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Strengthening Urban Food Resilience through a Community-Based Hydroponic Demonstration Model in a Flood-Prone Area

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Abstract

This community service program aimed to strengthen food resilience and community capacity in the flood-prone urban area of Kedaung Kali Angke, West Jakarta, through a community-based hydroponic demonstration model. The program employed participatory training, practical demonstrations, mentoring, and international knowledge sharing involving Universitas Mercu Buana and Universiti Sains Malaysia. Activities included stakeholder coordination, installation of a Nutrient Film Technique hydroponic unit, cultivation training, monitoring, harvesting, and program evaluation. The program successfully established a permanent hydroponic demonstration unit as a community learning and food-production facility. Evaluation involving 51 respondents showed consistently high importance and satisfaction scores, generally exceeding 3.2 on a four-point scale. Participants positively evaluated the relevance, implementation, facilitator competence, participation, and benefits of the program. Continuous community management, maintenance, and periodic mentoring are recommended to sustain the hydroponic facility and support replication in other flood-prone urban communities.

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INTRODUCTION

Urban food security has become an increasingly important challenge as rapid urbanisation, limited agricultural land, environmental pressures, and dependence on external food supply chains affect the capacity of urban communities to produce and access food locally. Urban and peri-urban agriculture has consequently gained increasing attention as an approach to strengthening resilient and sustainable urban food systems. The Food and Agriculture Organization of the United Nations (FAO) recognises urban and peri-urban agriculture as an important strategy for strengthening the resilience of urban food supplies while contributing to food and nutrition security, local economic development, and environmental sustainability (FAO, 2022). In densely populated communities, these functions are particularly relevant because conventional agricultural production is constrained by competition for land and other urban resources.

Environmental vulnerability can further intensify urban food-security challenges. Flood-prone communities may experience disruption to livelihoods, local economic activities, mobility, and access to food resources. In Kedaung Kali Angke, West Jakarta, previous community-based intervention has identified high population density, limited land availability, recurrent flooding, and dependence on external food supplies as interconnected challenges affecting community resilience (Hidayah et al., 2026). These conditions highlight the importance of food-production approaches that are spatially adaptive, relatively resource-efficient, and capable of being managed within densely populated urban environments.

Urban agriculture provides one potential response by integrating food production into available spaces within cities. Beyond producing food, urban farming can function as a mechanism for strengthening agricultural literacy, community participation, and local capacity. A community-based urban farming programme in South Jakarta, for example, demonstrated that participatory approaches combined with appropriate cultivation infrastructure can improve planting literacy and food-production efficiency (Stefani et al., 2025). More broadly, urban agriculture can contribute to household food access and sustainable food systems when technological interventions are accompanied by community participation and locally appropriate management mechanisms (Yani et al., 2025).

Among available urban agriculture technologies, hydroponic cultivation is particularly relevant to communities with limited access to conventional agricultural land. Hydroponics enables plants to be cultivated without soil by supplying water and nutrients directly to plant roots. This characteristic allows cultivation systems to be adapted to relatively compact spaces and provides opportunities for more controlled management of water and nutrients. Comparative evidence has shown that hydroponic production can substantially reduce land and water requirements relative to conventional cultivation, although energy requirements and technological management must also be considered (Barbosa et al., 2015). Hydroponics should therefore be understood not as a universal replacement for conventional agriculture, but as an adaptive cultivation option with particular relevance to land-constrained urban environments.

The Nutrient Film Technique (NFT) is one hydroponic approach suitable for leafy vegetable cultivation. In NFT systems, a relatively shallow stream of nutrient solution continuously circulates through cultivation channels, allowing plant roots to obtain nutrients and water while maintaining access to oxygen. Recent reviews of hydroponic technology identify NFT as an important method for urban agriculture because of its capacity for efficient nutrient delivery and application in spatially constrained cultivation environments (Cahyanti et al., 2025). Nevertheless, successful operation requires adequate technical understanding, particularly regarding nutrient management, water circulation, system cleanliness, and routine maintenance.

The effectiveness of community hydroponics therefore depends on more than the physical availability of cultivation infrastructure. Providing a hydroponic installation without developing users' knowledge and operational skills may create dependence on external technical assistance. Community empowerment programmes need to combine technology provision with education, practical demonstration, mentoring, and opportunities for direct participation. Nurmahmudah et al. (2024), for example, reported substantial improvements in participants' understanding following hydroponic farming education that combined cultivation knowledge with practical community empowerment activities. Their findings indicate that structured learning can strengthen the capacity of community members to utilise limited land productively.

Similarly, Silitonga et al. (2026) demonstrated that a hydroponic urban farming programme incorporating educational counselling, hands-on training, technical guidance, and interactive discussion could strengthen community capacity for sustainable urban agriculture. Such evidence reinforces the importance of experiential learning in community-based technological interventions. Participants need opportunities not only to receive information but also to observe system operation, practise cultivation techniques, identify problems, and participate directly in production activities (Silitonga et al., 2026).

Community participation is particularly important for sustaining urban farming initiatives after university-led or externally supported programmes have formally ended.

