# 2026 CLIMATE CHANGE GLOBAL CONFERENCE (Virtual)

## BOOK OF CONFERENCE PROCEEDINGS

ORGANISED BY CENTRE FOR CLIMATE CHANGE ACTION AND ENVIRONMENTAL STUDIES (CCCAES), IN COLLABORATION WITH SOCIETY FOR AGRICULTURE, ENVIRONMENTAL RESOURCES AND MANAGEMENT (SAEREM)

**THEME**: **Climate Smart Agriculture, Financing (CSAF), Wetland, Agroforestry and Challenges of Open Grazing**

**DATE: 14th – 16th April, 2026**

**VENUE: Centre for Climate Change Action and Environmental Studies (CCCAES), Uyo, Akwa Ibom State, Nigeria**

Prof. Stephen Ibitoye –Conference Chairman; Prof. Emma Opara –Conf. Moderator; Eteyen Nyong- Ph.D - Conference Coordinator

## WELCOME ADDRESS DELIVERED BY THE CONFERENCE CHAIRMAN, PROF STEPHEN IBITOYE ,FSAEREM, DURING THE 2026 CLIMATE CHANGE GLOBAL CONFERENCE ORGANISED

Good morning distinguished guests, esteemed colleagues, partners, ladies and gentlemen,

It is my great honor and privilege to welcome you all to this important conference focused on climate-smart agriculture financing, wetland conservation, agroforestry, and the challenges of open grazing.Today’s gathering comes at a critical time. Across our regions, we are witnessing the growing impacts of climate change—erratic rainfall, land degradation, declining biodiversity, and increasing pressure on our natural resources. These challenges are not isolated; they are deeply interconnected with how we produce food, manage land, and support livelihoods.

Climate-smart agriculture offers us a pathway forward. It calls for innovative approaches that increase productivity, enhance resilience, and reduce emissions. However, without adequate and accessible financing, even the most promising solutions remain out of reach for many farmers and communities. This conference therefore provides a platform to explore sustainable financing models that can unlock opportunities and scale impact.

Our wetlands, often undervalued, play a vital role in maintaining ecological balance. They act as natural water filters, buffers against flooding, and reservoirs of biodiversity. Protecting and restoring these ecosystems is not optional—it is essential for both environmental sustainability and human survival.

Agroforestry, on the other hand, represents a powerful intersection between agriculture and environmental stewardship. By integrating trees into farming systems, we can restore soil fertility, improve yields, and create additional sources of income, all while contributing to climate mitigation. At the same time, we must address the persistent and complex challenge of open grazing. This issue has far-reaching implications for land use, food security, environmental sustainability, and social cohesion. It requires thoughtful dialogue, inclusive policies, and practical solutions that consider the needs of farmers, herders, and communities alike.This conference brings together policymakers, researchers, financial institutions, development partners, and practitioners. Your expertise, experiences, and perspectives are invaluable. Over the course of our discussions, I encourage us all to engage openly, think innovatively, and work collaboratively toward actionable solutions.Let this not be just another conversation, but a turning point—where ideas are transformed into commitments, and commitments into measurable impact.

On behalf of the organizers, I warmly welcome you all and wish us a productive and inspiring conference.

Thank you.

# Bridging the Gap: Integrating Climate Smart Agriculture Financing and Agroforestry for Resilient Food Systems

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INTRODUCTION

Distinguished guests, colleagues, and partners in sustainable development, we gather at a defining moment for the global agriculture. As of 2026, food systems are under unprecedented strain from climate variability, land degradation, population growth and conflicts. The FAO estimates that hundreds of millions of people remain food insecure world-wide, while climate change continues to reduce agricultural productivity, particularly in vulnerable regions such as Sub-Saharan Africa (FAO, 2023; IPCC, 2022). In early 2026, the FAO reports a severe, escalating global food crisis driven by conflict, economic fragility, and climate-induced shocks, with Nigeria at the epicenter.

By mid-2026, 34.7 million people in Nigeria are projected to face acute food insecurity, while over 52 million are at risk in West and Central Africa (FAO in Nigeria, 2026).

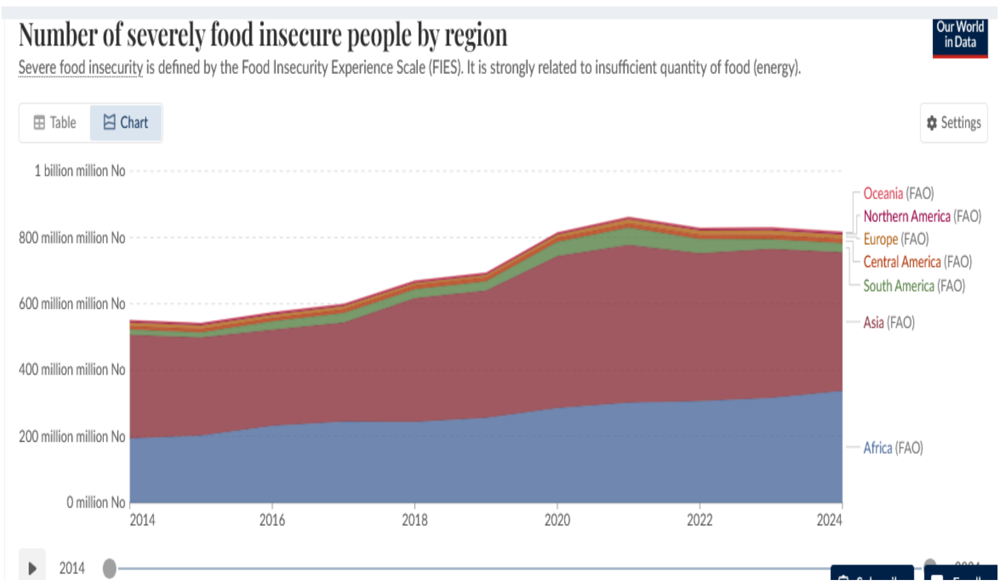
At the same time, agriculture contributes nearly one-quarter of global greenhouse gas emissions, making it both a victim and a driver of climate change (Crippa *et al*., 2021).

This brings us to a critical question:
How do we produce more food, sustainably, under increasing climate uncertainty?

One proven solution is agroforestry, which is the deliberate integration of trees into farming systems. Yet despite its well-documented benefits, adoption remains limited.

The missing link is not knowledge, it is finance.

Today, I argue that Climate Smart Agriculture Financing (CSAF) is the bridge needed to transform agroforestry from a niche practice into a scalable, resilient food system solution.


Number of severely food insecure people by region
Severe food insecurity is defined by the Food Insecurity Experience Scale (FIES). It is strongly related to insufficient quantity of food (energy).
Our World in Data
Table
Chart
Settings
1 billion million No
800 million million No
600 million million No
400 million million No
200 million million No
0 million No
2014
2016
2018
2020
2022
2024
Oceania (FAO)
Northern America (FAO)
Europe (FAO)
Central America (FAO)
South America (FAO)
Asia (FAO)
Africa (FAO)
2014


## THE AGROFORESTRY ADVANTAGE

Agroforestry represents one of the most robust and multifunctional land-use systems available for addressing the intertwined challenges of climate change, food insecurity, and environmental degradation. Its strength lies in its ability to simultaneously deliver *ecological resilience* and *economic sustainability*, making it a cornerstone of climate-smart agriculture.

### Ecological Benefits

From an ecological perspective, agroforestry systems significantly enhance biodiversity conservation by creating structurally diverse habitats that support a wide range of plant and animal species. The integration of trees into cropping systems increases species richness and promotes ecological balance, which in turn strengthens natural pest control and pollination services (Jose, 2019; Nair *et al*., 2021).

Agroforestry also plays a critical role in soil health restoration. Tree roots improve soil structure, reduce compaction, and enhance nutrient cycling through litter deposition and biological activity. This leads to increased soil organic carbon and improved soil fertility over time. Recent studies have shown that agroforestry systems can significantly increase soil carbon sequestration, thereby contributing to climate change mitigation (Zomer *et al*., 2022).

In addition, agroforestry systems are highly effective in microclimate regulation. Tree canopies reduce temperature extremes, lower evapotranspiration rates, and protect crops from wind damage. These functions are particularly important in semi-arid regions, where climate variability poses a major threat to crop productivity. By moderating environmental stress, agroforestry enhances crop resilience to drought and extreme weather events (IPCC, 2022).

Water management is another key ecological advantage. Trees improve water infiltration and retention, reduce surface runoff, and minimize soil erosion. This is especially critical in degraded landscapes, where conventional farming often accelerates land degradation (FAO, 2022).

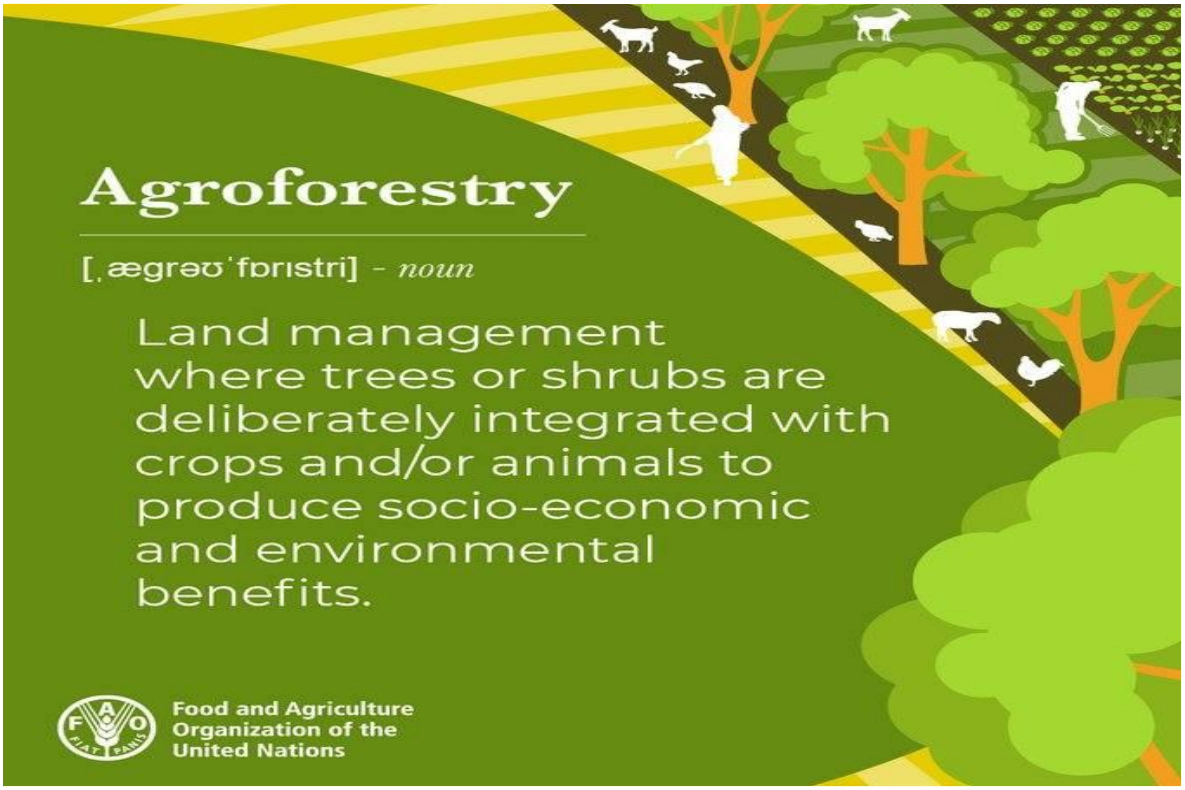
Economic Benefits

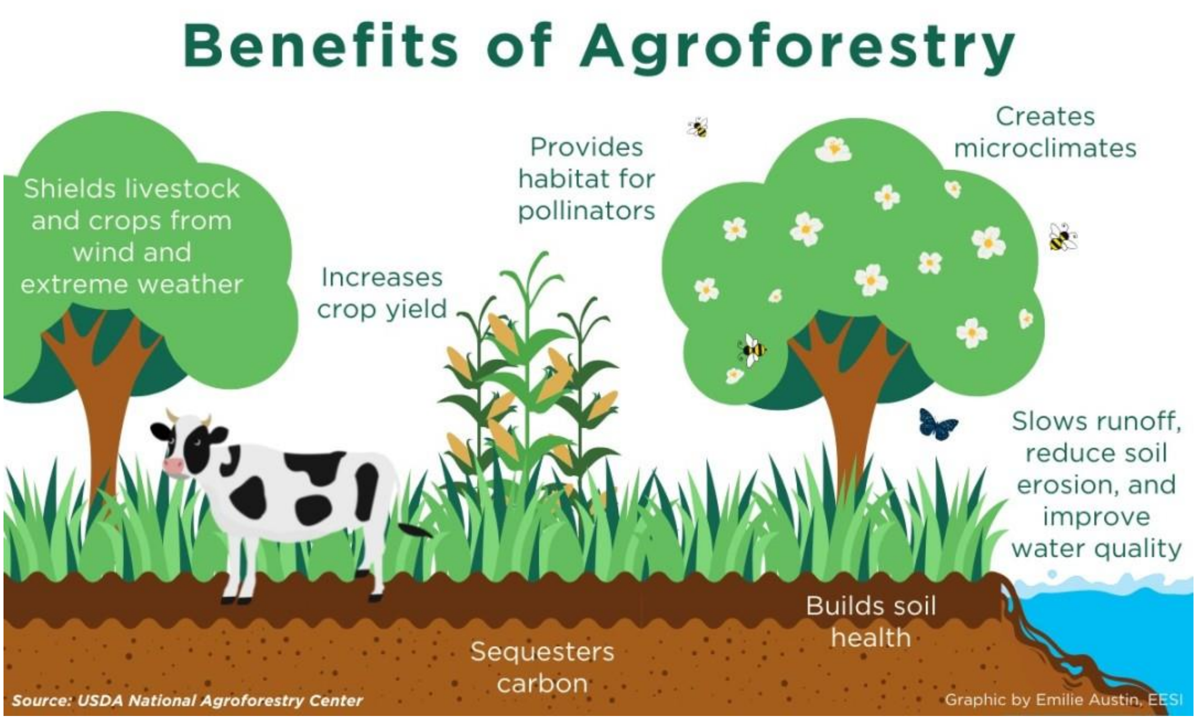
Economically, agroforestry systems provide income diversification, which is essential for reducing farmer vulnerability to market and climate shocks. Unlike monocropping systems, agroforestry allows farmers to generate multiple revenue streams from a single piece of land, including fruits, nuts, timber, fodder, and medicinal products.

This diversification enhances risk management, as farmers are not solely dependent on one crop. For example, if annual crops fail due to drought, tree-based products can still provide income or subsistence resources. Empirical evidence shows that agroforestry systems can improve household income stability and long-term asset accumulation (Mbow *et al*., 2018; Kuyah *et al*., 2019).

Moreover, trees in agroforestry systems function as natural capital assets. Over time, they increase in value and can be harvested strategically, providing a form of financial security for rural households. This long-term economic benefit is particularly important in regions with limited access to formal financial systems.

Agroforestry also reduces input costs by enhancing natural soil fertility and reducing the need for synthetic fertilizers and pesticides. This contributes to improved profit margins and sustainability for smallholder farmers (Pramanick *et al*., 2022).


Agroforestry
[ˌæɡrəʊˈfɒrɪstri] - noun
Land management where trees or shrubs are deliberately integrated with crops and/or animals to produce socio-economic and environmental benefits.
Food and Agriculture Organization of the United Nations


Benefits of Agroforestry
Shields livestock and crops from wind and extreme weather
Increases crop yield
Provides habitat for pollinators
Creates microclimates
Slows runoff, reduce soil erosion, and improve water quality
Builds soil health
Sequesters carbon
Source: USDA National Agroforestry Center
Graphic by Emilie Austin, EESI

Addressing the Challenge of Open Grazing

A particularly important, yet often underemphasized, advantage of agroforestry is its role in addressing the challenge of open grazing, which is a major source of conflict and environmental degradation in many parts of Africa.

Agroforestry systems can integrate fodder trees and shrubs, creating controlled and sustainable feeding systems for livestock. These systems:

Reduce dependence on open grazing

Minimize crop destruction by roaming animals

Lower farmer–herder conflicts

Improve livestock nutrition and productivity

Research indicates that silvi-pastoral systems where trees, pasture, and livestock are integrated can significantly enhance both crop and livestock productivity while restoring degraded land (FAO, 2022; World Bank, 2023).

Furthermore, by stabilizing soils and reducing overgrazing pressure, agroforestry contributes to landscape restoration and ecological balance, which are essential for long-term agricultural sustainability.

In summary, the agroforestry advantage lies in its multifunctionality, as it is not merely an agricultural practice but a holistic system that integrates environmental stewardship with economic resilience. It enhances productivity, reduces risk, restores ecosystems, and provides pathways for climate adaptation and mitigation.

However, despite these compelling benefits, its widespread adoption remains constrained bringing us to the critical issue of financing, which this keynote seeks to address.

THE FINANCING BOTTLENECK

Despite the compelling ecological and economic advantages of agroforestry, its large-scale adoption remains limited across many developing regions. This paradox high potential but low uptake can be traced to a fundamental structural issue: a misalignment between the nature of agroforestry systems and the design of conventional financial systems.

At its core, agroforestry is a long-term, biologically driven investment system, whereas modern agricultural finance is structured around short-term, high-liquidity, and predictable returns. This disconnect creates significant barriers for both farmers and financial institutions.

Temporal Mismatch: Long Gestation vs Short-Term Finance

One of the most critical constraints is the time horizon mismatch.

Agroforestry systems require patience:

Fruit trees (e.g., mango, citrus): 3–5 years before meaningful yield

Cash tree crops (e.g., cocoa): 4–7 years

Timber species: 10–20 + years

In contrast, most agricultural loans are designed for seasonal repayment cycles (6–12 months).

📌 Illustrative Scenario:
A farmer who takes a loan to grow maize can repay after harvest within the same year. However, a farmer investing in agroforestry cannot generate sufficient cash flow in the early years, making loan repayment schedules unrealistic.

☞ Result: Farmers avoid agroforestry, and lenders avoid financing it.

Cash Flow Uncertainty and Risk Perception

Agroforestry systems generate diversified but staggered income streams, which are inherently less predictable than monocropping systems.

Returns depend on:

Tree survival rates

Climate variability (droughts, floods)

Market access and price fluctuations

Management practices

📌 Example:
A cocoa-based agroforestry system in West Africa may experience:

Reduced yields in the early transition years

Delayed economic returns

Variable output depending on rainfall patterns

Financial institutions interpret these uncertainties as high default risk, even though agroforestry systems are often more resilient in the long term (IPCC, 2022).

☞ This creates a bias toward financing short-cycle crops, even when they are more vulnerable to climate shocks.

Collateral Constraints and Financial Exclusion

A major structural barrier is the limited financial inclusion of smallholder farmers, who are the primary actors in agroforestry adoption.

Most smallholders:

Do not possess formal land titles

Lack credit histories

Operate outside formal banking systems

📌 Key Statistic:
In Sub-Saharan Africa, fewer than 10–15% of smallholder farmers have access to formal credit (IFAD, 2022; World Bank, 2023).

Without collateral, farmers cannot secure loans. Even when financing is available, it is often:

Short-term

High-interest

Unsuitable for long-term investments

📌 Illustration:
A farmer may want to plant 200 trees but cannot access credit because their land is not formally registered, making agroforestry adoption financially impossible.

Institutional Bias and Knowledge Gaps

Beyond financial metrics, there is also a knowledge and perception barrier within financial institutions.

Banks often view agroforestry as:

Technically complex

Difficult to monitor

Lacking standardized investment models

📌 Example:
It is easier for a bank to evaluate a maize farm (with known inputs, timelines, and yields) than a diversified agroforestry system involving trees, crops, and possibly livestock.

☞ This leads to institutional bias, where familiar but less sustainable systems receive more funding.

The "Green Gap": A Systemic Disconnect

These combined challenges give rise to what is increasingly referred to as the "Green Gap"—a critical disconnect between:

Global climate finance availability, and

Local-level accessibility for farmers

Globally, billions of dollars are committed annually to:

Climate adaptation

Sustainable land management

Carbon mitigation

However, only a small fraction reaches smallholder farmers.

📌 Illustrative Example:
International climate funds often require:

Complex proposal processes

Institutional partnerships

Large-scale project design

Smallholder farmers who manage less than 2 hectares on average—are effectively excluded from these funding streams.

☞ Funds flow to:

Governments

NGOs

Large agribusinesses

But rarely to individual farmers or rural communities.

Scale and Fragmentation Challenges

Agroforestry systems are typically:

Small-scale

Geographically dispersed

Highly heterogeneous

This creates high transaction costs for lenders:

Monitoring many small farms is expensive

Loan administration is complex

Returns are fragmented

📌 Example:
Financing 1,000 small farmers individually is far more costly than financing one large plantation, even if the total investment is the same.

Real-World Consequences

The cumulative effect of these constraints is significant:

Farmers remain locked in low-input, low-output systems

Adoption of climate-resilient practices remains slow

Land degradation continues

Climate vulnerability persists

☞ In essence, the problem is not the absence of viable solutions but the absence of enabling finance.

In summary the financing bottleneck in agroforestry is not merely a funding issue it is a system design failure. Financial systems are optimized for short-term gains, while agroforestry delivers long-term value.

Bridging this divide requires innovative financial mechanisms that align capital flows with ecological timelines. This is precisely where Climate-Smart Agriculture Financing (CSAF) becomes essential not as an option, but as a necessity.

CSAF MECHANISMS: THE PATHWAY FORWARD

Bridging the financing gap in agroforestry requires more than incremental adjustments it demands a systemic rethinking of how agricultural finance is structured, delivered, and de-risked. Climate-Smart Agriculture Financing (CSAF) offers a pathway by aligning financial instruments with the long-term, multifunctional nature of agroforestry systems.

Blended Finance: De-risking Sustainable Agriculture

Blended finance is one of the most promising mechanisms for unlocking investment in agroforestry. It involves the strategic use of public or concessional funds to attract private capital by reducing perceived risks.

In practice:

Governments or development agencies provide first-loss guarantees or concessional loans

Private investors then enter with reduced exposure to risk

📌 Illustration:
A development bank funds 30% of an agroforestry project and agrees to absorb initial losses. This encourages commercial banks to finance the remaining 70%, knowing their risk is partially covered.

📌 Real-world example:
The Africa Agriculture and Trade Investment Fund (AATIF) use blended finance to support sustainable agriculture by combining public and private capital, enabling investments in long-term systems like agroforestry.

Blended finance is particularly effective because it:

Makes agroforestry bankable

Encourages private sector participation

Scales funding beyond limited public resources

However, its success depends on strong institutional frameworks and transparency (OECD, 2020; World Bank, 2023).

Green Bonds: Mobilizing Large-Scale Capital

Green bonds are debt instruments specifically designed to finance environmentally sustainable projects, including agroforestry, reforestation, and climate-resilient agriculture.

The global green bond market has expanded rapidly, exceeding $500 billion annually, yet agriculture and especially smallholder systems receive only a marginal share (Climate Bonds Initiative, 2023).

📌 Illustration:
A government issues a green bond to finance:

Large-scale tree planting programs

Agroforestry extension services

Climate-smart infrastructure

Investors purchase the bond, and the funds are directed toward sustainable land-use systems.

📌 Example:
Countries like Nigeria and Kenya have begun issuing sovereign green bonds to fund climate-related projects, but allocation to agroforestry remains limited.

Key challenge:
Green bonds typically finance large-scale, centralized projects, whereas agroforestry is often:

Smallholder-driven

Decentralized

Fragmented

☞ This creates a scale mismatch.

Solution:

Develop aggregation models (e.g., cooperatives, farmer clusters)

Channel bond financing through intermediary institutions

This allows smallholders to benefit indirectly from large capital flows.

Carbon Markets: Monetizing Ecosystem Services

Agroforestry systems are powerful carbon sinks, with significant potential for climate change mitigation through carbon sequestration. This creates an opportunity for farmers to earn income through carbon credits.

In theory:

Farmers adopt agroforestry

Trees capture carbon

Carbon is measured and certified

Credits are sold in carbon markets

📌 Illustration:
A farmer planting 100 trees could generate carbon credits over time, which are sold to companies seeking to offset emissions.

Barriers to Participation

Despite this potential, smallholder farmers face major constraints:

High cost of carbon measurement and verification

Complex certification procedures

Lack of awareness and technical capacity

Small farm sizes (low individual carbon volumes)

📌 Example:
A single farmer may not produce enough carbon credits to justify transaction costs, making participation economically unviable.

Pathways to Unlock Carbon Markets

To make carbon markets accessible:

Aggregation models

Group farmers into cooperatives

Pool carbon credits for scale

Digital MRV systems (Monitoring, Reporting, Verification)

Use satellite data and AI to reduce verification costs

Simplified certification frameworks

Reduce technical and administrative barriers

📌 Real-world example:
Projects in East Africa have successfully aggregated smallholder farmers into carbon programs, enabling them to earn additional income from agroforestry adoption (Zomer et al., 2022).

Integrating Mechanisms for Maximum Impact

Individually, these financial instruments are powerful but their real strength lies in integration.

📌 Illustration (Integrated Model):

Blended finance reduces risk

Green bonds provide large-scale capital

Carbon markets create long-term revenue streams

☞ Together, they form a comprehensive financing ecosystem for agroforestry.

Practical Scenario (Putting It All Together)

Imagine a national agroforestry program:

Government issues a green bond to raise capital

Development partners provide blended finance guarantees

Farmers adopt agroforestry practices

Carbon sequestration is measured and sold in carbon markets

Farmers receive both crop income and carbon payments

☞ This transforms agroforestry from a subsistence activity into a financially viable enterprise.

Synthesis

The pathway forward is not about a single solution, but about financial innovation that aligns with ecological realities. CSAF mechanisms provide the tools to:

De-risk investment

Mobilize capital at scale

Reward environmental services

By redesigning financial systems to support long-term sustainability, we can unlock the full potential of agroforestry as a driver of resilient food systems and climate action.

CASE STUDIES

Empirical evidence from diverse agro-ecological regions clearly demonstrates that the integration of agroforestry with appropriate financing mechanisms delivers measurable gains in productivity, resilience, and sustainability. These real-world experiences provide compelling validation that when innovation is matched with enabling finance, transformative outcomes are achievable.

East Africa: Productivity Gains and Soil Restoration (Kenya)

In East Africa, particularly Kenya, agroforestry has shown strong potential to simultaneously enhance crop productivity and restore degraded soils. Studies indicate that integrating trees such as *Faidherbia albida* into maize systems can significantly improve soil fertility through biological nitrogen fixation and organic matter accumulation.

📌Evidence:
Field-based studies have reported maize yield increases of up to 30–50% in agroforestry systems compared to conventional monocropping, alongside improvements in soil organic carbon and moisture retention (Kuyah *et al*., 2019; Manono & Mwami, 2026).

📌 Mechanism:

Trees recycle deep soil nutrients

Leaf litter enhances soil organic matter

Improved microclimate reduces evapotranspiration

☞ These findings demonstrate that agroforestry is not merely a conservation strategy—it is a productivity-enhancing system, especially under climate stress conditions.

Southeast Asia: Blended Finance and Income Stability

In Southeast Asia, where smallholder farming dominates, blended finance models have played a critical role in enabling farmers to adopt tree-based systems such as agroforestry involving rubber, coffee, and fruit trees.

📌Evidence:
FAO (2022) reported that farmers participating in financed agroforestry programs experienced:

Improved income diversification

Reduced vulnerability to price shocks

Greater long-term financial stability

📌Example:
In Indonesia and Vietnam:

Farmers integrate timber and fruit trees with annual crops

Early income is generated from intercrops

Long-term returns come from tree harvests

☞ This creates a layered income system, reducing dependence on a single crop.

📌 Financial Insight:
Blended finance mechanisms helped:

Offset initial establishment costs

Provide technical support

Reduce investor risk

West Africa: Landscape Restoration through FMNR

One of the most remarkable success stories comes from West Africa through Farmer-Managed Natural Regeneration (FMNR)—a low-cost, scalable agroforestry practice.

📌 Evidence:

Over 5 million hectares of degraded land restored in Niger alone

Significant improvements in crop yields, soil fertility, and household resilience (World Bank, 2023; Reij & Garrity, 2016)

📌 Mechanism:

Farmers protect and manage naturally regenerating trees

No need for expensive planting

Rapid restoration of ecosystem functions

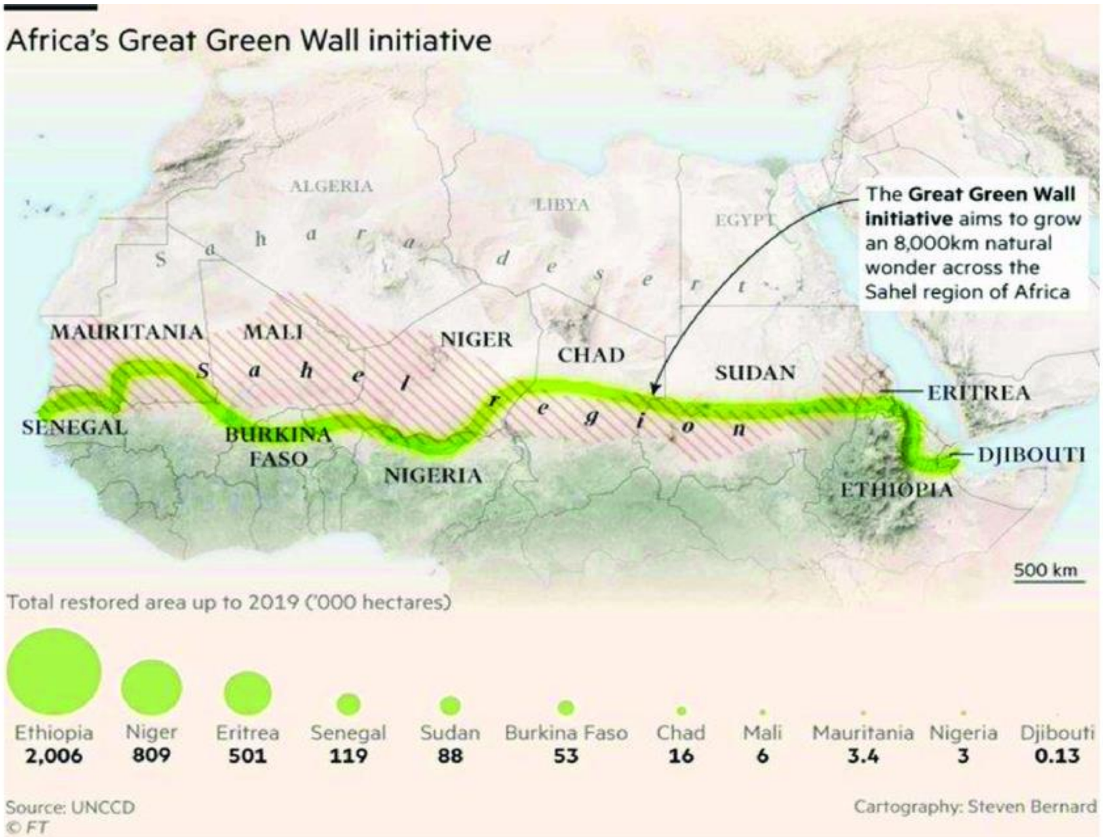
📌 Impact:

Increased crop yields under tree cover

Enhanced drought resilience

Improved livelihoods for millions of smallholders

☞ FMNR demonstrates that agroforestry does not always require heavy capital investment—knowledge and community engagement can drive transformation.




