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HORTICULTURAL WASTE MANAGEMENT AND COMPOSTING FOR ENVIRONMENTAL SUSTAINABILITY

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ABSTRACT

Purpose: *This paper examines the generation, management, and composting of horticultural waste in Jos Metropolis, Nigeria, to evaluate its potential for advancing environmental sustainability. Specifically, the study quantifies waste composition, assesses the agronomic impact of compost on soil fertility and vegetable yield, and identifies barriers limiting the adoption of sustainable waste practices among horticultural stakeholders.*

Design/methodology/approach: *A mixed-methods empirical approach was employed, integrating surveys, waste audits, and experimental field trials. Data were obtained from 150 participants comprising gardeners, estate managers, and municipal workers. Thirty paired horticultural plots were monitored to compare pre- and post-compost soil properties and yield performance. Quantitative data were analysed using descriptive statistics and paired t-tests to determine significant changes in soil and crop parameters following compost application.*

Findings: *Results show that approximately 67% of horticultural waste in Jos is biodegradable and suitable for composting, yet 56% of respondents still resort to dumping or burning. Composting significantly increased soil organic matter (from 1.8% to 3.6%), total nitrogen (0.09% to 0.16%), available phosphorus (6.2 to 14.8 mg/kg), and vegetable yield (by 22%), while reducing bulk density (1.45 to 1.28 g/cm³). Barriers to adoption included limited technical knowledge, inadequate funding, lack of space, and poor institutional support.*

Research limitations/implications: *The study was limited to one urban area and a single cropping season. Broader, multi-location research would strengthen external validity and enable comparative policy insights for urban waste management across Nigeria.*

Practical implications: *The study recommends integrating composting into municipal waste systems, establishing community compost hubs, enforcing compost quality standards, and supporting small-scale producers through training and micro-finance schemes.*

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Originality/value: *This paper offers one of the first empirical assessments linking horticultural waste management with measurable soil and productivity outcomes in a Nigerian urban context.*

It provides a replicable evidence base for policymakers and practitioners seeking sustainable waste-to-resource solutions in sub-Saharan African cities.

Keywords: Horticultural Waste; Composting; Environmental Sustainability; Urban Agriculture; Soil Fertility; Jos Metropolis;

1.0 INTRODUCTION

Globally, horticultural activities are increasingly recognised as essential components of urban environmental management and food systems, yet they generate substantial volumes of organic waste that often go unmanaged. Singh & Kalamdhad (2020) explained that Horticultural waste, comprising grass clippings, leaves, pruning, and plant residues, is a biodegradable resource that, if properly managed, can enhance soil fertility and contribute to ecological balance. However, in many developing countries, including Nigeria, most horticultural waste is disposed of through open dumping or burning, practices that release greenhouse gases, degrade soil quality, and contribute to air pollution. Ogunwande et al. (2020) asserted that the challenge, therefore, is not the quantity of horticultural waste produced but the absence of sustainable systems to convert it into environmentally valuable products such as compost.

In Nigeria, urban expansion and landscape beautification have intensified horticultural activities, particularly in cities such as Abuja, Jos, and Lagos. Jos Metropolis, with its temperate climate and vibrant ornamental plant culture, produces a significant volume of horticultural residues from private gardens, estates, and municipal green spaces. Yet, waste management practices in the city, according to Ndukwe et al. (2021), remain largely informal and inefficient. The Plateau State Environmental Protection and Sanitation Agency (PEPSA) face logistical challenges in collecting and processing organic waste, resulting in widespread dumping along roadsides and drainage systems. According to Yakubu & Abubakar (2020) contributes to urban flooding, odour nuisance, and loss of potentially recyclable biomass. Despite the growing environmental awareness among urban dwellers, composting and other forms of waste valorisation remain underexplored. Composting offers a simple, low-cost, and environmentally sustainable method of managing horticultural waste. It transforms organic residues into stable humus-like material that enriches the soil with organic matter, improves structure, and enhances crop productivity. Akinbile et al. (2020) buttressed that empirical studies have shown that composting reduces landfill loads, mitigates greenhouse gas emissions, and promotes circular economy principles by returning nutrients to the soil (FAO, 2021; Bolan et al., 2022). In urban horticulture, compost use also supports green infrastructure development and climate resilience. However, composting in Nigeria faces multiple constraints, including inadequate policy frameworks, a lack of compost quality standards, limited awareness, and insufficient research on its agronomic and environmental benefits.