Participatory communication and involvement can strengthen community engagement and empowerment within urban farming programmes (Oktarina et al., 2022). Similarly, community empowerment approaches that actively involve residents in problem identification, implementation, and evaluation can contribute to stronger local ownership of urban farming interventions (Sumiati & Falasifah, 2026). Thus, sustainability requires an implementation model in which community members progressively develop both technical competence and responsibility for managing the facility.

This principle is also consistent with the broader orientation of community service programmes published in Jurnal Pemberdayaan Nusantara, which emphasise community participation, capacity building, and collaborative action as important mechanisms for achieving sustainable local outcomes. Natadiharja et al. (2025), for example, adopted a participatory approach integrating training, capacity building, local government involvement, and community collaboration to promote environmentally sustainable community practices. Although their intervention focused on community-based waste management rather than hydroponics, the underlying empowerment principle is relevant: sustainable technological or environmental interventions require local actors to become active agents in implementation rather than passive recipients of assistance.

This perspective is especially relevant to the present programme because Kedaung Kali Angke has previously been the location of a community empowerment initiative combining hydroponic urban farming, financial literacy, and green micro-enterprise development. Hidayah et al. (2026) found that hydroponic cultivation could be incorporated into an integrated empowerment strategy addressing limited land availability and food-security challenges in this flood-prone urban community. The previous programme provides an important local foundation, but it also creates an opportunity to advance the intervention from introductory hydroponic empowerment toward a permanent demonstration model capable of supporting repeated learning, cultivation, monitoring, harvesting, and community management.

Accordingly, preliminary coordination for the present programme indicated that community interest in productive urban agriculture needed to be complemented by access to a structured practical learning facility. The central challenge was therefore not merely the absence of agricultural infrastructure. Community members required a platform through which they could directly observe plant development, practise hydroponic cultivation, understand nutrient and circulation management, participate in routine maintenance, and experience the complete production cycle from seedling preparation to harvesting. A one-time theoretical seminar would provide limited opportunity to develop these competencies.

To address this need, the programme established a community-based NFT hydroponic demonstration model. The installation was designed not merely as physical equipment transferred to the community but as a permanent learning and food-production facility. Through the demonstration unit, participants could engage in seedling preparation, transplanting, nutrient management, system operation, plant monitoring, routine maintenance, harvesting, and preparation for subsequent production cycles. This approach reflects evidence that community hydroponic programmes are more meaningful when practical technology is integrated with education and community empowerment (Nurmahmudah et al., 2024; Silitonga et al., 2026).

The programme further incorporated international knowledge sharing through collaboration between Universitas Mercu Buana, Indonesia, and Universiti Sains Malaysia, Malaysia. The international component was designed to enrich the local intervention with broader perspectives on sustainability, urban agriculture, and community resilience while maintaining the practical needs of the target community as the central orientation. International academic engagement was therefore integrated with stakeholder coordination, technical training, mentoring, cultivation activities, and programme evaluation rather than implemented as an isolated academic event.

The intervention consequently combined two dimensions that are sometimes treated separately in community service activities: technological adaptation and community capacity development. The NFT installation provided a tangible mechanism for food production in a spatially constrained environment, while training, mentoring, participation, and repeated cultivation activities were intended to develop the competencies necessary for continued local operation. This integration is important because the sustainability of urban farming programmes depends not only on technical feasibility but also on community participation, knowledge transfer, management capacity, and continuity of implementation (Rustanta & Sanjaya, 2025; Silitonga et al., 2026).

Programme evaluation was incorporated into the intervention to assess whether participants perceived the activities as relevant and satisfactorily implemented. The evaluation covered aspects such as programme relevance, implementation methods, facilitator competence, community participation, perceived benefits, and overall satisfaction. Quantitative participant feedback was used to complement physical implementation evidence and provide a structured assessment of how the programme was experienced by its beneficiaries.

The novel contribution of the present programme lies in developing hydroponics not merely as a short-term training topic or stand-alone cultivation infrastructure, but as a permanent community demonstration model integrating NFT technology, experiential learning, participatory management, production cycles, programme evaluation, and international knowledge sharing. In contrast to interventions focused primarily on introductory hydroponic education, the model was intended to provide an ongoing platform through which community members could repeatedly learn, cultivate, harvest, and maintain the production system.

Accordingly, this community service programme aimed to strengthen urban food resilience and community capacity through the establishment and implementation of a community-based NFT hydroponic demonstration model in Kedaung Kali Angke, West Jakarta. Specifically, the programme sought to establish an adaptive food-production and learning facility, strengthen community knowledge and practical skills in hydroponic cultivation, promote participation in facility management, enrich community learning through international academic collaboration, and quantitatively evaluate participant perceptions of programme implementation. The programme ultimately sought to develop a practical and potentially replicable model of community-based urban agriculture for densely populated and environmentally vulnerable urban communities.

