

The Implementation of Hydroponics as an Alternative Agricultural System in Sukamakmur Village, Ciomas District, Bogor Regency

Nurul Nisa'a Amin^{1*}, Dewi Juliah Ratnaningsih², Pepi Rospina Pertiwi¹, Ulul Hidayah³, Ariyanti Hartari⁴, Restu Para Ratu¹, Intan Oktaviani¹

¹Department of Agribusiness, Universitas Terbuka, Cabe Raya Street, South Tangerang 15437, Indonesia

²Department of Statistics, Universitas Terbuka, Cabe Raya Street, South Tangerang 15437, Indonesia

³Department of Urban and Regional, Universitas Terbuka, Cabe Raya Street, South Tangerang 15437, Indonesia

⁴Department of Food Technology, Universitas Terbuka, Cabe Raya Street, South Tangerang 15437, Indonesia

Article Information

Abstract

Article history

Received: December 9, 2025

Revised: May 5, 2026

Accepted: May 13, 2026

Keywords: Hydroponics; Sustainable Agriculture; Training; Urban Farming

Hydroponic cultivation has emerged as a strategic approach in community empowerment initiatives, particularly in contexts characterized by limited land availability, declining soil fertility, and constrained access to conventional agricultural practices. This study aimed to evaluate the effectiveness of a hydroponic training program in enhancing participants' knowledge and readiness to adopt soilless cultivation techniques. A pretest and posttest design was employed to assess ten indicators encompassing fundamental hydroponic concepts, system typologies, nutrient management, and critical plant growth parameters. The findings revealed substantial improvements in participants' knowledge, as evidenced by markedly higher post-test scores across all indicators. Significant gains were observed in participants' understanding of suitable crop selection, optimal pH regulation, nutrient solution management, and the appropriate use of measurement instruments. Importantly, these enhanced competencies were translated into practical implementation, with participants, particularly members of the PKK group, successfully establishing hydroponic systems, conducting harvesting activities, and commercializing their produce through local bazaars. This outcome underscores the program's tangible contribution to small-scale food production and the generation of supplementary household income. Taken together, the study demonstrates that structured and practice-oriented hydroponic training effectively strengthens technical capacity while fostering community empowerment and sustainable livelihood development.

*Corresponding Author

© 2026 Some rights reserved

Nurul Nisa'a Amin

E-mail: nurul.nisa@ecampus.ut.ac.id

INTRODUCTION

Agriculture is a vital sector for both the economy and food security in Indonesia. However, farmers in Sukamakmur Village, located in the Ciomas District of Bogor Regency, face various challenges that hinder agricultural productivity. Sukamakmur Village is located in the valley of Mount Salak, where most of the land has been fragmented and developed for housing, resulting in limited land for agriculture. It is difficult to develop rice field and garden farming businesses; therefore, one way to develop agriculture is through the use of yards or small plots of land that have the potential to be planted with crops for family needs. These challenges include limited agricultural land, climate change, and market price volatility. Consequently, conventional farming methods have

limitations, highlighting the need for innovation in sustainable agricultural systems.

One promising alternative to soil cultivation is hydroponics, a method of cultivating plants without soil using nutrient-rich water as a growing medium. Compared to conventional soil-based cultivation and simple container planting systems, which generally require lower technical expertise, hydroponic systems offer superior control over nutrient delivery, water use efficiency, and plant growth conditions. Although hydroponic cultivation requires greater technical knowledge and initial adaptation, it presents a more appropriate solution in contexts where land availability is limited and agricultural productivity needs to be optimized. Previous research has demonstrated that

hydroponics can significantly enhance the efficiency of land and water utilization (Resh, 2022; Gumisiriza, 2022; Rajaseger et al., 2023; Maisarah et al., 2023; Caniago, 2023; Mihrete, 2025), while also reducing the risk of crop losses due to pests and diseases (Gumisiriza, 2022; Pilanto, 2023; Caniago, 2023; Armas et al., 2023). In the context of PKK community groups located in densely populated rural areas with constrained land resources, the selection of hydroponic systems is justified by their capacity to optimize limited space, support household-level food production, and create potential income-generating activities when accompanied by appropriate technical training. Despite these advantages, the adoption of hydroponic systems among local farmers remains limited, highlighting the need for targeted training and capacity-building interventions. The central issue is the lack of understanding within the community regarding hydroponic technology and its potential benefits for enhancing agricultural productivity. The literature indicates that knowledge and access to technological information are crucial for the adoption of agricultural innovations (Gumisiriza, 2022; Caniago, 2023; Mihrete, 2025). Therefore, this study proposes the implementation of training and outreach programs aimed at improving community understanding of hydroponics while providing access to the necessary tools and materials.