Sub-Saharan Africa: Climate Resilience and System Stability

Across Sub-Saharan Africa, recent multidisciplinary studies highlight that agroforestry systems:

Buffer crops against heatwaves and rainfall variability

Improve water-use efficiency

Enhance long-term system stability

📌 Evidence:
Agroforestry-based systems have been shown to reduce climate risks and stabilize yields under extreme conditions (Olarewaju et al., 2025).

☞ This is particularly critical as climate change continues to disrupt conventional agricultural systems.

Cross-Case Synthesis: What Do These Examples Tell Us?

Across regions, several consistent themes emerge:

✓ Productivity Gains: Agroforestry increases yields through improved soil fertility and microclimate regulation

✓ Resilience Building: Tree-based systems buffer crops against climate variability

✓ Income Diversification: Multiple products (crops, fruits, timber) reduce economic risk

✓ Scalability with Finance: Adoption accelerates when supported by appropriate financial instruments

The Critical Link: Finance + Innovation = Transformation

These case studies collectively reinforce a central argument:

☞ Agroforestry works—but it scales only when supported by enabling financial systems.

In Kenya → productivity gains were realized with technical and financial support

In Southeast Asia → adoption increased through blended finance

In West Africa → low-cost models succeeded with institutional backing

📌 Key Insight: The limiting factor is not the viability of agroforestry, but the accessibility of finance and institutional support.



Farmer-managed regeneration before vs after

The global evidence is unequivocal: agroforestry is a proven pathway to sustainable intensification, climate resilience, and rural transformation. However, its success is neither accidental nor automatic it emerges at the intersection of scientific innovation, farmer knowledge, and enabling finance.

POLICY RECOMMENDATIONS

To scale this integration, coordinated action is required.

De-risk Climate Investments

Governments must provide guarantees, subsidies, and insurance schemes to attract private investment.

Enable Climate-Smart Banking

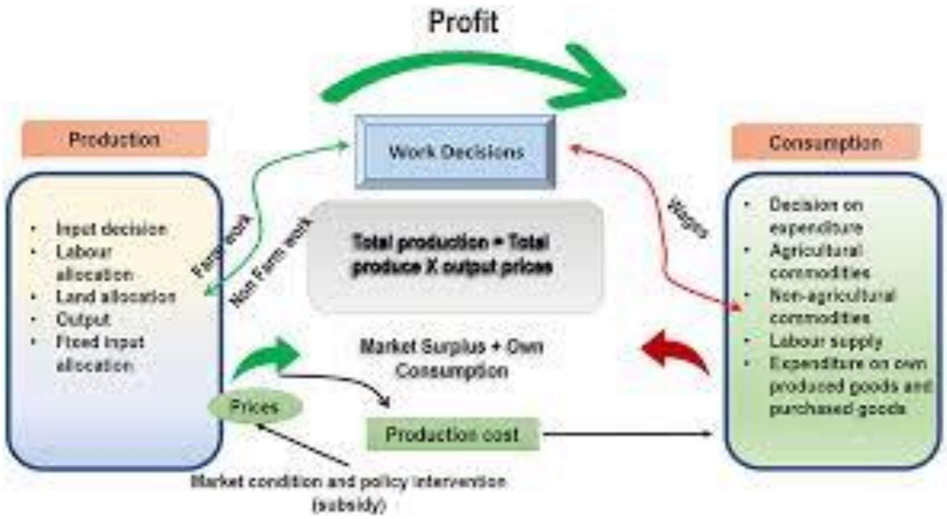
Financial institutions should develop products tailored to agroforestry cycles, including flexible repayment schedules.

Integrate Agroforestry into National Budgets

Agroforestry should be mainstreamed into agricultural and environmental policies, including wetlands and landscape restoration programs.

Promote Financial Literacy

Farmers must be equipped with knowledge to access and manage climate finance effectively.




Policy framework diagram linking government, finance, and farmers

CONCLUSION & CALL TO ACTION

In conclusion, agroforestry offers a proven pathway to resilient food systems but without financing, its potential will remain unrealized.

The integration of CSAF provides the bridge between ecological potential and economic reality.

We must move beyond being climate-aware to becoming climate-invested.

This requires collaboration:

Policymakers must create enabling environments

Financial institutions must innovate

Researchers must generate evidence

Farmers must be empowered

The future of food systems depends not only on what we grow but on how we invest.

Let us build that bridge together.

Thank you.

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# Agro-Forestry Resources Management as it Affects Animal Grazing in Nigeria: Government Financial Interventions and Institutional Roles

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## Abstract

Agro-forestry resources management plays a significant role in sustaining livestock grazing systems and maintaining ecological balance in Nigeria. However, increasing pressure on land due to population growth, deforestation, climate change, and farmer–herder conflicts has threatened both forestry resources and grazing systems. This paper examines the relationship between agro-forestry resource management and animal grazing in Nigeria, highlighting government financial interventions aimed at mitigating the challenges. The paper also analyzes the usefulness of institutions such as the Federal Ministry of Livestock Development and forestry departments across federal, state, and local government levels. It concludes that integrated policies, improved funding, and sustainable agro-forestry practices are essential for improving livestock productivity and environmental sustainability.

## Introduction

Agriculture remains a major component of Nigeria's economy, contributing significantly to employment and food security. Livestock production is an important subsector that depends largely on natural grazing resources. However, the sustainability of grazing systems is closely linked to forestry and land resource management.

Agro-forestry combines trees, crops, and livestock in a single land management system to improve productivity and environmental sustainability. Such systems allow the coexistence of livestock grazing with tree cultivation and crop production. Forests and trees provide fodder, shade, soil protection, and improved ecosystem services for grazing animals.

In Nigeria, poor management of forest resources, desertification, and overgrazing have led to declining pasture quality and increased conflicts between farmers and pastoralists. Consequently, the government has introduced several policies and financial measures to mitigate these problems.

Concept of Agro-Forestry Resources Management

Agro-forestry refers to a land-use system where trees, crops, and animals are deliberately integrated to enhance productivity and environmental sustainability.

Key agro-forestry systems include:

1. Silvopastoral systems – integration of trees with livestock grazing.
2. Taungya system – growing crops with forest trees.
3. Agrosilviculture – combination of crops and trees.

Agro-forestry improves soil fertility, reduces erosion, and provides fodder for livestock while maintaining forest resources. It also enhances biodiversity and climate resilience.

Effects of Agro-Forestry Resource Management on Animal Grazing

Agro-forestry significantly influences livestock grazing in several ways:

3.1 Provision of Fodder and Shade

Trees in agro-forestry systems provide leaves, pods, and fruits that serve as feed for animals. Tree shade also protects livestock from excessive heat.

3.2 Improved Soil Fertility

Trees fix nitrogen and increase organic matter in soil, improving pasture growth.

3.3 Reduced Land Degradation

Agro-forestry reduces erosion and desertification by stabilizing soil and protecting vegetation cover.

3.4 Sustainable Grazing Systems

Integrated systems such as rotational grazing help prevent overgrazing and allow pasture regeneration.

3.5 Climate Change Mitigation

Trees act as carbon sinks and improve environmental sustainability.

Challenges Affecting Agro-Forestry and Grazing in Nigeria

Despite its benefits, agro-forestry faces several challenges:

1. Deforestation and loss of forest cover
2. Desertification in northern Nigeria
3. Farmer–herder conflicts
4. Inadequate grazing reserves
5. Weak land-use planning
6. Limited access to funding and extension services

Nigeria has reportedly lost millions of hectares of forest due to unsustainable agricultural practices.

Government Financial Steps to Mitigate the Effects

The Nigerian government has implemented various financial and policy measures to address challenges in agro-forestry and livestock grazing.

5.1 Establishment of the Federal Ministry of Livestock Development

The Federal Ministry of Livestock Development, created in 2024, was designed to transform the livestock sector and improve grazing management.

The ministry aims to:

- Promote sustainable livestock production
- Encourage ranching systems
- Improve pasture development
- Reduce conflicts between farmers and herders
- Support research and investment in livestock farming

5.2 Development of Grazing Reserves

Nigeria currently has over 273 gazetted grazing reserves covering about 4.5 million hectares, which the government plans to rehabilitate and upgrade for livestock production.

Funding is directed toward:

- Infrastructure in grazing reserves
- Water points and veterinary services
- Pasture development

- Settlement facilities for pastoralists

5.3 Digitization of Grazing Routes

The government has begun mapping and digitizing cattle routes to prevent encroachment and improve land management.

This initiative helps authorities monitor grazing activities and prevent conflicts between farmers and pastoralists.

5.4 Afforestation and Agro-Forestry Programs

Government agencies such as the National Agency for the Great Green Wall implement afforestation and agro-forestry projects to restore degraded land.

Activities include:

- Establishment of shelterbelts
- Tree nurseries
- Woodlots and orchards
- Windbreak plantations
- Community forestry programs

These initiatives help provide fodder and improve grazing environments.

5.5 Financial Incentives and Subsidies

Government policies also encourage agro-forestry through:

- Subsidies for tree planting
- Agricultural loans for farmers and pastoralists
- Research funding
- Extension services and training programs

These measures aim to increase adoption of sustainable land-use practices.

Usefulness of the Ministry of Livestock

The Federal Ministry of Livestock Development plays several key roles:

1. Development of livestock policies

2. Coordination of grazing reserves
3. Promotion of ranching systems
4. Livestock disease control
5. Investment in livestock research
6. Conflict resolution between farmers and pastoralists

The ministry also supports sustainable grazing practices such as rotational grazing and integrated crop-livestock systems.

Role of Forestry Departments at Different Government Levels

7.1 Federal Government

Federal forestry departments develop national forestry policies and coordinate conservation programs.

They also manage national forest reserves and provide funding for afforestation programs.

7.2 State Government

State forestry departments:

- Implement forest policies
- Protect forest reserves
- Promote agro-forestry practices
- Provide forestry extension services

7.3 Local Government

Local governments assist in:

- Community forestry projects
- Tree planting campaigns
- Monitoring grazing activities
- Educating farmers and pastoralists

This multi-level governance approach improves sustainable land management.

Conclusion

Agro-forestry resource management is essential for sustainable livestock grazing in Nigeria. Proper integration of trees, crops, and livestock improves pasture quality, protects the environment, and enhances agricultural productivity

Government interventions such as the creation of the Federal Ministry of Livestock Development, grazing reserve rehabilitation, afforestation programs, and financial incentives represent important steps toward sustainable livestock production.

However, greater investment, stronger institutional coordination, and increased awareness among farmers and pastoralists are necessary to ensure long-term sustainability.

9. Recommendations

Increase government funding for agro-forestry programs.

Expand grazing reserves and ranching infrastructure.

Strengthen forestry departments and extension services.

Promote research on agro-forestry and pasture development.

Encourage community participation in forest and grazing management.

Improve land-use policies to reduce conflicts between farmers and pastoralists.

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# Climate Smart Agriculture Financing (CSAF): Wetlands and Water Resources Sustainability

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## Abstract

**Climate change poses a significant threat to agricultural productivity, water resources, and ecosystem sustainability, particularly in developing countries such as Nigeria, where irrigation is still limited due to the high cost.**

**Climate Smart Agriculture Financing (CSAF) has emerged as a strategic approach that integrates environmental risk assessment into agricultural investments to enhance resilience, productivity, and sustainability.**
**This paper examines the role of CSAF in promoting wetlands conservation and sustainable water resource management in Nigeria. It explores financing mechanisms, institutional frameworks, and climate-smart water management practices while highlighting challenges and opportunities.**
**The study concludes that strengthening public-private partnerships, improving financial inclusion, and investing in water-efficient technologies are essential for achieving long-term sustainability.**

## 1. Introduction

**Agriculture remains a cornerstone of Nigeria’s economy, yet it is highly vulnerable to climate variability, including erratic rainfall, drought, and**

**flooding. Climate change has intensified these challenges, threatening food security and livelihoods.**

**Climate Smart Agriculture (CSA) is an approach that aims to:**

**a. Increase agricultural productivity**

**b. Enhance resilience to climate change.**

**c. Reduce greenhouse gas emissions.**

**However, achieving these goals requires adequate financing mechanisms. Climate Smart Agricultural Finance (CSAF) integrates climate risk considerations into financial decision-making, ensuring that investments support sustainable and resilient agricultural systems.**
**Wetlands and water resources are critical to agriculture, yet they are under increasing pressure due to land overuse, pollution, and climate change. Sustainable financing is therefore essential for their protection.**

## 2. Conceptual Framework

### 2.1 Climate Smart Agriculture (CSA)

**CSA is a holistic framework designed to address food security and climate challenges simultaneously. It emphasizes adaptive practices such as improved irrigation, drought-resistant crops, and sustainable land management.**
**in Nigeria, studies show that over 87% of farmers have adopted at least one climate-resilient practice, particularly those aimed at improving water use efficiency and reducing crop losses.**

### 2.2 Climate Smart Agricultural Finance (CSAF)

**CSAF refers to financial systems that incorporate environmental and climate risk into agricultural lending and investment decisions.**
**These mechanisms help mobilize capital toward sustainable agriculture while mitigating risks for investors and farmers.**

### 2.3 Wetland and Water Resources in Agriculture

**Water is central to agricultural production, accounting for approximately 70% of global fresh water use.**
**Wetlands provide:**
**a. Water storage and flood regulation: Many wetlands, particularly floodplain wetlands, have the capacity to temporarily store flood waters during high runoff events.**
**b. Groundwater recharge: It is also referred to as deep drainage, where water moves downwards from surface water to groundwater.**
**c. Biodiversity Conservation: This is the practice of protecting, managing, and restoring Earth's species ecosystems and genetic diversity to prevent extinction and ensure ecosystem resilience.**
**d. Livelihood Support: Wetlands serve as critical natural infrastructure that directly and indirectly support the livelihood of over one billion people worldwide. People depend on it for farming, both food and fishing, water supply, water transportation, etc.**

## 3. Linkage Between CSAF, Wetland, and Water Sustainability

### 3.1 Financing Sustainable Water Management

**CSAF enables investment in:**

**a. Efficient irrigation systems: Drip irrigation and micro-sprinklers maximize water use by delivering water directly to the plant root zone, achieving up to 95% efficiency.**

**b. Rainwater harvesting: This is the sustainable collection and storage of rain from surfaces like rooftops, rather than letting it run off, for immediate or future use. It reduces dependence on municipal water, lowers utility bills, and provide sustainable, free water source for irrigation.**

**c. Watershed Management: This is the strategic process of guiding and organizing land, water, and related natural resources within a drainage basin to protect, conserve, and improve the ecosystems. Its aim is to boost rural livelihood, enhance groundwater recharge, reduce erosion, and prevent pollution.**

**d. Wetland restoration: This repairs degraded, damaged, or destroyed wetland ecosystems to reinstate their natural functions, such as biodiversity support, carbon storage, and flood mitigation.**

**International funding mechanisms such as the Adaptation Fund and Global Environment Facility Support Climate resilient water and agriculture projects.**

### 3.2 Climate-Smart Water Management Technologies

**Key technologies include:**

**a. Drip irrigation system as described earlier.**

**b. Soil moisture conservation techniques: This is achieved by reducing evaporation, increasing infiltration, and boosting soil organic matter. Key**

**methods include applying organic mulch, conservation tillage, and adding compost to improve structure.**

**These techniques minimize runoff and enhance water holding.**

**c. Smart Water monitoring systems: This technology uses sensors that track water quality (PH ect) and quantity (levels, flow rates) in real time. It detects leaks and contamination immediately, sending alerts to the user's smartphone. It enhances water retention, reduces evaporation, prevent erosion through practices similar to "b" above.**

**These technologies improve water-use efficiency and reduce waste, addressing one of the major needs of Nigerian farmers.**

### 3.3 Wetlands Conservation Through Finance

**a. Payment for Ecosystem Services (PES): This involves an incentive offered to landowners or managers - often farmers - in exchange for managing their land to provide ecosystem services, especially by the government.**

**b. Carbon Markets linked to wetland restoration: High mitigation potential. Wetlands can store massive amounts of carbon, offering up to several billion tonnes of CO2 potential.**

**c. Sustainable land-use financing: CSAF promotes sustainable land-use financing by directing capital toward practices that boost productivity, enhance climate resilience, and produce greenhouse gas emissions. Also, by soil conservation and improved water management.**

**Such mechanisms incentivize farmers while maintaining productivity.**

## 4. Institutional and Policy Framework in Nigeria

**Institutional and Policy Framework in Nigeria has made progress through initiatives such as the Nigeria Climate-Smart Agronomy Program (NC-SAP), which promotes sustainable agriculture, carbon markets, and climate resilience nationwide.**

**Key policies include:**

**a. Strengthening environmental regulations**

**b. Promoting Climate-Smart investments**

**c. Enhancing access to finance for smallholder farmers.**

## 5. Challenges to CSAF and Water Sustainability

### 5.1 Financial Barriers

**a. Limited access to credit for smallholder farmers**

**b. High investment risks**

**c. Long payback period for Climate-Smart projects**

### 5.2 Institutional Constraints

**a. Weak policy implementation**

**b. Limited technical capacity**

**c. Poor coordination among stakeholders**

### 5.3 Environmental Challenges

**a. Wetland degradation**

**b. Water scarcity**

**c. Climate variability**

## 6. Opportunities and Strategic Pathways

### 6.1 Public-Private Partnerships (PPP)

**Collaboration between government, private investors, and development agencies can unlock financing for sustainable agriculture.**

### 6.2 Innovative Financing

**a. Blended Finance: Blended Finance is the strategic combined use of development finance (from public or philanthropic sources) and private capital to invest in sustainable projects in emerging markets. It lowers the risk for commercial investors.**

**b. Climate funds: An example of this is the Green Climate Fund, which was a fund set aside by the United Nations for climate financing. It was established within the framework of the United Nations Convention on Climate Change.**

**c. Agricultural Insurance Schemes: This was established in 1987 (and incorporated in 1989) to protect farmers against losses caused by natural hazards and to encourage financial institutions to lend to the agricultural sector.**

**The main aim is to mitigate risk, allow more credit flow to farmers, ensure food security, and promote agricultural sustainability.**

### 6.3 Capacity Building and Technology Adoption

**Training farmers in Climate-Smart practices and water management technologies is essential for scaling impact.**

### 6.4 Strengthening the Data and Monitoring System

**Improved data collection enhances:**

**a. Risk assessment: Risk assessment transforms guesswork into objective, evidence-based insights, enabling organizations to identify, quantify, and mitigate potential threats proactively. By gathering, analyzing, and visualizing internal and external data, companies can pinpoint vulnerabilities, predict future issues, and enhance decision-making.**

**b. Investment decisions: Data collection enhances investment decisions by replacing intuition with evidence-based insights, allowing for better risk management, accurate valuation, and identification of emerging opportunities. It enables investors to analyze trends, monitor performance in real time, and perform due diligence to avoid fraudulent or poorly performing investments.**

**c. Policy effectiveness: Improved data allows for accurate information, allows policy makers to identify specific problems, tailor solutions to affected populations, and evaluate the success of programs.**

## 7. Policy Recommendations

**a. Expand access to CSAF for smallholder farmers**

**b. Promote water-efficient agricultural technologies.**

**c. Strengthen wetlands protection policies.**

**d. Encourage private sector investment**

**e. Enhance institutional coordination.**

**8. Conclusion*:* Climate Smart Agricultural Financing (CSAF) presents a transformative pathway for achieving sustainable agriculture in Nigeria. By integrating financial innovation with environmental sustainability, CSAF can**

**support wetlands conservation and efficient water resource management. However, its success depends on strong institutional frameworks, inclusive financing, and widespread adoption of climate-smart practices.**

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## TECHNICAL SESSION FOR THE 2026 CLIMATE CHANGE GLOBAL CONFERENCE (Virtual)

| S/N | TOPIC/AUTHOR(S) | REMARKS |
|---|---|---|
| LS 1 | Bridging the Gap: Integrating Climate Smart Agriculture Financing and Agroforestry for Resilient Food Systems<br>Prof. MUHAMMAD AUWAL HUSSAINI, *PhD* | Lead Speaker |
| LS 2 | Agro-Forestry Resources Management as it Affects Animal Grazing in Nigeria: Government Financial Interventions and Institutional Roles<br>Prof. Ironkwe Monica Ogochukwu | Lead Speaker |
| LP 3 | Climate Smart Agriculture Financing (CSAF): Wetlands and Water Resources Sustainability<br>Sir Michael Kolade Watti, FSAEREM | Lead Speaker |
| CCAES | Economics values of Groundnut (Arachis hypogaea L.) Farming in Ankpa Local Government Area of Kogi State Jeremiah Monday Precious, Amedu Antenyi Ankeli | 26CCGC/01 |
| CCAES | Exploring Determining Factors for Polished Local Rice Preference among Dutse Residents in Jigawa State, Nigeria.<br>Abdullahi, M. A.[1], Yahaya, M. K.[1], Ajayi, M. F.[1], Nazifi, B.[2], | 26CCGC/02 |
| CCAES | Constraints to Climate Change Adaptation Strategies among Cereal Crop Farmers in Kwara and Niger States, Nigeria<br>[1]Mohammed, N. U.; [1]Lawal A. F.; [1]Idris, N.; [1]Balaraba, A. S. | 26CCGC/03 |
| CCAES | Assessing the Crude Oil-Degrading Ability of Bacteria Isolated from Hydrocarbon-Polluted Soil.<br>A. A., Alhassan, W., T., Aborisade | 26CCGC/04 |
| CCAES | A Comparative Study of Biogas Production from some Organic Wastes by Fungal Biodegradation at Room Temperature.<br>Akintola T, Muhammed I.B, Umar A and Barnabas Y | 26CCGC/05 |
| CCAES | Application of Semivariogram Analysis in measuring Spatial Variability and Distribution of Selected soil Properties in Umuagwo, Imo State.<br>Okereafor, D. O., Onyechere A. U., Ukabiala, M.E., Amanze C.T. | 26CCGC/06 |
| CCAES | The Importance of Home Gardening in a Depreciating Economy<br>Odimba Victoria Onyekachi | 26CCGC/07 |
| CCAES | Determinants of ICT Adoption in Agricultural Extension Delivery and Its Effects on Inclusive Rural Development in Southern Taraba, Nigeria<br>Manga, T. A[1], Alhassan, Y.J[2] and Mba, R[2] | 26CCGC/08 |

| | | |
|---|---|---|
| **CCAES** | **Analysis of Effects of Climate Change and Armed Conflicts on Food Security of Smallholders in Mubi North Local Government Area, Adamawa State, Nigeria**<br>Abdulrahman Aliyu[*1] Salamatu Umar[1] and Jaafar Joshuwa Zongola[1] | **26CCGC/09** |
| **CCAES** | **Evaluation of Nutrient Content and Organoleptic Properties of Complementary Infant Diet Produced from Guinea Corn Starch, Green Beans and Soyabean Meals**<br>Ike, Ebenezer A[1], Ishola, Adedokun I[2]; Ekemenye, Augustus I[1]; Ekebor Maryfrances N[1] | **26CCGC/010** |

## Economics values of Groundnut (Arachis hypogaea L.) Farming in Ankpa Local Government Area of Kogi State

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*Abstract*

*The study was carried out to analyze the economics of groundnut (Arachis hypogea L.) farming in Ankpa Local Government Area of Kogi State, Nigeria. Multistage sampling technique which involves purposive selection of five wards from Ankpa LGA and simple random selection of 75 farmers from five wards were employed in collecting primary data using structured questionnaire. The data collected were analyzed using descriptive statistics, farm budgeting and regression analysis. The result showed that the mean age of the farmers was 35 years, 66.7% were married, 61% were female and 78% of the groundnut farmers had one form of education or the other. The mean years of farming experience was 6 years, the mean household size was 6 persons and the mean farm size was 2 ha. The analysis found that the total cost of producing groundnut per hectare was N170,610 and the gross margin was N 90,070. The profit of N75,040 was actualized with a benefit cost ratio of N1.44. The regression analysis indicated that Cobb-Douglas production function gave the best fit with R2 value of 0.64. The coefficients of fertilizer (2.2301), farm size (1.5795) and labour (0.3782) were all positive and statistically significant at varying levels of probability. The coefficient of herbicide (-0.9423) was negative and statistically significant. The result revealed that the most severe problems affecting groundnut production were inadequate finance, lack of improve seed and high cost of labor which were ranked 1st, 2nd and 3rd according to severity. In conclusion, groundnut production was profitable in the study area despite being affected with some problems. The study therefore recommends investment and participation in* *groundnut farming by investors as it is a profitable venture. Also, government should establish organized marketing systems to moderate the activities of middlemen which will enhance more profit for the farmers.*

Keywords: Economics, value, Groundnut, farming.

**Introduction.**

Groundnut (Arachis hypogaea L.) is the third most important oil seed crop in the world (FAO, 2019). It contains 48-50% oil, 26-28% protein and 11-27% carbohydrate, minerals and vitamin (Mukhtar, 2019). According to (FAO, 2018) groundnut is grown on 46.8 million hectares worldwide, with a total production of 57.1 million metric tons and an average productivity of 3.1 metric tons/ha. Developing countries like in Asia, Africa, and South America constitute 98% of global production of this crop (FOA, 2018). The production of groundnut is concentrated in Asia and Africa, where the crop is grown mostly by smallholder farmers under rain-fed conditions with limited inputs because of farmer's inability to access credit (NAERLS, 2014) Groundnut plays an important role in the diets of both rural and urban populations, particularly, because of its high contents of protein and carbohydrate. It is also rich in calcium, potassium, phosphorus, magnesium and vitamin E. groundnut meal, a by-product of oil extraction, is an important ingredient in livestock feed (Taru et al., 2010). The multiple uses of the groundnut plant make it an important food and cash crop for domestic consumption and export in many developing and developed countries. Globally, 50% of total groundnut production is used for oil extraction, 37 for confectionery use and 12 for seed (Taru et al., 2010). Over the years, groundnut farmers have been faced with a number of problems like poor yield and insufficient of credit facilitates which has drastically reduced their production level. Mukhtar (2019) noted that there seems to be no increase in the farmers' production level despite the use of improved varieties of groundnut. This shows that even though research findings have made a big headway during the past five decades, the benefit, of research findings may have not been fully utilized by farmers. Crop assessment and the post-harvest surveys reports over the last five years showed a continuous decline in the productivity of the main crops (Mukhtar, 2019). This has resulted in a knowledge gap and the persistence of the problems that hold back development. Therefore, it is worthwhile to identify and study groundnut production and marketing problems, to fill in the information gap and look into the possible ways and means of increasing the farmer income through accumulating capital and enhancing productivity and marketing. This is very necessary if we are to attain the noble target of self-sufficiency in food production. There is, therefore, the need for evaluation of the economics of groundnut production as an effort at contributing to the information base that could be used by groundnut farmers in Ankpa local government area of Kogi State to improve their productivity and profitability.

**Objectives of the Study;**

The specific objectives were to:

1 . describe the socio-economic characteristic of the groundnut farmers in the study area,

2 . estimate the cost and return of groundnut production of the farmers in the study area,

3 . identify constraints faced by the farmers in the study area.

Methodology

This study was carried out in Ankpa Local Government Area of kogi State, Nigeria. The local government shares boundary with Ohimini Local Government area at the South Eastern part, Ogbadibo Local Government area at the Northern part, Apa Local Government area at the North Eastern part. Ankpa Local Government falls under the Tropical Savannah Climate. The local government covers a land area of 9,146 square kilometers.. The crops produced in the study area includes; groundnuts, maize, rice, soybeans, sorghum, millet, cassava and yam. Beside the crops they also take part in livestock production such as; cattle, sheep's, goats, pigs, poultry among others. (Oruonye, 2013).

Data for this study was from primary source, the primary data were collected using structured questionnaire and personal interview. Sampling procedure and sample size Multi-stage sampling technique was used for the study. In stage 1, purposive selection of five wards ( Ankpa 1, Ankpa 2, Ankpa subsurb 1, Ankpa suburb 2 and Ojede Ward) from the eleven (11) wards in Ankpa Local Government Area, based on their predominance in groundnut production in the study area. In stage 2, simple random sampling was used to select seventy-five (75) respondents (sample size) from the five wards using 10% ratio proportional (Ankpa 1: 12, Ankpa 2: 14, Ankpa suburb 1: 17, Ankpa suburb 2: 18 and Ojede ward 2:14) to the population size of the farmers in each of the wards in the study area.

