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ROLE OF ARCHITECTURE IN NIGERIA'S AGRICULTURAL SECTOR: A SYSTEMATIC REVIEW

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Abstract

The demand for food in Nigeria has risen due to urbanization, especially in cities, leading to issues like food scarcity, waste, and expensive transportation. This study thoroughly examines how vertical farming could be a viable solution to these problems. Utilizing the PRISMA framework, the research reviews literature spanning from 2019 to 2024, emphasizing the advantages of vertical farming such as space utilization, higher crop production, decreased environmental harm, and water preservation. Vertical farming's capacity to function in controlled settings enables continuous production, lessening reliance on conventional supply chains susceptible to climate change, political turmoil, and economic interruptions. The results indicate that implementing vertical farming structures in cities can help address Nigeria's food security issues by enhancing local food production, cutting down on transportation-related carbon emissions, and boosting resistance to climate-related risks.

Keywords: Vertical farming, Urban-agriculture, Controlled environment agriculture (CEA), Food security, Sustainable agriculture, Water efficiency.

Introduction

In Nigeria, both climate change and resource depletion are worsening simultaneously as pressing environmental concerns. Vertical farming is a contemporary method of agriculture where crops are cultivated in controlled settings through stacked towers or layers. This method is increasingly important in urban areas and beyond as it maximizes efficient land use and minimizes harm to the environment (Nasr & Potteiger, 2023). The fruits and vegetables like carrots, tomatoes, onions, and cabbage that are consumed daily are mostly provided by the northern states of Nigeria. The long travel periods needed to transport agricultural products from northern fields to markets in other regions of the country, especially in the absence of efficient cold chain networks, raise the danger of food spoiling (Owoeye, 2022). Fruits, vegetables, and other perishable goods are especially prone to degradation and significant food loss. In addition to reducing the amount of food that is accessible, this also results in financial losses for farmers and traders whose earnings are lowered due to rotten and unsaleable items. The situation is worsened by the elevated transportation expenses caused by reasons like inadequate road infrastructure and high fuel prices. The expenses are frequently transferred along the supply chain, leading to increased food costs for customers, potentially causing financial difficulties for households and limiting food availability, particularly for families with low incomes (Obiezu, 2023); (Zaręba et al., 2021). The urgency for self-reliance in urban areas in Nigeria for food and agriculture is growing due to the possible risks brought by a highly interconnected society. During prosperous times, relying on complex food supply chains is beneficial and cost-efficient, enabling cities to take advantage of the various strengths of different regions (Sini, 2025). Urban areas frequently bring in food from agricultural regions and foreign nations, typically at a cheaper price compared to growing it within the city, expanding the options and quantities of food for city dwellers. Yet, these reliance results in notable weaknesses; in case of interruptions caused by economic recessions, political unrest, natural calamities, or worldwide health crises, these intricate supply networks may collapse, resulting in drastic food scarcities (Nwanojuo et al., 2025). These disturbances have the potential to kickstart a domino effect, causing a chain reaction of failures across the entire network. Cities that are not self-sufficient struggle to handle abrupt supply disruptions, leading to potential food crises. This weakness was clearly pointed out during the COVID-19 crisis as worldwide supply chains were significantly disturbed, resulting in food scarcities and cost increases in numerous cities. Nigeria, already dealing with issues such as climate change, inadequate infrastructure, and socio-political turmoil, faces increased risks (Siregar et al., 2022).

Aim and Objectives

This study aims to assess how architectural innovation in vertical farming can address challenges related to food security, environmental sustainability, and resource efficiency, particularly in response to the pressures of urbanization and climate change.

The objective of the paper aims to investigate the following;

i. the benefits of sustainable vertical farming facilities;
ii. the differences between vertical farming and traditional farming; and
iii. the possibility of vertical farming facilities effectively tackling Nigeria's food security issues.

1. Literature review

(Owoeye, 2022) Indicated that vertical farming has the potentials of providing a more sustainable and resource efficient solution to the problem of adequate food crop production, enabling the production of larger quantities of food crops closer to urban population where the demand is higher and also help reduce the distances associated with distribution.

(Vatistas & Bartzanas, 2022) Investigates how vertical farms can influence the sustainability and footprint of urban microclimate with local food production. A conclusion was drawn that vertical farming could highly influence a greener transition to the sustainability of urban consumption with reduced CO_2 emissions sourcing from food transportation and limited post-harvest processes.

(Krastanova et al., 2022) Postulates that aquaponics is an important and potentially sustainable method for producing environmentally friendly organic food near consumers, stating that this technology combines aquaculture, hydroponics and beneficial bacteria in a symbiotic environment which is environmentally friendly owing to high levels of water reuse and nutrient recycling.

(Ahamed et al., 2022) Proposes that indoor vertical farming has enormous potential to ensure food security for the increased world population and other socio-economic benefits than traditional agricultural systems.

