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Climate-Smart Vegetable Production in a Land-Constrained Urban Centre: Prospects for Lagos State, Nigeria

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Abstract

Rapid urbanisation and climate change are simultaneously transforming food production systems in African cities, creating particular challenges for urban and peri-urban vegetable production. Lagos State, Nigeria, represents an important case because a rapidly expanding population is placing intense pressure on a limited agricultural land base while farmers increasingly experience heat, rainfall variability, flooding, water shortages, soil degradation and pest pressure. Vegetable production remains strategically important because short-cycle leafy vegetables provide food, income and employment while occupying relatively small areas of land. This review examines the prospects for climate-smart vegetable production in Lagos State by synthesising findings and reports published between 2022 and 2025 on climate impacts, farmer adaptation, climate-smart agricultural practices, urban agriculture and institutional conditions in Nigerian settings. Findings showed a pronounced distinction between widespread low-cost adaptation and limited adoption of more capital- and knowledge-intensive practices. Farmers commonly adjust planting dates, diversify crops, use organic manure, practise multiple cropping, apply irrigation and respond to changing rainfall patterns. However, efficient irrigation, protected cultivation, stress-tolerant varieties, systematic recycling of urban organic waste, digital advisory services and integrated climate-smart production packages remain inadequately adopted. Constraints include high cost and limited access to credit, weak extension services, insecure land tenure, inadequate infrastructure, poor access to climate information and insufficient institutional coordination. Lagos, climate-smart vegetable production therefore requires a transition from individually managed short-term coping strategies towards integrated systems that increase productivity and resilience per unit of land and water. Priority interventions should combine protection of urban agricultural land with affordable finance, efficient water management, protected cultivation, improved planting material, organic-waste recycling, strengthened extension and digital climate information. Such measures could improve food and nutrition security, farmer livelihoods and urban resilience while allowing vegetable production to remain economically viable within a rapidly urbanising coastal environment.

Keywords: *Climate change; Vegetable production; Urban agriculture; Food security; Agricultural resilience*

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Background to the Study

The global food system has been reshaped by population growth and the interaction of urbanisation, environmental degradation and climate change. These pressures are particularly significant where cities are expanding rapidly as food demand increases steadily and agricultural systems remain strongly dependent on natural resources. Urban expansion frequently converts agricultural land into residential, commercial and infrastructural uses, thereby reducing the land available for food production around cities. At the same time, changing temperatures, rainfall patterns, flooding and water scarcity are increasing production risks. These interactions and processes create a fundamental challenge for urban food systems: cities must produce more food with less land and under increasingly uncertain climatic conditions.

Lagos State is one of Nigeria's most densely populated and rapidly urbanising areas, and agricultural land is continuously exposed to competing demands from housing, transportation, commerce and other urban uses. Analysis of satellite imagery indicates substantial reductions in urban farmland between 1984 and 2024, demonstrating the continuing contraction of the agricultural land base. Land-use transformation is vital because it limits the leeway of responding to increasing food demand through horizontal expansion of cultivation. Future increases in urban food production will therefore depend increasingly on intensification, improved resource efficiency and the protection of strategically important agricultural spaces rather than on expansion into new land (Olugbemi et al. 2026).

Vegetable production occupies a particularly important position within this constrained environment. Leafy vegetables such as Amaranth, Celosia, jute mallow, waterleaf and fluted pumpkin can be cultivated on relatively small plots and harvested within short production cycles. Their short maturity periods permit several production cycles in a year and provide frequent opportunities for income generation. Urban and peri-urban vegetable production also contributes to employment and household livelihoods. Findings show that vegetable production can positively influence several dimensions of farmers' livelihoods, including financial, natural, physical, social and human assets. The sector therefore has importance beyond the direct supply of vegetables because it links urban food security with employment and household income (Adewale & Makinde, 2023).

