THE JOURNAL OF INDONESIA SUSTAINABLE DEVELOPMENT PLANNING

VOL. 6 NO. 2 – AUGUST 2025

E-ISSN: 2722-0842 | P-ISSN: 2721-8309

Available online at

http://journal.pusbindiklatren.bappenas.go.id/

Policy Paper

Characteristics and Strategies of Rooftop Farming in Jakarta for Sustainable Development

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Abstract

This study explores the characteristics and implementation strategies of rooftop farming in Jakarta as a response to urban food insecurity and sustainability challenges. Using a mixed-methods approach, comprising literature review, semi-structured interviews, and policy gap analysis, the study investigates rooftop farming practices across 27 sites in Jakarta. It examines infrastructure, market access, and institutional support. The findings reveal limited access to funding, technology, and formal guidance, despite the practice's potential to enhance food security and green infrastructure. Comparative insights from cities such as Singapore and Melbourne highlight the effectiveness of targeted incentives and integrated planning. The study proposes practical policy recommendations, including technical guidelines, subsidies, urban spatial integration, and public education programs. These measures aim to support a more resilient and sustainable urban food system in Jakarta.

Keywords: Rooftop farming; sustainability; food security; Jakarta.

ARTICLE INFO
Received: January 15, 2025
Received in revised form: March 19, 2025
Accepted: August 31, 2025

doi: 10.46456/jisdep.v6i2.648

THE JOURNAL OF INDONESIA SUSTAINABLE DEVELOPMENT PLANNING
Published by Centre for Planners' Development, Education, and Training (Pusbindiklatren), Ministry of National Development Planning/National Development Planning Agency (Bappenas), Republic of Indonesia

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Supported by Indonesian Development Planners Association (PPPI)

Please cite this article in APA Style as:
Akbar, F. M., Janita, E. S., Muharrik, M., Giffari, A., Ajie, A., & Apsari, A. P. (2025). Characteristics and strategies of rooftop farming in Jakarta for sustainable development. *The Journal of Indonesia Sustainable Development Planning, Vol 6(2),* 328-346. https://doi.org/10.46456/jisdep.v6i2.648

1. Introduction

The surge in international food prices had become a major global issue, driven by conflicts and extreme weather resulting from the El Niño phenomenon (FAO, 2015; Viglione, 2024). This crisis threatened food security and heightened malnutrition risks, especially in resource-limited nations (FSIN, 2023). It underscored the lack of access to sufficient, safe, and nutritious food. According to the 2023 Global Food Security Index (GFSI) developed by The Economist Intelligence Unit (EIU), Indonesia experienced a decline in ranking, from 63rd in 2022 to 69th out of 113 assessed countries. The GFSI assessed food security across Affordability, Availability, Quality and Safety, and Sustainability and Adaptation, key factors influencing food accessibility, production capacity, nutritional quality, and resilience to climate change.

Urban population growth in developing countries, including Jakarta and Indonesia, has increased significantly more than in developed countries. Jakarta has faced rapid urbanization fueled by rural to urban migration, leading to high population density, slum growth, and strained infrastructure (Marta et al.,2020; United Nations, 2016). The city's population reached 10.67 million in 2023, increasing by 702,000 over a decade (BPS-Statistics Indonesia, 2023). Under Law No. 2 of 2024, Jakarta is set to become a national hub for trade, finance, and business, requiring strategic solutions to urban challenges, including food security.

Rapid urbanization in Jakarta has led to a significant reduction in arable land, while the city has simultaneously faced increasing challenges related to food security, climate resilience, and environmental degradation. The growing population has exacerbated health and malnutrition issues, intensified food insecurity, and imposed additional economic burdens on urban residents. This phenomenon has further destabilized food supplies and threatened the financial well-being of communities. In response, some migrants have turned to urban farming practices to produce their own food and secure more stable income sources. With limited space for traditional farming, urban agriculture has emerged as a viable solution by enhancing local food supply, supporting environmental sustainability, and reducing carbon footprints. Global innovations in sustainable food systems offer valuable insights: Nigeria has applied biotechnology to address food crises (Oluwambe, 2017); the Netherlands has pioneered IoT-based precision agriculture (Bakker et al., 2011); and China has integrated AI with vertical farming to improve urban food production (MARA, 2021). However, despite its potential, rooftop farming in Jakarta remains underutilized due to regulatory gaps, limited technological access, and a lack of coordinated policy support.

Rooftop farming on high-rise buildings in Jakarta holds significant potential to address the food crisis and enhance urban food security. This approach utilizes building rooftops as cultivation areas through techniques such as hydroponics, aeroponics, and container gardening (Mortuza et al., 2014). In this context, local governments must develop integrated strategies that not only promote sustainable rooftop farming but also optimize underutilized urban spaces. A comprehensive understanding of current conditions and the barriers faced by rooftop farming practitioners is urgently needed to inform effective policy development and unlock the full potential of this green infrastructure approach.

Several studies have explored strategies to mitigate the food crisis through urban farming. Some had examined the characteristics and typologies of urban agriculture in Jakarta (Chandra & Diehl, 2019), while others had analyzed the interaction between urban expansion, land-use change, and food security in developing countries (Abu Hatab et al., 2019). Other research had focused on mapping land-use changes for urban agriculture (Diehl et al., 2020) and designing indicator-based evaluation frameworks for urban farming in Aarhus, Denmark (Tapia et al., 2021). Additionally, studies have analyzed the role of actors in food systems and their contributions to food security (Soriano et al., 2023). The urgency of this research lay in the absence of prior studies that directly addressed the research questions and objectives explored here. Existing literature on rooftop farming tended to focus on cities outside Jakarta, and even those within Jakarta had not specifically examined the characteristics and challenges faced by rooftop farming practitioners. Moreover, no policy gap analysis was conducted to inform context-specific policy recommendations. In response, this study analyzed the characteristics and strategic implementation of rooftop farming in Jakarta to address the following research questions: (i) What are the key characteristics

and challenges faced by rooftop farming practitioners in Jakarta across different ownership sectors? (ii) How do government support and infrastructure conditions influence the implementation and sustainability of rooftop farming in Jakarta? Accordingly, key objectives of this research are: (i) to map the characteristics of rooftop farming practitioners in Jakarta, (ii) to identify the challenges and barriers in the implementation of rooftop farming, and (iii) to propose strategic policy recommendations for improving rooftop farming conditions. This research employed a mixed methods approach, combining quantitative and qualitative methods to provide a comprehensive understanding of rooftop farming practices. A comparative study was also conducted by examining global cities to derive relevant strategic recommendations, selecting cities based on their capacity for innovation and urban agriculture development to tackle local food crises.

This study has several limitations that may influence its findings and generalizability. It was conducted between July and August 2024. Therefore, the research reflected field conditions at the time. The sample size was determined using data from the Jakarta Provincial Food Security, Marine, and Agriculture Agency (DKPKP), and respondents were rooftop farming practitioners who had registered with DKPKP. This study focused solely on the characteristics of rooftop farming practitioners to make public policy recommendations to the Jakarta City Government, and it did not consider any other variables or factors that could influence the effectiveness and implementation of this approach.

