

## Implementation of Hydroponics in Urban Areas as an Effort to Improve Food Security: Perspectives from Literature Review

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### ABSTRACT

Food security is an increasingly pressing global issue, especially in urban areas. In the face of the challenges of limited land and resources, hydroponic technology offers an innovative solution to increase food production. Hydroponics is a soil-less method of plant cultivation, using nutrient-rich water, which enables faster and more efficient plant growth. This study analyzes the literature on the application of hydroponics in urban areas and its contribution to food security. Findings show that hydroponics improves crop productivity, land and water use efficiency, and food supply stability. In addition, hydroponics supports more sustainable and environmentally friendly local food production. However, challenges such as initial costs and technical knowledge requirements require special attention. Policy support and education are key to the successful implementation of hydroponics in urban areas. Thus, hydroponics has the potential to be an effective solution to improve food security in the era of urbanization.

**Keywords:** food security, hydroponics, urban, land efficiency, sustainability.

## **INTRODUCTION**

Food security is one of the most pressing and relevant global issues in this modern era. As the world's population increases, especially in urban areas, the challenge of meeting the need for safe, sufficient and sustainable food is increasingly complex. Food security includes not only food availability, but also accessibility, utilisation and stability of food supply (Godoy et al., 2014). In the midst of rapid urbanisation, conventional agricultural land is increasingly limited, so innovative solutions are needed to meet the food needs of the urban population.

One promising solution is the application of hydroponic technology. Hydroponics is a method of cultivating plants without using soil as a growing medium, but by utilising water that is rich in nutrients. This system allows plants to grow faster and more efficiently than conventional methods, because the nutrients needed by plants can be directly absorbed without the mediation of soil (Resh, 2022) Hydroponics is a very profitable business if done seriously. Vegetables from hydroponic cultivation can be utilised by the community and can realise food independence. The cultivation of hydroponic farming systems can be used as a technology utilisation for the process of improving environmental quality through the development of agricultural techniques, so that this can be a solution in increasing the potential of organic agriculture and food security. Food is one of the basic human needs that must be fulfilled every day.

Generally, in meeting food needs, Indonesia is still expanding land to meet the quantity of food so as to achieve food self-sufficiency and national food security. (Madusari et al., 2020) The need for food such as vegetables is increasing along with the development of an increasingly dense population, however, this growth is not matched by the growth of agricultural land. Therefore, hydroponic cultivation can be an alternative solution to modern agricultural systems that can be developed to overcome food security problems. With hydroponic cultivation, people are expected to be able to grow vegetables with limited land available. In addition to its fast harvesting nature, hydroponic vegetables will help food security because vegetables can grow throughout the year, regardless of the climate or weather outside.

The main advantages of hydroponic systems include more efficient land use and less water requirements compared to conventional farming. This is especially important for urban areas that have limited land and water resources. According to research conducted by (Kozai et al., 2019), hydroponics enables year-round crop production independent of seasonal conditions, thus ensuring more stable food availability. In addition, hydroponics also allows crop production in a controlled environment, so the risk of damage from pests and diseases can be minimised.

This literature review aims to analyse the various studies that have been conducted on the application of hydroponics in urban areas and identify how this technology can contribute to improving food security. The literature review includes analyses on the effectiveness of hydroponics in improving crop productivity, resource use efficiency, as well as its impact on urban food security.

Several studies have shown that hydroponics can result in higher productivity and better crop quality. For example, research conducted by (Majid et al., 2021) found that hydroponic systems can produce faster and healthier growth of lettuce plants compared to conventional growing methods. Another study by (Al-Kodmany, 2018) mentioned that hydroponics can be an effective solution for vertical farming in big cities, where agricultural land is very limited.

In addition, hydroponics also has the potential to improve the sustainability of urban food systems. Using this technology, food production can be done locally, reducing dependence on food supplies from outside the city or abroad. This can reduce the carbon footprint resulting from long-distance food transport and support a more environmentally friendly food system (Raviv et al., 2019).

Overall, the implementation of hydroponics in urban areas not only offers a solution to address limited land and water resources, but also has the potential to improve food security in a sustainable and efficient manner. Therefore, this literature review is important to provide a deeper understanding of the benefits and challenges of hydroponic systems, as well as how this technology can be effectively implemented in urban areas.

## **LITERATURE REVIEW**

There has been much research on the application of hydroponics in urban areas to understand its effectiveness, benefits and challenges in improving food security. This literature review will discuss some of the important studies that have been conducted in this field, that is:

### **1. Land and Water Use Efficiency**

One of the main advantages of hydroponic systems is the efficient use of land and water. According to research conducted by (Resh, 2022), hydroponics can produce crops using only a fraction of the land required for conventional agriculture. This is particularly relevant for urban areas that have limited land.

