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BREAKING BARRIERS TO UNLOCK ONE HEALTH IN AGRICULTURAL EXTENSION SERVICE FOR SUSTAINABLE RURAL TRANSFORMATION

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Abstract

The One Health approach, which emphasizes the interdependence of human, animal, and environmental health, holds immense promise for sustainable transformation of rural areas. Agricultural extension services, as frontline conduits between science and rural communities, are uniquely positioned to operationalize One Health principles but face significant barriers such as institutional fragmentation, limited resources, capacity gaps, and social constraints. This review examines these challenges in depth, drawing on recent empirical studies and global case examples. It further proposes evidence-based strategies such as policy integration, interdisciplinary capacity building, digital innovations, and participatory community engagement approaches, and a framework that can unlock One Health's transformative potential in agricultural extension. This integration is vital for addressing complex rural challenges, from zoonotic diseases to environmental degradation, in the end contributing to resilient and sustainable rural livelihoods.

Keywords: One Health, Agricultural Extension Service, Rural Development, Sustainability, Policy Integration

1. Introduction

Agricultural extension has long served as a critical bridge connecting research and rural farmers, traditionally focusing on improving agricultural productivity and livelihoods through knowledge transfer and technology dissemination (Anderson & Feder, 2004). However, rural communities today face multidimensional challenges that extend beyond farming to encompass human health, animal health, and environmental sustainability (Zinsstag et al., 2011). The One Health approach, which recognizes the inseparable links among these domains, provides a comprehensive

framework for addressing such intertwined challenges (Destoumieux-Garzón et al., 2018).

As a result, integrating One Health into agricultural extension can significantly enhance rural development outcomes by promoting holistic health management, controlling zoonotic diseases, improving nutrition, and ensuring environmental conservation. For example, by enabling extension agents to deliver integrated messages on crop management, livestock health, and human hygiene, communities become better equipped to prevent disease outbreaks, reduce antibiotic resistance, and mitigate environmental degradation (Buregyeya et al., 2020).

However, despite the promise of this much needed integration, the operationalization of One Health within agricultural extension service remains limited, primarily due to structural, technical, financial, and cultural barriers. This paper therefore explores these barriers in detail and synthesizes emerging strategies and innovations that can facilitate the integration of One Health principles into agricultural extension system, thereby driving sustainable rural transformation.

2. Barriers to Integration of One Health into Agricultural Extension

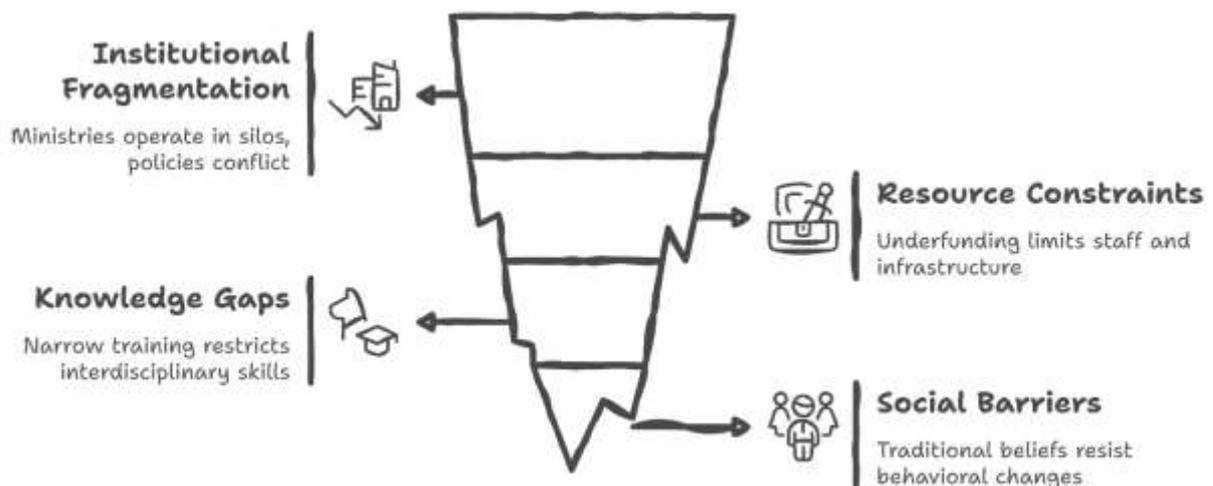


Fig. 1: Barriers to Integration of One Health into Agricultural Extension Service

