. The ingredients used in making cookies are mocaf flour, spinach leaves that have been dried

and made into flour, eggs, margarine and sugar. All these ingredients are mixed and stirred evenly until smooth. The dough that has been smooth is formed using a mold, then baked for 1.5 hours at a temperature of 170oC. The activities and products of the processing can be seen in Figure 5.

Figure 5. (a) Training activities and processing practices; (b) Cookie products resulting from the activities

Harvesting and packaging activities for fresh vegetable products and hydroponic vegetable products

The hydroponic vegetable harvesting activity was carried out 25 days after transplanting to the installation. The harvesting activity was carried out together with village government partners, PKK groups and women's farmer groups and students. The atmosphere of the hydroponic vegetable harvesting activity can be seen in Figure 6. The first harvest in this community service activity produced 16 kg of water spinach, 9 kg of pakcoy, 10 kg of kale, and 9 kg of red spinach and 9 kg of green spinach for each installation. The harvesting of these vegetables was faster and produced greater results compared to planting in soil media which is usually done by partners. In addition, the vegetables produced are also cleaner and retain their freshness because they are harvested with their roots. After harvesting, the hydroponic vegetables are then tidied up, tied using green tape, then put into plastic that has been given a sticker as seen in Figure 6c. Meanwhile, for the packaging of processed vegetables (cookies) using standing pouch paperclip.

Figure 6. (a) Harvesting activities; (b) Vegetable packaging practices; (c) Packaged vegetable products

Assistance

Hydroponic plant cultivation mentoring activities are carried out directly by the community service team. Partners are assisted from sowing, planting, maintenance to harvesting hydroponic vegetables. Routine mentoring is carried out until the first harvest, and for subsequent plantings mentoring is carried out once a week. Mentoring activities in the field can be seen in Figure 7.

Figure 7. (a) Planting assistance activities; (b) Transplanting vegetable seedlings

Monitoring and evaluation

Monitoring is done by directly controlling the field on the running of the program and the success of planting. The results of monitoring on planting there are pests that attack pak choy plants, caterpillar pests that attack the growing point. The condition of plants attacked by pests can be seen in Figure 8.

Figure 8. Bok coy plants attacked by pests

For evaluation activities, it is done by filling out the pretest and posttest forms with the aim of knowing the increase in partner knowledge. The results of the pretest and posttest can be seen in Figure 9.

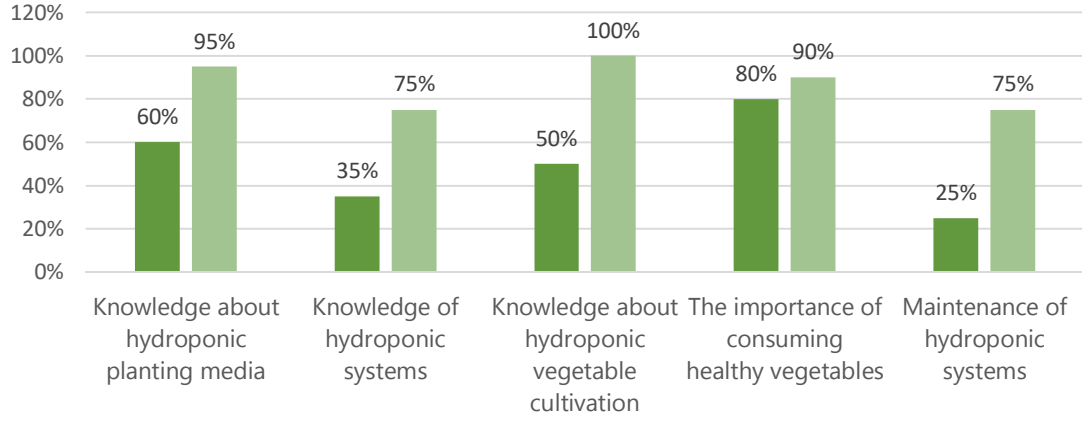

Figure 9. Pre- and post-test results

Through this community service activity, the vegetables grown by partners are given to families indicated as stunting through routine monthly PKK activities. Processed vegetables are also used as one of the menus in the Additional Food Provision (PMT) program for residents indicated as stunting. This is done by PKK cadres and KWT groups in an effort to prevent stunting.

Discussion

The community groups partnering in this activity were PKK and KWT, as they play essential roles in controlling public health and providing healthy and nutritious food for the community. According to Wahyuningsih et al. (2023), PKK has a significant role in preventing stunting in society. Stunting can result from several factors, including access to healthy and nutritious food. In this community service activity, KWT participated as a partner in stunting prevention efforts. According to Puspita (2023), KWT can contribute to stunting prevention by providing fresh and healthy food through home gardening.

The application of hydroponic technology is a practical effort for PKK and KWT in stunting prevention by supplying fresh, healthy, and nutritious vegetables. The hydroponic technology used in this activity was the Deep Flow Technique (DFT) system. According to Yustiningsih et al. (2019), the DFT hydroponic method involves growing plants without soil by placing plant roots in a nutrient solution at a depth of 4-6 cm, circulated continuously. This system is suitable for areas with limited electricity availability.

Socialization and preparation activities were carried out with the Cibalung Village government, PKK, and KWT partners. The purpose was to inform the community about the program to ensure acceptance and support. According to Amri et al. (2020), socialization is a crucial phase in community service programs. This activity received a positive reception from the Cibalung Village government, PKK, and KWT, which greatly facilitated the program's preparation and implementation.