The goal of these activities is to enhance agricultural literacy among the residents of Sukamakmur Village and promote the adoption of hydroponic systems as an alternative solution to improve food security and the economic welfare of the community. Through this initiative, it is expected that the community will gain a better understanding of hydroponic system construction and be able to conduct trials with appropriate crops. Additionally, the initiative aims to foster collaboration between farmers and agricultural experts to support the sustainable implementation of hydroponic systems.

MATERIALS AND METHODS

Materials

A hydroponic system was developed for the Family Welfare Empowerment Group (PKK) in Sukamakmur Village using locally available and cost-effective materials to support small-scale cultivation. Compared to conventional soil-based cultivation systems, which generally require lower technical expertise, hydroponic systems were selected because of their superior efficiency in terms of land and water use, particularly in densely populated rural areas with limited space.

The main materials used in the hydroponic installation were as follows:

1. Fiber Glass Sheets: Used as a supporting material in the hydroponic system due to their durability,

lightweight characteristics, and resistance to environmental conditions.

2. Light Steel: Utilized for the structural framework of the system, providing strength, stability, and resistance to corrosion.
3. PVC or PE pipes: Function as channels for nutrient solution distribution, enabling efficient water flow and delivery of nutrients to plant roots.
4. Reservoir: A storage container used to hold the nutrient solution before circulation through the system.
5. Water pump: Used to circulate the nutrient solution from the reservoir to the plant channels, thereby ensuring a continuous nutrient supply.
6. Aeration system: This system comprises an air pump and aeration stone and enhances oxygen availability in the nutrient solution, which is essential for root development.
7. Hydroponic nutrient solution: A formulated mixture of macro-and micronutrients required to support optimal plant growth and development.
8. Total Dissolved Solids Measurement Device: Used to monitor the nutrient concentration in the solution to maintain appropriate growing conditions.

The following materials were used for seedling propagation and sprouting:

1. Rockwool: Rockwool is made from rock fibers and has excellent aeration and water retention properties. It is commonly used as a growing medium for seedlings, providing strong support for seeds and young roots.
2. Growing trays or seedling trays: These plastic trays contain small cells that are typically filled with germination media, such as rockwool, allowing for the simultaneous germination of a large number of seeds.
3. Tackpot: A small container specifically designed to hold seeds during germination and early growth. Tackpots can also be used to place germination media.
4. Seed Trays: These trays have multiple small cells for seed germination and are typically made from durable plastic. Each cell serves as a growth medium for one seed, enabling the planting of multiple seeds at once.
5. Plastic containers with lids: Transparent plastic containers made from durable materials with lids protect the seeds. These containers provide a sterile environment for seed germination and can also be used to store planting media and seeds together.

Methods

The methods utilized in community service activities in Sukamakmur Village, Ciomas District, Bogor Regency, specifically for the PKK group. The number of participants involved from the PKK group

Table 1. Solution of dedication

Problem	Solution	Outputs	Measurable Indicators
Limited farmland in Sukamakmur Village, which is a densely populated area	Providing information and training on hydroponic systems that do not require large areas of land	The community can utilize limited spaces such as terraces, balconies, and rooftops for gardening	Number of participants applying hydroponic systems at home; number of hydroponic units installed
Lack of community knowledge about hydroponic techniques	Training on theory and practice of hydroponic installation, plant care, and monitoring	The community understands hydroponic systems and can apply them independently	Increase in pre test and post test scores; percentage of participants demonstrating correct practices
Lack of food self sufficiency among families	Encouraging households to cultivate hydroponic vegetables	Increased availability of fresh vegetables and improved food security	Frequency of harvest; quantity of vegetables produced; evidence of household consumption or sales

ranged from 15 to 20 individuals. To ensure that the addressed the specific needs of the target group, an initial problem identification and solution mapping process was conducted. Based on the identified problems and corresponding solutions presented in Table 1, the community empowerment program was systematically designed to address the specific needs of the target group. This framework served as the foundation for structuring a series of integrated activities aimed at enhancing participants' knowledge, technical skills, and practical implementation capacity.