The findings of this study provided valuable insights for the Jakarta City Government regarding effective regulations to enhance both the quantity and quality of rooftop farming activities in Jakarta. These improvements, in turn, contributed to local food security, environmental sustainability, and overall urban resilience. The study compared rooftop farming policies and initiatives across global cities during the literature review stage. For instance, Melbourne was recognized for its policies supporting food sustainability and green spaces, including financial assistance, tax reductions, and educational programs. Singapore had implemented the Skyrise Greenery Incentive Scheme and the Community in Bloom program, which extensively supported rooftop farming, including in public facilities such as hospitals. Meanwhile, New York City offered tax incentives, technical guidelines, and safety regulations to promote rooftop farming implementation. These three cities had successfully formulated policies that enhanced both the quality and quantity of rooftop farming, significantly contributing to local food security.

2. Methods

This research was conducted in the Special Capital Region (DKI) of Jakarta, where data was distributed across five Administrative Cities and one Administrative Regency, namely Central Jakarta, North Jakarta, West Jakarta, South Jakarta, East Jakarta, and the Administrative Regency of Kepulauan Seribu (The Thousand Islands). The selection of rooftop farming practitioners' locations was determined based on data from the Jakarta Provincial Food Security, Marine, and Agriculture Office (DKPKP), as the rooftop farming program, which is part of urban farming, falls under the duties and functions of the Jakarta Provincial DKPKP Office. Data collection was carried out over six (6) weeks, from July to the second week of August 2024, with semi-structured interviews conducted in the third week of August 2024, containing many open-ended questions that explore respondents' opinions or experiences in depth.

The research utilized both primary and secondary data. Primary data referred to data collected directly from respondents in the field, involving various stakeholders. It was gathered through questionnaires distributed to rooftop farming practitioners in Jakarta, agricultural extension officers, and representatives from the Jakarta Provincial Food Security, Marine, and Agriculture Office (DKPKP). Secondary data was obtained from the Ministry of Agriculture, the Jakarta Provincial DKPKP, existing policies, scientific papers such as journals, as well as books in both print and electronic media.

2.1. Data Collection Methods

This study utilized a combination of qualitative data collection methods, including literature review and semi-structured interviews. The literature review served as a qualitative approach by gathering, analyzing, and interpreting written or visual documents related to rooftop farming. Sources included government policies and regulations, training curricula, evaluation reports, scientific journals, and media content from both domestic and global cities. This method ensured the research was grounded in accurate

and reliable information regarding field conditions, strategic issues, challenges, and opportunities in the rooftop farming sector. Literature reviews have proven effective in understanding contemporary conditions and regulatory frameworks (Bowen, 2009; Snyder, 2019).

Semi-structured interviews were conducted with rooftop farming practitioners in Jakarta to gain in-depth insights into existing conditions, technical implementations, and strategies for improving rooftop farming quality. These interviews, held both in person and online, provided a detailed perspective from respondents. According to Sartison & Artmann (2020), rooftop farming practitioners can be categorized into three groups:

Table 1. Rooftop Farming practitioners

No	Rooftop Farming Actor Group	Description
1	Local/Regional Government	Actors who work as civil servants or apply rooftop farming to government buildings.
2	Community	Actors who are individuals or communities practicing rooftop farming on privately owned land.
3	Local Economy/Entrepreneurs	Includes all economic activities within the city or district, such as those conducted by farmers, gardeners, landscape architects, and housing associations.

Source: *Sartison & Artmann (2020)*

The purposive sampling technique was chosen to ensure that the respondents had relevant expertise and experience in rooftop farming, allowing for a more accurate and insightful analysis. This approach enabled selecting participants who were directly involved in or had substantial knowledge of the subject, ensuring that the data collected was rich, detailed, and meaningful. Additionally, given that this study examined both infrastructure and process variables as well as market share and impact variables, selecting knowledgeable respondents ensured a comprehensive understanding of the technical and economic aspects of rooftop farming in Jakarta. Based on the researcher's analysis of the reviewed literature study and semi-structured interview, the success variables of rooftop farming have been categorized into two groups: infrastructure and process variables, and market share and impact variables. Infrastructure and process encompassed the technical aspects of rooftop farming, while market share and impact addressed the utilization of harvests and their contribution to the local market.

Table 2. Variables and Indicators of Rooftop Farming Success

No	Variable	Indicator	Operational Definition
1	Infrastructure and Process	Building Structure	The condition of the rooftop building used for farming activities, including strength, safety, and suitability for crop cultivation
		Technology and Innovation	The types of technology used in rooftop farming activities, such as hydroponic, aquaponic, aeroponic systems, or irrigation and climate control technologies
		Accessibility	The ease of reaching the rooftop farming location, both for operators and for the distribution of harvests
		Irrigation	The irrigation systems used to meet the water needs of crops
		Maintenance	The frequency and types of plant maintenance activities, such as fertilization, pest and disease control, and pruning
		Production Process	The stages of activities from land preparation to the harvesting of crops on the rooftop.
2	Market Share and Impact	Crop Variation	The number of plant varieties cultivated in rooftop farming activities
		Output	The quantity and quality of harvests obtained from rooftop farming activities.
		Output Utilization	How rooftop farming practitioners use their harvests
		Market	Distribution channels or sales locations for rooftop farming harvests
		Government Role	Support or programs provided by the government for rooftop farming development
		Collaboration	Partnerships established with other parties, such as communities, NGOs, or companies, in rooftop farming activities
		Activities	Other activities conducted in rooftop farming areas, such as training, education, or social events
		Impact	Employment opportunities created by rooftop farming activities

Source: *Data Analysis, 2024*

2.2. Data Processing Methods

Data analysis employed a combination of quantitative and qualitative methods to provide a comprehensive understanding of rooftop farming practices. Quantitative analysis in this study processed numerical data obtained from secondary documents and quantified responses extracted from semi-structured interviews, focusing on key indicators such as technology adoption, infrastructure conditions, and crop yield performance. This approach provided a clear statistical representation of existing rooftop farming practices. Meanwhile, qualitative analysis was used to interpret narrative data from semi-structured interviews and literature reviews. It aimed to capture insights from practitioners' experiences, expert opinions, and policy implementations in other cities. By focusing on thematic interpretation, qualitative analysis helped uncover rooftop farming implementation's subjective and in-depth aspects, including challenges and opportunities.

As explained by Creswell (2013) and Sugiyono (2013), the combination of these two approaches balanced measurable numerical understanding with deeper qualitative insights. Miles and Huberman (1994) also emphasized the importance of qualitative analysis in capturing complex social dynamics, particularly in the context of Jakarta's rooftop farming ecosystem. By integrating both methods, this study has explored not only quantitative aspects such as crop yield measurements and technology use but also has provided a richer understanding of social interactions and policy challenges faced by rooftop farming practitioners.

3. Results and Discussions

Semi-structured interviews revealed that rooftop farming in Jakarta exhibited diverse characteristics shaped by limited government funding, lack of technical expertise, and infrastructure constraints. The rooftop farming practitioners who participated in this study were managers, with a total of 31 entities. However, only 27 entities were willing and qualified to answer all questions. Therefore, the data analysis was based on the available respondents. Participants highlighted the significance of government support and local incentives in fostering urban farming. This study found that community-led initiatives played a crucial role in the sustainability of rooftop farming, aligning with the research conducted by Smith et al. (2020), which found that strong local engagement significantly enhanced urban farming resilience. However, this study also identified challenges, such as inconsistent policy support and the high cost of implementation, which contradicted the findings of Jones (2018), who argued that rooftop farming in Asian megacities thrives primarily due to favorable policy frameworks. These discrepancies may have stemmed from methodological differences or variations in the regulatory environments of different cities.

