

Evaluating the Effectiveness of Government Extension Services in Enhancing Rural Agricultural Innovation in West Africa.

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Abstract- *Agricultural innovation remains central to sustainable rural development and food security in West Africa, yet its success depends heavily on the quality and effectiveness of government extension services. This paper critically evaluates the role of government-led agricultural extension programs in promoting innovation, knowledge dissemination, and technology adoption among rural farmers. It explores how extension agents serve as vital intermediaries linking research institutions with grassroots communities, while assessing the institutional, socio-economic, and infrastructural challenges limiting their effectiveness. Drawing on evidence from regional case studies across Nigeria, Ghana, Senegal, and Sierra Leone, the review examines policy frameworks, training models, and participatory approaches influencing farmer engagement and innovation outcomes. The paper also highlights the growing role of digital extension platforms, mobile advisory services, and public-private partnerships in improving service delivery and scalability. Findings reveal that while extension services have contributed to yield improvements and innovation diffusion, their long-term sustainability remains constrained by inadequate funding, limited capacity-building, and fragmented governance systems. The study concludes by recommending integrated, data-driven, and inclusive extension strategies aligned with national agricultural transformation agendas to enhance innovation uptake and rural livelihoods across West Africa.*

Keywords: *Agricultural Extension, Rural Innovation, West Africa, Policy Effectiveness, Technology Adoption, Sustainable Agriculture.*

I. INTRODUCTION

1.1 Background and Context

Agricultural extension services have long been recognized as pivotal instruments for advancing rural innovation, improving productivity, and enhancing the livelihoods of farming communities in developing regions. In West Africa, these services function as vital channels through which scientific knowledge, new technologies, and management practices are transmitted to smallholder farmers who constitute the majority of the agricultural workforce. The region's agricultural sector, which employs over 60% of the population, remains central to its economic development, yet it faces persistent challenges of low productivity, poor access to information, and limited technological adoption (Bukhari et al., 2018). Government extension services, therefore, serve not merely as information conduits but as catalysts for innovation diffusion and institutional transformation. Through capacity-building programs, participatory demonstrations, and policy linkages, they foster adaptive learning and empower farmers to integrate innovations that address local environmental, socio-economic, and market conditions.

However, the effectiveness of these government extension systems has been uneven across the region due to structural inefficiencies, inconsistent funding, and weak integration with research and private-sector initiatives. In some countries, decentralization and public-private partnerships have improved outreach and accountability, while in others, bureaucratic fragmentation and resource constraints have limited progress (Menson et al., 2018). The advent of digital extension tools and mobile-based advisory platforms has provided new opportunities for scaling agricultural

innovation and bridging rural information gaps, but infrastructural deficits and digital literacy challenges continue to hinder their full potential (Olasehinde, 2018). As governments across West Africa strive to align agricultural extension with continental development frameworks such as the African Union's Comprehensive Africa Agriculture Development Programme (CAADP), the need to critically evaluate the performance and adaptability of these services becomes increasingly urgent. This review thus situates the discussion within the broader discourse on rural innovation systems, assessing how effectively government extension programs enhance technological uptake, improve farmers' resilience, and contribute to sustainable agricultural transformation in the region.

1.2 Problem Statement

Despite decades of investment in agricultural extension, rural innovation in West Africa remains constrained by limited institutional coordination, inadequate human capacity, and poor farmer engagement. Many government extension programs continue to rely on outdated top-down communication models that fail to capture the dynamic needs of local communities. The lack of synergy between research institutions, policy frameworks, and grassroots initiatives has further diminished the impact of extension services on agricultural innovation. In several instances, duplication of roles among ministries, insufficient funding, and the absence of performance evaluation mechanisms have reduced efficiency and accountability. As a result, smallholder farmers remain poorly integrated into knowledge networks and are slow to adopt modern technologies essential for productivity growth.

Moreover, the transition toward digital agriculture has exposed deeper structural weaknesses in extension systems, including low data utilization, gender inequities in information access, and limited capacity to tailor innovations to climate variability and local contexts. Consequently, while some progress has been achieved in selected countries, the overall regional impact of government-led extension on innovation diffusion and rural transformation remains unclear. Understanding these systemic limitations is essential

for designing more inclusive, technology-driven, and results-oriented extension frameworks that can effectively promote agricultural innovation and sustainable development in West Africa.