Data for this study were analyzed using descriptive statistic, farm budgeting techniques and regression analysis. The descriptive statistic such as mean, frequency and percentages were employed to address objectives the socio-economics characteristics of the respondents and constraints to groundnut production while the farm budgeting techniques was used to address the cost and return of the groundnut farmers. Multiple regression analysis was used to address the factors influencing the productivity of groundnut farmers in the study area. Farm Budget Techniques This is defined as the difference between gross income and total variable cost (Mshelia et al., 2005). The equation is expressed as follow: $GM = GR - TVC$………………………………. (1)

Where GM = Gross margin (N), GR =Gross Revenue (N) and TVC = Total variable cost (N). GR which is also called total value of production is the physical product multiply by unit price of the product. Net Farm Income (NFI) analysis The net farm income is calculated mathematically as follows: $NFI = TR - TC$ …………..……………………………….. (2) Where NFI = Net Farm Income (N), TR = Total Revenue (N), TC = Total cost (#) Total revenue includes revenue incurred from sale of groundnut. The total cost consists of fixed and variable cost, (Olukosi and Earbhor. 1988). The fixed cost included the cost of depreciation of farm tools. The straight-line depreciation method will be use for the fixed assets. The variable cost includes cost of seeds, cost of fertilizer, cost of labour, cost of Agrochemicals, cost of shelling of nuts, cost of storage, cost of transportation. The net farm income could be positive depending on whether the total revenue exceeding the total cost. It will be used to determine the profitability of the groundnut enterprise. Regression Analysis Regression is defined as the amount of change in the value of one variable associated with a unit change in the values of the other variables. However, this study applied four functional forms as linear, double-log, semi-log and exponential functions to determine the inputs (independent variables) and output (dependent variable) relationship. The specifications of the functions are given as: (i). Linear functions $Y = b0 + b1X1 + b2X2 + b3X3 + b4X4 + Ui$ …………………………………… (3)

(ii). Double-log function $lnY = lnb0 + b1lnX1 + b2lnX2 + b3lnX3 + b4lnX4 + Ui$ ..................................(4)

(iii). Semi-log function $Y = lnb0 + b1lnX1 + b2lnX2 + b3lnX3 + b4lnX4 + Ui$ ……………………….... (5)

(iv). Exponential function $lnY = b0 + b1X1 + b2X2 + b3X3 + b4X4 + Ui$………………………………… (6) where

$Y$ = Groundnut yield (kg)

$X1$ = Seeds (kg)

$X2$ = Agrochemical (liters)

$X3$ = Farm size (ha)

X4 = Labour (N/Ha)

$b0$ = Constant

$Ui$ = Error term

$b1 - b4$ = Estimated regression parameters

The prior expectation was that the coefficients of $X1 - X4$ would be positive

**Results and Discussion**

Socio-economics characteristics of the respondents.

The results in table 1 revealed that majority (61%) of the respondents were female, while male constituted 39%. This shows that female dominate the groundnut production in the study area. Also, many (45%) of the respondents were within the age limit of 31-40 years, with a mean of 35 years. This implies that groundnut farmers in the study area were within their active and productive age. This result agrees with the finding of Aboki et al., (2018) who reported that farmers within their active age can positively contribute to agricultural production. On marital status, the result showed that majority (66.7%) of the respondents were married. This implies that groundnut production in the study area is dominated by married persons and could be a source of income for families. This finding is supported by Mohammed et al., (2014), who stated that the high number of married persons is evident that agricultural could serve as a source of job creation. Furthermore, majority (54%) of the respondents had household size of 6-10 persons with a mean size of 6. This implies that family labor would be readily available when needed for groundnut farming operation. The educational distribution of the respondents revealed that majority (78%) of the groundnut farmers had one form of education or the other while 12% had no formal education. Hence, they have high likelihood of adopting improved groundnut production technologies more than the uneducated respondents. Gali (2017) pointed out that education has positive and significant impact on farmers and greatly influence their decision making and adopting of innovations that consequently affects their productivity. Analysis in table 1 unveiled that the experience of the farmers in groundnut production was 6-10 years with the mean of 6 years of experience. This entailed that the farmers would use this experience to manage their groundnut farms better. This result is further supported by Idrisa et al. (2012) who revealed that the number of years spent in agricultural activities might serves as indication of practical knowledge acquired. As for source of capital, the table shows that majority (57.3%) of the respondents sourced their capital from personal saving. This finding agrees with that of Mohammed et al., (2013) which states that most farmers sourced capital from their personal savings. On farm size, the result shows that most (50.7%) of the respondents had farm size of 1-5 hectares with a mean farm size of 2 ha. This shows that groundnut production comprised mostly small-scale farmers in the study area.

This finding corroborates with the findings of Arene et al., (2010) who opined that majority of Nigeria farmers are small scale farmers who cultivates less than 5 hectares.

Table 1: Socio-economic Characteristics of the respondents in the Study Area

| Characteristics | Frequency (75) | Percentage (%) | Mean |
|---|---|---|---|
| Gender | | | |
| Male 29 | 39 | | |
| Female | 46 | 61 | |
| **Age (years)** | | | |
| 21-30 | 20 | 26.70 | |
| 31-40 | 34 | 45.0 | 35 |
| 41-50 | 14 | 18.70 | |
| 51 & above | 7 | 9.30 | |

| | | | |
|---|---|---|---|
| Marital status | | | |
| Married | 18 | 24 | |
| Single | 50 | 66.70 | |
| window | 17 | 9.30 | |
| **Household size** | | | |
| 1-5 | 25 | 33 | |
| 6-10 | 40 | 54 | 6 |
| 6 & above | 10 | 13 | |
| **Forms of Education** | | | |
| No formal Education | 10 | 13 | |
| Primary Education | 7 | 9 | |
| secondary Education | 30 | 40 | |
| Tertiary Education | 22 | 29 | |
| **Source of capital** | | | |
| Personal saving | 43 | 57.3 | |
| Cooperative | 11 | 14.7 | |
| Friends and family | 6 | 8 | |
| Proceed from farm | 15 | 20 | |
| Farm Size | | | |
| < 0.5 | 27 | 36 | |
| 1-5 | 38 | 50.7 | 2 |
| 6 & above | 10 | 13.3 | |
| Farming experience | | | |
| 1-5 | 25 | 33 | |
| 6-10 | 40 | 54 | 6 |
| 11 years & above | 10 | 13 | |

Average cost and return of groundnut production Table 2 below is the average cost and returns of groundnut production per hectare in the study area. The results revealed that the total cost of producing groundnut per hectare was N170,610 gross margin was N 90,070 and the profit obtained was N75,040. The gross margin analysis for groundnut production shows that the total variable cost per hectare was N155,580 which accounted.

for 91.2% of the total cost of groundnut production. The average fixed cost was N15,030 which accounted for 8.8% of the total cost of production. Thus, the total cost of groundnut production per hectare was N170,610. The total revenue (TR), Gross margin (GM) and Net farm income (NFI) per hectare were N245,650, N90,070 and N75,040 respectively. This implies that groundnut production is a profitable enterprise in the study area. The benefit cost ratio was 1.44. This implies that for every naira invested on ground nut production, there's a return of N1.4. This result is in agreement with the study of Aboki et al., (2018) who also found that groundnut production is highly profitable in the study area.

**Table 2. Analysis of Cost and Return of Groundnut production**

| Items | Amount (N /hectare) |
|---|---|
| Total Revenue | 245,650 |
| Variable Cost | |
| Seeds | 11,500 |
| Fertilizer | 45,150 |
| Agrochemicals | 25,200 |
| Labour | 65,200 |
| Transportations | 8,530 |
| Total Variable Cost | 155,580 |
| Fixed Cost | |
| Depreciation on Farm Tools | 9,830 |
| Depreciation on Land | 5,200 |
| Total Fixed Cost | 15,030 |
| Total Cost = TFC+TVC | 170,610 |
| Gross Margin= TR-TVC | 90,070 |
| Net Farm Income (GM-TFC) | 75,040 |

Benefit Cost Ratio= TR/TVC+TFC

Source: Field survey (2024)

**Factors that influenced groundnut production in the study area**

The regression analysis was used to determine the physical relationship between the groundnut inputs with yield. Groundnut output was regressed with the independent variables (Seeds, farm size, fertilizer, agrochemicals and labour). Based on the summary of the results, Double-logarithm function gave the best fit and was chosen as the lead equation. The selection of lead equation was based on the comparison of coefficients of multiple determinations (R2), statistical significance of the F-ratios, the magnitude of standard error of the estimated parameters, statistical significance of the estimated regression coefficients ($b1 - b7$) and the a priori expectation. The coefficient of determination R2 was 0.64 which indicated that 64% of the variation in the yield is explain by the variables included in the model. However, it is only fertilizer ($X2$), herbicide ($X3$), farm size ($X4$) and labour ($X5$) that were significant. The coefficient of fertilizer (2.2301) was positive and statistically significant at 1% level implying that a 1% increase in fertilizer will bring about 2.23kg increase in output. The coefficient of farm size (1.5795) was positive and statistically significant at 5 % level implying that a 1% increase in farm size of farmers will bring about 1.57kg increase in output. This also indicated that land as a factor of production is very important in groundnut production in the study area as farmers tend to derive the benefits of economies of scale. This result is in conformity with the finding of Lawal and Mohammed (2018) who found out that farm size is one of the most important factors in groundnut production. Also, the coefficient of labour (0.3782) was positive and statistically significant at 5 % level implying that an increase in labour of farmers will bring about increase in output. However, the coefficient of herbicide (-0.9423) was negative and statistically significant at 5% level implying that an increase in herbicide will bring about decrease in output. This could be the case of toxicity to plant as the case may be.

**Table 3. Result of Double Log regression analysis as the best fit equation**

| Variable | Coefficient | Std. Error | t- Statistic | Prob. |
|---|---|---|---|---|
| C | -1.41342 | 0.85312 | -1.66 0 | .102 |
| Seeds (X1) | -0.28054 | 1**0.23341** | **-1.20** | -0.234 |
| Fertilizer (X2) | 2.23013 | 0.46875 | 4.76 | 0.000*** |
| Herbicide (X3) | -0.94234 | 0.39986 | -2.36 | 0.021** |
| Farm size (X4) | 1.57947 | 0.49378 | 3.20 | 0.002** |
| Labour (X5) | 0.37816 | 0.17871 | 2.12 | 0.038** |
| R-squared | 0.6420 | | | |
| Prob. (F-statistic) | 0.0000 | | | |

| | | | | |
|---|---|---|---|---|
| Adjusted R-squared | 0.6161 | | | |
| | | | | |

Source: Field Survey, 2024 Note: *** Significant at 1% and ** significant at 5%.

**Major constraints to groundnut production in the study area**

The distribution of the respondents based on constraints faced by groundnut farmers in the study area is presented in Table 4. The result revealed that the most severe problems affecting groundnut production were inadequate finance (30.2%), lack of improve seed (25.6%) and High cost of labor (16.6%) where these ranked 1st, 2nd and 3rd respectively according to severity. Other constraints include poor storage facilities (16.3%) and pest and disease (9.3%) were ranked 4th, 5th, and 6th respectively. The finding revealed that all the respondents were faced with one problem or the other. Inadequate finance is a major problem affecting agricultural activities from production, processing, storage and marketing (Akarue and Ofoegbu, 2012).

Table 4: The Major Constraints of Groundnut Production in the Study Area

| Constraints | Frequency | Percentage (%) | Rank |
|---|---|---|---|
| High cost of labor | 40 | 16.6 | 3 |
| Poor storage facilities | 35 | 16.3 | 4 |
| Pest and disease | 20 | 9.3 | 5 |
| Inadequate Finance | 65 | 30.2 | 1 |
| Lack of Improved Variety | 55 | 25.6 | 2 |
| Total | 215* | 100 | |

Source: Field survey, 2024 *Multiple Responses

**Conclusion and Recommendations**

The study revealed that groundnut production is a profitable venture in the study area. The farmers in the study area are in their active age and literate. The problems that were found to be associated with groundnut production in the study area include: high cost of inputs, high cost of labour, lack of finance, lack of storage facilities and pest and diseases. These challenges have implications for farm yields and returns from production. The specific factors influencing the profitability of groundnut production in the study area are; farm size, cost of fertilizer and cost of labour.

Based on the outcomes of the study, the following recommendations are made to improve groundnut production in the study area.

1. Having known that, groundnut production in the study area is a profitable venture, investors are encouraged to invest and participate in groundnut farming.

2. The farmers should form cooperative groups. This would guarantee members to approach financial institutions for credit facilities thereby reducing the problems of collaterals which impeded access to credit facilities.

3. Government should establish organized marketing systems where farmers will have proper and reliable linkages with buyers there by reducing the undue exploitative tendencies of the middlemen. Moderating the activities of these middlemen will enhance more profit for the farmers.

4. Simple and improved storage facilities should be provided so that surplus of groundnut can be stored to avoid spoilage.

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# Exploring Determining Factors for Polished Local Rice Preference among Dutse Residents in Jigawa State, Nigeria.

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ABSTRACT

The study was aimed at determining consumer preference factors for polished local rice in Dutse, Jigawa state, Nigeria. Data for the study was collected using structured questionnaire from a multistage randomly sampled 202 rice consumers. The data was analyzed using descriptive statistics and factor analysis. The descriptive result for the consumer's socio-economics profile showed that most of the consumers of the polished local rice (59.4%) are within age range of 26-35 years and only about 30% of them have average monthly income of ₦60,000-₦159,999 although their majority are formally educated. Factor analysis result reveals that price of polished local rice is the most determining factor of polished local rice preference (α=0.872); followed by good packaging as the second vital factor determining the consumer preference; Quality attributes of polished local rice was found as the third determining factor of polished local rice preference among the consumers in the study area. Meanwhile other factors were color of polished local rice related attributes (α=0.754) and location of polished local rice (α=0.720). The study concludes that price, quality and packaging attributes are the major determinant of polished local rice in the study area. It therefore recommended that government should intervene in providing a mechanism to regulate the price that will ensure affordability of the polished local rice among consumers and also the processors as well as marketers should strategize on the best way to make the polished local rice of good quality and appealing package.

Key words: Preference, Polished Local Rice, Consumer, Quality, Color, Packaging

## INTRODUCTION

Rice (Oryza sativa) is an essential annual staple food consumed by the majority of the Nigerian population. Its production was projected to grow annually between 2018 and 2023 at an average of 3.2% due to private sector investments and pro-production trade policies (FMARD, 2022). Lately, it has occupied a significant percentage in most households' food budget; leading to building consumer patronage depending on certain factors that influence brand preference. Among the local dishes prepared with rice in Nigeria most especially the northern part includes "Masa", or "Waina", "Tuwo", and "Alkakki", while pudding and boiled form eaten with stew or combined with potatoes, yam, beans and pears form the most common form of food prepared with rice all over the country. Rice consumption preference by households has increased considerably compared to past years when it was only eaten during festive periods such as; christmas, easter, sallah, marriage and burial ceremonies (WARDA, 2016). In some areas down the ages, rice has been considered a luxury food for distinct occasions with increased availability in supply (Akinbile, 2017). Literature reported that the rice per capita consumption in Nigeria was 32kg indicating a 4.7% increase in the past decade, leading to a total consumption of 6.7 million tonnes in 2017 as against 3.7 million tonnes produced the previous year (Erhie et al. 2018).

Despite the rising consumer preference for rice in the country, the consumption preference of local rice continued to decline as most of the consumer's preferred imported rice due to its cleanliness, swelling capacity, taste, availability, grain shape, quick cooking potential unlike the local rice. According to Lancon et al. (2017), the heavy custom duty on imported rice did not stop its persistence importation and consumption. Also, the processing techniques of rice has been insufficient to meet food and industrial needs of the country. This could be attributed to low productivity from rice farms or that farmers have not adopted improved technologies for rice production among others (Lawton & Alvaro, 2020). Jigawa State is one of the important rice producing states in Nigeria; the state and its surrounding neighboring states such as Kano, Bauchi, and Yobe states produce good quality paddy rice. In 2019, statistics from the National Fadama Development Project III Additional Financing (NFDP III AF, 2020) reported that a total of 680,416.00 mt rice was produced in Jigawa State in 2019, qualifying it as one of the major producing states in the country. Despite the increasing production of local paddy rice over the years, its importation has also been increasing. In a bid to curtail that, improved rice strain varieties with recommended production practices and high yield qualities were introduced to farmers in Jigawa State (NFDP III AF, 2020). As such, job opportunities were largely created to a large population of producers and processors in the state. Nonetheless, the sustainability of the production depends on the demand for the local rice in the country. The demand for polished rice is locally increasing within the country and in the export market. However, there is still shortage of modern rice processing mills that can produce good quality rice in line with the Federal Government's policy to curtail rice importation (Ugalahi, Adeoye, Agbonlahor, 2016).

Literatures reported that households were dissatisfied with the buying of local rice from the market because of the series of strenuous activities like; removal of unwanted particles, multiple cleaning and washing before cooking for consumption (Okeke et al, 2015). As a response to the prevailing rice supply deficit situation, successive governments have been motivated to introduce initiatives designed to promote domestic rice production in order to displace rice imports and achieve self-sufficiency, either through import restrictions and/or via investments to improve product output and quality. This was expected to widen home nation's local rice production yet its demand has continued to decline/low. To this end, consumer preference for polished local rice study is central to understanding the changing strategies and consumption patterns of the people in Jigawa state, and Nigeria at large due to the dominance of the primary sector. A better understanding of the consumption preference for polished local rice in the study area can result in creating favorable government policies and reforms capable of bridging the gap between foreign rice and the polished local rice. The objective of this research paper is to identify the determinants of consumer preference for the polished local rice in the study area.

METHODOLOGY

The Study Area

This study was carried out in Dutse Local Government Area in Jigawa State, Nigeria. The area is located between latitude 11’44.2N and longitude 09’21.58E with an elevation of 780m. Dutse Local Government Area has a population of about 335,600 people; while the total population of Jigawa state was projected at 7,678,848 people with 3.5% growth rate (National Bureau of Statistics, 2024). It is currently the state capital, and also the largest city in Jigawa State followed by Hadejia, Gumel, and Birnin Kudu. The mean annual temperature is about $36^0$C with an annual rainfall of 1000mm.The rainfall season usually commences from May-September lingering up to early October in some occasions. Relative humidity is normally between 90%, but a thorough assessment of this condition suggests that the humidity fluctuate over time around July decreasing to 60-80%.

Sampling Procedure and Sample Size

A multistage sampling approach was employed for the study. The first stage involved a purposive selection of Dutse L.G.A this due to the dense population of rice consumers, being the state capital and largest city in the state. The second stage was also a purposive selection of all the 11 wards within the L.G.A. From each ward twenty (20) rice consumers were randomly identified and selected, altogether a total of 220 consumers were selected as study respondents. However, only 202 responses were appropriately filled and retrieved. The survey was conducted between June and August 2021 by a team of well-trained enumerators.

Data Collection

The primary data were collected through administration of pre-tested structured questionnaires that consist of close and open ended questions. Train enumerators under the supervision of the researcher administered the questionnaires.

Data Analysis

This study applied quantitative method to gain necessary information about consumers’ preference for polished local rice in the study area. The quantitative method approach in research enables to quantify variation and describe the characteristics of the population. Descriptive analysis, reliability test, and factor analysis were used to analyze the data.  The data was analyzed using SPSS (Statistical Package for Social Sciences) version 23. A five-point Likert scale (1=strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=strongly agree) was used in the study to generate statistical measurements of the consumers’ perception and opinions. A high score would indicate a higher preference for polished local rice, while a low score suggests vice-versa. Crombach’s alpha score was used to determine the reliability of the data. Finally, Factor analysis was piloted to explore the determinants of consumer preference for polished local rice in the study area.

Results and Discussion

Socio-Economic Characteristics Rice Consumers

The socio-economic characteristics of the consumers reveal that most of the consumers of the polished local rice (59.4%) fell within the productive age range of 26-35 years, meaning that majority of the consumers belonged to economically productive population (age 19-49) as defined by Food and Agriculture Organisation (FAO) in 2008. The implication is, as the polished local rice consumption increases, its demand will also increase leading to higher production by the farmers (Gbigbi, 2019). The result showed that both men and women were involved in the purchase of polished local rice but the percentage of female was actively more than the male. The female accounted for 53.0% while the male accounted for about 47.3%. The result supports the findings of Gbigbi (2019) which reported that a female-headed household is more likely to be conscious of quality and the combination of various food variety consumed by the household than a male-headed household. The result showed that about 47.0% of the respondents were single, another 37.6% were married, and 8.9% were divorced, while 6.5% were widowed. The implication of having singles with the highest percentage shows that they consume and purchase more of the polished local rice.

The modal class of educational level of the consumers was tertiary education (57%). Also, about 22.8% had Qur'anic education, while 11.39% and 8.42% had secondary and primary education respectively. However, in consumer survey, this result suggest that education is an added advantage for efficient utility management. This study agrees with the findings of Abdullahi et al. (2024) that greater percentage of the youths in Jigawa state had formal education. The result also shows that majority of the respondents (80.7%) fell within the household size of 1-5 persons, another 12.9% within the household size of 6-10 persons, 4.5% within the household size of 11-15 persons, 15% and 2.0% within the household size of 16 and above persons. This result means that the household size of 1-5 has the highest percentage which means they consume more of the polished local rice. This may be a case of voluntary or involuntary consumption due to the ban placed on foreign rice by the government.

The monthly income of the respondents was categorized thus, 65.3% fell within an income range of ₦5,000-₦59,999, followed by 27.2% with an income of within ₦60,000-₦159,999, 5.5% fell between ₦160,000-₦259,999 and ₦260,000-₦359,999 has 2.0%. The average monthly income was ₦5,000-₦59,999 per household. This implies that their monthly income influences their consumption preference for polished local rice, their earning and purchasing power determines how often they buy and consume the polished local rice.

Table 1: Socio economic characteristic of the rice consumers

| Variable Type | Frequency | Percentage |
|---|---|---|
| Sex | | |
| Male | 95 | 47.0 |
| Female | 107 | 53.0 |
| Age (years) | | |
| 18-25 | 3 | 1.5 |
| 26-35 | 120 | 59.4 |
| 36-45 | 49 | 24.3 |

| | | |
|---|---|---|
| 46-55 | 17 | 8.8 |
| >56 | 13 | 6.5 |
| Marital status | | |
| Single | 95 | 47.0 |
| Married | 76 | 37.6 |
| Divorced | 18 | 8.9 |
| Widow | 10 | 5.0 |
| Widower | 3 | 1.5 |
| House hold size (people) | | |
| 1-5 | 163 | 80.7 |
| 6-10 | 26 | 12.9 |
| 11-15 | 9 | 4.5 |
| >16 | 4 | 2.0 |
| Level of education | | |
| Qur'anic | 46 | 22.8 |
| Primary | 17 | 8.4 |
| Secondary | 23 | 11.4 |
| Tertiary | 116 | 57.4 |
| Monthly income (₦) | | |
| 5,000-59,999 | 132 | 65.3 |
| 60,000-159,999 | 55 | 27.2 |
| 160,000-259,999 | 11 | 5.5 |
| 260,000-359,999 | 4 | 2.0 |
| Total | 202 | 100 |

Source: Field survey data, 2021

Reliability of Measurement Scales

The reliability (internal consistency) of the items in this study was done using Cronbach's alpha (Cronbach, 1951). A study by Straub in 1989 highlighted that "high correlations between alternative measures or large Cronbach alphas are usually signs that the measures are reliable." There is no fixed cut-off point for the alpha coefficient, however, the standard accepted Cronbach alpha's lower limit is 0.7, even though it might fall below to 0.6 (Hair et al., 2010) in an exploratory study. Using SPSS version 23, item purification was carried out to determine the coefficient of the Cronbach alpha for each construct. All constructs had a value more than 0.70, demonstrating higher internal consistency as shown in Table 2, Price (0.872) had the highest Cronbach alpha value, followed by Good packaging (0.852), Colour (0.754), Location (0.720), while Quality had the minimum Cronbach alpha value of 0.708. Table 2 presents the reliability of the measurement scales.

Table 2: Reliability Analysis

| Items | α | Mean | Std Dev |
|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Quality | | | | |
| Qlty1 | Quality is first requirement | 0.708 | 3.89 | 0.684 |
| Qlty2 | Quality differs from one brand of rice to another | | 3.85 | 0.546 |
| Qlty3 | Taste, non-stickiness after cooking defines quality | | 3.88 | 0.685 |
| Qlty4 | I attribute good packaging to quality | | 3.78 | 0.689 |
| Qlty5 | There is no relationship between price and quality | | 3.88 | 0.699 |
| Good Packaging | | | | |
| Gdpg1 | Packaging reflects the quality of PLR | 0.852 | 4.13 | 1.008 |
| Gdpg2 | I'm moved by color and attractiveness | | 3.99 | 1.086 |
| Gdpg3 | Good packaging and quality are best for me | | 3.97 | 0.793 |
| Gdpg4 | Good packaging is a function of satisfaction | | 3.86 | 0.707 |
| Colour | | | | |
| Col1 | I prefer all white long grain | 0.754 | 3.89 | 0.649 |
| Col2 | Brown rice is the best for me | | 3.99 | 0.752 |
| Col3 | Size, quality or packaging of PLR does not matter | | 4.01 | 0.721 |
| Col4 | I get involved more with color than quality | | 3.98 | 0.714 |
| Price | | | | |
| Pr1 | Price is a determinant for purchase | 0.872 | 3.48 | 0.912 |
| Pr2 | Low price means low quality for me | | 3.46 | 1.005 |
| Pr3 | Difference in price matters when making choice | | 3.40 | 0.895 |
| Pr4 | Quality affects price of PLR | | 3.52 | 0.980 |
| Pr5 | Price is greatly influenced by good packaging | | 3.53 | 0.911 |
| Location | | | | |

| | | | | |
|---|---|---|---|---|
| LRF1 | Polished local rice can be purchased easily in my location | 0.720 | 3.24 | 1.401 |
| LRF2 | Polished local rice is easy to find | | 3.37 | 1.185 |
| LRF3 | Ease of delivery make it stress free to get | | 3.21 | 1.090 |
| LRF4 | I can always get polished local rice at my convenience | | 3.46 | 1.204 |

Source: Field survey data, 2021

Factor Analysis

The KMO measures the sampling adequacy (which determines if the responses given with the sample are adequate or not) which should be greater than 0.5 for a satisfactory factor analysis to proceed. Bartlett's test is another indication of the strength of the relationship among variables. In this study, the KMO measure is 0.798, which is greater than the recommended (0.5) and therefore is accepted (refer to Table 2). From the same table, we can see that the Bartlett's Test of Sphericity is significant (0.00). The result however showed five (5) latent factors influencing consumer preference for polished local rice among Dutse residents in Jigawa state had been identified which account for about 55.734% of the total variance. The factors were labelled as price of the polished local rice, good packaging of the polished local rice, quality of the polished local rice, colour of the polished local rice, and location for polished local rice purchase. The factor loadings from the principal component factor analysis were obtained after a varimax rotation of respondent' responses to twenty-two (22) statements respectively related to the factors that influence the youths' perception about the polished local rice.

Table 3: KMO and Bartlett's Test

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.798 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1765.305 |
| | Df | 231 |
| | Sig. | 0.000 |

Source: Field survey, 2021

The result of the study is presented in Table 4. The first factor is Price of polished local rice (α=0.872) which consists of four (4) sub-variables and has a total variance of 22.87%. The highest factor loading is PRI2 (0.855), followed by PRI5 (0.784), PRI4 (0.778), PRI3 (0.755) and PRI1 (0.720). Price is a very important determinant factor influencing the consumer preference of the respondents in the study area; therefore, government should intervene in providing a mechanism to regulate it, ensuring that there is a proper checking emphasize this point to make youths active in rice production. The finding is in line with what was reported by Samat, et al., (2022) that price is an important determinant of rice preference among its consumers. The second factor is good packaging of polished local rice (α=0.852). This factor consists of four (4) sub-variables and has a total variance of 10.573%. The highest factor loading is GDPG2 (0.859), followed by GDPG3 (0.850), GDPG1 (0.771), and GDPG4 (0.743). A good packaging is a vital factor determining the consumer preference of the respondents in Jigawa state. Similar result was obtained among milk consumers by Markova-Nenova & Wätzold (2018). Therefore, the rice value chain actors (producers, processors and marketers) should adopt/employ modern technologies in the conduct of their activities along the chain. The third factor is the quality of polished local rice (α=0.708). This factor consists of five (5) sub-variables and has a total variance of 9.469%. The highest factor loading is QLTY1 (0.711), followed by QLTY5 (0.707), QLTY2 (0.706), QLTY4 (0.638,), and QLTY3 (0.574). The quality of polished local rice determines the consumer preference for it among the respondents in the study area. The fourth factor is the colour of polished local rice (α=0.754). This factor consists of four (4) sub-variables and has a total variance of 8.607%. The highest factor loading is COL3 (0.830), followed by COL2 (0.744), COL4 (0.743), and COL1 (0.622). The colour of polished local rice is an important determinant factor influencing consumers' preference among the respondents in the study area. Therefore, farmers and other actors should emphasize this point to attract consumers. The fifth factor is the location of polished local rice (α=0.720). This factor consists of four (4) sub-variables and has a total variance of 6.783%. The highest factor loading is LRF2 (0.817), followed by LRF3 (0.738), LRF1 (0.696), LRF4 (0.693). The location of polished local rice is vital factor determining consumer perception among respondents in the study area. Therefore, marketers should strategize on the best way to make the polished local rice readily available to the consumers in the state.