METHOD

This community service programme employed a participatory community empowerment approach integrating practical training, technology demonstration, mentoring, international knowledge sharing, programme evaluation, and sustainability planning. The participatory approach was selected to encourage community members to become actively involved in the implementation and utilisation of the intervention rather than functioning solely as recipients of technological assistance. Similar participatory approaches have been applied in community-based urban farming and hydroponic programmes through stages of socialisation, training, technology implementation, mentoring, and sustainability planning

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(Solecha et al., 2025). Such an approach is particularly relevant to community empowerment because it combines technological intervention with local participation and capacity development.

The programme was conducted in Kedaung Kali Angke, West Jakarta, Indonesia, a densely populated urban community with limited conventional agricultural space and recurrent exposure to flooding. The intervention focused on two interconnected needs identified through preliminary coordination with the partner community: access to an adaptive food-production technology suitable for limited urban space and improvement of community capacity to operate and maintain the technology independently.

The central technological intervention was the establishment of a Nutrient Film Technique (NFT) hydroponic demonstration unit. The facility was designed to perform two functions simultaneously: as a small-scale community food-production facility and as a practical learning platform. Rather than providing the hydroponic installation as a stand-alone physical asset, the programme combined technology implementation with experiential learning so that participants could understand and practise the cultivation process from system preparation to harvesting and subsequent production cycles.

The programme was implemented through six interconnected stages: (1) preliminary assessment and stakeholder coordination, (2) preparation and installation of the hydroponic demonstration unit, (3) community training and practical demonstration, (4) international knowledge sharing, (5) mentoring, monitoring, and harvesting, and (6) programme evaluation and sustainability planning. The implementation stages are illustrated in Figure 1.

Figure 1. Stages of the Community-Based Hydroponic Demonstration Programme

Preliminary Assessment and Stakeholder Coordination

he first stage consisted of preliminary assessment and coordination with local stakeholders. This process was conducted to align programme implementation with the needs, environmental characteristics, available space, and implementation capacity of the target community. Initial discussions addressed the limitations of conventional agricultural space, vulnerability to flooding, community interest in productive urban agriculture, potential locations for the hydroponic installation, participant involvement, and arrangements for continued management after the formal programme period.

Coordination was undertaken among the implementation team from Universitas Mercu Buana, local stakeholders and community representatives, and the international academic partner. This stage established a common understanding of programme objectives, clarified stakeholder roles, identified implementation requirements, and determined how the hydroponic demonstration facility could be incorporated into existing community activities.

Community involvement during the initial and implementation stages reflects the principle of participatory community empowerment, in which beneficiaries are involved in identifying needs, implementing activities, and supporting programme continuity. Similar approaches have been employed in community hydroponic programmes to strengthen local capacity and self-reliance rather than limiting interventions to one-directional technology transfer (Solecha et al., 2025; Sumiati & Falasifah, 2026).

Preparation and Installation of the Hydroponic Demonstration Unit

The second stage involved the preparation and installation of the NFT hydroponic demonstration system. NFT was selected because hydroponic cultivation can be adapted to areas with limited conventional agricultural land, while NFT systems provide continuous circulation of nutrient solution through cultivation channels. The method is widely applied to leafy vegetable production and is particularly relevant to urban agriculture where efficient utilisation of available cultivation space is required (Cahyanti et al., 2025).

The installation consisted of the cultivation structure, hydroponic channels, planting holes, nutrient reservoir, water circulation system, pump, planting containers, and supporting equipment. The completed demonstration unit contained approximately 192 planting holes and was established as a permanent community facility.

Before cultivation activities commenced, the system was tested to ensure appropriate water circulation and operational functionality. Seedling preparation and transplanting were subsequently incorporated into the practical learning activities. Pakcoy (*Brassica rapa* subsp. *chinensis*) was used as one of the principal crops cultivated during programme implementation.

The NFT installation was not treated merely as an infrastructure output. It functioned as the primary practical learning medium throughout the programme, enabling participants to observe the interaction between the physical components of the system, nutrient circulation, plant development, maintenance requirements, and production outcomes.

Community Training and Practical Demonstration

The third stage consisted of community capacity-building activities through demonstration-based and hands-on training. Participants were first introduced to the fundamental principles of hydroponic cultivation and subsequently engaged in practical activities using the installed NFT demonstration unit.

Training materials covered seedling preparation, transplanting, nutrient management, water circulation, routine system maintenance, plant-growth monitoring, identification of common cultivation problems, harvesting, and preparation for subsequent planting cycles. Practical demonstrations were conducted directly at the hydroponic facility to connect conceptual explanations with actual system operation.

The training emphasised active learning rather than one-way delivery of information. Participants were encouraged to observe, practise, ask questions, discuss operational issues, and interact directly with facilitators. This approach is consistent with previous community hydroponic programmes demonstrating the value of combining educational counselling, hands-on training, technical guidance, and interactive discussion to strengthen participants' practical competencies (Silitonga et al., 2026).

The objective of this stage was therefore not only to increase participants' awareness of hydroponic agriculture but also to develop the practical skills required to operate and maintain the facility. The combination of technology implementation and experiential learning was intended to reduce long-term dependence on the university implementation team.