The review is justified because climate-smart agriculture provides a context-dependent framework for managing scarce urban resources. While Nigerian farmers widely adopt low-cost practices like adjusting planting dates, adoption of capital-intensive climate-smart agriculture technologies remains limited due to high costs, weak institutional support, and insecure land tenure. Evidence shows that adoption depends on financial resources, technical capacity, and institutional support—not just awareness. This distinction is critical for Lagos, where farmers can implement low-cost adaptations but are unable to invest in advanced systems without secure land tenure, credit, and technical assistance

Current Adaptation Practices and Constraints

Climate change, however, threatens the sustainability of these production systems. A study of agricultural production in Lagos State found that farmers perceived changing rainfall and

temperature conditions and were already modifying production practices in response. The study reported that farmers used practices including manure application, fertilisation, chemical application, multiple cropping, irrigation and other adjustments to cope with changing conditions. Vegetable farmers were particularly concerned about water availability, while multiple cropping was used partly as a response to limited land. These findings demonstrate that adaptation is already occurring at farm level, even where farmers may not describe their practices using the terminology of climate-smart agriculture (Tajudeen et al., 2022). The concept of climate-smart agriculture provides a useful framework for interpreting these responses. Rather than representing a single technology, climate-smart agriculture describes an approach to agricultural development that seeks to increase productivity and incomes, strengthen resilience to climate variability and change, and reduce or avoid greenhouse-gas emissions where technically and economically feasible. The approach is therefore inherently context-dependent. A practice that is appropriate for an extensive rural farm may not be appropriate for a highly fragmented urban vegetable plot. Consequently, climate-smart agriculture for Lagos should be understood primarily as the efficient management of scarce land, water, nutrients, labour and capital under conditions of climate and urbanisation pressure.

Recent Nigerian evidence confirms that farmers are already using a range of practices consistent with this approach. A systematic synthesis of 98 publications on climate-smart agricultural practices in Nigeria found that indigenous and relatively low-cost practices, particularly adjustment of planting dates and natural pest management, were widely documented. Other commonly reported approaches included conservation practices, crop diversification, soil management and improved agricultural practices. However, the review also identified low technical capacity, high implementation costs, inadequate government support and limited awareness as important barriers to wider adoption. Access to credit, extension contact, farming experience and education were identified among the important determinants of adoption (Izuogu et al., 2025).

Evidence from southeastern Nigeria reinforces this pattern. Mbanasor et al. (2024), examining climate-smart agricultural practices among crop farmers, found that farmers were using different adaptation practices and that adoption intensity was influenced by socioeconomic and institutional conditions. Their findings demonstrate that climate-smart agricultural adoption is not simply a question of whether farmers know about climate change. Rather, adoption depends on whether farmers have the financial resources, information, technical capacity and institutional support necessary to change production practices. This distinction is particularly important for Lagos. Farmers operating on small and insecure urban plots may be highly adaptive without necessarily adopting technologically sophisticated climate-smart production systems. Adjusting planting dates, changing crops, applying manure or increasing irrigation may require relatively limited investment and can be implemented quickly. In contrast, constructing a protected vegetable structure, installing efficient irrigation, purchasing improved planting material or investing in digital monitoring equipment requires capital, technical knowledge and some expectation that the farmer will retain access to the land long enough to recover the investment. Thus, the level of climate-smart production cannot be adequately represented by a simple distinction between adopters and non-adopters.

Climate-Smart Interventions for Lagos

Water Management

Water management is likely to be one of the most important components of climate-smart vegetable production in Lagos. Vegetables have relatively high-water requirements, and short production cycles mean that water stress during critical stages can rapidly reduce yield and quality. At the same time, Lagos experiences the paradox of both excessive water and water scarcity. Heavy rainfall can cause flooding, waterlogging, erosion and crop destruction, while dry periods can create serious irrigation requirements. The appropriate climate-smart response must therefore include both water conservation and water control.