(Sharma et al., 2023) Advocate that vertical farming offers a large variety of benefits including high food production, safe and sustainable food, and retaining high-quality standards of food.

(Suleiman et al., 2022) States that since vertical farming is fast becoming an acceptable trend worldwide due to the overwhelming population increase, the technique could be practiced to produce crops in tight spaces to boost yield to feed the growing populace. Horizontal farming, on the other hand, is just not enough to meet the needs of this ever-increasing population due to the rapid rate of urbanization.

(Olabinjo & Opatola, 2023), Postulate that sustainable agricultural practices in the form of CEA such as vertical farming focuses on soil conservation, water management, biodiversity preservation, and the responsible use of resources, and that this practice can also contribute to stable food prices, reduce the risk of market shocks, and promote economic stability in the agricultural sector.

(Bolanle et al., 2022) Advocates that the ability to respond to the need for food is threatened by the scarcity of urban farmers (UF) in the elevation of the urban population. Which shows that the availability of food is a cultivated land function, indicating that agriculture is only a mirage when sites are unavailable for farming.

2. Methodology

In this study, a systematic literature review was conducted to determine the feasibility and study of vertical farming as a solution for sustainability in urban agriculture. As illustrated in **Figure 1**, this research used a qualitative approach with the PRISMA 2020 framework to survey and analyze the studies that have been done on vertical farming. The keywords "vertical farming" was used to construct the search expression. In this step, only complete articles available online, written in English and relevant to the study will be included.

In the second stage, the articles were organized into those cited and published within the years 2019–2024. The aim was to better explore the most relevant and recent trends within the proposed theme. Abstracts were then screened one by one in order to identify articles relevant to investigating the highlighted aims of the study. Finally, 30 literatures were selected to be reviewed for this study.

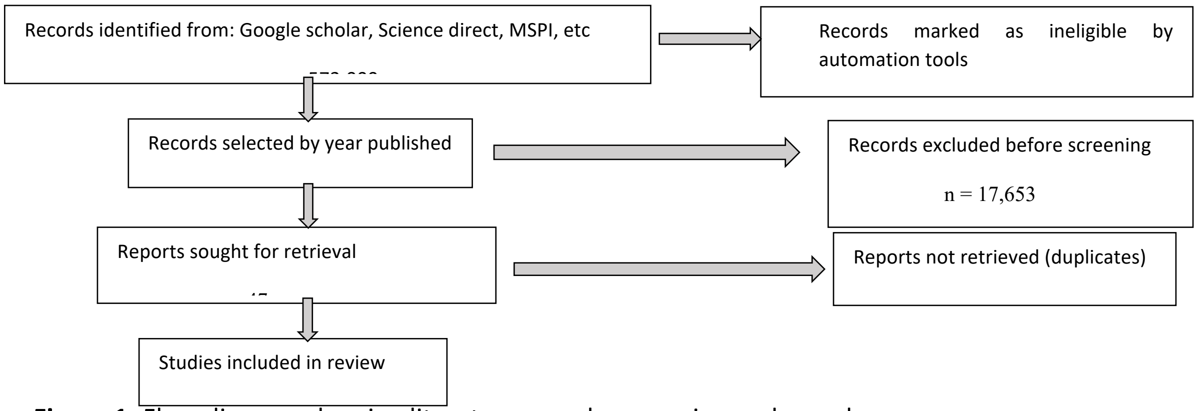

Figure 1: Flow diagram showing literature search, screening and search process

3. Results and Discussion

3.1 Benefits of vertical farming

1. Space efficiency

Vertical farming optimizes vertical space by stacking or arranging crops in multiple layers. Vertical farms can be built in cities, on roofs, or in empty buildings, which decreases the demand for extensive agricultural land. This is especially advantageous in city areas with limited and costly land (Kumar et al., 2023); (Roberto, 2022); (van Delden et al., 2021).

2. Increased crop yield

Crop yields can be increased in vertical farms as factors needed for their development can be controlled, ensuring the best growth conditions are maintained all through the crops growth phase before harvest (van Delden et al., 2021); (Wong et al., 2020).

3. Year-round production

Vertical farms are capable of operating year-round, despite changes in seasons and harsh weather. Consistently producing fresh goods helps fulfill the constant need for fresh produce (Oh & Lu, 2022); (Petrovics & Giezen, 2021); (van Delden et al., 2021).

4. Reduced environmental impact

Vertical farming has the potential to greatly diminish the environmental effects linked to conventional agriculture. It decreases the requirement for extensive land, preserves water with effective irrigation techniques, and lowers the reliance on chemicals like pesticides and herbicides (Blom et al., 2022); (van Delden et al., 2021).