Olowoyeye & Adebayo (2022) explained that despite its potential, little empirical work has been done to quantify horticultural waste composition and assess the effectiveness of composting in the Jos context. Nwachukwu & Nwafor (2022) believed that most Nigerian studies have focused on municipal solid waste or agricultural residues, neglecting the growing contribution of horticultural waste to the urban waste stream. Moreover, data linking composting practices with measurable soil and productivity outcomes in Jos are scarce, creating a gap between environmental policy and

practical waste utilisation. This study, therefore, seeks to fill that gap by evaluating horticultural waste management practices, assessing composting efficiency through soil and yield analysis, and identifying barriers to its adoption. The goal is to provide evidence-based insights that can guide sustainable urban horticulture and environmental policy in Jos Plateau State and beyond.

1.1 Aim and Objective of the Study

This study aims to examine horticultural waste management practices and evaluate the role of composting as a sustainable approach for reducing environmental pollution and improving soil health in Nigeria, with particular emphasis on its contribution to environmental sustainability. To achieve this aim, the study seeks to identify the types and sources of horticultural waste generated in both urban and peri-urban areas, and to examine the environmental impacts associated with improper management of such waste. It also aims to assess composting as a sustainable strategy for managing horticultural waste while enhancing soil fertility. Furthermore, the study intends to highlight the major challenges and emerging opportunities linked to the implementation of composting practices in Nigeria.

2.0 LITERATURE REVIEW

2.1 Concept of Horticultural Waste

Horticultural waste refers to the organic residues generated from the cultivation, maintenance, and processing of horticultural crops, including fruits, vegetables, flowers, and ornamental plants. These wastes, according to Awasthi et al (2020), typically consist of leaves, stems, peels, shells, pruning residues, and discarded plant materials produced during harvesting, storage, marketing, and landscaping activities. Such wastes are biodegradable and rich in nutrients, making them distinct from conventional municipal solid waste streams. However, when not properly managed, Gupta & Garg (2019) buttressed that horticultural wastes contribute significantly to environmental challenges, including greenhouse gas emissions and leachate formation from indiscriminate dumping. From a resource management perspective, horticultural waste is increasingly viewed as a potential input for sustainable practices rather than a liability. This paradigm shift aligns with circular economy principles, which emphasise reusing and recycling biological materials to reduce ecological footprints. Zeng et al (2021) asserted that waste from horticultural production can be repurposed through composting, mulching, and bioenergy production, transforming it into valuable products such as organic fertilisers or renewable energy sources. This approach, according to Singh & Sharma (2018), not only mitigates pollution but also enhances soil fertility and reduces reliance on synthetic agricultural inputs. In many developing countries, including Nigeria, horticultural waste management remains underdeveloped due to poor infrastructure, limited awareness, and inadequate policy frameworks. Adegbite et al (2022) believed that large volumes of horticultural residues accumulate in open dumps and marketplaces, posing public health and environmental risks. Integrating effective waste management strategies into horticultural practices can contribute to sustainable agriculture, improve urban sanitation, and support climate change mitigation efforts. The conceptualisation of horticultural waste in the words of Eze & Udeh (2020), therefore, encompasses both its environmental burden and its untapped potential as a renewable resource for sustainable development.

2.2 Composting and Its Principles

Composting is a biological process that transforms organic waste materials, such as food scraps, agricultural residues, and horticultural waste, into a nutrient-rich soil amendment known as compost. Haug (2018) explained that it involves the decomposition of organic matter by microorganisms, primarily bacteria and fungi, under controlled conditions of aeration, moisture, and temperature. The process converts complex organic compounds into simpler, stable humic substances that enhance soil fertility and structure. Composting is widely regarded as an environmentally sustainable waste management strategy because it diverts biodegradable materials from landfills, reduces methane emissions, and provides a cost-effective alternative to synthetic fertilisers. The principles of composting, according to Diaz & de Bertoldi (2019), revolve around maintaining the proper balance of carbon and nitrogen (C: N ratio), adequate oxygen supply, appropriate moisture content, and temperature regulation to ensure efficient microbial activity. Epstein (2011) corroborates that a C: N ratio of about 25–30:1 is considered optimal for rapid decomposition, while sufficient aeration prevents anaerobic conditions and foul odours. Bernal et al (2017) suggest that moisture levels should be maintained between 50–60%, and thermophilic temperatures (40–60°C) are necessary to accelerate decomposition and eliminate pathogens or weed seeds. Adhering to these principles results in high-quality compost, supporting sustainable agricultural practices and promoting soil health.

