UFOR (*Urban Farm On The Rooftop*) as a Food Security Solution in the Jakarta Area During Price Fluctuations

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ABSTRACT
Jakarta serves as the center economy and industry in Indonesia, causing the city to become densely populated. Over a span of 25 years (2000–2025), Jakarta's population tripled from 9.3 million to 30 million people. This rapid population growth has led to increasing demands for fulfilling basic needs, such as food, clothing, and shelter. Among these requirements, food is the most essential necessity that must be met to ensure human survival. Indonesia itself is a developing country well-known since the past for agriculture as its population's main livelihood. However, today the nation is actually facing serious issues regarding food security. Along with the population growth in Jakarta, many agricultural lands have been converted. The rate of agricultural land conversion has reached a very alarming level. The pattern of land conversion shows that 58.7% of the total land has turned into residential areas. This condition can trigger a food crisis, where the population continues to increase but is not balanced by the food supply. As a solution, UFOR (Urban Farm On The Rooftop) is presented to address the issues of food crisis and agricultural land scarcity in Jakarta. The UFOR concept utilizes rooftops found on buildings in Jakarta to be transformed into productive agricultural land. The crops used are vegetable plants capable of surviving in Jakarta's climate, such as chili (*Capsicum annuum* L.), tomato (*Solanum lycopersicum* L.), and eggplant (*Solanum melongena*). The applied farming method is the hydroponic Wick system, chosen because it is simple yet produces high-quality yields.

ABSTRAK
Jakarta merupakan pusat ekonomi dan industri di Indonesia. Kondisi ini yang menyebabkan Jakarta padat akan penduduk. Selama 25 tahun (2000-2025) penduduk Jakarta bertambah tiga kali lipat dari 9,3 juta ke 30 juta penduduk. Meningkatnya jumlah penduduk ini menyebabkan tuntutan terpenuhinya kebutuhan pangan,sandang dan papan semakin tinggi. Di antara kebutuhan yang lainnya pangan merupakan kebutuhan yang harus dipenuhi agar kelangsungan hidup seseorang dapat terjamin. Indonesia merupakan satu di antara Negara berkembang yang dulu hingga sekarang masih terkenal dengan mata pencaharian penduduknya sebagai petani. Namun, dewasa ini Indonesia justru menghadapi masalah yang serius dalam ketahanan pangan. Saat ini seiring peningkatan penduduk di Jakarta banyak lahan-lahan pertanian yang telah dikonversi. Tingkat konversi lahan pertanian sudah sampai pada taraf yang sangat menghawatirkan. Pola konversi lahan sebanyak 58,7% berubah menjadi lahan pemukiman. Hal tersebut dapat menyebabkan krisis pangan yaitu suatu kondisi penduduk yang terus meningkat namun tidak diimbangi dengan pasokan pangan. UFOR (*Urban Farm On The Rooftop*) merupakan solusi dalam menjawab permasalahan krisis pangan dan sedikitnya lahan pertanian di daerah Jakarta. Konsep UFOR ini memanfaatkan *Rooftop* yang terdapat pada bangunan di Jakarta untuk dijadikan lahan pertanian. Tanaman yang dipakai adalah tanaman sayuran yang mampu bertahan hidup di daerah Jakarta seperti cabai (*Capsicum annum* L), tomat (*Solanum lycopersicum* L), terong (*Solanum melongena*). Cara pertanian yang dilakukan yaitu secara Hidroponik sistem Wick, cara ini dipilih karena sederhana namun dapat menghasilkan produk yang berkualitas.

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KEYWORDS
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INTRODUCTION

Agricultural development currently plays a strategic role in supporting food security. However, Indonesia continues to face several major challenges that hinder sustainable agricultural development. One of the most significant issues is the continuous reduction of agricultural land. According to Anton Apriyantono, there are five major land-related problems in Indonesia. First, farmers own relatively small plots of land, making it difficult to

support their families' livelihoods. Second, land productivity continues to decline due to excessive intensification and the prolonged use of chemical fertilizers. Third, agricultural land conversion to non-agricultural purposes, such as industrial development and residential areas, has increased significantly. Fourth, the implementation of commodity mapping based on agroecosystems has not yet been optimized. Fifth, a considerable amount of land remains idle and unutilized (Anton Apriyantono, *Agricultural Development in Indonesia*, p. 13).

The rate of agricultural land conversion has reached an alarming level. According to the Ministry (2012), approximately 58.7% of converted agricultural land has been transformed into residential areas. This phenomenon has serious consequences for agricultural development, as it threatens Indonesia's food security and contributes to fluctuations in food prices. A clear example occurred in early January 2017, when chili prices increased by nearly threefold due to unfavorable weather conditions that significantly reduced chili production and supply (Lestari, 2017). Another factor contributing to fluctuations in chili prices is that chili cultivation is generally confined to specific regions and relies on conventional farming methods. If chili cultivation could be expanded into urban areas using greenhouse technology capable of controlling environmental conditions, adverse weather would no longer pose a major obstacle to agricultural production.

