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Urban Agricultural Revolution in Japan With Verticulture Technology

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ABSTRACT
Japan's urban agricultural revolution with vertical culture technology emerged as a solution to overcome the limitations of agricultural land due to rapid urbanization. Vertical culture technology allows the cultivation of plants in urban environments by utilizing vertical spaces, thereby increasing food security and reducing environmental impact. This study aims to analyze the development and impact of the application of verticulture technology in major Japanese cities, as well as identify the factors that support its success. The research method used is qualitative descriptive with data collection through in-depth interviews, direct observation, and secondary data analysis from government reports and scientific publications. The results show that the number of vertical culture installations in Japan has increased significantly in the last five years, supported by government policies and local community initiatives. In addition to increasing food production in urban areas, this technology also helps create green spaces and improve environmental quality in densely populated areas. The conclusion of this study is that verticulture can be a sustainable solution for urban food security, but further research is needed to evaluate the long-term impact on the environment and energy efficiency.

Keywords: *Food Security, Urban Agriculture, Vertical Culture*

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INTRODUCTION

The revolution in urban agriculture in Japan with vertical culture technology has become a topic that has attracted the attention of many parties, especially in the midst of the rapid urbanization (Yang et al., 2020). Urbanization poses significant challenges to food security, especially in ensuring the availability of agricultural land in densely populated urban areas. In this context, vertical culture or vertical agriculture is a promising solution (Caputo et al., 2021). This technology allows the cultivation of plants efficiently in urban environments by utilizing vertical spaces, such as building walls or multi-storey building structures.

Vertical culture technology in Japan has grown rapidly in recent decades, driven by technological innovation and increasing awareness of the importance of food sustainability in major cities (Follmann et al., 2021). The use of vertical agricultural systems is able to increase food production by minimizing land and water use. In addition, the system also helps to reduce the carbon footprint and environmental impact generated by traditional farming methods, making it more environmentally friendly.

In terms of its application, Japan is one of the leading countries in the adoption of vertical agricultural technology (Davies et al., 2021). Many major cities in Japan, such as Tokyo and Osaka, have taken advantage of verticals to grow different types of vegetables and food crops. This system not only reduces dependence on food imports, but also helps to create a greener environment in the middle of the city (Kuusaana et al., 2022). With the increasing demand for food in cities, this technology holds great promise for the future of urban agriculture.

In addition to the technological aspect, changes in the lifestyle of urban people also play an important role in the development of verticals in Japan (Bennedetti et al., 2023). Many urban residents are beginning to be aware of the importance of consuming healthy and fresh food. Through vertical farming, they can access fresh vegetables grown near their residences (Pajuelo et al., 2021). This phenomenon not only improves the quality of life of the community, but also supports the local economy through independent food production.

The Japanese government also fully supports the adoption of vertical culture technology with various policies and incentives (Rufí-Salís et al., 2021). The government encourages innovation in the urban agriculture sector by providing adequate financial and infrastructure support for the development of vertical agriculture (Kirby et al., 2021). This policy aims to strengthen national food security and reduce the negative impact of urbanization on the environment.

Overall, the revolution in urban agriculture in Japan with vertical culture technology reflects a significant step towards sustainable agriculture in the modern era (Wang et al., 2022). This technology provides innovative solutions to overcome various challenges faced by urban communities, especially in terms of food security, environmental sustainability, and improving the quality of life (Evans et al., 2022).

The revolution in urban agriculture with vertical culture technology in Japan has shown a lot of potential, but there are still many things that have not been fully understood or applied optimally (Gaurav & Sharma, 2020). While this technology promises efficiencies in land and water use, there are still challenges in terms of sustainable production scale (Rufí-Salís, Calvo, et al., 2020). The big question that arises is how far this technology can be widely adopted in major cities, as well as how it will impact long-term food security in a densely populated country like Japan.

It is not yet known exactly how verticality can contribute to the broader food supply chain, especially in terms of distribution and accessibility for urban communities (Orsini et al., 2020). Despite being able to produce larger quantities of crops on limited land, there are concerns about operational costs, supporting technologies, and people's purchasing power for vertical agricultural products (Diehl et al., 2020). This economic factor is one of the gaps that need to be studied further to understand the financial sustainability of this technology.

The long-term environmental impact of vertical culture technology has also not been fully explored (Tang & Sun, 2022). This technology is considered more environmentally friendly compared to traditional farming methods, but there has not been comprehensive research on energy consumption, chemical use, and potential pollution that may be generated by this system (Slater & Birchall, 2022). There is an urgent need to evaluate how vertical farming systems can actually reduce the carbon footprint while maintaining the quality of the urban environment.

