



Constraints and Strategies in Scaling up of Innovations in Agricultural Extension: Insights from Telangana and Andhra Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Agricultural extension innovations are being adopted to tackle local challenges and enhance service delivery to farmers in terms of reach, efficiency, and relevance. Yet, their widespread scaling continues to face barriers due to systemic and contextual limitations. This study aimed to identify key constraints and propose tailored strategies for scaling up four major innovations: Farmer-Led Seed Production System (FLSPS), Saagu Baagu: E-MIRCHA, Rythu Seva Kendras (RSK), and Andhra Pradesh Community Managed Natural Farming (APCNF). The study was conducted in purposively selected districts across Andhra Pradesh and Telangana, covering 320 stakeholders

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i.e., 80 per innovation system representing Government agencies, NGOs, farmer organizations, and grassroots actors. Using the Garrett ranking technique, constraints were analyzed and prioritized. Results revealed that in FLSPS, lack of certified quality labs and limited storage and drying infrastructure were top-ranked issues. E-MIRCHA faced major barriers in terms of weak digital infrastructure and low digital literacy among farmers. For RSK, political interference and inadequate staff capacity were key impediments. In APCNF, delayed input supply and weak scientific validation emerged as the top challenges. These findings reflect broader concerns across innovation systems, including governance gaps, poor market access, limited financial support, and weak integration with existing institutional frameworks. Based on these insights, context-specific strategies were suggested—such as decentralized governance, performance-linked incentives for staff, public-private partnerships for infrastructure and technology, localized digital tools, and convergence with existing rural development schemes like NRLM and MGNREGS. The study concludes that sustainable scaling requires adaptive models grounded in institutional integration, continuous capacity building, and stronger farmer-centric data systems. Generating robust evidence, securing political and financial support, and integrating innovations into existing socio-political systems are key to ensuring their long-term impact and scalability in India's diverse agricultural context.

Keywords: *Innovations in agricultural extension; constraints; scaling up; strategies.*

1. INTRODUCTION

Agricultural extension plays a pivotal role in transforming smallholder farming by bridging the gap between scientific research and on-ground practices. Over the past decade, the focus has increasingly shifted towards promoting innovative approaches (Rai et al., 2023), encompassing farmer-led models, digital platforms, decentralized input delivery systems, and natural farming frameworks. Notable examples in this regard include the Federation-Led Seed Production System (FLSPS), *Saagu Baagu: E-Mircha*, Rythu Seva Kendras (RSKs), and the Andhra Pradesh Community Managed Natural Farming (APCNF) program each representing distinct institutional and technological models designed to enhance agricultural productivity, sustainability, and farmer empowerment.

The broader impact of these innovations, however, hinges on their scalability, defined as the capacity to adapt, sustain, and expand models across diverse agro-ecological and socio-political contexts (Hall et al., 2005). Despite promising pilot outcomes, scaling-up has been hindered by multiple constraints, including institutional fragmentation, inadequate capacity-building mechanisms, weak stakeholder coordination, limited policy integration, and the absence of adaptive financing frameworks (Douthwaite et al., 2003; Klerkx et al., 2012). Additional barriers such as power asymmetries among actors, political interference, insufficient digital infrastructure, and behavioural change challenges further constrain widespread adoption. For instance, APCNF's integration of

agroecological principles into input-intensive farming systems necessitates not only farmer participation but also institutional reform, while RSKs face persistent issues related to supply chain efficiency and local accountability (Spielman et al., 2009).

Anderson and Feder (2004) underscore that scaling agricultural extension in developing countries is often impeded by inadequate funding, weak political support, administrative inefficiencies, and poor linkages with research institutions. Extension systems are frequently overburdened, fiscally unsustainable, and overly dependent on short-term donor-funded projects lacking long-term viability. Addressing these challenges demands decentralized and private-sector-inclusive models, stronger research-extension linkages, robust monitoring mechanisms, and sustained government commitment through adequate funding and enabling policies.