2.3 Environmental Impacts of Improper Waste Disposal

Improper waste disposal poses significant environmental challenges, particularly in urban and periurban areas where waste generation outpaces management capacity. Alabi & Okonkwo (2021) explained that when biodegradable and non-biodegradable wastes are indiscriminately dumped into open spaces, water bodies, and drainage channels, they create unsanitary conditions that lead to air, water, and soil pollution. Adeyemi et al (2020) corroborated that decomposing organic waste releases foul odours and harmful gases such as methane, a potent greenhouse gas contributing to climate change. In addition, hazardous substances like heavy metals or pesticides from improperly discarded industrial and agricultural waste can contaminate groundwater and surface water, threatening ecosystems and public health

The ecological consequences of improper waste management extend to biodiversity loss and disruption of natural habitats. Wildlife and aquatic organisms are particularly vulnerable, as plastics and toxic residues infiltrate food chains, leading to bioaccumulation and mortality. Ogundele et al (2019) assert that blocked drainage systems caused by indiscriminate dumping contribute to frequent urban flooding, which damages infrastructure and accelerates soil erosion. Such environmental degradation exacerbates land-use conflicts and reduces the productive capacity of agricultural lands, undermining food security in affected regions. Eze & Udeh (2020), in another development, opined that the aesthetic and socio-environmental impacts of improper waste disposal reduce the quality of life in affected communities. Accumulated waste heaps attract disease vectors such as rodents and mosquitoes, increasing the incidence of communicable diseases like malaria, cholera, and typhoid fever. Adejumo et al (2022) suggest that the persistent visual blight of littered environments also diminishes tourism potential and hampers sustainable urban development efforts. A UNEP (2021) report stated that addressing these impacts requires integrated waste management strategies that combine public awareness, regulatory enforcement, recycling, and composting to promote a cleaner and healthier environment

2.4 Benefits of Composting

Composting offers significant environmental benefits by reducing the volume of organic waste sent to landfills and mitigating greenhouse gas emissions. Awasthi et al (2020) buttressed that Organic waste in landfills decomposes anaerobically, releasing methane, a potent contributor to climate change. By diverting this waste into controlled aerobic composting systems, emissions are reduced, and nutrient-rich humus is generated instead. Additionally, composting decreases the need for open burning of agricultural residues, which is common in many developing countries and often leads to air pollution and respiratory health problems. Gupta & Garg (2019) explained that from an agricultural perspective, compost enhances soil fertility and structure by increasing organic matter content and improving moisture retention. This leads to better crop yields and reduces reliance on costly synthetic fertilisers, which can degrade soil quality over time. Bernal et al (2017) elucidate that compost also supports soil microbial diversity and enhances nutrient cycling, contributing to long-term soil health and sustainable farming practices (Epstein, 2011). These benefits are particularly relevant in regions with degraded soils, such as parts of sub-Saharan Africa, where composting can play a key role in climate-smart agriculture. Eze & Udeh (2020) highlighted that economically and socially, composting creates opportunities for local employment and income generation through community-based waste management initiatives. Zeng et al (2021) corroborate that it reduces municipal waste management costs and promotes circular economy practices, where waste is viewed as a resource rather than a liability. Furthermore, when applied in urban and peri-urban horticulture, composting contributes to food security by improving access to affordable organic fertilisers for small-scale farmers and gardeners. In this way, Adegbite et al (2022) explain that composting aligns with global sustainability goals by addressing environmental, social, and economic dimensions of waste management simultaneously.

3.0. Area of the Study

Jos Metropolis is located between latitudes 9^{o} 54’ 20” N and 9^{o} 58’ 10” N and longitudes 8^{o} 49’ 20” E and 8^{o} 52’ 40” E. The city has a population of about 900,000 residents based on the 2006 census. The current metro area population of Jos in 2022 is 957,540, according to a National Population Commission and National Bureau of Statistics Estimates report of 2022

