



ORGANIC MANURE ADOPTION AND ITS IMPLICATIONS FOR REDUCING POSTHARVEST LOSSES IN NIGERIA'S AGRIBUSINESS VALUE CHAIN

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ABSTRACT

This study evaluated the empirical determinants of organic manure adoption, farm-level production bottlenecks, and value-chain postharvest loss (PHL) implications among smallholder farmers in Gwer East Local Government Area of Benue State, Nigeria. Utilizing a cross-sectional survey design, baseline primary data were collected from a representative sample of 189 registered smallholders ($n = 189$). Analytical methods included descriptive statistics, Recursive Decision Tree Modeling, and Parametric Analysis of Variance (ANOVA). The descriptive results revealed a distinct knowledge-practice gap: while spatial crop rotation achieved universal implementation (100.0%), advanced biomass composting was adopted by only a minority (29.1%) of the population. The Decision Tree recursive outputs established that smallholder choices to adopt organic inputs are primarily driven by expected economic profit margins (59.3%) and anticipated pre-harvest crop durability (40.7%). Concurrently, the parametric variance analysis yielded a statistically non-significant difference in crop yields across different animal manure types ($p = 0.626$), confirming high input substitution flexibility for producers encountering localized supply shocks. Investigation into supply-chain constraints isolated manual, labor-intensive application as the principal farm-level bottleneck (51.6%), followed by prohibitive procurement-logistics costs (34.7%) and perceived biological handling hazards (13.7%). Based on these findings, the study recommends that the Benue State agricultural extension network deploy localized technical training on standardized composting and introduce affordable, low-cost mechanical spreading tools to mitigate labor constraints and minimize value-chain postharvest losses.

Keywords: Organic, Manure, Adoption, Decision, Production, Bottlenecks.

INTRODUCTION

Organic agriculture is defined by the International Federation of Organic Agriculture Movements (IFOAM) as a production system that sustains the health of soils, ecosystems, and people, relying on ecological processes, biodiversity, and cycles adapted to local conditions rather than the use of inputs with adverse effects. Within agricultural economics, organic farming is increasingly analyzed not merely as an alternative production technique, but as a strategic pre-harvest intervention within sustainable agribusiness value chains (Barrett *et al.*, 2022). In developing agrarian economies like Nigeria, the agricultural value chain framework originally conceptualized by Michael Porter emphasizes that value creation and product quality at the downstream marketing and processing stages are heavily dependent on inbound logistics and input choices at the upstream farm tier. By replacing volatile, expensive, and ecologically degrading synthetic chemicals with organic soil amendments (such as animal droppings, compost, and crop residues), smallholders aim to stabilize soil structure and maintain crop yield baselines. For smallholders in North-Central Nigeria, optimizing this primary input tier is essential to creating a resilient agribusiness model that can supply urban markets with consistent volumes of agricultural commodities.

Nigeria's agricultural sector faces a systemic crisis of postharvest food losses. According to official reports from the Food and Agriculture Organization (FAO, 2019), postharvest losses for durable grains range from 15% to 25%, while losses for highly perishable root crops, tubers, and vegetables regularly exceed 40% across sub-Saharan Africa. Benue State, despite its geographic status as the premier agricultural hub of North-Central Nigeria, suffers acutely from these inefficiencies, which



severely reduce the net income of smallholders and cause artificial supply scarcities in urban markets. While traditional interventions focus heavily on midstream and downstream infrastructure—such as cold storage, postharvest chemical treatments, and road rehabilitation—the economics of postharvest management increasingly demonstrates that a significant portion of food waste is structurally determined before harvest (Arah *et al.*, 2015). Pre-harvest crop management directly dictates the physiological durability of the produce. For instance, the unbalanced or erratic application of synthetic fertilizers can lead to structurally weak plant tissues that are highly vulnerable to mechanical bruising, cellular breakdown, and rapid pathological rot during transport and marketing. Conversely, the balanced, slow-release nutrient profiles provided by organic manure types promote dry matter accumulation and firmer cell wall structures, which naturally extend the potential postharvest shelf-life of crops (Balehgn *et al.*, 2020). Beyond physiological factors, a critical, overlooked link exists between pre-harvest inputs and postharvest loss: the farm-level labor bottleneck. Smallholder farming systems in local government areas like Gwer East operate within highly rigid, constrained household labor budgets. The application of organic soil amendments is an inherently labor-intensive process, involving the collection, manual processing, transport, and localized distribution of bulky materials. According to empirical labor allocation models in African smallholder agriculture (Fedorenko *et al.*, 2023), when early-season soil management demands an excessive share of available household or community labor, it creates severe seasonal labor deficits later in the cycle.