International Knowledge Sharing

The fourth stage incorporated international knowledge sharing involving Universitas Mercu Buana, Indonesia, and Universiti Sains Malaysia, Malaysia. This component was integrated into the community empowerment programme to provide broader perspectives on sustainable urban agriculture, community resilience, and community-based development.

The international partner contributed academic perspectives and knowledge enrichment that complemented the technical hydroponic training. The activity was designed to connect practical local intervention with broader sustainability and resilience perspectives while maintaining the needs of the target community as the primary orientation.

International knowledge sharing was therefore not implemented as a stand-alone academic or ceremonial activity. Instead, it formed part of the integrated learning process involving community participants, local stakeholders, the implementation team, and the international academic partner.

Mentoring, Monitoring, and Harvesting

Following installation and initial training, mentoring and monitoring activities were conducted throughout the cultivation period. The purpose of this stage was to support participants during actual system operation while gradually strengthening their ability to manage the hydroponic facility.

Monitoring included observation of water circulation, nutrient availability, plant condition, system cleanliness, and routine maintenance requirements. Community members participated in the maintenance process, while technical assistance was provided when operational problems were identified.

This mentoring approach is consistent with participatory hydroponic community programmes in which training is followed by technology application and continued assistance to strengthen technical competence and programme sustainability (Solecha et al., 2025).

The cultivation cycle concluded with harvesting activities involving community participants and the implementation team. Harvesting served two methodological purposes. First, it provided a tangible production outcome from the installed system. Second, it completed the experiential learning cycle by allowing participants to observe and participate in the entire cultivation process from preparation and planting to maintenance and harvesting. Following the harvest, community participants were encouraged to maintain the facility and initiate subsequent planting cycles. This process was intended to transition the hydroponic unit from a university-supported demonstration facility toward a community-managed learning and production asset.

Programme Evaluation

Programme evaluation was conducted after implementation using a structured participant questionnaire. A total of 51 respondents completed the evaluation instrument. The questionnaire was used to assess participant perceptions of the quality, relevance, and benefits of the programme rather than to measure long-term changes in household food security or income.

The evaluation instrument covered major dimensions of programme implementation, including the relevance of training materials, implementation methods, competence of the

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implementation team, adequacy of facilities and learning media, community participationperceived programme benefits, and overall satisfaction. The questionnaire contained 12 assessment items representing these programme-evaluation dimension

Each assessment item was evaluated from two perspectives: importance and satisfaction. Importance represented the extent to which respondents considered a programme component important, whereas satisfaction represented their assessment of how well the component had been delivered.

Responses were recorded using a four-point Likert-type response format. The use of a structured rating scale enabled participant perceptions to be summarised quantitatively across the evaluated programme components. Because the purpose of the evaluation was descriptive and programme-oriented rather than inferential, the analysis focused on response distributions and mean scores for each item. The mean score was calculated as:

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where X represents the mean score, Xi represents the score provided by each respondent, and represents the total number of respondents.

Importance and satisfaction scores were calculated separately for each evaluation item and subsequently compared descriptively. This comparison was used to determine whether programme components considered important by participants were also associated with positive assessments of programme implementation. Higher satisfaction scores represented more favourable participant perceptions of programme delivery.

No inferential claim regarding population-level programme impact was made from the questionnaire results. The evaluation was used as participant-feedback evidence and was interpreted together with implementation evidence, including establishment of the hydroponic unit, participation in training and practical activities, completion of the cultivation cycle, harvesting, international knowledge-sharing activities, and continued community involvement in facility management.

Sustainability Planning

The final methodological component focused on the continuity of the intervention after completion of the formal community service activities. Sustainability planning was integrated into programme implementation because community-based hydroponic initiatives require continued maintenance, technical competence, cultivation inputs, and local participation after external facilitation has ended.

The hydroponic installation was therefore designed to remain with the community as a permanent learning and production facility. Participants were encouraged to participate in routine maintenance, plant monitoring, harvesting, and subsequent planting cycles. Practical knowledge was transferred throughout the programme so that operational responsibilities could gradually shift toward local management.

Previous participatory urban farming programmes have similarly incorporated mentoring and sustainability planning as essential stages for strengthening community self-reliance (Solecha et al., 2025), while community-based hydroponic interventions indicate that active participation and practical capacity development are important for sustaining food-production initiatives beyond initial training activities (Silitonga et al., 2026).

The sustainability strategy in the present programme therefore emphasised routine NFT system maintenance, continuation of cultivation cycles, transfer of practical knowledge among community members, utilisation of production outcomes to support subsequent

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cultivation inputs, and continued coordination with relevant stakeholders where necessary. This approach was intended to extend programme benefits beyond the initial implementation period and provide a foundation for potential replication of the community-based hydroponic demonstration model.

RESULTS AND DISCUSSION

Implementation of the Community-Based Hydroponic Demonstration Programme

The community service programme was implemented through an integrated sequence of stakeholder coordination, installation of hydroponic infrastructure, practical community training, international knowledge sharing, mentoring, cultivation monitoring, harvesting, and programme evaluation. The implementation was designed to move beyond a one-time technology-transfer activity by establishing a physical facility that could continue to function as both a community learning platform and a small-scale food-production facility.