Simple practices such as mulching, appropriate planting dates, soil organic matter management and careful field positioning can reduce water stress. More advanced measures include rainwater harvesting, improved drainage, efficient micro-irrigation and protected water storage. The objective should not simply be to increase the amount of water supplied to crops, but to improve the efficiency, reliability and timing of water application. Efficient irrigation is particularly valuable in a land-constrained urban environment because it allows high-value vegetables to be maintained through dry periods without requiring substantial expansion of cultivated land. A systematic review of climate adaptation in vegetable farming systems found that drought and water scarcity, rainfall variability, extreme temperatures and flooding were among the major climate hazards affecting vegetable producers. Water-related responses were particularly prominent, while urban and peri-urban production received substantially less research attention than rural systems. Only 23 per cent of the studies reviewed considered urban or peri-urban systems, compared with 83 per cent focusing on rural production. Nigeria accounted for approximately 12 per cent of the studies included in the review, but this does not imply adequate evidence for Lagos specifically (Obossou et al., 2025). The importance of efficient water management is also demonstrated outside Nigeria. Research among small-scale urban crop farmers in eThekwini Municipality, South Africa, shows that climate-smart agricultural practices can influence household food and nutrition outcomes and that adoption is associated with socioeconomic and institutional characteristics. The evidence from this urban setting is relevant to Lagos because both cities demonstrate how agricultural production can persist within a broader urban environment but remain constrained by access to resources, knowledge, infrastructure and institutional support (Khumalo et al., 2025).

Soil Management and Organic Waste Recycling

Soil management is another central component of climate-smart vegetable production. Intensive cultivation of vegetables on small plots can rapidly deplete soil nutrients, particularly when crop residues are removed and organic matter is not adequately replenished. Declining soil quality reduces productivity and can increase vulnerability to drought because soils with low organic matter generally have reduced capacity to retain water and support healthy root development. Climate-smart soil management should consequently combine nutrient replacement with measures that improve soil structure and biological functioning.

Organic manure, compost, crop residues, cover crops and other organic amendments can contribute to this objective. The urban environment creates an additional opportunity because cities generate substantial quantities of biodegradable organic material. Properly managed organic waste can be converted into compost or other soil amendments, thereby connecting urban waste management with agricultural production. This represents a circular resource pathway in which nutrients are recovered from urban waste streams and returned to food production. However, the use of urban organic waste must be accompanied by appropriate quality control because poorly managed waste may contain pathogens, heavy metals or chemical contaminants. The latter concern is particularly relevant to Lagos. Research conducted along the urban-peri-urban gradient of Lagos has documented heavy-metal contamination in soils and commonly consumed vegetables, highlighting the importance of site selection and monitoring for urban food production. Climate-smart intensification should therefore not be interpreted as simply producing more vegetables on every available piece of land. It must also protect consumer health and environmental quality. Areas affected by industrial contamination, polluted irrigation water or hazardous waste should be excluded from food production or subjected to appropriate remediation and monitoring.

Protected Cultivation and Improved Planting Materials

Protected cultivation offers another promising pathway for Lagos. Shade nets, screenhouses, low tunnels and other simple protective structures can reduce excessive solar radiation, moderate temperature, protect crops from intense rainfall and reduce exposure to insect pests. The value of such structures is particularly high in urban agriculture because they can increase production per square metre. Rather than requiring additional land, protected cultivation allows farmers to increase the productivity and reliability of existing plots. The economic feasibility of protected cultivation remains an important consideration. Sophisticated greenhouses and automated systems may be beyond the financial capacity of many small-scale vegetable farmers. However, climate-smart production does not necessarily require expensive infrastructure. Locally appropriate shade structures, low-cost protected beds and simple rain and pest exclusion systems may provide substantial benefits at lower investment levels. The appropriate strategy is therefore to match technology to farmers' financial capacity, land tenure, crop value and production scale.

Improved and stress-tolerant planting material should form part of this transition. Heat-tolerant, disease-resistant, flood-tolerant and short-duration varieties can reduce production risk while allowing farmers to maintain high cropping intensity. Nevertheless, access to quality seed remains a constraint in Nigeria.