5. Water efficiency

Vertical farming often employs hydroponic or aeroponic systems, which use water more efficiently than traditional soil-based farming. The closed-loop systems in these methods recirculate excess water, minimizing waste (Emmanuel et al., 2022); (Jurga et al., 2021); (Shi et al., 2025);(Stein, 2021); (van Delden et al., 2021).

6. Local food production

Vertical farming can be implemented in cities to move food production nearer to consumers. This decreases the distance of transportation, which in turn reduces the carbon footprint linked to the delivery of fresh produce. Also, placing vertical farms close to or in urban areas shortens the distance from the farm to consumers (Salim et al., 2022); (van Delden et al., 2021).

3.2 Vertical farming vs Traditional farming

Vertical farming often housed within controlled indoor environments like repurposed warehouses or specially designed structures, make efficient use of space which is a major advantage (Yumi et al., 2022). Vertical farming can achieve a greater yield per square foot than traditional farming by expanding vertically instead of horizontally (Varghese & Lavanya, 2025). Cities, where land is limited and expensive, find vertical farming advantageous because it only needs a little over 10% of the land typically utilized in traditional farming to generate the same amount of crops (Agrotonomy, 2024). This stands in stark contrast to conventional farming, which needs large areas of land to produce food on an urban level (Kobayashi et al., 2022). Vertical farms can produce crops all year long thanks to their controlled environment, regardless of the seasons or weather. This consistency guarantees a reliable food source, which is essential for densely populated urban areas.

Secondly, vertical farms are highly resource-efficient. They use up to 95% less water than traditional farming methods, as the water in hydroponic and aeroponic systems can be recirculated within the system rather than lost to evaporation or runoff (Agrotonomy, 2024). Moreover, because vertical farms are enclosed, they are not exposed to pests or diseases commonly found in outdoor environments, both reducing the need for chemical pesticides, as well as increasing crop yield, unlike in traditional farming, where crops are subject to environmental variables such as weather, pests, and diseases, which can drastically affect yields (SharathKumar et al., 2020).

3.3 Potential of Vertical Farming Facilities to Address Nigeria's Food Security Challenges

Urban redevelopment Vertical Farming can contribute to the revitalization of urban spaces by repurposing vacant buildings or underutilized areas. This can enhance the aesthetic appeal of urban landscapes and provide functional green spaces (Avgoustaki & Xydis, 2020); (Basso et al., 2023); (van Delden et al., 2021).

Most fruits and vegetables such as tomato, onions, cabbage and carrots which are consumed daily by Nigerians are produced in the northern states of the country (Ugonna et al., 2015). The adoption of vertical farming facilities in Nigeria would reduce the travel time necessary to transport agricultural products from the northern farms to markets in other sectors of the country, reducing the risk of food spoilage, especially in the absence of efficient cold chain systems. The integration of these facilities can also help in reducing the cost of food commercially as factors such as poor road infrastructure and fuel prices would not be a major concern due to shorter travel distances for distribution (Owoeye, 2022).

Local food production through vertical farming has the potential to significantly contribute to a greener transition in urban consumption, reducing CO2 emissions associated with food transportation and minimizing post-harvest processes. Additionally, the adoption of aquaponics, a technology combining aquaculture, hydroponics, and beneficial bacteria in a symbiotic environment, emerges as an environmentally friendly method with high levels of water reuse and nutrient recycling. This makes aquaponics a promising and sustainable approach for producing organic food near consumers (Despommier, 2019); (van Delden et al., 2021).

In southern and coastal Nigeria, rainfall has increased in duration and intensity, causing significant runoff and flooding in numerous locations. Concurrently, Northern Nigeria is experiencing frequent droughts as a result of reduced precipitation and elevated temperatures, a pattern that is predicted to persist. The nation is confronted with a twofold danger from flooding and drought, intensifying the susceptibility of its farming industry. Vertical farms are more resilient to the challenges brought about by climate change, like severe weather conditions and variations in temperature. Controlled environments shield crops from adverse conditions, contributing to more stable production (van Delden et al., 2021).

The urgency of self-sufficiency in Nigerian urban areas for food and agriculture is growing due to issues such as climate change, inadequate infrastructure, and socio-political unrest, which increase the likelihood of cascade failures (Maria et al., 2021);(Nwanojuo et al., 2025). Cities that are not self-sufficient struggle to handle abrupt supply interruptions, leading to potential food crises. This vulnerability was clearly demonstrated during the COVID-19 crisis as global supply chains were significantly disrupted, resulting in food shortages and increased prices in numerous urban areas (Maria et al., 2021). Nigerian cities can lessen reliance on outside sources, improve food security, and maintain a consistent flow of fresh food by growing some of their own food locally (Rajan et al., 2019).

Conclusion

In conclusion, vertical farming presents a transformative opportunity for addressing Nigeria's food security challenges. Incorporating this new farming technique in cities not only utilizes space better and boosts crop output, but also lessens environmental effects by saving water and promoting local food growth.

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