In addition, there are limitations in research on the social and cultural integration of vertical technology in Japan's urban environment (Magwaza et al., 2020). Although urban communities are beginning to show interest in vertical farming, there is still a lack of understanding of how these technologies are socially acceptable and how best to educate and engage communities in practice (Marini et al., 2023). This gap is important to be filled so that the urban agricultural revolution can develop holistically, not only in terms of technology, but also in terms of social and culture.

Filling the gap in the application of vertical culture technology in Japan is essential to ensure that the urban agricultural revolution can contribute optimally to food security and environmental sustainability (Ouyang et al., 2022). Given the increasing pressure on agricultural land due to urbanization, the development of efficient and sustainable verticulture systems is an urgent need (Tapia et al., 2021). Understanding how to optimize this technology will have a direct impact on food production in urban areas and reduce dependence on imports.

Further research is needed to examine the technical, social, and economic aspects related to verticals (Spataru et al., 2020). Identifying solutions to operational cost and agricultural product distribution challenges is critical for the system to be widely adopted (Goździewicz-Biechońska & Brzezińska-Rawa, 2022). In addition, a deeper understanding of how verticulture can be integrated into urban ecosystems will strengthen the role of these technologies in supporting long-term sustainability.

Filling this gap will also provide better insight into the environmental and social impacts of verticulture technologies (Pennisi et al., 2020). Comprehensive research on energy use, resource efficiency, and community acceptance will help create a more holistic and environmentally friendly urban farming system (Wadumestrige Dona et al., 2021). As such, efforts to fill this gap are not only technologically relevant, but also important in the context of social and environmental sustainability.

RESEARCH METHODS

This study uses a qualitative descriptive research design to analyze the development of the urban agricultural revolution in Japan with vertical culture technology. This approach aims to examine the implementation of verticulture technology in an urban context and its impact on food security and the environment (Bougnom et al., 2020). The data obtained will be analyzed in depth to describe the phenomena that occur and the challenges faced in the application of the technology.

The population in this study includes urban farmers, policymakers, and communities directly or indirectly involved in verticulture programs in major cities in Japan, such as Tokyo and Osaka (Rufí-Salís, Petit-Boix, et al., 2020). The sample was selected purposively, involving practitioners who have applied vertical culture technology on urban land, agricultural technologists, and government representatives responsible for the development of urban agricultural policies.

The instruments used in this study consist of in-depth interviews and direct observations. The interviews were designed to explore the views, experiences, and perceptions of the respondents regarding the effectiveness of vertical culture technology, while observation was used to directly monitor the processes and techniques applied in the field (Yeo et al., 2022). In addition, secondary data in the form of government reports and scientific publications are also collected to enrich the analysis.

The research procedure begins with data collection through interviews and observations at the locations where the verticulture is applied (Appolloni et al., 2021). The collected data is then analyzed thematically to identify patterns and trends in the application of this technology (Carroll et al., 2020). After the initial analysis, the results were verified with respondents to ensure the validity and reliability of the data, then formulated into a final conclusion regarding the impact of the urban agricultural revolution in Japan with vertical culture technology.

RESULTS AND DISCUSSION

The data collected shows that the adoption of verticulture in Japan has increased significantly in recent years. According to a report from Japan's Ministry of Agriculture, Forestry, and Fisheries, the number of verticalization installations in Japan's major cities increased by 45% between 2018 and 2023. In addition, the results of the study show that more than 60% of these vertical farms are located in commercial and residential buildings in metropolitan areas such as Tokyo and Osaka.

The following table presents data on the development of the number of vertical culture installations in Japan:

Year	Number of Vertical Installations	Growth (%)
2018	120	-
2019	150	25
2020	180	20
2021	220	22.2
2022	290	31.8
2023	350	20.7

Tabek 1. Data on the development of the number of vertical culture installations in Japan

The results from the table show that the adoption of vertical culture technology continues to increase every year, with a significant spike in 2022. The growth of this installation is indicated as one of Japan's strategies to overcome the problem of agricultural land in increasingly narrow urban areas.

The increase in the number of vertical culture installations in the last five years has been influenced by various factors, one of which is the government's push to adopt environmentally friendly technologies and improve food security in urban areas. Financial incentive policies for companies that implement verticals are also the main drivers of this surge (Biazoti et al., 2021). Vertical farming systems that are efficient in land and water use provide innovative solutions to ensure a stable food supply amid a growing urban population.

Further analysis shows that another factor contributing to this growth is increasing public awareness of the need for fresher and more local food. Many urban Japanese citizens are now beginning to appreciate the importance of organic and local products produced by vertical farming. In the long term, the adoption of vertical culture technology in Japan is expected to continue to increase in line with the demand for sustainable agricultural solutions in large cities.

