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Empowering Communities Through Hydroponic Urban Farming: Skill Development, Business Opportunities, and Green Village Implementation

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Abstract: This community service program aims to enhance the capacity of the Sampora Village community, Tangerang, in developing sustainable urban farming through the implementation of hydroponic systems. The program addresses the need for alternative agricultural practices in urban areas to support food security and environmental sustainability. The methods employed included educational counseling on sustainable agriculture, hands-on training in basic hydroponic techniques, technical guidance on advanced hydroponic piping systems, and interactive discussions and question-and-answer sessions to strengthen participants' understanding. Community members were actively involved as participants, while practical learning tools such as hydroponic installation equipment and nutrient management systems were utilized throughout the program. Data were analyzed using a descriptive approach, combining quantitative analysis of pre-test and post-test results. The findings indicate significant improvements in participants' competencies, including increased understanding of hydroponic systems from 20% to 85%, installation skills from 15% to 80%, nutrient management knowledge from 10% to 78%, and maintenance skills from 12% to 82%. In addition, participants developed awareness of potential business opportunities, such as selling fresh produce to local markets. In conclusion, the implementation of hydroponic-based urban farming had a positive impact on community empowerment, environmental awareness, and local economic development, thereby contributing to the creation of sustainable and resilient urban communities.

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Introduction

Village development plays a crucial role in improving community welfare through integrated programs that encompass economic, social, and environmental aspects. Government initiatives, such as village fund allocations and rural development programs, have contributed to infrastructure improvement and economic empowerment in rural areas (Rustanta et al., 2025; Nurhasanah et al., 2024; Nurmahmudah et al.; 2024). However, despite these efforts, many communities still face challenges in achieving economic independence and sustainable livelihoods. These challenges are often associated with limited utilization of local resources and the lack of adoption of innovative agricultural practices (Wibawa et al., 2025; Maulida et al.; 2025)

Traditional farming methods remain highly dependent on land availability, which becomes a significant constraint in densely populated and semi-urban areas. In addition, low levels of technological literacy, limited entrepreneurial capacity, and insufficient access to market information further hinder the effectiveness of community-based economic development programs (Harisadani et al., 2019; Artika et al., 2025; Maulida et al., 2023;

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Benke et al.,2017). These conditions indicate a gap between policy implementation and the actual needs of communities at the grassroots level. Therefore, alternative approaches that integrate technology, sustainability, and community empowerment are needed to address these issues.

Urban farming has emerged as a strategic solution to improve food security, environmental sustainability, and economic resilience. Among various urban agriculture techniques, hydroponic systems have gained significant attention due to their efficiency in water usage, space optimization, and crop productivity (Setiany et al., 2024; Fatmawati et al., 2023; Benke et al., 2017). Hydroponics allows cultivation without soil by utilizing nutrient-enriched water solutions, making it highly suitable for areas with limited land availability (Al-Kodmany, 2018; Kalantari et al., 2017). This characteristic is particularly relevant to Sampora Village, Tangerang, which is undergoing rapid urban expansion, resulting in decreasing availability of agricultural land and increasing population density. Most residents rely on informal or small-scale economic activities, while access to productive land for conventional farming is very limited. In addition, prior to the program, community members had minimal exposure to modern agricultural techniques and limited knowledge of alternative farming systems. These conditions highlight the need for innovative, space-efficient, and resource-saving agricultural solutions. Hydroponic systems address these challenges by requiring significantly less land and water compared to conventional farming, while still enabling high-yield crop production in confined spaces such as home yards or community areas. Previous studies have demonstrated that hydroponic farming can increase agricultural productivity, reduce environmental degradation, and generate additional income opportunities for communities (Specht et al., 2014; Mok et al., 2014; Eigenbrod et al., 2015).