2.1 Institutional Fragmentation

A primary barrier is the fragmentation of sectors responsible for agriculture, human health, animal health, and environment. These sectors traditionally operate under separate ministries or agencies with distinct mandates, budgets, and priorities (Omuse et al., 2025). This siloed governance structure impedes the coordinated delivery of integrated extension services required for One Health.

In many low and middle income countries (LMICs), agricultural extension agencies rarely collaborate closely with veterinary or public health services. For instance, Nyokabi et al. (2023) highlight that in East African countries, the lack of formal coordination mechanisms leads to duplicated efforts and missed opportunities for joint zoonotic disease surveillance and prevention through extension services. Similarly, Buregyeya et al. (2020) document institutional gaps in Uganda where

agricultural and health extension programs operate independently, limiting holistic outreach.

Moreover, policy environments often lack harmonized frameworks that embed One Health principles across sectors. Contradictory or overlapping regulations hinder joint planning, funding, and monitoring (Raja, 2024). Without supportive governance, efforts to mainstream One Health within extension system remain fragmented and unsustainable.

2.2 Resource Constraints

The current services offered by the Agricultural extension system in many LMICs face chronic underfunding and limited human resources (Rivera & Qamar, 2003; Karodia, 2013). The recent COVID-19 pandemic further exposed resource vulnerabilities in extension infrastructure and service delivery (Ayisi-Nyarko et al., 2024). Financial constraints restrict recruitment of skilled staff with interdisciplinary expertise necessary for One Health, limit training opportunities, and hinder logistics such as transport and communication (Nguyen-Viet et al., 2025).

For example, Ibrahim (2024) reports that in Nigeria, extension workers lack both the materials and technical knowledge to adequately incorporate nutrition and zoonotic disease control in their advisory services. Similarly, Buregyeya et al. (2020) emphasize how limited access to digital tools and poor internet connectivity constrain One Health outreach in rural Uganda. These challenges highlight the urgent need for innovative funding solutions and partnerships that can enhance the capacity of extension services, which in the end improve agricultural productivity and public health outcomes, especially in vulnerable regions. Collaborative initiatives involving local communities, governments, and NGOs could play a pivotal role in addressing these pressing concerns.

2.3 Knowledge Gaps

Agricultural extension workers typically receive training focused on crop or livestock production and management, with limited exposure to integrated One Health concepts encompassing human health and environmental sustainability (Effiong & Aboh, 2024). This creates capacity gaps that limit the extension workforce's ability to deliver comprehensive One Health messages or recognize complex interconnections between agricultural practices and zoonotic risks (Wako et al., 2025).

Besides, the current institutional curricula and training programs seldom incorporate interdisciplinary learning or systems thinking approaches that are essential for One Health (Cai et al., 2024). Ongoing professional development opportunities that build competencies in disease ecology, nutrition, ecosystem management, and social behaviour change communication are scarce (Nguyen-Viet et al., 2025). To address these gaps, it is vital to develop targeted training initiatives that enhance knowledge and skills, which would foster a more holistic understanding of the complex relationships among agriculture, health, and the environment.

2.4 Social Barriers

Rural communities often adhere to traditional beliefs and customs governing farming, animal husbandry, and health practices (Mafimisebi & Oguntade, 2010). Resistance to changing entrenched behaviours or skepticism towards modern health

interventions can limit acceptance and adoption of One Health-integrated extension services (Rimi et al., 2016). Similarly, gender dynamics and social hierarchies also affect participation and access to extension services. Women, who play key roles in agriculture and household health, frequently face barriers in accessing information and resources (Midamba & Ouko, 2024).