Moreover, a study by (Kozai et al., 2019) showed that hydroponics uses about 70-90% less water compared to conventional growing methods. This efficient water use is due to the closed system that allows water and nutrients that are not absorbed by the plants to be collected and reused.

### **2. Plant Productivity and Quality**

Hydroponics is proven to increase crop productivity and quality. Research by (Majid et al., 2021) found that lettuce plants grown with a hydroponic system grew faster and healthier than plants grown on soil. This is due to better control of environmental conditions and nutrients provided optimally.

Another study by (Al-Kodmany, 2018) revealed that hydroponics can be used in vertical farming in urban areas, enabling food production in tall buildings. Vertical farming uses space efficiently and can produce high yields in a limited area.

### **3. Stability of Food Supply**

Hydroponics allows year-round crop production independent of seasonal conditions, thus ensuring more stable food availability. According to research published by (Hazell et al., 2007), seasonal dependency can be overcome by using hydroponic systems, which allow full control over growth factors such as light, temperature and humidity.

### **4. Environmental Impacts**

The use of hydroponics in urban areas also has a positive impact on the environment. According to (Raviv et al., 2019), local food production with hydroponics can reduce the carbon footprint resulting from long-distance food transport. Plus, it reduces the use of pesticides and herbicides, which often contaminate soil and water.

### 5. Challenges and Obstacles

Despite its many advantages, implementing hydroponics in urban areas also faces some challenges. The initial cost of installing a hydroponic system can be quite high, and it requires technical knowledge for operation. A study by (Kozai et al., 2019) mentioned that education and training for urban farmers and agricultural entrepreneurs is crucial for the successful implementation of hydroponics.

In addition, regulatory issues and government policies can also be barriers. According to (Al-Kodmany, 2018), policies that support urban agriculture and technological innovations such as hydroponics need to be developed to encourage wider adoption.

By (Sari et al., 2024) Access to markets is another critical challenge. While hydroponic produce is often of higher quality, urban farmers may struggle to establish distribution networks and gain consumer trust.

## RESEARCH METHOD

This research will be conducted using the literature study method, which involves collecting, analysing and interpreting data from various relevant sources. This method was chosen because it aims to examine the application of hydroponics in improving food security in urban areas through reviewing various studies that have been conducted previously.

## RESULTS

This study presents the main findings from the literature review on the application of hydroponics in urban areas to improve food security. These findings include land and water use efficiency, crop productivity and quality, food supply stability, environmental impacts, as well as challenges and solutions faced in the implementation of hydroponics, namely:

### 1. Land and Water Utilisation Efficiency

Hydroponic systems are proven to be more efficient in land and water use compared to conventional farming methods. (Resh, 2022) revealed that hydroponics can utilise limited land in urban areas to produce crops with high productivity. This is especially important for urban areas that face land limitations. In addition, research by (Kozai et al., 2019) showed that hydroponics uses about 70-90% less water compared to conventional farming methods. This water saving is very significant, especially in urban areas that often experience limited water resources.

### 2. Productivity and Crop Quality

Hydroponics has also been shown to improve crop productivity and quality. (Majid et al., 2021) found that lettuce plants grown with a hydroponic system grew faster and healthier than those grown in soil. (Al-Kodmany, 2018) showed that vertical farming with hydroponic systems in urban areas can produce high production in a limited area, utilising vertical space to significantly increase output per unit area.

### 3. Food Supply Stability

One of the main benefits of hydroponics is its ability to produce crops all year round, without depending on seasonal conditions. (Godoy et al., 2014) revealed that dependency on seasonality can be overcome by using hydroponic systems, which allow full control over growth factors such as light, temperature and humidity. This can ensure more stable food availability in urban areas, which often experience fluctuations in food supply due to seasonal changes.

#### 4. Environmental Impacts

The use of hydroponics in urban areas also has a positive impact on the environment. According to (Raviv et al., 2019), local food production with hydroponics can reduce the carbon footprint resulting from long-distance food transport. In addition, hydroponic systems reduce the use of pesticides and herbicides, which often contaminate soil and water in conventional farming systems. These positive impacts make hydroponics a more environmentally friendly farming method.

#### 5. Challenges and Solutions

Despite its many benefits, the implementation of hydroponics in urban areas also faces several challenges. One of the main challenges is the high initial cost of installing a hydroponic system. In addition, the technical knowledge required to operate a hydroponic system can be a barrier for some people. (Kozai et al., 2019) mentioned that education and training for farmers and urban agriculture entrepreneurs are crucial for the successful implementation of hydroponics.