The main technological output was the establishment of a Nutrient Film Technique (NFT) hydroponic demonstration unit with 192 planting holes in Kedaung Kali Angke, West Jakarta. The system consisted of cultivation channels, a nutrient reservoir, water circulation components, a pump, planting containers, and other supporting equipment. Unlike temporary demonstration equipment used only during training, the installation was established as a permanent community facility.

The establishment of the NFT unit was relevant to the spatial characteristics of the target community. Hydroponic systems provide an alternative cultivation method in urban environments where conventional agricultural land is limited. Wulandari et al. (2022) similarly demonstrated that hydroponic technology can enable productive use of small urban spaces when combined with community training, demonstration plots, mentoring, and evaluation. More broadly, FAO identifies urban and peri-urban agriculture as an important component of resilient urban food systems because it can increase access to fresh food while utilising spaces within and around cities (FAO, 2022).

The programme nevertheless treated the physical installation as an enabling infrastructure rather than the final outcome of community empowerment. The hydroponic unit was used directly during training and cultivation activities so that participants could observe and practise seedling preparation, transplanting, nutrient management, water circulation, plant monitoring, maintenance, and harvesting. This approach was intended to connect the physical technology with the development of local technical capacity.

Previous community hydroponic programmes support this integrated approach. Nurmahmudah et al. (2024) found that hydroponic education involving practical cultivation activities substantially improved participants' understanding of hydroponic farming, while Silitonga et al. (2026) demonstrated that educational counselling combined with hands-on training, technical guidance, and interactive discussion can strengthen community capacity for sustainable urban farming. The present programme extends these approaches by retaining the NFT installation as a permanent demonstration facility for repeated community learning and cultivation cycles.

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Figure 2. Installation and Practical Implementation of the NFT Hydroponic Demonstration Unit in Kedaung Kali Angke

The practical orientation of the programme is consistent with the principle that community empowerment requires more than the delivery of physical technology. Community members need opportunities to develop the knowledge and practical competencies necessary to operate the technology independently. Previous community-based hydroponic initiatives have similarly emphasised the importance of combining infrastructure provision with training, demonstration, and community participation to improve the sustainability of urban farming interventions.

Community Capacity Building through Participatory and Experiential Learning

Community capacity building constituted a central component of programme implementation. Training combined conceptual explanations with direct practical demonstration using the installed NFT unit. Participants therefore had opportunities to observe the technology and apply cultivation procedures rather than receiving information solely through classroom-based instruction.

The practical activities covered seedling preparation, transplanting, nutrient management, water circulation, routine maintenance, plant-growth monitoring, identification of cultivation problems, harvesting, and preparation for subsequent production cycles. Participants were encouraged to ask questions, practise cultivation techniques, interact with facilitators, and participate in the operation of the demonstration facility.

The participatory orientation is particularly important in technology-based community service because the sustainability of an intervention depends on whether beneficiaries acquire sufficient knowledge and confidence to use the technology after external facilitation ends. Wulandari et al. (2022) employed a comparable combination of counselling, demonstration plots, mentoring, supervision, and evaluation in empowering urban communities to utilise limited spaces for hydroponic cultivation. Their approach illustrates that hydroponic technology becomes more relevant to community empowerment when technical infrastructure is accompanied by structured learning and continued assistance.

Similarly, Nurmahmudah et al. (2024) reported an 83.4% improvement in participants' understanding of hydroponic farming following an educational community intervention. Although the present programme did not employ a pre-test/post-test design and therefore cannot be directly compared quantitatively with that study, both programmes indicate the importance of combining hydroponic technology with educational and practical activities.

Silitonga et al. (2026) also emphasised the combination of educational counselling, hands-on hydroponic training, advanced technical guidance, and interactive discussions in developing community capacity for sustainable urban farming. The present findings are consistent with this implementation principle: the physical installation served as a practical learning medium through which participants could experience the cultivation process directly.

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Figure 3. Community Training and Hands-on Hydroponic Cultivation Activities

The contribution of the programme should therefore not be interpreted solely from the number of planting holes installed. Its broader community-service value lies in the combination of infrastructure, practical learning, mentoring, and community participation. This distinction is important because technology provision without local capacity development may result in facilities that become inactive after programme completion.

International Knowledge Sharing and Collaborative Community Empowerment

A distinctive component of the programme was the integration of international academic collaboration between Universitas Mercu Buana, Indonesia, and Universiti Sains Malaysia, Malaysia. International knowledge sharing complemented the practical hydroponic activities by providing broader perspectives on sustainable urban agriculture, community resilience, and community-based development.

The international component was incorporated into the community empowerment process rather than organised as an isolated ceremonial activity. Academic perspectives from the international partner complemented the technical and practical components delivered locally and created opportunities for knowledge exchange among the implementation team, community participants, local stakeholders, and international collaborators.

Figure 4. International Knowledge-Sharing Activity involving Universitas Mercu Buana and Universiti Sains Malaysia

The collaborative structure illustrates that internationalisation of community service can be locally grounded. In this context, the contribution of international collaboration did not depend on introducing sophisticated foreign technology. Instead, its value was derived from enriching the learning process and connecting a local intervention with broader sustainability and resilience perspectives.