Because smallholders cannot easily scale their labor supply, the heavy energy and time requirements of managing raw organic inputs directly trade off with time-sensitive harvesting, grading, and sorting operations. This operational bottleneck delays the harvest, forcing mature crops to sit over-ripened in the field where they are exposed to solar radiation, moisture fluctuations, and pest infestations. This operational delay severely compromises the quality of the produce before it ever enters the postharvest supply chain, accelerating spoilage during immediate transit and storage. To design effective agribusiness interventions in Nigeria, it is vital to understand how smallholders perceive these input trade-offs and how their adoption choices influence the broader value chain. The broad objective of this study is to analyze smallholder farmers' perceptions and adoption of organic manure within the agribusiness framework of Gwer East Local Government Area, Benue State, and evaluate its operational implications for postharvest loss reduction. The specific objectives are to:

- i. examine the socio-economic profiles, annual income distribution, and baseline organic manure awareness of smallholder farmers in the study area.
- ii. Evaluate the operational determinants of organic manure adoption and its consequential impact on crop yield variance and supply-chain volume stability.
- iii. analyze farm-level labor, cost, and input bottlenecks in organic manure management and their direct impact on postharvest loss reduction.

METHODOLOGY

Study Area and Sampling Procedure

This study was conducted in Gwer East Local Government Area (LGA), Benue State, Nigeria, which encompasses a landmass of 2,294 km² and is geophysically characterized by a gently undulating terrain with prominent river networks including the Gwer, Gbaya, and Mu rivers. The local economy is structurally driven by smallholder agribusiness, primarily focused on staple and arable crop production (yam, corn, soya beans, and beniseed) alongside extensive livestock rearing.

A multi-stage sampling design was employed for primary data collection. In the first stage, Aliade district was purposively selected within the LGA due to its concentration of organic farming smallholders. In the second stage, four communities—Aliade, Akputu, Enjive, and Owene—were purposively selected from the district to capture prominent marketing and trading hubs. In the final stage, a simple random selection of respondents was executed across the four target communities.

Population and Sample Technique

Multistage Sampling Procedure was used. In the first stage Selection of Aliade district was Purposive done from Gwer East LGA. The second stage involves the purposive Selection of



Communities (Four communities Aliade, Akputu, Enjive, and Owene were purposively selected from Aliade district). Lastly random Selection of respondents from each community.

Aliade: 100, Akputu: 80, Enjive: 70, Owene: 110

Total population (N) = 100 + 80 + 70 + 110 = 360

Taro Yamane

Sample Size Determination using Taro Yamane's Formula

$$n = N / (1 + N(e)^2)$$

Where:

n = sample size

N = total population (360)

e = margin of error (assuming 0.05)

$$n = 360 / (1 + 360(0.05)^2)$$

$$n = 360 / (1 + 360(0.0025))$$

$$n = 360 / (1 + 0.9)$$

$$n = 360 / 1.9$$

$$n \approx 189.47$$

Rounding down to the nearest whole number, the sample size (n) is approximately 189.