Government regulations and policies also play an important role in supporting the implementation of hydroponics in urban areas. (Al-Kodmany, 2018) highlighted the need for policies that support urban agriculture and technological innovations such as hydroponics to encourage wider adoption. Support from the government in the form of subsidies, incentives, and training programmes can help address these challenges.

### **DISCUSSION**

This discussion will integrate the findings from the reviewed literature and analyse how hydroponics can improve food security in urban areas. The analysis covers aspects of land and water use efficiency, crop productivity and quality, food supply stability, environmental impacts, as well as challenges and solutions faced in implementing hydroponics.

#### 1. Land and Water Efficiency

The application of hydroponics in urban areas can be significant in overcoming the limitations of conventional agricultural land. (Resh, 2022) notes that hydroponic systems allow for more efficient use of both vertical and horizontal space, maximising crop output per unit of land area used. A clear example of this can be seen in the use of rooftops or other unproductive spaces for vertical planting, such as the Brooklyn Grange in New York.

Furthermore, (Kozai et al., 2019) mentioned that hydroponics uses about 70-90% less water than conventional agriculture, as water in hydroponic systems is recyclable and does not experience significant losses through evaporation and percolation as it does in soil. This not only makes hydroponics more environmentally friendly in terms of water resource management, but also reduces pressure on urban water systems that often face water availability challenges.

#### 2. Plant Productivity and Quality

Plant productivity in hydroponic systems is often higher than that of soil-grown plants. Comparative studies by (Majid et al., 2021) showed that hydroponically grown lettuce had faster growth and better production compared to plants grown on soil. This is due to better control of environmental factors such as nutrients, light, temperature, and humidity in the hydroponic system.

In addition, research by (Savvas & Passam, 2002) highlighted that hydroponics allows for more precise nutrient optimisation, which can enhance the accumulation of bioactive compounds and antioxidants in plants. This has a positive impact on the nutritional quality and added value of the products produced.

### 3. Food Supply Stability

According to (Okuputra et al., 2022) Currently, awareness of healthy lifestyles in the community has not been fully formed. However, there is a process of awareness to consume healthy food through socialisation activities during the development of hydroponic businesses. In some neighbouring houses, hydroponic advantages in ensuring the stability of food supply in urban areas are very important. (Godoy et al., 2014) noted that urban food security is often vulnerable to seasonal fluctuations and extreme weather changes. With the ability to more accurately control the growing environment, hydroponics enables year-round crop production, reducing dependence on external factors such as seasons and climate. This ensures stable food availability for urban dwellers, who often experience accessibility issues to healthy and affordable food sources.

### 4. Environmental Impacts

The environmental aspect of hydroponics is one of its advantages. In conventional agriculture, the use of chemical fertilisers and pesticides can contaminate soil and water, and pose a risk of environmental pollution. (Raviv et al., 2019) mentioned that hydroponics reduces or even eliminates the need for chemical pesticides, as the tightly controlled growing environment reduces the risk of plant pests and diseases.

In Addition, by reducing reliance on long-distance transport, hydroponics can reduce the carbon footprint generated by the food supply chain. This is especially relevant in dense urban contexts, where food transport from outside the city often contributes to air pollution and greenhouse gas emissions.

### 5. Challenges and Solutions

Despite its many advantages, implementing hydroponics in urban areas also faces a number of challenges. A major challenge is the high initial cost of building and operationalising hydroponic systems. A study by (Benke & Tomkins, 2017) noted that the initial investment for hydroponic infrastructure can be a barrier for small and medium-scale farmers who may not have sufficient capital. In addition, according to (Henly Yulina, 2019) the technical knowledge required to design and operate hydroponic systems is also a limiting factor.

According to (Asriani et al., 2020) To overcome these challenges, technical education and training are key. Education programmes tailored to local needs can help improve farmers' knowledge and skills in adopting hydroponic technology effectively. Support from the government, including subsidies and incentives for investment in urban agriculture, can also accelerate the adoption of this technology.

## **CONCLUSION**

In conclusion, the application of hydroponics in urban areas holds promise as an innovative solution to improve food security. With its high land and water use efficiency, increased crop productivity and quality, and ability to maintain stable food supply throughout the year, hydroponics has great potential to address food security challenges in the context of rapid urbanisation.

However, maximising its potential requires a holistic approach that includes education, training, policy support and collaboration between the government, private sector and local communities. Thus, hydroponics can not only be a solution to food security issues, but also play a role in creating a more sustainable and environmentally-friendly agricultural system in the future.

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