This model also reinforces the programme's orientation toward collaborative empowerment. Sustainable urban agriculture involves not only cultivation technology but also communities, institutions, local resources, and governance processes. FAO similarly conceptualises urban and peri-urban agriculture as involving interconnected actors, communities, methods, institutions, systems, and local economies rather than agricultural production alone.

Cultivation Outcomes and Community Harvest

Following installation and initial training, the hydroponic unit entered the cultivation and monitoring stage. Community participants and the implementation team monitored plant development and system operation, including water circulation, nutrient availability, plant condition, cleanliness of the installation, and routine maintenance.

Pakcoy (*Brassica rapa* subsp. *chinensis*) was cultivated as one of the principal crops. The cultivation process enabled participants to observe the complete production cycle from seedling preparation and transplanting to plant maintenance and harvesting.

A tangible production outcome was achieved on 26 May 2026, when the programme recorded a pakcoy harvest of 12.7 kg. The harvesting activity involved community stakeholders, including representatives of the Family Welfare Movement (PKK), local government, and the community. Documentation from the final PKM report confirms the joint harvesting activity and identifies it as evidence of successful implementation of the hydroponic cultivation system.

Table 1. Key Implementation and Production Outcomes

Programme Indicator	Achievement
Hydroponic technology	Nutrient Film Technique (NFT)
Installed capacity	192 planting holes
Demonstration function	Community learning and food-production facility
Principal demonstrated crop	Pakcoy
Harvest date	26 May 2026
Recorded harvest	12.7 kg
Post-harvest utilisation	Sold to local stakeholders/community
Revenue utilisation	Reinvested in seeds, nutrients, and planting media
Continuity mechanism	Subsequent cultivation cycles and community maintenance

The harvest is important because it demonstrates that programme implementation progressed beyond infrastructure installation and training. The facility completed an actual cultivation cycle and generated an observable food-production output. However, the 12.7 kg harvest should not be interpreted as evidence of commercial-scale production or as proof that the programme independently improved food security across the wider community. Rather, it represents an initial demonstration of the operational functionality and productive potential of the community hydroponic facility.

This distinction is important in evaluating community-based urban agriculture. FAO recognises urban agriculture as contributing to access to fresh food and strengthening resilient urban food systems, but the magnitude of its contribution depends on scale, continuity, integration with local food systems, and sustained operation.

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The programme also introduced an initial mechanism for operational continuity. Vegetables harvested from the demonstration unit were sold to local stakeholders, and the proceeds were reused to purchase inputs such as seeds, nutrients, and planting media for subsequent cultivation activities. This reinvestment mechanism is relevant because hydroponic production requires recurring inputs even after the initial infrastructure has been established.


Figure 5. Pakcoy Harvest from the Community Hydroponic Demonstration Unit

The combination of productive output and resource reinvestment differentiates the demonstration model from one-time hydroponic training. The facility was not only used to show participants how hydroponics operates but was incorporated into a repeated cycle of learning, cultivation, harvesting, reinvestment, and replanting.

Programme Evaluation Based on Participant Perceptions

Programme outcomes were also evaluated from the perspective of participants. A structured questionnaire was completed by 51 respondents following programme implementation. The evaluation covered major aspects of programme quality, including the relevance of training materials, implementation methods, competence of the implementation team, adequacy of facilities and learning media, community participation, perceived benefits, and overall satisfaction.

Table 2. Program Evaluation Indicators

No.	Evaluation Aspect	Evaluation Objective
1	Relevance of training materials	To assess whether the training materials addressed community needs.

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No.	Evaluation Aspect	Evaluation Objective
2	Implementation methods	To evaluate the suitability of practical demonstrations and knowledge-sharing approaches.
3	Competence of the implementation team	To assess participants' perceptions of the facilitators' expertise and ability to deliver the program.
4	Facilities and learning media	To evaluate the adequacy of facilities and supporting equipment during program implementation.
5	Community participation	To assess the level of participant involvement throughout the activities.
6	Perceived program benefits	To determine whether participants considered the program beneficial for improving knowledge and skills.
7	Overall satisfaction	To evaluate participants' overall satisfaction with the implementation of the International Joint Community Service Program.

Table 2. Importance and Satisfaction Scores across Programme Evaluation Indicators (n = 51)

The questionnaire consisted of 12 assessment items representing these broader evaluation dimensions. Each item was assessed from two perspectives, namely importance and satisfaction, using a four-point response scale. Importance represented how important participants considered each programme component, while satisfaction reflected their assessment of actual programme delivery.

The descriptive evaluation showed consistently positive importance and satisfaction assessments across the programme indicators. This indicates that participants generally considered the evaluated programme components relevant while also responding positively to their implementation.