RESULTS AND DISCUSSION

Community service activities were implemented in Sukamakmur Village, considering the characteristics of a densely populated rural area with limited agricultural land. The program targeted members of the PKK group, who were expected to act as agents of change by disseminating knowledge and promoting community participation in sustainable food production.

Rapid urbanization in Sukamakmur Village has led to significant land conversion from agricultural use to residential areas, resulting in reduced food production capacity and increased dependence on external food sources. In response, the program introduced hydroponic cultivation as an alternative approach to support household-level food production and community resilience.

Urban farming has been widely recognized as a strategic response to land constraints and increasing food demand in densely populated regions. Previous studies have demonstrated that hydroponic systems provide an efficient use of water and nutrients while enabling cultivation in limited spaces (Wibawa et al., 2025; Abraham et al., 2024; Okuputra et al., 2023). These characteristics make hydroponics particularly

relevant to communities such as Sukamakmur Village.



Fig. 1. Training on vegetable cultivation using hydroponic systems

Training and educational interventions play an essential role in enabling communities to adopt hydroponic technology (Fig. 1). Harisdani et al. (2023) reported that community-based hydroponic training increased participants' knowledge and technical capacity, enabling them to independently set up and manage hydroponic systems. Similar outcomes were observed by Rahmah et al. (2022), who highlighted the effectiveness of hands-on hydroponic learning for capacity building, particularly among educators and local community groups. Empowerment outcomes are not limited to knowledge acquisition. Puspitasari et al. (2022) showed that hydroponic programs involving marginalized communities helped foster self-confidence and provided opportunities for behavioral change toward healthier and more sustainable food production.

To assess whether the program achieved its intended outputs, changes were evaluated using measurable parameters related to land utilization, knowledge improvement, and household food production (Table 2).

Table 2. Changes resulting from service activities

Initial Condition	Intervention	Condition Change	Measurable Parameters
Limited availability of agricultural land in densely populated rural areas, resulting in minimal household food production	Implementation of hydroponic training, assistance, and technical guidance programs for PKK community members	Participants are able to utilize limited household spaces such as terraces and small yards for hydroponic cultivation	PKK women as participants implementing hydroponic systems (15 women)
Low level of community knowledge and technical skills in hydroponic systems	Delivery of structured training programs combined with hands on practice and continuous mentoring	Increased knowledge and technical competence by improved pre test and post test results and participants' ability to independently manage hydroponic systems	Pre test and post test improvement
Limited household food self sufficiency and dependence on external vegetable sources	Encouragement of household level hydroponic production and ongoing technical support	Increased availability of fresh vegetables for household consumption and additional income opportunities through small-scale sales	Harvest activity and participation in local bazaars

Following the intervention, participants demonstrated a clear transition from limited awareness to the active implementation of hydroponic systems. Several households successfully established small-scale hydroponic units and were able to manage plant growth independently (Fig. 2). This shift indicates that the program not only improved knowledge but also strengthened practical skills and self reliance. The ability to convert underutilized household spaces into productive cultivation areas highlights the adaptability of hydroponic systems in densely populated rural settings. This finding supports previous research indicating that hydroponic and urban farming systems are effective solutions in environments where conventional agriculture is constrained (Aydin, 2023).



Fig. 2. Hydroponic installations in Sukamakmur Village

Knowledge Improvement

The level of knowledge of training participants on hydroponics was measured through pre-tests and

post-tests conducted before and after the training. Fifteen participants, comprising PKK women, answered questions on the pre-test and post-test according to their level of understanding of hydroponics. The pre-test and post-test assessments measured participants' knowledge across ten key aspects of hydroponic cultivation, including conceptual understanding, system types, nutrient management, and plant growth requirements. The post-test results demonstrated a consistent and substantial increase in correct answers across all indicators (Fig. 3).

