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Agricultural Extension Innovation System for Rural Development

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Abstract

Agricultural extension in Nigeria has evolved from traditional knowledge-sharing systems to structured government-led models and, more recently, to participatory and digitally driven innovation approaches. This transformation reflects a broader shift towards an Agricultural Innovation System (AIS), which conceptualises innovation as an interactive, multi-actor process involving farmers, research institutions, extension agencies, private-sector actors, financial institutions, and policy bodies. Within this framework, rural development extends beyond increased agricultural output to encompass income growth, market integration, social inclusion, institutional strengthening, and environmental sustainability. Unlike conventional top-down models focused primarily on technology transfer, the AIS framework positions extension as an innovation broker that facilitates linkages, knowledge exchange, market access, and collaborative learning. By strengthening interactions among actors and institutions, extension contributes to improved productivity, livelihood diversification, climate resilience, and inclusive rural transformation. However, persistent challenges such as inadequate funding, weak institutional coordination, low extension worker-to-farmer ratios, and unequal access to digital technologies continue to constrain its effectiveness. Strengthening a functional and inclusive extension innovation system is therefore essential for achieving sustainable and transformative rural development in Nigeria

Key words: Agricultural Extension, agricultural innovation system and Rural Development

Introduction

Rural development has historically impacted Nigeria's socio-economic trajectory, with objectives that include poverty alleviation, enhanced agricultural productivity, and improved living standards for rural households. Early development interventions and projects during the colonial era prioritised infrastructure and marketing systems to support the export of agricultural produce, while post-independence strategies between 1960 and 1970 emphasized farm settlement schemes, research institutions, and extension services to boost domestic agricultural development (FMARD, 2016). Despite these efforts, structural, social, and physical challenges continue to constrain sustainable rural transformation. These challenges include persistent rural poverty, low agricultural productivity among smallholder farmers in rural areas, weak market integration, institutional fragmentation, infrastructure deficits,

gender and social disparities, conflicts, insecurity, and the impacts of climate change and environmental degradation.

Rural development is inherently multi-sectoral, context-specific, and central to sustainable development. Improving the well-being of rural households cannot be achieved through isolated sectoral interventions but requires coordinated action across agriculture, infrastructure, nutrition, health, education, markets, finance, and governance. Effective strategies must be responsive to local ecological conditions, indigenous knowledge systems, and the socio-economic realities of rural communities to ensure sustainability and equity (Nwachukwu, 2018). In practice, this necessitates integrated, place-based interventions that combine technical advisory services with market access, social services, and environmental safeguards, thereby ensuring that productivity gains translate into lasting livelihood improvements.

Within this broader rural development architecture, agricultural extension occupies a strategic position. Extension systems facilitate knowledge exchange, strengthen farmers' adaptive capacities, and connect rural producers to research institutions, markets, and innovation networks. However, conventional extension approaches in Nigeria have largely operated through linear technology transfer models that emphasize top-down dissemination of innovations, often with limited stakeholder interaction and weak institutional coordination. Such approaches have proven insufficient in addressing the complexity and dynamism of contemporary rural development challenges.

Nigeria remains substantially rural, with approximately 45% of its population residing in rural areas as of 2024, underscoring the centrality of agriculture to national development (World Bank, 2024). The agriculture, forestry, and fisheries sector contribute between 20-23 per cent of gross domestic product and continue to employ a significant proportion of the labour force (World Bank, 2024; ILO, 2023). In this structural context, strengthening the institutional foundations of agricultural extension is critical for achieving food security, poverty reduction, and inclusive growth.

This paper advances the proposition that repositioning agricultural extension within an Agricultural Innovation System (AIS) framework offers a transformative pathway for accelerating rural development in Nigeria. The Agricultural Innovation System perspective moves beyond the traditional technology transfer paradigm by emphasising interactive learning, multi-actor collaboration, institutional linkages, and enabling policy environments. By promoting pluralistic participation, digital integration, market orientation, and equity sensitivity, an innovation systems approach provides a more comprehensive and adaptive model for rural transformation.