Table 4: Pattern Matrix

| | Factor Loading | | | | |
|---|---|---|---|---|---|
| Items Statement | 1 | 2 | 3 | 4 | 5 |
| Price of polished local rice (α) | 0.872 | | | | |
| Price is a determinant for purchase | 0.720 | | | | |
| Low price means low quality of produce for me | 0.855 | | | | |
| Difference in price matters when making choice of purchase | 0.755 | | | | |
| Quality affects price of PLR | 0.778 | | | | |
| Price is greatly influenced by good packaging | 0.784 | | | | |
| Variance (% explained) | 22.868 | | | | |
| Good packaging of polished local rice (α) | | 0.852 | | | |
| Packaging reflects the quality of PLR | | 0.771 | | | |
| I'm moved by color and attractiveness | | 0.859 | | | |

| | | | | | |
|---|---|---|---|---|---|
| Good packaging and quality are best for me | | 0.850 | | | |
| Good packaging is a function of satisfaction for me | | 0.743 | | | |
| Variance (% explained) | | 10.573 | | | |
| Quality of polished local rice (α) | | | 0.708 | | |
| Quality is first requirement | | | 0.711 | | |
| Quality differs from one brand of rice to another | | | 0.706 | | |
| Taste, non-stickiness after cooking defines quality | | | 0.574 | | |
| I attribute good packaging to quality | | | 0.638 | | |
| There is no relationship between price and quality | | | 0.707 | | |
| Variance (% explained) | | | 9.469 | | |
| Colour of polished local rice (α) | | | | 0.754 | |
| I prefer all white long grain | | | | 0.622 | |
| Brown rice is the best for me | | | | 0.744 | |
| Size, quality or packaging of PLR does not matter | | | | 0.830 | |
| I get involved more with color than quality | | | | 0.743 | |
| Variance (% explained) | | | | 8.607 | |
| Location of polished local rice (α) | | | | | 0.720 |
| Polished local rice can be purchased easily in my location | | | | | 0.696 |
| Polished local rice is easy to find | | | | | 0.817 |
| Ease of delivery make it stress free to get | | | | | 0.738 |
| I can always get polished local rice at my convenience | | | | | 0.693 |
| Variance (% explained) | | | | | 6.783 |
| Total Variance Explained (%) | 55.734 | | | | |

Source: Field survey data, 2021

Conclusion and Recommendation

Findings from the study shows that the majority of the respondents consume the polished local rice in the state. The study concludes that price, quality and packaging attributes are the major determinant of polished local rice in the study area. It therefore recommended that government should intervene in providing a mechanism to regulate the price that will ensure affordability of the polished local rice among consumers and also the processors as well as marketers should strategize on the best way to make the polished local rice of good quality and appealing package. The location should be accessible shall be improve in order to enhance accessibility of the rice to consumers.

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## Constraints to Climate Change Adaptation Strategies among Cereal Crop Farmers in Kwara and Niger States, Nigeria

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## Abstract

This study examined the constraints to climate change adaptation among cereal crop farmers in Kwara State and Niger State. Primary data were collected from 396 respondents using a structured questionnaire administered via Kobo Toolbox. The data were analyzed using descriptive statistics and Kendall's Coefficient of Concordance (KCC) to determine and rank the severity of constraints faced by farmers. The result in Table 1 indicates that the mean age of the cereal crop farming households was 36 and 32 years in Kwara and Niger States respectively, majority (78.2%) of cereals crop farming households in Kwara and Niger States were married, while the average household size of cereal crop farming households in Kwara and Niger States was 6 and 8 persons respectively. Table 1 also indicates that 44.0% and 41.8% of the cereal crop farming households in Kwara and Niger States, respectively, had no formal education, while 31.1% and 32.1% had only primary education, results from table 1 further reveals that a majority of cereal crop farming households in Kwara (88.0%) and Niger State (93.3%) were engaged in farming on a full-time basis. The reported R-squared values from table 2 were 0.7872 for Kwara and 0.7591 for Niger, indicating that approximately 78.7% and 75.9% of the variation in net farm income (profitability) among cereal crop farming households in the respective states was explained by the included independent variables. The findings from table 3 revealed that major constraints to the adoption of climate change adaptation strategies include high costs of farm inputs, limited access to credit facilities, inadequate extension services, poor access to improved technologies, and insufficient climate information. The results further indicated a high level of agreement among farmers regarding the severity of these constraints. The study concludes that economic and institutional barriers significantly impede effective climate change adaptation among cereal crop farmers. It therefore recommends improved access to affordable credit, strengthening of extension service delivery, and the provision of subsidized climate-smart technologies to enhance farmers' adaptive capacity and resilience.

Keywords: Constraints, Climate Change, Adaptation Strategies, Cereal Farmers, Nigeria

## Introduction

Climate change remains a major threat to agricultural productivity and rural livelihoods, particularly in developing countries such as Nigeria where farming is predominantly rain-fed (IPCC, 2021; FAO, 2020). Cereal crop farmers in Kwara and Niger States are increasingly exposed to erratic rainfall, rising temperatures, and extreme weather events (Ojeleye et al., 2018; Iheke et al., 2017). While several climate change adaptation strategies exist, their effective adoption is often constrained by socio-economic, institutional, and environmental factors (Nyong et al., 2020; Lipper & Zilberman, 2018). Understanding these constraints is essential for designing policies that enhance farmers' resilience and livelihood sustainability (Collins-Sowah, 2018; IPCC, 2020). Climate change presents a significant threat to agricultural productivity in Nigeria, as it increases the frequency of extreme weather events, disrupts traditional rainfall patterns and exacerbates temperature fluctuations (Echeverría, 2016; Aturihaihi *et al*., 2022). These climatic changes further complicate farming activities in Nigeria, disrupting traditional agricultural calendars and affecting the timing and success of planting, harvesting and other critical operations. In Nigeria, climate change adaptation strategies include both on-farm and off-farm approaches. On-farm strategies involve changing crop varieties, adjusting planting times, adopting improved irrigation techniques, applying fertilisers and manure, employing conservation tillage practices, and using advanced farm equipment. Off-farm strategies, on the other hand, include diversifying household income through paid employment, establishing small-scale businesses, and engaging in cooperative farming arrangements that supplement income (Nyong *et al.*, 2020). The successful implementation of climate change adaptation strategies has the potential to improve the livelihood status of farming households by enhancing their resilience and capacity to withstand climatic shocks. This study therefore focuses on identifying and ranking the key constraints limiting the adoption of climate change adaptation strategies among cereal crop farmers.

Problem Statement

Climate change poses significant challenges to agricultural productivity and rural livelihoods in Nigeria, particularly among smallholder cereal crop farmers who depend heavily on rain-fed systems. In states such as Kwara State and Niger State, increasing climate variability—manifested through irregular rainfall patterns, prolonged dry spells, flooding, and rising temperatures—has adversely affected cereal crop yields, food security, and farmers' incomes. Many farmers continue to face persistent constraints, including limited access to climate information, inadequate extension services, poor access to credit and farm inputs, low levels of education, weak institutional support, and socio-cultural barriers. These challenges significantly hinder their capacity to effectively respond to climate risks. Despite growing policy attention and intervention efforts, there is insufficient context-specific empirical evidence on the key constraints limiting farmers' adoption of adaptation strategies in Kwara and Niger States. This knowledge gap restricts the development of targeted, evidence-based policies and programs that can enhance farmers' resilience. Therefore, a critical need exists to systematically examine the constraints to climate change adaptation among cereal crop farmers in these regions in order to inform effective intervention strategies and promote sustainable agricultural productivity

Aim and Objectives of the Study

The aim of the study is to analyse climate change adaptation strategies and household livelihoods status among cereal crop farmers in Kwara and Niger States, Nigeria. The specific objectives were to:

describe the socio-economic characteristic of the respondents in the study area

assess the effects of climate change adaptation strategies on profitability and technical efficiency of cereal crop production in the area;

identify the constraints associated with climate change adaptation strategy adopted by the cereal crop farming households.

Study Area

This study was conducted in Kwara and Niger States located within the North Central region of Nigeria. The North Central region is made up of Niger, Nasarawa, Plateau, Benue, Kogi, Kwara, States, and the Federal Capital Territory (FCT), Abuja. Niger State is the largest state in Nigeria by landmass with 25 Local Government Areas (LGAs). According to recent demographic projections, Niger State has an estimated population of approximately 7,500,000 people in 2025, comprising about 3,650,000 males (48.7%) and 3,850,000 females (51.3%). (NPC projection, 2025). While Kwara State is located in the North Central geopolitical zone of Nigeria with its 16 Local Government Areas (LGAs), The state capital, Ilorin, serves as the administrative and commercial centre of the state. Based on recent demographic projections for 2025, Kwara State has an estimated population of approximately 3,834,000 people, comprising about 1,900,000 males (49.5%) and 1,934,000 females (50.5%). This population estimate reflects continued growth since the 2006 National Population Census and is based on trends in urbanisation and demographic change. (NPC projection, 2025).

Methodology

Multi-stage sampling method was used in the selection of respondents for this study.

The first stage involved purposive selection of Niger and Kwara States because of prevalence production of cereal crops that is maize, rice, millet and guinea corn in the States.

In the second stage six (6) Local Government Areas (LGAs) were randomly selected from each of the two States following their agricultural zones. The LGAs that were randomly selected are Borgu, Lapai, Mariga, Mokwa, Paikoro, Shiroro in Niger State and Edu, Ifelodun, Ilorin East, Kwara Central Asah, Moro, and Patigi in Kwara State.

The third stage involved the random selection of two villages from each of the selected Local Government Areas (LGAs), resulting in a total of twenty-four (24) villages. In the final stage, the sample size was determined using the Yamane formula, while proportionate allocation techniques were employed to select respondents, as adopted by Omonona and Agoi (2018). Consequently, a total of 396 respondents were included in the study.

Primary data were collected from the farmers using a structured questionnaire administered through Kobo Toolbox software. The data obtained were analyzed using both descriptive and inferential statistical methods. Descriptive statistics, including means, frequencies, and percentages, were used to summarize the data. Farm budgeting analysis was conducted using the Net Farm Income (NFI) model to assess profitability.

Furthermore, Objective I was achieved using Kendall’s Coefficient of Concordance (KCC) to rank the severity of constraints faced by the respondents.

## Results and Discussion

Socio-economic Characteristics of the Respondent

This section describes the socio-economic characteristics of the respondents in the study area. The socio-economic characteristics considered for this study were age, marital status, household size, level of education, farming experience and level of crop farming.

Age of the respondents

The result in Table 1 indicates that the mean age of the cereal crop farming households was 36 and 32 years in Kwara and Niger States respectively. This suggest that they were still within the active and productive age, strong, energetic and full of innovative ideas that could be advantageous in the adoption of new technologies like climate change adaptation strategy (CCAS). Younger farmers often have better physical capacity, are more receptive to training and are more willing to experiment with and implement new technologies compared to older farmers (Mignouna *et al.*, 2021).

Marital status of the respondents

Table 1 reveals that the majority (78.2%) of cereals crop farming households in Kwara and Niger States were married. This indicates that most of the respondents in the study areas had established family units. Akinbode and Dipeolu (2022) found that 80% of arable crop farmers in Ogun State were married, which they linked to the need for family labour in farming operations. Likewise, Tijani and Bakari (2020) reported that about 76% of rice farmers in Kwara and Niger States Nigeria were married, highlighting marriage as a common social feature among farming households.

Household size

The result in Table 1 also reveals that the average household size of cereal crop farming households in Kwara and Niger States was 6 and 8 persons respectively. This implies that the farmers in the study areas generally had moderate to large household sizes. This finding aligns with the National Bureau of Statistics (NBS) Household Panel Survey (2020), which reported that the national average household size in Nigeria in 2019 was six (6) persons. This is expected to influence adoption of CCAS, this is because larger household sizes typically provide more family labour, which is a valuable asset in rural farming systems where mechanization is limited

Education status of the respondents

Table 1 also indicates that 44.0% and 41.8% of the cereal crop farming households in Kwara and Niger States, respectively, had no formal education, while 31.1% and 32.1% had only primary education. On average, respondents in Kwara and Niger States attained approximately 7 and 6 years of formal education, respectively. This implies that the level of formal education among cereal crop farming households in the study areas is generally low, with the majority of them having either no education or only basic primary schooling. This is in tandem with Adebayo and Akogwu (2020) that reported more primary education among climate smart agriculture adopters in Ogun State. Ejechi *et al*. (2021) also reported low literacy status among potato farmers in Nasarawa State of Nigeria.

Level of involvement in crop farming

Table 1 further reveals that a majority of cereal crop farming households in Kwara (88.0%) and Niger State (93.3%) were engaged in farming on a full-time basis. With a slightly higher proportion in Niger State, this suggests that farming is the primary occupation for most farmers in the study areas. This could mean that these farmers rely heavily on the success of their agricultural activities for income and sustenance. This also indicates that majority of smallholder farmers had a limited diversification of income sources.

Table 1: Distribution of respondent according to socioeconomic characteristics

| | **Kwara n=225** | | **Niger n= 165** | |
|---|---|---|---|---|
| **Variables** | Frequency | Percentage | Frequency | Percentage |
| **Age** | | | | |
| **<20** | 32 | 14.2 | 23 | 13.9 |
| **21-30** | 36 | 16.0 | 38 | 23.0 |
| **31-40** | 67 | 29.8 | 38 | 23.0 |
| **>40** | 90 | 40.0 | 66 | 40.0 |
| **Mean** | 36 | | 32 | |
| **Marital status** | | | | |
| **Single** | 47 | 20.9 | 35 | 21.2 |
| **Married** | 176 | 78.2 | 129 | 78.2 |
| **Widow** | 2 | 0.9 | 1 | 0.6 |
| **Household size** | | | | |
| **1-5** | 84 | 37.3 | 18 | 10.9 |
| **6-10** | 126 | 56.0 | 85 | 51.5 |
| **<10** | 15 | 6.7 | 62 | 37.6 |
| **Mean** | 6.0 | | 8.0 | |
| **Education level** | | | | |
| **Primary** | 70 | 31.1 | 53 | 32.1 |
| **Secondary** | 29 | 12.9 | 21 | 12.7 |
| **Tertiary** | 27 | 12.0 | 21 | 12.7 |
| **Non formal** | 99 | 44.0 | 69 | 41.8 |
| **Mean** | 7 | | 6 | |
| **Level of crop Farming** | | | | |
| **Full time** | 198 | 88.0 | 154 | 93.3 |
| **Part-time** | 27 | 12.0 | 11 | 6.7 |

Source: Field survey, 2024

Effects of climate change adaptation strategies on profitability of cereal crop farming households

The findings from the Ordinary Least Squares (OLS) regression analysis presented in Table 2 show the effects of climate change adaptation strategies (CCAS) on the profitability of cereal crop farming households in Kwara and Niger States. The reported R-squared values were 0.7872 for Kwara and 0.7591 for Niger, indicating that approximately 78.7% and 75.9% of the variation in net farm income (profitability) among cereal crop farming households in the respective states was explained by the included independent variables. These high R-squared values imply that the explanatory variables used in the regression model had strong predictive power in explaining profitability outcomes..

Table 2: Regression result on effects of CCA Practices on profitability

| **Coefficient** | **Kwara** | **Niger** | **Pooled** |
|---|---|---|---|
| Sex | .4955 | .2335 | .8069 |
| | (1.43) | (1.33) | (2.59)*** |
| Age | .1987 | .0228 | -.1459 |
| | (0.41) | (1.71) | (-1.50) |
| Household size | .2612 | .0124 | .1403 |
| | (1.32) | (0.30) | (1.27) |
| Years spend in school | .2882 | .0193 | .2107 |
| | (2.90***) | (0.89) | (1.79) |
| Farming experience | .1905 | .0771 | -.5260 |
| | (1.06) | (0.66) | (-0.57) |
| Early maturing variety | .2563 | .1813 | .1825 |
| | (1.98*) | (0.99) | (1.95*) |
| Crop rotation | .34028 | .0514 | -.3152 |
| | (2.10) ** | (2.29**) | (-0.51) |
| Drought resistant varieties | .0681 | .01831 | .3678 |
| | (0.61) | (2.40**) | (0.39) |
| Mixed cropping | .2730 | .0047 | .8809 |
| | (1.62) | (2.49**) | (2.25)** |
| Liming | .0835 | .0082 | .3138 |
| | (1.94*) | (1.28) | (1.51) |
| Mulching | .6780 | .0257 | .3907 |
| | (2.71) *** | (2.19**) | (2.15)** |
| Training received on CSA | .4852 | .2419 | -.1353 |
| | (3.50)*** | (2.34**) | (-1.04) |
| Total labour | .08158 | .0226 | .2102 |
| | (0.58) | (2.87) | (0.28) |
| Constant | 10.2515 | 10.4105 | .7211 |
| | (3.80***) | (3.74)*** | (2.37**) |
| R-squared | 0.7872 | 0.7591 | 0.6532 |
| Adj R-squared | 0.7513 | 0.7184 | 0.6007 |
| Prob > F | 0.0000*** | 0.0000*** | 0.0000*** |

Source: Field survey, 2024

***=1% level of significance, **=5% level of significance, It reveals that years spent in school ($\beta = 0.2882$; $p < 0.01$), early maturing variety ($\beta = 0.2563$; $p < 0.10$), crop rotation ($\beta = 0.3403$; $p < 0.05$), liming ($\beta = 0.0835$; $p < 0.10$), mulching ($\beta = 0.6780$; $p < 0.01$) and training received on CCAS ($\beta = 0.4852$; $p < 0.01$) were the major CCAS practices influencing the profitability of cereal crop farming households in Kwara State, while crop rotation ($\beta = 0.0514$; $p < 0.05$), drought resistant varieties ($\beta = 0.0183$; $p < 0.05$), mixed cropping ($\beta = 0.0047$; $p < 0.05$), mulching ($\beta = 0.0257$; $p < 0.05$) and training on CSA ($\beta = 0.2419$; $p < 0.05$) were the major CCAS practices influencing the profitability of cereal crop farming households in Niger State. This implies that both Kwara and Niger States were influenced by similar CCAS, though with slight variations in specific practices and strength of influence. In both States, crop rotation, mulching, and training *on CCAS* significantly contributed to profitability.

Education plays a vital role in enhancing farmers' profitability. The positive and significant coefficient implies that farmers with more years of formal education are more likely to adopt improved climate-smart agricultural practices (CCAS) effectively. Educated farmers are better positioned to understand training, interpret weather information, and apply innovations that reduce climate risks. Therefore, education strengthens adaptive capacity and resilience, enabling cereal crop farming households to operate profitably in an increasingly uncertain climatic environment. This corroborated with the study of Ndamani and Watanabe (2019) in Lawra district in Ghana who reported that education significantly influenced farmers' decision on climate change adaptation strategies.

Liming was found to have a statistically significant positive effect on profitability, though at a 10% level. In many tropical regions like Kwara State, soils are naturally acidic due to high rainfall and intensive cultivation. Acidic soils limit the availability of essential nutrients such as phosphorus and inhibit microbial activity, leading to poor crop performance. Applying lime helps neutralize soil acidity, improving nutrient availability and uptake, especially in maize and other cereal crops (Mignouna *et al.*, 2021). This enhances root development, crop vigour and ultimately yields.

Mulching showed a strong positive influence on profitability at the 1% level, signifying its importance as a cost-effective adaptation strategy. By covering the soil with organic or synthetic material, mulching conserves soil moisture, suppresses weed growth, and regulates soil temperature. This is especially important in Kwara and Niger State, where farmers face irregular rainfall and rising temperatures. Mulching reduces water loss through evaporation and enhances the effectiveness of limited rainfall, promoting better crop performance even during dry spells. It also improves soil fertility as organic mulches decompose, contributing nutrients.

Training on CCAS significantly increases profitability, as shown by its strong statistical influence at the 1% level. Training enhances farmers' awareness, technical skills and capacity to adopt context-specific CCAS that mitigate the effects of climate change. Trained farmers are better able to integrate these techniques into their production systems effectively, thus improving efficiency, yields, and income. Training also fosters innovation, risk management, and resource optimization, enabling farmers to make better agronomic and economic decisions. This finding is consistent with Ayanwuyi *et al.* (2016), who reported that extension training significantly improved farmers' adoption of water conservation and soil fertility practices in Oyo State. Similarly, Issahaku and Abdulai (2020) demonstrated that climate-smart agriculture training improved technical efficiency and profitability among smallholder farmers in Ghana.

Constraints associated with climate change adaptation strategy adopted by the cereal crop farming households.

Table 3 presents the result of the Kendall's Coefficient of Concordance ($W_A$) which measure the level of agreement among respondents regarding the constraints associated with climate change adaptation. The $W_A$ values were 0.031 for Kwara State and 0.128 for Niger State. These relatively low $W_A$ values indicate weak agreement among farmers, especially in Kwara, suggesting diverse experiences with adaptation challenges. However, the associated chi-square values (77.084 for Kwara and 347.228 for Niger) were both statistically significant at $p<0.01$, confirming that the rankings of constraints are not due to chance. The results highlighted that the major features of the two states influences the constraints faced in the states. While the most pressing constraint in Kwara State was inadequate extension and farm advisory services (mean = 8.38), pilfering and theft (mean = 8.10) and limited farmland (mean = 7.86). In contrast, the most significant constraint in Niger State was conflict with Fulani herdsmen (mean = 8.43), high cost of farm inputs (mean = 8.11) and flooding (mean = 8.49).

Table 3: constraints associated with climate change adaptation strategy adopted by the cereal crop farming households

| | Kwara | | Niger | |
|---|---|---|---|---|
| **Challenge** | Mean | Rank | Mean | Rank |
| **Inadequate extension and farm advisory services** | 8.38 | 1st | 5.32 | 15th |
| **Pilfering/theft** | 8.10 | 2nd | 7.32 | 6th |
| **Limited farm land** | 7.86 | 3rd | 6.66 | 8th |
| **Impoverished farm land** | 7.60 | 4th | 7.71 | 4th |
| **Conflict with Fulani herdsmen** | 7.49 | 5th | 8.43 | 1st |
| **Poor road access and transport facilities** | 7.48 | 6th | 7.38 | 5th |
| **High cost of acquiring credit facilities** | 7.42 | 7th | 7.20 | 7th |
| **High cost of farm inputs** | 7.37 | 8th | 8.11 | 2nd |
| **Inadequate market information** | 7.35 | 9th | 6.83 | 9th |
| **Low and unattractive prices for farm produce** | 7.07 | 10th | 6.38 | 10th |
| **Insufficient rainfall** | 6.73 | 11th | 6.08 | 11th |
| **High incidence of pests and diseases** | 6.65 | 12th | 5.77 | 12th |
| **Inadequate storage facilities** | 6.46 | 13th | 5.69 | 13th |
| **Large post-harvest losses** | 6.07 | 14th | 5.64 | 14th |
| **Cultural barriers** | 5.58 | 15th | 5.90 | 12th |
| **Weak co-operative/farmer association support** | 5.32 | 16th | 4.21 | 18th |
| **Illiteracy** | 5.32 | 17th | 4.87 | 16th |
| **Religious barriers** | 4.98 | 18th | 4.32 | 17th |
| **Flood problem** | 6.07 | 14th | 8.49 | 3rd |
| **Kendall's W[a]** | .031 | | .128 | |
| **Chi-Square** | 77.084 | | 347.228 | |
| **Asymp. Sig.** | .000 | | .000 | |

Source: Field survey, 2024

Extension services are crucial for disseminating climate-related information such as early warning systems, best agronomic practices and innovations like drought-tolerant seeds. Their absence limits farmers' awareness and adaptive capacity, leaving them vulnerable to unpredictable climate events. Inadequate support also leads to a knowledge gap regarding available resources or government interventions, ultimately affecting productivity and livelihood resilience. Adebayo and Oladele (2020) emphasise, weak extension delivery in Nigeria undermines the diffusion of innovations, which in turn reduces productivity and resilience.

Pilfering and theft (mean = 8.10) rank as another major constraint in Kwara State. Climate adaptation often requires investment in inputs like fertilizers, tools and irrigation equipment, making farms more valuable and attractive to thieves..

Limited farmland (mean = 7.86) restricts farmers' capacity to diversify crops or practice climate-resilient strategies like crop rotation or fallowing. Population pressure and land tenure issues may aggravate this constraint. Place *et al*. (2017), limited access to land in sub-Saharan Africa is a major barrier to scaling climate-smart agriculture, as many adaptive practices require spatial flexibility.

The top constraint in Niger State was conflict with Fulani herdsmen (mean = 8.43). Farmer-herder conflicts disrupt farming activities, lead to crop destruction and sometimes cause physical displacement or loss of life. Okoli and Atelhe (2014) note, persistent farmer-herder conflicts in Nigeria remain one of the most serious threats to agricultural sustainability. High cost of farm inputs (mean = 8.11) was a major adaptation barrier.

Flooding (mean = 8.49) also ranked high in Niger State. Increased rainfall variability and extreme weather events have led to recurrent floods that wash away crops, degrade soil fertility and damage farm infrastructure. Flooding discourages investment in vulnerable areas and erodes the benefits of previously adopted adaptation strategies.

## Conclusion and Recommendations

The study concludes that cereal crop farmers in Kwara State and Niger State face substantial constraints that hinder the adoption of climate change adaptation strategies and limit their capacity to effectively cope with climate variability. These constraints are predominantly economic and institutional, including high input costs, limited access to credit, and inadequate extension services. Additionally, restricted access to modern agricultural technologies and timely climate information further constrains informed decision-making. Collectively, these challenges weaken farmers’ resilience and reduce the overall effectiveness of adaptation efforts within the study area. To address these challenges, it is therefore recommended that policymakers should prioritize the implementation of targeted input subsidy programs, expansion of inclusive and farmer-friendly agricultural credit schemes, and the strengthening of extension service delivery systems. In addition, investments in the dissemination and adoption of climate-smart agricultural technologies should be scaled up to enhance sustainable productivity and build resilience among smallholder farmers.

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## Assessing The Crude Oil-Degrading Ability Of Bacteria Isolated From Hydrocarbon-Polluted Soil.

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Abstract

Microbial biodegradation has been recognized as an effective and environmentally friendly approach for the remediation of hydrocarbon-contaminated environments. This study assessed the crude oil-degrading ability of bacteria isolated from hydrocarbon-polluted soil. Soil samples were collected from contaminated sites and bacterial isolates were obtained using the serial dilution and spread plate technique. The isolates were screened for hydrocarbon utilization using Mineral Salt Medium supplemented with crude oil as the sole carbon source. Growth and turbidity observed in the medium indicated the ability of the isolates to degrade crude oil. Five bacterial isolates were obtained from hydrocarbon-polluted soil. Screening in Mineral Salt Medium containing crude oil revealed that all isolates were capable of utilizing crude oil as a carbon source to varying degrees. Optical density measurements showed that isolate HB2 (*Pseudomonas* spp.) exhibited the highest growth ($0.82 \pm 0.03$), indicating strong hydrocarbon utilization. Crude oil degradation analysis showed that HB2 achieved the highest degradation efficiency (65%), followed by HB1 (58%) and HB4 (52%). These findings suggest that the isolated bacteria possess significant potential for application in the bioremediation of hydrocarbon-contaminated soils. The results revealed that several bacterial isolates demonstrated significant growth in the crude oil-containing medium, suggesting their potential for hydrocarbon degradation. The findings highlight the presence of indigenous bacteria capable of utilizing petroleum hydrocarbons and emphasize their potential application in the bioremediation of oil-contaminated environments.

Keywords: Crude oil, Hydrocarbon, Pollution, Bacteria, Isolation.

### Introduction

Petroleum hydrocarbons are among the most widespread environmental pollutants due to extensive exploration, production, transportation, and refining of crude oil worldwide. Accidental spills, leakages from pipelines, and improper disposal of petroleum products frequently lead to the contamination of soil ecosystems (Obi *et al.*, 2016). These pollutants contain complex mixtures of aliphatic and aromatic hydrocarbons that are toxic, persistent, and capable of causing severe ecological damage to soil microorganisms, plants, animals, and human health. Consequently, crude oil pollution has become a major environmental concern in many oil-producing regions of the world. Crude oil contamination significantly alters the physical, chemical, and biological properties of soil. High concentrations of petroleum hydrocarbons can reduce soil fertility, disrupt microbial communities, and inhibit plant growth (Adeleye *et al.*, 2021). The toxic components of crude oil, particularly polycyclic aromatic hydrocarbons (PAHs), are known to persist in the environment for long periods and pose serious risks to ecosystems and human health.

As a result, there is increasing interest in developing environmentally friendly and cost-effective technologies for the remediation of hydrocarbon-polluted environments. Among the various remediation strategies, bioremediation has emerged as a promising and sustainable approach for the cleanup of oil-contaminated environments. Bioremediation involves the use of microorganisms such as bacteria, fungi, and algae to degrade or transform hazardous pollutants into less toxic compounds (Adebiyi 2021). Many indigenous microorganisms possess metabolic pathways that enable them to utilize hydrocarbons as their sole source of carbon and energy, thereby facilitating the natural breakdown of petroleum contaminants in soil and aquatic environments. Bacteria play a particularly important role in the biodegradation of petroleum hydrocarbons (Ani *et al.*, 2019). Numerous bacterial genera including *Pseudomonas*, *Bacillus*, *Acinetobacter*, *Enterobacter*, and *Achromobacter* have been reported to possess strong hydrocarbon-degrading capabilities. These microorganisms produce enzymes and biosurfactants that enhance the bioavailability of hydrophobic hydrocarbon molecules, thereby accelerating the degradation process (Oyewole *et al.*, 2021). In many cases, bacterial consortia are more effective than individual strains because different species degrade different fractions of crude oil. Hydrocarbon contaminated soils often harbor indigenous microbial communities that have adapted to utilize petroleum compounds as energy sources. Isolating and evaluating these native bacteria is an important step in identifying efficient strains for environmental cleanup. The assessment of crude oil-degrading bacteria typically involves isolating microorganisms from contaminated sites and evaluating their growth and degradation efficiency in media containing crude oil as the sole carbon source. Such studies provide valuable insight into the microbial potential for bioremediation and the development of effective strategies for restoring polluted ecosystems (Shahida *et al.*, 2015).

Therefore, this study aims to assess the crude oil-degrading ability of bacteria isolated from hydrocarbon-polluted soil in order to determine their potential for use in the bioremediation of petroleum-contaminated environments.

The objectives of the study were to:

Isolate bacteria from hydrocarbon-polluted soil samples.

Screen the bacterial isolates for their ability to utilize crude oil as a sole carbon source.

Assess the crude oil-degrading ability of the isolated bacteria using Mineral Salt Medium supplemented with crude oil.

MATERIALS AND METHODS

Study area

This study was conducted in Minna, Niger state Nigeria and lies between latitude 9.5836$^0$ N and longitude 6.5463$^0$E at an altitude of 256m above sea level and has a land area of about 88 Km$^2$ (www.minna.climatetemps.com/map.php). The map of Niger State showing the study is presented in Figure 1.