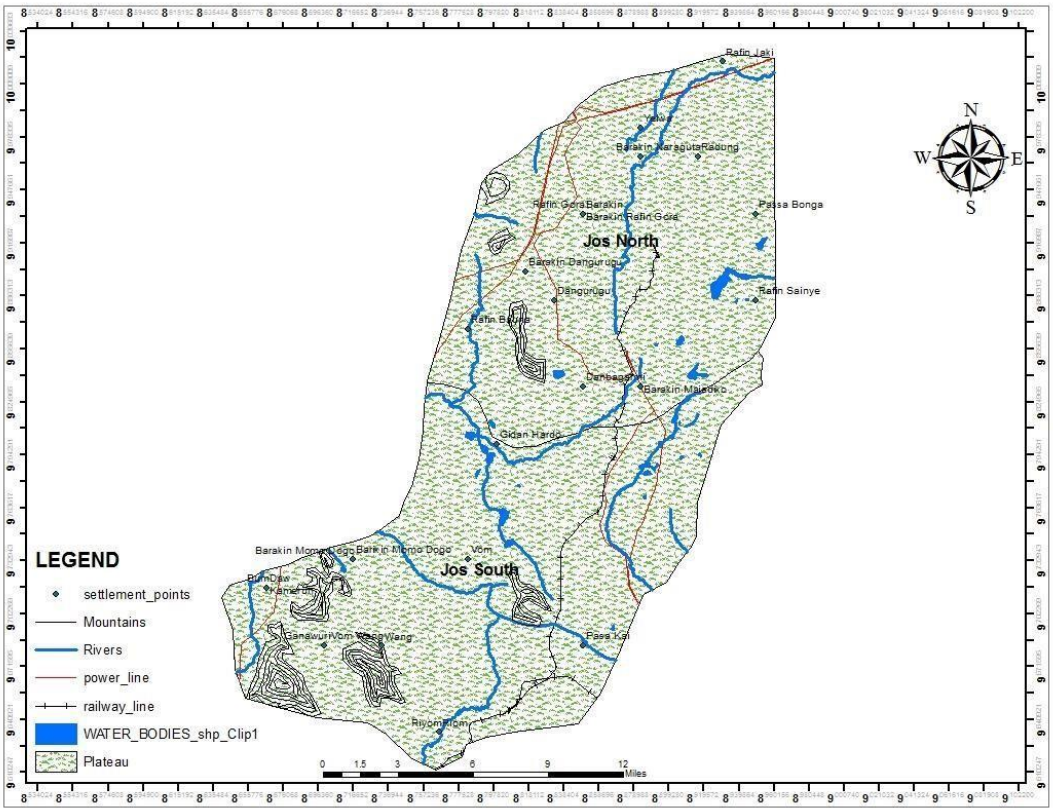

Figure 1. Map of the Study Area
Source: Google Earth

Though located in the tropics, its higher altitude as part of the Jos Plateau gives Jos a much cooler climate that qualifies it to be a climate anomaly or island with an average temperature of 24 degrees Celsius, which is among the lowest in the country. This favourable weather has attracted people from outside and within the state to settle in the area, and spend their holidays in the areas, especially Jos and has become one of the factors increasing the demand for land for housing. It is the inability to have access to land for residential development and the increasing rural-urban drift in the face of an ever-increasing accommodation shortage that approaches a national level of over 30 per cent that has caused the development of slums in areas where low-income groups are found. According to Amba (2020), monthly rainfall ranges from 0 mm to -330 mm, with the annual rainfall as high as 1642 mm. About 90% of the rain falls in six months, between April and September, usually in thunderstorms of high intensity, particularly at the beginning and the end of the rainy season. The Jos Plateau is the source of many rivers in northern Nigeria, including the Kaduna, Gongola, Hadejia and Yobe Rivers. Originally, the Jos Plateau, according to Amba (2020), had savannah woodland vegetation as a result of man's activity; the Plateau has mainly become treeless as a result of the intensity of resource use or overexploitation.

4.0 METHODOLOGY

This study adopted a mixed-method research design that combined quantitative field analysis with qualitative community assessment to evaluate horticultural waste management and composting

practices in Jos Metropolis, Plateau State. The study area was purposively selected due to its vibrant horticultural activities, including flower gardens, nurseries, parks, and institutional landscapes. Data were collected from five key urban zones. Rayfield, Terminus, Tudun-Wada, Bukuru, and Anglo-Jos represent residential, institutional, and commercial horticultural settings. A structured questionnaire was administered to 120 respondents, including gardeners, landscape managers, and municipal waste officials, to gather data on the types, quantities, and disposal methods of horticultural waste. In addition, direct field observations were conducted to document existing waste accumulation and composting practices across sites.