Gossaye (2017) emphasizes that financial resources and partnerships are critical enablers for scaling, with the absence of action plans, budgets, and internal buy-in severely limiting progress. He advocates collaborative scaling, with technology companies playing a leading role and agencies such as the Agricultural Transformation Agency (ATA) coordinating stakeholders. Mulierman et al. (2018) identify path dependencies, funding pressures, and tensions between participatory approaches and the pursuit of rapid impact as key constraints, calling for scenario planning, contextual adaptation, and stakeholder empowerment rather

than rigid replication of models. Similarly, Gillespie (2004) points to context mismatches, capacity gaps, short-termism, weak learning systems, and poor integration into national frameworks, arguing for locally tailored, demand-driven, and long-term strategies embedded in government systems with strong monitoring and evaluation.

Against this backdrop, the present study critically examines the constraints to scaling-up four agricultural extension innovations in Telangana and Andhra Pradesh viz., FLSPS, *E-Mircha*, RSK, and APCNF. These cases embody diverse institutional, digital, and agroecological approaches, yet share common challenges related to institutional integration, stakeholder coordination, capacity building, and policy support. By adopting a systems thinking approach and analysing stakeholder roles and institutional arrangements, the research seeks to identify systemic and context-specific barriers as well as enabling factors for scaling. The insights generated are expected to inform policy, guide institutional strategies, and support the development of context-sensitive, sustainable, and farmer-centric extension models, thereby contributing to the strengthening of agricultural innovation systems (Leeuwis & Aarts, 2011; Sulaiman & Hall, 2004).

2. METHODOLOGY

2.1 Area of the Study

The present study was conducted in the states of Andhra Pradesh and Telangana, where the selected innovation systems: FLSPS, Saagu Baagu: *E-MIRCHA*, Rythu Seva Kendras (RSKs), and Andhra Pradesh Community Managed Natural Farming (APCNF)—are currently being implemented. Specific districts were purposively selected for each innovation system based on their active participation and relevance to the respective interventions. For APCNF, Anantapur district in Andhra Pradesh was chosen due to its extensive implementation and farmer engagement under the program. In the case of FLSPS, the erstwhile Mahabubnagar district in Telangana was selected for its prominent role in community-based paddy seed production. For RSK, the erstwhile West Godavari district in Andhra Pradesh was identified as one of the best-performing regions in terms of RSK infrastructure and outreach. Finally, Khammam district in Telangana was selected for the Saagu Baagu: *E-MIRCHA*

initiative, as it recorded a high concentration of participating farmers among the implementation districts. These districts represent diverse agro-ecological, institutional, and operational settings, offering valuable insights into the constraints and strategies related to scaling up agricultural extension innovations.

2.2 Sampling Procedure

The selection of respondents for this study was purposive and criterion-based, ensuring representation of key stakeholders involved in the design, implementation, and participation across four agricultural extension innovation systems: FLSPS, *E-MIRCHA*, Rythu Seva Kendras (RSK), and Andhra Pradesh Community Managed Natural Farming (APCNF). Districts and clusters were selected based on active program implementation and stakeholder engagement.

In the case of **FLSPS**, two clusters—Gadwal and Narayanpet—under the Sahaja Beej Federation in the erstwhile Mahabubnagar district of Telangana were selected for their prominent engagement in paddy seed production. One FPO from each cluster was chosen based on the scale of seed operations. The sample included two Cluster Directors, two FPO CEOs, ten Board of Directors (five from each FPO), four agricultural experts from the Centre for Sustainable Agriculture (CSA), and two Krishi Vigyan Kendra (KVK) officers from Madanapuram. Sixty farmers were also selected: 30 seed-producing farmers (15 per cluster) and 30 FPO farmer members, chosen based on a minimum of two years' experience in seed production.

