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Modern Farming Transformation to Support Food Security using Hydroponic NFT System Design and IoT Implementation in Ancol Village

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A B S T R A C T

The aim of this community service is to introduce and train local farmer community about hydroponic NFT system design combined with IoT (Internet of Thing), to support local farmer community and support food security in Ancol Village, Sindangkasih District, Ciamis Regency. The partners' main problems are limited fertile land, low productivity of conventional agriculture, and lack of access to modern technology. Methods for implementing activities include outreach, training, building a modular hydroponic greenhouse, installing a Nutrient Film Technique (NFT) hydroponic system, as well as implementing IoT sensors. Interim results show an increase in farmers' knowledge and skill capacity. The achievements of this program are to provide a socio-economic impact and create sustainability-oriented hydroponic farming community to enhance local farmer income.

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INTRODUCTION

Agriculture and local food supply by local farmer is crucial to nation's economy because it will feed society and will has stable price and less distribution cost, made the product more affordable for consumer (Phasinam et al., 2022). Local food supply also can enhance local farmer income. At the other hand, local farmer in Ancol village must face several obstacles such as limited fertile land, low productivity of conventional farming agriculture, and lack of access to modern technology. Almost farmer in Ancol village is farming using conventional technique. Farming using conventional technique gives low productivity of yield, as the result the product of local farmer cannot meet the market needs (Maisarah et al., 2023; Zee et al., 2024).

Food security is important issue that received global attention at the SDGs (Sustainable Development Goals). Innovative and modern farming technique is needed to achieve SDG point 2 (Zero hunger) and point 12 (Responsible Consumption and Production). Hydroponic farming can increase yield eleven times higher. The higher harvest yields are an important point in supporting food security. Hydroponic also more resilient to diverse climate conditions (Dahiya et al., 2025; Zee et al., 2024).

Hydroponics make plants grow faster and have higher concentrations of vitamins and mineral, enhancing nutritional contents to overcome malnutrition (Aminullah et al., 2024). Hydroponic methods like Nutrient Film Technique (NFT) provide the favourable growing conditions to plants and save up to 90 per cent of water. Nutrient and water managing using NFT only need shallow nutrients solution and the nutrient will flow through waterproof conduit. Hydroponic system using NFT is suitable to support efficient nutrient uses and the excess of nutrient can be collected and recycled again (Rajendran et al., 2024). Even though it has many advantages, its implementation has several obstacles, such as required knowledge in installing hydroponic installations and large initial cost in purchasing materials for hydroponic installations. However, that cost will be covered by production results. Hydroponic farming planning can hopefully also enhance economic, ecological, social, and institutional. Those aspects make hydroponic greenhouse a long-term investment (Dahiya et al., 2025; Maisarah et al., 2023; Rajaseger et al., 2023).

Monitoring nutrient and environmental parameters are the crucial things in hydroponic (Dahiya et al., 2025; Rajaseger et al., 2023). Technology is a tool to effectively managing hydroponic greenhouse, especially when dealing with large number of plants. Hydroponic combines with smart technology also provide environmentally friendly plant production (Dahiya et al., 2025; Maisarah et al., 2023; Rajaseger et al., 2023).

Modern farming offer better approach to farm management, which include agricultural and information to monitor field crop condition. The lack of knowledge about modern farming technique among local farmer is huge obstacle to implementation of modern farming, especially in rural area. Basic knowledge and strong interest are the crucial things for learning and doing modern farming. Unfortunately, most people in rural area are lack of resources to gives them training and doing modern farming technique, including hydroponic (Khastini & Maryani, 2025; Phasinam et al., 2022).