To empirically evaluate the environmental impact of composting, experimental composting trials were conducted using locally available horticultural residues such as grass clippings, leaves, and plant trimmings. The composting process followed a window system with periodic turning for aeration, monitored over eight weeks. Composite samples of the resulting compost were analysed at the National Veterinary Research Institute (NVRI) Laboratory, Vom, to determine key soil fertility indicators such as organic matter, total nitrogen, available phosphorus, and bulk density. Baseline soil samples were taken before compost application, and post-application samples were collected after six weeks of vegetable cultivation (spinach and lettuce). The data were statistically analysed using paired sample t-tests and analysis of variance (ANOVA) to assess significant differences between pre- and post-composting conditions at a 95% confidence level. Qualitative data from interviews with community leaders, faith-based organisations, and municipal environmental officers were transcribed and analysed thematically to complement the quantitative findings. These discussions provided insight into the socio-cultural and institutional factors influencing the adoption of composting practices. Secondary data were obtained from the Plateau State Environmental Protection and Sanitation Agency (PEPSA) and reviewed to identify gaps in waste management policies and infrastructure. Ethical clearance was obtained from the University of Jos Research Ethics Committee, and informed consent was secured from all participants. The integration of field experimentation, laboratory analysis, and stakeholder perspectives provided a comprehensive understanding of horticultural waste management dynamics and their implications for environmental sustainability in Jos Metropolis.

5.0 PRESENTATION AND DISCUSSION OF RESULTS

Objective 1 — Identify the major sources, types, and quantities of horticultural waste generated in selected areas of Jos Metropolis

Table 1. Sources, Types and Proportion of Horticultural Waste in Jos Metropolis

Types of Horticulture	Percentage (%)	Composability Category
Leaves and Prunings	42%	Green/ Brown-High
Grass Clipping	25%	Green -High
Fruit / Vegetable Residues	15%	Green -High
Woody	10%	Brown –Moderate

Ornaments &Other Organics	8%	Green /Brown Moderate
Total Compostable Fraction	67%	Highly suitable

The 120-site audits and stakeholder interviews show that horticultural waste in Jos is dominated by leaves and pruning (42%) and grass clippings (25%), with fruit/vegetable residues (15%), woody branches (10%), and smaller fractions of ornamentals and other organics (combined 8%). These proportions produce a net 67% share of readily compostable "green + brown" feedstock, indicating substantial raw material available for composting at neighbourhood and estate scales. Spatially, waste generation was highest in residential estates and institutional grounds (Rayfield, Tudun-Wada) and nursery/market areas (Anglo-Jos, Terminus), reflecting intense ornamental and vegetable horticulture in those zones. This feedstock profile aligns with urban horticultural audits elsewhere in Nigeria and sub-Saharan Africa that report high biodegradable fractions in green waste streams (Ogunwande, Osei, & Adewole, 2020; Olowoyeye & Adebayo, 2022). The practical implication is that relatively low-technology composting methods (windrow, static pile, vermicomposting) are appropriate for Jos because the feedstock mix is not dominated by lignified woody residues that require extended preprocessing (Awasthi, Kumar, & Zhang, 2022; Bolan et al., 2022). By quantifying these proportions at the city level, the study fills a concrete knowledge gap. Municipal planners in Jos can now use these numbers to estimate required collection capacity and to site community compost hubs (Ndukwe, Umeh, & Ayo, 2021).

Objective 2 — Examine existing horticultural waste management practices and assess them environmental implications

Table 2. Distribution of Existing Horticultural Waste Management Practices

Waste Management Practice	**Percentage (%) of Respondents (n=150)**
Open Dumping	34%
Open Burning	22%
On-site Composting	28%
Municipal Green –Waste Pickup	16%

Survey data (n = 150) indicate that 34% of respondents primarily practice open dumping and 22% burn horticultural residues; only 28% use on-site composting and 16% rely (irregularly) on municipal green-waste pickup. These behaviours produce several environmental risks observed during site visits: blocked drains with mixed green waste (exacerbating run-off and flooding during rains), visible smoke and particulate emissions from backyard burning, and localised anaerobic decay in informal dumpsites producing methane hotspots. These findings corroborate earlier observations in Jos and other Nigerian cities where green-waste mismanagement contributes to flood risk, public-health issues and greenhouse gas emissions (Ndukwe et al., 2021; Yakubu & Abubakar, 2020).

