



Urban Vertical Farming in Pakistan: A Strategic Plan for Sustainable Agriculture and Food Security



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The country has been affected by climatic changes in recent years, which have harmed agriculture. The productivity of this sector is very sensitive to adverse weather events such as floods and droughts, as well as the frequency of unusual heat waves, precipitation, and melting glaciers. In 2022, Pakistan experienced an unprecedented regional rainy season followed by a flash flood that largely damaged crops and livestock.

As a result, the country had to import food, raising prices due to higher import prices¹. In the Global Hunger Index of 2023, Pakistan ranks 102nd with a score of 26.6, which shows the level of hunger in Pakistan and considers it a serious matter².

According to an Integrated Food Security Phase Classification (IPC) analysis of 43 rural districts in Pakistan's three most vulnerable provinces—Balochistan (18 districts), Khyber Pakhtunkhwa (9 districts), and Sindh (16 districts)—nearly 10.5 million people were reported to have experienced high acute food insecurity (IPC Phase 3 or higher) from April to October 2023. About 2.1 million people are in IPC stage 4 (crisis), and about 8.4 million are

in IPC stage 3 (crisis). In the second half of 2022, heavy monsoon rains and floods affected most of these regions, especially in Sindh and Balochistan, significantly affecting food production, consumption, livelihoods, and limited job opportunities for flood victims³.

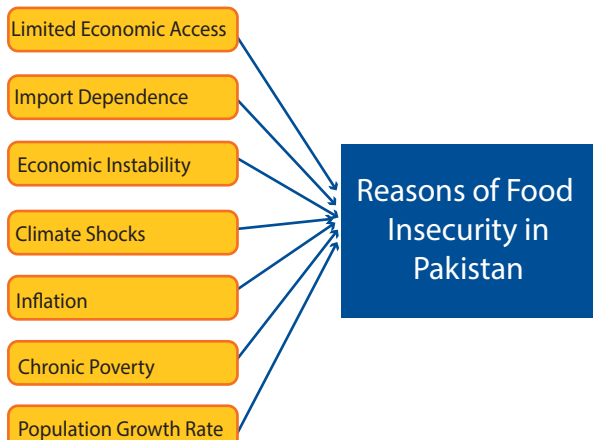
Food insecurity in Pakistan is a multifaceted issue influenced by various factors such as economic instability, limited economic access, import dependence for certain items, climate shocks and events, high inflation, chronic poverty, and population growth⁴.

The country's economy has faced numerous challenges, including fiscal deficits, low foreign exchange reserves, and a large debt burden. Economic instability leads to reduced agricultural investments, lower productivity, and ultimately, higher food prices, making it difficult for the population to access affordable food. Limited economic access is another critical factor contributing to food insecurity. A significant 37.2 percent of Pakistan's population lives below the poverty line per the World Bank report 2023⁵. It highlights the widespread issue of poverty, which directly impacts people's economic access to food.

Pakistan relies heavily on imports for essential food such as wheat, pulses, and edible oils. This dependence makes the country vulnerable to global market fluctuations and trade policies of exporting countries. Climate shocks and events, such as floods, droughts, and extreme weather conditions, significantly affect food security in Pakistan.

The country is highly vulnerable to climate change due to its geographic location. According to the UN-Habitat Pakistan 2023 report, Pakistan is among the top 5th vulnerable countries affected by climate change, underlining the persistent threat posed by climate-related events to food security⁶.

Figure 1: Reasons of Food Insecurity in Pakistan



High inflation rates erode the purchasing power of consumers, making it difficult for them to afford basic food items. In 2024, food inflation was reported average rate of 24.8 from January 2024 to April 2024 as per IMF, which is high in the South Asian region, leading to reduce the ability of households to buy sufficient food, contributing to food insecurity⁷.

Chronic poverty is deeply entrenched in Pakistan, affecting millions of people and perpetuating food insecurity. Pakistan is ranked 52nd on the world's poorest countries list, according to the recently published ranking by the International Monetary Fund (IMF). Chronic poverty restricts access to resources, limits economic opportunities, and prevents people from achieving food security. The country's population will be 244,625,792 in 2024, with a growth rate of approximately 1.96 %. This rapid population increase demands a corresponding rise in food production and distribution; however, agricultural productivity has not kept pace with population growth, leading to increased food insecurity⁸.