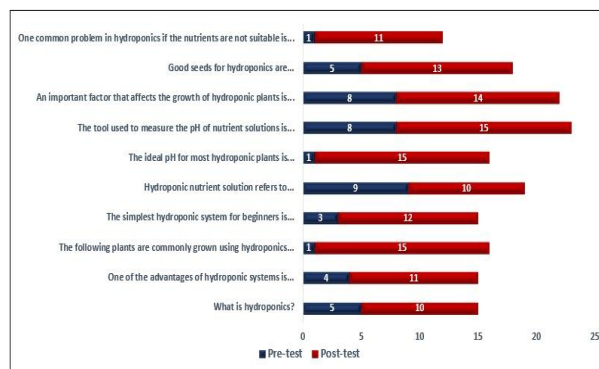


Fig. 3. Training participants' level of knowledge on hydroponics

The significant increase in post-test scores demonstrates that the training program effectively improved participants' comprehension and technical skills related to hydroponics. Prior to the training, participants showed limited familiarity with core concepts such as the definition of hydroponics,

its benefits, and the types of plants suitable for hydroponic systems. This knowledge gap is typical among beginner-level trainees and aligns with the findings of Nyamwamu et al. (2014), who reported that agricultural training programs often reveal low initial literacy in modern cultivation technologies.

After the training, the participants exhibited a strong understanding of foundational hydroponic knowledge. The improvement in the item definition of hydroponic (from five to ten correct answers) suggests that the participants gained a clearer conceptual framework, an essential first step for adopting soil-less cultivation technologies. This is consistent with the work of AlShrouf (2017), who emphasized the importance of conceptual clarity in promoting the adoption of hydroponic farming.

Technical knowledge regarding nutrient management, pH requirements, and proper measurement tools also improved significantly. For instance, knowledge of the ideal pH range increased from 1 to 15 correct answers, demonstrating mastery of a critical aspect of hydroponic crop success. Nutrient and pH management are core determinants of plant health in hydroponic systems, and the importance of this knowledge is widely documented in the literature (Trefitz & Omaye, 2016; Resh, 2022). The training appears to have effectively filled major knowledge gaps in these areas.

Similarly, participants' ability to identify important growth factors, good seed selection, and common hydroponic problems improved markedly in the post-test. This suggests that the training not only conveyed theoretical content but also strengthened participants' problem-solving skills related to real-world hydroponic challenges. Such gains align with the findings of Rohaeti & Nurhayati (2023), who reported that targeted hydroponic training enhances farmers' readiness to troubleshoot nutrient deficiencies and environmental imbalances.



Fig. 4. Harvesting of hydroponic vegetables managed independently by PKK Sukamakmur

The consistently increased performance across all indicators reflects the overall effectiveness of the training program. The results demonstrate that structured, hands-on learning is highly beneficial for

accelerating knowledge acquisition in hydroponic technology, supporting previous studies that highlight the role of practical exposure in boosting farmer competence and technology adoption. Although the improvement in test scores confirms the effectiveness of the training, a more significant outcome is the participants' ability to apply the acquired knowledge in real practice, as reflected in the successful implementation of hydroponic systems at the household level (Fig. 4).

Economic Impact Analysis

The economic impact of the program was observed through household consumption and small-scale marketing activities. Although harvest quantities varied and were not produced in fixed cycles, participants were able to harvest vegetables for daily consumption, thereby reducing household expenditure on vegetables.

In addition, PKK women sold their produce in local bazaars at prices ranging from IDR 5,000 to IDR 10,000 per pack. Although the scale of production remained relatively small, this activity demonstrates the potential of hydroponic cultivation to generate supplementary income (Fig. 5). These findings indicate that even small scale hydroponic practices can contribute to household economic resilience by reducing dependency on purchased vegetables and providing additional income opportunities.



Fig. 5. Sale of hydroponic vegetables by PKK Sukamakmur at a local bazaar

Challenges and Implementation Constraints

Despite these positive outcomes, several challenges were encountered during the implementation process. The primary difficulty was related to participants' initial technical skills, particularly in managing nutrient solutions, maintaining water circulation, and monitoring plant growth conditions.

Some participants experienced difficulties in consistently applying maintenance practices, such as checking nutrient concentration and ensuring proper aeration. In addition, limited familiarity with measurement tools posed challenges during the early stages of adoption. However, these challenges

were gradually addressed through continuous assistance and technical guidance, which played a crucial role in improving participants' confidence and skills. This highlights the importance of sustained mentoring in ensuring long-term program success.

