EMPOWERING COMMUNITIES THROUGH HYDROPONIC FARMING AS A SUSTAINABLE APPROACH TO FOOD SECURITY IN URBAN INDONESIA

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ABSTRACT

Food security has become a strategic issue in urban Indonesia as agricultural land continues to shrink due to housing, infrastructure, and development projects. This condition has led to the heavy dependence of major cities, such as Jakarta, on vegetable supplies from surrounding regions. At the same time, the demand for healthy, fresh, and pesticide-free vegetables is increasing, in line with government campaigns on balanced nutrition and efforts to reduce stunting. However, previous studies have mostly focused on the technical aspects of hydroponic farming or short-term economic impacts, while research connecting hydroponics with community empowerment strategies for urban food self-sufficiency remains limited. This study employed a participatory approach through training, mentoring, and demonstration of simple hydroponic installations. Respondents were recruited using snowball sampling, involving households, neighborhood communities, schools, and universities. The findings reveal that hydroponics not only produces fresher, longer-lasting, and pesticide-free vegetables but also functions as a tool for empowerment by enhancing skills, strengthening community solidarity, and creating economic opportunities through the sale of vegetables and hydroponic installations. The study implies that hydroponics can serve as a sustainable strategy to address urban food security challenges while fostering micro-level food resilience at the household, school, and community levels.

Keywords: Food Security, Hydroponics, Community Empowerment, Urban Farming.

1. INTRODUCTION

Urban food security is a serious challenge in Indonesia, especially in major cities such as Jakarta, which depend on vegetable supplies from buffer areas such as Bogor, Sukabumi, and Subang. This dependence leads to vulnerability to price fluctuations, distribution disruptions, and logistical uncertainty. At the same time, people's need for relatively affordable vegetables is becoming increasingly urgent, especially as a complement to a balanced diet that is important to support government programs such as free nutritious meals and efforts to reduce stunting rates. However, land crises due to urban expansion, infrastructure projects, and housing are eroding the usable space for local food farming—a paradox between increasing nutritional needs and declining availability of productive land.

Food security is defined as the condition for meeting food needs for households which is reflected in the availability of sufficient, safe, nutritious, and affordable food (FAO, 2015). In the urban context, food security faces serious challenges, including land constraints, dependence on supplies from other regions, and high distribution risks due to long supply chains (Saliem H. P. S., 2016). Rapid urbanization in Indonesia has resulted in significant shrinkage of agricultural land, so new innovations are needed in food cultivation, one of which is through hydroponic systems (Suryani, 2020).

In response to these challenges, urban agricultural innovations such as hydroponic systems are present as potential solutions. Hydroponic cultivation does not require a large area of land and can be applied in limited spaces, such as roofs, balconies, or yards, with the result being fresh vegetables that are healthy and pesticide-free. Furthermore, hydroponics also has the potential as a means of empowering communities at the micro level—both families, the environment, schools, and the workplace—to increase food independence. By integrating hydroponic cultivation into community empowerment programs, communities can not only meet their nutritional needs independently but also support the government's efforts to reduce stunting rates and realize sustainable food security in Indonesia's urban areas.

In addition to the technical aspect, hydroponic systems also have a social dimension through community empowerment. The concept of community empowerment according to Chambers (Chambers, 1997) is the process of improving the ability of people to control the resources they have, make decisions, and act according to their needs. In the context of food, empowerment means involving the community in every stage of production, distribution, and consumption of healthy food.

Hartono's research emphasizes the importance of hydroponic training in the educational environment to build the awareness of the younger generation towards modern agriculture (Hartono, 2023). Wachdijono through the socialization of urban farming in Cirebon proves that the demonstration of urban farming practices strengthens the involvement of local communities (Wachdijono, 2021). This approach is in line with the diffusion theory of innovation which explains that the adoption of innovation, including hydroponics, can spread from early adopters to the wider community through social mechanisms (Rogers, 2003).

Various research and community service programs have explored the potential of hydroponics as an urban farming solution in Indonesia. For example, in Tasikmalaya, hydroponic training has succeeded in increasing public understanding of the benefits of healthy food and the potential income of families through a community empowerment approach (Nurmahmudah, 2023). In Ubung Village, Bali, the application of the Deep Flow Technique (DFT) system shows that vegetables such as kale and pakcoy can grow optimally on narrow land, strengthening urban food independence (Adnyana, 2022). In Tangerang, education about antioxidant sources and hydroponic skills in households increased public knowledge from 42% to 66% (Kusuma, 2021).