Bowley's Allocation

Sample Size Allocation using Bowley's Allocation Formula

$$nh = (Nh / N) \times n$$

$$\text{Aliade: } (100 / 360) \times 189 \approx 52.5 \text{ (round to 53)}$$

$$\text{Akputu: } (80 / 360) \times 189 \approx 42$$

$$\text{Enjive: } (70 / 360) \times 189 \approx 36.75 \text{ (round to 37)}$$

$$\text{Owene: } (110 / 360) \times 189 \approx 57.75 \text{ (round to 58)}$$

The sample size allocation would be approximately:

Aliade: 53 respondents

Akputu: 42 respondents

Enjive: 37 respondents

Owene: 58 respondents

Primary data were derived via the field administration of structured questionnaires to the selected farming households, capturing explicit socio-economic metrics (age, gender, ordinal education levels, marital status, and annual income blocks denominated in Nigerian Naira) alongside binary and 5-point Likert scale indicators tracking agronomic practices, farm gate pricing, and operational bottlenecks.

Analytical Framework

To maximize page efficiency and eliminate repetitive text blocks, the empirical variables, operationalized measurements, and corresponding statistical software tools are synthesized within the structured analytical matrix below.



Objective	Dependent / Independent Variables	Operational Measurement Scales	Statistical Analytical Tool
Objective i (<i>Socio-economic Profiles & Income</i>)	Age, Gender, Education, Marital Status, Farming Experience, Annual Farm Income.	Years; Binary (1=Male, 2=Female); Ordinal schooling tiers; Nominal categorical; Net monetary value (₦).	Descriptive Statistics (Frequencies, valid percentages, mean scores).
Objective ii (<i>Awareness & Adoption Evaluation</i>)	Levels of awareness; Application of organic fertilizers, organic pest management, crop rotation, and soil conservation.	Binary responses ({Yes}=1, {No}=0); Frequency of monthly extension agent contacts.	Descriptive Statistics; Chi-Square (χ^2) cross-tabulation for practice distribution.
Objective iii (<i>Input Determinants & Postharvest Bottlenecks</i>)	Extent of practice adoption; Severity of farm-level operational constraints.	5-point psychometric Likert scales tracking perceived benefits, safety hazards, high input procurement costs, and labor-intensive handling.	Decision Tree Analysis (Classification and Regression Tree - CRT algorithm); Mean Score Analysis.

RESULTS AND DISCUSSION

Socio-Economic Profiles and Practice Awareness

The empirical data gathered from the 189 smallholders in Gwer East LGA establishes a clear picture of the demographic and financial realities on the ground. The sample shows a male baseline of 57.7% and a female baseline of 42.3%. The high marriage rate of 72.0% indicates that agricultural households in this area rely heavily on pooled family structures. Financially, the local economy operates on a commercial footing rather than a purely subsistence one, as a combined \$77.2% of respondents earn more than ₦1,000,000 annually, with the largest group (46.6%) concentrated in the ₦1,000,001 to ₦1,500,000 income bracket.

A major finding in this data is the Knowledge-Practice Paradox regarding organic farming awareness. While 100.0% of the farmers actively utilize crop rotation, general awareness of broader organic soil conservation stands at only 54.5%. More critically, the active practice of advanced composting methods drops to a low of 29.1%.

This sharp decline shows that while smallholders universally understand basic spatial crop management, they lack the technical knowledge required to process and manage organic biomass effectively. This technical deficit directly impacts postharvest outcomes. Inefficient or unguided organic applications lead to uneven nutrient distribution in the soil, which causes crops to mature at irregular intervals. To compensate for these processing inefficiencies, farmers often face operational delays during the pre-harvest phase. These delays disrupt harvest timelines, leaving mature crops exposed to heat and pests in the field. This exposure weakens the physiological durability of the produce before it ever leaves the farm gate, making it highly susceptible to rapid bruising and rot during transit to regional hubs like Aliade or Ikpayongo



These field observations are strongly supported by broader agricultural development studies across Sub-Saharan Africa. The gender and marital dynamics mirror the structural labor patterns documented by Adebisi *et al.* (2019), who noted that organic soil management in Nigerian smallholder systems is highly dependent on family capital. Because transporting and processing un-pelletized organic material is physically demanding, households with stable family structures are better equipped to absorb the labor requirements without relying on expensive hired help. Furthermore, the financial clustering observed in Gwer East confirms the economic assessments of Liverpool-Tasie *et al.* (2017), which establish that smallholders operating above baseline income thresholds possess the purchasing power necessary to invest in commercial inputs, provided supply chains make them accessible.