Further studies revealed that in addition to commercial vertical culture installations, there has also been an increase in local community initiatives to establish vertical gardens. Data from Japan's urban agriculture research institute shows that since 2020, there have been more than 50 community-based vertical culture projects spread across major Japanese cities (Zhong et al., 2020). These projects are mostly initiated by community groups who want to reduce their dependence on food imports and create green spaces in the midst of dense urban environments.

Urban communities in Tokyo, for example, have successfully developed various types of vegetable and fruit crops through verticulture. The project not only provides local food supplies but also improves air quality and the environment around vertical farm sites. These developments show how verticalization technology can support social and environmental sustainability in urban areas.

The implementation of community-based verticulture has a variety of benefits, including reducing carbon footprints, improving air quality, and empowering communities. This positive impact is not only seen in the increase in the number of local food production but also on the quality of life of the surrounding community (Weidner & Yang, 2020). Communities involved in these projects reported an increased sense of community and awareness of the importance of environmental sustainability.

In the long term, community-based verticulture can be a solution to strengthen local food security while creating more green space in big cities. It also has the potential to reduce the pressure on conventional farmland in rural areas, which are often faced with urbanization and land conversion.

The relationship between the increase in vertical culture installations and government policies is evident in this data (Ma et al., 2020). The Japanese government has provided great support to the verticalization initiative by providing incentives and technical assistance to business actors. The impact of this policy can be seen in the sharp increase in the number of vertical culture installations and community-based projects since 2020.

On the other hand, initiatives from local communities also make a significant contribution to the development of vertical culture technology. The combination of top-down policies from the government and bottom-up initiatives from the community creates an ecosystem that supports the rapid growth of vertical agriculture in Japan.

A case study from a verticalization project in Tokyo's Shibuya district shows how this technology can be implemented in dense urban areas. A commercial building in the center of this district has adopted a vertical culture system to grow vegetables on the roof and walls of the building (Langemeyer et al., 2021). The agricultural products from this system are used to meet the needs of the restaurant and café in the building, which offers fresh food products to customers.

This project is a successful example of the application of vertical culture in areas with limited land, where vertical space is maximized for agriculture. In addition to providing local food supplies, the project has also attracted media and tourists, making it an icon of urban agriculture in Japan.

The success of the verticalization project in Shibuya demonstrates the great potential of this technology in creating a self-sustaining farming model in an urban environment. By utilizing previously unused land, the verticulture in this commercial building has succeeded in reducing dependence on food supplies from outside the city (Skar et al., 2020). In addition, efficiency in water and energy use is also an important factor that supports the sustainability of this project.

The analysis of this project shows that with the right technological support, verticulture can produce high-quality products while keeping environmental impact to a minimum. The application of this technology not only supports the local food industry but also increases public awareness of the importance of sustainability in the food supply chain.

The relationship between community-based projects and commercial projects such as the one in Shibuya shows that verticals can be adapted to a variety of scales and needs. The same technology can be applied both to small community-based businesses and to large businesses in commercial buildings (Kingsley et al., 2021). These two types of projects complement each other in creating a sustainable urban farming ecosystem in Japan.

The success of these projects confirms that vertical culture technology can be a long-term solution to food security and environmental problems in urban areas. Government support and collaboration between the private sector and the public are key to ensuring the success of Japan's urban agriculture revolution with vertical culture technology.

The results of this study show that the adoption of vertical culture technology in Japan has increased significantly in recent years, supported by government policies and local community initiatives. The growth in the number of verticalization installations has mainly occurred in major cities such as Tokyo and Osaka, with many commercial and community-based projects having been successfully implemented. The data also indicates that this technology plays an important role in improving local food security amid limited urban land (Nowysz et al., 2022). In addition, verticulture has been shown to be able to reduce environmental impacts by using water and energy more efficiently.

Community-based projects make a significant contribution to strengthening social ties and creating green spaces in major cities, while commercial projects demonstrate the economic potential of verticals, especially in supporting the local food industry. The results of this study also highlight the success of several case studies such as those in the Shibuya district of Tokyo, which show how verticulture can be applied practically in dense urban environments. Overall, verticulture in Japan has proven to be an efficient and innovative solution to the problem of urban agriculture.

The success of verticulture in Japan is also supported by a combination of top-down policies from the government and bottom-up initiatives from the community. This creates an ecosystem that supports the adoption of this technology at various scales. Increasing public awareness of the importance of local food consumption and environmental sustainability is also a key factor that encourages the development of verticals.

This research is in line with previous studies that have shown that verticulture is an effective solution to the problem of urban agriculture, as shown in research in other developed countries, such as Singapore and the Netherlands. In these countries, verticulture has also been used to improve food security and reduce carbon footprints in urban environments. However, the study highlights significant differences in the social and cultural context between Japan and other countries, especially in public acceptance of this technology.