Comparing these findings to existing urban agriculture theories, this study supported that social and economic factors were as important as environmental considerations in determining urban farming success. The agreement with Smith et al. (2020) emphasized the importance of community-driven strategies, reinforcing the placemaking approach in urban sustainability literature. These findings have added to the broader research landscape by highlighting the significance of a localized approach to rooftop farming strategies that considers socioeconomic dynamics and policy gaps unique to Jakarta.

3.1. Overview of Rooftop Farming in Jakarta

The researchers conducted observations while carrying out semi-structured interviews accompanied by the DCKTRP of DKI Jakarta Province to gather relevant information on farming techniques, resource management, economic feasibility, and stakeholder involvement. This study was conducted across five administrative regions and one administrative regency in the DKI Jakarta Province, encompassing Central Jakarta, North Jakarta, West Jakarta, South Jakarta, East Jakarta, and the Administrative Regency of Thousand Islands. A total of 31 rooftop farming locations were studied, with data collected from the DKI Jakarta Provincial Food Security, Marine, and Agriculture Agency. The sample distribution included 8 locations in Central Jakarta, 5 in South Jakarta, 9 in East Jakarta, 2 in West Jakarta, 8 in North Jakarta, and 1 in the Thousand Islands.

Table 3. List of Rooftop Farming Practitioners in Jakarta

Location	Rooftop Farming Practitioner Name
Central Jakarta	1. Roof Garden DCKTRP (*Dinas Cipta Karya, Tata Ruang dan Pertanahan* - Department of Public Works, Spatial Planning, and Land Affairs) 2. *Smart Farming* Masjid Asy-Syifa RSCM 3. *Rooftop* Yasmine Hidroponik 4. *Rooftop* Cikini 73 5. *Rooftop Farm* DKPKP 6. *Rooftop* DPRD DKI Jakarta 7. *Rooftop* Balaikota Blok H 8. *Rooftop* Masjid As. Syifa
North Jakarta	1. Rooftop Saung Hidroponik 2. Rooftop Kantor Camat Penjaringan 3. Rooftop UPPP Muara Angke 4. Rooftop Tower 6 Koptan RW 27 GNR-GEA (Gading Nias Residences - Grand Emera Apartment) 5. Rooftop Masjid At-Taqwa Sunter Muara 6. Rooftop Dinanti Farm 7. Rooftop Walikota Administrasi Jakarta Utara 8. Rooftop Ibu Martini
West Jakarta	1. Rooftop Kelompok Tani At Taufiq 2. Ro*oftop* Damkar Tambora *Farm*
South Jakarta	1. Rooftop Latar Babe 2. Rooftop Yayasan At–Taufiq 3. Rooftop Puskesmas Tebet 4. Rooftop Kenanga 5. Rooftop Ibu Susi Widiarti
East Jakarta	1. Rooftop Kebun Anggur Atap Surga Cipinang Muara 2. Rooftop Kelurahan Pondok Ranggon 3. Rooftop Kelurahan Bambu Apus 4. Ro*oftop* PPKM (Pembudidayaan PPSU Kelurahan Kebon Manggis) 5. Rooftop Kantor Kelurahan Balimester 6. Rooftop Hydro Tani 7. Rooftop P2L Masjid 8. Roofto*p Farm* Jakarta Timur 9. *Rooftop* Kebon Manggis
Thousand Islands	*Rooftop* KWT Hijau Lestari

Source: Food Security, Marine, and Agriculture Agency, 2024

3.2. Demographics of Rooftop Farming in Jakarta

This study involved 27 rooftop farming practitioners. As a result, the data analysis was conducted using the available respondents. The respondents' characteristics included gender, age, educational level, type of occupation, duration of involvement in rooftop farming activities, primary motivation, and goals for rooftop farming. Table 4 presents the detailed characteristics of these respondents.

Table 4. Characteristics of Rooftop Farming Practitioners in Jakarta

Characteristics	Number of Practitioners (Entities)	Percentage (%)
Gender		
Male	20	74,07
Female	7	25,93
Age		
20-30 years	1	3,70
31-40 years	8	29,63
41-50 years	12	44,44
51-60 years	5	18,52
>60 years	1	3,70
Educational Level		
Junior High School	1	3,70
Senior High School	13	48,15
Diploma	2	7,41
Undergraduate	8	29,63
Postgraduate	3	11,11

Characteristics	Number of Practitioners (Entities)	Percentage (%)
Occupation		
Civil Servants	7	25,93
Private Employees	5	18,52
Entrepreneurs	4	14,81
Contracted Workers	5	18,52
Armed Forces	1	3,70
Housewife	3	11,11
Public Infrastructure Workers	1	3,70
Freelance Workers	1	3,70
Total	**27**	**100**

Source: Data Analysis, 2024

The demographic analysis of rooftop farming practitioners in Jakarta revealed a significant gender disparity, with male participants dominating at 74.1%, while female participants accounted for only 25.9%. This suggested that men had more commonly undertaken rooftop farming, possibly due to cultural norms, physical labor requirements, or differences in occupational roles. The lower female participation may have indicated potential barriers such as time constraints, accessibility, or differing levels of interest in urban farming activities.

Regarding age distribution, the most active group in rooftop farming fell within the 41–50 age range (44.4%), followed by those aged 31–40 (29.6%). This pattern suggested that middle-aged individuals, who were likely to have stable careers and financial resources, had been the primary drivers of rooftop farming. Participation rates declined among both younger (20–30 years, 3.7%) and older (over 60 years, 3.7%) age groups, possibly due to limited experience, competing professional priorities, or physical limitations in maintaining rooftop farms. The relatively low involvement of younger individuals may have indicated a need for stronger engagement strategies, such as educational programs or incentives, to encourage participation among the next generation of urban farmers.

The educational background of rooftop farming practitioners in Jakarta indicated that most participants had attained a formal education level equivalent to senior high school (48.2%), followed by undergraduate graduates (29.6%). This suggested that rooftop farming had been accessible to individuals with varying educational levels and did not necessarily require higher education in agriculture or urban planning. The presence of undergraduate graduates among practitioners may have reflected an interest in urban farming as a sustainable practice, particularly among those with environmental studies, business, or engineering backgrounds.

The occupational diversity among rooftop farming practitioners further reflected a broad socioeconomic range. Civil servants comprised the largest professional group (25.9%), likely due to their stable working hours and access to institutional support, allowing them to engage in and sustain farming initiatives. This aligned with observations conducted during semi-structured interviews, which revealed that government rooftop farms were often managed directly by employees. Private sector employees, entrepreneurs, and contract workers each represented 18.5% of participants, highlighting that rooftop farming had been adopted across different work sectors. However, the relatively lower involvement of private sector employees may have been influenced by time constraints and job demands. These findings suggested that institutional support and job flexibility had significantly enabled rooftop farming participation.

3.3. The Existing Conditions of Rooftop Farming in Jakarta

3.3.1. Variable 1: Related to Infrastructure and Process Aspects

3.3.1.1. Building Structure

The development of rooftop farming in Jakarta required a deep understanding of the physical condition of buildings, especially the roofs that could be used for agricultural activities. Based on observations and semi-structured interviews conducted at 27 rooftop farming locations across six administrative areas of Jakarta, it was found that most buildings had utilized concrete as their primary rooftop material (96.3%), with only one location (3.7%) using autoclaved aerated concrete and reinforced concrete. No buildings were reported to use steel or wood structures. The use of concrete as the primary

material had proven to be highly beneficial, as it was known for its durability and ability to support the additional loads of rooftop farming activities, such as hydroponic systems and irrigation installations, without compromising the building's stability (Pratama et al., 2023). Concrete also helped reduce building damage caused by extreme weather variations in urban areas (Diehl et al., 2019).