Concept of Rural Development in Nigeria

Rural development is a multidimensional and dynamic process shaped by local ecological conditions. It aims to improve the standard of living in rural areas, enabling communities to effectively utilise their knowledge, technology, and indigenous resources to achieve sustainable livelihoods. According to the Food and Agriculture Organization (FAO, 2017), rural development is not limited to agricultural productivity but also encompasses social, economic,

institutional, and environmental aspects, highlighting the need for integrated and context-specific approaches.

Ndem, Angioha, and Dike (2020) explain that rural development entails the exploitation of the human and physical potentialities of rural areas to raise the living standards of the rural pouplation. Similarly, Azumah, Davies, and Ogele (2021) define rural development as a human-centred process concerned with improving the living standards of low-income rural populations on a self-sustaining basis through transforming the socio-spatial structures of their productive activities. Todaro and Smith (2020) and the World Bank (2024) further emphasize that rural development requires interventions tailored to local ecological conditions, socio-cultural realities, and existing institutional frameworks.

From these definitions, it is evident that rural development is characterised by a broad-based reorganization and mobilization of rural resources and populations. It involves integrated, place-based approaches that link agricultural productivity with social services, market access, and institutional strengthening. It is achieved through a combination of communities' own efforts and strategic support from government and development partners. Such a collaborative approach is essential for realizing sustainable, inclusive, and equitable rural transformation.

Since Nigeria's independence in 1960, rural development has been a major priority of successive federal governments. Numerous policies and programmes have aimed at transforming and empowering rural communities socially, economically, and institutionally. Key initiatives include:

- Farm settlement and plantation schemes (1959–1960): Introduced modern agricultural methods and laid the groundwork for structured extension services.
- National Accelerated Food Production Programme (NAFPP, 1972): Increased staple crop production through improved seeds, fertilizers, mechanized farming, and strengthened research-to-farmer linkages.
- Agricultural Development Programmes (ADPs, 1975 onward): Combined extension services with rural infrastructure, input supply, and credit schemes, representing Nigeria's first large-scale integrated rural development model.
- Operation Feed the Nation (OFN, 1976): Mobilized the population to embrace agriculture and food self-sufficiency.
- River Basin Development Authorities (RBDAs, 1976–1977): Promoted irrigated agriculture, employment, and water resource management.
- Green Revolution Programme (1980) and Directorate of Food, Roads and Rural Infrastructure (DFRRI, 1986): Boosted agricultural productivity, expanded rural infrastructure, and linked rural communities to markets.
- Better Life Programme for the African Rural Woman (1987): Addressed gendered dimensions of rural development by supporting rural women in entrepreneurship, market access, and community organization.
- National Fadama Development Project (1990s): National Agricultural Land Development Authority (NALDA, 1992), and National Special Programme for Food Security (NSPFS, 2003): Focused on sustainable land and water resource management, improved productivity, and poverty reduction.