Furthermore, integrating hydroponics with community empowerment programs has been shown to enhance skill development and promote local entrepreneurship (Sanyé-Mengual et al., 2015; Thomaier et al., 2015). In the context of Sampora Village, the adoption of hydroponic technology provides a practical and scalable solution to overcome land constraints, improve household food security, and create new income-generating opportunities, while simultaneously promoting environmentally sustainable practices aligned with the green village concept.

Nevertheless, most existing studies primarily focus on the technical aspects of hydroponic systems, with limited attention to holistic community empowerment approaches that include training, mentoring, and business model development (Martellozo et al., 2014; FAO, 2023). This indicates a research gap in integrating technological innovation with social and economic empowerment within community-based urban farming initiatives. In the case of Sampora Village, the baseline conditions further highlight the urgency of such an approach. The village is characterized by increasing population density and rapid land-use conversion, resulting in very limited availability of agricultural land, with most households lacking access to productive farming space. A significant portion of the community relies on informal employment, and some residents—particularly housewives and youth—experience underemployment or lack stable income-generating activities. Prior to this program, there were no structured or sustainable agricultural initiatives implemented in the area, and community knowledge of modern farming techniques, including hydroponics, was very limited. Previous attempts at small-scale planting were largely conventional, sporadic, and unsuccessful due to land constraints and lack of technical guidance. These initial conditions demonstrate the need for an integrated community empowerment model that not only introduces appropriate agricultural technology but also strengthens community capacity

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through training, mentoring, and entrepreneurship development, thereby addressing both economic and environmental challenges simultaneously..

To address this gap, this study proposes the implementation of a hydroponic-based urban farming program in Sampora Village, supported by structured training, technical assistance, and continuous mentoring. The novelty of this program lies in the integration of three key components: (1) practical hydroponic skills development, (2) community-based entrepreneurship, and (3) the green village concept emphasizing sustainability and environmental awareness. Unlike previous studies that often focus solely on production outcomes, this study adopts a holistic approach that combines technical, economic, and ecological dimensions (Tabrez, 2025; Saikanth et al., 2023).

The contribution of this community service is the development of an applied community empowerment model that bridges the gap between knowledge transfer and real-world implementation in rural contexts. This model is expected to enhance community capacity, promote sustainable agricultural practices, and create new economic opportunities. Ultimately, this program contributes to strengthening rural economic resilience and supporting sustainable development goals through an integrated and sustainable urban farming approach.

Method

Based on a community-based participatory approach, this community service program involved 20 participants from Sampora Village, Tangerang. The participants were selected using purposive sampling criteria, focusing on community members who had limited access to productive land, low or unstable income, and a strong interest in participating in urban farming activities. The participants consisted of a mix of housewives, unemployed or underemployed youth, and general community residents, including individuals affiliated with local community groups which are from Sampora Farming members. This selection aimed to ensure that the program directly targeted groups with the greatest need for economic empowerment and capacity building. The choice of this approach relies on its efficacy to embed knowledge transfer, skills development, and active community engagement as sustainable outcomes. Participatory approaches allow the community to learn from and actively engage in the planning, implementation, and monitoring of the program, thereby fostering a sense of ownership and long-term sustainability

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Figure 1. Hydroponic Urban Farming Program Stages

With step-wise processes, this flowchart on Figure 1 depicts the systematic implementation of the hydroponic urban farming program in Sampora Village through five stages. This process is initiated with **problem identification and needs assessment** of the communities they serve, conducting field observations, interviews, and community discussions to explore the local conditions, challenges, and resource availability that are crucial. The program starts in the first stage of the process by tailoring the design of the program according to community needs. The next phase is program design and preparation where we develop training materials and hydroponic equipment to set up systems and tools necessary for implementation. After this the program progresses to **training and technical assistance**, which provides hands-on experience on hydroponic installation, techniques for cultivation, and maintenance, along with continuous mentorship. The process is then completed with sustainability and business development. Participants can have this exposed to marketing strategies, plan future business for achieving long-term success and generate profits on the whole. Taken together, the flowchart shows an effort by the whole organization to link community needs, capacity building, evaluation and sustainable development.