Institutional and Enabling Conditions

Land Tenure and Access

Land tenure is perhaps the most distinctive constraint affecting climate-smart vegetable production in Lagos. Urban and peri-urban farmers frequently operate on land that is rented, borrowed, informally occupied or potentially subject to conversion. Such conditions create a major disincentive to investment in practices with long payback periods. A farmer who is uncertain whether the land will remain available for the next production season is unlikely to invest heavily in irrigation infrastructure, permanent protective structures, drainage systems or long-term soil rehabilitation.

Recent research on innovative urban farming in sub-Saharan Africa demonstrates that agricultural policy and extension systems often overlook urban farmers. Benjamin et al. (2024) found that practitioners and the public sector can be marginalised within innovative urban farming systems, despite the contribution of urban agriculture to food security, livelihoods and environmental sustainability. Their findings are especially relevant to Lagos, where urban agriculture occupies a space between agricultural policy and urban land-use planning. The relationship between urbanisation and adaptation is also evident in Ghana. Tuffour et al. (2024), showed that urbanisation itself affects how urban vegetable farmers respond to changing production conditions. The significance of this finding for Lagos is that climate adaptation cannot be treated separately from urban development. Farmers are not responding only to rainfall or temperature; they are also responding to land conversion, changing markets, infrastructure development, competition for space and changes in access to resources.

Consequently, protecting agricultural land should be considered a climate adaptation measure. If urban vegetable plots disappear faster than farmers can intensify production, the food-producing capacity of the city will decline regardless of improvements in individual farm technology. Climate-smart urban agriculture therefore requires integration between agricultural planning and spatial planning. Designated urban and peri-urban agricultural areas, temporary agricultural zones, protected wetlands where appropriate, institutional lands suitable for controlled food production and other land-use instruments could help provide farmers with sufficient tenure security to invest in climate-resilient systems.

Access to Finance and Extension Services

Access to finance is a second major determinant of the transition from basic adaptation to more advanced climate-smart production. Farmers can often adjust planting dates or diversify crops without substantial capital expenditure, but efficient irrigation, protected cultivation, improved seed, water storage and digital technologies require investment. Nigerian evidence consistently identifies access to credit as an important factor influencing climate-smart agricultural adoption. Without suitable financial mechanisms, the benefits of climate-smart technologies remain inaccessible to many small-scale producers (Izuogu et al., 2025). Financial interventions should therefore be designed around the specific characteristics of urban vegetable production. Conventional agricultural loans may be poorly suited to farmers with short production cycles, informal tenure arrangements and irregular cash flows. More appropriate approaches could include small asset-financing schemes, group lending, equipment leasing, cooperative-based irrigation systems, targeted grants for demonstration farms and credit products linked to production cycles. Finance should also be combined with technical assistance so that farmers can use the technologies effectively.

Agricultural extension is equally important. Climate-smart agriculture involves knowledge as much as physical technology. Farmers require information about appropriate planting periods, varieties, irrigation scheduling, pest management, soil fertility, protected cultivation and climate forecasts. Yet conventional extension systems have historically focused heavily on rural agriculture and staple crops. Urban vegetable producers can be mobile, informal and spatially dispersed, making them difficult to reach through traditional extension structures.

Digital technologies provide opportunities to overcome some of these limitations. Mobile phones and other communication platforms can provide weather forecasts, planting advisories, pest alerts, market information and technical guidance. However, digital agriculture should not be assumed to be automatically accessible. Devices, connectivity, digital literacy, affordability and trust influence whether farmers can use such services. Digital tools should therefore complement rather than replace field-based extension. Recent research on climate-smart agriculture in Nigeria demonstrates that access to information and institutional support remains a central issue. Izuogu et al. (2025) found that extension contact, education, experience and credit were among important factors associated with climate-smart agricultural adoption. This suggests that investment in technology without corresponding investment in farmer capacity may produce limited results.