From a rapid visual observation, most buildings appeared in excellent condition, with 19 entities (70.4%) in good condition or without significant damage and able to bear heavy loads. Meanwhile, eight entities (29.6%) of buildings were also in good condition, with minor damage, which still allowed the building to support moderate loads. No buildings were reported to be in poor or adequate condition. The good condition of the building structures indicated that most buildings in Jakarta were ready to support the implementation of rooftop farming without requiring major repairs.

Regarding the age of the buildings, the majority were between 11 and 20 years old (44.4%), followed by those aged 5 to 10 years (29.6%). Buildings under five years old accounted for 18.5%, while only 3.7% were older than 30. The age of the building played an important role in determining its readiness to be adapted for rooftop farming. Older buildings might have required additional adjustments, but those constructed within the past 20 years generally adhered to more flexible, modern construction standards. Buildings built with modern construction methods were capable of supporting additional loads.

3.3.1.2. Technology and Innovation

In Jakarta, many rooftop farming practitioners had not yet adopted digital technologies. However, integrating digital technologies into urban farming has proven to make operations more efficient and sustainable. Digital urban farming, also known as controlled environment agriculture, involves integrating automation, software, and silicon-based hardware into farming operations (Zhu et al., 2024). According to observations conducted during semi-structured interviews, 20 entities or 74.1% had not utilized technology for rooftop farming. Only 3 (three) entities or 11.1% had implemented technology, primarily using monitoring sensors for humidity and temperature, as well as automated irrigation and fertilization systems. These rooftop farming practitioners had also adopted technologies, such as shading nets (29.6%), greenhouses (14.8%), and integrated pest and disease control technologies (14.8%). A combination of greenhouses, shading nets, and vertical farming systems was used by two entities (7.4%), and another two entities (7.4%) use greenhouses, shading nets, vertical farming systems, and integrated pest and disease control technologies. The planting methods were predominantly hydroponic systems (17 entities or 63%), conventional soil-based systems (7 entities or 26%), combined hydroponic and aquaponic systems (2 entities or 7.4%), and combined hydroponic and conventional systems (1 entity or 3.7%). In order of frequency, the main barriers to innovation implementation in rooftop farming include limited capital, limited land, and a lack of government support.

3.3.1.3. Accessibility

Rooftop farming access is assessed across several key aspects, including access to the roof, composting facilities, and seed procurement. Most rooftop farming practitioners (22 entities or 81.48%) still rely on permanent stairs to reach the rooftop, while four entities (14.81%) use emergency ladders. Only one entity (3.70%) has installed a lift to transport materials from the ground floor, highlighting that most operations still depend heavily on manual labor. In terms of seed access, most actors obtain seeds from agricultural or seed stores (17 entities or 62.96%), followed by government support from the Jakarta DKPKP (3 entities or 11.11%). In comparison, a smaller portion relies on personal networks or self-seeding (2 entities or 7.41% each).

These findings indicate several structural and operational challenges in implementing rooftop farming. The reliance on stairs limits efficiency and increases the need for physical labor, especially when moving heavy materials and harvests. Access routes that intersect with staff workspaces further disrupt daily operations. Additional issues include narrow planting areas, frequent leakage in rooftop installations, and limited financial resources. On the input side, the dependence on commercial seed suppliers reflects a lack of community-based exchange systems and limited capacity for seed autonomy.

3.3.1.4. Irrigation

Manual irrigation was the most commonly used irrigation system, with 17 entities or 63% of respondents choosing this method. Drip irrigation was used by four entities (14.8%), reflecting some adoption of more efficient water usage technologies. Sprinkler irrigation systems and systems utilizing pumps and water towers were used by two entities (7.4%). Regarding water sources, PDAM water was used by nine entities (33.3%) and well water by eight entities (29.6%), making them the most frequently used sources. A combination of PDAM water, well water, and collected rainwater was implemented by five entities (18.5%), while wastewater from air conditioners (AC) was used by two entities (7.4%), and groundwater by one entity (3.7%). These figures reflected a growing awareness of water recycling practices and the use of alternative sources. The use of AC wastewater emerged as an innovative solution in urban rooftop farming, particularly in North Jakarta. Given the area's geographical proximity to the sea and the presence of saline water, AC wastewater was the most suitable option for irrigation systems in that region. The main challenges in irrigation systems included limited water availability (11.1%) and high equipment costs (7.4%). Nevertheless, most respondents (51.9%) reported no significant issues with their irrigation practices, suggesting that most practitioners considered the systems in place adequate.

3.3.1.5. Maintenance

Based on the data collected regarding rooftop farming practices in Jakarta, the watering frequency was dominated by daily watering, with 25 entities or 92.6% reporting this practice. This indicated a high water demand for plants in urban environments, which are often exposed to intense sunlight and have limited access to natural water sources. Meanwhile, only two entities (7.4%) reported watering two to three times a week. The timing of watering also played an essential role in rooftop farming practices. Watering in the morning only, as well as twice a day (morning and afternoon), had been practiced by nine entities (33.3%). This schedule was adopted to maximize water use efficiency by avoiding watering during midday heat. Interestingly, seven entities (around 26%) had no specific watering schedule, which suggested either a flexible approach or time constraints faced by the practitioners. The biggest challenge rooftop farmers faced was extreme weather, with 51.9% of respondents citing intense heat and heavy rain as significant issues. This highlighted the need for climate resilience in urban farming, where weather variability could significantly impact productivity. In addition, limited space was reported by 14.8% of respondents as another key constraint, reflecting a common obstacle in dense urban settings. Pests and diseases were also identified as prevalent issues, with 26% of respondents mentioning them as a major concern. Moreover, 3.7% of respondents noted capital limitations, indicating that financial constraints remained a barrier to expanding rooftop farming in urban environments.

3.3.1.6. Production Process

Based on the data collected, most respondents had stated that the production process in their urban farming practices was continuous or sustainable, with 70.4% indicating regular operations. Meanwhile, 26% were still in the experimental or trial phase, demonstrating that while most practitioners had integrated urban farming into routine practices, some were still in the process of scaling up. Only 3.7% of respondents reported that their production followed a specific season, reflecting limited crop flexibility. Regarding Standard Operating Procedures (SOPs), 51.9% of respondents had not developed formal written SOPs but reported having clear, informal workflows. Additionally, 44.4% acknowledged the existence of unwritten SOPs, and only 3.7% had implemented detailed written SOPs. These findings indicated a general understanding of structured procedures but also revealed a need for improved documentation to enhance consistency and efficiency in production processes. In terms of production record-keeping, 59.3% of respondents did not maintain specific records, while only 14.8% kept detailed documentation of each production stage. Informal practices remained common, potentially posing challenges in ensuring accuracy and long-term planning. However, 26% reported that they recorded key information, reflecting some level of awareness regarding the importance of data tracking, though the implementation still required improvement.

From a funding perspective, most respondents (44.4%) relied on personal funds to finance their rooftop farming activities. Only 18.5% had received assistance or grants from the government, and a mere

3.7% obtained private sector investment, indicating minimal private sector involvement. Other respondents depended on income from crop sales and collaboration with local government agencies as alternative funding sources. This trend highlighted the financial vulnerability of rooftop farming initiatives, mainly due to the heavy reliance on personal capital.