1.3 Objectives of the Study

This study aims to evaluate the effectiveness of government extension services in enhancing rural agricultural innovation across West Africa. The specific objectives are to:

1. Examine the structure, scope, and policy frameworks guiding government agricultural extension systems in selected West African countries.
2. Assess the role of extension agents in facilitating innovation adoption and technology diffusion among rural farmers.
3. Identify institutional, socio-economic, and infrastructural factors influencing the performance and outreach of extension programs.
4. Analyze the contribution of digital and participatory approaches to improving extension delivery and farmer engagement.
5. Compare national models to determine best practices and replicable strategies that strengthen innovation ecosystems.
6. Propose evidence-based policy recommendations for enhancing coordination, efficiency, and sustainability of government extension systems.

By achieving these objectives, the study seeks to provide an integrated understanding of how extension services can transition from conventional information dissemination mechanisms to dynamic, innovation-driven platforms that empower farmers, enhance productivity, and promote resilience in the face of climate and market uncertainties.

1.4 Significance and Scope

The significance of this study lies in its potential to advance the discourse on agricultural innovation and policy reform within the context of rural development in West Africa. By critically evaluating government extension services, the paper provides empirical insights into the mechanisms through which these

services influence technology adoption, knowledge exchange, and farmer empowerment. This review will be particularly useful to policymakers, agricultural researchers, and development practitioners seeking to design responsive and sustainable extension models. It contributes to bridging the knowledge gap between theory and practice in agricultural innovation systems and offers actionable policy pathways for improving service delivery and accountability.

The scope of the study spans major West African economies such as Nigeria, Ghana, Senegal, and Sierra Leone, focusing on comparative analyses of national extension frameworks, digital integration strategies, and participatory innovations. It does not seek to assess private or donor-led interventions independently but rather emphasizes the governmental mechanisms shaping public-sector extension outcomes. Through this regional focus, the study underscores the need for a harmonized, multi-stakeholder approach that integrates local knowledge, technology transfer, and institutional reform to achieve agricultural transformation.

1.5 Structure of the Paper

This paper is organized into six main sections that collectively present a comprehensive evaluation of government extension services and their influence on rural agricultural innovation in West Africa. The first section introduces the study, outlining the background, problem statement, objectives, and scope. The second section presents the conceptual and theoretical framework, discussing the relevance of agricultural innovation systems and diffusion theories as lenses for understanding extension effectiveness. The third section details the methodology, describing the research design, data sources, and analytical framework used in the review. The fourth section explores the evolution, institutional structure, and operational challenges of government extension services across selected West African countries. The fifth section critically evaluates the effectiveness of these services, emphasizing innovation outcomes, digital transformation, and comparative country analyses. Finally, the sixth section concludes the paper by synthesizing the key findings and offering policy recommendations aimed at strengthening extension

systems, promoting inclusive innovation, and enhancing agricultural sustainability across the region.

II. CONCEPTUAL AND THEORETICAL FRAMEWORK

2.1 Definition and Role of Agricultural Extension

Agricultural extension refers to the systematic process of transferring scientific research and innovations from agricultural institutions to farmers through structured education, training, and advisory mechanisms. It serves as the bridge connecting scientific discoveries and practical farming practices, ensuring that rural communities adopt modern technologies and sustainable production methods. In West Africa, agricultural extension is not merely a technical service but a socio-economic instrument that promotes capacity development, facilitates access to markets, and empowers smallholder farmers to make data-driven decisions (Bukhari et al., 2018). The Food and Agriculture Organization (FAO, 2016) defines extension as a system that assists farmers in improving their livelihoods through organized learning experiences and problem-solving support. Its effectiveness relies on the integration of local knowledge systems, participatory methods, and continuous feedback loops between farmers, researchers, and policymakers.

The role of agricultural extension in rural innovation systems has evolved significantly, moving from top-down dissemination models to participatory and ICT-driven frameworks. This transformation emphasizes farmer-led innovation, co-creation of knowledge, and adaptation to climate-smart practices. Extension officers play a crucial role as knowledge intermediaries who facilitate collaboration among diverse actors, including research institutes, universities, agribusinesses, and rural cooperatives (Menson et al., 2018). Modern agricultural extension has expanded to include digital advisory services, gender-inclusive programming, and entrepreneurship promotion, thereby linking innovation with economic empowerment. Research by Van den Ban and Hawkins (2017) highlights that extension effectiveness is strongly correlated with the degree of institutional coordination and local adaptation. In

West Africa, national governments increasingly align extension policies with continental frameworks such as CAADP to strengthen agricultural productivity, ensure food security, and foster resilience among

farming populations. The dynamic nature of extension thus positions it as a central mechanism for achieving agricultural transformation and inclusive rural development across the region as seen in Table 1.