- **National Economic Empowerment and Development Strategy (NEEDS) (2004 -2007):** Served as a comprehensive national development framework aimed at poverty reduction, wealth creation, employment generation, and improved service delivery, with significant implications for rural development and economic empowerment.
- **Community-Based Agriculture and Rural Development Project (CBARDP) (2001–2009):** Improved rural livelihoods through community participation in the provision of agricultural infrastructure, natural resource management, and income-generating activities.
- **Root and Tuber Expansion Programme (RTEP) (2001–2008):** Enhanced the production, processing, and marketing of cassava, yam, cocoyam, and sweet potato to improve food security and increase rural incomes.
- **National Programme for Food Security (NPFS) (2002):** Promoted sustainable increases in agricultural productivity through improved technologies, farmer training, irrigation development, and better access to agricultural inputs.
- **National Fadama Development Project II (2004–2009):** Promoted community-driven rural development by improving access to productive assets, rural infrastructure, extension services, and markets for farmers, fishers, pastoralists, and other rural resource users.
- **National Fadama Development Project III (2008–2019):** Expanded support for agricultural productivity and rural livelihoods through community participation, value-chain development, capacity building, and improved access to markets and financial services.
- **Commercial Agriculture Development Project (CADP) (2009–2017):** Facilitated the commercialisation of agriculture by strengthening value chains, improving access to agricultural technologies, and enhancing linkages between smallholder farmers and markets.
- **Rural Finance Institution-Building Programme (RUFIN) (2010–2019):** Strengthened rural financial institutions and expanded access to credit, savings, and financial services for smallholder farmers and rural entrepreneurs.
- **Agricultural Transformation Agenda (ATA) (2011–2015):** Sought to reposition agriculture as a profitable business by improving input delivery systems, promoting private-sector investment, enhancing value addition, and increasing rural employment opportunities.
- **Cassava Transformation Agenda (2011–2015):** Encouraged value addition, processing, and commercialisation within the cassava sector to generate employment and increase rural incomes.
- **Growth Enhancement Support Scheme (GESS) (2012–2015):** Improved farmers' access to subsidised fertilisers and improved seeds through an electronic wallet system, thereby reducing inefficiencies in agricultural input distribution.
- **Nigeria Incentive-Based Risk Sharing System for Agricultural Lending (NIRSAL) (2013):** Encouraged financial institutions to increase lending to the agricultural sector by reducing investment risks and improving access to agricultural finance.
- **Youth Employment and Social Support Operation (YESSO) (2013):** Supported vulnerable and unemployed young people through skills

development, temporary employment opportunities, and social protection interventions, particularly in rural communities.

- **Youth Employment in Agriculture Programme (YEAP) (2014):** Targeted youth unemployment by encouraging young people to engage in agriculture through training, entrepreneurship development, access to finance, and agribusiness opportunities.
- **Anchor Borrowers' Programme (ABP) (2015):** Improved access to credit and agricultural inputs for smallholder farmers while strengthening linkages between producers and Agro-processors to enhance productivity and food security.
- **Agriculture Promotion Policy (The Green Alternative) (2016–2020):** Focused on achieving food security, promoting agricultural exports, enhancing value-chain development, increasing private-sector participation, and supporting sustainable rural livelihoods.
- **National Social Investment Programme (NSIP) (2016):** Addressed poverty and vulnerability through social protection initiatives, including conditional cash transfers, youth employment schemes, and support for vulnerable households in rural communities.
- **National Home-Grown School Feeding Programme (2016):** Improved child nutrition while creating market opportunities for local farmers through the procurement of food from local agricultural producers.
- **National Livestock Transformation Plan (NLTP) (2018):** Sought to improve livestock production, reduce farmer–herder conflicts, enhance rural security, and promote sustainable livestock management systems.
- **Livelihood Improvement Family Enterprises Project in the Niger Delta (LIFE-ND) (2019):** Focused on reducing youth unemployment and poverty through agribusiness development, vocational training, enterprise support, and improved livelihood opportunities in rural communities.

According to Filo (2026), the key components of rural development include:

- Economic Development: Creating employment opportunities, promoting rural industries, and improving income levels.
- Infrastructure Development: Building and maintaining roads, electricity, water supply, and telecommunication networks.
- Social Development: Improving access to education, healthcare, housing, and sanitation.
- Human Resource Development: Enhancing skills through training and literacy programs.
- Environmental Sustainability: Managing natural resources such as land, water, and forests to ensure long-term productivity.

