JHSS (Journal of Humanities and Social Studies)
https://journal.unpak.ac.id/index.php/jhss
Volume 09, Number 02, Page 1714-1718
e-ISSN: 2598-120X; p-ISSN: 2598-117X

INTEGRATING HYDROPONIC URBAN FARMING TO IMPROVE FOOD SUSTAINBILITY IN ISLAMIC BOARDING SCHOOLS, TASIKMALAYA

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Article history: *received 21 July 2025; revised 02 August 2025; accepted 24 October 2025* *DOI: https://doi.org/10.33751/jhss.v9i2.12792*

Abstract. Food security has increasingly become a crucial issue in Indonesia, especially amid climate change, urbanization, and population growth. The government's free nutritious lunch program further emphasizes the need for healthy and sustainable food availability. However, various challenges remain, such as limited productive land, the conversion of agricultural land, and the high dependency on food imports. This community engagement program is designed through a literature study that explores the potential of applying hydroponic-based urban farming technology in Suryalaya Islamic Boarding School, Tasikmalaya. The novelty of this program lies in integrating food security concepts with the pesantren environment, which has rarely been addressed by modern agricultural innovations. Pesantren are considered strategic, as they serve not only as educational centers but also as broad-based communities capable of fostering food self-sufficiency. Through education and training grounded in literature-based studies, this program is expected to enhance the skills of students and teachers in managing sustainable cultivation, while also providing a pilot model for other Islamic boarding schools in Indonesia.

Keywords: urban farming, hydroponics, food sustainability, Islamic boarding school

I. INTRODUCTION

Food security has become a strategic issue in Indonesia, particularly in the context of climate change, urbanization, and increasing pressure on the availability of productive agricultural land. Efforts toward diversification and decentralization of food production, including the practice of urban farming, are regarded as one approach to addressing land limitations and ensuring the availability of local vegetables in urban areas[1]

The hydroponic method, as a form of soilless urban farming, offers advantages in terms of productivity on limited land, efficient use of water and nutrients, and relatively short harvesting cycles, making it suitable to meet local food needs within institutional settings such as Islamic boarding schools (pesantren) [2].

Pesantren hold strategic potential as actors in food security: in addition to having yard space and an organized community structure, they also function as educational centers that enable the integration of food production with vocational learning for students (santri). Feasibility studies on hydroponic nutrition gardens in several pesantren demonstrate that this model not only increases the local supply of vegetables but also opens opportunities for economic empowerment within the pesantren community[3].

Although hydroponic systems have been implemented in educational and community settings (including pesantren), few studies have focused on the full integration of technical aspects (hydroponic system design), student training, and economic sustainability models within the context of traditional pesantren. Therefore, the Hydroponic Urban Farming program at the Islamic Boarding School in Tasikmalaya is designed to (1) test the technical-operational feasibility of a simple hydroponic system at the pesantren scale, (2) develop training modules integrated with the pesantren learning process, and (3) design a pilot model that has the potential to be replicated in other pesantren[4]. In addition, the development of this program is also aligned with efforts to increase young people's interest in the agricultural sector through an educational approach based on hydroponic practice[5].

Urban farming is defined as an agricultural practice in urban areas that utilizes limited land, home yards, or alternative media for food production. Recent studies indicate that this agricultural model can serve as a solution to land scarcity while also supporting the provision of sustainable local food.

Hydroponics, as one form of urban farming, offers advantages over conventional cultivation. This system allows for better nutrient control, more efficient use of water, and relatively higher productivity of leafy vegetables[1]. Furthermore, hydroponics has proven to be effective when implemented in educational settings, both in schools and pesantren, as it not only produces food but also enhances modern agricultural literacy among students [2].