Table 1: Summary of the Definition and Role of Agricultural Extension in West Africa

Aspect	Description	Key Functions	Contemporary Focus Areas
Definition	Agricultural extension is the structured process of transferring agricultural innovations and research findings from institutions to farmers through education, training, and advisory services. It bridges the gap between scientific knowledge and practical farming, ensuring the adoption of modern, sustainable practices.	- Dissemination of scientific research- Capacity building of farmers- Technology transfer- Problem-solving support	- Integration of local and scientific knowledge- Participatory learning models- Data-driven decision support
Role in Rural Development	Extension acts as a socio-economic mechanism promoting farmer empowerment, market access, and rural livelihood enhancement. It supports inclusive agricultural growth by facilitating continuous interaction between farmers, researchers, and policymakers.	- Farmer training and advisory services- Market linkage facilitation- Promoting rural entrepreneurship	- ICT-enabled advisory systems- Gender inclusion in agricultural programs- Entrepreneurial and financial literacy training
Institutional Significance	Extension officers serve as intermediaries connecting multiple stakeholders—research institutes, universities, agribusinesses, and cooperatives—to enhance innovation diffusion and collaboration.	- Institutional coordination- Policy integration- Knowledge co-creation	- Digital communication platforms- Inter-agency collaboration frameworks
Contribution to Agricultural Transformation	Agricultural extension underpins national and regional strategies for achieving productivity growth, food security, and climate resilience. Its participatory and adaptive approach fosters inclusive innovation in line with regional frameworks such as CAADP.	- Strengthening food systems- Enhancing resilience and sustainability- Supporting climate-smart practices	- ICT-driven extension services- Community-based innovation hubs- Policy alignment for sustainable transformation

2.2 Innovation Systems Theory

Innovation Systems Theory provides a conceptual framework for understanding how knowledge creation, diffusion, and utilization occur through complex interactions among multiple actors. In the agricultural context, this theory emphasizes that

innovation is not a linear process driven solely by research institutions but an interactive system involving farmers, government agencies, private enterprises, NGOs, and educational institutions. The effectiveness of agricultural extension services depends largely on their ability to function as catalysts within this innovation ecosystem, linking

technological development with localized applications (Olasehinde, 2018) . Lundvall (2016) argues that innovation emerges through learning-by-doing and learning-by-interacting, making social and institutional networks essential for knowledge transfer.

In West Africa, the application of Innovation Systems Theory has helped reshape extension services from mere knowledge dissemination units to collaborative platforms that integrate research, policy, and market dynamics. According to Hall et al. (2017), agricultural innovation thrives when supported by strong feedback mechanisms and enabling institutions that promote experimentation and adaptive learning. Government extension systems, therefore, must align with broader innovation policies that foster inter-organizational linkages, technology diffusion, and capacity building. Studies reveal that when extension frameworks are structured around innovation system principles, farmers are more likely to adopt context-specific technologies and sustainable practices (World Bank, 2018). The integration of ICT and digital tools has further enhanced interactive learning and real-time feedback within these systems. However, challenges such as weak institutional coordination, inadequate funding, and insufficient policy coherence continue to hinder the operationalization of innovation systems across many West African countries. Addressing these challenges requires strengthening collaborative governance, promoting innovation intermediaries, and investing in capacity development for extension personnel to ensure sustained agricultural transformation.

2.3 Diffusion of Innovation in Rural Contexts

The diffusion of innovation theory, developed by Rogers (2015), explains how new ideas, technologies, and practices spread through populations over time. In the context of rural West Africa, this theory provides a critical lens for understanding how farmers adopt agricultural innovations introduced through government extension programs. Diffusion occurs through a social process that depends on communication channels, adopter categories, and the perceived relative advantage of innovations. Agricultural extension agents play a pivotal role as

change facilitators who influence adoption decisions by demonstrating the compatibility, simplicity, and effectiveness of new technologies (Scholten et al., 2018).

In rural communities, innovation adoption is influenced by socio-economic factors such as education, income, gender, and access to resources. As observed by Matuschke (2016), peer networks, farmer cooperatives, and local leadership significantly enhance innovation diffusion by creating trust and reducing uncertainty. The use of mobile communication, radio broadcasts, and community-based training has accelerated the diffusion of improved seeds, fertilizers, and irrigation technologies in many parts of West Africa. Nonetheless, diffusion challenges persist due to infrastructural deficits, risk aversion, and cultural resistance to change (Nsa et al., 2018) . Digital extension tools are increasingly mitigating these barriers by providing tailored, data-driven advisory services that enhance decision-making. The integration of behavioral economics into diffusion studies has further improved understanding of adoption behavior among rural farmers, highlighting the need for context-specific extension strategies. Overall, the diffusion of innovation framework underscores that successful agricultural transformation in West Africa hinges on participatory communication, adaptive learning, and institutional trust between farmers and extension systems.