Taking a critical look at these rural development components, it becomes evidently clear that the objectives of rural development closely align with these components. These objectives include:

a) Reduce rural poverty by improving income-generating opportunities and equitable access to resources.
b) Increase agricultural productivity through the adoption of innovations, improved inputs, and better farming practices.

c) Enhance living standards by improving access to education, healthcare, housing, and sanitation.
d) Promote human and institutional capacity through skill development and participatory governance.
e) Ensure environmental sustainability by maintaining productive natural resources and resilience to climate change.
f) Foster inclusive and equitable development by ensuring women, youth, and marginalized groups benefit from interventions.

These conceptualizations, components, objectives, and historical government programmes collectively illustrate that rural development in Nigeria is an integrated, multi-sectoral, and long-term endeavour. They also highlight the critical role of agricultural extension as a mechanism for knowledge transfer, innovation adoption, and linking rural communities to research, markets, and policy networks, a role that will be explored in the next section.

Agricultural Extension and Its Evolution in Nigeria

The evolution of agricultural extension in Nigeria reflects a gradual shift from traditional knowledge-sharing systems to state-led, top-down extension models, and more recently to pluralistic and participatory approaches. In the immediate post-independence period, extension services were largely linear in nature, focusing on the transfer of technologies from research institutes to farmers through public extension agents. While this approach contributed to the early dissemination of improved technologies, it was constrained by weak feedback mechanisms, limited farmer participation, and poor adaptation of innovations to local conditions (FAO, 2023; World Bank, 2023).

From the 1980s through the early 2000s, Nigeria implemented several agricultural development programmes that expanded institutional presence in rural areas. However, these interventions were often fragmented, underfunded, and heavily reliant on public sector delivery. Extension systems were characterised by weak coordination, low agent-to-farmer ratios, and limited sustainability beyond project cycles. Moreover, the focus remained largely on production increases, with insufficient attention to markets, value addition, and institutional linkages (FAO, 2023).

A critical assessment of the conventional extension model reveals several structural weaknesses. First, it is predominantly linear and top-down, assuming that innovation flows unidirectionally from research to farmers, thereby underestimating farmers' role as co-creators of knowledge. Second, there is institutional fragmentation, with weak linkages between research, extension, input supply, finance, and markets. Third, sustainability challenges persist due to reliance on short-term government and donor-funded projects. Fourth, limited inclusiveness excludes women, youth, and marginalised rural groups from innovation processes. Finally, the system has struggled to respond effectively to emerging challenges such as climate change, digital transformation, and market volatility (FAO, 2023; Daum et al., 2025).

The Agricultural Innovation System (AIS) represents a shift away from linear extension thinking towards a multi-actor, interactive innovation framework. It conceptualises innovation as the outcome of dynamic interactions among actors such as farmers, research institutes, extension services, private sector

organisations, financial institutions, and policymakers operating within an enabling institutional environment (FAO, 2023; World Bank, 2023).

Recent AIS literature further emphasises that innovation is not solely technological but also organisational, institutional, and social in nature. It emerges through co-production of knowledge, continuous learning processes, and stakeholder collaboration rather than one-way technology transfer mechanisms (Daum et al., 2025; TAP-AIS/FAO, 2022).

By promoting knowledge exchange and multi-actor collaboration, extension services under the Agricultural Innovation System (AIS) paradigm ensure that innovations, best practices, and market opportunities are effectively disseminated and adopted at community level. This integrative role transforms extension from a simple information delivery mechanism into a catalyst for systemic rural development, enhancing productivity, sustainability, and inclusive growth (Issa et al., 2025).

Building on this conceptual foundation, the evolution of agricultural extension in Nigeria can be traced through four major phases, each characterised by distinct models and institutional arrangements. Over time, the country has experimented with multiple extension approaches, reflecting changing development priorities, resource availability, and institutional capacities. The major models are summarised in Table 1.