Food security is a fundamental issue in ensuring public welfare because it directly influences a country's economic, social, and political stability. Among all basic human needs, food is the most essential requirement for sustaining life. Indonesia, as a developing country, has long been recognized as an agrarian nation, with a large proportion of its population engaged in farming. Nevertheless, Indonesia is currently facing serious food security challenges. Figure 1 illustrates that the country's food security steadily declined each year from 2008 to 2012.

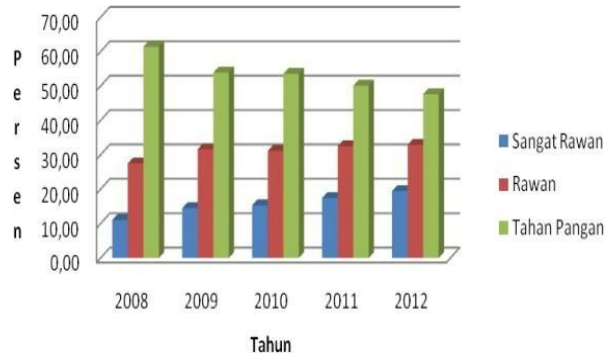


Figure 1. Indonesia's Food Security and Food Vulnerability, 2008–2012

Jakarta is Indonesia's metropolitan city, capital, and a major center of government, commerce, and industry. These characteristics have made Jakarta one of the most densely populated cities in the country. Over a period of 25 years (2000–2025), Jakarta's population tripled from 9.3 million to approximately 30 million inhabitants (R. E. Waterman, 2008). According to the 2010 Population Census conducted by Statistics Indonesia (BPS), Jakarta had a population of 9.6 million, representing approximately 4% of Indonesia's total population of 237.6 million (BPS, 2010). This rapid population growth has significantly increased the demand for food as well as for infrastructure such as housing, hotels, hospitals, and commercial buildings, resulting in a continuous reduction of available land. On the other hand, numerous buildings in Jakarta possess rooftops with considerable potential for productive use. Siswantih (1973) argued that the rooftops of multi-story buildings represent a unique environment that presents opportunities to be transformed into productive spaces. Likewise, Khan (1995) noted that building rooftops constitute valuable resources that remain largely underutilized. Therefore, these unused rooftops could be converted into agricultural areas where urban residents cultivate vegetables and other crops through urban farming practices.The Food and Agriculture Organization (FAO) defines urban agriculture as an industry that produces, processes, and markets agricultural products primarily to meet the daily demands of urban consumers. Urban agriculture utilizes intensive production methods while recycling urban resources and waste to produce a wide variety of food crops for city populations (Smit, J., A. Ratta, & J. Nasr, 1996).

Japan is one of the countries that has successfully implemented urban farming. Despite being one of the world's leading industrialized nations, agricultural land remains a common feature within urban landscapes across the country. Nearly one-third of Japan's total agricultural production originates from urban agriculture, while urban farmers account for approximately 25% of all farming households. Furthermore, urban agriculture in Japan has proven to be more productive than its rural counterpart. According to the Ministry of Agriculture, Forestry and Fisheries (MAFF, 2010), urban agricultural land is the most productive type of farmland in terms of economic

output per unit area, generating production values approximately three times higher than the national average. In terms of farmers' income, urban agriculture generates approximately twice the income of farming in mountainous regions and around 10% more than farming in rural lowland areas. Even in Tokyo, one of the world's largest and most densely populated cities, local urban agriculture produces enough vegetables to potentially supply food for nearly 700,000 residents despite the city's extensive networks of railways, roads, buildings, and utility infrastructure. Considering Japan's success in implementing urban agriculture, there is significant potential to adopt a similar approach in Indonesia, particularly in Jakarta, where population density is extremely high. Implementing UFOR (Urban Farm on the Rooftop) in Jakarta offers a promising solution to strengthen food security while simultaneously optimizing the utilization of unused rooftop spaces throughout the city.