Urban farming with hydroponic systems has evolved into one of the modern agricultural solutions capable of addressing land limitations in urban areas as well as in educational institutions. Various studies demonstrate that hydroponics not

Volume 09, Number 02, Page 1714-1718
e-ISSN: 2598-120X; p-ISSN: 2598-117X

only provides more efficient harvests but also creates an educational learning environment for communities. The implementation of this technology in pesantren carries strategic significance, as pesantren serve a dual role: both as centers of religious education and as relatively self-sufficient social communities.

Pesantren, with their large student (santri) communities, provide an ideal setting for integrating modern agricultural innovations. Hydroponic training and mentoring programs in pesantren have been shown to enhance students' skills in plant cultivation while also fostering awareness of the importance of food self-sufficiency. The harvests obtained can be used to meet the daily consumption needs of the pesantren or sold to surrounding communities as an additional source of income.

Thus, the literature emphasizes that the development of hydroponic-based urban farming in pesantren is not merely an agricultural practice, but also a means of socio-economic empowerment aligned with the spirit of sustainable education and community self-reliance.

In the context of pesantren, the implementation of hydroponics serves a dual function: first, as a means of strengthening internal food self-sufficiency; and second, as a platform for vocational learning that can nurture entrepreneurial skills among students (santri) (Rohmah et al., 2024). Research in several pesantren has shown that integrating hydroponic systems can open opportunities for the development of small-scale sustainable farming enterprises, while also reinforcing community food security.[3]

II. RESEARCH METHODS

This study employed a literature review approach by examining national and international journal articles published within the last five years (2019–2025). The criteria for selecting the literature included: (1) topics related to urban farming and hydroponics; (2) relevance to food security issues; and (3) applicability within educational or pesantren community contexts.

This approach was chosen as it aligns with the objective of the research, namely to formulate an evidence-based conceptual model that can serve as a foundation for practical implementation in pesantren.

III. RESULTS AND DISCUSSION

The literature review findings indicate that urban farming, particularly through hydroponic systems, has strong relevance in supporting food security and sustainable education in pesantren. Urban farming has been proven to be an effective strategy for addressing the scarcity of productive land while maintaining the availability of local food amidst increasing pressures of urbanization and land conversion. In the context of pesantren, which generally operate within limited space, the application of hydroponics presents a promising alternative as it enables the production of agricultural outputs with high efficiency in the use of water and land[1]

Beyond serving as a food solution, hydroponics also makes a significant contribution to strengthening the educational aspects of pesantren. The integration of hydroponic literacy into the curriculum has been shown to improve students' knowledge and skills in modern agriculture[2]. These findings align with the role of pesantren as educational institutions that not only provide religious instruction but also serve as centers for community empowerment. Moreover, the implementation of hydroponics has proven effective in increasing young people's interest in agriculture—an important factor in ensuring the long-term sustainability of the national agricultural sector[6]

From the perspective of community economics, hydroponics in pesantren also offers significant opportunities. Studies in several pesantren have shown that hydroponic vegetable cultivation can be developed into productive business units that contribute to institutional self-reliance while providing economic benefits for both students (santri) and surrounding communities.[3]. Thus, hydroponics is not merely a technical tool of agriculture but can also be positioned as a strategy for community-based economic empowerment.

The integration of food security concepts within the pesantren context carries broader implications than simply producing food within the institution. More specifically, this integration includes: developing cultivation models suited to the pesantren's unique conditions (space, human resources, and cultural environment), implementing direct education and training programs for santri, and generating economic added value for the pesantren through harvest outputs or processed products. A concrete example can be seen in the study "Enhancing Food Security and Santri Skills through the Application of Hydroponic Technology and Its Derivatives", where santri were trained not only in hydroponic techniques but also in processing harvested vegetables, thereby improving health benefits and maximizing the utilization of local resources[7]

Another study at Pesantren Al-Ishlah Mangkangkulon, Semarang, adopted an aquaponic approach that integrates fish and vegetable cultivation. This model provided dual benefits: supplying protein and fresh vegetable intake for the pesantren community, while simultaneously serving as a platform for entrepreneurship training and resource management for santri [8]. This integration demonstrates that pesantren can serve both as sites for the application of modern agricultural technology and as practice-based learning centers, enabling santri to understand the entire cycle of food production.