The AIS framework addresses the weaknesses of traditional extension systems in several fundamental ways. It replaces the linear transfer-of-technology model with an interactive learning system in which farmers actively participate in experimentation, adaptation, and knowledge creation, thereby improving the relevance and adoption of innovations. According to FAO (2023), AIS strengthens institutional coordination by linking research organisations, extension services, private agribusiness actors, and financial institutions, thereby reducing fragmentation and duplication of efforts in the development of agricultural technologies. Furthermore, FAO (2023) emphasises that AIS enhances inclusiveness by ensuring that women, youth, and vulnerable groups are actively integrated into innovation platforms and decision-making structures, thereby promoting equitable access to knowledge and resources. The World Bank (2023) notes that AIS improves sustainability by integrating private sector actors, cooperatives, and value chain stakeholders into innovation processes, thereby reducing dependence on government and donor-driven programmes. In addition, AIS enhances coordination in the development and dissemination of agricultural technologies by reducing fragmentation and avoiding duplication of efforts.

Overall, these improvements demonstrate how AIS overcomes the identified pitfalls of traditional extension models. It strengthens resilience and adaptability through continuous feedback loops, multi-stakeholder collaboration, and digital advisory systems, enabling the agricultural system to respond more effectively to climate change, shocks, and market uncertainties. Finally, AIS promotes market orientation and value chain integration by linking innovation processes to processing, marketing, and agribusiness development, thereby shifting the focus beyond production alone towards broader rural transformation and income diversification (World Bank, 2023; Daum et al., 2025).

The Agricultural Innovation System therefore represents a fundamental shift from conventional extension approaches in Nigeria. By conceptualising innovation as a dynamic, interactive, and multi-actor process embedded within institutional and policy environments, AIS addresses the fragmentation, top-down orientation, and sustainability challenges of earlier models. Its emphasis on collaboration, inclusiveness, and system-wide learning makes it a more effective framework for achieving sustainable agricultural development and rural transformation.

Table 1: Phases of Extension Models

Period	**Extension Model / Approach**	**Key Features / Focus**
Pre 1960s–1960s	Traditional / Informal Extension	Indigenous knowledge transfer, peer-to-peer learning, community-based, apprenticeship, socially embedded
1960s – 1980s	Transfer-of-Technology (ToT) / Training & Visit (T&V)	Linear technology transfer from research to farmers, regular training of extension agents, scheduled farm visits, top-down approach
1980s – 2000s	Research–Extension–Farmer–Input Linkage System (REFILS)	Strengthened coordination among researchers, extension agents, farmers, input suppliers; joint planning, on-farm adaptive trials
1980s – 2000s	Farming Systems Research and Extension (FSRE)	Holistic understanding of farmers' socio-economic and agro-ecological conditions, adaptive technology, location-specific solutions
1980s – 2000s	Participatory Extension / Farmer Field Schools (FFS)	Experiential learning, farmer empowerment, gender and social inclusion, NGO and community involvement
2010s – Present	Digital / Innovation-Driven Extension (within AIS)	Mobile advisory services, SMS alerts, e-extension platforms, climate and market information services; multi-stakeholder collaboration among farmers, researchers, extension services, private-sector actors, NGOs, and policymakers; market-oriented and network-based innovation.

This table highlights how Nigerian extension evolved from informal, community-based practices to structured, top-down systems (T&V), then to participatory and pluralistic approaches (REFILS, FSRE, FFS), and finally to digital and innovation-driven platforms aligned with AIS principles. Some models overlapped in practice, reflecting gradual transitions rather than abrupt shifts.

1. Traditional Extension (Pre-1960s to 1960s): Extension during this period relied on indigenous knowledge, apprenticeship, and peer-to-peer learning within communities. These approaches were socially embedded and context specific. While locally effective, traditional extension lacked structured research linkages, scalability, and mechanisms for multi-actor collaboration, limiting broader agricultural modernization.