III. METHODOLOGY

3.1 Research Design and Approach

This review adopts a qualitative research design guided by a systematic and interpretive approach to evaluate the effectiveness of government extension services in enhancing rural agricultural innovation across West Africa. The design integrates documentary analysis and comparative evaluation to synthesize findings from empirical studies, policy reports, and institutional assessments. Emphasis is placed on identifying thematic consistencies in extension program implementation, challenges, and innovation outcomes. Using a multi-country comparative framework, this approach enables an in-depth understanding of how contextual variables—

such as governance structures, socio-economic factors, and technological readiness—influence the efficiency of extension services (Bukhari et al., 2018; Menson et al., 2018; Olasehinde, 2018). Qualitative synthesis allows for a nuanced interpretation of institutional dynamics and their implications for innovation diffusion, rather than mere statistical generalization.

The analytical orientation follows a thematic synthesis method where insights are organized around core variables including institutional design, service delivery models, digital integration, and innovation adoption. Following the interpretive paradigm, the design acknowledges the interconnectedness of social, policy, and technological systems in shaping agricultural extension outcomes (Nsa et al., 2018; Scholten et al., 2018). The research thus employs a deductive-inductive reasoning blend—deductive in identifying theoretical constructs such as the Innovation Systems Theory and Diffusion of Innovation Model, and inductive in generating insights from observed regional patterns. This mixed interpretive orientation ensures that the research captures both empirical realities and theoretical coherence, aligning with established approaches in extension research (Anderson & Feder, 2017; Swanson & Davis, 2014; Ragasa et al., 2016). Overall, the research design emphasizes a critical, multi-dimensional, and comparative analysis that situates West Africa's extension systems within a broader developmental and technological transformation context.

3.2 Data Sources and Selection Criteria

The study relies on secondary data derived from a comprehensive review of scholarly literature, government policy documents, and development agency reports. Data sources include academic journals, institutional publications from the Food and Agriculture Organization (FAO), the World Bank, and regional agricultural research networks. Ten primary references were drawn from the curated document provided, representing diverse disciplinary insights and country-specific analyses across the 2014–2018 period. Complementary sources from Google Scholar were selected to ensure balance, credibility, and

regional representation. The inclusion criteria centered on relevance to government-led extension programs, innovation adoption, and rural transformation in the West African context.

Articles were included if they met at least one of the following: (a) discussed public extension frameworks or institutional reforms, (b) analyzed the relationship between extension services and technological innovation, or (c) presented empirical or comparative evidence on West African rural development. Studies emphasizing private or donor-driven initiatives without direct linkage to governmental systems were excluded. Preference was given to peer-reviewed sources published between 2014 and 2018 to ensure contemporary analytical relevance. Reports that combined quantitative outcomes with qualitative insights were prioritized for triangulation (Durowade et al., 2018; Solomon et al., 2018). The data extraction process involved identifying major themes, methodological similarities, and contrasting perspectives across selected works. This robust data selection ensures analytical rigor and enhances the validity of findings, supporting cross-country comparability and theoretical generalization within the study's scope (Anderson et al., 2015; Rivera & Alex, 2016; Davis & Terblanche, 2016; Spielman et al., 2017; Aker, 2016).

3.3 Analytical Framework

The analytical framework for this study is anchored on the Agricultural Innovation Systems (AIS) approach and Diffusion of Innovation (DOI) theory, integrating both institutional and behavioral dimensions of agricultural change. AIS provides a structural perspective for understanding the interdependencies between extension institutions, policy frameworks, and innovation networks, emphasizing collaboration among government agencies, research institutions, and farmers. DOI complements this by explaining how information flow, communication channels, and perceived utility influence technology adoption among rural populations (Rogers, 2015). The combined framework thus allows the study to evaluate not only the institutional efficiency of extension services but also their socio-psychological and technological impacts on rural innovation.

Data analysis follows a multi-stage interpretive process that begins with coding thematic categories, such as governance, training efficiency, and digital adoption, and progresses toward pattern recognition across regional contexts (Babatunde et al., 2014; Durowade et al., 2016; Osabuohien, 2017). This framework enables comparative insights into how different government approaches affect innovation diffusion and sustainability. The analytical model also integrates the systems thinking perspective, which views agricultural innovation as an outcome of continuous interaction between knowledge institutions, extension actors, and policy environments (Klerkx & Leeuwis, 2018; Birner et al., 2018; Spielman et al., 2017). This comprehensive interpretive mechanism ensures that both micro-level (farmer engagement) and macro-level (policy and governance) dimensions are addressed. In doing so, the study aligns its analysis with contemporary trends in development research that emphasize adaptive learning, participatory governance, and technology-driven agricultural transformation in West Africa.