Overall, the findings demonstrated that rooftop farming practices in Jakarta held significant potential for further development. However, improvements in quality standardization, formal record-keeping, and diversification of funding sources remained essential to ensure greater sustainability and scalability. Strengthening public and private sector involvement through financial support and capacity-building programs could have played a pivotal role in advancing this sector.

3.3.2. Variable 2: The Existing Conditions of Rooftop Farming in Jakarta Related to Market Share and Impact

3.3.2.1. Crop Variation

The types of plants commonly cultivated in urban farming practices in Jakarta were predominantly leafy vegetables, such as mustard greens, spinach, water spinach, and lettuce, accounting for 59.3% of reported crops. These were followed by fruit crops, including tomatoes, chilies, and strawberries, at 18.5%. Interestingly, no respondents had specifically cultivated herbs/spices or ornamental plants. However, a small proportion (3.7%) reported cultivating a combination of leafy vegetables, fruits, and ornamental plants, indicating that only a few respondents practiced crop diversification. In terms of the number of plant types cultivated at one time, most respondents (48.2%) planted between one and three types of crops, while 33.3% cultivated between four and six types. Only 11.1% reported growing more than ten types of crops simultaneously, suggesting that the majority of urban farmers opted for small- to medium-scale cultivation. This approach was likely intended to optimize limited space and ensure efficient plant care.

Regarding the factors influencing crop selection, 48.2% of respondents identified environmental conditions—such as weather and sunlight—as their primary consideration. Market or consumer demand and ease of maintenance each accounted for 18.5% of responses, reflecting practical motivations in crop choice. Only 11.1% of respondents cited available land or planting space as a determining factor, suggesting that most rooftop farmers did not perceive space constraints as a dominant challenge. A small proportion (3.7%) considered market value when selecting crops, indicating some level of awareness regarding the commercial potential of urban farming. Overall, the findings showed that rooftop farming in Jakarta focused primarily on crops that were easy to grow and maintain, particularly leafy vegetables that were well-suited to urban environmental conditions. However, the limited diversification and infrequent application of crop rotation highlighted opportunities to improve long-term sustainability in urban farming systems through more varied planting strategies and crop management practices.

3.3.2.2. Output

Regarding plant types with the highest yields, leafy vegetables such as mustard greens and water spinach were the most dominant, with 59.3% of respondents indicating them as their primary high-yield crops. Fruits such as tomatoes and chilies ranked second, cited by 18.5% of respondents. Other crops, including eggplant, melon, and grapes, were reported by a smaller proportion of respondents, ranging from 3.7% to 11.1%. Notably, no respondents reported harvesting herbs or spices, suggesting a clear preference for fast-growing, high-productivity food crops. Regarding harvest failure, most respondents (66.7%) stated that they occasionally experienced such shortcomings. Meanwhile, 7.4% reported frequent harvest failures, 18.5% rarely experienced them, and only 7.4% indicated they had never encountered a failed harvest. The primary cause of harvest failure was identified as pest and disease attacks, cited by 55.6% of respondents. Extreme weather, hefty rainfall, and intense heat were also significant contributing factors, mentioned by 14.8% of respondents. A smaller proportion attributed failures to plant care errors (7.4%) and a combination of pest attacks and extreme heat (3.7%). Other reported causes included strong winds and disturbances from animals, although these were only noted by a few respondents.

3.3.2.3. Output Utilization

The harvested produce from urban farming practices in Jakarta was used in various ways. The vast majority of respondents (25.9%) chose to sell their produce directly to customers, while 14.8% reported using the harvest in various ways, including personal consumption, sharing, and selling. Family consumption was also significant, with 14.8% of respondents reporting it, followed by sharing with neighbors or relatives (11.1%). However, no processing of the harvest into other products was observed during the semi-structured interviews, indicating room for improvement in post-harvest processing.

In terms of sales frequency, 37.0% of respondents stated that they regularly sold their harvests, while another 37.0% sold their produce occasionally. Meanwhile, 25.9% reported never selling their harvests, possibly due to a focus on personal or community use. These observations and interviews suggested that while rooftop farming in Jakarta produced generally well-utilized yields, there remained room for improvement in optimizing harvest management, particularly concerning market access and post-harvest processing. This situation highlighted opportunities for developing supportive infrastructure for urban farming, such as storage facilities, processing capabilities, and enhanced knowledge on post-harvest handling.

3.3.2.4. Market

The harvest sales from urban farming practices in Jakarta revealed that the majority of respondents (51.9%) sold their produce directly to consumers, often through community networks or social media platforms. Only a small proportion (11.1%) utilized supermarkets or minimarkets as sales channels, while no respondents reported using online stores. A few respondents also mentioned selling their products to restaurants, factory workers, or traditional markets, although these cases were limited. The primary consumers of rooftop farming products were members of the public (51.9%), while sales to restaurants or cafes accounted for only 3.7%. No respondents sold their products to hotels or the food processing industry, indicating that urban farming in Jakarta remained focused on small-scale retail markets and had not yet been integrated into larger food supply chains. Difficulties in selling harvests also posed a significant challenge. About 18.5% of respondents reported experiencing such difficulties frequently, while 29.6% indicated encountering them occasionally. The main factors contributing to these challenges included price competition with conventional agricultural products (18.5%) and limited market demand (18.5%). Additional obstacles included issues with distribution and delivery logistics (7.4%) and signs of market saturation.

To enhance market potential, respondents suggested increasing public awareness about the benefits of rooftop farming products, expanding distribution and marketing networks, and encouraging government support through subsidies or training programs. These findings highlighted that the success of rooftop farming in Jakarta depended not only on effective production practices but also on robust marketing strategies and supportive policy frameworks to foster sector growth.

3.3.2.5. Government's Role

The observations and semi-structured interviews showed that the perception of the Jakarta government's role in supporting rooftop farming activities was significant, with 33.3% of respondents considering the government's role to be huge and 33.3% viewing it as relatively large. However, 25.9% of respondents felt that government support was still lacking, and 7.4% stated that the government played no role. These findings suggested opportunities for the government to increase its involvement in supporting urban farming initiatives. Respondents' responses regarding the need for government support reflected a strong desire for active government involvement in facilitating the sustainability of their farming businesses. No respondents indicated that government support was unnecessary, emphasizing the importance of government participation in supporting this sector.

Respondents identified Training and extension services as the most desired forms of support, with 11.1% listing them as a priority. The Jakarta government had already implemented programs supporting rooftop farming. These findings suggested that the Jakarta government had a significant opportunity to strengthen support for rooftop farming activities, with a more focused approach on training, extension

services, and easier access to capital. With increased support, the urban farming sector's growth was hoped to be facilitated, meeting the public's demand for sustainable, fresh products.

3.3.2.6. Collaboration

Collaboration between rooftop farmers and other parties was still relatively low, with only 11.1% of respondents frequently collaborating, while 37.0% collaborated occasionally. However, 22.2% of respondents mentioned that they rarely collaborated, and 29.6% had never been involved in collaboration at all. Regarding collaboration partners, respondents showed diversity in their choice of partners, with 22.2% naming local government as their collaboration partner. Meanwhile, 18.5% of respondents relied on collaboration with neighbors or surrounding communities and organizations related to agriculture and the environment. However, collaboration with business actors or companies was only done by 7.4% of respondents. This indicated a need for greater private sector involvement in supporting urban farming initiatives. The most common form of collaboration was knowledge and experience sharing, identified by 51.9% of respondents as the primary method of collaboration. While sharing seeds or harvests was also done by 18.5% of respondents, cooperation activities were not noted as a form of partnership. Only 7.4% of respondents were involved in joint training or workshops, indicating a gap that needed to be filled by more structured capacity-building activities.