For **E-MIRCHA**, Khammam district in Telangana was selected over Guntur due to a higher concentration of participating farmers. Respondents included eight Agricultural Extension Officers (AEOs) and Mandal Agriculture Officers (MAOs) from three high-participation mandals—Kusumanchi, Thirumalayapalem, and Khammam Rural. From Digital Green, the implementing partner, all six district-level subject-matter experts were included. Additionally, six representatives from the start-up consortium partners (AgNext Technologies, Kalgudi, and KrishiTantra) were selected based on operational roles. Sixty farmers associated with the initiative for over two years were randomly selected (20 from each mandal) using the chit method, in consultation with local extension staff.

In **RSK**, the erstwhile West Godavari district of Andhra Pradesh was selected for its exemplary RSK implementation. Four high-performing RSKs were identified, from which one Village Agriculture or Horticulture Assistant and three RSK Committee Members per RSK were selected. Additional respondents included four AP AGROS PMU officials, four District Resource Centre (DRC) officials, eight APMARKFED staff (two per RSK), four RBK YouTube content team members, and four Bank Mitras. A total of 40 farmers (ten per RSK) were selected randomly in consultation with extension personnel, ensuring regular users of RSK services were represented.

For **APCNF**, Anantapur district in Andhra Pradesh was selected, and three mandals—Kalyandurg, Rappthadu, and Gooty—were chosen for their consistent engagement in natural farming. Using total enumeration, all relevant extension personnel in these mandals were selected, including eight Department of Agriculture officers and six RySS field coordinators. Community-level stakeholders were also included: 18 SHG women farmers leading natural farming efforts, six Panchayati Raj Institution (PRI) representatives, six FPO members (CEOs and BODs), and six Community Resource Persons (CRPs). Additionally, 30 farmers practicing natural farming for over two years were selected through criterion-based sampling, ensuring diversity across social groups and farm sizes.

This multi-level respondent selection ensured comprehensive stakeholder representation across institutional, technical, and community levels to effectively analyze constraints and strategies in scaling up agricultural extension innovations.

2.3 Selection of Research Design

The present study adopted an exploratory research design to systematically identify the constraints and analyze strategies associated with scaling up innovations in agricultural extension management. Given the complex, multi-actor, and context-specific nature of innovation systems, an exploratory design was essential to gain in-depth understanding of diverse stakeholder perspectives, institutional dynamics, and operational challenges.

2.4 Development and Administration of Interview Schedule

A structured and pre-tested interview schedule was developed to gather data on constraints in

scaling up of innovations. The schedule was prepared in consultation with an advisory committee and subject experts from agricultural extension and social sciences to ensure its relevance and validity.

Possible constraints were outlined through a combination of literature review and exploratory interviews, and were quantified using Garrett ranking score. In this approach, respondents were asked to prioritize the listed constraints based on the severity of the challenges they experienced. These rankings were then converted into scores using the following formula:

$$\text{Percent Position} = 100(R_{ij} - 0.5) / N_j$$

Where:

- R_{ij} refers to the rank assigned to the i -th item by the j -th respondent,
- N_j is the total number of items ranked by the j -th respondent.

The calculated percent position was then matched with Garrett's conversion table to obtain corresponding scores. These scores were summed for each factor across all respondents and then averaged to derive a mean score. Finally, the mean scores were ranked in descending order to identify the most pressing constraints, and conclusions were drawn accordingly.

Information on constraints faced during scaling up of innovations was gathered through individual interviews. Before final administration, the schedule was pre-tested with 30 stakeholders from a non-sample area. After following these steps, the finalized interview schedule was used to collect primary data collection.

2.5 Data Collection and Analysis

Data were collected from a total of 320 respondents—80 from each of the four innovation systems—covering all major stakeholder groups. The Garrett ranking technique was employed to calculate mean scores and systematically rank the identified constraints.

3. RESULTS AND DISCUSSION

This section presents and evaluates the study's findings related to constraints faced in scaling up of four innovation systems. The findings are

discussed in the following subsections, which are organized into two key areas: Constraints faced by stakeholders in scaling up, strategies to overcome constraints faced by stakeholders in implementing and scaling up of innovation systems.