In this regard, culturally insensitive approaches risk alienating marginalized groups, undermining the inclusiveness and effectiveness of One Health extension programs. Combating these requires fostering community engagement through participatory methods to enhance understanding and promote dialogue, leading to a more effective integration of local knowledge and practices with innovative solutions in health and agriculture. This collaborative approach can empower communities and facilitate a more holistic understanding of health challenges and nexus preached by the One Health.

3. Strategies and Innovations to Overcome Barriers

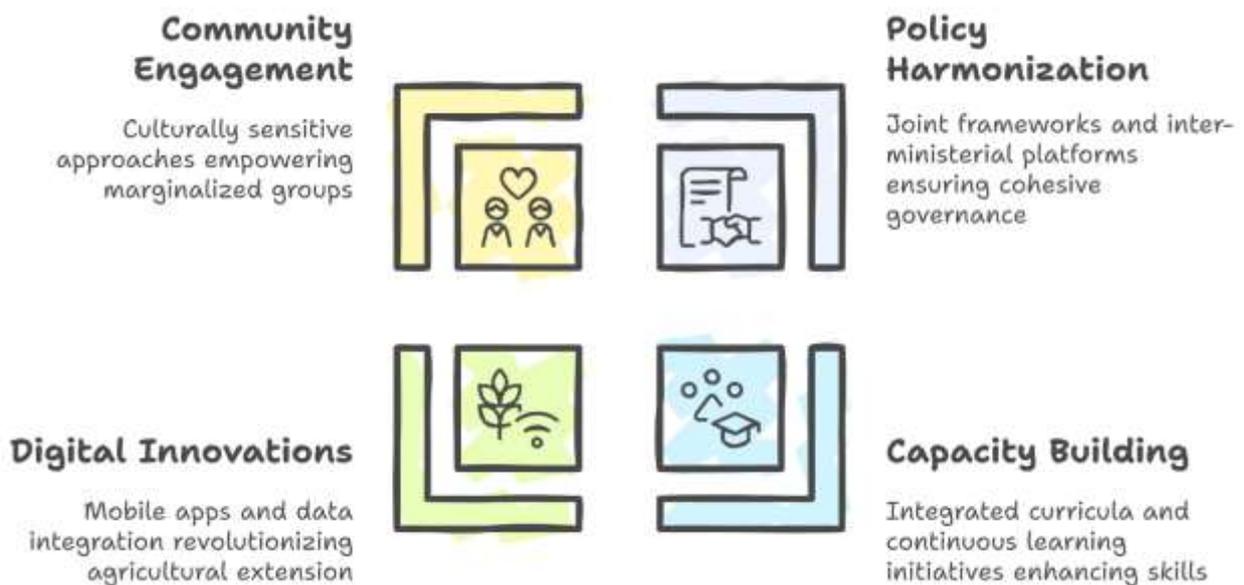


Fig. 2: Strategies and Innovations to Overcome Barriers to Integration of One Health into Agricultural Extension Service

3.1 Policy Harmonization

Establishing formal inter-ministerial One Health platforms or task forces can facilitate joint planning, budgeting, and monitoring. To address institutional fragmentation, countries must develop integrated policy frameworks aligning agricultural, health, and environmental goals (Raja, 2024). Successful examples include Uganda’s One Health coordination platforms that enable agricultural, veterinary, and public health agencies to share data and coordinate extension activities (Buregyeya et al., 2020; Nyokabi et al., 2023). Embedding One Health objectives within national agricultural extension policies and strategies institutionalizes integrated approaches (Destoumieux-Garzón et al., 2018).