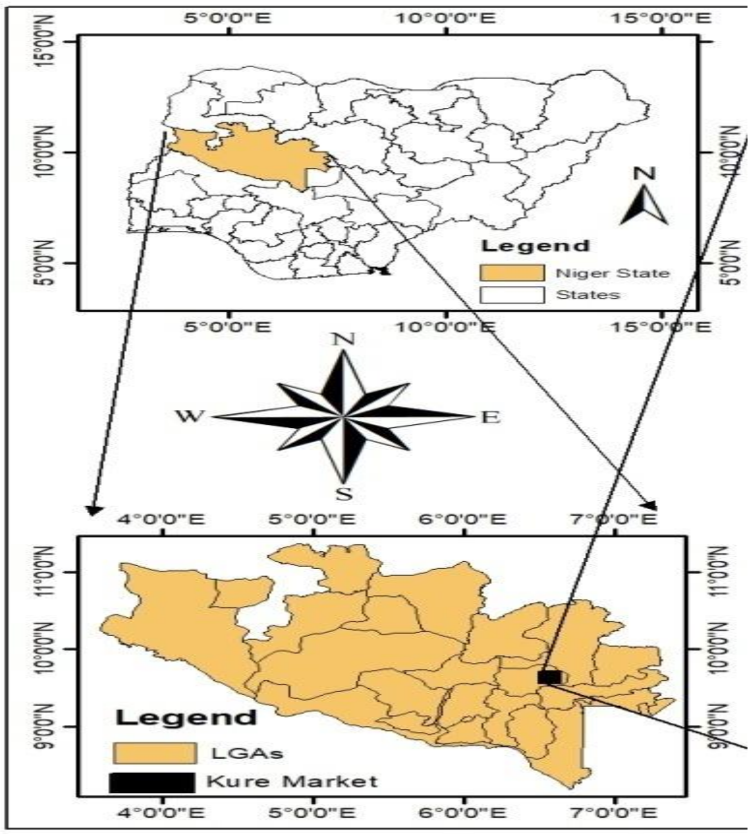


**Figure 1: Map showing Kure Market, Minna Niger State** (Source: Niger State Geographical System, NGSS. 2022)

Sample Collection

Soil samples were collected from hydrocarbon-polluted sites with a history of crude oil contamination. The samples were obtained at a depth of approximately 5–10 cm using sterile tools and transferred into sterile sample containers. The collected samples were properly labeled and transported to the laboratory for microbiological analysis. The samples were stored at 4 °C and processed within 24 hours to preserve the microbial population.

Isolation of Bacteria from Contaminated Soil

Bacteria were isolated from the soil samples using the serial dilution and spread plate technique. One gram of soil sample was suspended in 9ml of sterile distilled water and serially diluted up to $10^{-6}$ dilution. Aliquots (0.1ml) from appropriate dilutions were spread onto nutrient agar plates and incubated at 37°C for 24–48 hours. Distinct bacterial colonies were selected based on morphological characteristics and sub-cultured repeatedly to obtain pure isolates (Cheesebrough, 2014).

Screening for Hydrocarbon-Utilizing Bacteria

The bacterial isolates were screened for their ability to utilize crude oil as the sole carbon source using Mineral Salt Medium (MSM) supplemented with crude oil. The medium contained essential inorganic nutrients but lacked an organic carbon source. A small quantity of sterile crude oil (about 1% v/v) was added to the medium as the only carbon and energy source. Each bacterial isolate was inoculated into the medium and incubated at 30–37°C for 5–7 days. Growth in the medium indicated the ability of the bacteria to utilize crude oil. (Cheesebrough, 2014).

Assessment of Crude Oil Degradation Ability

The crude oil-degrading ability of the isolates was evaluated by monitoring bacterial growth and turbidity in the MSM containing crude oil. Increased turbidity of the culture medium compared with the control indicated microbial growth and hydrocarbon utilization. Visual observations such as emulsification of oil and reduction in oil layer were also recorded as indicators of degradation activity.

RESULTS AND DISCUSSION

Bacterial isolates were successfully obtained from the hydrocarbon-polluted soil samples using standard microbiological techniques. Several distinct colonies with varying morphological characteristics such as shape, size, color, and texture were observed on nutrient agar plates, indicating the presence of diverse bacterial species in the contaminated soil. The bacteria isolated from polluted soil include *Pseudomonas*, *Bacillus*, *Acinetobacter*, and *Micrococcus*. *Pseudomonas aeruginosa* is frequently reported as the most abundant (up to 50% in some studies), followed by *Bacillus spp.* which was described by Musa *et al.*, (2021) as the most frequent and efficient oil degraders (sometimes >20% of total isolates) due to their ability to produce biosurfactants and degrade complex aromatic hydrocarbons.

Table 1: Bacterial Isolates Obtained from Hydrocarbon-Polluted Soil

| Isolate Code | Colony Morphology | Gram Reaction | Probable Identity |
|---|---|---|---|
| HB1 | Large, creamy, circular colonies | Gram positive | *Bacillus* spp. |
| HB2 | Smooth, pale colonies | Gram negative | *Pseudomonas* spp. |
| HB3 | Yellow pigmented colonies | Gram positive | *Micrococcus* spp. |
| HB4 | Small white colonies | Gram negative | *Acinetobacter* spp. |
| HB5 | Rough irregular colonies | Gram positive | *Bacillus* spp. |

The results from table 2 shows the screening of the bacterial isolates using Mineral Salt Medium (MSM) supplemented with crude oil revealed that some isolates were capable of utilizing crude oil as their sole carbon and energy source. This was indicated by visible growth, increased turbidity in the culture medium, and partial emulsification of the oil layer during the incubation period. The presence of growth in MSM suggests that these isolates possess metabolic pathways that enable them to degrade petroleum hydrocarbons. Isolate HB2 (*Pseudomonas* spp.) showed the highest growth, indicating strong hydrocarbon utilization ability. Research by Chaudhary *et al.*, (2020) indicates that *Pseudomonas sp.*, *Bacillus sp.*, and *Acinetobacter sp.* are often the most effective oil degraders, yielding the highest OD600 values, often exceeding within 7–10 days.

Table 2: Optical Density (OD600) of Bacterial Isolates in Mineral Salt Medium with Crude Oil

| Isolate | Replicate 1 | Replicate 2 | Replicate 3 | Mean ± SD |
|---|---|---|---|---|
| HB1 | 0.71 | 0.68 | 0.73 | 0.71 ± 0.03 |
| HB2 | 0.82 | 0.79 | 0.85 | 0.82 ± 0.03 |
| HB3 | 0.55 | 0.58 | 0.57 | 0.57 ± 0.02 |
| HB4 | 0.64 | 0.66 | 0.62 | 0.64 ± 0.02 |
| HB5 | 0.43 | 0.45 | 0.41 | 0.43 ± 0.02 |
| Control | 0.05 | 0.05 | 0.05 | 0.05 ± 0.00 |

Crude Oil Degradation Efficiency

In table 3, Some isolates demonstrated stronger growth and higher turbidity compared to others, indicating a greater capacity for crude oil degradation. The highest degradation was recorded in HB2 (65%), followed by HB1 (58%) and HB4 (52%). These findings are consistent with that of Ajiboye *et al.*, (2020) which reported that bacteria isolated from oil-contaminated soils often exhibit strong hydrocarbon-degrading capabilities. The presence of these hydrocarbon-degrading bacteria highlights the natural potential of microorganisms to participate in the cleanup of petroleum-contaminated environments through the process of bioremediation. Indigenous bacteria are particularly advantageous for bioremediation because they are already adapted to the environmental conditions of the contaminated site.

Table 3: Percentage Crude Oil Degradation by Bacterial Isolates After 7 Days

| Isolate | Initial Oil Concentration (%) | Final Oil Concentration (%) | Degradation (%) |
|---|---|---|---|
| HB1 | 100 | 42 | 58 |
| HB2 | 100 | 35 | 65 |
| HB3 | 100 | 60 | 40 |
| HB4 | 100 | 48 | 52 |

| Isolate | Initial Oil Concentration (%) | Final Oil Concentration (%) | Degradation (%) |
|---|---|---|---|
| HB5 | 100 | 70 | 30 |

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study assessed the crude oil-degrading ability of bacteria isolated from hydrocarbon-polluted soil. The results showed that contaminated soils harbor diverse bacterial populations capable of utilizing crude oil as a source of carbon and energy. The growth of bacterial isolates in Mineral Salt Medium supplemented with crude oil confirmed their ability to metabolize petroleum hydrocarbons. The presence of such hydrocarbon-degrading bacteria highlights the natural capacity of microorganisms to contribute to the cleanup of petroleum-contaminated environments. Some isolates demonstrated stronger growth and degradation potential, suggesting that they possess efficient metabolic mechanisms for breaking down complex hydrocarbon compounds. These findings indicate that indigenous bacteria from contaminated soils can play a significant role in bioremediation processes.

Therefore, the study demonstrates the potential of bacteria isolated from hydrocarbon-polluted soils as promising candidates for the biological remediation of crude oil-contaminated environments.

Recommendations

Further studies should be carried out to identify the bacterial isolates at the molecular level to accurately determine their species.

Quantitative analysis should be conducted to measure the exact rate and efficiency of crude oil degradation by the bacterial isolates.

Environmental factors such as temperature, pH, and nutrient availability should be optimized to improve the efficiency of microbial degradation.

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## A Comparative Study of Biogas Production from some Organic Wastes by Fungal Biodegradation at Room Temperature.

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Online Presentation at

Society is today confronted with dwindling and depletion of fossil fuel , green house emission and the proliferation of wastes generated by municipalities, agriculture and industries.The conversion of these wastes to biogas will help in mitigating the above challenges. These challenges have necessitated research *on the comparative study of the production of biogas from biodegradable organic wastes: elephant grass, maize cub, maize chaff and saw dust in the presence of yeast at room temperature(25$^{oc}$) and slurry condition of ratio 4g to 30cm$^3$.Elephant grass, sawdust, maize cub and maize chaff were dried in the sun for about two weeks and ground to fine particles separately in different mortals. 4g of each sample was weighed separately and placed in different digesters. 0.6g of yeast and 30cm$^3$ of water was added to the samples in the four different digesters. The results showed that maize curb produced 245 cm$^3$ of biogas, elephant grass produced 235 cm$^3$ of biogas, sawdust and maize chaff produced 116 cm$^3$and 670 cm$^3$ of biogas respectively. Maize chaff was found to produce the highest yield of biogas. Therefore, for maximum production of biogas, maize chaff is preferable above others. The graphs plotted show a similar pattern. it increases gradually for the first few days and a sudden rise as the days progress and finally reach a plateau(constant).*

*KEY WORD: Comparative, biodegradable, Slurry, organic waste, Biogas, yeast and digester.*

## INTRODUCTION

Society is today confronted with dwindling and depletion of fossil fuel and battling with the proliferation of wastes generated by municipalities, agriculture and industries. The conversion of these wastes to biogas will help in mitigating the above challenges (Obrecht,2011). Biogas is a mixture of gases produced by the breakdown of organic matter in the absence of oxygen (Badiyya,2018) by anaerobic bacteria (Garba, Zuru & Sambo, 1996). Ekwenchi &Yaro (2010) produced biogas from banana leaves and also from cow dung (Ekwenchi,2007).The gas is a mixture of methane ($CH_4$) 50 %-70%, carbon dioxide 30%-40%, hydrogen 5%-10%, nitrogen 1%-2%, hydrogen sulphide (trace)and water vapour 0.3%. The gas is useful domestic cooking and electricity. The main contributors of waste energy are municipal solid waste (Adeyemo, 2001). Biogas is also a key option for short and medium term to mitigate Green House gas emissions and replace fossil fuels since it can be used as source of heat, electricity and produce transport fuel (Elaiyaraju & Partha, 2016).

MATERIAL AND METHOD

The materials used as biodegradable wastes are elephant grass, sawdust, maize cub and maize chaff. The apparatus used are measuring cylinder, delivering tube, retort stand, digester, rubber cork, weighing machine and water trough. The organic waste materials: elephant, grass, sawdust, maize cub and maize chaff were dried in the sun for about two weeks and ground to fine particles separately in different mortals with pestle 4g of each sample was weighed in a weighing machine and transferred to four different digesters (reacting vessels) of the same capacity of 100 $cm^3$. 30$cm^3$ of water and 0.6g of yeast were added to the contents of the four digesters which were connected by delivering tubes to measuring cylinders of 100$cm^3$, emerged in a water trough .The biogas production was recorded daily for the different set up. Working temperature for the digesters is $25^{0c}$ (room temperature)

RESULTS AND DISCUSSION

TABLE 1: CUMULATIVE DAILY BIOGAS PRODUCTION FROM MAIZE CUB

| DAY | Cumulative Daily Biogas Production($Cm^3$) |
|---|---|
| 1 | 70 |
| 2 | 91 |
| 3-10 | 116 |
| 11 | 185 |
| 12-20 | 245 |

TABLE 2: CUMULATIVE DAILY BIOGAS PRODUCTION FROM ELEPHANT GRASS

| DAY | cumulative Daily Biogas Production($Cm^3$) |
|---|---|
| 1 | 30 |
| 2 | 40 |
| 3-10 | 45 |
| 11 | 55 |
| 12 | 55 |
| 13 | 79 |
| 14 | 165 |
| 15 | 175 |
| 16-20 | 235 |

TABLE 3: CUMULATIVE DAILY BIGAS PRODUCTION FROM SAW DUST

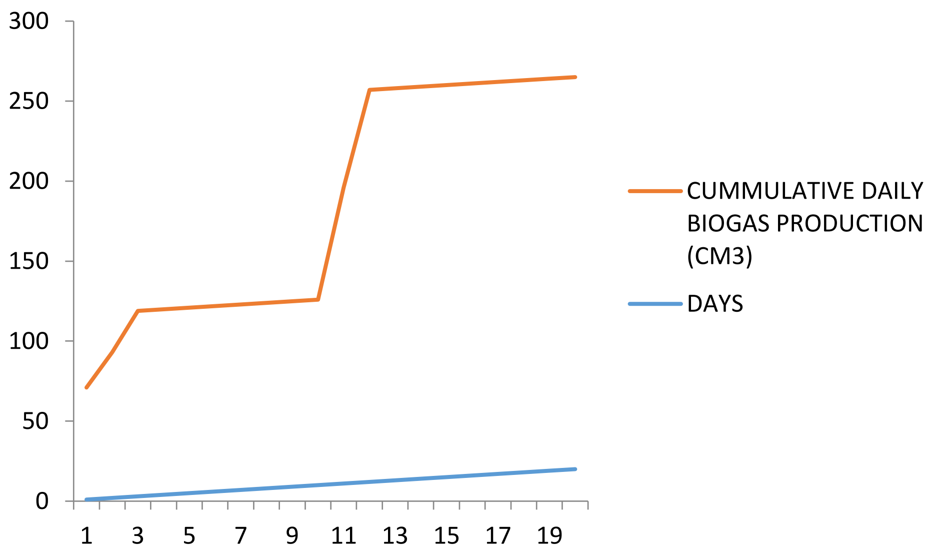
| DAY | Cumulative Daily Biogas Production |
| --- | --- |
| 1 | 10 |
| 2-9 | 15 |
| 10 | 30 |
| 11 | 35 |
| 12 | 35 |
| 13 | 35 |
| 14 | 35 |
| 15 | 35 |
| 16-20 | 116 |

TABLE4: CUMULATIVE DAILY BIOGAS PRODUCTION FROM MAIZE CHAFF

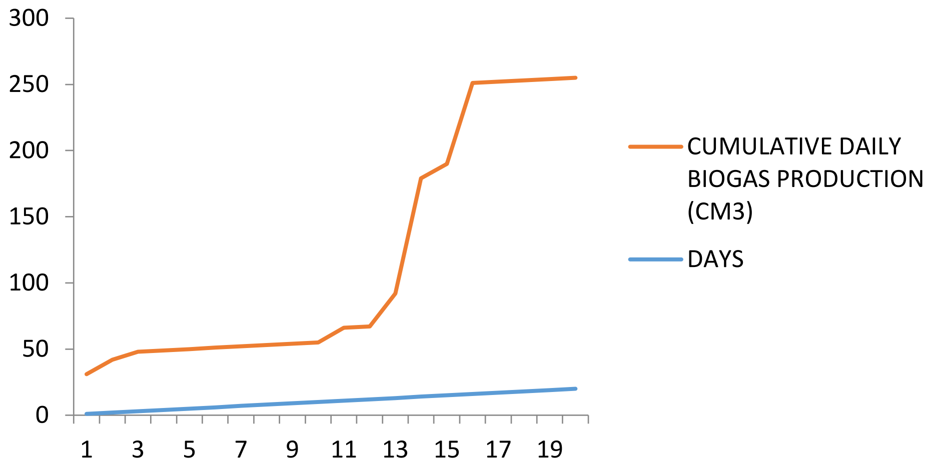
| DAY | Cumulative Daily Biogas Production |
| --- | --- |

| | |
|---|---|
| 1 | 120 |
| 2 | 160 |
| 3-8 | 200 |
| 9 | 260 |
| 10 | 320 |
| 11 | 370 |
| 12 | 545 |
| 13-20 | 670 |

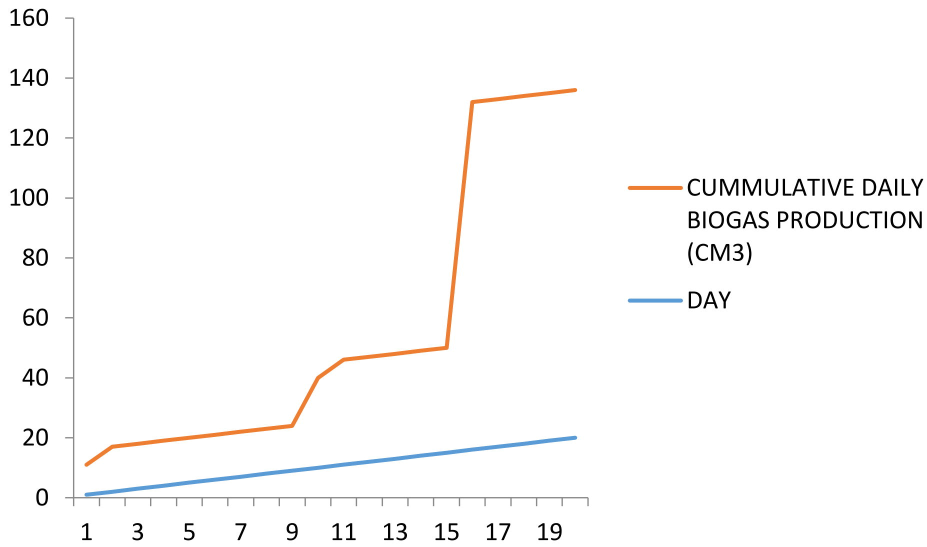
GRAPH1: MAIZE CUB



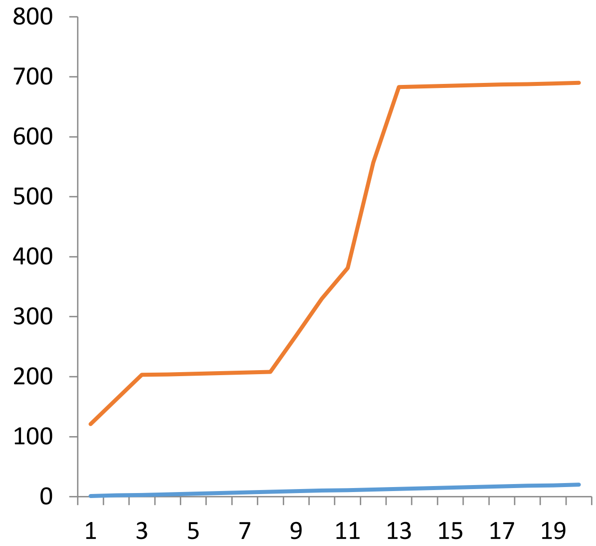
GRAPH2: ELEPHANT GRASS




Graph3: SAW DUST




Graph4: MAIZE CHAFF




RESULTS AND DISCUSSION

From the results shown in table 1-4, maize chaff produced a biogas yield of 245cm$^{3,}$ elephant grass produced 235 cm$^3$, sawdust produced 116 cm$^3$ and maize chaff produced 670 cm$^3$. The graphs plotted above, show a similar pattern. It increases gradually for the first few days and a sudden rise as the days progress and finally reach a plateau(constant).

CONCLUSION: From the above results, the sample that produced the highest maximum yield of biogas production is maize chaff with a value of 670 cm$^3$.Therefore for maximum yield of biogas production, maize chaff is preferable above others.

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## Application of Semivariogram Analysis in measuring Spatial Variability and Distribution of Selected soil Properties in Umuagwo, Imo State.

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ABSTRACT:

This study investigates the application of Semivariogram analysis to evaluate the spatial variability and distribution of selected soil properties in Umuagwo, Imo State, Nigeria. By utilizing geostatistical techniques, the research analyzes five soil samples collected from a profile pit from the study area to map the spatial structure of selected soil properties such as Soil pH, organic matter content, and nutrient levels. The semivariogram serves as a critical tool in understanding the degree of variability and spatial dependence of these properties, enabling the identification of trends and patterns within the soil data. The results of the semivariogram analysis showed that all the selected soil properties exhibited spatial dependence within some distances. The spatial dependence for pH is 5.56; organic carbon is 8.59; Available Phosphorus is 17.14, which gave rise to strong spatial class, using exponential and Gaussian models. The findings aim to enhance soil management practices in the region, provide insights for agricultural planning and environmental conservation. Overall, this study contributes to a deeper understanding of soil dynamics in Umuagwo, supporting sustainable land use and resource management strategies. The study also highlights the relevance of semivariogram analysis in supporting site-specific nutrient management and sustainable land use planning.

Keywords: Geostatistics, Semivariogram, Spatial Variability,Kriging, Soil Properties.

Introduction

Soil properties vary spatially due to inherent factors such as parent material, topography, and climate, as well as extrinsic factors including management practices, land use, and fertilizer application (Okereafor et al., 2025). This variability has profound implications for sustainable agriculture, as ignoring it often results in mismanagement of soil resources, reduced crop yields, and environmental degradation.

In Nigeria, studies have shown that land-use planning and soil management are often hindered by poor knowledge of variability patterns (Fabami, 1990). Traditional statistical approaches describe averages but fail to capture spatial dependence among soil properties. Geostatistics, however, provides a robust framework to quantify spatial relationships and model soil heterogeneity effectively.

The semivariogram, a fundamental tool in geostatistics, describes how similarity between samples decreases with distance. When combined with kriging, it allows for the generation of continuous prediction maps from discrete sample data (McBratney et al., 2003). Previous research across different regions

(Cambardella et al., 1994; Goovaerts, 1998) has demonstrated that soil properties commonly display strong to moderate spatial dependence.

Despite progress globally, limited work has been conducted in southeastern Nigeria using semivariogram analysis. Umuagwo, Imo State, is an intensively cultivated area where soil degradation, nutrient depletion, and inefficient fertilizer use are pressing challenges. By applying semivariogram analysis to key soil properties; pH, organic carbon, and available phosphorus, the study provide insights into variability patterns that can guide site-specific nutrient management and sustainable land-use practices.

Materials and Methods

Study Area

The study was conducted in Umuagwo, Imo State, southeastern Nigeria as shown in figure 1. The region lies within the humid tropical climate zone, characterized by an annual rainfall of 2000–2500 mm and mean annual temperatures of 25–30°C. Rainfall is bimodal, with a wet season extending from March to October and a dry season from November to February.The soils of the area are predominantly Ultisols, which are highly weathered, strongly acidic, and prone to nutrient leaching. Due to intensive cultivation, fertility is often low, necessitating frequent fertilizer and organic amendments (Okereafor et al., 2024).

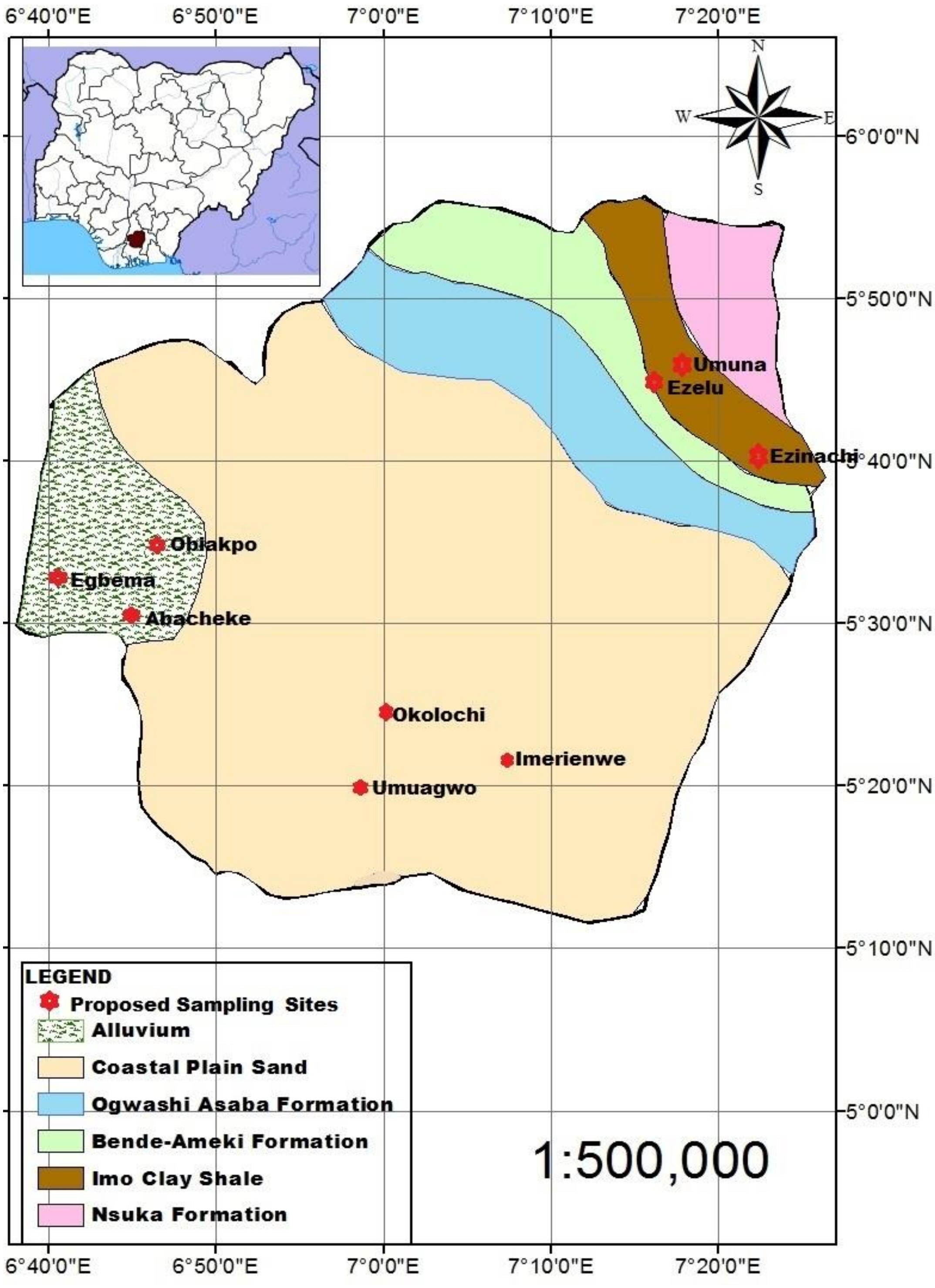


Fig. 1: Map of Imo State showing the study area

Soil Sampling

A profile pit was excavated at the study location and described according to FAO guidelines for soil description (FAO, 2006). Genetic horizons guided soil sample collection from the bottom to layer to the topmost layer. Five (5) soil samples were collected using free grid-base sample approach for more accurate spatial variable data, and subjected to laboratory analysis.

Laboratory Analyses

Soil pH was measured in a 1:2.5 soil-to-water suspension using a pH meter (Hendershot et al., 1993). Soil Organic Carbon (SOC) was determined using the Walkley and Black dichromate oxidation method (Nelson & Sommers, 1982). Organic matter content was calculated using a factor of 1.724. Available Phosphorus (P) was extracted with Bray I solution and measured colorimetrically using the molybdenum blue method (Udo et al., 2009).

Statistical Analysis

Basic descriptive statistics (mean, standard deviation, coefficient of variation) were computed. The coefficient of variation (CV) was used to classify variability following Wilding et al. (1994): Low: <15%; Moderate: 16–35%; High: >35%.

Geostatistical Analysis

Semivariograms were constructed for each property using ArcGIS 10.2 software. Theoretical models (exponential and Gaussian) were fitted to experimental semivariograms. Key parameters included: Nugget (C0): representing measurement error or microscale variability. Sill (C0 + C): total variance. Range (a): distance beyond which spatial correlation disappears. Spatial dependence was classified according to Cambardella et al. (1994): Strong (<25%), Moderate (25–75%), Weak (>75%). Ordinary Kriging (OK) interpolation method was used for the prediction of the values of the un-sampled locations.

Results and Discussion

Descriptive Statistics

Descriptive statistics revealed variability in the studied properties. Soil pH was consistently acidic, ranging between 4.0 and 4.2, indicative of strong acidity across the study area. Organic carbon levels were low, reflecting continuous cropping and insufficient organic inputs. Available phosphorus showed wider variation, which may be attributed to uneven fertilizer application and soil chemical fixation (Table 1).

Semivariogram Models

Soil pH: The semivariogram showed strong spatial dependence with a short range of 5.56 m, suggesting localized variability due to fertilizer use and leaching. Organic Carbon: Range = 8.59 m, indicating moderate-scale variability influenced by crop residues and organic amendments. Available Phosphorus: Range = 17.14 m, the broadest, reflecting fertilizer placement and P fixation dynamics (Table 2).