The operation of the program was in five well-defined phases. The first stage was the **problem identification and needs assessment**, conducted through field observations, informal interviews, and community discussions to understand community knowledge,

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resources, and challenges regarding urban farming. This phase tried to find gaps in technical knowledge, limited understanding of hydroponic systems, and lack of awareness of business opportunities.

The second step was **program design and preparation**, which involved designing training resources and modules in accordance with established needs. The program highlighted hydroponic techniques appropriate to their local conditions, such as the Nutrient Film Technique (NFT) system. Hands-on training activities were facilitated by preparation of necessary tools and materials like pipes, water pumps, nutrient solutions, planting media, etc.

The third stage was **training and technical assistance in implementation**. This stage included:

1) counseling on sustainable agriculture and urban farming significance;
2) hands-on training with respect to installation of hydroponic systems, such as seed preparation, nutrient mixing and piping system assembly; and
3) mentoring sessions for helping participants uphold plant growth and solving technical difficulties. This training was experiential in nature and included hands-on practices of each step of the hydroponic task.

The fourth step was monitoring and evaluation, intended to measure the success of the program. Evaluation included qualitative and quantitative data collection such as participant engagement observation, skill transfer assessment, and feedback collection through discussions and questionnaires. The quantitative data were analyzed using descriptive statistical techniques, including percentage calculations and comparison of pre-test and post-test results to measure improvements in participants' knowledge and skills. Meanwhile, the qualitative data obtained from observations and discussions were analyzed using a thematic analysis approach, involving data reduction, categorization, and interpretation to identify patterns related to participant engagement, learning experiences, and program effectiveness. Success criteria included participants' capability to independently establish hydroponic systems, sustain plant growth, and understand potential business applications.

The fifth stage was **sustainability and business development planning**, in which participants were exposed to basic models for hydroponic farming. This involved the marketing of fresh produce, cost estimation, and local market identification. The inclusion of the economic aspects was carried out to guarantee that the program doesn't merely enhance the quality of the technical skills, but also to provide more money and income for the community.

Result and Discussion

The current community service findings indicate that the introduction of the hydroponic urban farming program in Sampora Village has led to significant improvements in participants' knowledge, technical skills, and level of engagement. The participants' understanding of hydroponic systems increased substantially based on pre- and post-training assessments. This finding is consistent with previous studies emphasizing that structured training and hands-on learning significantly enhance participants' technical competencies and knowledge transfer in community-based agricultural programs (Harisdani et al., 2019; Nanda et al., 2023). The observed improvement also supports the concept that experiential learning approaches, particularly those combining practice and mentoring, are more effective in building sustainable skills compared to purely theoretical instruction.

Furthermore, the increase in participants' practical abilities aligns with prior research demonstrating that hydroponic training can improve agricultural productivity and community

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capacity, especially in areas with limited land resources (Specht et al., 2014; Mok et al., 2014). The high level of participant engagement throughout the program also reflects findings from Sanyé-Mengual et al. (2015) and Thomaier et al. (2015), which highlight that integrating technological innovation with community empowerment strategies can foster active participation and strengthen local entrepreneurship.

In addition, the success of this program can be attributed to the participatory and mentoring-based approach applied, where continuous guidance and peer learning enabled participants to better understand and apply hydroponic techniques. This supports earlier studies suggesting that community involvement and collaborative learning environments significantly contribute to the effectiveness and sustainability of empowerment programs (Nurmahmudah et al., 2024; Rustanta et al., 2025). Overall, these findings confirm that combining technical training with social and economic empowerment elements is essential for achieving meaningful and sustainable community development outcomes.