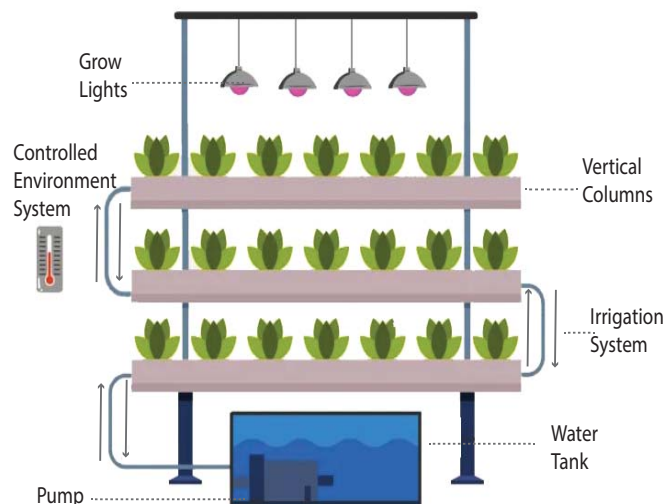
Vertical Farming: Revolutionizing Agriculture in Pakistan

As urbanization accelerates and land availability dwindles in cities like Karachi and Lahore, Pakistan faces a pressing challenge in ensuring food security for its rapidly growing population. In response to this challenge, the role of vertical farming technology in controlled environment agriculture has emerged as a revolutionary solution, offering the potential to produce fresh, locally grown produce within urban environments⁹.

It is considered for sustainable and efficient way to produce food. Vertical farming grows crops in a controlled environment with inertial layers. This allows it to be made throughout the year regardless of weather conditions and significantly reduces the water and land needed to grow the crop. Vertical farming technology plays an important role in the managed organic farming industry, helping to make it more efficient and sustainable. Vertical farming maximizes land use efficiency by stacking growing layers vertically, enabling high yields in limited spaces such as rooftops, warehouses, and vacant lots^{10, 11}.

Burgeoning population and limited land availability for traditional agriculture characterizes major cities like Karachi and Lahore. As urban sprawl encroaches upon arable land, the challenge of feeding urban populations intensifies. With over 40% of Pakistan's population residing in urban areas, the demand for fresh produce continues to rise, exacerbating the strain on existing agricultural systems and supply chains. Due to population boost, arable land in Pakistan is facing the crisis of fragmentation between generations. Over 80% of

Figure 2: Vertical Farming



the farm area is 2 – 2.5 acres for one farmer. This means more than 80% of farmers have land less than 2 acres which is too little for mechanized farming.

Table 1: Affordable Technologies for Vertical Farming in Pakistan

Technology	Description	Cost-saving Measures
Hydroponics: Soil-Free Farming	Basic setups like Nutrient Film Technique (NFT) or Deep Water Culture (DWC).	Utilize locally available materials, DIY nutrient solutions.
Aquaponics: Symbiotic Growth	Combining fish farming with hydroponics.	Use local fish species, low-cost materials like PVC pipes and containers.
Vertical Gardens: Utilizing Urban Spaces	Stacked planters: wall-mounted pockets: or recycled bottle gardens.	Install in small urban spaces: community-based initiatives.
LED Grow Lights: Energy-Efficient Lighting	Low-cost energy-efficient LED grow lights.	Locally manufactured LEDs, solar-powered solutions.
Automated Drip Irrigation: Efficient Water Use	Simple drip irrigation systems for precise watering	Inexpensive tubing and emitters, gravity-fed systems.
Local Materials and DIY Approaches: Cost-Effective Construction	Use of recycled and locally sourced materials for structures	DIY kits, community workshops for setup.