A similar program in Surabaya shows that communities are able to independently produce vegetables and reap local economic benefits (Renata, 2021), while in Cilegon, training for housewives strengthens the ability to cultivate vegetables in the yard (Herawati, 2020). In Boyolali, simple hydroponic training using a wick system resulted in an increase in participants' knowledge of more than 80% (Syaifudin, 2022).

In other regions, such as Kulonprogo (Yogyakarta), hydroponic systems were introduced to reduce dependence on external supplies by itinerant traders (Andriani, 2021). Urban farming *program* in Cirebon enriches PKK skills through vertical and hydroponic demonstrations (Wachdijono, 2021), while in Pekalongan, hydroponic training not only improves technical skills but also creates micro-entrepreneurship potential (Sari, 2021). Finally, in Sidoarjo, hydroponic assistance by youth organizations strengthens awareness of modern agriculture and economic independence (Prasetyo, 2020).

A number of service programs also emphasize the empowerment of certain community groups. Axis system hydroponics training for housewives in Bandung, as well as strengthening *posyandu* cadres in Sidrap, South Sulawesi, emphasized that hydroponics can play a direct role in increasing family food independence while supporting stunting prevention efforts. Similarly, women's empowerment through hydroponic kale cultivation in Bringin Lawang Hamlet shows that this technology is able to improve skills while providing additional income for families.

Hydroponics is also used to support marginalized groups and the education of the younger generation. Simple hydroponic training for street children in Depok not only equips practical skills but also provides access to healthy vegetable consumption. Meanwhile, similar activities in vocational high schools in Bandung proved that adolescents showed a significant increase in knowledge and interest in modern agriculture, thus opening up opportunities for the integration of hydroponics in the vocational education curriculum.

In the context of the family economy, hydroponics has been proven to contribute to increasing household productivity. Programs in Poso and Cisauk Girang, Tangerang, for example, show that the use of yards with hydroponics can increase family income while expanding public understanding of crop marketing. A similar program in Bogor involving housewives with used plastic bottles also emphasizes environmentally friendly aspects while increasing family food productivity in urban areas.

From these various studies, it can be concluded that hydroponic systems have been widely applied in various regions of Indonesia with various target groups—ranging from housewives, posyandu cadres, street children, to school students. However, most of these activities are still local and limited to one community or group. The novelty of this research lies in a multi-level and cross-sectoral approach, namely the application of hydroponics starting from households, then expanding to the village level, industrial environment, campus, and school. With a wider scope, this study offers a new perspective on how hydroponics can be replicated as a model of community empowerment as well as a sustainable urban food security strategy.

Although a wide range of research and community service has been conducted, most of them are local, limited to one target group, and emphasize technical education aspects. There is still little research that highlights hydroponics as a model of empowerment across sectors—ranging from households, urban communities, industries, universities, to schools (see Table 1). Thus, this study presents a novelty by showing how hydroponics can be replicated in layers through social mechanisms such as the snowball effect and positioned as a micro-strategy that is relevant to the national policy of providing free nutritious food and stunting control.

The presentation of the empowerment model is multi-level and cross-sectoral: starting from households, then extending to urban villages (local community scale), industrial environments, campuses, and finally schools. Thus, this study not only documents hydroponics as an urban farming activity, but also as an integrated community empowerment strategy that supports food security, nutrition, and stunting, in an urban context.

Table 1. Research Contributions

Aspects	Trevious Research	This Research
Diverse Segments	Families, *posyandu* cadres, women, teenagers, marginalized communities	Starting from private houses → urban villages → industrial → campuses → vocational schools
Scale and Replication	Generally limited to one group or location	Cross-sector replication and settings strengthen scalability
Purpose	Service, education, family economy	Focus on food security, nutrition, and stunting prevention in big cities
Academic Value	Local service or evaluation reports	Systematic as an evidence-based study for international conferences

Based on this context and review, this study is designed to answer the following research questions (1) how can the application of hydroponic systems be a strategy for community empowerment in meeting the needs of healthy vegetables in urban areas? (2) What are the challenges and opportunities for the development of hydroponics as a model of sustainable food independence at the family, school, and community levels? Thus, the research objective is (1) to describe the practice of community empowerment through hydroponic cultivation in various contexts (households, urban villages, industries, campuses, and vocational schools. (2) to identify challenges, opportunities, and strategies for hydroponic development to support government programs in the provision of nutritious food and stunting control in urban areas.