Before the program, only 20% of participants had some knowledge of hydroponics, which increased to 85% after the training. This substantial improvement can be attributed to several key success factors, particularly the use of **hands-on experiential learning methods**, continuous mentoring, and peer-learning interactions among participants. During the training, participants who demonstrated faster understanding were able to assist others, creating a collaborative learning environment that enhanced overall knowledge transfer. In addition, the availability of adequate tools and direct practice opportunities, such as hydroponic installation equipment and nutrient management systems, enabled participants to immediately apply theoretical knowledge into practice. This finding is consistent with previous studies indicating that participatory training approaches and experiential learning significantly improve skill acquisition and retention in community-based programs (Harisdani et al., 2019; Nanda et al., 2023). Furthermore, the role of mentoring and community engagement has been widely recognized as a critical factor in strengthening learning outcomes and sustaining behavioral change (Sanyé-Mengual et al., 2015; Nurmahmudah et al., 2024). Likewise, practical installation skill improved from 15% to 80% through hands-on training and mentoring. Table 1 shows Improvement of Participants' Knowledge and Skills.

Table 1. Improvement of Participants' Knowledge and Skills.

Indicator	Before (%)	After (%)
Understanding of hydroponics	20	85
Ability to install system	15	80
Nutrient management knowledge	10	78
Maintenance skills	12	82

Participant involvement throughout the duration of the program was also very high. Average attendance and active engagement were 88%, demonstrating high community interest and participation.

Table 2. Level of Community Participation

Activity Stage	Participation (%)
Training sessions	90
Practical installation	85
Mentoring and discussion	88
Evaluation sessions	87

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In the practical implementation phase hydroponic systems were installed with success using the Nutrient Film Technique (NFT) shown in Figure 1 (Hydroponic System Design) and Figure 3 (Hydroponic System Implemented). Lettuce, pakcoy and other leafy vegetables could be cultivated, and they grew satisfactorily, showing that it is still possible to transfer knowledge and use skills.

Figure 2. Hydroponic System Design

Figure 3. Hydroponic System Sampora Urban Farming

This study supports previous research that shows hydroponic farming enhancing community capacity and food security. Also, community empowerment programs using hydroponic systems have reported similar increases in knowledge and skills, where training dramatically enhances participants' technical skills. Programs in Indonesia for example have showed that structured hydroponic training has the potential of enhancing community engagement and agricultural productivity, which corroborates the high participation rate (88%) reported in this research.

Importantly, the efficacy of hydroponic systems in limited space is well-established in the literature. In this study, it is shown that hydroponics works for semi-urban communities and can yield quality crops effectively and efficiently resource utilizing. While the bulk of previous studies have revolved around technical performance, this research integrates a well-

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rounded framework that involves training, mentoring, and business development. This is consistent with recent studies highlighting the necessity of integrating technological innovations with socio-economic empowerment. Moreover, though studies globally have shown some environmental advantages of urban agriculture, this study contributes to our understanding by showing how an urban practice can become operationalised at a local level. The blending of green village concepts with hydroponic farming creates a more holistic model for linking sustainability to economic opportunity.

Data show that structured and participatory training increases community capacity to adopt new agricultural technologies significantly. Also, the improvements of knowledge (20% versus 85%) and in hands-on skills (15% versus 80%) indicates that experiential learning is an effective mechanism for community service activities. This is consistent with prior reports that participatory methods improve learning and sustained utilization of innovations. Economically, high-level of participation and growing interest in hydroponic-based entrepreneurship imply high potential of income generation. Consistent with research revealing that community and micro-socio-environmental contexts improve the resilience and dependency of urban environments; urban farming can thus be promoted to promote local resilience and to minimize dependency on nonlocal food supply. In fact, the added business planning aspect of this program will make these programs even more sustainable - it shows a shift in participants' perception that hydroponics is not only a means of sustenance, but a commercial interest. Ecologically, the successful application of hydroponic systems facilitates green agriculture by conserving water and minimizing land use. This finding is consistent with previous studies highlighting hydroponics as a resource-efficient agricultural method that optimizes water consumption and enables high productivity in limited spaces (Al-Kodmany, 2018; Kalantari et al., 2017). In addition, the environmentally friendly nature of hydroponic systems supports earlier research emphasizing their role in reducing environmental degradation and promoting sustainable food production systems (Specht et al., 2014; Eigenbrod et al., 2015).