Training and practice in hydroponic technology application with PKK and KWT partners began with seedling preparation. Rockwool was used as the growing medium due to its excellent water retention, sterility, and availability in the Bogor area. According to Payumi et al. (2022), rockwool is a suitable medium for hydroponic vegetable seedling because of these advantages. In this activity, partners successfully seeded 1,000 vegetable seedlings, including red spinach, green spinach, water spinach, and kale. The selection of these vegetable types aligns with the community's nutritional needs to prevent stunting.

According to Sa'diyah et al. (2024), optimal nutrition plays a crucial role in normal growth and physical and intellectual development in children. Sari & Astriana (2023) highlight that fresh spinach and its processed products can be beneficial for pregnant and nursing mothers in preventing stunting from an early stage, as spinach is rich in iron, vitamins, and essential minerals.

The training activities in this empowerment program educated the community on the application of hydroponic technology, which can be implemented by both PKK and KWT even on limited and infertile land. According to Amri et al. (2020), hydroponic farming can be a solution for utilizing narrow and infertile land. This technology is particularly important in areas with stunting prevalence, as it enables the community to produce healthy, fresh vegetables in a relatively short time.

According to Yulianti et al. (2021), Cahyanda et al. (2022), and Sesanti & Sismanto (2016), leafy vegetables grown using hydroponic systems can be harvested more quickly, and the results are cleaner and fresher. In this community service activity, plants were grown using vertical PVC pipe installations filled with circulating hydroponic nutrient solutions. The circulation system ensures the continuous flow of nutrients to the plants using a pump, eliminating the need for regular manual watering.

This feature was particularly appealing to the partners, especially women, as hydroponic farming requires less effort in terms of plant maintenance, such as watering. Additionally, the vegetables produced are cleaner compared to soil-based farming systems, and the cultivation process itself is cleaner. The results of hydroponic vegetable cultivation using the DFT system in this activity are shown in Figure 10.

According to Madusari et al. (2022), implementing hydroponic technology can be an effort to enhance community food security. Yulianti et al. (2024) similarly reported that adopting hydroponic technology can improve food security at the community level. Additionally, Supatmin (2018) noted that hydroponic training can contribute to improving the community's economy.

Figure 10. Vertical hydroponic DFT system

In addition to hydroponic training, this community service program also provided training on the importance of consuming fresh vegetables to prevent stunting and processing hydroponic vegetables. Vegetable processing was introduced as an alternative to provide vegetable-based food choices in other forms. During the activity, spinach was processed into cookies. Both PKK and KWT groups were trained to process hydroponic vegetables by practicing making cookies. This was done so that PKK and KWT cadres would acquire the skills to process food, which could then be shared with the broader community. According to Wahyuningsih et al. (2024), enhancing the capacity of PKK cadres through training can increase the PKK's role in preventing stunting in the community.

Guidance was necessary to ensure that the target partners could fully master the aspects of hydroponic plant cultivation, from seedling, planting, maintenance, harvesting, processing, to packaging. According to Zeki et al. (2022), mentoring is essential to ensure that partners are capable of applying hydroponic technology. Evaluation results showed an increase in knowledge. Pre and post-test results revealed that the partners' knowledge of hydroponic planting media increased by 35 percent, from 60 percent before the training to 95 percent after the training. Knowledge of hydroponic systems increased by 40 percent (pre-test 35 percent to post-test 75 percent). Knowledge of hydroponic plant maintenance and seedling preparation increased by 50 percent (pre-test 50 percent to post-test 100 percent). Knowledge of the importance of consuming healthy vegetables increased by 10 percent (pre-test 80 percent to post-test 90 percent). Knowledge of hydroponic system maintenance increased by 50 percent (pre-test 25 percent to post-test 75 percent).

The evaluation results showed that the training conducted for the target partners, both PKK and KWT, significantly improved their knowledge. This is expected to become a foundation for partners to enhance their roles in the community and encourage others to utilize narrow and infertile land for hydroponic farming as an effort to prevent stunting. The productivity of the vegetables grown by the partners also increased after the application of hydroponic technology, with an increase of 4kg for water spinach grown in the same area. The hydroponically grown spinach produced a higher yield compared to the one grown in soil, which was the method used by the partners before the community service activity.

4. CONCLUSION AND RECOMMENDATIONS

This community service program was conducted by providing training and hands-on practice in hydroponic vegetable cultivation and processing the results into vegetable-based cookies. As a result of this activity, the participants (partners) experienced improvements in their knowledge and skills related to hydroponic vegetable cultivation and its processing. Through this program, facilities for hydroponic vegetable cultivation were provided, including 4 DFT hydroponic installations with a capacity of 200 plants per installation and the necessary processing equipment for the partners. The partners' knowledge improved in various aspects, including a 35 percent increase in their understanding of hydroponic planting media, a 30 percent improvement in their knowledge of hydroponic systems, and a 50 percent enhancement in their ability to maintain hydroponic plants and prepare seedlings. Additionally, their awareness of the importance of consuming healthy vegetables also increased. Beyond knowledge, the partners' skills developed as they became proficient in cultivating plants using the hydroponic system. The variety of products they produced also expanded, including different types of leafy vegetables and processed products. Providing fresh hydroponic vegetables and processed products to the community, particularly those with stunting indicators, has become part of the efforts by PKK and KWT groups in preventing stunting in Desa Cibalung.

The limitations of this community service activity include the presence of pests that affected the vegetables in the hydroponic installations. Therefore, in the future, it is necessary to set up greenhouses to protect the plants from pest attacks. Similar community service activities should be conducted for other partners facing issues related to stunting, so that fresh and healthy vegetables can be made available in villages with communities showing stunting indicators.

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