METHODS

The method employed in designing this written ideas is descriptive qualitative, based on literature studies and the development of strategic urban planning concepts. The stages carried out in realizing this idea consist of six main strategic steps that are continuously interconnected. The first stage begins with building transition arenas and constructing a shared vision through multi-sector coordination involving the city government, academics, corporations, and civil society representatives to align the project's goals. The second stage focuses on providing the public with in-depth insights regarding efficient urban hydroponic farming methods. The third stage is to mobilize relevant stakeholders, specifically through the allocation of incentives and stimulus funding for the communities managing rooftop farming. The fourth stage is focused on selecting horticultural commodities that are adaptive to urban temperatures, such as chili (*Capsicum annum l.*), tomato (*Solanum lycopersicum l.*), and eggplant (*Solanum melongena*). The fifth stage executes the cultivation process using the hydroponic Wick system on building rooftops, which is estimated to take a three-month crop cycle duration. The final stage concludes with local harvest distribution management to directly supply the fresh food demands of the urban community in the Jakarta region. UFOR design sketch.

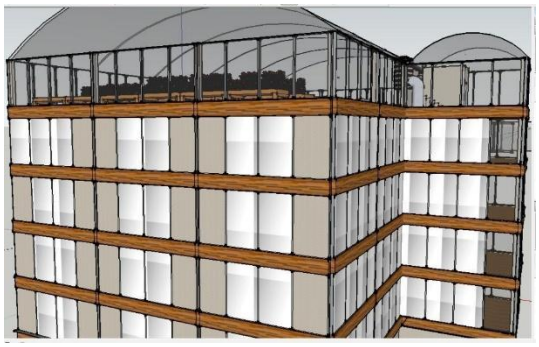


Figure 2. UFOR outer cross section



Figure 3. The interior of the UFOR

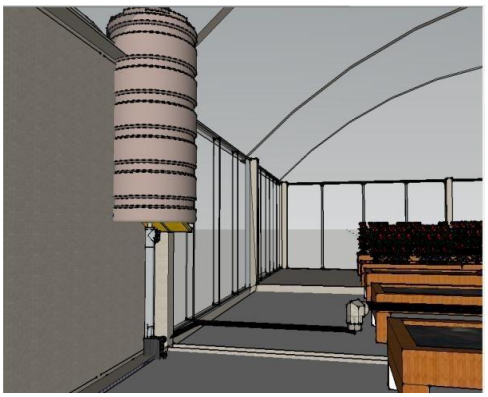


Figure 4. Reservoir containing nutrient solution

RESULTS AND DISCUSSIONS

The findings of the literature review indicate that rooftop greenhouses are a promising urban agriculture approach that optimizes the utilization of underused spaces on multi-story buildings, thereby addressing the challenges associated with limited agricultural land in urban environments. Furthermore, rooftop greenhouse

systems enhance land-use efficiency while achieving high crop productivity per unit area (Drottberger et al., 2023). Based on a comprehensive analysis of various relevant scientific literatures, key findings have been obtained that reinforce the urgency, technical feasibility, and positive impact of implementing the Urban Farm on the Rooftop (UFOR) concept. Literature studies indicate that the limitation of horizontal land in urban areas resulting from massive land-use conversioncan be overcome by optimizing the flat rooftops of high-rise buildings as productive spaces.Technically, the use of a passive hydroponic system (Wick system) combined with a protective greenhouse structure is scientifically proven to engineer microclimate conditions. This engineering is crucial to protect crops from extreme weather fluctuations on the rooftop, while simultaneously mitigating the risk of pest attacks without overloading the building's concrete structure.From the dimensions of food security and urban economy, on-site food production shortens long distribution chains. This not only mitigates the risk of price fluctuations caused by crop failures in conventional production centers, but also curbs food inflation and creates new green economy based job opportunities for urban communities.

Table 1. Analytical Aspects of Urban Farm on The Rooftop

No	Analytical Aspect	Literature Synthesis Results	References
1	Land Availability & Optimization	The flat rooftops of high-rise buildings represent potential vertical spaces (idle land) that have not been optimally utilized and hold high feasibility for development into urban farming areas to address the horizontal land crisis.	Siswantih (1973); Khan (1995)
2	Urban Land Use Conversion	The conversion of productive land into residential areas and infrastructure triggers urban food vulnerability, necessitating a transition toward vertical farming systems.	Tahrir (2011); BPS (2013)
3	Efficient Cultivation Technology	The application of hydroponics increases the efficiency of water and nutrient use in limited spaces without exerting excessive mechanical loads on the building's concrete slab structure.	Setiawan et al. (2014)
4	Microclimate Control	The use of protective structures such as greenhouses (roof gardens) is capable of manipulating temperature, humidity, and strong wind exposure at rooftop heights to maintain stable crop growth and development.	Sutanto (2011); Setiawan et al. (2014)
5	Urban Food Security	Urban farming enhances the self-sufficient availability of fresh food products in urban areas and reduces dependence on vegetable commodity supplies from other regions.	FAO / Smit et al. (1996)
6	Supply Chain	The short food distribution chain directly from the rooftop to urban consumers reduces post-harvest losses and eliminates high logistical transportation costs.	FAO / Smit et al. (1996); Bulog (2023)
7	Economic Benefits & Pricing	Continuous, self-sufficient vegetable production in urban environments is capable of stabilizing commodity market prices during adverse weather conditions in buffer zones	Susilowati & Rachman (2008); Lestari (2017); Wan (2016)
8	Productivity & Welfare	The integration of urban agriculture is economically proven to yield higher production value per area compared to rural areas, while also boosting the income of urban communities.	MAFF (2010); Rizkfath (2015)