Beyond cultivation technology, the pesantren environment also embodies social and institutional aspects that support the integration of food security. The study "Food Management in Pesantren based on Integrated Farm Education and Entrepreneurship" found that when agricultural education and entrepreneurial spirit are incorporated into the pesantren curriculum, the effectiveness of food management increases significantly. Santri not only learn how to cultivate crops, but also how to plan planting schedules, market their harvests, and sustain continuous production[9].

Furthermore, pesantren possess strong social and cultural capital that position them as agents of transformation within society. The successful implementation of hydroponics in one pesantren has the potential to serve as a pilot model that can be replicated by other pesantren in various regions. This strengthens the role of pesantren as strategic loci for

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e-ISSN: 2598-120X; p-ISSN: 2598-117X

sustainable agricultural development, while simultaneously providing tangible contributions to the achievement of national food security.

Based on this synthesis of findings, it can be affirmed that the Hydroponic Urban Farming initiative at Pondok Pesantren Tasikmalaya demonstrates novelty in its integration of three key dimensions: food security, santri education, and community-based economic empowerment. This integration simultaneously reinforces the position of pesantren as institutions that are adaptive to contemporary challenges while maintaining their traditional role as centers of education and moral development. The Concept of Hydroponics in Islamic Boarding Schools :

Table 1. The Concept of Hydroponics in Islamic Boarding Schools ITB Hydroponics Team 2025

Aspect	Description
Objective	1. Increasing the food self-sufficiency of the boarding school 2. Providing practical skills to the students
Implementation Strategy	1. Hydroponic cultivation training for students and teachers 2. Utilization of limited land within the boarding school environment 3. Integration into the curriculum or extracurricular activities
Benefits	1. Availability of healthy and nutritious food in the boarding school 2. Strengthening the boarding school's economy through the marketing of harvests 3. Enhancing students' literacy in modern agricultural technologies
Challenges	1. Limited initial funding for hydroponic infrastructure 2. Consistency in plant maintenance and program sustainability

The implementation of hydroponic systems in Islamic boarding schools (pesantren) is an innovative approach that addresses both food security challenges and the need for practical skill development among students. Hydroponics—a soil-less cultivation method that uses nutrient-rich water—offers an efficient and sustainable solution for schools with limited land availability. Hydroponic systems are ideal for constrained environments due to their low water usage and compact design, making them particularly suitable for pesantren settings.[10]

The primary goals of integrating hydroponics into pesantren are twofold: to promote food self-sufficiency and to equip students with modern agricultural skills. When integrated into the school curriculum or extracurricular activities, hydroponics serves as a contextual learning tool that blends religious values with scientific knowledge. Umam et al.[11] emphasize that school-based farming not only enhances cognitive development but also cultivates discipline, teamwork, and responsibility among student.

The benefits of hydroponics go beyond merely producing food. Pesantren can generate economic value by selling surplus crops to local communities or using them to support their own meal services. In addition, students are introduced to modern agrotechnology, including automated irrigation systems, nutrient monitoring tools, and data-based plant management. As highlighted by Sultan et al[12], incorporating smart agriculture in education prepares students to meet future challenges in a rapidly evolving, climate-sensitive world.

Despite the promising benefits, the initial setup cost of hydroponic systems and their long-term maintenance remain significant challenges. To address this, scholars have proposed Islamic finance-based solutions. Salim et al.[13] advocate for the use of productive zakat funds to support school-based farming initiatives, while Musalman[14] proposes green sukuk (Islamic bonds) as a sustainable financing mechanism aligned with Sharia principles

In conclusion, implementing hydroponics in pesantren is more than a technical farming practice; it is a transformative educational model that integrates Islamic values with sustainability, technological literacy, and economic empowerment. With proper planning, training, and financial support, pesantren can evolve into green educational hubs that foster resilient, skilled, and environmentally-conscious students. This model offers a practical solution for addressing both food insecurity and educational relevance in a changing world.