Social Dimensions and Policy Integration

The social dimensions of adoption also deserve greater attention. Women constitute an important part of vegetable production and marketing in many African urban food systems, but they may face greater constraints in accessing land, credit, extension, technology and markets. Climate-smart programmes that are formally gender neutral can therefore reproduce existing inequalities if they fail to address differences in access to productive resources. Financial products, training programmes, cooperative development and digital advisory services should be designed so that women farmers can participate effectively. The economic case for climate-smart vegetable production is nevertheless promising. Adaptation practices can protect yields, reduce production losses and improve farm income. Evidence from Nigeria indicates that climate-smart agricultural adoption can improve household food security and dietary outcomes. A study involving farming households in southwestern Nigeria found a significant relationship between climate-smart agricultural practices and food security, reinforcing the argument that climate adaptation has implications extending beyond farm productivity to household welfare (Adeyemi et al., 2024).

The food and nutrition implications are especially significant for urban vegetable production. Vegetables provide vitamins, minerals, fibre and other components of healthy diets, and their production close to consumers can reduce some transportation and storage requirements. In a city such as Lagos, maintaining local vegetable production can therefore contribute to food-system resilience. However, this benefit depends on safe production. Climate-smart production must include appropriate management of irrigation water, soil contamination, pesticide use, compost quality and post-harvest handling. Pest and disease management represents another area where climate change and urban intensification interact. Changes in temperature and humidity can influence pest populations and disease development. Heavy rainfall can increase some disease pressures, while warmer conditions may expand the range or reproduction rates of certain pests. Farmers frequently respond through chemical application, but excessive reliance on pesticides can increase production costs, environmental contamination and risks to consumers and farm workers. Integrated pest management offers a more resilient alternative. It combines crop monitoring, biological control, resistant varieties, cultural practices, appropriate planting schedules and carefully targeted pesticide application. The approach is particularly appropriate for high-frequency vegetable production, where

repeated pesticide applications may otherwise become routine. However, farmers need practical training and access to safer pest-management options before chemical dependence can be reduced.

Summary

The evidence on climate-smart agricultural adoption in Lagos requires careful interpretation. While Nigerian studies demonstrate considerable use of individual adaptation practices, this does not equate to adoption of integrated climate-smart production systems. A farmer may apply manure and adjust planting dates while lacking efficient irrigation, protected cultivation, improved varieties or climate information—such a farm is adapting, but adaptation remains incremental. This distinction is clearly illustrated by evidence from Delta State, where Nwokobia and Ayoola (2025) found that although intercropping was widely adopted, the overall extent of climate-smart agricultural adoption remained relatively low, highlighting the gap between individual practices and comprehensive packages.

Obossou et al. (2025) further revealed that technological responses dominated climate adaptation in African vegetable systems, followed by behavioural and ecosystem-based approaches, while institutional responses were much less prominent. Most adaptation occurs at the individual or household level, with comparatively limited involvement of government and private-sector actors. This pattern is particularly problematic in urban systems because many constraints facing farmers—including land access, drainage, water infrastructure and extension—cannot be solved at the individual farm level. The Lagos State Climate Adaptation and Resilience Plan provides an important policy foundation, identifying extreme heat, extreme rainfall and sea-level rise among major climate risks while recognising the vulnerability created by rapid urbanisation. However, the major challenge lies in translating strategic policy commitments into practical farm-level support. Climate plans have limited impact if farmers cannot obtain land, credit, irrigation equipment, quality seed or extension services. Climate adaptation must be operationalised through institutions that directly influence production decisions, requiring coordinated action among agricultural authorities, local governments, urban planners, environmental agencies, research institutions, financial institutions, farmer organisations and private technology providers. Lagos also has an important opportunity to connect climate-smart vegetable production with urban organic-waste management. Composting biodegradable municipal waste can provide soil amendments while reducing pressure on landfill systems. Such systems should be based on source separation, controlled composting and quality testing to prevent contaminant transfer. When properly managed, organic-waste recycling contributes simultaneously to soil restoration, waste reduction and agricultural productivity.