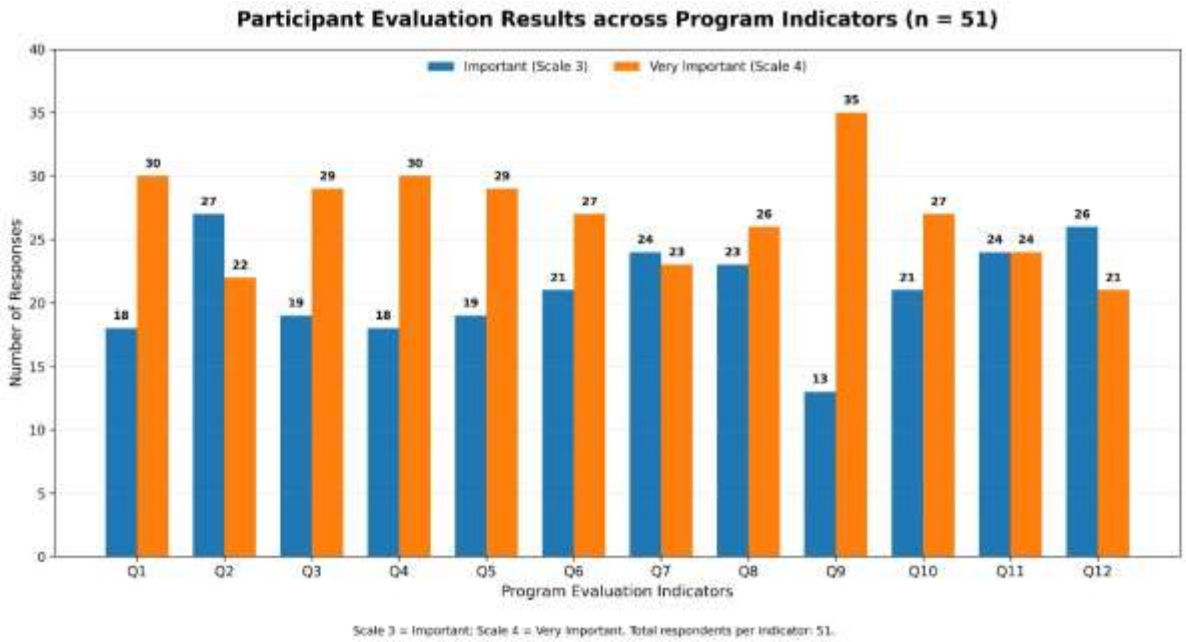

Figure 6. Comparison of Importance and Satisfaction Scores across Programme Evaluation Indicators (n = 51)

The positive participant perceptions are consistent with findings from previous community hydroponic interventions. Nurmahmudah et al. (2024) reported improvements in hydroponic knowledge following structured education and practical activities, while Silitonga et al. (2026) found that participants responded positively to a programme integrating educational counselling, hands-on training, technical guidance, and interactive learning.

The present evaluation adds a complementary perspective by examining both importance and satisfaction. The comparison is useful because high satisfaction alone does not necessarily indicate that programme delivery fully corresponds with participant priorities. When a component is perceived as highly important but receives comparatively lower satisfaction, it may represent an area requiring further improvement. Conversely, relatively close importance and satisfaction scores suggest better alignment between participant expectations and programme implementation.

The evaluation nevertheless needs to be interpreted within its methodological boundaries. The questionnaire measured participant perceptions immediately following programme implementation. It did not measure longitudinal changes in household food consumption, income, vegetable expenditure, nutritional outcomes, or resilience during subsequent flood events. Consequently, the results support conclusions regarding perceived programme relevance, implementation quality, and immediate benefits, but they do not provide causal evidence that the intervention has already produced long-term improvements in household food security.

This limitation also identifies an important direction for future programme evaluation. Subsequent monitoring could incorporate indicators such as continuity of planting cycles, quantity of vegetables produced over time, number of active community managers, use or distribution of harvested vegetables, operating costs, reinvestment of revenues, and continued functionality of the NFT system.

Sustainability of the Community-Based Hydroponic Model

Sustainability is a critical issue in technology-oriented community service because successful installation does not guarantee continued utilisation. The long-term value of the present intervention depends on whether the hydroponic facility remains operational, cultivation cycles continue, technical knowledge is retained within the community, and responsibility progressively shifts from the university team to local participants.

Several elements were incorporated to provide an initial foundation for sustainability. First, the NFT installation was established as a permanent community facility. Second, community participants were involved in practical system operation rather than receiving only theoretical instruction. Third, mentoring continued during the cultivation period. Fourth, the programme completed a cultivation and harvesting cycle. Finally, part of the value generated through the harvest was redirected towards purchasing inputs for subsequent cultivation activities. These implementation features are documented in the programme records.

This approach is consistent with community hydroponic programmes that combine training with demonstration plots, mentoring, supervision, and evaluation (Wulandari et al., 2022). Silitonga et al. (2026) similarly emphasise practical capacity building as a component of sustainable community hydroponics.

The sustainability mechanism developed through the programme can therefore be represented as a continuous cycle:
Learning → Cultivation → Monitoring → Harvesting → Resource Reinvestment → Replanting → Continued Community Learning.