Moreover, developing partnerships between government, academia, and civil society can enhance knowledge sharing and resource mobilization, resulting into resilient

health systems and sustainable agricultural practices that benefit both communities and ecosystems.

3.2 Capacity Building

Mainstreaming One Health into agricultural extension service requires expanding curricula to cover zoonotic diseases, ecosystem health, nutrition, and interdisciplinary collaboration. Tiku et al. (2024) observed that universities and other training institutions should incorporate One Health modules to build foundational competencies.

Continual professional development through workshops, mentoring, and exchange visits can also enhance extension agents' skills and motivation (Nguyen-Viet et al., 2025). Interdisciplinary training encourages systems thinking and equips extension workers to complex support rural health and address sustainability challenges.

So, agricultural and health sectors most work collaboratively to facilitate capacity building through knowledge sharing and exchange of skills, leading to innovative solutions that benefit both community health and agricultural productivity. Such integration is requisite to overcome barriers to integration of One Health into agricultural extension service and create adaptable food systems.

3.3 Digital Innovations

Digital tools offer scalable solutions for overcoming resource and capacity constraints. Mobile phones, SMS platforms, apps, and online portals enable rapid dissemination of One Health information, data collection, and farmer engagement (Zhang et al., 2024; Buregyeya et al., 2020).

For example, a mobile-based surveillance system in Uganda integrated livestock and crop health data, improving early detection of zoonotic outbreaks and facilitating coordinated responses (Buregyeya et al., 2020). E-extension platforms in India have enhanced farmer access to nutrition-sensitive One Health education (Prashant et al., 2023).

These digital innovations foster community collaboration, empowering farmers with knowledge and resources, thereby promoting sustainable agricultural practices that enhance food security and public health initiatives across diverse regions.

3.4 Community Engagement

Successful One Health extension demands culturally sensitive community engagement. Participatory rural appraisal techniques enable identification of local priorities and co-design of relevant interventions (Suluk et al., 2024).

Empowering women and marginalized groups enhances inclusivity and leverages indigenous knowledge, which is vital for contextualizing One Health practices. Building trust through continuous dialogue and respect for local customs fosters sustainable behaviour change (Arif, 2024).

Integrating local leaders and stakeholders into the decision-making process can further bolster community commitment. Participatory engagements such as educational workshops and training sessions tailored to specific cultural contexts can

also enhance understanding and acceptance, ensuring that One Health initiatives are effectively adopted and sustained across communities.

4. Case Studies and Examples

4.1 Rwanda Dairy Development Project (RDDP)

RDDP exemplifies an agriculture initiative that integrates the One Health approach, aimed to enhance dairy farming practices while promoting sustainability and resilience. It led to increased milk production, improved livelihoods for farmers, and enhanced food security. The project has contributed to a healthier environment, reduced disease transmission risks, and promoted sustainable agricultural practices. RDDP's holistic approach serves as a model for integrating health considerations into agricultural development (Duncan et al., 2022).

4.2 GIZ's One Health and Agroecology Project, India

The project exemplifies an integrated approach to agriculture that harmonizes human, animal, and environmental health. Running from October 2021 to March 2026, this initiative underscores the interdependence of these health domains, particularly in a densely populated country like India, where zoonotic diseases pose significant risks (GIZ, 2021).

4.3 Agricultural Extension Reforms in Nigeria

Recent reforms expanded extension mandates to include nutrition (J-PAL, 2023) and zoonotic disease prevention (Nana et al., 2022), though challenges related to capacity and resources remain (Ibrahim (2024).

4.4 One Health Surveillance in Uganda

Uganda's mobile-based disease surveillance platform improved coordination between veterinary, agricultural, and public health sectors, enhancing early warning systems and response capacities (Buregyeya et al., 2020).

5. Framework for One Health-Driven Sustainable Rural Transformation Integration through Agricultural Extension Service

Sustainable rural transformation requires an all-inclusive integrated approach to address the complex interplay between agriculture, human health, animal health, and environmental sustainability. The **One Health** concept which recognizes the interconnection between people, animals, plants, and their shared environment provides an effective foundation for such a transformation.