Conclusion

The evidence reviewed indicates that farmers are already responding to climate pressure, but most responses remain incremental. The next stage should be a deliberate transition from individual coping to supported climate-smart intensification. This requires secure access to productive land, affordable finance, efficient water systems, appropriate planting material, soil-health management, protected cultivation, integrated pest management, reliable climate

information and effective extension. It also requires better evidence on what works under Lagos conditions.

Climate-smart vegetable production in Lagos should therefore be understood as a practical pathway for producing more food safely and profitably from a shrinking resource base while reducing vulnerability to climate shocks. Success will depend less on introducing a single technological innovation than on creating an enabling system in which farmers can invest, learn, adapt and remain on productive land long enough to benefit from those investments. If this transition is supported through coordinated agricultural, climate, urban-planning and food-system policies, Lagos can convert the pressure of land scarcity and climate change into an incentive for more efficient, resilient and productive urban horticulture.

The prospects for climate-smart vegetable production in Lagos are positive but conditional. The city possesses several favourable characteristics: a large consumer market, demand for fresh vegetables, relatively short production cycles, existing farmer knowledge, access to agricultural institutions and substantial urban organic-resource streams. However, the sector faces severe constraints arising from land competition, insecure tenure, climate exposure, limited finance, inadequate infrastructure and weak institutional coordination. The central policy implication is that climate-smart vegetable production should be treated as an urban food-system strategy rather than simply as an agricultural technology programme. Protecting productive land, improving drainage and water infrastructure, supporting efficient irrigation, strengthening extension and providing finance are all climate adaptation interventions. Similarly, safe recycling of organic waste, improved seed systems, protected cultivation and digital advisory services should be integrated into a coordinated urban food strategy. Productivity should be measured per unit of scarce resource—how much safe, nutritious food can be produced per square metre of land, per litre of water and per unit of investment—favouring efficient irrigation, improved soil management, protected cultivation, intensive beds, container systems and carefully selected vertical production technologies. The transition must also be socially inclusive, ensuring equitable access for women and young people to land, credit, training, digital information and markets. Ultimately, Lagos does not need to choose between urban development and agricultural resilience—vegetable farms can contribute to local food supply, employment, income generation, nutrient recycling and resilience when integrated into urban planning rather than treated as temporary land uses awaiting development.

Recommendations

1. **Protect agricultural land:** Designate urban and peri-urban agricultural zones integrated with spatial planning to provide farmers with sufficient tenure security for investment in climate-resilient systems.
2. **Support incremental upgrading**: Assist farmers in transitioning from manual to efficient irrigation, conventional to improved beds, basic manure use to managed compost systems, and simple shade to effective protected cultivation, matching technology to financial capacity and production scale.
3. **Invest in water management:** Develop efficient irrigation, rainwater harvesting,

improved drainage and protected water storage that address both flooding and water scarcity while prioritising water-use efficiency.

4. **Establish composting systems:** Convert urban organic waste into safe soil amendments through controlled composting with quality testing, promoting practices that improve soil structure and water retention.
5. **Strengthen extension services**: Develop advisory services tailored to urban vegetable producers, combining field-based support with digital platforms for weather forecasts, planting advisories, pest alerts and market information, while addressing digital literacy barriers.
6. **Design accessible finance**: Create financial products suited to urban vegetable production, including small asset-financing, group lending, equipment leasing and credit linked to production cycles, combined with technical assistance.
7. **Ensure social inclusion**: Guarantee equitable access to land, credit, training, information and markets for women and young people, supporting farmer organisations that reduce transaction costs.
8. **Promote integrated pest management**: Combine crop monitoring, biological control, resistant varieties and targeted pesticide application with practical training to reduce chemical dependence.
9. **Conduct location-specific research**: Measure outcomes including yield stability, water-use efficiency, profitability and household food security under Lagos conditions, examining land tenure-technology relationships and conducting economic analyses.
10. **Establish coordinated mechanisms**: Create platforms for coordinated action among agricultural authorities, local governments, urban planners, environmental agencies, financial institutions, research bodies and farmer organisations to integrate agricultural resilience into broader climate and urban-development planning.

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