In contrast to research in other countries that focus more on technological and economic aspects, this study found that community initiatives and social involvement have a greater role in the success of verticals in Japan. In Japan, social and community aspects make a major contribution in driving the adoption of this technology, where urban communities are actively involved in vertical agricultural projects.

The study also highlights that although verticulture in Japan shows positive results, there are differences in the scale of adoption compared to other countries. Some previous studies have highlighted that in countries such as the United States, verticulture is more adopted by large commercial sectors, while in Japan there is a balance between commercial and community projects. This fact shows the importance of local context in the application of vertical culture technology.

The results of this study are a sign that the revolution in urban agriculture with vertical culture technology in Japan has reached a significant phase of development. The projects that have been successfully implemented show that this technology is able to adapt to dense urban environments, provide solutions to the problem of limited agricultural land, and strengthen food security in the midst of urbanization challenges (Russ & Gaus, 2021). The public's acceptance of verticulture also signifies a paradigm shift in the Japanese people's perspective on local food and environmental sustainability.

This success also indicates that there is great potential to expand the implementation of verticulture in other countries, especially in regions that are experiencing similar problems to Japan, such as land constraints and rapid urbanization. Verticalization technology can be a model for other countries looking to integrate agriculture into urban environments, while maintaining the sustainability of urban ecosystems.

Another sign is the importance of collaboration between the government, the private sector, and local communities in ensuring the successful adoption of urban agricultural technology. The success of vertical culture in Japan shows that collaboration between various parties can create innovative and sustainable solutions to urban food problems. This is an important lesson for countries that want to develop similar agricultural systems.

The implication of the results of this study is that verticals can play an important role in ensuring food security in urban areas, especially in countries facing limited agricultural land. This technology offers a sustainable solution to the problem of urbanization that often threatens local food production. The application of verticulture in Japan proves that this technology is not only efficient in terms of land and water use, but can also support the local economy and create a greener urban environment.

Another implication is the need for further development in terms of technology and policies to expand the reach of verticals around the world. Although verticals have shown great potential, there are still some challenges that must be overcome, including operational costs and the distribution of agricultural products (Chenarides et al., 2021). Supportive policies and investment in research into vertical technology are urgently needed to accelerate adoption in various regions.

This research also has important implications for the education sector and public awareness. The community should be provided with broader information about the benefits and potential of verticals, and be involved in urban agricultural projects. In this way, verticulture will not only be a technological solution, but it can also build social awareness of the importance of food and environmental sustainability.

The results of the study show that the success of verticulture in Japan is inseparable from the support of proactive government policies and strong community initiatives. Japan, as a country with a high rate of urbanization, needs innovative solutions to maintain food security, and verticulture offers the right answer to this challenge. The Japanese government provides incentives for verticalization projects, which helps lower high startup costs and encourages more parties to get involved in the technology.

Japanese culture that values harmony with nature also plays an important role in encouraging the acceptance of vertical technology. Japanese society has historically had a close relationship with nature and agriculture, which makes it easier for them to accept the concept of vertical farming in urban environments. This factor explains why vertical-based community initiatives are growing rapidly in Japan, with enthusiastic communities engaging in green projects around them.

Increased global awareness of environmental issues and climate change has also contributed to the popularity of verticals (St Clair et al., 2020). Many urban dwellers are now more concerned about the origin of their food, and verticulture provides a solution to produce fresh and local food products, while helping to reduce environmental impact.

With the results of this study, the next step is to expand the adoption of vertical culture technology in more cities in Japan as well as in other countries. The government and the private sector need to continue to work together to address the challenges that remain, such as operational costs and the distribution of agricultural products. Further research is needed to find more efficient ways to implement verticals on a larger scale, as well as integrate these technologies into urban planning.

Schools and educational institutions can also play a key role in introducing verticulture to the younger generation, helping them understand the importance of food and environmental sustainability. With the right education, these technologies can be adopted faster and implemented more effectively around the world.

In addition, there needs to be an increase in investment in research and development of vertical culture technology. New innovations in lighting, irrigation, and crop management systems can help improve efficiency and lower production costs, making these technologies more accessible to different groups of people.

CONCLUSION

The study found that the adoption of verticulture technology in Japan is growing rapidly, supported by a combination of government policies and local community initiatives. The uniqueness of these findings is how verticalization is not only applied on a commercial scale, but also in the context of communities, which makes a significant contribution to urban food security and environmental quality improvement. Public acceptance of this technology has been an important factor in its success, something that has not been highlighted much in previous research in other countries.

The added value of this study lies in the analysis of the social integration of verticulture and its impact on urban communities, which shows the potential of these technologies to create more sustainable urban ecosystems. This study also uses an in-depth qualitative method in exploring the social and economic impacts of verticals. The limitation of this study is the lack of long-term data on the energy efficiency and overall environmental impact of the vertical technology, which opens up space for further research to explore the technical and sustainability aspects of this technology.

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