At the center of this framework lies **Agricultural Extension Services (AES)**, which serve as the conduit for information flow, capacity building, innovation dissemination, and community engagement. This framework presents a **systems diagram** to visualize the relationships among various components that contribute to rural sustainability through a One Health lens (Fig.

3).

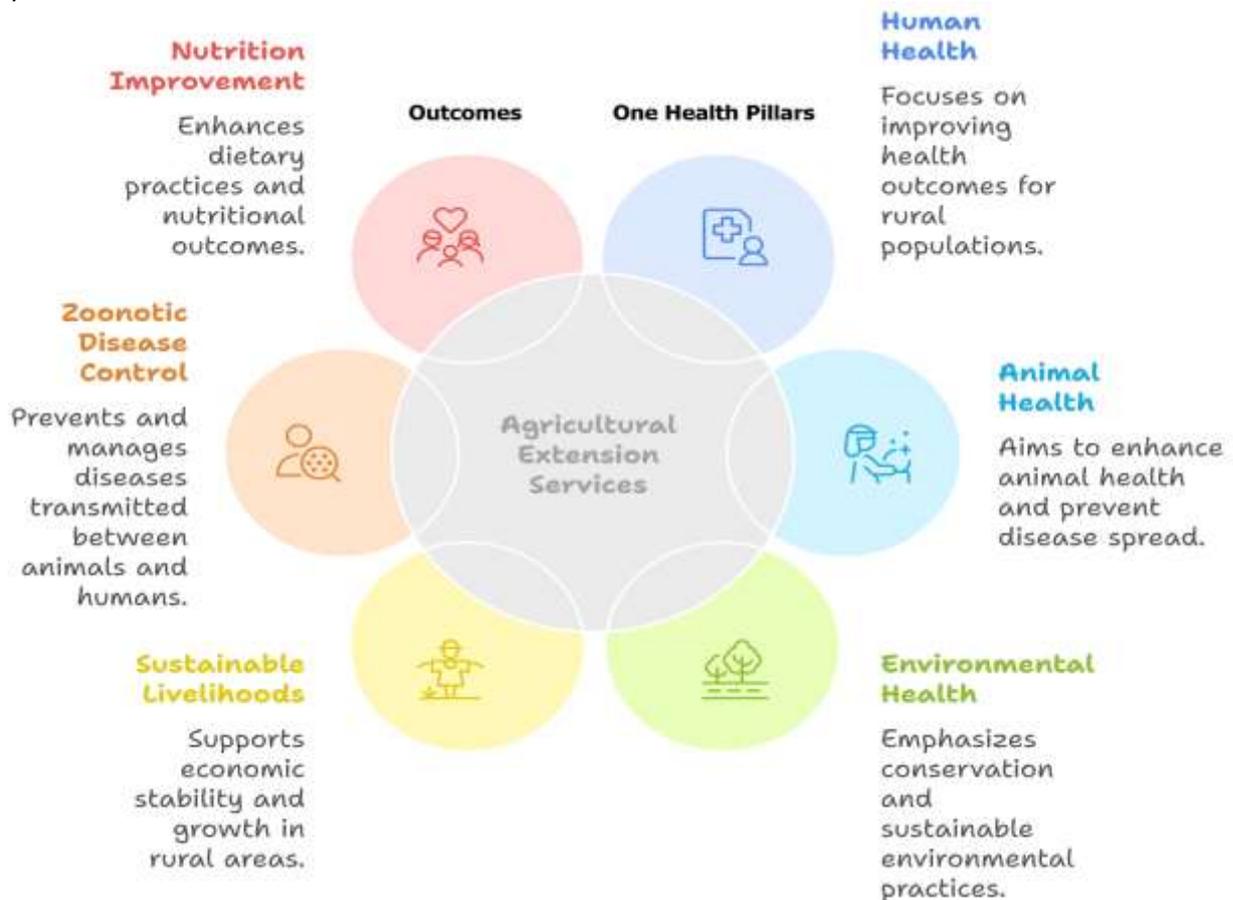


Fig. 3: Framework for One Health-Driven Sustainable Rural Transformation Integration through Agricultural Extension Service