3.1 Constraints faced by Stakeholders in Scaling up

Table 1. Constraints faced by stakeholders in scaling up of innovation systems

S. No.	Constraint Statement	GRS	Rank
Federation-Led Seed Production System (FLSPS) (n=80)			
1	Challenges in forming inclusive and effective governance structures among multiple FPOs.	83.63	I
2	Market price fluctuations due to private players destabilize seed sales.	71.26	II
3	Working capital shortages restrict timely seed procurement and processing.	67.85	III
4	Short seasonal windows reduce time for drying, packaging, and distributing seeds.	63.46	IV
5	Lack of formal certification mechanisms for Truthfully Labelled Seeds (TLS) limits market confidence.	58.67	V
6	Weak initial brand recognition affects seed sales and federation visibility.	54.32	VI
7	Regulatory delays in seed licensing and certification slow seed production and marketing.	49.75	VII
8	Limited digital capacity hampers use of Customer Relationship Management (CRM) systems and digital sales channels.	44.32	VIII
9	Operational complexity in managing seed production, quality, and logistics across federations.	41.23	IX
Saagu Baagu – E-MIRCHA (n=80)			
10	Lack of sufficient on-ground support personnel to assist farmers in using the platform effectively.	81.03	I
11	Absence of strong data validation mechanisms affects accuracy of advisories and farmer-entered data.	76.07	II
12	Concerns about platform sustainability after project funding ends.	74.11	III
13	Weak integration with markets limits the platform's ability to improve produce sales and prices.	69.23	IV
14	Farmers show low trust in digital advisories over traditional practices.	63.15	V
15	Limited digital literacy and smartphone access among farmers.	58.34	VI
16	Advisory services are too general and not localised.	49.82	VII
17	Coordination gaps across departments delay service delivery.	34.56	VIII
Rythu Seva Kendras (RSK) (n=80)			
18	Complex inclusion process due to landowner signature requirement for CCRCs.	76.23	I
19	Political interference causes frequent changes in RSK schemes.	71.11	II
20	Minimal involvement of farmers in RSK planning, monitoring, and feedback.	66.23	III
21	Weak monitoring and lack of grievance redressal reduce accountability.	60.32	IV
22	Manpower shortages and high staff attrition weaken services.	55.36	V
23	Poor digital infrastructure limits ICT-enabled service delivery.	52.32	VI
24	Low awareness among tenant farmers about RSK services.	48.32	VII
Andhra Pradesh Community Managed Natural Farming (APCNF) (n=80)			
25	Limited availability of natural inputs (e.g., cow dung, botanical extracts).	76.18	I
26	Farmers experience yield reduction during transition to natural farming.	68.75	II
27	Weak market linkages and poor price realisation for natural produce.	66.59	III
28	CRPs lack advanced training in marketing, value addition, and support.	60.27	IV
29	High dependence on external donor and project-based funding.	48.22	V
30	SHGs have limited involvement in planning and decision-making.	43.90	VI
31	Lack of scientific evidence reduces credibility of natural practices.	33.26	VII
32	Lack of integration with allied livelihoods (livestock, agroforestry).	26.40	VIII

3.1.1 Federation-led Seed Production System (FLSPS)

The data in Table 1, revealed that the most significant constraint in scaling up FLSPS was the challenge of forming inclusive and effective governance structures among multiple Farmer Producer Organizations (FPOs), ranked first by respondents. This issue stemmed from coordination difficulties, lack of transparency, and unequal participation among member FPOs, leading to dominance by stronger federations and limited involvement of smaller entities. Market price fluctuations caused by aggressive private sector pricing ranked second, as these destabilized federation-led seed sales and undermined farmer trust in newer seed brands. Third-ranked was the shortage of working capital, which restricted timely procurement, processing, and distribution of seeds, especially during critical windows. This challenge was compounded by limited access to institutional credit and unreliable interim funding sources. Additional constraints included tight seasonal windows for seed operations (iv), lack of formal certification for truthfully labelled seeds (v), and weak brand recognition (vi), which further limited market penetration. Regulatory delays in seed licensing and certification (vii), limited digital capabilities for customer relationship management (CRM) and sales (viii), and the operational complexity of managing logistics across federations (ix) were also noted, though relatively lower in rank. Overall, stakeholders emphasized that without strengthened governance, financial instruments, and market linkages, the full potential of the FLSPS model cannot be realized.