Hydroponic farming using PVC pipes requires careful planning of tools, materials, construction methods, and maintenance. Essential equipment includes saws, soldering irons, cutters, trays, sprayers, tweezers, buckets, TDS meters, electrical cables, aquarium pumps, hoses, PVC glue, net pots, PVC pipes, rockwool, seeds, and nutrient solutions. The installation process begins with cutting pipes to size, drilling holes for net pots, connecting them with adhesive, and attaching them to a reservoir equipped with a pump and hose for continuous nutrient circulation. This design aligns with the principles of the Nutrient Film Technique (NFT), which is widely recognized as an efficient hydroponic model for leafy vegetables[15]

Seed preparation is critical for system success. Seeds are first germinated in rockwool cubes because the medium is sterile, porous, and provides good aeration. Once seedlings reach 3–4 true leaves, they are transferred into net pots and placed on the pipe installation. Previous studies emphasize that transplanting at this stage ensures stable nutrient absorption and minimizes transplant shock[16]. In addition, vertical hydroponic models using rockwool have been shown to produce high yields while optimizing limited urban spaces[17]

Nutrient management must be monitored daily. EC and pH are the main indicators of nutrient solution quality. Studies indicate that lettuce grown hydroponically achieves optimal growth at an EC of 0.8–1.8 dS/m and a pH between 5.6 and 6.0[18]. Smart sensors for TDS and EC have been developed to improve accuracy and reduce human error in monitoring nutrient solutions[19]. Maintaining these parameters not only optimizes yield but also enhances nutrient-use efficiency and water sustainability[20].

Flow rate in NFT channels also determines plant health. Research confirms that medium flow rates improve fresh biomass compared to excessively low or high flow rates, which either limit nutrient contact or reduce root absorption

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e-ISSN: 2598-120X; p-ISSN: 2598-117X

time[21]. Consequently, pump calibration and channel gradient should be standardized to maintain consistent nutrient film thickness.

Maintenance is essential to prevent biofilm and pathogen build-up in the system. Biofilms can form rapidly on PVC surfaces, serving as reservoirs for harmful microorganisms such as Salmonella, which threaten food safety[22]. Regular cleaning, flushing, and sanitation using UV-C disinfection of recirculating water have proven effective in reducing microbial loads in hydroponic systems[23]. Such hygiene protocols are now considered critical control points in food-safe hydroponic production systems.

Environmental conditions must also be considered. Hydroponic crops are sensitive to seasonal variations in temperature and light. Research indicates that EC levels and nutrient uptake must be adjusted across seasons to avoid stress in plants and ensure consistent productivity[20]. Shading, ventilation, and microclimate management are therefore integral to hydroponic farming in tropical and subtropical regions.

IV. CONCLUSIONS

The Urban Hydroponic Farming program at the Tasikmalaya Islamic Boarding School demonstrates that integrating modern agricultural technology within a religious-based educational environment can offer innovative solutions to food security challenges. Traditionally known as centers of education and moral development, boarding schools have proven to play a strategic role in promoting food self-sufficiency through hydroponic systems that are efficient, sustainable, and easily adaptable. The study findings indicate that the implementation of hydroponics not only contributes to increased food production on a small scale but also strengthens students' practical skills and broadens their awareness of global food issues. Thus, this approach underscores the importance of hands-on, practice-based education that fosters environmental consciousness, economic independence, and young generations' interest in the agricultural sector. Moving forward, the development of hydroponic models in boarding schools is expected to be replicable in other regions, with adjustments made to local social, cultural, and resource contexts. Moreover, government policy support and collaboration with academic institutions and private entities will be crucial factors in enhancing the sustainability of similar programs. In this way, boarding schools can become key actors in the national food security ecosystem while making a tangible contribution to sustainable development in Indonesia.

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