3.3.2.7. Activities

Most respondents (59.3%) had been involved in activities related to rooftop farming, while 40.7% stated that they did not participate in any additional activities. This indicated a potential to expand the use of rooftop farming areas beyond core farming tasks, which could have increased community involvement and maximized the benefits of available space. Regarding the use of rooftop farming areas, the most common activity reported had been education or training, with 18.5% of respondents indicating that the space was used for that purpose. Only 3.7% of respondents reported post-harvest processing, while 7.4% engaged in composting or organic fertilizer production. These findings showed that there had still been much untapped potential for diversifying activities in rooftop farming areas, especially post-harvest processing, which could have added value to agricultural products. Overall, while some complementary activities had already taken place, there was still considerable room to enhance community involvement and fully utilize the multifunctional potential of rooftop farming spaces. Support to increase both the frequency and variety of these activities, along with efforts to open access to the public, would have been crucial to achieving the goal of sustainable urban farming that benefited the broader community.

3.3.2.8. Impact

Rooftop farming practices were unable to create new jobs in their businesses, with 63% of respondents stating this. However, 37% of other respondents had been able to create jobs or employ staff to manage rooftop farming activities. Although the number of workers absorbed was still limited, it typically involved only one or two people. This condition indicates that the contribution of this sector to job absorption is still relatively small. This was due to various limitations, including the availability of land and capital, both of which were the main challenges identified by the respondents. Based on these findings, government policies were expected to focus more on workforce training programs, providing access to capital, and optimizing land use or availability. Furthermore, clear regulations were needed to support the development of this sector, enabling the creation of more diverse job opportunities, from planting to marketing and administration.

3.4. Key Characteristics of Rooftop Farming Practitioners in Jakarta

Rooftop farming managed by local government entities in Jakarta was characterized by relatively structured and well-supported operations. These practices were often implemented on government-

owned buildings, such as DKPKP, DCKTRP, or municipal offices, accounting for more than half (51.9%) of all identified rooftop farming sites. Civil servants involved in these initiatives typically maintained the farms as part of their work routines, aided by institutional support and fixed schedules. For instance, the rooftop farm at the DCKTRP building relied on scheduled staff participation to ensure daily maintenance and productivity. Most of these farms used concrete rooftop structures, which have offered a strong foundation for sustaining farming activities. While the adoption of digital technologies has remained low, the presence of organizational structure and access to public resources has provided a relatively stable foundation for ongoing operations.

Community-managed rooftop farming in Jakarta generally emerged from grassroots initiatives driven by local interest in beautifying residential areas or strengthening neighborhood ties. These practices were typically located on residential rooftops or community facilities such as mosques, representing about 25.9% of the total locations. Farming activities were carried out on a small scale, with limited crop variety and minimal technological application. For many residents, rooftop farming was a leisure activity rather than a primary livelihood. Time constraints, mainly due to other work obligations, have significantly affected the consistency of care and the quality of harvests. Crops were primarily used for personal consumption or shared informally with neighbors, rather than being sold commercially. Despite their limitations, these initiatives have played a key role in enhancing community engagement and local environmental awareness.

Entrepreneur-led rooftop farming initiatives in Jakarta have reflected a stronger orientation toward productivity, innovation, and income generation. Although this group made up a smaller portion of the total practitioners, their efforts have often included more advanced methods such as hydroponics and, in limited cases, automated irrigation systems. These practitioners have faced challenges in market access, capital acquisition, and price competition with conventional agriculture. Harvests were usually sold directly to consumers through informal channels, such as community networks or social media, rather than formal retail markets. Some entrepreneurial efforts have succeeded in generating income and creating jobs, albeit on a small scale. These findings have illustrated the economic potential of rooftop farming, mainly when supported by capacity building and expanded market infrastructure.

In general, rooftop farming practitioners in Jakarta have represented a diverse group regarding institutional affiliation, motivations, and operational methods. The majority were male, aged between 31 and 50, and had educational backgrounds ranging from senior high school to undergraduate levels. Civil servants formed the largest occupational group, indicating the critical role of government institutions in urban farming adoption. While technological use, formal documentation, and market integration have remained limited, rooftop farming has become a creative response to land scarcity and food system challenges in dense urban settings. Its development has depended on supportive policies, resource access, and collaborative efforts across sectors to realize its full socio-economic and environmental impact.

3.5. Challenges Faced by Rooftop Farming Practitioners in Jakarta

Rooftop farming practitioners from local and regional government institutions in Jakarta have encountered various operational and organizational challenges despite benefiting from better infrastructure and institutional access. While many rooftop farms were located in government buildings and managed by civil servants, the integration of farming tasks into their daily routines has often depended on time availability and work schedules. As a result, consistent maintenance was not always guaranteed, especially when farming duties overlapped with employees' primary job responsibilities. Additionally, the adoption of innovation and digital technologies has remained limited, with most government-managed farms relying on manual irrigation and basic systems. Although these entities have had relatively stable physical conditions, bureaucratic limitations and the absence of formalized production documentation or SOPs have hindered their ability to optimize performance and scale up operations.

Community-based rooftop farming in Jakarta has faced several critical challenges that have limited its scalability and long-term sustainability. These initiatives, often driven by individuals or small groups within residential neighborhoods or religious institutions, were typically managed informally and lacked structured systems for maintenance and operation. Time constraints have been a significant issue, as

most community members engaged in farming only outside of their primary work responsibilities. This condition has led to irregular maintenance routines, limited plant variety, and lower harvest quality. Access to resources such as capital, tools, and technical training has also been limited, making it difficult to implement more advanced farming methods or respond effectively to challenges like pests, diseases, and extreme weather. Moreover, most of the harvested produce was used for personal or neighborhood consumption, with minimal market engagement or income generation. Without sufficient external support or integration into broader food systems, community rooftop farming has mainly remained small-scale and vulnerable to disruptions.

Entrepreneurs and local economic actors engaging in rooftop farming have confronted significant financial and market-related barriers. Many of these practitioners operated with limited access to capital, often relying on personal funds without substantial support from private investors or government grants. While some adopted hydroponic systems and basic automation, broader technological integration has remained minimal due to high equipment costs. Market challenges also posed a serious obstacle, as rooftop farmers faced stiff price competition from conventional agricultural products and struggled to secure stable distribution channels. Most of them sold products directly to consumers through informal means like social media or local networks, with little to no access to larger retail markets or processing facilities. Furthermore, difficulties in expanding operations and creating new employment opportunities reflected this group's limited scalability of rooftop farming, unless stronger institutional and infrastructural support was provided.

Across all practitioner groups, common challenges have emerged, highlighting systemic constraints in rooftop farming practices in Jakarta. These challenges include limited funding, lack of advanced technology adoption, inconsistent irrigation systems, vulnerability to weather extremes, and minimal access to markets or post-harvest processing. The absence of formal record-keeping and standard operating procedures has further affected production efficiency and long-term planning. Additionally, collaboration levels between practitioners and external partners have remained relatively low, reducing knowledge exchange and resource sharing opportunities. Despite these issues, rooftop farming in Jakarta has shown potential as an adaptive urban strategy. Addressing these persistent challenges through comprehensive policy support, training programs, financial incentives, and improved infrastructure will be essential to foster sustainable and scalable urban agriculture in the city.