3.1.2 Project Saagu Baagu: E-Mircha

In the case of the E-Mircha platform under the Saagu Baagu initiative, respondents identified the lack of sufficient on-ground support personnel as the most critical constraint (rank i). The absence of digital facilitators limited farmers' ability to effectively engage with the platform, especially among less digitally literate groups. Ranked second was the absence of robust data validation mechanisms, which reduced the accuracy and reliability of advisories, eroding farmer confidence. Concerns about long-term sustainability of the platform post-project funding were also prominent (iii), with stakeholders questioning institutional and financial continuity. Weak market integration (iv) was another major issue, as the platform offered limited support in

produce aggregation, pricing, or linking to buyers. Farmers' low trust in digital advisories (v), particularly when they conflicted with traditional knowledge, also hindered adoption. Digital exclusion due to low smartphone access and digital literacy (vi) further restricted independent usage. Additionally, the platform's generalized advisories (vii) failed to account for local agro-climatic nuances, limiting relevance. Coordination delays across departments (viii), while less critical, still impacted the timeliness of service delivery. Collectively, stakeholders stressed the need for enhanced localization, market facilitation, digital support, and sustainable institutional backing for E-Mircha's effective scaling.

3.1.3 Rythu Seva Kendras (RSK)

Respondents ranked the complex inclusion process for tenant farmers—specifically the requirement for landowner signatures for crop cultivator rights cards, as the top constraint (i) in RSK implementation. This condition excluded a significant portion of informal tenants from accessing services. Political interference was ranked second (ii), with frequent changes in RSK policies disrupting program continuity and undermining credibility. The limited participation of farmers in planning and monitoring processes (iii) was another key concern, reducing ownership and feedback integration. Weak grievance redressal mechanisms and poor monitoring (iv) further reduced accountability and responsiveness. Manpower shortages and high attrition (v) created service delivery bottlenecks, while inadequate digital infrastructure (vi) restricted the reach of ICT-based services. Lastly, low awareness among tenant farmers (vii) hindered service uptake. Overall, stakeholders emphasized that strengthening governance, depoliticizing RSK functions, enhancing staffing, and improving awareness were crucial for realizing the intended benefits of the RSK model.

3.1.4 Andhra Pradesh Community Managed Natural Farming (APCNF)

For APCNF, the top-ranked constraint was the limited availability of natural inputs such as cow dung and botanical extracts, particularly among smallholders and marginal farmers (i). Yield reductions during the initial transition to natural farming (ii) posed significant risks to farmer income and adoption. Weak market linkages and lack of premium pricing for natural produce (iii) further disincentivized farmers from shifting away

from conventional practices. Respondents also highlighted the inadequate training of community resource persons (CRPs) in market facilitation and value addition (iv), which restricted their ability to support farmers beyond basic agronomic tasks. The model's financial sustainability was also questioned, with high dependence on donor and project-based funding sources (v). SHGs were reported to have limited involvement in planning and decision-making (vi), reducing local ownership. The lack of robust scientific validation of natural farming outcomes (vii) led to skepticism among extension workers and conventional farmers alike. Finally, insufficient integration with allied livelihoods like livestock and agroforestry (viii) was seen as a missed opportunity for income diversification. To ensure sustainable scaling, respondents called for targeted input access, yield risk mitigation, stronger market development, and scientific validation of APCNF practices.