The cycle is conceptually important because it shifts the intervention away from a linear “training–handover–completion” model towards repeated learning and production. Nevertheless, the sustainability of this cycle still requires empirical verification after the formal programme period. Continued operation should therefore be monitored rather than assumed.

Community ownership is particularly important in this process. The programme's sustainability planning explicitly emphasised routine maintenance, continuity of cultivation cycles, transfer of practical knowledge, and continued coordination between community stakeholders and the university team where required.

Implications for Urban Food Resilience and Replication

The programme provides several implications for community-based urban agriculture. First, the establishment and operation of the NFT unit demonstrate the technical feasibility of introducing small-scale food-production infrastructure in a densely populated urban environment with limited conventional agricultural space. This is consistent with previous Indonesian community interventions showing that hydroponics can facilitate productive utilisation of small urban spaces (Wulandari et al., 2022; Nurmahmudah et al., 2024).

Second, the results reinforce the importance of integrating technology with community capacity development. Physical infrastructure alone cannot create community empowerment. Participants need practical knowledge, mentoring, opportunities for direct involvement, and mechanisms through which responsibility can gradually transition to local management. The positive experiences reported in comparable hydroponic empowerment programmes support this interpretation (Nurmahmudah et al., 2024; Silitonga et al., 2026).

Third, the programme suggests that a hydroponic installation can serve multiple functions simultaneously: production infrastructure, demonstration facility, practical learning medium, and focal point for community collaboration. This multifunctional orientation is consistent with FAO's broader view of urban and peri-urban agriculture as a system involving food production, communities, institutions, local economic activity, and urban resilience.

Fourth, the programme extends previous community empowerment activities conducted in Kedaung Kali Angke. Rather than positioning hydroponics only as an introductory training activity, the present intervention established a permanent NFT demonstration unit and linked cultivation to mentoring, harvesting, programme evaluation, and an initial reinvestment mechanism. This provides a stronger basis for repeated learning and production, although longer-term monitoring is still required before sustainability can be conclusively established.

Finally, replication should focus on the empowerment process rather than simply copying the physical hydroponic structure. Differences in available space, water and electricity access, community organisation, local leadership, participant commitment, maintenance capacity, and financial resources may influence outcomes. A technically identical NFT installation may therefore generate different results across communities if the institutional and participatory dimensions are not adapted to local conditions.

Overall, the findings indicate that the community-based NFT demonstration model was successfully implemented as a combined food-production facility and experiential learning platform. The completion of a 192-hole NFT installation, community participation in practical activities, production of a 12.7 kg pakcoy harvest, reinvestment of harvest proceeds, international knowledge sharing, and positive participant evaluation provide evidence of successful initial programme implementation. However, the programme's longer-term contribution to urban food resilience should be evaluated through continued monitoring of production continuity, community management, facility functionality, and utilisation of subsequent harvests.

CONCLUSION

The community-based hydroponic demonstration programme was successfully implemented in Kedaung Kali Angke, West Jakarta, as an integrated intervention combining Nutrient Film Technique (NFT) hydroponic technology, participatory community training, experiential learning, mentoring, international knowledge sharing, and programme evaluation. The programme established a permanent NFT hydroponic demonstration unit with 192 planting holes, functioning simultaneously as a practical learning platform and a small-scale community food-production facility.

The implementation demonstrated that hydroponic technology can be introduced in a densely populated and flood-prone urban community when physical infrastructure is accompanied by practical capacity-building activities. Community participants were involved in the cultivation process from seedling preparation and transplanting to system maintenance, monitoring, and harvesting. The first cultivation cycle produced 12.7 kg of pakcoy, providing tangible evidence that the demonstration unit was operational and capable of supporting community-based food production. The utilisation of harvest proceeds to support the purchase of seeds, nutrients, and planting media for subsequent cultivation cycles also provided an initial mechanism for operational continuity.

Programme evaluation involving 51 respondents indicated consistently positive participant perceptions, with mean importance and satisfaction scores generally exceeding 3.2 on a four-point scale. These findings indicate that participants considered the programme components relevant and responded positively to their implementation. The integration of international knowledge sharing between Universitas Mercu Buana and Universiti Sains Malaysia further enriched the programme by connecting practical community activities with broader perspectives on sustainable urban agriculture and community resilience.

Overall, the programme demonstrates the potential of a community-based hydroponic demonstration model as an adaptive approach to urban agriculture in land-constrained and environmentally vulnerable communities. Its principal contribution lies not only in providing hydroponic infrastructure but also in integrating technology with practical learning, community participation, institutional collaboration, and an initial mechanism for continued cultivation. However, the findings primarily represent initial implementation and participant-perception outcomes and should not be interpreted as direct evidence of long-term improvements in household food security or income.

Future implementation should therefore focus on strengthening community-led management, maintaining regular cultivation cycles, monitoring production and operational costs, documenting the utilisation of harvests, and providing periodic technical mentoring where necessary. Longer-term evaluation is also recommended to assess the continuity of the hydroponic facility, community participation, production performance, and its contribution to local food resilience. With appropriate adaptation to local conditions, the model has the potential to be replicated in other densely populated and flood-prone urban communities.

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