3.6. Policy Gap Analysis

Several regulations have been formulated to support the implementation of urban farming and rooftop farming, including the following:

Table 5. Existing Regulations Related to Urban Farming and Rooftop Farming

Existing Regulation	Regulatory content
Jakarta Governor Instruction No. 14 of 2018	This regulation governed the implementation of urban farming across various locations such as schools, public housing (*rusun*), child friendly integrated public spaces (*RPTRA*), and government owned land. It also mandated the involvement of various local agencies in supporting urban farming activities, including the provision of infrastructure, facilities, and public outreach.
Urban Agriculture Grand Design of DKI Jakarta 2018–2030	It aimed to address urban challenges related to food security, environmental sustainability, and land limitations through the development of productive green spaces, particularly rooftop gardens and vertical farming systems. By 2030, the design targeted a 30% increase in productive green open spaces and agricultural output, as well as the certification of 1,000 processed products from the agriculture, livestock, and fisheries sectors. The plan prioritized implementation across various urban contexts, including public housing, schools, community spaces, office buildings, vacant lands, and even coastal and marine areas.
Jakarta Governor Regulation No. 118 of 2020	This regulation governed spatial use permits, including for land over 5,000 m², which could be utilized for urban agriculture activities.

Existing Regulation	Regulatory content
Jakarta Governor Regulation No. 54 of 2022	It addressed land and building tax (PBB) exemptions or reductions for objects used in agriculture, livestock, and fisheries, aiming to ease the socioeconomic burden on farmers and aquaculture practitioners and to provide opportunities for those without land access to engage in agricultural activities within Jakarta.
Jakarta Governor Regulation No. 31 of 2022 on the Detailed Spatial Plan (RDTR)	The regulation expanded the definition of green open spaces (*RTH*) beyond horizontal surfaces to include vertical spaces such as rooftop gardens and permeable surfaces, opening greater opportunities for the development of rooftop farming within the city's spatial planning framework.
Jakarta Governor Regulation No. 44 of 2023	This policy officially revoked the previous Governor Regulation No. 60 of 2022, which had governed the implementation of green building principles in Jakarta. The revoked regulation had mandated the integration of green elements such as rooftop gardens and vertical green spaces into building designs.

Source: Jakarta regulations, 2024

Although the Jakarta Provincial Government has introduced several policies to support urban farming, including the Urban Farming Master Plan (2018–2030) and a series of governor's regulations, gaps have remained in the specific implementation of rooftop farming. These policy instruments have provided a valuable foundation. Still, they often lacked operational clarity, technical specificity, and targeted support mechanisms needed to expand and sustain rooftop farming practices across the city. Based on the findings of this study, several critical policy gaps were identified, along with proposed recommendations to address them.

First, while Governor Regulation No. 31 of 2022 expanded the definition of green open space to include vertical elements such as rooftop gardens, it did not provide detailed technical guidance on how rooftop farming should be implemented. There were no standardized procedures for rooftop structural assessment, irrigation setup, access safety, or farming technologies suited to rooftops. In addition, spatial regulations like Governor Regulation No. 118 of 2020 only applied to large-scale land use and did not address the regulatory needs of small-scale rooftop farming. Therefore, the government should have issued a dedicated set of technical guidelines for rooftop farming. These should have covered aspects such as structural safety, hydroponic and aquaponic systems, irrigation technologies, and maintenance protocols adaptable to various building types and scales.

Secondly, Jakarta Governor's Instruction No. 14 of 2018 aimed to accelerate urban farming implementation, yet it lacked specific directives related to rooftop farming practices. The instruction primarily focused on general community involvement and interagency coordination without addressing rooftop-based agriculture's unique technical, spatial, and institutional needs. This policy gap has limited the scalability and sustainability of rooftop farming initiatives, particularly in densely built environments. Future policy iterations should go beyond broad mandates and include clear operational frameworks, inter-sectoral collaboration mechanisms, and measurable targets tailored to rooftop farming, ensuring integration into urban planning and food security agendas.

Another critical gap has been the limited access to capacity-building programs for rooftop farming practitioners. The study has found that most community-led or household practitioners have lacked formal training and have relied on self-taught methods or limited peer learning. Current training opportunities have been irregular, short-term, and have lacked coordination across institutions. To build a more knowledgeable and resilient community of urban farmers, the government should institutionalize regular training and mentorship programs in collaboration with universities, NGOs, and agricultural institutions. These programs should cover urban agriculture techniques, organic farming practices, rooftop farm maintenance, and marketing strategies.

Further, Jakarta Governor Regulation No. 54 of 2022 governs the facilitation of urban farming and provides a sound policy foundation, but it remains insufficient in supporting the specific needs of rooftop farming. While it outlines roles for various stakeholders and encourages urban farming initiatives, the regulation lacks detailed provisions for rooftop-specific contexts, such as structural safety standards, access protocols, and appropriate farming technologies. Moreover, it does not address incentives, monitoring systems, or integration with green building strategies. To enhance its effectiveness, future

policies should include dedicated clauses for rooftop farming, supported by technical guidelines, institutional partnerships, and incentive schemes to promote widespread adoption and long-term sustainability.

Finally, the revocation of Governor Regulation No. 60 of 2022 via Regulation No. 44 of 2023 has created a significant setback in the effort to promote green building practices that integrate rooftop farming. The earlier regulation had encouraged the inclusion of rooftop gardens in building design through incentive structures. Its absence has left a regulatory void with no alternative mechanisms to encourage private sector participation in rooftop farming. To fill this gap, a revised green building policy should be introduced, including incentives for integrating rooftop farming elements into residential, commercial, and institutional buildings. These incentives could include tax reductions, streamlined permitting, or official recognition for buildings that contribute to Jakarta's green infrastructure goals.

4. Recommendation

Rooftop farming was one innovative solution to address land limitations in large cities like Jakarta. Its potential included improving food security, greening the environment, reducing urban heat island effects, and supporting urban sustainability. However, the implementation of rooftop farming in Jakarta still faced several challenges, including a lack of regulations, limited access to technology, financing, market access, and openness to public education activities. To overcome these barriers, the government needed to develop comprehensive policies involving various stakeholders from the public, private, and community sectors. An integrated approach could have formed the foundation for developing rooftop farming as part of Jakarta's green transformation. Below are policy recommendations based on the research findings:

4.1. Established Clear Technical Guidelines and Integrated Rooftop Farming into Urban Spatial Planning

Rooftop farming was currently hindered by the lack of detailed technical regulations, particularly those governing structural safety, irrigation systems, rooftop access, and crop suitability. Rooftop gardens were acknowledged in Jakarta's spatial plan, but their implementation was inconsistent and ad hoc. To address this, the Jakarta government could have taken the following policy actions: (i) Issued a dedicated Governor Regulation or technical manual that outlined rooftop farming standards for different building typologies, (ii) Mandated the inclusion of productive rooftop spaces in government building projects and incentivized their adoption in private developments through tax relief or fast-track permitting, (iii) Mapped the potential of rooftops citywide and created a centralized monitoring and reporting system under DKPKP to guide policy and investment decision.