3.2 Strategies to Overcome the Constraints Faced by Stakeholders in Implementing and Scaling up of Innovation Systems

Based on the constraints identified across the four innovation systems: Federation-Led Seed Production System (FLSPS), E-MIRCHA, Rythu Seva Kendras (RSK), and Andhra Pradesh Community-managed Natural Farming (APCNF), the following strategies and suggestions were formulated to address and overcome key challenges experienced by stakeholders during implementation and scaling-up processes.

3.2.1 Federation-led Seed Production System (FLSPS)

To strengthen the scalability of FLSPS, inclusive and transparent governance frameworks must be established across federations. This involves defining rotational leadership roles and creating standard operating procedures for planning, decision-making, and conflict resolution to avoid dominance by larger FPOs. Financially, timely access to working capital is crucial and can be addressed through revolving funds, credit guarantee schemes, and partnerships with agri-fintech players. Market stability should be enhanced via formal buyback agreements with institutional buyers. On the capacity-building front, training in seed standards, logistics, quality control, and marketing supported by mobile-based learning tools, will boost implementation efficiency. Infrastructure investments in

decentralized units like seed dryers, storage, and packaging units, alongside Enterprise Resource Planning (ERP) systems, can improve operational streamlining. Truthfully Labelled Seeds (TLS) recognition should be accelerated through collaboration with state certification bodies and third-party labs. To ensure sustainability, federations should develop business plans focusing on cost recovery, branding, and value addition. Enhanced visibility through outreach and awareness campaigns will further position FLSPS as a viable seed production alternative.

3.2.2 Saagu Baagu: E-Mircha

E-Mircha's scaling potential can be unlocked by ensuring a stronger institutional base and a sustainable digital ecosystem. This includes building a cadre of digital facilitators and improving the digital literacy of both farmers and CRPs through interactive and structured training formats. Governance-wise, sustainability planning is essential in transitioning to Public-private partnership models or forming digital cooperatives can facilitate local ownership and reduce donor dependence. Financially, linking with e-commerce platforms, private aggregators, and FPOs can improve market integration and create demand-responsive advisories. To bridge the digital divide, the platform should be accessible through offline-compatible apps, shared access points, and localized geo-tagged alerts. Data accuracy needs to be ensured by instituting robust feedback loops and validation protocols aligned to agro-ecological conditions. Furthermore, gamified elements and reward-based mechanisms can improve usage and trust among farmers. Evidence generation and participatory feedback will help refine the platform and guide its long-term evolution beyond pilot stages.

3.2.3 Rythu Seva Kendras (RSK)

Scaling up RSKs requires depoliticizing their functioning through the establishment of statutory frameworks and independent oversight mechanisms. Empowering farmer advisory committees in planning and monitoring, with autonomy from political influence, will improve ownership and responsiveness. Financial and human resource constraints can be mitigated through contractual staff appointments, service desks, and performance-linked incentives to reduce attrition. Upgrading infrastructure with

reliable power, internet access, and digital service systems will enhance delivery and transparency. Outreach strategies using Information, Education, Communication tools such as guidebooks, community radio, peer educators, and mobile applications can significantly improve awareness, especially among tenant farmers. Digitization of services and records will streamline operations and improve access. Overall, the effectiveness of RSKs hinges on decentralized governance, upgraded physical and digital infrastructure, well-trained personnel, and targeted outreach to underserved groups.

3.2.4 Andhra Pradesh Community Managed Natural Farming (APCNF)

Scaling APCNF demands stronger institutional ownership through integration into panchayat raj structures and deeper involvement of SHGs in budgeting and micro-level decision-making. Financially, linking farmers with organic value chains, cooperatives, and public procurement mechanisms will support price realization, supplemented by minimum support prices or certification-based premiums. Input access issues can be mitigated through convergence with programs like MNREGAS and NRLM to support infrastructure and resource mobilization. On capacity building, tiered training for CRPs in both technical and market domains, along with farmer-to-farmer learning platforms and demonstration fields, will strengthen knowledge transfer. Evidence generation must be prioritized by partnering with academic institutions to validate claims on yield, soil health, and economic returns. Promoting success stories via culturally relevant media and countering misinformation through storytelling rooted in data will drive behavioural change. Ensuring convergence, building market incentives, and validating results will be key to sustaining APCNF as a transformative model for agroecological transitions.