Source: Generated by Author

Vertical farming represents a paradigm shift in agriculture, allowing food to be grown in vertical layers in a controlled indoor environment. This innovative approach uses hydroponics and aquaponics to increase space efficiency and resource utilization. In Karachi and Lahore, where land is limited and people are plentiful, vertical farming is a good solution to meet the growing demand for fresh local produce. Vertical farming methods help to grow crops throughout the year and use only a fraction of the total land used in conventional farming methods in Pakistan. Hydroponics or aeroponics is very water-efficient, using 40% to 70% more water efficient than traditional growing methods.

Table 2: Potential Urban Locations and Benefits

City	Potential Locations	Benefits
Karachi	Industrial areas, rooftops of commercial buildings, unused urban spaces	- Reducing dependence on imported food - Minimizing transportation costs - Providing fresh produce locally
Lahore	Residential rooftops, abandoned warehouses, commercial spaces	- Enhancing urban greenery, - Reducing heat islands - Improving air quality alongside food production
Islamabad	Government buildings, educational institutions, commercial rooftops	- Setting a model for other cities - Ensuring food security for the growing population
Rawalpindi	Multi-story buildings, shopping centers, residential complexes	- Supplementing the food supply for Rawalpindi and Islamabad - Utilizing available vertical spaces effectively
Faisalabad	Industrial zones, factory rooftops, large residential areas	- Providing fresh food to urban dwellers - Improving quality of life for factory workers
Peshawar	Government and commercial buildings, educational campuses, urban green spaces	- Ensuring a stable supply of fresh produce - Enhancing urban resilience against food shortages
Multan	Commercial rooftops, industrial estates, residential complexes	- Reducing strain on traditional agricultural area - Providing locally-grown fresh produce

Source: Proposed by Author

Pakistan's first urban vertical farms are commercial enterprises using technology and innovation to transform urban agriculture, with some pioneering vertical farming projects emerging in Karachi and Lahore, with produce served in the city's best restaurants and supermarkets. However, hydroponics, where plants are grown in a nutrient solution instead of traditional soil, and the water is recycled, uses 90% less water than agriculture and uses no pesticides, eliminating the greenhouse gas emissions associated with agriculture and making it a friendly work environment. The long transport routes from the countryside to the cities lead to the freshest vegetables in town. Sky Greens in Lahore another leading vertical farming enterprise, operates vertical hydroponic farms in Lahore's urban landscape. With a focus on sustainability, Sky Greens utilizes renewable energy sources and water-saving techniques to cultivate a diverse range of vegetables, including tomatoes, cucumbers, and peppers, catering to the city's growing demand for locally sourced produce¹². Table-2 summarizes the suitability of various urban areas in Pakistan for vertical farming and each city's potential locations and benefits.

Why Do We Need Vertical Farming?

The SWOT analysis of vertical farming in urban areas of Pakistan reveals a nuanced picture of its internal strengths and weaknesses and external opportunities and threats. Vertical farming showcases resource efficiency, optimizing limited land, water, and energy resources. It fosters local food production, reducing reliance on imports and enhancing food security in urban settings. Moreover, vertical farming benefits from technological advancements, leveraging innovations such as hydroponics and aeroponics for higher productivity and quality standards. However, challenges

include the high initial investment costs associated with infrastructure setup, a lack of widespread technical expertise among stakeholders, and regulatory constraints that may impede smooth operations. Despite these weaknesses, vertical farming presents promising opportunities, including economic development through job creation and entrepreneurship, contributions to sustainable agriculture practices, and government support through policy incentives and funding programs. Nonetheless, threats such as market competition from traditional farming methods and imported produce, infrastructure challenges related to access to affordable land and utilities, and

vulnerability to external shocks like natural disasters and global market fluctuations necessitate careful consideration and strategic planning for the long-term success and sustainability of vertical farming initiatives in urban Pakistan.

Figure 3: SWOT Analysis of Vertical Farming

Source: Illustrated by Author

A Strategic Roadmap for Vertical Farming Implementation in Pakistan's Urban Areas

Recognizing the pressing issues and the need for innovative approaches, a comprehensive framework for implementing vertical farming in urban areas of Pakistan has been suggested.