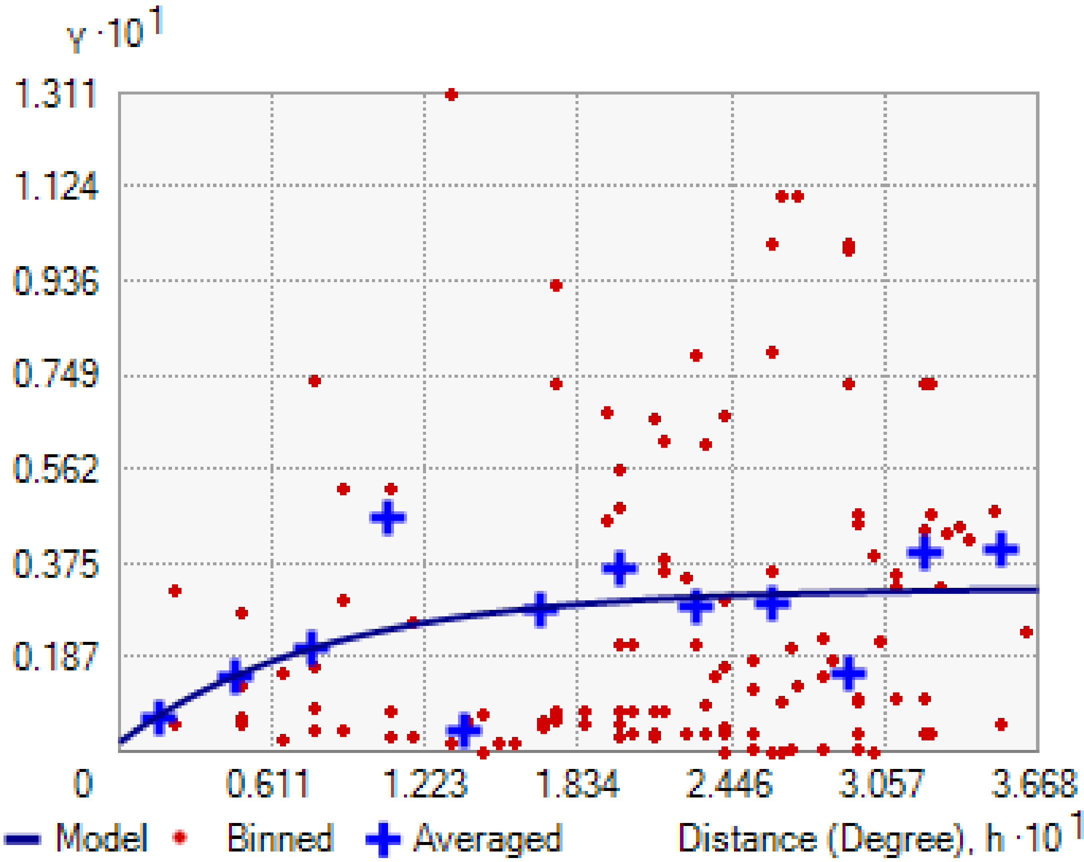


Figure 2. Semivariogram of pH in 1N KCl

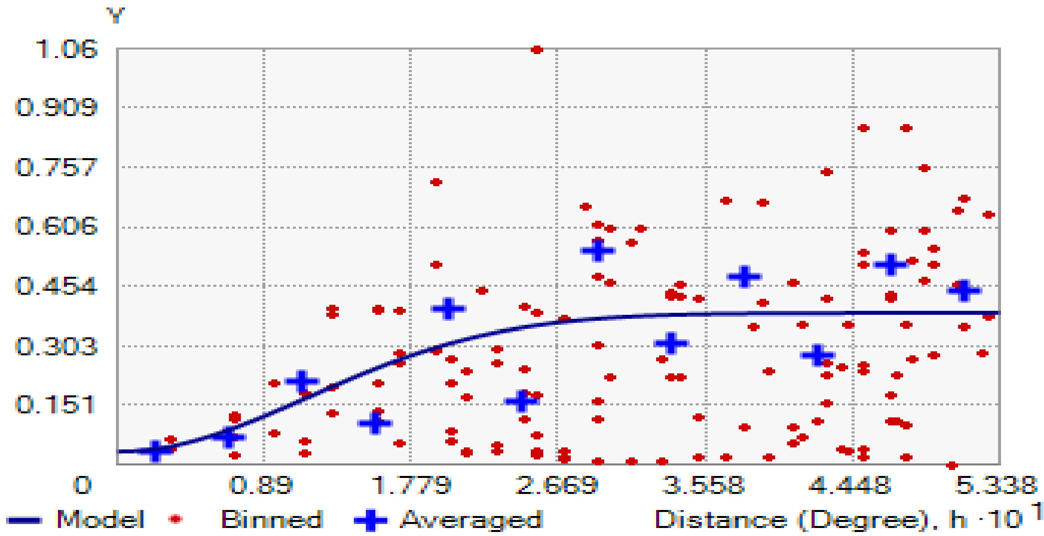


Figure 3. Semivariogram of Soil Organic Carbon

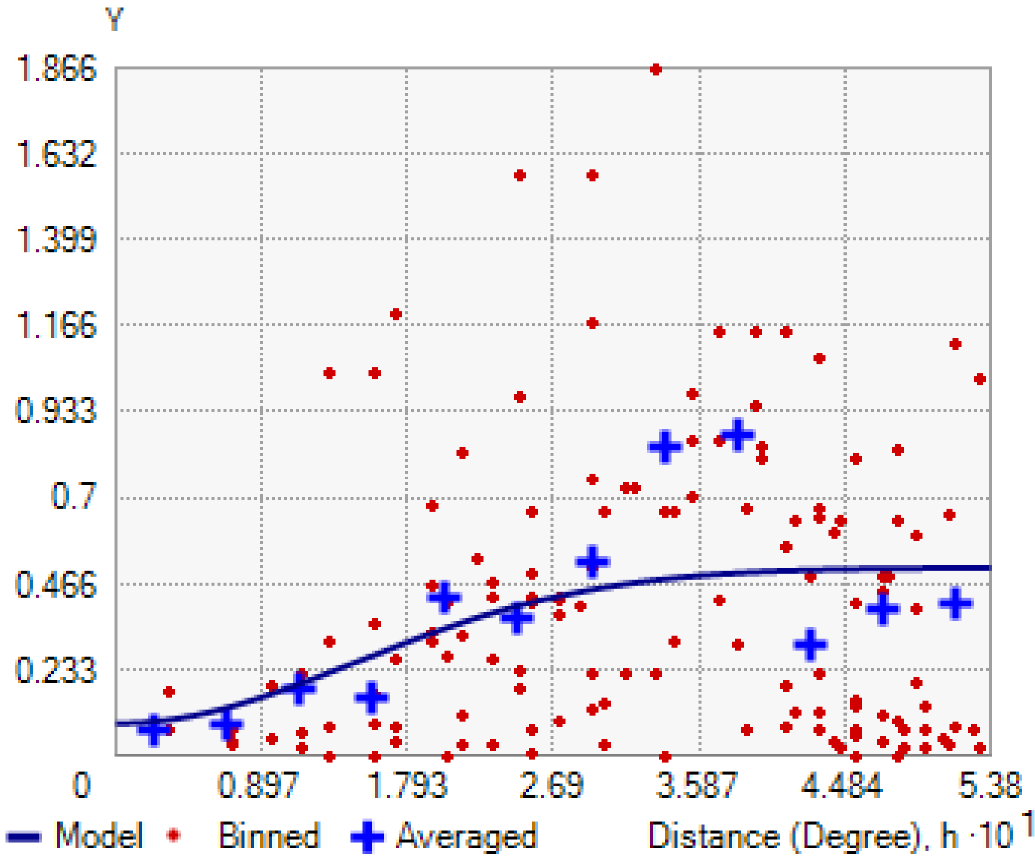


Figure 4. Semivariogram of Available Phosphorus

Kriging Prediction Maps

Kriging maps derived from semivariogram models displayed spatial gradients of soil properties: pH values clustered in small pockets, highlighting micro-scale variability. Organic carbon showed larger patches of variability, consistent with differences in land management. Available phosphorus exhibited distinct zones of enrichment and depletion (Figure 5-7).

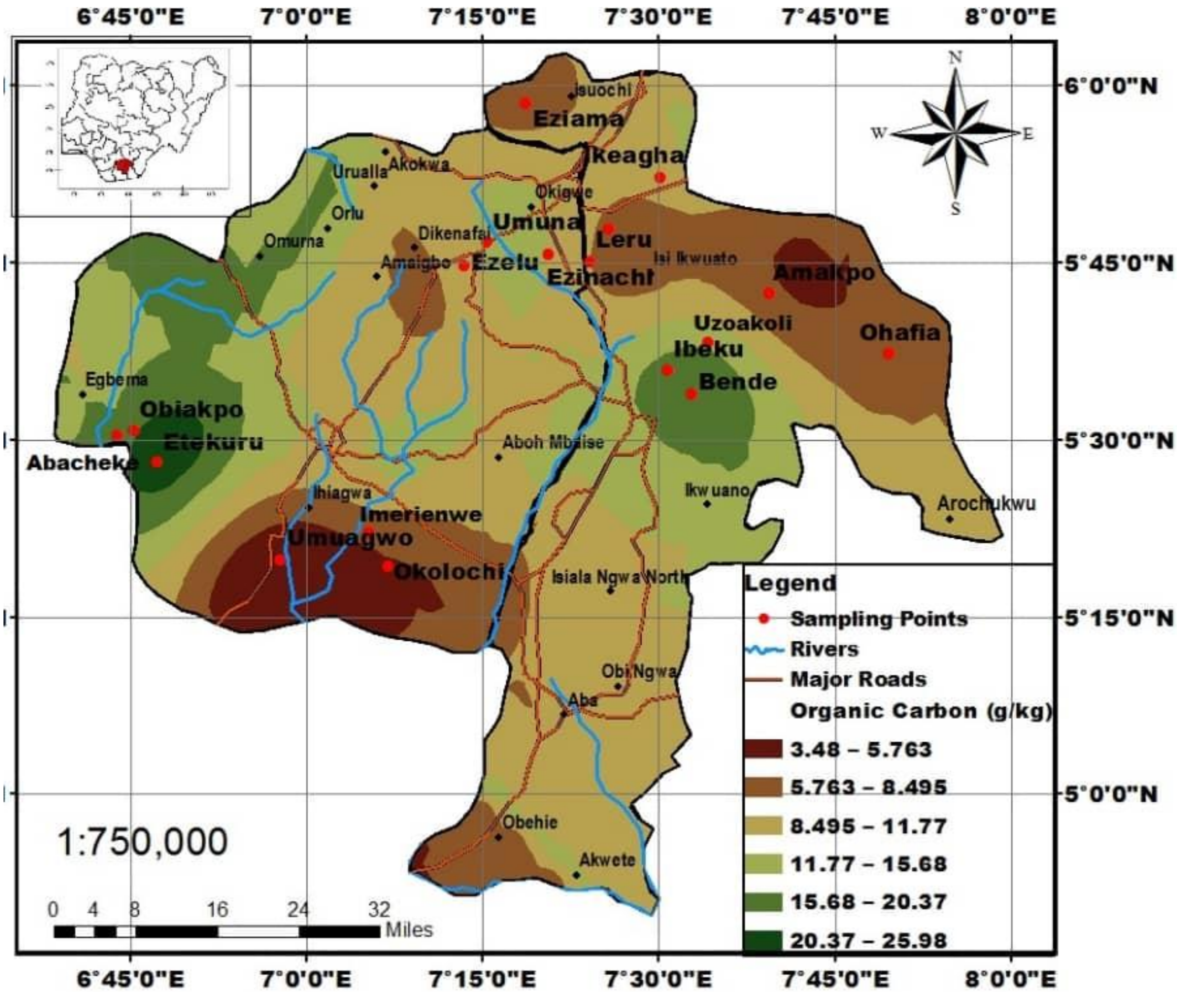


Figure 5. Kriged Map showing the spatial distribution of Organic Carbon in the study location.

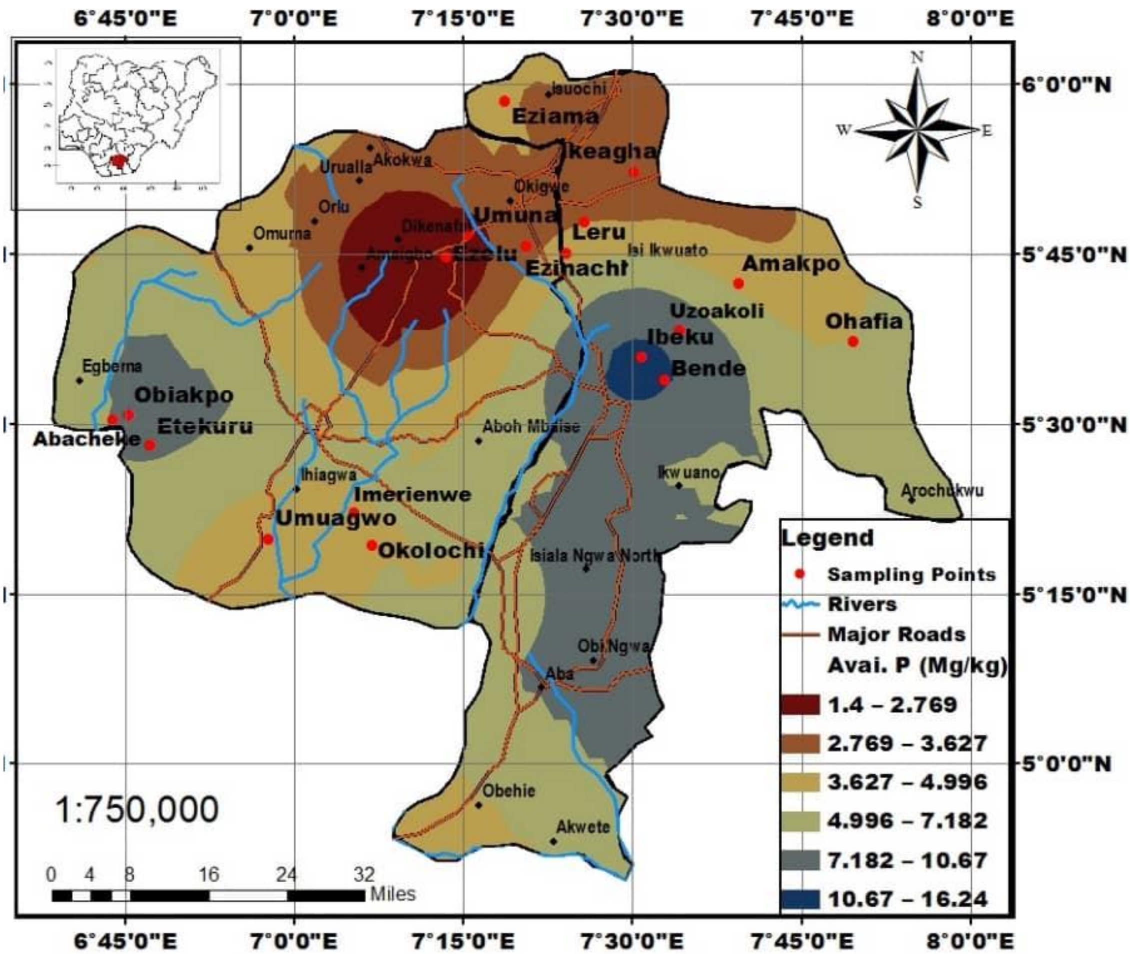


Figure 6. Kriged Map showing the spatial distribution of Available Phosphorus in the study location.

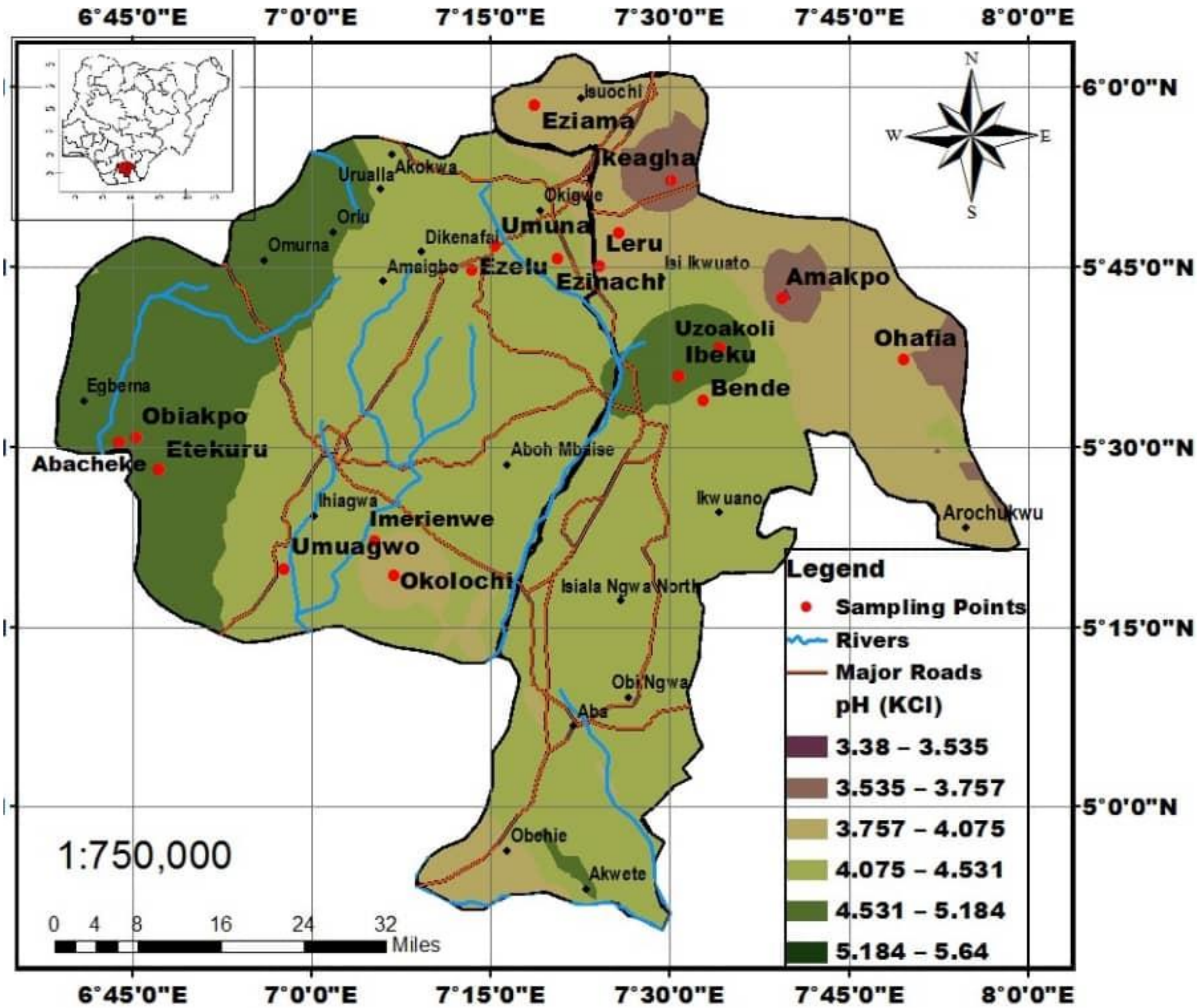


Figure 7. Kriged Map showing the spatial distribution of pH (KCl) in the study location.

Spatial Dependence Patterns:

The strong dependence of soil properties suggests that intrinsic factors (parent material, soil forming processes) and extrinsic factors (fertilizer, tillage, residue management) both play important roles in variability. The short range of pH reflects localized influences, while organic carbon and phosphorus variability spans broader distances, consistent with management practices.

Comparison with Previous Studies:

These findings align with Cambardella et al. (1994), who reported strong spatial dependence in Iowa soils, and Goovaerts (1998), who demonstrated similar patterns in European contexts. Locally, they corroborate studies in southeastern Nigeria that highlighted high variability in fertility indices under intensive cultivation.

Implications for Precision Agriculture:

Identifying ranges of variability provides practical guidance for fertilizer and lime application. Site-specific nutrient management (SSNM) could reduce wastage, improve input efficiency, and sustain yields. Spatial maps also provide tools for policymakers in land allocation and conservation planning.

Table 1. Mean physicochemical properties of soils of the study area.

| Horizon | Depth (cm) | Sand | Silt | Clay | SCR | pH | Organic Carbon (%) | Avail. P. | Ca | Mg. | K | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Cml/kg ← | | | | → |
| A | 0-21 | 964 | 12.8 | 23.2 | 0.55 | 4.10 | 7.2 | 5.39 | 0.5 | 0.25 | 0.005 | 0.020 |
| AB | 21-50 | 964 | 12.8 | 43.2 | 0.3 | 4.12 | 3.4 | 2.94 | 0.7 | 0.30 | 0.005 | 0.021 |
| $Bt_1$ | 50-80 | 924 | 22.8 | 53.2 | 0.43 | 4.03 | 3.6 | 3.64 | 0.5 | 0.19 | 0.003 | 0.021 |
| $Bt_2$ | 80-131 | 914 | 42.8 | 43.2 | 0.99 | 4.17 | 1.8 | 3.43 | 0.6 | 0.23 | 0.003 | 0.022 |
| $Bt_3$ | 131-200 | 864 | 13 | 123.2 | 0.11 | 4.08 | 1.4 | 2.52 | 0.5 | 0.16 | 0.003 | 0.018 |
| Mean | | 926 | 62.42 | 57.2 | 0.48 | 4.12 | 3.48 | 3.58 | 0.56 | 0.23 | 0.00 | 0.02 |
| CV (%) | | 4.48 | 4.48 | 67.26 | 69.42 | 1.82 | 65.85 | 30.68 | 16.13 | 23.95 | 28.83 | 7.10 |

Table 2: Semi-variogram models and parameters of the selected soil properties

| Properties | Model | Partial Sill | Nugget | Sill | Range (m) | Spatial Dependence (%) | Spatial Class |
|---|---|---|---|---|---|---|---|
| Sand (g/kg) | Gaussian | 0.2428 | 0.0324 | 0.2752 | 28633.3 | 11.77 | Strong |
| Clay | Gaussian | 0.5335 | 0.1632 | 0.6967 | 76977.8 | 23.43 | Strong |
| SCR | Gaussian | 0.9092 | 0.232 | 1.1412 | 28633.3 | 20.33 | Strong |
| pH (KCl) | Exponential | 0.0308 | 0.0018 | 0.0326 | 27300.0 | 5.56 | Strong |
| Organic Carbon | Gaussian | 0.3536 | 0.0333 | 0.3869 | 31377.8 | 8.59 | Strong |
| Available Phosphorus | Gaussian | 0.4225 | 0.0874 | 0.5099 | 40155.6 | 17.14 | Strong |
| Calcium | Gaussian | 0.2205 | 0.1989 | 0.4194 | 44322.2 | 47.43 | Moderate |
| Magnesium | Exponential | 0.7511 | 0.1125 | 0.8637 | 41544.4 | 13.03 | Strong |
| Potassium | Gaussian | 4.2282 | 0.121 | 4.3492 | 78177.8 | 2.78 | Strong |

Conclusion and Recommendations

This study demonstrates that semivariogram analysis is a powerful tool for quantifying soil variability. In Umuagwo soils, pH, organic carbon, and available phosphorus all exhibited strong spatial dependence, with distinct ranges of variability. These results underscore the need for site-specific soil management to enhance input efficiency and sustain agricultural productivity. The study was limited by sampling density and focused only on three soil properties. Incorporating additional parameters (e.g., micronutrients, bulk density, CEC) and temporal monitoring could provide a more comprehensive understanding. Future work should link kriging maps directly with crop yield data for improved decision-making and as cross validate the data to select the best-fit model for each soil property.

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## The Importance of Home Gardening in a Depreciating Economy

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Abstract

Economic depreciation characterized by inflation, declining purchasing power, currency devaluation, unemployment, and food price volatility poses serious challenges to household food security and livelihoods. In such contexts, home gardening has re-emerged as a vital coping, adaptation, and resilience strategy. This paper examines the importance of home gardening in a depreciating economy, with emphasis on food security, household income savings, nutrition and health outcomes, environmental sustainability, and social resilience. Drawing on economic theory, sustainable livelihoods frameworks, and empirical evidence from developing and developed economies, the paper argues that home gardening is not merely a subsistence or traditional activity but a strategic socio-economic intervention that enhances household and community resilience during economic downturns. The paper concludes that stronger policy recognition, institutional support, and integration into food security, urban planning, and economic recovery strategies are necessary to maximize the contributions of home gardening.

Keywords: Home gardening; depreciating economy; food security; household resilience; sustainable livelihoods; inflation; nutrition-sensitive agriculture

## INTRODUCTION

Economic depreciation is a persistent challenge facing many national economies, particularly in developing countries. It is commonly expressed through inflation, declining purchasing power, currency devaluation, unemployment, and rising food prices. These conditions directly affect household welfare, as food expenditures typically consume a large proportion of household income. When prices rise faster than wages, households struggle to maintain adequate and nutritious diets.

In depreciating economies, food insecurity becomes more widespread and severe. Families often respond by reducing meal sizes, lowering dietary quality, or skipping meals altogether. Such coping strategies have negative consequences for health, productivity, and long-term human capital development. As a result, alternative approaches that strengthen household food access outside formal markets are increasingly important.

Home gardening involves the cultivation of crops within household compounds or nearby plots, primarily for household consumption. Although often considered a traditional practice, home gardening has re-emerged as a strategic response to modern economic crises. By producing food locally, households reduce exposure to volatile market prices and supply disruptions.

The objective of this study is to examine the importance of home gardening in a depreciating economy. Specifically, the paper analyzes its role in enhancing food security, reducing household expenditure, improving nutrition and health, supporting environmental sustainability, and strengthening social resilience. The study also discusses policy implications for integrating home gardening into development planning.

## LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Scholarly literature consistently highlights the contribution of home gardening to household food security and livelihood sustainability. Research across Africa, Asia, and Latin America indicates that home gardens significantly increase access to fresh vegetables and fruits, particularly among low-income households (FAO, 2021; Galhena, Freed, & Maredia, 2013). These studies emphasize that even small plots can produce meaningful quantities of food.

Marsh (1998) documents the role of traditional gardening systems in income smoothing and poverty reduction, noting that households often intensify garden production during economic downturns. Similarly, Zezza and Tasciotti (2010) show that subsistence food production reduces household vulnerability by lowering dependence on purchased food.

The sustainable livelihoods framework provides a theoretical foundation for understanding these outcomes. According to Scoones (2015), households rely on combinations of natural, human, financial, physical, and social capital to pursue livelihood strategies. Home gardening enhances natural capital through land use, human capital through knowledge and skills, social capital through cooperation, and financial capital through cost savings and occasional income generation.

Resilience theory further explains the adaptive value of home gardening. Barrett and Constas (2014) define resilience as the ability to withstand and recover from shocks without long-term decline in well-being. Home gardening strengthens resilience by diversifying food sources and reducing reliance on unstable mar

## ECONOMIC AND FOOD SECURITY CONTRIBUTIONS OF HOME GARDENING

Home gardening contributes directly to household food availability by supplying vegetables, fruits, legumes, and sometimes staple crops. This local production reduces the need for frequent market purchases and ensures that food remains available even during price spikes or supply shortages.

Food accessibility improves as households rely less on cash income to obtain food. In depreciating economies where inflation erodes wages, this reduced dependence on markets provides an important buffer against food insecurity. Households with gardens are better able to maintain stable consumption patterns compared to those fully dependent on purchased food.

Home gardens also support food utilization by improving dietary diversity. Access to a variety of fresh foods enhances nutrient intake and reduces reliance on energy-dense but nutrient-poor diets. Improved utilization contributes to better health outcomes, particularly for children and women.

Food stability is strengthened through crop diversification and staggered planting. By growing multiple crops with different harvest periods, households reduce the risk of complete crop failure and seasonal food shortages. Surplus produce may be sold or exchanged locally, generating supplementary income that further enhances food security (Zezza & Tasciotti, 2010).

## NUTRITIONAL, HEALTH, ENVIRONMENTAL, AND SOCIAL BENEFITS

Home gardening plays a critical role in improving nutrition by increasing access to micronutrient-rich foods such as leafy vegetables, fruits, and legumes. These foods supply essential vitamins and minerals that are often lacking in diets during economic hardship. Research links home gardening with improved dietary diversity and reduced malnutrition (Ruel, Quisumbing, & Balagamwala, 2018).

Health benefits extend beyond nutrition. Gardening activities promote physical exercise, which supports cardiovascular health and reduces the risk of non-communicable diseases. In addition, interaction with green spaces has been shown to improve mental well-being and reduce stress and anxiety (Soga, Gaston, & Yamaura, 2017).

Environmental benefits of home gardening include improved soil fertility through composting, reduced household waste, and increased biodiversity through crop diversification. These practices align with agroecological principles and reduce dependence on synthetic inputs (Altieri & Nicholls, 2020).

Socially, home gardening strengthens household self-reliance and dignity. It also enhances community cohesion through seed sharing, knowledge exchange, and cooperative labor. Women, elderly persons, and unemployed household members often play central roles in gardening, contributing to empowerment and social inclusion (FAO, 2011).

## POLICY IMPLICATIONS, RECOMMENDATIONS, AND CONCLUSION

Despite its demonstrated benefits, home gardening remains underrepresented in many agricultural and economic policies. Policy frameworks often prioritize large-scale commercial agriculture, overlooking the cumulative contribution of household-level food production.

Governments and development agencies should integrate home gardening into food security, nutrition, and economic recovery strategies. Policy support may include extension services, training programs, access to quality seeds and water, urban land allocation, and inclusion of home gardening in social protection programs.

Educational institutions and community organizations can play a role by promoting gardening skills and awareness. Integrating home gardening into climate-smart and nutrition-sensitive agriculture initiatives would further enhance its relevance in depreciating economies.

In conclusion, home gardening represents a practical, affordable, and sustainable response to economic depreciation. By enhancing food security, reducing household expenditure, improving nutrition and health, supporting environmental sustainability, and strengthening social resilience, home gardening serves as a vital household survival and adaptation strategy. Stronger policy recognition can significantly amplify its contribution to sustainable development.