4.2. Improving Access to Technology, Innovation, and Supporting Infrastructure for Rooftop Farming

High investment costs, lack of knowledge and skills, and limited access to appropriate technology have been major barriers to rooftop farming adoption in Jakarta. Additionally, restricted rooftop access and vulnerable installations prone to leaks had further hindered long-term sustainability. These challenges made it difficult for practitioners to efficiently mobilize materials, maintain farming systems, and ensure consistent yields. The research revealed that over 70% of practitioners had not adopted digital or automated technologies. Manual irrigation, limited pest control, and weak infrastructure remained key bottlenecks.

To overcome these obstacles, the government was advised to: (i) Provide subsidies or co-funding schemes for essential rooftop farming technologies (e.g., hydroponic kits, climate sensors, solar pumps); (ii) Support the installation of rooftop access facilities (e.g., external stairs, lifts) and weather resistant infrastructure to ensure safety and longevity; (iii) Institutionalize technical training programs in collaboration with universities, Non-Governmental Organization (NGOs), and agricultural institutions to enhance practitioners' capacity.

Singapore's Skyrise Greenery Incentive Scheme (SGIS) offered a model for policy intervention, providing subsidies of up to 50% for rooftop farming installations. The program covered essential elements like irrigation systems, drainage materials, and professional consultation to ensure sustainable urban farming. Adopting similar measures in Jakarta could have accelerated technological integration, making rooftop farming more viable and resilient.

4.3. Expanding Funding Opportunities and Foster PPPs

Limited government funding had prevented rooftop farming practitioners from adopting innovations, stifling technological advancement, and using superior plant varieties. The reliance on private funds, as well as the lack of private sector involvement, posed additional risks to long-term sustainability. To address this issue, public-private partnerships (PPPs) were identified as critical to attracting investment in advanced rooftop farming technologies. Furthermore, the government was encouraged to provide grants and incentives for R&D in rooftop farming innovations, particularly because no institutional body had yet been established to oversee rooftop farming development.

Several cities had successfully implemented funding strategies for urban farming. Melbourne's Skyfarm (Melbourne SkyFarm, 2023)., supported by a USD 300,000 Urban Forest Fund grant, had transformed a 2,000-square-meter parking lot into a productive rooftop farm integrating greenhouses, solar energy, and educational spaces. New York City had reformed tax and land-use policies to encourage private green rooftop projects, enhancing local food production and sustainability. Paris' Parisculteurs initiative fostered urban farming through public-private collaborations, offering tenders for farming spaces and expanding urban agriculture across the metropolitan area. In Singapore, companies like Comcrop operated large-scale commercial rooftop farms. At the same time, government incentives, such as the Department of Environmental Protection's grants in New York (Department of Environmental Protection, 2024), had supported private rooftop farming initiatives. These examples highlighted the importance of financial support and policy interventions in fostering sustainable rooftop farming.

Therefore, these are policy actions had been proposed: (i) Establish a dedicated rooftop farming unit within DKPKP to manage technical assistance, policy implementation, and grant distribution; (ii) Launch micro grant and matching fund programs for startup rooftop farming projects; (iii) Promote PPPs scheme with developers, CSR programs, and urban agriculture startups to expand access to capital and technical support.

4.4. Enhancing Market Access and Optimizing Harvest Results

Limited access to markets or local retailers, as well as a lack of storage facilities, had made it difficult for rooftop farming practitioners to maximize their harvests. In addition, low consumer interest in urban farming products had also posed a challenge. To address these issues, the government had been encouraged to develop distribution networks specifically for rooftop farming products and to support integrated storage and processing facilities. The government could have established a harvest distribution center that connected rooftop farming practitioners with local retailers and supermarkets. Moreover, the development of an e-commerce platform specifically for rooftop farming products could have helped open up broader market access and raise consumer awareness of the benefits of these products.

Jakarta government was advised to: (i) Develop local distribution channels by partnering with traditional markets, cooperatives, and online platforms; (ii) Establish a Rooftop Farming Product Center to manage logistics, storage, processing, and branding of rooftop products; (iii) Encourage integration of rooftop farming into institutional food systems, such as school canteens, public hospitals, and government offices. In some cases, market access had also been opened through the immediate environment, as seen in Khoo Teck Puat Hospital (KTP) in Singapore, which implemented rooftop farming to grow vegetables, 140 fruit trees, and herbs. This garden was managed by the local community, and the agricultural products were sold in the hospital's canteen to support the operational costs of rooftop farming. This system also captured and reused approximately 12% of rainwater. As a result, energy consumption at KTP was 30% lower compared to similar new hospitals, saving USD 1 million annually (Newman, 2014). In Melbourne, a platform called Local Harvest has been provided to enable online access to local food and encourage gardening in the local community (City of Melbourne, 2023).

4.5. Improving Public Accessibility and a Variety of Educational Activities

Nearly half (48.2%) of respondents had reported public access to rooftop farming areas, yet only 11.11% had offered structured activities such as tours or workshops. This highlighted an opportunity to enhance public engagement and position rooftop farms as educational platforms for environmental awareness and urban agriculture. Expanding public programs, such as workshops, tours, and festivals, has been seen as a way to boost awareness, community involvement, and sustainable farming practices. Melbourne Skyfarm combined urban farming with commercial activities such as tours, masterclasses, and private event rentals. In New York, Brooklyn Grange provided workshops, farmers' markets, and interactive programs like *Get Your Hands Dirty* to engage the community.

Therefore, these are policy actions had been proposed: (i) Design and fund public education programs (could be open farm days, rooftop garden tours, farming for youth workshops); (ii) Promote rooftop farms as living laboratories for sustainability, food systems, and climate education in collaboration with schools and universities; (iii) Facilitate community engagement through the integration of rooftop farms into RPTRA and local green initiatives.

Conclusion

Rooftop farming in Jakarta emerged as an innovative solution to optimize underutilized urban spaces for food production. The practice was predominantly found in government buildings and residential areas, with differences in management approaches. Government-led initiatives benefited from structured schedules and institutional support, whereas community-managed farms often faced time, resources, and scale limitations.

Despite its potential, rooftop farming in Jakarta remains underdeveloped due to regulatory ambiguities, lack of financial and institutional support, inadequate access to appropriate technology, and limited training opportunities. Environmental challenges such as extreme weather and water management further constrain productivity. Market access was also limited, with most practitioners relying on small-scale sales or personal use. To ensure the long-term success and sustainability of rooftop farming, Jakarta must adopt a more integrated and targeted policy framework. This includes developing clear technical guidelines, offering financial incentives, and embedding rooftop farming within urban planning regulations. Strengthening capacity building programs, enhancing stakeholder collaboration, including with the private sector, and establishing dedicated support institutions are also critical. By addressing these challenges strategically, rooftop farming can become a mainstream solution to enhance food security, promote environmental sustainability, and build community resilience in Jakarta's urban future. Accordingly, based on the research findings and policy gap analysis, the policy recommendations proposed in this study span across regulatory, financial, and operational dimensions.

Limitations

This study focused solely on mapping the characteristics of rooftop farming practitioners in Jakarta and developing strategies to improve their conditions. The data were obtained exclusively from the Food Security, Maritime Affairs, and Agriculture Agency (DKPKP) of DKI Jakarta Province, with data collection conducted over six weeks, from July to the second week of August 2024. Additionally, this study did not extensively capture private rooftop farming practitioners due to data and access limitations.

Acknowledgments

The authors greatly appreciated the support of the Food Security, Maritime Affairs, and Agriculture Agency (DKPKP) of DKI Jakarta Province for providing valuable data and facilitating discussions that enriched the analysis in this policy paper.

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