IV. GOVERNMENT EXTENSION SERVICES IN WEST AFRICA

4.1 Historical Evolution and Institutional Structures

The evolution of agricultural extension services in West Africa reflects a complex interplay between colonial legacies, post-independence policy experimentation, and contemporary institutional reforms aimed at promoting rural innovation. Historically, extension systems emerged under colonial administrations that emphasized export-oriented agriculture and cash crop production, often neglecting food security and local innovation. Post-independence governments sought to reorient these systems toward national development goals, leading to the establishment of state-run agencies such as the Agricultural Development Programs (ADPs) in Nigeria, the Directorate of Agricultural Extension Services in Ghana, and similar institutions in Senegal and Sierra Leone (Durowade et al., 2018). These early initiatives were characterized by centralized planning, public financing, and hierarchical management structures that often prioritized administrative control over participatory learning.

By the 1980s and 1990s, structural adjustment programs and declining public budgets led to institutional reorganization, decentralization, and partial privatization of extension delivery. Governments began to collaborate with NGOs, farmer associations, and international development agencies to enhance efficiency and inclusivity (Menson et al., 2018). Over time, the adoption of pluralistic extension models expanded the range of actors involved in technology dissemination, while ICT integration introduced mobile and radio-based knowledge transfer systems (Olasehinde, 2018). Today, national frameworks emphasize participatory and demand-driven approaches, aligning with regional institutions like the Economic Community of West African States (ECOWAS) and the Comprehensive Africa Agriculture Development Programme (CAADP), which advocate coordinated policy action for agricultural innovation (Amegnaglo et al., 2017). Nonetheless, institutional fragmentation and inadequate resource allocation persist, constraining the full realization of these frameworks (Anderson & Feder, 2017). This historical trajectory underscores the shift from top-down, bureaucratic systems toward multi-stakeholder networks designed to foster innovation, knowledge sharing, and resilience among rural farmers.

4.2 National and Regional Extension Programs

Government extension programs across West Africa vary in structure, objectives, and operational scope, reflecting the diverse political economies of the region. Nigeria's National Agricultural Extension and Research Liaison Services (NAERLS) provides a model of federal coordination through research-extension linkages and the integration of ICT-enabled advisory services. Similarly, Ghana's Directorate of Agricultural Extension Services promotes participatory farmer field schools to strengthen innovation capacity among smallholders. In Senegal, the Agricultural and Rural Council System (ANCAR) adopts a public-private partnership model to deliver tailored extension support at community levels (Bukhari et al., 2018). Sierra Leone's Smallholder Commercialization Programme, supported by the Ministry of Agriculture and Forestry, focuses on improving access to technology and market-oriented extension services. These programs collectively

emphasize the integration of research institutions, universities, and farmers to co-create locally adapted innovations.

At the regional level, ECOWAS and the West and Central African Council for Agricultural Research and Development (CORAF/WECARD) coordinate agricultural policy frameworks that enhance intergovernmental collaboration, capacity building, and information exchange (Ragasa et al., 2016). Regional initiatives such as CAADP further promote the harmonization of extension standards, aiming to boost productivity and reduce rural poverty (Aker, 2016). However, despite policy alignment, implementation gaps remain due to weak institutional capacity, inconsistent funding, and limited monitoring mechanisms. Recent reforms have sought to incorporate digital advisory tools, e-extension platforms, and gender-sensitive approaches to strengthen inclusivity and scalability (Ayanbode & Essien, 2018). These developments reflect a gradual transition toward hybrid extension ecosystems that blend traditional interpersonal communication with technology-enabled advisory systems, positioning government programs as facilitators of innovation diffusion and sustainable agricultural transformation across West Africa.

4.3 Challenges Facing Extension Systems

Despite their strategic importance, government extension systems in West Africa face multifaceted challenges that undermine their effectiveness and sustainability. Institutional inefficiencies, insufficient funding, and inadequate human capacity remain primary constraints (Nsa et al., 2018). Many programs are hindered by bureaucratic fragmentation, poor coordination among ministries, and lack of accountability mechanisms, resulting in duplication of efforts and limited outreach to marginalized communities. The weak integration of research findings into extension curricula and limited collaboration between government agencies and private stakeholders have also constrained innovation dissemination (Durowade et al., 2016). Furthermore, gender disparities and low youth participation have restricted inclusivity, reducing the overall impact of extension initiatives.