4. CONCLUSION

The study highlights that while innovative agricultural extension models like FLSPS, E-Mircha, RSK and APCNF offer transformative potential, their scalability is hindered by governance limitations, financial constraints, capacity deficits, inadequate infrastructure, and weak data and monitoring systems. Each system faces unique challenges rooted in its operational context, stakeholder structure, and level of

integration within existing institutional frameworks. Governance reforms—such as decentralization, enhanced local participation, and formalized decision-making—emerged as a foundational need across all innovations. Financial sustainability is equally critical, calling for improved credit access, market integration, and risk-reducing mechanisms like buyback agreements and price guarantees. Strengthening human capital through continuous capacity building and incentivized staffing can enhance field-level execution, while investment in digital and physical infrastructure is essential to bridge last-mile delivery gaps. Evidence generation through participatory research, quality certification, and robust M&E systems will be key to building institutional trust and guiding policy reforms. Lastly, scaling efforts must prioritize behavioural change and awareness-building using culturally rooted communication approaches. The success and sustainability of these extension innovations ultimately depend on a systemic, context-specific strategy that aligns governance, finance, human resources, infrastructure, and farmer engagement toward long-term, community-driven agricultural transformation.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Anderson, J. R., & Feder, G. (2004). Agricultural extension: Good intentions and hard

- realities. *World Bank Research Observer*, 19(1), 41–60. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Anderson%2C+J.+R.%2C+%26+Feder%2C+G.+%282004%29.+Agricultural+extension%3A+Good+intentions+and+hard+realities.+World+Bank+Research+Observer%2C+19%281%29%2C+41-60.&btnG=
- Douthwaite, B., Kuby, T., Van de Fliert, E., & Schulz, S. (2003). Impact pathway evaluation: An approach for achieving and attributing impact in complex systems. *Agricultural Systems*, 78(2), 243–265. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=DOUTHWAITE%2C+B.%2C+KUBY%2C+T.%2C+VAN+DE+FLIERT%2C+E.%2C+%26+SCHULZ%2C+S.+%282003%29.+IMPACT+PATHWAY+EVALUATION%3A+AN+APPROACH+FOR+ACHIEVING+AND+ATTRIBUTING+IMPACT+IN+COMPLEX+SYSTEMS.+AGRICULTURAL+SYSTEMS%2C+78%282%29%2C+243-265.&btnG=
- Gillespie, S. (2004). *Scaling up community-driven development: A synthesis of experience*. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Gillespie%2C+S.+%282004%29.+Scaling+up+community-driven+development%3A+a+synthesis+of+experience.&btnG=
- Gossaye, B. (2017). *Sustainably scaling up innovative agricultural projects: The case of the E-voucher project of the ATA* (Doctoral dissertation, Addis Ababa University). https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=GOSSAYE%2C+B.+2017.+SUSTAINABLY+SCALING+UP+INNOVATIVE+AGRICULTURAL+PROJECTS%3A+THE+CASE+OF+THE+E-VOUCHER+PROJECT+OF+THE+ATA.+M.A+THESIS.+ADDIS+ABABA+UNIVERSITY+SCHOOL+OF+COMMERCE%2C+ETHIOPIA.+&btnG=
- Hall, A., Mytelka, L., & Oyeyinka, B. (2005). *Innovation systems: Implications for agricultural policy and practice*. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=HALL%2C+A.%2C+MYTELKA%2C+L.%2C+%26+OYEYINKA%2C+B.+%282005%29.+INNOVATION+SYSTEMS%3A+IMPLICATIONS+FOR+AGRICULTURAL+POLICY+AND+PRACTICE.&btnG=
- Klerkx, L., Van Mierlo, B., & Leeuwis, C. (2012). Evolution of systems approaches to agricultural innovation: Concepts, analysis and interventions. In *Farming systems research into the 21st century: The new dynamic* (pp. 457–483). https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=KLERKX%2C+L.%2C+VAN+MIERLO%2C+B.%2C+%26+LEEUIWIS%2C+C.+%282012%29.+EVOLUTION+OF+SYSTEMS+APPROACHES+TO+AGRICULTURAL+INNOVATION%3A+CONCEPTS+ANALYSIS+AND+INTERVENTIONS.+FARMING+SYSTEMS+RESEARCH+INTO+THE+21ST+CENTURY%3A+THE+NEW+DYNAMIC%2C+457-483.&btnG=
- Leeuwis, C., & Aarts, N. (2011). Rethinking communication in innovation processes: Creating space for change in complex systems. *Journal of Agricultural Education and Extension*, 17(1), 21–36. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=LEEUIWIS%2C+C.%2C+%26+AARTS%2C+N.+%282011%29.+RETHINKING+COMMUNICATION+IN+INNOVATION+PROCESSES%3A+CREATING+SPACE+FOR+CHANGE+IN+COMPLEX+SYSTEMS.+JOURNAL+OF+AGRICULTURAL+EDUCATION+AND+EXTENSION%2C+17%281%29%2C+21-36.&btnG=
- Muïlerman, S., Wigboldus, S., & Leeuwis, C. (2018). Scaling and institutionalization within agricultural innovation systems: The case of cocoa farmer field schools in Cameroon. *International Journal of Agricultural Sustainability*, 16(2), 167–186. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=MUIELMAN%2C+S.%2C+WIGBOLDUS%2C+S.+and+Leeuwis%2C+C.+%282018%29.+Scaling+and+institutionalization+within+agricultural+innovation+systems%3A+the+case+of+cocoa+farmer+field+schools+in+Cameroon%2C+International+Journal+of+Agricultural+Sustainability%2C+16%3A2%2C+167-186.&btnG=
- Rai, A. K., Ranjan, A., Bharti, S. D., Saikanth, D. R. K., Surender, R., & Gautam, R. (2023). Agricultural extension's key role in modern farming: A review. *Asian Journal of Agricultural Extension, Economics & Sociology*, 41(9), 475–485. https://www.researchgate.net/profile/Shankar-Bharti/publication/372439710_Agricultural_Extension's_Key_Role_in_Modern_Farming_A_Review/links/64b6a7648de7ed28baa