The 'Internet of Things' is a network of physical object such as cars or other household that are connected and exchange data. These objects are connected into software, sensor, actuators, adn connectivity. They can work together within the current internet infrastructure (Ghashim & Arshad, 2023; Letting & Mwikya, 2020). The implementation of IoT (Internet of Things) into hydroponic systems make it possible to do precision agricultural system in managing water and nutrient needs as well as monitoring existing environmental parameters. There is hope that hydroponic farming not only being supported by IoT in operation but also be supported by an environmentally friendly energy system in its operation (Dahiya et al., 2025; Shahab et al., 2025). Hydroponic greenhouse farming which is supported by the implementation of technology makes it possible to achieve production scaling to larger level and made the farming operation cost effective, due to precise monitoring (Anjaneyulu et al., 2024; Dhanaraju et al., 2022; Zee et al., 2024).

The aim of this community service is to introduce and gives training for farmer local community about hydroponic NFT system design combine with IoT (Internet of Thing), to support local farmer community and support food security. This community service is designed to improve agronomic practices, economic cycle, and managerial capability of local farmer group in Ancol village. This community service also is a form of conveying knowledge among academics and university to the community. The continuity of this service program is also our main concern. Hence, a greenhouse was built for the farming community in Ancol village to ensure the sustainability of this program in the future.

IMPLEMENTATION AND METHODS

This community service program is carried out in September-October 2025. The method for implementing this community service program is designed with a participatory and collaborative approach, which places the partner community (20 participants from Local Farmer Community Tani SAWARGI in Ancol Village) as the main subject of activity, not just the object of benefit recipients. This approach was chosen to ensure a sustainable knowledge transfer process, while building a sense of belonging and shared responsibility for program sustainability.

The activity stage begins with socialization to introduce the concept of greenhouse-based hydroponic farming and the benefits of technology integration Internet of Things (IoT). The next stage is technical and managerial training for installing hydroponic installation, maintaining nutrition system, and hydroponic production planning. To ensure the sustainability of the program, the team carries out intensive mentoring which is carried out regularly through field visits, technical guidance and evaluation of results. Overall, the method of implementing this program not only emphasizes the technology transfer aspect, but also holistic community empowerment, with the goal of creating a modern agricultural model that is productive, sustainable, and able to improve the welfare of rural farmers.

Figure 1. Conceptual Framework

RESULTS AND DISCUSSION

The activity stage begins with socialization, which aims to introduce the concept of greenhouse-based hydroponic farming and the benefits of technology integration Internet of Things (IoT) to partner farmer groups. Socialization is carried out in the form of group meetings, interactive discussions, and presentation of material in easy-to-understand language, so that partners have the same initial understanding regarding the urgency and benefits of the program (Picture 4).

The next stage is technical and managerial training, which includes two main aspects. First, the technical aspect of cultivation, including assembling the Nutrient Film Technique (NFT) hydroponic installation, maintaining the nutritional system, environmental monitoring, as well as greenhouse-based melon cultivation techniques. Second, the managerial aspect of farming, which focuses on simple financial recording, production planning, and marketing strategies for hydroponic products. Training is carried out directly in the field to improve partner skills.

The technology was applied, in the form of building a modular greenhouse unit measuring ±10×6 meters with a capacity of ±160 planting holes (Picture 2). This installation is equipped with an NFT hydroponic system and IoT sensors connected to an Android-based monitoring application. This technology allows farmers to monitor temperature, humidity, light intensity and nutrient concentrations in real-time, so that plant environmental conditions can be controlled more precisely.

To ensure the sustainability of the program, the team carries out intensive mentoring which is carried out regularly through field visits, technical guidance and evaluation of results. This assistance is focused on resolving technical obstacles, strengthening farmer group institutions, and optimizing the use of technology. Apart from that, the team also facilitated discussions on sustainability plans, including strategies for establishing independent hydroponic farming business units.

The implementation of the community service program in Ancol village has produced several real achievements in technical, social and economic aspects. A modular hydroponic greenhouse unit with the Nutrient Film Technique (NFT) system has been built for technical aspects (Picture 2). This installation is equipped with a nutrient circulation pump, water distribution channels, and rockwool-based planting media. To support precision agriculture, the greenhouse is equipped with Internet of Things (IoT) sensors which can monitor temperature, humidity, light intensity and nutrient concentration in real-time via an Android application. Initial test results show the system is working well, and the data obtained can help farmers carry out more effective environmental controls.