2. METHOD

The method used in this hydroponic empowerment program emphasizes not only the technical aspects of cultivation, but also on social strategies to foster community interest and participation. The initial approach was carried out by showing real examples of hydroponic cultivation results in the form of green, fresh, and ready-to-consume vegetables. The presence of products that have grown well is an effective means of persuasion, because the public can directly see the quality of clean, healthy, and pesticide-free hydroponic vegetables. On several occasions, the harvested vegetables were distributed to neighbors and close colleagues and even sold on a small scale to the surrounding community. This has proven to lead to greater curiosity and interest in trying to grow your own.

Interested participants were then invited to take part in a short training on the basic principles of hydroponics. Training is not only provided formally, but also accompanied by hands-on experience, such as tasting crops or seeing hydroponic installations that work in home environments. In this way, hydroponics is not seen as an abstract concept, but rather as a real practice that directly provides benefits. Some previous studies have shown that this kind of hands-on experience strategy can increase community involvement in urban farming practices (Herawati, 2020; Nurmahmudah, 2023).

After the introduction stage, the participation development method is carried out with a snowball mechanism. Individuals or groups who have experienced the benefits of hydroponics, either through consumption or their own harvest, naturally invite their friends, neighbors, or co-workers to try it. This spread of interest expands the reach of the program without the need for massive formal promotion. For example, activities that were originally only carried out in private households then expanded to the village level, expanded to the industrial environment (carousel office), developed in universities, and finally applied in vocational high schools. Each replication point involves a growing social network, which demonstrates the effectiveness of the snowball sampling method in capturing community participation (Syaifudin, 2022).

In addition, assistance is still provided flexibly according to the needs of each family or community. Participants who are just starting out are assisted in making simple installations, seed selection, and basic maintenance. The team also provides additional assistance if needed, both in the form of nutrition, seeds, and installation repairs. This approach fosters a sense of community while strengthening the participants' motivation to persevere. With a combination of real-life examples, hands-on experience, yield distribution, snowball approach, and ongoing mentoring, the program has succeeded in building a growing hydroponic community over time.

By combining demonstrations, training, installations, mentoring, and replication through *the snowball effect*, this method has succeeded in growing a growing hydroponic community. The method used not only produces fresh vegetables for consumption and sale but also builds the skills and motivation of the community to continue hydroponic practices independently.

3. RESULTS AND DISCUSSION

Results

In the implementation of hydroponic cultivation activities, various installation models have been tried, ranging from pyramid systems, vertical systems, to flat table systems. Figure 1 shows a pyramid-style hydroponic installation. Based on experience, flat table systems have proven to be the most effective because they are easy in terms of maintenance, water flow regulation, as well as the harvesting process. In addition, plants grown with a table system show more fertile and consistent growth compared to other models. This advantage makes the table system the first choice to be propagated and widely implemented in the later stages. However, the installation model depends on the desired choice with different arguments.

Figure 1. Hydroponic Vegetable Cultivation Training in South Bekasi

Along with the increase in the number of installations, the variety of vegetables produced is increasing, including lettuce, kale, spinach, and pakcoy as shown on Figure 3 and Figure 4. The harvest is not only enough for their own consumption but also begins to be enjoyed by the surrounding neighbors. A positive response came when the neighbors were introduced to fresh, pesticide-free hydroponic vegetables, which they had never consumed before. This enthusiasm then developed into an economic opportunity, when some of the crops began to be sold. The sale of hydroponic vegetables is proven to provide a promising additional income, with the number of customers continuing to grow over time.

Figure 2. Hydroponic System

In addition to selling crops, initiatives are also carried out to offer the manufacture of hydroponic installations to interested communities. Initially, this offer was carried out in the RT environment in Taman Galaxi Village, then expanded to the village level, entered the industrial environment, expanded to campus, and finally reached vocational high schools. Figure 2. Hydroponic installation in schools/campuses. Each expansion of the implementation area is always accompanied by practical training on how to make installations, plant seeds, and maintain until harvest. With this approach, people not only acquire fresh vegetables, but also the skills to produce their own in their respective environments.

Figure 3. Red lettuce, Pakchoi, Kailan, Celery, Green lettuce

As a result, the participants who took part in the training were able to harvest vegetables independently and continue hydroponic cultivation after the initial program ended. The dissemination of knowledge takes place naturally through a word-of-mouth mechanism, more and more families and communities are inspired to try hydroponics. Even though the price of hydroponic vegetables is relatively more expensive than vegetables sold in traditional markets, people are still interested because the quality and freshness are more guaranteed. This fact shows that hydroponics not only contributes to food security at the household level but also opens up sustainable business opportunities that can be expanded to various levels of urban society.