2. Public-Funded Extension Systems and the Transfer-of-Technology Model (1960s to 1980s): Following independence, Nigeria institutionalized agricultural extension to promote agricultural modernization. The dominant philosophy was the Transfer-of-Technology (ToT) model, operationalized through the Training and Visit (T&V) system under Agricultural Development Programmes (ADPs). T&V focused on regular training of extension agents and scheduled farm visits to transfer technology from research institutions to farmers. While it improved coverage and productivity, the system was largely top-down, linear, and resource-constrained, with limited feedback mechanisms or integration with markets and private-sector actors.

3. Participatory, Farming Systems, and Pluralistic Extension Approaches (1980s to 2000s)

Economic and structural adjustments exposed the weaknesses of centralized extension systems. Extension gradually shifted toward participatory and farming systems approaches (FSRE, FFS), emphasizing adaptive, location-specific solutions, farmer empowerment, and inclusive participation. Initiatives like the Better Life Programme for Rural Women and the National Fadama Development Project expanded extension beyond productivity to social inclusion, resource management, and community-driven problem solving. These approaches began aligning with AIS principles by encouraging multi-actor engagement, co-creation of knowledge, and local innovation networks.

4. Digital, Market-Oriented, and Innovation-Driven Extension (2010s to Present)

Recent years have seen the adoption of mobile advisory services, SMS alerts, e-extension platforms, and networked innovation approaches. These innovations are explicitly framed within the AIS paradigm, providing farmers with real-time agronomic, market, and climate information while connecting research institutions, private sector actors, cooperatives, and government agencies. Digital platforms strengthen innovation networks, support data-driven decision-making, and enable market-oriented, context-specific, and inclusive solutions, reflecting the AIS emphasis on collaborative problem-solving and knowledge brokering (Izuogu et al., 2023).

Although Agricultural Innovation Systems (AIS) have been promoted in Nigeria since around 2010, challenges in agricultural extension service delivery persist. This suggests that the adoption of AIS does not automatically eliminate extension constraints. Rather, AIS provides a framework for innovation, learning, and collaboration among multiple stakeholders, whose effectiveness depends largely on the quality of its implementation. Consequently, several persistent challenges continue to constrain the effectiveness of AIS in agricultural extension delivery in Nigeria.

1. Weak Institutional Coordination: AIS requires effective collaboration among farmers, researchers, extension agencies, private-sector actors, non-governmental organizations (NGOs), and policymakers. However, these

actors often operate independently, resulting in fragmented service delivery and weak innovation linkages, thereby limiting the collaborative potential of AIS.

2. Inadequate Funding: Many Agricultural Development Programmes (ADPs), public extension services, and even private extension providers face chronic funding constraints. This limits field visits, training activities, demonstrations, and the dissemination of agricultural technologies and innovations.

3. Low Extension Agent-to-Farmer Ratio: AIS continues to rely on extension personnel to facilitate knowledge exchange, learning, and innovation processes. However, despite the increasing involvement of private-sector actors in extension delivery, the number of extension personnel in Nigeria remains inadequate relative to the farming population, thereby limiting farmers' access to advisory services.

4. Digital Divide: Although digital extension services have expanded, many rural farmers continue to face challenges such as poor internet connectivity, inadequate electricity supply, low smartphone ownership, and limited digital literacy. These factors restrict the effectiveness and reach of ICT-based extension services.

5. Limited Capacity of Extension Personnel: The transition from traditional extension approaches to AIS requires extension personnel to perform additional roles, including innovation facilitation, stakeholder networking, value-chain coordination, and digital advisory support. Many extension workers require continuous capacity building to effectively perform these functions.

6. Policy and Governance Challenges: Frequent policy changes, weak monitoring and evaluation systems, and inconsistent implementation of agricultural programmes can undermine the effectiveness and sustainability of AIS initiatives.

7. Socio-Economic Constraints of Farmers: Even when farmers have access to extension information, the adoption of innovations may be constrained by limited access to credit, agricultural inputs, markets, and secure land tenure. These limitations reduce farmers' capacity to implement recommended practices and technologies.