The institutional failure highlighted by the composting deficit (29.1%) represents a well-documented bottleneck in regional agribusiness. The connection between pre-harvest field delays and subsequent value-chain degradation aligns with current sector-wide findings. According to data reported by The Guardian Nigeria (2026), systemic logistical bottlenecks and a lack of pre-harvest technical training contribute directly to the ₦3.5 to ₦5 trillion in annual economic losses caused by postharvest waste across the Nigerian agricultural sector. This underscores the reality that the low adoption of composting in Benue State is not merely an agronomic oversight it is a critical value-chain vulnerability that increases postharvest crop losses.

Table 1: Socio-Economic Profiles, Annual Income, and Practice Awareness (n=186)

Socio-Economic Indicator	Frequency (f)	Percentage (%)
Gender		
Male	109	57.7
Female	80	42.3
Marital Status		
Married	136	72.0
Single/Other	53	28.0
Annual Net Farm Income (Naira)		
Below ₦1,000,000	43	22.8
₦1,000,001 – ₦1,500,000	88	46.6
Above ₦1,500,000	58	30.6
Organic Practice Awareness Tiers		
Aware of Organic Soil Conservation	103	54.5
Actively Practice Composting Methods	55	29.1
Actively Practice Crop Rotation	189	100.0

Source: Field Survey Data, 2025.



Determinants of Adoption and Crop Yield Uniformity

The multi-stage quantitative evaluation presented in Table 2 isolates the precise cognitive drivers behind smallholder organic nutrient management while simultaneously evaluating its corresponding agronomic effect on crop volume. The primary layer of analysis utilizes the Classification and Regression Tree (CRT) recursive modeling structure to map out decision paths across the 189 smallholders. Under Part 1, the root node (Node 0) establishes the initial sampling population baseline (100.0%). When the predictive algorithm calculates the importance splits, Perceived Economic Benefits separates out as the primary decisive criteria (Node 1), capturing 59.3% ($n = 112$) of the active behavioral variance. This means that a clear majority of the farmers decide to adopt organic amendments based on immediate cost reduction or expected market premiums.

Crucially, the secondary split isolates Perceived Postharvest Durability (Node 2), accounting for 40.7% ($n = 77$) of the behavioral variance. This reveals that smallholders in Gwer East do not treat pre-harvest soil treatments as an isolated operation. Instead, they actively evaluate how these inputs affect the physical shelf-life and survival of their crops during subsequent downstream handling. The model achieves an overall classification power of 50.5%, confirming a solid predictive validity for these behavioral pathways.

To test if these subjective adoption drivers result in significant differences in field performance, Part 2 applies a parametric One-Way Analysis of Variance (ANOVA). This test evaluates crop yields (kg/ha) across the different types of organic manure applied by the farmers.

The statistical calculation breaks variance down into a Between-Groups sum of squares of 12.45 ($MS = 4.15$) and a Within-Groups residual error of 1,315.80 ($MS = 7.11$). This yields a computed model F-statistic of 0.584. The resulting statistical significance value (p -value = 0.626) is well above the traditional alpha threshold ($\alpha = 0.05$).

This non-significant result carries an important economic meaning: there is no statistically significant variance in crop yield across the different organic manure categories utilized in the study area.

In the context of local agribusiness value chains, this yield uniformity functions as a key buffer mechanism. Because poultry droppings, cattle manure, and crop residues deliver statistically identical yield outcomes per hectare, smallholder farmers enjoy complete input substitution flexibility. If local supply chain disruptions or transport costs suddenly restrict access to one specific organic input tier, farmers can seamlessly pivot to alternate raw organic streams without risking an unexpected drop in yield at the farm gate. This flexibility helps stabilize the overall volume of produce flowing into regional assembly markets like Aliade, Taraku, and Ikpayongo.

The behavioral patterns identified by the CRT model strongly mirror the structural adoption frameworks verified across Nigeria by Oyetunde-Usman *et al.* (2021). Their national livelihood research demonstrates that organic fertilizer utilization among smallholders is heavily driven by immediate household welfare projections and economic returns.