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# Determinants of ICT Adoption in Agricultural Extension Delivery and Its Effects on Inclusive Rural Development in Southern Taraba, Nigeria

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ABSTRACT

This study examined determinants of ICT adoption in agricultural extension delivery and its effects on inclusive rural development in Southern Taraba, Nigeria. A total of 330 respondents (300 smallholder farmers and 30 extension agents) were surveyed using structured questionnaires. Binary logistic regression results revealed that education (B) = 1.84), ICT training (B) = 2.67), organizational support (B) = 2.21), and access to ICT infrastructure (B) = 3.05) significantly increased the likelihood of ICT adoption. Respondents with ICT training were approximately 2.7 times more likely to adopt ICT, while those with access to adequate infrastructure were three times more likely to adopt ICT compared to their counterparts. Descriptive statistics showed that 85% of respondents used mobile phones, 62% used WhatsApp, 58% accessed the internet, and 40% used social media, with an average daily ICT use of 2.8 hours. Correlation analysis indicated that ICT utilization was positively associated with productivity ($r = 0.62$, $p < 0.05$), income ($r = 0.58$, $p < 0.05$), and access to agricultural information ($r = 0.71$, $p < 0.05$). Chi-square tests showed significant associations between ICT adoption and gender ($\chi^2 = 7.21$, $p = 0.007$), age ($\chi^2 = 10.15$, $p = 0.001$), and farmer type ($\chi^2 = 15.32$, $p < 0.001$). It is concluded that ICT-based extension enhances agricultural performance and rural development, although disparities exist for women, older adults, and smallholder farmers. The study recommends digital literacy training, improved ICT infrastructure, gender-inclusive policies, promotion of diverse ICT tools, and targeted support for smallholders to ensure equitable access.

Key words: ICT adoption; Agricultural extension services; Farmers' productivity; Inclusive rural development.

## INTRODUCTION

Agricultural extension services play a central role in bridging the knowledge gap between research innovations and rural farmers by facilitating information exchange, technology transfer, and advisory support. In recent years, Information and Communication Technologies (ICTs) have been recognized as transformative tools that can enhance the reach, timeliness, and inclusiveness of extension service delivery, particularly for smallholder farmers in sub-Saharan Africa and Nigeria (Olagunju et al., 2024; Oladipo et al., 2024). ICTs such as mobile phones, social media, and digital platforms can reduce traditional communication barriers, improve access to agronomic advisories, and support farmers' decision-making processes (Oladipo et al., 2024). However, despite the potential of these digital solutions, adoption by extension agents and farmers remains limited in many rural contexts due to structural and individual constraints (Olagunju et al., 2024; Sa'adu et al., 2022). Empirical studies in Nigeria have identified multiple determinants that influence ICT adoption in agricultural extension delivery. For instance, Olagunju et al. (2024) found that although extension agents demonstrated high awareness of ICT tools, actual usage was low due to obstacles such as unreliable electricity, limited access to ICT facilities, ICT illiteracy, and inadequate institutional support. These socio-economic and infrastructural factors significantly shaped agents' capacity to integrate ICT into their daily extension work. Similarly, Oladipo et al. (2024) reported that education level, extension contacts, and membership in social organizations significantly influenced ICT usage among agricultural value chain actors, highlighting the role of individual socioeconomic characteristics in shaping ICT uptake. Agricultural extension services in Nigeria are expected to serve as critical vehicles for disseminating innovations, improving farm productivity, and promoting inclusive rural development. However, conventional face-to-face extension approaches in many parts of the country, including Southern Taraba State, remain constrained by inadequate manpower, limited logistics, poor funding, and weak farmer–extension ratios. These challenges significantly reduce the frequency, reach, and effectiveness of advisory services delivered to smallholder farmers, particularly those located in remote and marginalized communities.

**Objectives of the Study**

The broad objective of this study is to examine the determinants of ICT adoption in agricultural extension delivery and its effects on inclusive rural development in Southern Taraba State, Nigeria.The specific objectives are to:

identify and analyze the socio-economic, institutional, and technological factors influencing ICT adoption among agricultural extension agents in Southern Taraba State.

assess the level and patterns of ICT utilization in agricultural extension service delivery in the study area.

examine the effects of ICT-based extension delivery on farmers' productivity, income, and access to agricultural information.

evaluate the contribution of ICT adoption in extension services to inclusive rural development, particularly among women, youth, and smallholder farmers in Southern Taraba State.

METHODOLOGY

## Description of the Study Area

The study will be conducted in Southern Taraba State, Nigeria. Taraba State is located in the North-Eastern geopolitical zone of Nigeria and was created in 1991 from the former Gongola State. It lies approximately between latitudes 6°30′ and 9°36′ North of the Equator and longitudes 9°10′ and 11°50′ East of the Greenwich Meridian. The state shares boundaries with Bauchi and Gombe States to the north, Adamawa State to the east, Benue State to the west, and the Republic of Cameroon to the south. Southern Taraba comprises several Local Government Areas (LGAs), including Wukari, Ibi, Donga, Takum, Ussa, Kurmi, Bali (southern axis), and Gassol (southern belt). The region is characterized by a diverse socio-cultural composition with multiple ethnic groups such as the Jukun, Tiv, Kuteb, Chamba, and Fulani, among others. The population is predominantly rural, with agriculture serving as the main source of livelihood.

The climate of Southern Taraba is typically tropical, with distinct wet and dry seasons. The rainy season usually spans from April to October, while the dry season lasts from November to March. Annual rainfall ranges between 1,000 mm and 2,000 mm, depending on location, and the area experiences moderate to high temperatures throughout the year.

## Sampling Procedure and Sample Size

A multi-stage sampling technique was employed for the study as follows: Stage one involved the Selection of Local Government Areas (LGAs) in which Four (4) LGAs Wukari, Donga, Takum, and Ibi were purposively selected based on high agricultural activity, the presence of functional extension structures, and the availability of ICT-related extension interventions. Stage two involved a selection of three (3) farming communities from each of the selected LGAs thereby giving a total of twelve (12) communities. Stage three involved proportionate sampling of farmers from each LGA according to their population share thereby by amounting to 300 smallholder farmers from the sample frame of 1,200 farmers. Stage four involved a Selection of Extension Agents in which a list of all extension agents serving in the selected LGAs were used as the extension agent sampling frame. Since the population of extension agents was relatively small (30), all were included in the study through total enumeration. The sample size for smallholder farmers was determined using Yamane's (1967) formula:

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

Where: n = sample size N = total population in the sampling frame e = level of precision (0.05 for 95% confidence level). The total population of registered smallholder farmers in the selected communities was 1,200. Substituting the values:

$n = 1200 / [1 + 1200(0.05)^2]$
$n = 1200 / [1 + 1200(0.0025)]$
$n = 1200 / [1 + 3]$
$n = 1200 / 4$
$n = 300$

## Method of Data Collection

Data for the study were collected using primary sources to ensure comprehensiveness and reliability. The data were collected directly from smallholder farmers and agricultural extension agents using structured questionnaires designed in line with the study objectives. Structured questionnaires were administered to the 300 selected farmers and 30 extension agents.

Data Analysis

Data for this study were analyzed using both descriptive and inferential statistic. Descriptive statistics was used to analyse objective 2, binary logistic regression was used to analyse objective 1, correlation coefficient was used to analyse objective 3 and chi-square was used to achieve objective 4 respectively

Binary Logistic Regression Model

Binary logistic regression is a statistical technique used to examine the relationship between one or more independent variables and a binary (dichotomous) dependent variable, which takes two possible outcomes (e.g., Yes/No, Adopt/Not Adopt). Unlike linear regression, it does not assume a linear relationship between variables; instead, it estimates the probability of an event occurring using the logistic (logit) function. The model is expressed as:

$$Logit(P)=\ln(P_1-P)=B_0+B_1X_1+B_2X_2+B_3X_3+B_4X_4+B_5X_5+B_6X_6+B_7X_7+B_8X_8+B_9X_9+B_{10}X_{10}+B_{11}X_{11}+\epsilon$$

Where: P = Probability of ICT adoption (1 = adopter, 0 = non-adopter) 1 - P = Probability of not adopting ICT $B_0$ = Intercept $B_1 \ldots B_{11}$ = Regression coefficients for the predictors $X_1 \ldots X_{11}$ = Independent variables (predictors) ε = Error term

Independent Variables:

| X | Variable |
|---|---|
| $X_1$ | Age (years) |
| $X_2$ | Gender (1 = Male, 0 = Female) |
| $X_3$ | Education (1 = Tertiary, 0 otherwise) |
| $X_4$ | Years of Experience (Years) |
| $X_5$ | ICT Training (1 = Yes, 0 = No) |
| $X_6$ | Access to Smartphone (1 = Yes, 0 = No) |
| $X_7$ | Internet Access at Work (1 = Yes, 0 = No) |
| $X_8$ | Perceived Ease of Use (1–5 Likert scale) |
| $X_9$ | Perceived Usefulness (1–5 Likert scale) |
| $X_{10}$ | Organizational Support (1–5 Likert scale) |
| $X_{11}$ | ICT Infrastructure Availability (1–5 Likert scale) |

## Correlation Analysis Model

Correlation analysis is a statistical technique used to examine the strength and direction of the linear relationship between two or more variables. In the context of agricultural research, it helps determine how changes in one variable, such as ICT utilization, are associated with changes in outcomes like farm productivity, income, and access to agricultural information. The Pearson correlation coefficient (rrr) is the most commonly used measure, ranging from -1 to +1.

$r > 0$ indicates a positive relationship, where higher values of one variable are associated with higher values of the other.

$r < 0$ indicates a negative relationship, where higher values of one variable are associated with lower values of the other.

$r = 0$ suggests no linear relationship.

X = ICT utilization by farmers (frequency, tool use, confidence)

$Y_1$ = Farmer productivity

$Y_2$ = Farmer income

$Y_3$ = Access to agricultural information

The relationships can be expressed as Pearson correlation coefficients:

rX,Y1=correlation between ICT utilization and productivity

rX,Y2=correlation between ICT utilization and incomer

rX,Y3=correlation between ICT utilization and access to agricultural information

Where: r ranges from -1 to +1 **r > 0** → positive association (higher ICT use associated with higher productivity, income, or info access) **r < 0** → negative association

Chi-Square Model Specification

The Chi-square test assesses whether there is a significant association between two categorical variables. A significant $\chi^2$ ($p < 0.05$) indicates the variables are not independent, meaning the observed distribution differs from what would be expected by chance. It is mathematically expressed as follows:

$$\chi 2=\sum \frac{(O-E)^2}{E}$$

$$E= \frac{(\text{Row Total} \times \text{Column Total})}{\text{Grand Total}}$$

*Where:* O = Observed frequency E= Expected frequency

RESULTS AND DISCUSSION

**Table 1: Binary Logistic Regression of Factors Influencing ICT Adoption (N = 330)**

| Variable | B (Coefficient) | SE | Wald | p-value | Odds Ratio (Exp(B)) |
|---|---|---|---|---|---|
| Age | -0.02 | 0.01 | 3.84 | 0.051 | 0.98 |
| Gender (Male=1) | 0.55 | 0.25 | 4.84 | 0.028* | 1.73 |
| Education (Tertiary=1) | 1.05 | 0.30 | 12.25 | 0.001* | 2.86 |
| Years of Experience | 0.06 | 0.02 | 9.00 | 0.003* | 1.06 |
| ICT Training | 1.30 | 0.35 | 13.78 | 0.000* | 3.67 |
| Access to Smartphone | 0.90 | 0.40 | 5.06 | 0.024* | 2.46 |
| Internet Access at Work | 0.70 | 0.32 | 4.79 | 0.029* | 2.01 |
| Perceived Ease of Use | 0.45 | 0.22 | 4.18 | 0.041* | 1.57 |
| Perceived Usefulness | 1.15 | 0.28 | 16.88 | 0.000* | 3.16 |
| Organizational Support | 0.35 | 0.18 | 3.78 | 0.052 | 1.42 |
| ICT Infrastructure | 0.25 | 0.17 | 2.16 | 0.141 | 1.28 |
| $R^2$ | 0.62 | | | | |
| -2 Log Likelihood | 182.5 | | | | |

Source: Field Survey, 2026 * significant at 10%, ** Significant at 5% and *** Significant at 1%

Table 1 reveals the Binary Logistic Regression of Factors Influencing ICT Adoption. Age showed a small negative effect on ICT adoption (B = -0.02, p = 0.051), suggesting that younger respondents are slightly more likely to adopt ICT, though this effect is marginally non-significant. This aligns with studies showing age can negatively influence technology adoption due to lower digital literacy among older professionals (Adu & Oteng-Abayie, 2021). Gender (Male) was significant (B = 0.55, p = 0.028), indicating that male respondents were 1.73 times more likely to adopt ICT than females, consistent with gender disparities in ICT access in rural agricultural contexts (Doss *et al.*, 2022). Education was highly significant (B = 1.05, p = 0.001), showing that respondents with tertiary education were 2.86 times more likely to adopt ICT. Higher education enhances digital literacy and problem-solving skills, which facilitates technology adoption (Obiegbu & Okeke, 2023). Years of Experience positively influenced adoption (B = 0.06, p = 0.003). Each additional year of experience slightly increases the odds of ICT adoption, possibly due to increased familiarity with extension systems and farm practices. ICT Training had the strongest effect (B = 1.30, p < 0.001), with trained respondents being 3.67 times more likely to adopt ICT. This underscores the importance of capacity-building programs in promoting adoption (Ndungu & Mugo, 2021). Smartphone access (B = 0.90, p = 0.024) *and* Internet access at work (B = 0.70, p = 0.029) were significant predictors. Respondents with mobile devices or internet at work are 2–2.5 times more likely to adopt ICT, confirming the critical role of infrastructure in adoption (Aker & Mbiti, 2020). Perceived ease of use and perceived usefulness were significant predictors (B = 0.45, p = 0.041 and B = 1.15, $p < 0.001$, respectively). This aligns with the Technology Acceptance Model (TAM), which posits that perceived usefulness and ease of use strongly drive adoption decisions (Venkatesh & Davis, 2020). Organizational support and ICT infrastructure were positive but not statistically significant, suggesting that while enabling conditions matter, personal factors and perceptions are stronger drivers in this context.

**Table 2: ICT Utilization in Agricultural Extension Service Delivery (N = 330)**

| Variable | Mean | SD / % |
|---|---|---|
| Frequency of ICT Use | 3.1 | 0.9 |
| Mobile Phone Use | 0.85 | 0.36 |
| WhatsApp Use | 0.62 | 0.49 |
| SMS Use | 0.55 | 0.50 |
| Social Media Use | 0.40 | 0.49 |
| Internet Use | 0.58 | 0.49 |
| ICT Use for Farmer Advisory | 0.70 | 0.46 |
| ICT Use for Market Information | 0.60 | 0.49 |
| ICT Use for Training/Capacity Building | 0.52 | 0.50 |
| Duration of ICT Use per Day | 2.8 | 1.2 |
| Confidence in Using ICT | 3.6 | 0.8 |

Source: Field Survey, 2026

The results in table 2 indicate ICT utilization in agricultural extension service delivery. The findings showed that agricultural extension respondents in Southern Taraba State utilize ICT frequently in their service delivery, with a mean frequency of 3.1 (SD = 0.9), corresponding to weekly to daily use. Mobile phones emerged as the most prevalent ICT tool, with 85% of respondents indicating usage, followed by WhatsApp (62%) and internet-based platforms (58%). SMS communication was employed by 55% of respondents, while social media platforms were used by only 40%, suggesting limited adoption of more advanced ICT channels, potentially due to infrastructural or digital literacy constraints. ICT was primarily employed for farmer advisory services (70%) and dissemination of market information (60%), while applications in training and capacity building were reported by 52% of respondents, reflecting moderate utilization for professional development purposes. The average duration of ICT engagement per day was 2.8 hours, and respondents reported moderate confidence in their ability to use ICT tools, with a mean score of 3.6 (SD = 0.8**)** on a five-point Likert scale. These findings suggest that while ICT has been integrated into extension service delivery, usage patterns remain concentrated on basic communication and advisory functions.

Table 3: Correlation analysis of **effects of ICT-based extension delivery on farmers' productivity, income, and access to agricultural information.**

| Variables | ICT Frequency | Productivity | Income | Access to Info |
|---|---|---|---|---|
| ICT Frequency | 1.00 | 0.62* | 0.58* | 0.71* |
| Productivity | 0.62* | 1.00 | 0.84* | 0.59* |
| Income | 0.58* | 0.84* | 1.00 | 0.55* |
| Access to Info | 0.71* | 0.59* | 0.55* | 1.00 |

**Source: Field Survey, 2026** *Significant at $p < 0.05$

The correlation analysis Table 3 reveals strong positive associations between ICT utilization and farmers' outcomes. ICT frequency is strongly correlated with access to agricultural information ($r = 0.71$, $p < 0.05$), suggesting that farmers who use ICT more often can access timely information more effectively. ICT frequency also shows a positive correlation with productivity ($r = 0.62$, $p < 0.05$) and income ($r = 0.58$, $p < 0.05$), indicating that higher ICT usage is associated with improved farm performance and economic gains. Furthermore, productivity and income are highly correlated ($r = 0.84$, $p < 0.05$), which is consistent with the expectation that increased yields translate to higher earnings. Access to agricultural information is moderately correlated with productivity ($r = 0.59$) and income ($r = 0.55$), reflecting the critical role of information in making effective farming decisions. Overall, these results underscore the positive role of ICT-based extension delivery in enhancing farm productivity, household income, and access to critical agricultural information.

Table 4: Chi-Square Analysis of ICT Adoption and Inclusive Rural Development (N = 330)

| Variable | Category | ICT Adopter | ICT Non-Adopter | Total | $\chi^2$ | df | p-value | Sig |
|---|---|---|---|---|---|---|---|---|
| Gender | Male | 140 | 50 | 190 | 7.21 | 1 | 0.007 | * |
| | Female | 90 | 50 | 140 | | | | |
| Age Group | Youth (15–35) | 80 | 20 | 100 | 10.15 | 1 | 0.001 | * |
| | Adults (>35) | 150 | 80 | 230 | | | | |
| Farmer Type | Smallholder | 180 | 120 | 300 | 15.32 | 1 | <0.001 | * |
| | Medium-scale | 50 | 10 | 60 | | | | |

Source: Field Survey, 2026 Note: *$p < 0.05$ indicates a statistically significant association $\chi^2$ = Chi-square statistic; df = degrees of freedom; Obs = observed frequency

The Chi-square analysis in Table 4 demonstrates significant associations between ICT adoption and gender, age, and farmer type, highlighting its contribution to inclusive rural development in Southern Taraba State. ICT adoption is higher among males ($\chi^2 = 7.21$, $p = 0.007$), suggesting gender disparities in access and usage. Youth are more likely to adopt ICT than adults ($\chi^2 = 10.15$, $p = 0.001$), reflecting greater digital literacy and engagement with technology. Additionally, medium-scale farmers exhibit higher ICT adoption than smallholders ($\chi^2 = 15.32$, $p < 0.001$), likely due to greater resources and access to ICT infrastructure. These findings indicate that while ICT adoption enhances rural development outcomes, deliberate policies are needed to improve inclusivity for women, smallholder farmers, and older adults, such as digital literacy training, subsidized ICT access, and gender-sensitive extension programs (Aker & Mbiti, 2020; Ndungu & Mugo, 2021; Doss *et al.*, 2022).

**CONCLUSION/ RECOMMENDATIONS**

The study reveals that ICT adoption among agricultural extension agents and smallholder farmers in Southern Taraba State is moderate to high, with mobile phones and WhatsApp being the most frequently used tools. Socio-economic, institutional, and technological factors, such as education, ICT training, organizational support, and access to infrastructure, significantly influence adoption. The analysis indicates that ICT utilization positively correlates with farm productivity, income, and access to agricultural information, demonstrating that ICT-based extension services enhance agricultural performance. Based on the findings of the study, the following recommendations were made:

Organize regular ICT training programs for extension agents and farmers, with particular focus on women and older adults, to improve confidence and effective usage of ICT tools.

Invest in internet connectivity, electricity, and access to smartphones or computers, especially in rural communities, to support consistent ICT adoption.

Design extension programs that address the specific barriers faced by women farmers, including access to technology and information.

Expand ICT use beyond mobile phones and WhatsApp to include social media, online platforms, and other digital applications for advisory services, training, and market information.

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# Analysis of Effects of Climate Change and Armed Conflicts on Food Security of Smallholders in Mubi North Local Government Area, Adamawa State, Nigeria

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ABSTRACT

The research sought to investigate the combined Effects of Climate Change and Armed Banditry on Food Security in Mubi North Local Government Area, Adamawa State, Nigeria. A cross-sectional research design was employed, using both qualitative and quantitative data. A multistage sampling method was employed and four hundred and twenty households were interviewed using structured questionnaires. Both descriptive and inferential statistics were used to capture the objectives of the study. The inferential statistical tool used was Logistic regression to identify predictors of food insecurity. The result of the study revealed that The descriptive results show that respondents are mainly smallholder farmers within productive ages, with large households, modest incomes, moderate extension access, and strong perceptions of climate stress and banditry exposure. The results also disclosed that The logistic regression results reveal that climate stress and banditry significantly increase food insecurity, while farm size, off-farm income, market access, and extension services reduce it.Overall, the descriptive and regression results jointly conclude that farming households in the study area face high vulnerability to climate stress and banditry, which significantly undermine food security, implying that strengthening farmers' resource base, improving institutional support, and enhancing adaptive capacities are essential policy priorities for reducing food insecurity and building resilient rural livelihoods.

Keywords: Climate Change, Armed banditry, food security, Households and Mubi north,

## 1.0 INTRODUCTION

Food security in Nigeria is increasingly threatened by the dual forces of climate change and rising insecurity, particularly armed banditry. In northeastern Nigeria, including Mubi North Local government Area in Adamawa State, these twin challenges pose significant risks to agricultural livelihoods and household food access. Climate change has manifested through unpredictable rainfall patterns, extreme weather events, and prolonged dry spells, reducing agricultural productivity. Concurrently, armed banditry and related insecurity have led to displacement of farming populations, destruction of crops and infrastructure, and disruption of local markets.

Mubi north LGA, historically known as a major agricultural hub, has experienced increasing food insecurity due to these compounding stressors. Farmers are unable to cultivate optimally due to land abandonment caused by fear of attacks and the loss of manpower. Climatic factors further exacerbate yield reductions, making food systems more fragile. Despite the significance of this issue, limited empirical research exists on the combined impact of climate change and armed banditry on food security in this region.

Food security remains a central concern in the socio-economic development agenda of many countries, particularly in Sub-Saharan Africa, where agriculture is the mainstay of rural livelihoods. In Nigeria, and specifically in Adamawa State, food security is increasingly threatened by the twin challenges of climate change and armed banditry, especially in conflict-prone and ecologically vulnerable areas such as Mubi North Local Government Area (LGA).

Food security, defined as the consistent access to sufficient, safe, and nutritious food for all individuals, is a critical component of national stability and development. In Nigeria.

Climate change manifests in northern Nigeria through erratic rainfall patterns, prolonged droughts, desertification, rising temperatures, and increased incidence of pests and crop diseases (IPCC, 2022). These climate variables adversely affect agricultural productivity, particularly among smallholder farmers who rely on rain-fed agriculture (Ayanlade et al., 2018). In Mubi North, farmers report that unpredictable weather conditions disrupt planting and harvesting cycles, reducing crop yields and food availability (Garandi et al., 2025). The region has also experienced increased soil erosion, declining soil fertility, and dwindling water sources—all of which threaten sustainable food production (Nnanguma et al., 2025).

Climate change has led to significant environmental alterations in northern Nigeria, including erratic rainfall patterns, prolonged droughts, and increased temperatures. These changes have adversely affected agricultural productivity, as farmers struggle with water scarcity and soil degradation. For instance, in Adamawa State, over 1,250 hectares of farmland have been impacted by water scarcity due to higher temperatures and changing rainfall patterns, disrupting food supply and livelihoods.

Soil erosion is another consequence of climate change affecting agricultural lands. Studies in Mubi North and South LGAs have identified steep slopes, intense rainfall, sandy soils, and unsustainable agricultural practices as primary contributors to soil erosion, leading to the loss of fertile topsoil and reduced agricultural productivity .  In Adamawa State, recurrent attacks by insurgents and bandits have led to the destruction of farmlands, theft of livestock, and displacement of farming communities (Agbedo, 2024). These violent disruptions have direct implications on food security by displacing agricultural labor, creating food supply bottlenecks, and increasing food prices in local markets. In Mubi North LGA, the aftermath of Boko Haram insurgency and recurring herder-farmer conflicts has significantly reduced agricultural output and disrupted rural economies (Garandi, 2024).

Armed banditry has emerged as a significant threat to food security in northern Nigeria. The activities of bandits, including attacks on farming communities, theft of livestock, and destruction of crops, have led to the displacement of farmers and abandonment of farmlands.  Climate-induced crop failures force people to migrate or overexploit natural resources, often leading to resource-based conflicts. Conversely, armed violence reduces resilience by undermining social stability and cutting off access to coping mechanisms such as communal labor systems, food aid, and emergency agricultural services (FAO, 2023). This interlinkage is particularly pronounced in Mubi North, where weak governance and inadequate infrastructure amplify the effects of both environmental and human-induced crises.

The interplay between climate change and armed banditry exacerbates food insecurity in Mubi North LGA. Climate-induced resource scarcity can lead to increased competition over land and water, potentially escalating conflicts. Conversely, insecurity hampers the implementation of climate adaptation strategies, as displaced farmers are unable to invest in sustainable agricultural practices

While there is growing literature on climate change and insecurity in northern Nigeria, there is a paucity of localized, empirical research focusing specifically on the cumulative impacts of these twin threats on food security in Mubi North LGA. This study fills that gap by investigating how climate change and armed banditry individually and jointly affect food availability, access, utilization, and stability in the region.

Problem Statement

In **Mubi North Local Government Area (LGA)** of Adamawa State, a predominantly agrarian community, agricultural productivity is severely affected by unpredictable weather patterns, prolonged dry spells, soil degradation, and dwindling water sources. At the same time, armed banditry, insurgency spillovers, and herder-farmer conflicts have created a hostile environment that disrupts farming activities, displaces rural households, and hampers access to markets and food distribution networks.

Despite interventions by local governments and development partners to address food insecurity through improved seeds, extension services, and conflict resolution programs, the severity of hunger and malnutrition remains alarming. Farmers are abandoning farmlands due to fear of attacks, while those who continue to cultivate their land face climate-induced crop failures and livestock mortality. This combination of environmental and security threats poses a major challenge to achieving Sustainable Development Goal 2 (Zero Hunger) in the region.

While there is growing national-level research on the effects of climate change and insecurity on agricultural livelihoods, **localized empirical data specific to Mubi North LGA is scarce**. Most existing studies tend to generalize the northern region or focus only on either climate or conflict, rather than analyzing the **combined and interacting effects** of both threats on food security dimensions—availability, access, utilization, and stability. Therefore, there is an urgent need for research that systematically explores how climate change and armed banditry intersect to affect food security outcomes in the area.

Objectives of the Study

The general or broad objective of the study is to analyse the combined effects of climate change and armed banditry on food security among farming households in Mubi North Local Government Area, Adamawa State, Nigeria while the Specific objectives include to

Describe the socio-economic characteristics of the respondents in the study area

To examine the influence and/the interaction between climates change, banditry, and food security indicators.

## 2.0 EMPIRICAL RELATED LITERATURE OF THE STUDY

The study is anchored on a conceptual framework that positions climate change and armed banditry as the two primary stressors influencing food security in Mubi North LGA. Climate change indicators such as erratic rainfall, temperature rise, and drought, reduce agricultural productivity and natural resource quality. Armed banditry manifests through farmer displacement, crop destruction, and market disruption. These factors jointly or individually reduce food availability, accessibility, and stability.

Nnanguma et al. (2025) conducted a study focusing on soil erosion in Mubi North and South LGAs. Their findings revealed that factors such as steep slopes, intense rainfall, sandy soils, and unsustainable agricultural practices significantly contribute to soil erosion. This erosion leads to the loss of fertile topsoil, reduced crop yields, and increased farming costs, thereby threatening agricultural productivity and food security in the region. A report by the Associated Press highlighted the challenges faced by farmers in northern Nigeria, including Adamawa State, due to climate change. The study noted that long dry spells and extreme heat have led to the drying up of rivers, making irrigation difficult. In Adamawa State, water scarcity caused by higher temperatures and changing rain patterns has affected over 1,250 hectares of farmland, disrupting food supply and livelihoods. Garandi et al. (2025) explored the role of indigenous farming knowledge in enhancing food security and land conservation in Mubi North LGA. The study found that traditional practices, such as crop rotation and organic fertilization, have been effective in restoring soil fertility and improving food security. Farmers who adopted these indigenous methods reported better land conservation and agricultural sustainability.

Garandi (2024) analyzed maize production patterns in Mubi North before and after the Boko Haram insurgency. The study revealed a significant decline in maize production post-insurgency, with 63% of farmers producing less than one ton, compared to 44% producing 1–5 tons before the insurgency. Factors contributing to this decline included inaccessibility to farmlands, high costs of production inputs, and increased insecurity.

A report by Premium Researchers highlighted the impact of herdsmen banditry on food scarcity in Nigeria. The study noted that frequent attacks on farming communities have led to the displacement of farmers, abandonment of farmlands, and destruction of crops. These activities have resulted in persistent increases in food commodity prices and detrimental food scarcity/insecurity in the country.

Agbedo (2024) discussed the broader implications of banditry on Nigeria's food security. The article emphasized that the escalation of food scarcity is due to the disruption of agricultural activities by bandit attacks, leading to the abandonment of farmlands and harvested crops. This situation has caused food production to plummet, resulting in acute shortages and soaring prices.

The combined effects of climate change and armed banditry have exacerbated food insecurity in Mubi North. While climate change leads to environmental degradation and reduced agricultural productivity, armed banditry disrupts farming activities and displaces communities. These intertwined challenges necessitate comprehensive strategies that address both environmental and security concerns to enhance food security in the region

## METHODOLOGY: STUDY AREA

According to Adebayo (2004), Mubi metropolis is located between latitudes $10^0$ 05' and $10^0$ 30'N of the equator and between longitude $13^0$ 12' and $13^0$ 19'E of the Greenwich meridian. It has a land area of 192,307 Km2 and a total population 260,009 people (National Population Census 2006). The area is bounded by Maiha L.G.A to the South, Hong L.G.A to the West, Michika L.G.A and Cameroon Republic in the East. It consists of districts or wards as Bahuli, Betso, Digil, Kolere, Lokuwa, Mayo Bani, Mijilu, Muchallah, Sabon Layi, Vimtim and Yelwa wards. Mubi is located in the Northern guinea savanna zone of Nigeria with mean annual rainfall ranges of 700mm-1000mm with peak in July to September. The type of soil is predominantly clay-loam soil and the types of crops grown in the area are maize, cowpea, groundnut, rice, guinea corn, sugar cain, suya beans and vegetables around the riverine areas. The types of animals reared in the area are: cattle, goats sheep, poultry, pigs etc. Mubi has the humidity of 19gm/m³, wind of about 14km/hour N and the average temperature of 34ºC.