Technological barriers further exacerbate these institutional weaknesses. While digital and mobile platforms offer new opportunities for service delivery, many rural areas still lack the infrastructure and literacy levels required for effective utilization (Solomon et al., 2018). Climatic uncertainties, conflicts, and market volatility compound these challenges, making extension planning highly unpredictable (Aker, 2016). Additionally, donor dependency and the absence of long-term sustainability frameworks limit the institutional autonomy of extension systems (Birner et al., 2018). Addressing these challenges requires reimagining extension beyond traditional information dissemination to include participatory co-learning, real-time data analytics, and climate-smart agricultural practices (Kristjanson et al., 2017). Strengthening human capacity, ensuring consistent funding, and promoting gender-responsive digital tools are vital for transforming extension services into resilient platforms that drive innovation, empowerment, and sustainable rural development across West Africa.

V. EVALUATING EFFECTIVENESS AND INNOVATION OUTCOMES

5.1 Assessment of Service Delivery Models

Agricultural extension in West Africa operates through pluralistic service delivery frameworks that combine government-led, private-sector, and non-governmental actors to foster innovation diffusion and enhance smallholder productivity. Despite the diversity of models, the government remains the primary provider, often constrained by limited institutional capacity and fragmented coordination (Bukhari et al., 2018). In Nigeria, the Agricultural Development Programs (ADPs) were initially effective in linking research institutions to farmers but have since suffered from bureaucratic delays and inconsistent funding (Menson et al., 2018). In contrast, Ghana and Senegal have adopted participatory models emphasizing multi-stakeholder engagement and decentralization, which improve responsiveness and accountability (Anderson & Feder, 2017). Studies by Swanson and Rajalahti (2014) affirmed that institutional pluralism enhances extension outreach

when backed by clear mandates and sustainable resource allocation.

Nonetheless, weak interagency coordination and inadequate policy coherence undermine service delivery efficiency. The absence of performance-based evaluation mechanisms and limited private-sector integration often restrict innovation scaling (Olasehinde, 2018). Comparative analyses across the region indicate that participatory and demand-driven models—such as Farmer Field Schools—yield better innovation outcomes by aligning services with farmer priorities (Ajayi & Gunn, 2017). Moreover, Klerkx et al. (2017) highlighted that flexible, network-oriented delivery structures outperform rigid bureaucratic models in adapting to rapid technological change. As such, a hybrid extension approach that harmonizes public oversight with private-sector dynamism and community participation appears most effective for achieving rural agricultural innovation and sustainability across West Africa.

5.2 Impact on Farmer Productivity and Technology Adoption

Government extension services significantly influence productivity growth and technology adoption among smallholder farmers in West Africa. Bukhari et al. (2018) found that targeted extension programs promoting improved seed varieties, fertilizers, and irrigation technologies enhance yield performance by up to 30%. Similarly, Menson et al. (2018) noted that participatory demonstration plots and farmer training

centers in Nigeria and Ghana encourage experiential learning, increasing the rate of innovation diffusion. Ragasa et al. (2016) identified that the frequency and quality of contact between farmers and extension agents directly affect technology adoption. This finding aligns with Kassie et al. (2015), who revealed that adoption of sustainable agricultural practices rises when extension incorporates localized training and farmer feedback. Furthermore, Olasehinde (2018) emphasized that gender-inclusive extension programs improve women’s participation in innovation activities, particularly in agro-processing and storage technologies.

Despite these gains, challenges persist in achieving widespread adoption. Benin et al. (2018) observed that underfunding and staff shortages reduce service coverage, limiting the reach of innovation programs. Msuya and Annor-Frempong (2017) noted that while farmer field schools have been instrumental in capacity building, many extension models lack mechanisms for continuous technical support. Similarly, Davis et al. (2016) argued that performance monitoring and incentive-based systems increase accountability and productivity. According to Teklewold et al. (2017), integrated extension services that link agronomic training with market access yield higher innovation outcomes. Hence, strengthening extension institutions through improved funding, agent training, and participatory monitoring systems remains critical for maximizing technology adoption and productivity enhancement in West Africa as seen in table 2..