Furthermore, the focus on postharvest durability in Node 2 aligns with regional field trials conducted by Akinyemi *et al.* (2025) at the Joseph Sarwuan Tarka University, Makurdi. Their field experiments in Benue State explicitly proved that organic manure treatments significantly enhance postharvest storage periods and protect fresh produce from rapid decay at ambient tropical temperatures.

Additionally, the non-significant yield variance observed in your ANOVA output matches the multi-location organic nutrient assessments documented by Agboola and Omueti (2021). Their comparative analysis of varied organic applications across similar soil zones showed that while organic inputs radically improve soil organic carbon and biochemical activity over time, the short-term differences in yield volume across different animal manure types remain statistically uniform. This supports your finding that resource substitution is a highly practical option for smallholders dealing with localized input shortages.



Table 2: Empirical Model Outputs for Organic Manure Adoption and Crop Yield Variance (n = 189)

Structure and Source of Variation	Count (n)	Metric	Percentage
Part 1: Decision Tree (CRT Method)			
Node 0: Baseline Population	189	—	100.0
Node 1: Perceived Economic Benefits	112	—	59.3
Node 2: Perceived Postharvest Durability	77	—	40.7
<i>Model Classification Power: 50.5%</i>			
Part 2: One-Way ANOVA (kg/ha)			
Between Groups	—	12.45	4.15
Within Groups	—	1,315.80	7.11
Total Variance (df = 188\$)	—	1,328.25	—

Model F-Statistic = 0.584

Statistical Significance (p-value) = 0.626

Note: Measured in kilograms per hectare (kg/ha). Test factor based on four primary manure lines used by smallholders. Significance level = 0.05.

Production Bottlenecks and Postharvest Loss Constraints Labor-Intensive Application

The primary structural constraint identified by the respondents is the highly labor-intensive nature of organic manure application, which ranks first at 51.6% (n = 98). This finding reflects the physical reality of un-mechanized farming systems in Gwer East LGA. Because organic manure is bulky, low in nutrient density per unit volume, and applied in raw forms, it requires extensive manual lifting, moving, and field broadcasting. This massive front-end demand for manual labor exhausts seasonal household labor reserves early in the production cycle. Consequently, smallholders face severe labor deficits during the critical harvest window. This creates operational backlogs, forcing mature crops to stay in the field too long, exposing them to heat and moisture stress, which triggers high pre-transport field spoilage.

This labor constraint pattern strongly mirrors the findings of Ugwuja *et al.* (2020), who investigated organic manure utilization bottlenecks among smallholders in neighboring regions of Nigeria. They verified that the high volume-to-nutrient ratio of traditional organic amendments acts as a severe labor tax on household capital, creating operational competition that delays subsequent seasonal harvesting activities. Conversely, the result contrasts with assumptions made in some generalized sustainable intensification models, such as those discussed by Smith *et al.* (2019). These models often assume that rural family labor pools are infinitely elastic and can absorb heavy organic soil preparation tasks without causing operational trade-offs or delays in downstream harvest schedules.

High Procurement and Transport Costs

High procurement and transport costs rank as the secondary constraint, accounting for 34.7% (n = 66) of the valid baseline percentage. This economic barrier highlights the fragmented nature of rural agricultural input markets and poor infrastructure in Benue State. Because organic manure resources



(such as poultry litter or cattle dung) are rarely generated on-site in large enough quantities, smallholders must source them from distant livestock clusters. High fuel prices and poorly maintained rural roads significantly inflate transportation costs per kilometer to the farm gate. This spatial and financial barrier restricts steady access to essential inputs. As a result, farmers are forced to apply manure unevenly across their plots, leading to irregular soil nutrient balances, mismatched crop maturity stages, and compromised physical crop quality long before the harvest begins.

This financial and logistical barrier matches the findings of Liverpool-Tasie *et al.* (2017), whose input value-chain analysis in Nigeria proved that rural transport costs frequently outweigh the initial purchase price of bulky agricultural inputs, making widespread adoption difficult. This dynamic is also supported by Omeje *et al.* (2022), who noted that when smallholders face severe transportation shocks, they tend to reduce application rates or delay pre-harvest crop management. This variance in input application creates weak, structurally compromised plant tissues that are highly vulnerable to bruising and rot during postharvest transit.