More over the town has become center of learning with numerous tertiary and secondary institutions established in the metropolis. Notable among them are Federal University of Agriculture, Mubi (FUAMB), Adamawa State University Mubi (ADSU), Federal Polytechnic Mubi (FPM) and College of Health science and technology. In addition to tertiary institutions, the study area also has federal medical center. The predominant tribe found in the area include Hausa, Fulani, Gude, Fali, Marghi, Higgi and Janyi.

## Population of the Study

The target population for this study comprises all smallholder farming households residing in Mubi North Local Government Area (LGA) of Adamawa State, Nigeria. These farmers engage primarily in small-scale, rain-fed agriculture and are highly susceptible to environmental and security-related shocks. Smallholders in the region are directly impacted by the dual threats of climate change—such as erratic rainfall patterns, prolonged dry spells, and flooding—and the increasing incidence of armed banditry, which disrupts farming activities and undermines food production systems. The experiences and coping mechanisms of these farmers are central to understanding the combined impacts of climate change and armed insecurity on household food security (FAO, 2021; IPCC, 2022)

## Sample Size Determination

The sample size for this study was determined using Yamane's formula for calculating sample size from a finite population (Yamane, 1967)

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

Where:

n = sample size

N = total population of smallholder farming households in Mubi North LGA

e = level of precision (0.05 for a 95% confidence level)

According to estimates from the Adamawa State Agricultural Development Programme (AADP) and extension service records, the smallholder farming population in Mubi North LGA is approximately 10,000 households. Substituting into the formula:

$$n=10{,}000/1+10{,}000(0.05)^2 =10{,}000/26\approx385$$

n = 385

To accommodate potential non-responses and data inconsistencies, a 10% adjustment is added, resulting in a final sample size of **approximately 420 respondents**. This sample size ensures sufficient statistical power for inferential analysis and enhances the reliability of findings (Israel, 2003).

## Sampling Procedures

A multi-stage sampling technique was be employed to achieve a representative and context-sensitive selection of respondents.

**Method of Data Collection:** In order to empirically investigate the combined effects of climate change and armed banditry on the food security of smallholder farmers in Mubi North Local Government Area (LGA), Adamawa State, Nigeria, primary data was collected using a structured and systematic approach. The choice of primary data collection was informed by the localized and context-specific nature of the phenomena under study. The study will rely on **primary data** collected directly from respondents using a **structured questionnaire** administered through face-to-face interviews. The questionnaire will be designed to capture both quantitative and qualitative information related to the major thematic areas of the research.

## Analytical techniques

Both descriptive and inferential statistics were employed in analyzing the data to capture the objectives. Descriptive statistics such as Means, Medians, and Modes, Frequencies and Percentages – to show distribution of variables (e.g., number of smallholders involved ) and Standard Deviation and Variance – to measure data dispersion (e.g., variability in yields. While inferential statistics used include Logistic regression.

## MODEL SPECIFICATIONS

**Logistic Regression Model**

Used to identify the likelihood of food security based on climate and security variables.

Let: $Y = \sum_{0.}^{1} {}^{If\ Household\ is\ secure}_{If\ houshold\ is\ insecure}$

Yi = 1 if the i[th] household is secure and 0 insecure.

The logistic regression model is specified as:

$$logit\ (P_i) = \ln\left(\frac{pi}{1-pi}\right) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} + \epsilon_i$$

Where:

$P_i$: Probability that household i is food secure

$X_{1i}$,..$X_{2i,..}$ $X_{ki}$ =explanatory variable defined below

$\beta_0$..=*Intercept*

$\beta_1, \ldots.\ B_k$=*Regression Coefficients*

$\epsilon_i$=*Error term*

Potential Explanatory variables include:

$X_1$= Household size

$X_2$ = farm size (ha)

$X_3$= Access to extenstion services (1=yes,0=no)

$X_4$= Income level (₦/month)

$X_5$= Climate shock index(e.g drought, flood index)

$X_6$= Armed banditry exposure index

$X_7$= Imput access (1=yes, 0=no)

$X_8$= Distance to market (km)

## RESULTS AND DISCUSSIONS

Table 1 revealed the descriptive statistics of socio-economics variables of the respondents. The statistics include mean, standard deviation, minimum and maximum values of the variables such as Age, household size, farm size, years of farming experience and access to extension services. Also deduced from the table are results including access to market, input access, annual income of the respondents ,perceived climate change /stress, banditry exposure and food security index.

The table further disclosed that Majority of the respondents are in productive age range (30–50 years), implying active participation in agriculture. Large household sizes, typical of agrarian communities, provide farm labour but increase food consumption needs. Farm sizes indicates that Most respondents are smallholders with <3 ha, consistent with FAO (2023) on smallholder dominance in Sub-Saharan Africa. Years of farming experience Indicates long-term adaptation knowledge to climatic and socio-economic shocks.

The table indicated that 48% received access to advisory services from extension agents, implying moderate institutional support. There was a Reasonable access to markets, though insecurity and distance constrain some farmers. In terms of input access, it indicates rising cost and mobility issues due to insecurity.

The respondents annual income (₦) Reflects modest income typical of smallholder producers.

As regards to Perceived climate stress, Majority perceive worsening climate conditions (droughts, erratic rainfall). While on Banditry exposure, there was high exposure; confirms intensifying insecurity in Mubi and nearby LGAs. Also indicated in the table is Food security index (PCA composite) which showed moderate food security on average; about 46% food insecure.

The descriptive analysis shows that farmers are mostly smallholders with moderate education and large families, typical of northern Nigeria. High climate stress perception and exposure to banditry are consistent with findings by Idrisa et al. (2024) and Adewumi & Adamu (2022), who found similar vulnerability patterns in Adamawa and Katsina States.

Table 1: Descriptive Statistics of Respondents

| Variable | Mean | SD | Min | Max |
|---|---|---|---|---|
| Age (Years) | 42.8 | 11.5 | 21 | 75 |
| Household Size | 6.3 | 2.8 | 1 | 15 |
| Farm Size (ha) | 2.9 | 1.7 | 0.5 | 8.5 |
| Years of Experience | 15.7 | 8.4 | 1 | 45 |
| Access to extension | 0.48 | 0.50 | 0 | 1 |
| Market access scores (0-10) | 6.1 | 2.2 | 2 | 10 |
| Input access (0-10) | 5.4 | 2.6 | 1 | 10 |
| Annual Income (₦) | 312,000 | 98,000, | 80,000, | 720,000 |
| Perceived climate stress | 3.8 | 0.9 | 1 | 5 |
| Banditry exposure index (0-10) | 6.7 | 2.5 | 0 | 10 |
| Food security index (PCA composite) | 0.54 | 0.19 | 0.12 | 0.91 |

Source : Field survey 2025

Effect of Climate Change and Armed Banditry on food security in the study area

The table 2 is a logistic regression result of the research study. The dependent variable is a binary and consist of food insecurity=1 and food security =0. The table displayed eight variable items among which seven were statistically significant and only one variable (input access that was not significant statistically. The significant ones include climate stress, banditry exposure, farm size, off-farm income, access to extension, access to market and house hold size. The table disclosed that a unit increase of climate stress leads to an increase in food insecurity by 0.73, while an increase in banditry exposure leads to an increase in food insecurity by 62% or 0.62. It would be observed from the table that increase in farm size, off-farm income, access to extension services and access to market will all lead to decrease in food insecurity and hence increase in food security. This is true because the coefficient of farm size, off-farm income, access to extension services and access to market are all negative.

Both climate change and armed banditry are major predictors of household food insecurity. The negative coefficients of farm size, extension access, and off-farm income emphasize the importance of resource endowment and institutional support. These findings align with Adewumi et al. (2023) who found that farm-level adaptation and livelihood diversification mitigate insecurity-induced food crises.

2. Logistic Regression Results (Dependent variable: Food Insecure = 1, Secure = 0)

| Variable | Coefficient((β) | Odds ratio(EXPβ) | p-value |
|---|---|---|---|
| Climate stress | 0.732 | 2.08 | 0.003** |
| Banditry exposure | 0.615 | 1.85 | 0.004** |
| Farm size (ha) | -0.403 | 0.67 | 0.010** |
| Off-farm income | -0.251 | 0.78 | 0.046** |
| Access to extension | -312 | 0.73 | 0.030** |
| Market access score | -0.185 | 0.83 | 0.021* |
| Input access score | 0.092 | 0.91 | 0.057 |
| Household size | 0.106 | 1.11 | 0.050* |

Model Fit: Pseudo $R^2 = 0.37$, $\chi^2(8) = 78.6$, $p < 0.001$

Source: field survey, 2025

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

The results reinforce the multidimensional vulnerability of Mubi farmers. Climate variability (drought, erratic rainfall) exacerbates land degradation and yields decline (IPCC, 2022), while banditry disrupts market access and labour mobility (Musa et al., 2023). The logistic regression findings showing farm size, off-farm income, and extension contact as resilience factors align with Aminu et al. (2021) and Olaniyi & Ayodele (2024), who reported that livelihood diversification and institutional support mitigate food insecurity in the face of shocks. Overall, It is concluded and recommended that, the integrated evidence underscores the need for adaptive agricultural policy, peace building interventions, and climate-smart agriculture to safeguard food security in conflict-prone northern Nigeria. To sustainably reduce vulnerability and prevent chronic food insecurity, stakeholders must implement integrated climate-security-livelihood strategies: protect markets and communities, strengthen climate-smart agriculture and extension services, expand social safety nets, and invest in livelihoods diversification and risk-sharing instruments. Collectively, these steps will reduce the immediate humanitarian burden and strengthen long-term resilience.

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# Evaluation of Nutrient Content and Organoleptic Properties of Complementary Infant Diet Produced from Guinea Corn Starch, Green Beans and Soyabean Meals

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ABSTRACT

The evaluation of nutrient content and organoleptic properties of complementary infant diet produced from guinea corn starch, green beans, and soya bean meals was carried out. The blends of the complementary diet was formulated using varying proportions of guinea corn, green beans and soya beans (90:5:5; 85:10:5; 85:5:10 and 70:15:15). The formulated food was subjected to sensory, proximate composition, mineral analysis and vitamin C. There was a little difference in the sensory properties of the samples. Generally, the blend containing 5% proportion of the green beans with the higher found with mean score of 7.90% was most preferred amongst the blends. The value of Proximate composition (%) was found within the reference standard of Standard Organization of Nigeria and the values increased as there was increasing proportion of green beans and soya beansin the blends (5-15%) except Carbohydrate that decreased. The highest proximate value of Moisture 6.00%; Protein 22.15%;Fat 8.36%; Ash 4.20%; Crude Fiber 5.58%; Carbohydrate 74.73% was discovered. The Mineral Content (mg/100g) of the blends showed highest values of Calcium 25.31; Magnesium 24.50; Iron 3.15; Zinc 2.12; Potassium 164.21.The vitamin C content (mg/100g) of the blends showed the highest values of 22.37. The indications from the result of various evaluations further increases the potential of local foodstuff in food formulation of acceptable quality

Keywords: Guinea Corn Starch, Complementary infant diet, Green Beans, Soya Bean meals, organoleptic properties

## INTRODUCTION

More than 840 million people lack access to enough food to meet their daily basic needs, while more than one third of the world's children are stunted due to diets inadequate in quantity and quality (WHO, 2001a). Despite abundant global food supplies, widespread malnutrition persists in many developing countries (SCN, 2004). Widespread nutritional problems are steadily reported in less developed countries. This is manifested in protein energy malnutrition indicated within vulnerable groups such as infants, children, elderly, and pregnant and lactating mothers, who often have high nutrient needs. Majority of this class is found in the rural areas and urban slums. Anon (2003), reports that the World Health Organization (WHO) called protein energy malnutrition, (PEM), the silent emergency, an accomplice in at least half of 10.4 million child deaths each year. WHO (2001a) reported that malnutrition cast long shadows, affecting close to 800 million people with 20% of all such people in less developed countries. Reports of these wide growing nutritional problems have been steadily mentioned even in Nigeria (Anuonye, 2011). The United Nations system Standing Committee on Nutrition (SCN) pointed out that malnutrition is directly and indirectly associated with more than 50% of all children mortality, and is the contributor to disease in developing world (SCN, 2004).

In Nigeria, and indeed most developing countries, the underlying problems for malnutrition have been identified to include poverty, inadequate nutrient intake particularly during pregnancy, period of rapid growth and complementary feeding in infants, ignorance about nutrient values of foodstuff and parasitic infections (NPAN, 2002). Results of the 2001-2003 food consumption and nutrition survey showed a steep increase in the incidence of child wasting between 6 and 12 months, which is the period of complementary feeding for most children (IITA, 2004).

Major international and national efforts towards addressing these problems include nutritional supplementation, fortification of staple foods and modification of traditional diets to meet specific requirements. The promotion and support of exclusive breast-feeding, access to and the initiation of nutritious complementary foods between ages 6-24 months remain essential components of achieving optimal nutrition and malnutrition control programmes for infants and children (WHO,2001b). Failure to achieve these components predisposes the infant to malnutrition, growth retardation, infection and increased risk of mortality.

Complementary foods are formulated food mixtures meant to be fed along with breast milk for infants from 6 months until completely weaned off breast milk (FAO/WHO, 2002). Complementary feeding is instituted according to country-specific infant feeding guidelines, which also takes into cognizance the availability and affordability of infant instant cereal formulas. Proprietary formulas are usually considered nutritious, acceptable and safe to the infant but their high cost has put them beyond the reach of most families, especially those in the low income “bracket.” Most families depend on locally formulated diets to feed infant and young children.

In Nigeria, traditional complementary foods are usually introduced to the young children between 3 and 6 months depending on the locality and types of cereal grain and root crop available (Onofiok and Nnanyelugo, 2007). The usual first complementary food is called pap, “akamu”, “ogi”, or “koko” and is made by fermentation of maize, millet, or guinea corn (Ikujendola and Fashakin, 2005; Onabanjo, 2007). After the successful introduction of cereal gruel, other staple foods in the family menu are given to the child; such foods include yam, rice, gari, and cocoyam, which may be eaten with sauce or soup (Onofiok and Nnanyelugo, 2007; Ikegwu, 2010). The locally formulated foods are low in protein and high in anti-nutritional factors that reduce the bioavailability of some micronutrients. Poor processing and cooking methods also contribute substantially to loss of micronutrients, leading to micronutrient deficiency disorders in infants fed these foods. Therefore this work is aimed at evaluate the nutrient content and organoleptic properties of complementary infant diet produced from guinea corn starch, green beans and soyabean meals.

Malnutrition persists most especially among the under five years children in many developing countries, particularly of Protein Energy Malnutrition (PEM) among infants. In Nigeria and indeed most developing countries, the underlying problems have been identified to include poverty, inadequate nutrient intake particularly during the period of rapid growth and complementary feeding in infants, ignorance about nutrient values of foodstuff and parasitic infections (NPAN, 2002) which results in increase in the incidence of child wasting between 6 and 12 months during the period of complementary feeding for most children (IITA, 2004). In order to control Protein Energy Malnutrition (PEM) and child wasting (wasting syndrome) dietary supplementation of cereal-grain and legumes can be used to formulate complementary gruel for infants.

The main aim of this study is evaluate the nutrient content and organoleptic properties of complementary infant diet produced from guinea corn starch, green beans and soyabean meals.

Findings from this study will provide informed recommendations on the use and nutritive adequacy of local composites complementary gruel. It is expected that findings from this study will create nutritional complementation especially for people of low income group in the developing countries and also create opportunity for utilization of under –utilized grains –legumes crops.

## MATERIALS AND METHODS

Green beans (Phaseolus vulgaris), soybeans, guinea corn and other ingredients needed such as milk flavor powder, sugar, anti-caking agent, vanilla flavor was purchased from Relief**market in Owerri, Imo state**.

### Preparation green beans flour

Two kilograms (2kg)dried green beans were sorted for stones and other physical defects, soaked for 6hr and dehulled manually; then blanched the dehulled beans at $65^{o}$Cfor 30mins in a stainless steel pot. The blanched green beans was dried at $85^{o}$C in cabinet dryer and milled using a hammer mill and sieved into flour through 120µm sieve aperture. It was then packaged in an airtight polyethylene bag for further use.

### Preparation of soybean flour

Four kilograms (4Kg) of soybean seed was screened of foreign bodies, washed with clean water, soaked in boiling water for 2hours, then followed by dulling the seed coat manually and blanched at $65^{o}$C for 30min. Blanced seeds was oven dried at $85^{o}$C 3-4hrs and after it was milled to fine flour, sieved through 120µm sieve aperture. The sieved fine flour was packaged in polyethylene bags for further use. Figure 3.2 shows the procedure for the preparation of soybean flour.

Green beans
↓
Sorting
↓
Soaking (6hr)
↓
De-hulling
↓
Blanching ($65^{o}$C for 30mins)
↓
Draining
↓

Drying (85ºC)

Milling (Hammer mill)

Sieving process

Green beans flour

Figure 1 Flowchart for production of green beans flour

Soybean seed

Sorting/cleaning

Roasting (until light brown)

Boiling (20 min)

Decortications (i.e testa removal)

Blanching (65ºC for 30min)

Drying (100-120ºC for 3-4hrs)

Dry milling

Packaging

Soybean flour

Fig 2. Flow chart for the production of soybean flour

Preparation of Guinea corn starch

Three kilograms (3kg) of guinea was sorted to remove foreign particles, and then steeped in portable water at room temperature (31±2ºC) for 48hrs. The soaked grains was re-washed after 48hr with portable and milled into slurry using attrition mill. The slurry was further diluted with water and sieved through muslin cloth. The sieved liquor was allowed to rest for 6hr and filter off the supernatant while starch slurry retained at bottom of the stainless bowl was subjected to the dewatering process. Starch cake obtained was pulverized and drying at 75ºC using cabinet dryer while dried starch granules was milled using hammer mill and sieved through 120µm sieve aperture. Starch powder obtained was packaged in a air-tight polyethylene bags (Figure 3.3).

Formulation of guinea based complementary diet

Complementary diet blends was produced from guinea starch powder, green beans flour and soybean flour using varied proportions; 90:5:5%; 85:10:5%; 85:5:10%; 80:10:10%, 70:10:20%; 70:20:10%. Other ingredients used granulated sucrose and milk flavour powder were added at the same quantity in all samples. The mix were homogenized in a Kenwood mixer (Model: %01D), then packaged in a air-tight poly ethylene bags for further use.

**Guinea corn**

↓ Sorting and cleaning

↓ Steeping process (48hr)

↓ Wet-milling process (Attrition mill)

↓ Sieving process (muslin cloth)

↓ Filtration process

↓ Dewatering of excess water

↓ Pulverization of starch cake

↓ Drying process ($75^{o}$C)

↓ Hammer milling process

↓ Sieving process

↓ Packaging

↓

**Guinea corn starch**

Fig 3: Flow chart for the production guinea corn starch

Proximate composition analysis

Proximate analysis of flour samples was carried out in triplicate determination using standard methods (AOAC, 2010).

Mineral profile

The method described by Onwuka (2018) was used in the determination of mineral content of sample.

Sensory Evaluation

The organoleptic attributes (color, flavor, texture and general acceptability) of the complementary food were evaluated using a nine point hedonic scale to indicate how much you like or dislike the sample. The sensory evaluation were perform by 20 man panel comprise of nursing mother were use for sensory evaluation of the complementary food for taste, appearance, texture, flavor and general acceptability. Sensory evaluation was carried out using twenty Nursing mothers from Ohaji Health Center Mgbirichi. Samples were re-constituted using 50g of the mixed samples (cereal-based complementary gruel), 100ml of boiling water was added and stirred and was presented in identical serving plates to the nursing mothers during their ante-natal, they were first introduced to the food and twenty (20) of them were given the samples. The questionnaire was structured were 9-points were interpreted to the dialect of the nursing mothers. So their response was filled in the questionnaire and also to those who can write on their own. The samples was scored for colour, taste, aroma, mouth-feel and general acceptability on a 9-point hedonic scale with 1 representing dislike extremely and 9 like extremely (Iwe, 2002).

RESULTS AND DISCUSSION

Evaluation of Proximate Composition of Complementary Diet from Blends of guinea corn, green beans and soya beans

The result on Table 1 showed the proximate composition of complementary diet from blends of guinea corn, green beans and soya beans. The amount of moisture content found in the blends range from 4.85 – 6.00%. Furthermore, the amount of moisture discovered was within the standard specified by SON(1998) and PAG (1971) for complementary diet. The variation discovered on residual moisture may be attributed to the conditions of drying system used during the preparation of flour meal from the raw materials. Ihekoronye and Ngoddy (1985) stated that the extent of moisture removal in food is dependent on the drying temperature and length of exposure to heat energy. The amount of moisture in foodstuff is a good index in determining the shelf-stability of food during storage, distribution and sale. The crude protein (%) increased from 10.06 – 22.15%. Standard organization of Nigeria (1988) recommended protein value of 14-17% minimum range in the diet of infants of 0-12 months. The increase in protein may be attributed to the initial chemical composition of guinea corn and as well as the proportion of formulation used. There was no much difference in the fat content of the various blends, it range between 3.35-8.36% for complementary diet by SON (1988). The ash content discovered was in the range of 2.31-4.20%. These values comply with the standard specification of SON (1988) and PAG (1971). Onyeka (2008) stated that ash content of a food is a good index for determining mineral composition in food. The crude fiber increased in value from 3.84-5.58% as there was an increase in the proportion of blending, while the percentage of carbohydrate ranged from 53.70-74.73%. There is significant difference for complementary diet by SON (1988).

Table 1 Proximate composition of Complementary Diet from blends of Guinea corn, Green beans and Soya beans

| Sample Code | Moisture % | Protein % | Fat % | Ash % | C. Fiber % | Carbohydrate % |
|---|---|---|---|---|---|---|
| S.A | $5.70^{b}\pm0.02$ | $10.6^{c}\pm0.02$ | $3.35^{d}\pm0.03$ | $2.31^{d}\pm0.02$ | $3.84^{d}\pm0.06$ | $74.73^{a}\pm0.05$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| S.B | 4.85$^{d}$±0.04 | 10.99$^{c}$±0.05 | 4.57$^{c}$±0.01 | 2.93$^{c}$±0.06 | 4.08$^{c}$±0.04 | 72.57$^{b}$±0.78 |
| S.C | 5.20$^{c}$±0.02 | 17.20$^{b}$±0.04 | 7.62$^{b}$±0.02 | 3.69$^{b}$±0.03 | 5.00$^{b}$±0.00 | 61.27$^{c}$±0.00 |
| S.D | 6.00$^{a}$±0.00 | 22.15$^{a}$±0.04 | 8.36$^{a}$±0.02 | 4.20$^{a}$±0.02 | 5.58$^{a}$±0.06 | 53.70$^{d}$±0.02 |
| LSD | 0.02937 | 0.32675 | 0.02761 | 0.04153 | 0.4987 | 0.39373 |

Mean values with different letters along the same column are significantly different (P < 0.05).

Key

S.A = 90:5:5 % Guinea corn green beans and soya beans blend

S.B = 85:10:5 % Guinea corn green beans and soya beans blend

S.C = 85:5:10 % Guinea corn green beans and soya beans blend

S.D = 70:15:15% Guinea corn green beans and soya beans blend

Evaluation of the Mineral content of the complementary Diet from blends of guinea corn, green beans and soya beans

Table 2 shows the mineral composition of complementary diet produced from blends of guinea corn, green beans and soya beans. The value of mineral content (mg/100g) varied among the blends visually. The calcium range from 10.50-25.31 mg/100g, it was found that the percentage of calcium increased. The potassium of the blends also varied highly in values and found within the range of 122.31-164.21 mg/100g, this implies that increasing the proportion of green beans may cause an increase in the amount of potassium.The iron (Fe ) content of the supplementary diet was discovered between 2.33-3.15 mg/100g and this variation could be attributed to the effect of blending guinea corn with green beans and soya beans at different proportions. There was also a noticeable increase in the zinc and magnesium content of the blends as the proportion of green beans and soya beans increases respectively.

Table 2: Mineral content of complementary diets from blends of guinea corn, green beans and soya beans

| Sample Code | Calcium mg/100g | Magnesium mg/100g | Iron mg/100g | Zinc mg/100g | Potassium mg/100g | VitaminC mg/100g |
|---|---|---|---|---|---|---|
| S.A | 19.41$^{a}$±0.02 | 15.07$^{d}$±0.00 | 2.33$^{d}$±0.04 | 1.16$^{d}$±0.02 | 122.31$^{d}$±0.02 | 12.54$^{d}$±0.05 |

| | | | | | | |
|---|---|---|---|---|---|---|
| S.B | $10.50^{a}\pm14.84$ | $19.04^{b}\pm0.06$ | $2.73^{c}\pm0.03$ | $1.63^{c}\pm0.05$ | $148.39^{c}\pm0.21$ | $15.00^{c}\pm0.00$ |
| S.C | $25.31^{a}\pm0.02$ | $16.50^{c}\pm0.03$ | $3.00^{b}\pm0.00$ | $1.99^{b}\pm0.01$ | $151.13^{b}\pm0.04$ | $16.91^{b}\pm0.02$ |
| S.D | $18.15^{a}\pm0.04$ | $24.50^{a}\pm0.05$ | $3.15^{a}\pm0.03$ | $2.12^{a}\pm0.02$ | $163.21^{a}\pm0.34$ | $22.37^{a}\pm0.02$ |
| LSD | 7.42468 | 0.04623 | 0.03298 | 0.03279 | 0.20697 | 0.03482 |

Mean values with different letters along the same column are significantly different ($P < 0.05$).

Key

S.A = 90:5:5 % Guinea corn green beans and soya beans blend

S.B = 85:10:5 % Guinea corn green beans and soya beans blend

S.C = 85:5:10 % Guinea corn green beans and soya beans blend

S.D = 70:15:15% Guinea corn green beans and soya beans blend

The iron (Fe ) content of the supplementary diet was discovered between 2.33-3.15 mg/100g and this variation could be attributed to the effect of blending guinea corn with green beans and soya beans at different proportions. There was also a noticeable increase in the zinc and magnesium content of the blends as the proportion of green beans and soya beans increases respectively.

Sensory Evaluation of Complementary Diet from Blends of Guinea corn, Green beans and Soya beans.

The result in Table 4.4 showed the mean scores of sensory characteristics of complementary diet blends. Statistically, there was no significant difference ($p>0.05$) found on each of the sensory attributes of the blends and control sample. The implication from this result implies that the diet from these blends as well as the proportions of the formula used in the blending is the reason there was no significant difference on the sensory characteristics of the complementary diet. The blend sample (Sample A) has the highest score in the overall acceptability and therefore is the most preferred blend among others. This further support the result of the proximate composition in (Table 3) of the legume-based complementary diet formulated with incorporated Green beans.

Table 3. Mean score of sensory characteristics of Complementary diet from blends of Guinea corn, Green beans and Soya beans

| Sample code | Color | Taste | Aroma | Mouth-feel | Overall acceptability |
|---|---|---|---|---|---|
| Sample A | $6.40^{a}\pm2.11$ | $5.90^{a}\pm1.85$ | $5.20^{a}\pm2.44$ | $4.50^{1}\pm2.36$ | $7.90^{a}\pm1.59$ |
| Sample B | $5.90^{a}\pm1.96$ | $6.10^{a}\pm2.42$ | $5.00^{a}\pm2.10$ | $3.20^{1}\pm2.25$ | $6.40^{ab}\pm2.45$ |
| Sample C | $5.80^{a}\pm1.31$ | $5.00^{a}\pm2.35$ | $4.80^{a}\pm1.13$ | $4.40^{1}\pm1.89$ | $5.50^{ab}\pm1.84$ |
| Sample D | $5.60^{a}\pm1.83$ | $5.00^{a}\pm2.00$ | $4.00^{a}\pm1.82$ | $4.90^{1}\pm1.79$ | $4.90^{b}\pm2.13$ |
| Reference (Nutribom) | 8.40±8.94 | 7.00±1.22 | 8.00±7.07 | 6.40±8.94 | 7.00±1.41 |
| LSD | 0.82091 | 0.97125 | 0.86667 | 0.93512 | 0.90891 |

Mean values with different letters along the same column are significantly different ($P < 0.05$).

Key

S.A = 90:5:5 % Guinea corn green beans and soya beans blend

S.B = 85:10:5 % Guinea corn green beans and soya beans blend

S.C = 85:5:10 % Guinea corn green beans and soya beans blend

S.D = 70:15:15% Guinea corn green beans and soya beans blend

## CONCLUSION AND RECOMMENDATION

### Conclusion

The complementary diet from blends of guinea corn, green beans and soya beans have improved nutritional values and such reduced the risks of PEM (protein energy malnutrition) in children. The mineral content detected from the samples further showed the nutritional values of the complementary diet formulated. The blends of the formula prepared were good sources of protein, vitamins, energy, and their values were found within the recommended dietary allowance stipulated by standard organization of Nigeria (SON). The product also contained mineral elements of importance in human nutrition. The green beans contributed significantly on the level of nutrient obtained from the complementary diet from blends. The study has also demonstrated that combined effect of guinea corn, green beans and soya beans enhance the acceptability of the product by the opinion of the judges.

Recommendation

It can be recommended that guinea corn be used in combination with soya beans and green beans for producing composite complementary mixes, which will prove to be of immense benefit especially for young children.

Since green beans are good sources of fiber, potassium and folate, and are an excellent source of protein, iron and zinc which can improve heart health and help prevent cancer and manage/prevent diabetes, it is highly recommended.

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