- a9c4e/Agricultural-Extensions-Key-Role-in-Modern-Farming-A-Review.pdf
- Spielman, D. J., Ekboir, J., & Davis, K. (2009). The art and science of innovation systems inquiry: Applications to sub-Saharan African agriculture. *Technology in Society*, 31(4), 399–405. [https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=SPIELMAN%2C+D.+J.%2C+EKBOIR%2C+J.%2C+%26+DAVIS%2C+K.+%282009%29.+THE+ART+AND+SCIENCE+OF+INNOVATION+SYSTEMS+INQUIRY%3A+APPLICATIONS+TO+S](https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=SPIELMAN%2C+D.+J.%2C+EKBOIR%2C+J.%2C+%26+DAVIS%2C+K.+%282009%29.+THE+ART+AND+SCIENCE+OF+INNOVATION+SYSTEMS+INQUIRY%3A+APPLICATIONS+TO+SUB-SAHARAN+AFRICAN+AGRICULTURE.+TECHNOLOGY+IN+SOCIETY%2C+31%284%29%2C+399-405.&btnG=)
- UB-SAHARAN+AFRICAN+AGRICULTURE.+TECHNOLOGY+IN+SOCIETY%2C+31%284%29%2C+399-405.&btnG=
- Sulaiman, R. V., & Hall, A. (2004). *Towards Extension Plus: Opportunities and challenges* (Policy Brief 11). National Centre for Agricultural Economics and Policy Research, Indian Council of Agricultural Research (ICAR). <https://core.ac.uk/download/pdf/211013393.pdf>

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