Table 2: Summary of Key Findings on the Impact of Government Extension Services on Farmer Productivity and Technology Adoption in West Africa

Focus Area	Key Insights	Observed Outcomes	Policy Implications
Extension Program Design and Implementation	Targeted extension programs promoting improved seed varieties, fertilizers, and irrigation technologies significantly boost productivity and innovation. Participatory demonstration plots and farmer training centers enhance experiential learning and knowledge transfer.	Yield performance increased by up to 30%, with greater diffusion of new technologies and improved production efficiency among smallholders.	Governments should strengthen agricultural extension frameworks through targeted, data-driven, and participatory approaches to enhance innovation uptake.

Focus Area	Key Insights	Observed Outcomes	Policy Implications
Quality of Farmer-Agent Interaction	Frequent and high-quality contact between farmers and extension agents leads to better technology adoption and sustained innovation behavior. Localized and farmer-centered training improves learning outcomes.	Increased adoption of sustainable agricultural practices and improved capacity for decision-making on farm inputs and management techniques.	Extension systems should emphasize continuous engagement, localized training, and feedback integration to align services with farmer needs.
Gender Inclusion and Equity	Gender-inclusive extension services promote active participation of women in agricultural innovation, particularly in processing and post-harvest technologies.	Enhanced women's involvement in agro-processing, storage, and small-scale agribusiness development, contributing to household income diversification.	Extension models must incorporate gender equity strategies to close participation gaps and promote inclusive agricultural innovation.
Institutional and Funding Challenges	Inadequate funding, staff shortages, and lack of continuous technical support limit the scale and effectiveness of extension services. Performance-based monitoring and market-linked training improve efficiency.	Limited outreach capacity and uneven access to modern technologies, reducing productivity gains across rural areas.	Increased investment in extension workforce development, sustainable financing, and participatory monitoring is needed to sustain productivity and innovation adoption.

5.3 Role of Digital and Mobile Extension Platforms

Digital and mobile-based extension services are reshaping agricultural innovation systems by improving access to timely information, fostering inclusion, and strengthening decision-making. Olasehinde (2018) highlighted that mobile advisory platforms in Nigeria and Ghana have democratized agricultural information, allowing farmers to receive weather forecasts, pest alerts, and input prices via SMS. Bukhari et al. (2018) found that digital tools reduce transaction costs and bridge spatial gaps between rural communities and extension agents. Aker et al. (2016) similarly observed that ICT adoption enhances knowledge transfer efficiency, while Baumüller (2018) emphasized the potential of mobile applications to increase smallholder resilience. Moreover, Nakasone and Torero (2016) revealed that ICT-enabled services improve communication transparency and promote adaptive farming strategies, particularly under climate uncertainty.

However, the digital divide persists across rural West Africa, driven by inadequate infrastructure, high data costs, and low digital literacy. Menson et al. (2018) pointed out that most mobile-based initiatives are donor-dependent, raising concerns about sustainability. According to Rivera and Qamar (2014), integrating e-extension into broader institutional frameworks requires capacity-building and localized content development. World Bank (2015) findings corroborate that hybrid digital-human approaches are more effective than fully automated systems in developing contexts. Similarly, Benin et al. (2018) argued that establishing centralized agricultural data repositories enhances service coordination. In line with Klerkx et al. (2017), institutionalizing digital tools within national innovation systems can accelerate technology diffusion, reduce knowledge asymmetry, and foster inclusive agricultural transformation in the region.

5.4 Comparative Analysis Across Selected Countries

A comparative analysis of extension systems across West Africa reveals both shared challenges and context-specific successes. Bukhari et al. (2018) reported that Nigeria's Agricultural Development Programs remain central to innovation diffusion but are limited by inconsistent funding and administrative inefficiencies. Conversely, Ghana's decentralized model, supported by ICT-based advisory services, has improved knowledge dissemination and technology adoption rates (Menson et al., 2018). Senegal's participatory approach integrates local councils into extension planning, enhancing accountability and resource allocation (Olasehinde, 2018). Ragasa et al. (2016) noted that cross-sectoral collaboration, especially between research institutes and farmers, improves innovation uptake. Similarly, Etwire et al. (2017) found that collaborative innovation networks in Ghana promote adaptive learning and increase resilience to environmental stress.

Despite these advancements, regional disparities in service quality persist. Davis et al. (2016) identified weak evaluation mechanisms and limited data analytics capacity as critical bottlenecks. Benin et al. (2018) noted that fragmented policy frameworks hinder regional knowledge exchange. Swanson and Rajalahti (2014) underscored that participatory governance and performance-based extension significantly enhance effectiveness. Aker et al. (2016) and Baumüller (2018) highlighted that nations integrating digital innovations within participatory frameworks demonstrate higher innovation diffusion rates. According to Birmer and Anderson (2017), sustained reform requires harmonized institutional mandates and intergovernmental coordination. The comparative insights emphasize that while Ghana and Senegal exemplify adaptive models, regional alignment, continuous capacity building, and policy coherence remain essential for strengthening extension effectiveness and advancing rural innovation across West Africa.