Role of Agricultural Extension in Rural Development

Agricultural extension plays a pivotal role in rural development, serving as a bridge between knowledge generation and practical application at the farm and community levels. By facilitating access to innovations, technologies, and best practices, extension enables farmers to improve productivity, diversify livelihoods, and adapt to changing environmental, social, and economic conditions. Embedded within an Agricultural Innovation System (AIS) perspective, extension is no longer just about transferring technology; it functions as a dynamic mechanism for coordinating multiple actors, fostering collaboration, and co-creating solutions that respond to the complex realities of rural communities (Issa et al., 2025).

Through this lens, agricultural extension contributes to rural development not only by enhancing farm-level productivity but also by supporting broader structural transformations, which can be summarized in several key areas:

- **Innovation adoption and productivity growth**: Extension facilitates the uptake of new technologies, improved seeds, fertilizers, and modern farming practices, helping farmers to increase yields, reduce losses, and optimize resource use.
- **Capacity building and managerial skill development**: Beyond technical knowledge, extension empowers farmers with decision-making skills, planning strategies, and farm management techniques, strengthening the human capital of rural communities.
- **Market access and value chain integration**: Extension helps farmers connect with input suppliers, cooperatives, and buyers, promoting participation in value chains and improving income opportunities.
- **Climate resilience and sustainable resource management**: Extension services introduce strategies for conserving soil, water, and biodiversity while promoting adaptive practices that mitigate climate variability.
- **Social inclusion and equitable access**: By targeting women, youth, and marginalized groups, extension promotes inclusive participation in agricultural innovation, ensuring that knowledge transfer and technology adoption benefit the wider community.

By integrating these dimensions, agricultural extension functions as a strategic driver of inclusive, resilient, and sustainable rural development. When aligned with AIS principles, extension facilitates multi-actor collaboration, knowledge networks, and innovation co-creation, transforming rural communities into adaptive, innovative, and market-oriented systems capable of addressing the multifaceted challenges of modern Nigeria.

Challenges of Agricultural Extension in Nigeria

Despite its critical role and decades of evolution, agricultural extension in Nigeria continues to face persistent structural, institutional, and operational challenges that limit its effectiveness and reach. These challenges hinder the development of a fully functional Agricultural Innovation System (AIS) capable of driving sustainable rural transformation. Key challenges include:

- **Persistent financial constraints**: Extension services suffer from inadequate and inconsistent budgetary allocations, affecting staffing, mobility, training, and program delivery. Limited financial resources restrict the ability of extension agencies to adopt modern technologies, provide timely support, or scale innovations to reach all farmers.
- **Low extension agent-to-farmer ratios**: Nigeria’s extension workforce is insufficient relative to its large rural farming population. In many areas, one extension officer is expected to serve hundreds or thousands of farmers, reducing personalized support, follow-up, and effective technology adoption.
- **Weak implementation of pluralistic models like REFILS**: Although frameworks such as REFILS were designed to strengthen collaboration among researchers, extension agents, input suppliers, and farmers, poor

coordination, inadequate monitoring, and limited institutional capacity have hindered their full implementation. This reduces the ability to facilitate multi-actor innovation networks.

- **Poor rural infrastructure and limited ICT access**: Many rural areas lack reliable roads, electricity, and telecommunications, which constrain the delivery of extension services, digital tools, and mobile advisory platforms. Without adequate infrastructure, innovations and market information cannot reach remote communities efficiently.
- **Fragmented coordination in a pluralistic system**: Nigeria now operates multiple extension actors—including government agencies, NGOs, cooperatives, and private sector providers. However, coordination among these actors is often weak, leading to duplication of efforts, uneven service coverage, and inconsistencies in messaging to farmers.
- **Limited capacity for innovation and knowledge brokering**: Many conventional extension agents still operate within a top-down, technology-transfer mindset, with limited skills in facilitating participatory innovation, managing knowledge networks, or brokering collaborations between actors. This restricts the system's ability to function as a true AIS.
- **Socio-cultural and adoption barriers**: Farmer literacy levels, socio-economic constraints, and gender disparities affect the uptake of innovations. Even where technologies are available, adoption may be slow due to lack of awareness, risk aversion, or limited access to credit and inputs.
- **Unequal access to digital and market-oriented services**: While digital extension platforms and mobile advisory services have emerged, access remains uneven, particularly among smallholder farmers in marginalized regions. This digital divide undermines equitable knowledge dissemination and reinforces existing inequalities in rural development.