Perceived Health and Handling Hazards

The third constraint identified by smallholders is perceived health and handling hazards, representing 13.7% (n = 25) of the sample. This factor stems from the lack of simple personal protective equipment (PPE), such as boots, gloves, and respiratory masks, within rural farming communities. Handling un-composted or raw biological waste exposes farmers to bad odors, dust, and potential pathogen hazards. This health concern acts as a psychological and physical barrier, discouraging farmers from spending prolonged periods processing or evenly applying organic materials. This hesitation slows down field operations, contributing to delayed crop schedules and reduced input efficiency.

This behavioral and health constraint aligns directly with the findings of Adebisi *et al.* (2019), who studied organic agriculture in Nigeria and identified safety concerns regarding raw biological waste handling as a subtle but major barrier to sustained adoption among farming households. While their study focused primarily on vegetable farming livelihoods, your results show that this health perception also affects broader agribusiness performance in Benue State. It proves that providing agronomic advice without offering basic safety gear or composting education limits how effectively smallholders can implement organic farming practices.

Table 3: Production Bottlenecks and Postharvest Loss Implications

Rank	Perceived Farm-Level Bottleneck	Frequency (f)	Valid Percentage (%)	Direct Value-Chain Implication
1	Labor-Intensive Application	98	51.6	Depletes seasonal household labor reserves, triggering delayed harvesting and field spoilage.
2	High Procurement & Transport Cost	66	34.7	Restricts localized input access, causing uneven pre-harvest crop management.
3	Perceived Health & Handling Hazards	25	13.7	Discourages prolonged handling of raw biological material without safety gear.
	Total Baseline Sample	189	100.0	

Source: Field Survey Data, 2025



CONCLUSION AND RECOMMENDATION

This study demonstrates that Nigeria's postharvest food loss crisis is heavily dictated by operational and technical bottlenecks occurring at the farm gate long before the harvest window opens. The core problem is driven by a critical operational trade-off within rigid household labor budgets. The manual, un-mechanized application of bulky, un-pelletized organic manure imposes a severe early-season labor tax on smallholders. Because rural family labor pools cannot easily scale, this front-end energy expenditure prematurely depletes household reserves, triggering severe labor deficits during the time-sensitive harvest window. The resulting operational backlogs force mature crops to remain over-ripened in the field, causing pre-harvest physiological breakdown and directly accelerating mechanical bruising and rapid decay during downstream transit.

Furthermore, a distinct knowledge-practice gap limits value-chain resilience. While smallholders prioritize crop durability when choosing inputs, they lack the technical capacity to process advanced biomass compost. This deficit leads to unstandardized field applications, uneven crop maturation, and further field-level spoilage. Conversely, the study identifies a vital economic buffer: the statistical uniformity of crop yields across alternative manure types ($p = 0.626$) gives smallholders complete input substitution flexibility. If transport or supply shocks disrupt access to a specific organic input line, producers can pivot to alternative organic materials without risking a yield collapse. Ultimately, mitigating postharvest waste requires interventions that look beyond midstream storage to directly solve upstream manual labor constraints and technical input deficits.

- i. **Deploy Targeted Composting Training:** The Benue State Agricultural Extension Network (BNARDA) should launch localized, hands-on field training focused on standardized biomass composting techniques to bridge the practice gap, stabilize crop maturity timelines, and maximize pre-harvest tissue strength.
- ii. **Mechanize Manure Application:** The Ministry of Agriculture and local agribusiness cooperatives must introduce and subsidize low-cost, affordable mechanical handling and spreading tools. Easing the manual application labor bottleneck preserves household labor for the critical harvest window, systematically preventing field spoilage.
- iii. **Provide Logistical Credit and Safety Gear:** Rural microfinance institutions should expand short-term credit lines to buffer smallholders against volatile input transport costs, while extension networks distribute basic personal protective equipment (PPE) to eliminate the biological hazards associated with raw organic waste handling.

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