The adoption of the green village concept in this program further reinforces the importance of integrating environmental awareness into community development initiatives. This aligns with findings from Sanyé-Mengual et al. (2015) and Thomaier et al. (2015), which stress that combining technological innovation with community-based approaches can enhance both ecological sustainability and socio-economic outcomes. Moreover, the results of this community service activity demonstrate that integrating technical training with community participation and economic planning is a key factor for program success. This supports previous studies indicating that holistic approaches—combining skill development, mentoring, and entrepreneurship—are more effective in achieving sustainable community empowerment compared to purely technical interventions (Mok et al., 2014; Benke et al., 2017). The structured implementation process, as illustrated in Figure 2, also contributes to the sustainability of the program by ensuring systematic knowledge transfer and continuous engagement. Overall, these findings provide empirical support that a holistic and participatory model can effectively bridge the gap between knowledge and practical implementation, leading to meaningful and sustainable community empowerment outcomes.

Conclusion

The establishment of Sampora Urban Farming through hydroponic systems has proven to be an effective strategy for community empowerment. The program successfully enhanced knowledge, technical skills, and entrepreneurial awareness among participants. By

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combining agricultural innovation with sustainability principles, this initiative supports the development of a green village while creating new economic opportunities. Participants not only gained practical expertise in hydroponic cultivation but also developed confidence in managing small-scale agribusinesses. The integration of hydroponics into the green village framework further reinforced environmentally responsible behaviors, such as water conservation and waste reduction. Moreover, the high levels of community engagement observed throughout the program indicate strong local ownership and readiness for continued collaboration. These outcomes suggest that hydroponic urban farming can serve as a replicable model for other rural and peri-urban communities facing similar economic and environmental challenges. Future programs should focus on scaling up production, strengthening market access, and integrating digital tools for monitoring and marketing to ensure long-term sustainability. By addressing these strategic areas, the initiative can evolve from a pilot project into a self-sustaining community enterprise. Ultimately, the success of Sampora Urban Farming demonstrates that participatory, innovation-driven approaches hold significant promise for advancing both rural livelihoods and ecological resilience.

Recommendation

Based on the results of this community service program, several strategic actions are recommended to ensure the sustainability and scalability of hydroponic urban farming initiatives. The village government is expected to play a crucial role by integrating hydroponic programs into village development planning and funding schemes, such as the allocation of village funds (Dana Desa).

This support may include providing communal land for hydroponic installations, facilitating infrastructure and training programs, and strengthening collaboration with local agencies and private sectors to improve market access and distribution channels. Embedding hydroponic initiatives within the broader green village development agenda will further reinforce environmental sustainability and long-term impact.

At the community level, participants and local partners are encouraged to establish community-based business groups or cooperatives to manage production, distribution, and marketing activities collectively. Such institutionalization can enhance economic resilience, improve bargaining power, and ensure continuity beyond the initial program. Continuous peer-learning, mentoring, and knowledge-sharing practices should also be maintained to sustain and expand participants' technical capabilities. In addition, diversifying crop production and developing value-added products are important strategies to increase income potential and market competitiveness.

For future academics and researchers, further studies are recommended to enhance the effectiveness and sustainability of hydroponic systems through technological innovation, such as the development of automated nutrient control systems, IoT-based monitoring, and smart farming applications. Longitudinal research is also needed to evaluate the long-term socio-economic and environmental impacts of community-based hydroponic programs. Moreover, developing scalable and replicable empowerment models that integrate technical training, entrepreneurship, and digital technologies will be essential to expand the implementation of similar initiatives in other communities.

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