The findings demonstrate that community-based hydroponic training programs can effectively enhance technical capacity and support sustainable food production in land-constrained environments. The integration of training, assistance, and technical guidance contributed to the successful adoption of hydroponic practices among participants. Beyond knowledge improvement, the program facilitated behavioral change, enabling participants to actively engage in food production and small-scale economic activities. This indicates that hydroponic-based community empowerment initiatives have strong potential to support both food security and livelihood development in similar contexts.

CONCLUSION

The hydroponic training implemented as part of the community empowerment initiative successfully enhanced participants' knowledge and skills in soilless cultivation. Prior to the training, participants demonstrated limited understanding of basic hydroponic concepts, nutrient management, pH monitoring, and crop selection. Following the training, the post-test results showed substantial improvements across all knowledge indicators, confirming the effectiveness of the program in strengthening both the foundational and practical competencies of PKK members.

Measurable outcomes were reflected in the successful implementation of household-level hydroponic systems, where participants were able to utilize limited spaces and conduct independent cultivation and harvesting. The program also demonstrated economic potential through reduced household vegetable expenditures and small-scale income generation from sales at local bazaars, with prices ranging from IDR 5,000 to IDR 10,000 per pack. However, limitations were observed in the form of small and inconsistent production and varying levels of technical skills among participants. To ensure sustainability, continued mentoring, periodic training, and strengthened collaboration among PKK members are recommended to support long-term implementation.

ACKNOWLEDGEMENTS

The authors extend their sincere appreciation to the Faculty of Sciences and Technology, Universitas Terbuka, for the continuous support, guidance, and facilities provided during community empowerment activities in Sukamakmur Village, Ciomas District,

Bogor Regency. This community empowerment was financially supported through university funding provided by the Lembaga Penelitian dan Pengabdian kepada Masyarakat (LPPM) Universitas Terbuka, which greatly facilitated the smooth implementation of all program components. The success of this initiative was further strengthened by the assistance of institutional leaders, program coordinators, and administrative staff, whose dedication and professionalism ensured effective planning and execution.

The authors also express their heartfelt gratitude to the community partners, local leaders, and residents of Sukamakmur Village, especially the PKK women, for their enthusiastic participation, cooperation, and commitment throughout the activities. Their willingness to engage and collaborate played a vital role in achieving the program's objectives. This initiative highlights the strong partnership between the academic institution and the local community in advancing sustainable agricultural practices and enhancing community capacity. The authors gratefully acknowledge that the accomplishments of this program were made possible through the collective contributions and shared efforts of all those involved.

REFERENCES

- Abraham, H. E. M., Dumais, J. N. K., & Pakasi, C. B. D. (2024). Profit analysis of hydroponic lettuce farming in urban farming in Batu Kota, Malalayang Sub-district, Manado City. *Jurnal Agribisnis dan Pengembangan Pedesaan*, 3(3), 365-370. <https://ejournal.unsrat.ac.id/v2/index.php/agrirud/article/view/37097>
- AlShrouf, A. (2017). Hydroponics, aeroponics and aquaponics as compared with conventional farming. *International Journal of Horticultural Science*, 27(1), 247-255. https://asrjetsjournal.org/American_Scientific_Journal/article/view/2543
- Armas, K. L., Lorenzo, E. G., & Cruz, C. D. (2023). Financial Viability of Business Models For Engineered Vertical Hydroponics Systems For Sustainable Onion Production in The Philippines. *Journal of Applied Engineering and Technological Science (JAETS)*, 4(2), 864-872. <https://doi.org/10.37385/jaets.v4i2.2040>
- Aydin, R. (2023). Hydroponics and urban agriculture: Redefining food production in cities. *African Journal of Food Science and Technology*, 14(12), 1-2. <https://doi.org/10.14303/ajfst.2023.057>
- Caniago, D. P. (2023). Smart indoor hydroponic garden using Internet of Things. *Simetris Jurnal Teknik Mesin Elektro dan Ilmu Komputer*, 14(2), 311-318. <https://doi.org/10.24176/simet.v14i2.9756>
- Gumisiriza, M. S., Ndakidemi, P. A., & Mbega, E. R. (2022). A simplified non-greenhouse hydroponic system for small-scale soilless urban vegetable farming. *MethodsX*, 9, 1-7. <https://doi.org/10.1016/j.mex.2022.101882>