Great potential of growing with hydroponics

The application of hydroponic systems in urban areas shows great potential as a community empowerment strategy in meeting the needs of healthy vegetables. People basically have an interest in planting activities, especially if the methods offered are easy to do, not dirty, and pleasing to the eye so that they can also function as decorative elements of the house. Hydroponics meets this criterion because the system is clean, neat, and flexible to be applied in confined spaces.

The advantages of hydroponic vegetables over conventional vegetables are its own attraction. Consumers who have tried to admit that hydroponic vegetables taste fresher, crispier, contain no pesticide residues, and are more durable to be stored in the refrigerator, which is 3-5 days without experiencing a deterioration in quality. This is different from conventional vegetables which are often dirty due to the long distribution process from the garden to the market,

exposed to flies and dust in traditional markets, and potentially contain harmful pesticides. Thus, hydroponics offers quality assurance as well as a very important health aspect for urban communities who tend to need practical but still nutritious food.

Figure 4. Pakchoi, Red Lettuce and Green Lettuce

In terms of strategy, hydroponic system actually opens up new opportunities. This system allows urban people who have limited land to continue to produce healthy vegetables. Hydroponic installations can be placed in a variety of non-conventional locations, such as house terraces, roofs commonly used for drying clothes, fences, or guardrails between houses. Figure 5 is hydroponik installation on the roof top. Spaces that were previously arid and unused can be empowered into productive spaces that produce fresh vegetables for family consumption, while reducing dependence on out-of-town supplies.

Figure 5. Hydroponic installation on the roof top

Another advantage of hydroponic farming is ease of maintenance. The plant can grow well without having to get your hands dirty with the soil, the planting capacity is more than conventional methods, and the installation can be moved or rolled up when no longer in use. Hydroponics also provides psychological benefits, especially for urban communities who tend to live with a dense rhythm and are prone to stress. Seeing the greenery of vegetables every day, caring for the plants, and harvesting the results can be a form of simple recreation, visual therapy, as well as a means of reducing saturation. Figure 6 is the happy atmosphere of lettuce harvesting. In this way, hydroponics not

only serves as a food solution, but also as a medium for empowering people towards a healthier and more sustainable urban life.

Figure 6. The Great Harvest

The challenges of growing with a hydroponic system

The development of hydroponics as a model of sustainable food independence faces a number of challenges, although it also holds great opportunities to be developed at the family, school, and community levels. In terms of challenges, the availability of production facilities is still limited. Shops that provide hydroponic equipment, seeds, and plant nutrition have not been found in many places, so prospective hydroponic farmers often have difficulty obtaining basic equipment. This has implications for relatively higher costs in the early stages, giving the impression that hydroponics is an exclusive activity and difficult for the general public to reach.

In addition, hydroponic plants are still considered rare in the community. Many people are not familiar with the types of vegetables that are commonly cultivated through this system, such as kailan, pagoda mustard, basil, caisim, or romaine lettuce. This limited knowledge led to low initial interest, because people were more accustomed to consuming conventional vegetables that are commonly found in traditional markets. Another challenge is more specific technical needs, especially related to electricity supply. Water pumps that function to maintain nutrient circulation are highly dependent on the availability of electrical power, so that in the event of a blackout, plants are at risk of dying or failing to harvest.

Environmental factors also affect the success of hydroponics. Hydroponic plants need enough sunlight. If light exposure is reduced, for example because the installation location is in an area that is blocked by buildings or trees, plant growth becomes suboptimal. Vegetables tend to grow thin, elongated, and produce few leaves. In addition, hydroponic cultivation requires high attention and discipline from actors, including in monitoring water quality, nutrition, and cleanliness of installations. For some urban people who have high busyness, this can be an obstacle to sustainability.

Behind these challenges, hydroponics offers great opportunities. At the family level, hydroponics allows the use of narrow spaces, such as terraces, roofs, or fences, to produce fresh vegetables for household consumption. In schools, hydroponics can be a practical learning medium to introduce students to the principles of modern agriculture, food independence, and environmental awareness. Meanwhile, at the community level, hydroponics has the potential to become a forum for social collaboration that strengthens community solidarity while opening up micro business

opportunities. If managed properly, hydroponics not only provides healthy food, but also creates economic added value and increases local food security.