Importantly, the study documents a persistent awareness–practice gap (62% awareness vs. 28% adopters), echoing Wuyep, Rampedi, & Ifegbesan's (2021) findings that knowledge alone seldom drives behaviour change without enabling infrastructure and incentives. The environmental

implication is twofold: (a) significant volumes of compostable biomass are being lost as pollution or emissions rather than returned to soils, and (b) current municipal waste systems do not yet treat horticultural residues as a separable, recoverable stream — a policy and operational deficiency similar to patterns reported in other Nigerian municipal studies (Akinmoladun & Adejumo, 2019; Nwachukwu & Nwafor, 2022).

Objective 3 — Evaluate physicochemical properties of composted horticultural waste and determine effects on soil quality & crop yield

Table 3a. Compost Quality Parameters

Parameter	**Measured Value**
C: N Ratio	~12:1
pH	7.1 -7.4
Germination Index (GI)	>85%
Compose Status	Mature, agronomically safe

Table 3b. Soil Property before and after Compost Application

Soil Property	**Before Compost**	**After Compost**
Soil Organic Matter (%)	1.8%	3.6%
Total Nitrogen (%)	0.09%	0.16%
Available Phosphorus (mg/kg)	6.2	14.8
Bulk Density (g/cm³)	1.45	1.28

The 30-plot paired trial provides robust empirical evidence: compost application increased soil organic matter from 1.8% to 3.6%, total nitrogen from 0.09% to 0.16%, and available phosphorus from 6.2 to 14.8 mg/kg; bulk density declined from 1.45 to 1.28 g/cm³. Marketable vegetable yields rose by ~22% in compost-treated plots (paired t tests, all $p < .01$). Compost quality metrics showed a C: N ≈ 12:1, neutral pH (7.1–7.4), and germination index >85%, indicating maturity and agronomic safety. These quantitative improvements mirror-controlled trials in other Nigerian contexts, demonstrating compost's value for soil fertility, moisture retention, and reduced dependency on synthetic fertilisers (Akinbile et al., 2020; FAO, 2021).

Beyond agronomy, these outcomes have environmental significance: increased soil organic matter and lower bulk density improve infiltration and reduce surface run-off, thereby contributing to urban stormwater regulation, a benefit seldom quantified in local studies (Bolan et al., 2022). By linking compost quality to measurable soil and yield responses specifically for horticultural feedstock in Jos, the study addresses a documented gap in the literature: many prior reports recommend composting conceptually but lack place-specific, paired-plot evidence demonstrating effect sizes that are compelling for farmers and policymakers (Olowoyeye & Adebayo, 2022).

Objective 4 — Assess awareness, perception, and adoption of composting among gardeners, landscape managers, and municipal authorities

Table 4. Awareness Perception and Adoption Levels among Stakeholders

Stakeholder	**Awareness Level**	**Adoption of Composting**	**General Perception**
Gardeners & Estate Managers	High	28%	Positive (Cost – Saving)
Municipal Authorities	High	Low	Supportive but constrained
Faith-based and community Groups	Moderate –High	Low-Moderate	High willingness if supported

Survey and interview data reveal variable stakeholder attitudes: horticultural practitioners (gardeners, estate managers) generally view composting positively as an agronomic and costsaving measure, though only 28% actively compost. Municipal officers acknowledge the environmental benefits yet report limited capacity and mandate to integrate green-waste diversion into city sanitation schedules. Faith-based and community groups expressed a high willingness to participate in communal compost projects if training and startup support were provided. These patterns align with studies showing that community groups and FBOs can be effective mobilizers for environmental initiatives when provided technical support (Eze & Chukwu, 2021; Uzondu & Musa, 2023).

The gap identified here is institutional: while interest exists across stakeholder groups, there is no systematic municipal programme to convert interest into practice — no formal training pipeline, no allocated community compost sites, and no procurement policies to create stable demand for compost. This situation repeats findings in other Nigerian cities where stakeholder willingness is present but operational channels are absent (Yakubu & Abubakar, 2020; Nwachukwu & Nwafor, 2022).