- Harisdani, D. D., Hadinugroho, D. L., & Sitorus, R. (2023). Hydroponic training as an alternative urban farming. *Abdimas Talenta: Jurnal Pengabdian Kepada Masyarakat*, 3(2), 134-140. <https://doi.org/10.32734/abdimastalenta.v3i2.4035>
- Maisarah, N. P., Fariyanti, A., & Rosiana, N. . (2023). Sustainability of Vegetable Hydroponic System in Pekanbaru City. *Jurnal Manajemen Dan Agribisnis*, 20(2), 214. <https://doi.org/10.17358/jma.20.2.214>
- Mihrete, T. B. (2025). Crop Substrates for Sustainable Hydroponic Farming. In Ali, B., Iqbal, J., Ahmed, T. *Hydroponic Farming - A Modern Agriculture Technique*. Intech Open. <https://doi.org/10.5772/intechopen.1007945>
- Nyamwamu, R. O., Ombati, J. M., & Mwangi, J. G. (2014). Effectiveness Of Agricultural Training Centers' Curriculum In Promoting Adoption Of Agricultural Technologies: Evidence From Small-Scale Potato Farmers In Nyandarua County, Kenya. *International Journal Of Agricultural Management And Development (IJAMAD)*, 4(2), 133-145. <https://sid.ir/paper/624903/en>
- Okuputra, M. A., Faramitha, T. R., Hidayah, I., Siregar, V. N., & Prastio, G. D. (2023). Analysis of business opportunities for urban farming: hydroponic development in Desa Karangwidoro, Malang Regency. *Jurnal Manajemen*, 13(1), 15-31. <https://doi.org/10.32832/jm-uika.v13i1.5123>
- Pilanto, A. A., Ma'arif, A., & Setiawan, M. H. (2023). IoT-Based Real-Time Monitoring of Hydroponic Systems for Caisim (*Brassica juncea*) with Spreadsheet Integration. *Journal of Science in Agrotechnology*, 1(2), 89-98. <https://doi.org/10.21107/jsa.v1i2.19>
- Puspitasari, R. L., Pambudi, A., & Effendi, Y. (2022). Simple hydroponics for street-children community empowerment. *Jurnal Pemberdayaan Masyarakat Universitas Al Azhar Indonesia*, 4(3), 84-89. <https://doi.org/10.36722/jpm.v4i3.965>
- Rahmah, M. H., Wahid, M., & Nurhidayah, N. (2022). Introduction to urban farming through simple hydroponic practice as an effort to utilize limited open land for teachers in Polewali Mandar Regency. *Sipakaraya: Jurnal Pengabdian Masyarakat*, 1(2), 78-85. <https://doi.org/10.31605/sipakaraya.v1i2.2438>
- Rajaseger, G., Chan, K. L., Yee Tan, K., Ramasamy, S., Khin, M. C., Amaladoss, A., & Kadamb Haribhai, P. (2023). Hydroponics: current trends in sustainable crop production. *Bioinformation*, 19(9), 925-938. <https://doi.org/10.6026/97320630019925>
- Resh, H. M. (2022). *Hydroponic Food Production*. CRC Press. <https://doi.org/10.1201/9781003133254>
- Rohaeti, R. & Nurhayati, S. (2023). Education on Hydroponic Technology to Increase the Productivity of Modern Farmers. *Journal of Education Research*, 4(3), 1317-1324. <http://doi.org/10.37985/jer.v4i3.409>
- Treftz, C., & Omaye, S. T. (2016). Hydroponics: potential for augmenting sustainable food production in non-arable regions. *Nutrition & Food Science*, 45(5), 672-684. <https://doi.org/10.1108/NFS-10-2015-0118>
- Wibawa, D. P., Wulandari, A., & Saputra, H. M. (2025). Urban farming: hydroponic alternative solution to utilize narrow land to increase food security in island regions. *Wikrama Parahita : Jurnal Pengabdian Masyarakat*, 9(1), 116-122. <https://doi.org/10.30656/jpmwp.v9i1.9393>