Collectively, these challenges demonstrate that conventional extension approaches alone are insufficient to meet the needs of modern agriculture and rural livelihoods. They highlight the urgency of adopting an innovation system perspective, where multi-actor collaboration, knowledge sharing, adaptive solutions, and market integration are central to addressing the complex and dynamic realities of Nigerian rural communities.

While Nigeria has experimented with multiple extension models—from traditional and top-down systems to participatory and digital approaches—these interventions have not fully addressed the complexities of modern rural development. Conventional extension approaches, particularly T&V and REFILS, were largely linear, production-oriented, and resource-constrained, often failing to integrate farmers' knowledge, market dynamics, and multi-actor collaboration. Even participatory and digital innovations face challenges of coordination, access, and scalability.

As rural livelihoods become increasingly diverse, market-oriented, and technology-dependent, conventional agricultural extension alone is no longer sufficient to drive sustainable and inclusive rural transformation. This underscores the need to shift toward AIS-based extension, which prioritizes

knowledge networks, innovation brokering, and multi-actor engagement, setting the stage for why conventional approaches are insufficient.

Conclusion

Agricultural activities remain the backbone of rural livelihoods and play a crucial role in ensuring food security, employment, and overall economic and social development. The Agricultural Innovation System (AIS) provides a comprehensive and collaborative framework for improving agricultural productivity and promoting rural development by connecting people, knowledge, technology, and institutions. Through this system, innovations are developed, shared, and effectively utilized by farmers to improve their livelihoods. AIS emphasizes interaction and cooperation among key stakeholders such as farmers, researchers, extension agents, private sector actors, financial institutions, and policy-making bodies, all working together to generate, disseminate, and apply agricultural knowledge and innovations for sustainable development.

As rural economies continue to evolve and become more market-oriented, knowledge driven, and technology dependent, the traditional agricultural extension approach alone is no longer adequate to address the complex challenges facing rural communities for. The AIS approach strengthens agricultural extension by encouraging knowledge exchange, innovation brokering, and stronger linkages among different actors in the agricultural sector. Through these interactions, farmers gain better access to improved technologies, information, financial services, and markets, which ultimately enhances agricultural productivity and improves rural livelihoods.

In conclusion, adopting and strengthening the Agricultural Innovation System will significantly enhance agricultural productivity, improve rural livelihoods, and contribute to sustainable rural development and national economic growth**.**

Recommendations

- Strengthen collaboration among stakeholders: Governments and development agencies should promote strong partnerships among farmers, researchers, extension agents, private sector actors, financial institutions, and policy makers to enhance innovation and knowledge sharing.
- Support capacity building: Training and capacity development programs should be provided for farmers and extension workers to improve their ability to adopt and disseminate innovative agricultural practices.
- Promote investment in agricultural innovation: Public and private investments should be increased in agricultural research, technology development, and rural infrastructure to support the effective functioning of the Agricultural Innovation System.
- Encourage policy support: Governments should develop favorable policies and institutional frameworks that promote innovation, facilitate access to credit, and support agricultural entrepreneurship in rural communities.
- Strengthen extension services: Extension systems should be reoriented toward the AIS approach, focusing on participatory learning, knowledge networks, and innovation platforms that connect farmers with other actors in the agricultural sector.

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