Table 3: Strategic Plan and Framework for Vertical Farming Implementation

Steps	Interventions	Strategies
1. Site Selection and Assessment	- Identify rooftops, unused buildings, and vacant urban plots - Conduct feasibility studies - Collaborate with urban planners and local authorities	- Map urban areas for potential sites - Prioritize locations based on accessibility and infrastructure - Evaluate structural integrity, sunlight exposure, and accessibility - Integrate vertical farming into urban development plans
2. Technology Adoption	- Implement hydroponic and aeroponic systems - Use automated systems for lighting, irrigation, and climate control - Utilize IoT devices and sensors for real-time monitoring and data collection	- Select appropriate systems based on space and resource availability - Deploy automated control systems for efficiency - Use LED lighting and climate control technologies - Install sensors for monitoring temperature, humidity, and nutrient levels
3. Economic Feasibility and Funding	- Conduct detailed cost analysis - Explore funding options - Encourage financial institutions to provide low-interest loans and incentives	- Analyze initial setup, operational costs, maintenance, and revenue streams - Secure government grants, private investments, and public-private partnerships - Develop financial models to attract investors - Offer tax incentives and subsidies for vertical farming projects
4. Regulatory Support and Policy Framework	- Advocate for supportive policies - Develop zoning laws that permit vertical farming in commercial, residential, and industrial areas - Ensure compliance with food safety regulations and environmental standards	- Lobby for subsidies, tax incentives, and reduced import duties on technology - Collaborate with municipal authorities to create inclusive zoning regulations - Implement best practices for food safety and sustainability
5. Community Engagement and Awareness	- Launch public awareness campaigns - Promote community-supported agriculture (CSA) programs	- Use media and social platforms to promote the benefits of vertical farming - Conduct hands-on training and demonstration projects
6. Research and Development	- Partner with universities and research Centres - Establish innovation hubs and incubators - Support startups focused on vertical farming solutions - Encourage research on crop varieties suitable for vertical farming and local climate conditions	- Foster collaborative research and innovation projects - Support entrepreneurship and development of new technologies - Provide mentorship and funding for agri-tech startups - Develop crop varieties optimized for indoor farming
7. Sustainability and Environmental Impact	- Implement water recycling and rainwater harvesting systems - Use renewable energy sources, such as solar panels - Promote composting and biogas production using organic waste - Minimise packaging waste with reusable and biodegradable materials	- Use closed-loop water systems to conserve resources - Install solar panels and other renewable energy systems - Develop waste-to-energy systems - Adopt sustainable packaging practices
8. Monitoring and Evaluation	- Develop key performance indicators (KPIs) to measure project success - Conduct regular assessments of social and environmental benefits - Use data-driven insights for continuous improvement of farming practices and technology adaptation	- Set targets for yield, resource efficiency, and economic impact - Schedule periodic evaluations and adjust strategies as needed - Implement feedback loops for ongoing optimization

Source: Developed by Author

The goal is to leverage advanced agricultural technologies, capitalize on urban infrastructure, and foster community engagement to establish sustainable and efficient food production systems within cities. By integrating vertical farming into urban landscapes, we aim to address several key challenges simultaneously: ensuring food security, mitigating the environmental impact of agriculture, promoting economic growth, and enhancing resilience to climate change. This framework outlines a systematic approach to navigating the complexities of urban agriculture in Pakistan. Each stage is carefully designed to address specific barriers and capitalize on opportunities for vertical farming adoption. From site selection and technology adoption to economic feasibility and regulatory support, every aspect is meticulously planned to maximize the effectiveness and sustainability of vertical farming initiatives. Moreover, the framework emphasizes the importance of community involvement, research and development, sustainability practices, and continuous monitoring and evaluation to ensure long-term success and scalability.

Conclusion

By implementing this framework, we aspire to revolutionize urban agriculture in Pakistan, transforming cities into centers of innovation, productivity, and resilience. Through collaborative efforts and strategic interventions, we envision a future where vertical farming meets the nutritional needs of urban populations and fosters economic empowerment, environmental stewardship, and social well-being. This framework represents a pathway towards a more sustainable and inclusive food system, laying the foundation for a brighter and more resilient future for all Pakistanis.