Hydroponic prospects with increasingly narrow agricultural land

Along with the reduced availability of land due to infrastructure development, housing, and the conversion of agricultural land into industrial areas, urban communities face serious challenges in meeting their food needs, especially fresh vegetables. In this context, hydroponics comes as an innovative solution. This system allows for the production of healthier, and fresher vegetables compared to conventional methods on the same land area. For example, on a limited plot of space such as a yard or roof of a house, multi-storey or horizontal hydroponic installations can accommodate a larger number of plants than conventional cultivation that relies solely on soil as a medium.

In addition to higher planting capacity, hydroponics also excels in terms of yield quality. Vegetables produced through hydroponics tend to have a fresher and crispier taste, are free from soil contamination or pesticide residues, and have a longer shelf life. In other words, the limitations of urban land can actually be overcome with the application of this simple but effective technology. Hydroponics is not only an alternative but also offers added value in the form of efficient use of space and improved food quality, both of which are very relevant in answering the challenge of sustainable food independence in urban areas.

Discussion

The findings of this study confirm that hydroponic cultivation can be a micro solution to overcome food security challenges in cities. Jakarta as a big city faces limited agricultural land due to the conversion of functions into housing and infrastructure, so that dependence on vegetable supply from buffer areas such as Bogor, Sukabumi, and Subang is getting higher. In this context, hydroponics is present as an efficient alternative because it does not require large land, is able to produce fresh vegetables, and supports the provision of healthy food for families (FAO, 2015). This is in line with the concept of food security which emphasizes the availability, access, and stability of food for all (Saliem H. P. S., 2016).

From the perspective of community empowerment, this hydroponic program shows the active participation of the community in managing food sources independently. Chambers (Chambers, 1997) explained that empowerment emphasizes the direct involvement of communities in controlling the resources that affect their lives. This approach is seen when the community is not only a beneficiary, but also a food producer by building their own hydroponic installations, carrying out maintenance, and harvesting vegetables for consumption or sale. This process provides added value in the form of increasing skills, confidence, and food independence at the household and community levels.

Furthermore, the spread of hydroponics in various locations (households, urban villages, industrial environments, campuses, and schools) reflects the diffusion mechanism of innovation as explained by Rogers (Rogers, 2003). Hydroponic innovation spreads through a snowball mechanism, which is from one successful individual or group then inviting others to try. The success of the harvest that is visible and the distribution of vegetable products is a demonstration effect that encourages wider adoption. In this context, hydroponic innovation functions not only as a food production technology, but also as a social learning medium that connects individuals, communities, and institutions.

The social impact of this program is quite significant. People who were previously only passive consumers are now transforming into small-scale food producers. This increases social solidarity due to the practice of sharing crops with neighbors before eventually developing into an economic activity through the sale of hydroponic vegetables. Economically, hydroponics opens up new business opportunities, although the price of vegetables is relatively higher than the traditional market, consumers are still interested because quality and freshness are more guaranteed. From an environmental perspective, hydroponics provides benefits because it uses water more economically than conventional agricultural systems and does not require pesticides, making it more environmentally friendly (Wachdijono, 2021).

Thus, this study shows that hydroponics not only answers the need for healthy food in urban areas, but also creates a dual impact on empowerment, economy, and environmental aspects. This shows that hydroponics can be a sustainable strategy that supports the national program for the provision of nutritious food as well as efforts to combat stunting. The novelty of this research lies in a cross-sectoral and sustainable model of community empowerment, which shows the great potential of hydroponics as a practical as well as a strategic approach to urban food security.

4. CONCLUSION

This research succeeded in providing answers to the three research questions asked. First, the results show that hydroponics has been proven to be a micro solution to support urban food security. With limited land in Jakarta and high dependence on vegetable supplies from buffer areas, hydroponics presents a practical alternative that allows communities to produce healthy, fresh, and pesticide-free vegetables in household and community environments.

Second, from the perspective of community empowerment, hydroponic practices are able to increase the active participation of the community in food production. Through training, crop demonstrations, and ongoing mentoring, the community not only becomes a beneficiary, but also transforms into small-scale food producers. This supports the empowerment theory that the direct involvement of the community in managing resources will strengthen independence and self-confidence (Chambers, 1997).

Third, the social, economic, and environmental impacts of this hydroponic program are quite clearly identified. Socially, solidarity emerges through the practice of sharing crops and spreading knowledge by word of mouth. Economically, hydroponics provides additional income from the sale of vegetables, although the price is slightly higher than the traditional market, but it is still in demand because of its quality. From an environmental perspective, hydroponics is more environmentally friendly because of the efficient use of water and pesticide-free. Thus, all research questions can be answered through these findings.

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