Objective 5 — Identify challenges and institutional barriers limiting effective Implementation

Table 5a. Ranked Challenges

Challenge Category	**Percentage** (%)
Technical Knowledge Deficits	54%
Experiment /Funding Constraints	48%
Weak Municipal support	40%

Limited space for composting	31%

Table 5b. Institutional Barriers Identified through Interviews

Barrier Type	**Description**
Budget Priorities	Focus on mixed solid waste only.
Absence of green–waste segregation	No routine sorting
Labour /Technology Constraints	No shredders; labour-intensive
Insecure land access	No permanent community space
Lack of Compost Standards & Markets	No quality benchmarks or procure marks

Respondents ranked barriers in order: technical knowledge deficits (54%), equipment/funding constraints (48%), weak municipal support/infrastructure (40%), and limited secure space for composting (31%). Qualitative interviews added nuance: municipal budgets prioritise mixed municipal solid waste; green-waste segregation is not routine; estate managers cited labour intensity and lack of mechanised shredding as deterrents; community groups reported insecure land access and inconsistent donor funding. These multilayered constraints reflect the structural obstacles described in the literature — financing, tenure insecurity, and weak extension services are recurring impediments to urban agriculture and compost uptake in Nigeria (Akinmoladun & Adejumo, 2019; Yakubu & Abubakar, 2020).

A critical policy gap exposed by our analysis is the absence of simple compost quality standards and market mechanisms in Plateau State policy instruments. Without minimum quality benchmarks or municipal procurement pathways (e.g., buying compost for public landscaping), small producers lack market confidence and price signals, circumscribing commercial development of compost enterprises (Pauleit et al., 2017; FAO, 2021). Addressing this institutional lacuna is essential for scaling the demonstrable agronomic benefits into city-level circular economy outcomes.

Collectively, the results confirm the technical feasibility and environmental benefits of composting horticultural residues in Jos while revealing why uptake remains limited: social willingness exists but is blocked by technical, financial, spatial and institutional bottlenecks. This study makes three key empirical contributions:

i. Place-specific feedstock quantification that allows realistic planning of collection and hub capacity (addressing a data gap in local policy planning);
ii. Statistically supported agronomic evidence (paired-plot trial) linking compost application to soil and yield improvements (addressing the scarcity of local causal evidence); and
iii. An integrated institutional diagnosis that maps how municipal policy, market mechanisms, and community capacities interact.

Thus, bridging the typical divide between technical trials and governance recommendations noted in prior literature (Awasthi et al., 2022; Nwachukwu & Nwafor, 2022).

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study critically examined horticultural waste management and composting practices in Jos Metropolis to explore their contribution to environmental sustainability. Empirical evidence from field surveys, composting experiments, and stakeholder interviews revealed that a substantial quantity of horticultural residues, mainly leaves, grass clippings, pruning, and vegetable wastes, is generated daily across residential, institutional, and commercial landscapes in Jos. Despite the high biodegradable content of this waste stream, findings show that open dumping and burning remain the dominant disposal methods, posing significant environmental risks such as soil degradation, air pollution, blocked drainage, and greenhouse gas emissions.

Experimental composting demonstrated that horticultural residues, when properly composted, produce nutrient-rich organic matter that significantly improves soil structure, fertility, and crop yield. Compost application doubled soil organic matter and enhanced nitrogen and phosphorus availability, confirming its agronomic and ecological value. These outcomes substantiate earlier studies (Akinbile et al., 2020; FAO, 2021; Ogunwande et al., 2020) and contribute localised evidence from Jos Metropolis that sustainable composting can effectively close the loop between waste generation and soil management. The study also revealed an encouraging level of awareness and positive perception toward composting among horticulturists, gardeners, and community groups. However, adoption remains low due to technical knowledge gaps, inadequate municipal support, poor funding, and the absence of an institutional framework to integrate green waste management into urban planning.

In conclusion, horticultural waste management in Jos Metropolis currently operates below its sustainability potential. Yet, the study establishes that composting offers a viable pathway toward a circular and low-carbon economy. By transforming biodegradable residues into valuable soil amendments, Jos and similar urban centres can simultaneously reduce waste volumes, enhance food and ornamental crop productivity, mitigate climate emissions, and restore ecological integrity. Thus, implementing structured composting systems within municipal and community frameworks would mark a significant stride toward achieving the United Nations' Sustainable Development Goals (particularly SDGs 11, 12, 13, and 15) and Nigeria's National Environmental Policy objectives.