Horizontal land limitations in urban areas resulting from massive land-use conversion can be overcome by optimizing the flat rooftops of multi-story buildings as productive agricultural spaces. Spatially, the rooftop areas that have functioned as idle land on high-rise buildings in metropolitan regions like Jakarta possess high theoretical and technical feasibility to be converted into green spaces that support food security for urban communities (Siswantih, 1973; Khan, 1995). The phenomenon of urban productive land conversion into residential areas and commercial infrastructure significantly triggers serious urban food vulnerability (Tahrir, 2011; BPS, 2013). The pattern of land conversion, which reaches 58.7% into residential areas, demands spatial innovation. Therefore, a spatial transition toward utilizing vertical space and upper building structures has become an urgent necessity to

maintain a balance between rapid urban population growth and the availability of green spaces for producing major horticultural commodities without opening new land.

From the perspective of cultivation technology, the application of hydroponic farming systems is scientifically proven to significantly increase water-use efficiency and nutrient solution absorption in highly limited spaces (Setiawan et al., 2014). The choice of passive hydroponic technology, such as the Wick system, provides crucial mechanical advantages for rooftop ecosystems. Because it does not require soil media, which possesses a high specific gravity, this system minimizes hydrostatic pressure loads and excessive structural burdens that could endanger the construction of concrete slabs or decks of multi-story buildings. The operational reliability on top of these roofs is further supported by microclimate engineering modifications through the integration of protective greenhouse structures (greenhouses or roof gardens) capable of manipulating temperature parameters, air humidity, and reducing exposure to strong winds that commonly occur at urban rooftop heights (Sutanto, 2011; Setiawan et al., 2014). The physical protection provided by the greenhouse also functions as a natural barrier to minimize the risk of pest and plant pathogen attacks, thereby ensuring that the quality and quantity of vegetable products remain at an optimal level.

Regarding the dimensions of food security and urban macroeconomic stability, implementing on-site food production through rooftop farming directly contributes to increasing the accessibility of fresh food products and reduces the high dependence on vegetable commodity supplies from buffer zones (FAO / Smit et al., 1996). Shortening the food distribution chain—from what originally involved inter-regional logistics into a short, direct pathway from the rooftop to the consumer's dining table—is proven capable of significantly reducing post-harvest losses and eliminating high logistical transportation costs (FAO / Smit et al., 1996; Bulog, 2023). This approach is highly effective for cutting the long supply chains that often serve as the primary agent of urban food inefficiency.

Economically, the continuous and self-sufficient production of urban vegetables acts as a market shock absorber. This system is capable of stabilizing retail price fluctuations of vegetable commodities in local markets during crop failures caused by extreme weather conditions in rural production centers (Susilowati & Rachman, 2008; Lestari, 2017; Wan, 2016). By providing a constant supply from building rooftops, food inflation at the city level can be suppressed periodically. Ultimately, the integration of urban agriculture not only yields a significantly higher economic production value per unit area compared to conventional rural farming, but also opens up new employment corridors based on the green economy (green jobs) that tangibly improve the standard of living, food self-sufficiency, and sustainable welfare of urban communities (MAFF, 2010; Rizkfath, 2015).

CONCLUSIONS

The proposed implementation of UFOR (Urban Farm on the Rooftop) is the first concept of its kind in Indonesia and is particularly suitable for urban areas, especially Jakarta. UFOR is an urban farming system that utilizes building rooftops as agricultural land. The cultivation method employed in this concept is the wick hydroponic system, which is considered more efficient and advantageous because it does not require soil as the growing medium. Instead, plants are cultivated using nutrient-enriched water, thereby preventing damage to rooftop structures. In addition, greenhouses are incorporated to create and maintain controlled environmental conditions that optimize plant growth. The vegetable crops are arranged vertically using wooden support structures, enabling higher production within limited space. Through the implementation of UFOR, food prices can become more affordable because distribution requires lower transportation costs. Furthermore, UFOR has the potential to strengthen urban food self sufficiency by providing locally produced food through rooftop farming. In addition, the implementation of this concept can generate new employment opportunities by promoting the development of urban agricultural industries.

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