Figure 2. Hydroponic Greenhouse for Local Community Farmer in Ancol Village

Training activities carried out succeeded in increasing the knowledge and skills of partner farmer groups in hydroponic cultivation (to achieve social aspect). This can be seen from the active involvement of farmers in the process of assembling installations, plant maintenance, and operating monitoring applications. Active community participation shows an effective knowledge transfer process and increased technological literacy among rural farmers. The effectiveness of knowledge transfer evaluates based on pretest and posttest scores of participants (Picture 3). Involvement of the younger generation villages is also a positive indicator that modern agricultural innovation can attract their interest in getting involved in the agricultural sector, thereby strengthening aspects of farmer regeneration (Picture 4).

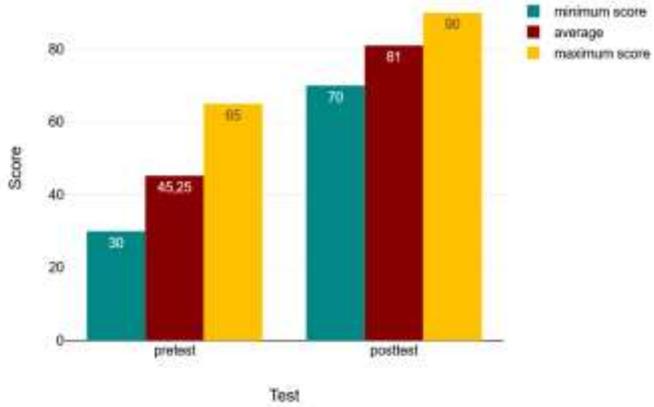

Figure 3. Pretest and Post Test Scores of Participants

This activity opens new opportunities for farmers to produce high-value hydroponic melon commodities (to achieve economic aspect). Based on preliminary analysis, the potential profit from one cycle of hydroponic melon planting is higher than traditional food crops which are usually cultivated on limited land. Apart from that, farming management training encourages farmers to start keeping simple production and financial records, which is the first step towards a more professional farming system.

Figure 4. Training Activities Carried Out in Ancol Village (A. Socialization About Hydroponics, B. Pretest and Post-Test, C. Socialization About the Implementation of IoT in Hydroponics, D. Explanation of Hydroponics Installation

The institutional formation of hydroponic farmer groups that are starting to adapt to modern technology is an important achievement (to achieve sustainability perspective). The intensive assistance provided plays a role in building farmers' confidence to manage the system independently. With a functioning greenhouse prototype, Ancol Hamlet has a pilot model that can be replicated in other rural areas with similar conditions.

Overall, the results of program implementation show that the implementation of IoT-based hydroponic greenhouses not only has a positive impact on increasing agricultural productivity but also encourages socio-economic empowerment of the community. This is in line with the concept of sustainable agriculture which emphasizes resource efficiency, food security and improving farmer welfare. Thus, this activity proves that the integration of technology in the village agricultural system can be a transformation strategy towards smart farming in Indonesia.

CONCLUSIONS AND RECOMMENDATIONS

The community service program through the implementation of a greenhouse-based hydroponic system with the integration of IoT technology in Ancol Hamlet has succeeded in showing significant achievements in technical, social and economic aspects. From a technical perspective, a modular hydroponic greenhouse prototype has been built with a Nutrient Film Technique (NFT) system that functions optimally and is equipped with IoT-based monitoring sensors. This community service increases the knowledge and skills capacity of farmers, while encouraging the participation of the younger generation in modern agricultural practices. Hydroponic greenhouses with NFT system have been built to ensure the sustainability of this community service. The sustainability of this community service and real economic impact will be achieved if Tani SAWARGI local farmer community can produce melon as a commodity using hydroponic and IoT implementation. Hence, we recommended for Tani SAWARGI farmer community apply hydroponic and IoT implementation in producing melon commodity and fulfilling the market needs.

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