VI. CONCLUSION AND POLICY RECOMMENDATIONS

6.1 Summary of Key Findings

This review established that government extension services remain indispensable for promoting agricultural innovation, rural productivity, and sustainable development in West Africa. Despite the diversity of national frameworks, extension systems across the region share similar structural limitations—most notably weak institutional coordination, inadequate funding, and insufficient monitoring mechanisms. Evidence indicates that the traditional top-down model of service delivery, while historically dominant, has not adequately fostered participatory learning or farmer-driven innovation. Conversely, pluralistic and decentralized approaches, integrating public agencies, private firms, and community organizations, have shown stronger performance in aligning agricultural knowledge systems with farmers' real-world needs. Participatory models, such as Farmer Field Schools, have proven effective in enhancing experiential learning, peer-to-peer knowledge sharing, and local problem-solving capacities.

The review further highlights that digital transformation is reshaping extension systems through mobile-based advisory services, e-extension platforms, and information and communication technologies (ICTs) that enable real-time interaction between farmers and service providers. However, infrastructural limitations, low digital literacy, and the digital divide continue to constrain widespread implementation. Additionally, comparative evidence from Ghana, Nigeria, and Senegal underscores that extension programs grounded in inclusivity, gender sensitivity, and adaptive governance yield more resilient innovation outcomes. Overall, while extension services have made notable progress in improving farmer productivity and technology adoption, their transformative potential remains contingent upon strategic reforms that strengthen institutional linkages, enhance data-driven management, and promote accountability in service delivery.

6.2 Policy Implications

The findings of this review carry profound implications for policy formulation and institutional reform in West African agricultural systems. First, policymakers must recognize that extension services are not merely technical mechanisms but social systems that facilitate innovation, knowledge co-creation, and rural empowerment. Strengthening these systems therefore requires integrated policy approaches that promote collaboration across research institutes, local governments, and farmer associations. National agricultural strategies should prioritize capacity-building for extension agents, ensuring that they are equipped with both technical expertise and communication skills necessary for participatory engagement. Governments must also allocate sustained funding and embed monitoring and evaluation frameworks within extension programs to enhance accountability and impact measurement.

Moreover, the growing role of ICT-driven extension necessitates digital policy reforms that improve rural connectivity, support mobile infrastructure, and incentivize the development of localized agricultural content. Policies encouraging public-private partnerships can further diversify service delivery and foster innovation ecosystems linking universities, agribusinesses, and farming cooperatives. Gender-responsive policy design is equally critical, as women farmers remain underrepresented in extension participation despite their central role in agricultural production. Regionally, harmonized policy frameworks—coordinated through ECOWAS or the African Union—could facilitate cross-country learning, reduce redundancy, and accelerate technology diffusion. Hence, effective policy responses must blend decentralization, inclusivity, and technological modernization to achieve sustainable agricultural innovation across West Africa.

6.3 Strategic Recommendations for Future Extension Reforms

Future reforms in government extension services should prioritize institutional integration, technological adaptation, and participatory governance to maximize agricultural innovation

outcomes. Firstly, governments should strengthen coordination among research institutes, extension agencies, and local governments through shared databases and collaborative platforms that enable evidence-based decision-making. Establishing national agricultural innovation councils or multi-stakeholder coordination bodies could facilitate this integration. Secondly, reforms must focus on human resource development by modernizing training curricula for extension agents, incorporating climate-smart agriculture, digital literacy, and market-oriented advisory skills. This will enhance responsiveness to emerging environmental and socio-economic challenges.

Thirdly, digital transformation must be institutionalized, not treated as a temporary donor-driven initiative. Governments should invest in ICT infrastructure, create enabling regulatory environments for agri-tech startups, and expand access to affordable mobile services in rural areas. Fourthly, sustainability requires community ownership—therefore, embedding participatory planning processes, farmer-led monitoring, and local innovation platforms into extension systems will increase effectiveness and accountability. Moreover, adopting performance-based funding mechanisms tied to measurable outcomes—such as technology adoption rates and yield improvements—can incentivize efficiency. Finally, regional cooperation among West African countries should be deepened through shared policy frameworks, training exchanges, and innovation networks. By integrating these strategic reforms, government extension systems can evolve into dynamic, data-driven, and inclusive institutions that catalyze rural transformation, enhance food security, and drive sustainable agricultural innovation across West Africa.

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