Core Components of the Framework

1. **Agricultural Extension Services (AES):** act as the knowledge broker and catalyst, facilitating integration across sectors by being the conduit:
 - ❖ Transferring knowledge and technologies
 - ❖ Coordinating One Health activities at the community level
 - ❖ Bridging stakeholders: researchers, farmers, veterinarians, health workers, environmentalists, and policymakers
2. **One Health Pillars:** These three interconnected domains underpin the health and sustainability of rural systems:
 - ❖ **Human Health:** Nutrition, disease prevention, water and sanitation, healthcare access
 - ❖ **Animal Health:** Livestock management, veterinary care, zoonotic disease control
 - ❖ **Environmental Health:** Ecosystem services, land use, biodiversity, water quality
3. **Desired Outcomes**
 - ❖ **Sustainable Rural Livelihoods:** Income diversification, climate resilience, food security
 - ❖ **Zoonotic Disease Control:** Reduced transmission of diseases between animals and humans

- ❖ **Environmental Conservation:** Sustainable resource management, pollution control
- ❖ **Nutrition Improvement:** Better dietary diversity, reduced malnutrition

Key Inter-linkages of the Framework

1. Agricultural Extension ↔ One Health Components

- ❖ AES delivers information on safe livestock handling (animal health), crop diversification for nutrition (human health), and agroecological practices (environmental health).
- ❖ Facilitates surveillance and early warning systems for zoonotic outbreaks.

2. One Health ↔ Outcomes

- ❖ Improved animal health leads to higher productivity and fewer zoonoses.
- ❖ Environmental conservation supports sustainable agriculture, clean water, and biodiversity.
- ❖ Human health interventions improve labor productivity and resilience.

Functional Dynamics of the Framework

1. Information Flow

- ❖ Knowledge moves from **research institutions** → **AES** → **community**.
- ❖ Community feedback moves from **grassroots** → **AES** → **policymakers/researchers**, adjusting strategies dynamically.

2. Resource Optimization

- ❖ Avoid duplication of services by integrating veterinary, environmental, and human health campaigns.
- ❖ Use AES to synchronize vaccination programs, water management, and climate adaptation.

3. Risk Reduction

- ❖ By addressing environmental degradation, improving animal management, and enhancing human health, the system reduces vulnerability to shocks (e.g., pandemics, climate change, and market disruptions etc.).

This framework anchored in Agricultural Extension Services creates a resilient, adaptive, and participatory system that can sustainably improve rural livelihoods. With favourable policy structures, technology deployment, and community participation, this model addresses the root causes of rural vulnerability while enhancing synergies across sectors. The integration is not just theoretical, but also a practical imperative in a world facing climate change, emerging diseases, and food insecurity.

6. Conclusion

Agricultural extension services stand at a critical link for operationalizing One Health principles to foster sustainable rural transformation as underscored in the present review. Addressing the discussed barriers through sustainable strategies and innovations is essential to unlock this potential link. The evidences revealed that

these strategies and innovations are interdependent: policies enable funding and collaboration; capacity building ensures skilled extension agents; digital tools overcome infrastructural gaps; and community engagement ensures cultural relevance and sustainability. Notably, gender and social inclusion must be mainstreamed throughout. Such integration promises improved human, animal, and environmental health outcomes, resilience against emerging zoonoses, and enhanced rural livelihoods globally in line with the developed framework. Future research should explore context-specific barriers and innovations, assess the long-term impacts of integrated extension on rural health and sustainability, and develop scalable models for diverse socioecological settings.

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