Vertical farming initiatives in urban areas of Pakistan can prove to be a transformational approach to urban agriculture, offering a sustainable solution to the challenges of food insecurity. As vertical farming continues to evolve, its role in shaping the future of urban agriculture in Pakistan will be increasingly significant, paving the way for a healthier, more resilient food system for future generations.

Implementing vertical farming in urban areas of Pakistan offers a promising solution to address food insecurity, urbanization challenges, and sustainability concerns. The strategic roadmap, through specific stages, accompanied by targeted interventions and strategies, provides a comprehensive roadmap for successful implementation. By identifying suitable sites, adopting advanced technologies, ensuring economic feasibility, securing regulatory support, engaging the community, fostering research and development, emphasizing sustainability, and establishing robust monitoring and evaluation

mechanisms, Pakistan can significantly enhance its urban agricultural practices.

This approach aims to provide fresh, locally-grown produce and contribute to economic growth, environmental sustainability, and improved quality of life in urban centers. Embracing vertical farming can transform Pakistan's urban landscapes, making them more resilient, self-sufficient, and sustainable for future generations.

Reference:

1. Sustainable Development Policy Institute https://sdpi.org/the-state-of-food-security-in-pakistan/news_detail
2. Global Hunger Index 2023 <https://www.globalhungerindex.org/pakistan.html>
3. Integrated Food Security Phase Classification (IPC) <https://www.ipcinfo.org/ipcinfo-website/where-what/asia/pakistan/en/>
4. State Bank of Pakistan, Third Quarterly report <https://www.sbp.org.pk/reports/quarterly/fy19/Third/Special-Section-2.pdf>
5. World Bank 2023, Poverty & Equity Brief South Asia (Pakistan) https://databankfiles.worldbank.org/public/ddpext_download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/current/Global_POVEQ_PAK.pdf
6. UN-HABITAT Pakistan COUNTRY REPORT 2023 https://unhabitat.org/sites/default/files/2023/06/4._pakistan_country_report_2023_b5_final_compressed.pdf
7. IMF <https://www.imf.org/external/datamapper/PCPIPCH@WEO/zz/WEO/ORLD/PAK>
8. Worldometers <https://www.worldometers.info/world-population/pakistan-population/>
9. <https://www.app.com.pk/national/agri-scientist-for-opting-vertical-farming-for-beauty-and-productivity/>
10. Birkby, J., 2016. Vertical farming. *ATTRA sustainable agriculture*, 2(1), pp.1-12.
11. Pradeepa, S., Lalithavani, J., & Priyadarshikadevi, T. (2020). A New Modern Agriculture Technique Using IOT With Hydroponic Vertical Farming. *Solid State Technology*, 63(6), 10241-10249.
12. Safdar Abbas, 2023 Revolutionizing Agriculture: Exploring the Potential of Vertical Farming <https://www.agribusiness.com.pk/revolutionizing-agriculture-exploring-the-potential-of-vertical-farming/#:~:text=Various%20initiatives%20have%20been%20undertaken,optimal%20plant%20growth%20and%20production.>

Note:

- Acute food insecurity is usually considered more of a short-term phenomenon related to artificial or unusual natural shocks, such as drought. The IPC Acute Malnutrition Scale is a five-phase scale of increasing severity: Phase 1: Acceptable; Phase 2: Alert; Phase 3: Serious; Phase 4: Critical; Phase 5: Extremely Critical. Each phase is characterized by a certain prevalence of acute malnutrition.
- A method of growing plants without soil, with their roots hanging directly down into nutrient-based water, is called a phase.
- Aeroponics: A method of growing plants with their roots suspended in the air that is constantly misted with water and nutrient solutions

About the Author: Dr. Azeema Begam is currently serving as an Assistant Manager at SAVIOURS and has pursued a Ph.D. from the Department of Economics at the University of Karachi. With 20 research publications in various national and international journals, significant contributions have been made to the fields of Gender Economics, Labor Economics, and International Economics. Research has been presented at more than 15 national and international conferences.