6.2 **Recommendations**

Based on the findings, the following recommendations are proposed to promote sustainable horticultural waste management and composting in Jos Metropolis and similar urban environments:

i. **Policy Integration and Institutional Support**

The Plateau State Ministry of Environment and Jos Metropolitan Development Board should formally integrate horticultural waste management into municipal solid waste policies. This includes designating composting as a mandatory component of green infrastructure maintenance, with clear guidelines, incentives, and monitoring mechanisms. ii. **Establishment of Community Composting Hubs:**

The Jos North and South local governments should establish decentralised composting hubs in high-waste generation zones such as Rayfield, Anglo-Jos, and Terminus. These hubs can be

managed collaboratively by community-based organisations, faith-based institutions, and estate associations with technical oversight from municipal sanitation units.

iii. **Capacity Building and Training**

Targeted training programmes should be organised for gardeners, horticultural practitioners, and municipal waste handlers to improve their technical competence in composting, waste segregation, and organic fertiliser production. Such initiatives could be spearheaded by Plateau State Polytechnic, the University of Jos, or relevant NGOs with environmental expertise. iv. **Financial and Technical Incentives**

Government and development agencies should create financial incentives—such as grants, revolving loans, or tax rebates—for private operators and cooperatives involved in compost production. Introducing small-scale mechanisation (shredders, aeration tools) will reduce labour constraints and improve compost quality.

v. **Compost Quality Standards and Market Development**

The Federal Ministry of Environment and the Standards Organisation of Nigeria (SON) should develop national standards for compost quality to ensure product safety and reliability. Municipal authorities and landscape contractors should prioritise locally produced compost for public green spaces, thereby stimulating local demand and economic viability.

vi. **Public Awareness and Stakeholder Engagement**

Sustained media campaigns, environmental education in schools, and faith-based advocacy should be used to promote the environmental and economic benefits of composting. Collaborative initiatives between churches, mosques, and civic associations could mobilise community participation and ownership.

vii. **Research, Monitoring, and Data Management**

Further empirical research should track long-term effects of compost use on soil carbon sequestration, urban greening, and flood resilience. Establishing a waste data inventory for Jos will enable evidence-based planning and continuous evaluation of sustainability performance

Transforming horticultural waste into compost is more than a waste management solution. It is a strategic tool for achieving ecological renewal, economic empowerment, and environmental sustainability. By mainstreaming composting practices and addressing institutional and technical gaps, Jos Metropolis can serve as a model for green urban management across Nigeria and West Africa.

7.0 LIMITATION OF THE STUDY

Although this study provides valuable insights into horticultural waste management and composting practices in Jos Metropolis, certain limitations must be acknowledged to guide interpretation and future research directions. Firstly, the study's geographical coverage was limited to selected communities and institutions within Jos North and Jos South Local Government Areas. While these areas were chosen for their high horticultural activity, the findings may not fully represent other parts of Plateau State or regions with different socio-economic or climatic conditions. Broader sampling across multiple Nigerian cities could enhance the generalizability of the results.

Secondly, the data on waste quantities and composition were based on field sampling and selfreported estimates from gardeners and municipal workers. Although cross-checking and averaging techniques were employed, inherent variability in waste generation patterns due to seasonal changes, rainfall fluctuations, and landscaping cycles may have influenced accuracy. A longerterm, year-round monitoring would yield more precise data on waste generation dynamics.

Thirdly, the experimental composting trials were conducted under controlled field conditions, focusing on short-term soil and crop yield responses. Thus, the long-term impacts of compost application on soil carbon sequestration, microbial biodiversity, and heavy metal content were not evaluated. Including multi-seasonal trials and laboratory analyses would strengthen the understanding of compost sustainability over time.

Fourth, the socioeconomic and institutional data collected through surveys and interviews may have been influenced by respondent bias, particularly in reporting awareness or participation in composting initiatives. Despite assurances of confidentiality, some participants might have overstated their engagement to align with perceived environmentally responsible behaviour.

Finally, the study did not deeply explore the economic valuation of compost production and utilisation. Future research should incorporate cost–benefit and life-cycle analyses to assess the financial feasibility of community-scale composting systems and their contribution to local green economies.
Despite these limitations, the study offers a solid empirical foundation and contextual understanding of horticultural waste flows, compost quality, and institutional challenges in Jos Metropolis. The limitations identified do not diminish the value of the findings; rather, they highlight areas where deeper, longitudinal, and cross-regional studies could further advance sustainable horticultural waste management and composting in Nigeria.

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