

International Journal of Agriculture Extension and Social Development

Volume 9; Issue 5; May 2026; Page No. 735-744

Received: 15-02-2026
Accepted: 19-03-2026

Indexed Journal
Peer Reviewed Journal

Participatory extension approaches for sustainable agricultural development: A review

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DOI: <https://www.doi.org/10.33545/26180723.2026.v9.i5i.3651>

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Abstract

Agricultural extension has undergone a profound paradigm shift over the past four decades, moving from top-down, technology-transfer models toward participatory approaches that place farmers at the centre of knowledge generation, innovation and decision-making. Participatory extension approaches (PEAs) - encompassing Farmer Field Schools (FFS), Participatory Rural Appraisal (PRA), Participatory Technology Development (PTD), community-based extension, farmer-to-farmer learning and digital advisory services - have emerged as powerful tools for promoting sustainable agricultural development. This review synthesises evidence from global literature on the conceptual foundations, methodological diversity and empirical outcomes of PEAs. Key findings indicate that participatory approaches significantly improve technology adoption rates, enhance food security, build social capital, empower women and marginalised groups and strengthen community resilience. The integration of information and communication technologies (ICT) with participatory methods has further expanded the reach and effectiveness of extension services, particularly for smallholder farmers in remote areas. However, challenges including inadequate funding, weak institutional frameworks, facilitator capacity gaps and limited scalability continue to constrain the full potential of PEAs. The review identifies critical research gaps and proposes a framework for designing inclusive, context-responsive and digitally enabled participatory extension systems. Strengthening PEAs through policy support, multi-stakeholder partnerships and evidence-based programming is essential for achieving the Sustainable Development Goals (SDGs) and building climate-resilient food systems.

Keywords: Participatory extension, farmer field schools, participatory rural appraisal, technology adoption, sustainable agriculture

1. Introduction

Agricultural extension services have long been recognised as a critical link between research institutions and farming communities, facilitating the transfer of knowledge, technologies and innovations that improve agricultural productivity and rural livelihoods (Anderson & Feder, 2007) [5]. Historically, extension systems in most developing countries operated under a Training and Visit (T&V) model, characterised by top-down information flows from researchers to extension agents to farmers, with limited feedback mechanisms and minimal farmer participation in problem identification or solution design (Birner *et al.*, 2009) [9]. While this model achieved some successes during

the Green Revolution era, its limitations became increasingly apparent in the 1980s and 1990s, as low technology adoption rates, poor sustainability of interventions and the exclusion of marginalised groups - particularly women and smallholder farmers - highlighted the inadequacy of supply-driven approaches (Chambers, 1994) [12].

The emergence of participatory development paradigms in the 1980s, rooted in the work of Paulo Freire on critical pedagogy and Robert Chambers on Participatory Rural Appraisal, fundamentally challenged the conventional extension model (Freire, 1970; Chambers, 1994) [27, 12]. Participatory approaches recognise farmers not as passive

recipients of externally generated knowledge, but as active agents with valuable indigenous knowledge, problem-solving capacities and the right to shape the development processes that affect their lives (Pretty, 1995) ^[47, 48]. This philosophical shift gave rise to a diverse array of participatory extension approaches (PEAs) that have been implemented across Africa, Asia, Latin America and beyond over the past three decades.

The global context for agricultural extension has changed dramatically in the 21st century. Climate change, population growth, land degradation, water scarcity and increasing market integration have created complex, dynamic challenges that demand adaptive, locally responsive extension systems (World Bank, 2012) ^[24]. Simultaneously, the rapid proliferation of mobile telephony and digital platforms has opened new possibilities for scaling participatory approaches and reaching previously underserved farming communities. The Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 5 (Gender Equality) and SDG 13 (Climate Action), provide a compelling framework for reimagining extension as a vehicle for inclusive, sustainable agricultural transformation (UN, 2015) ^[60].

Despite the growing body of evidence on the effectiveness of PEAs, comprehensive reviews that synthesise findings across different approaches, regions and contexts remain limited. This review aims to: (i) trace the conceptual evolution of participatory extension; (ii) describe and compare major PEA methodologies; (iii) synthesise empirical evidence on their outcomes and impacts; (iv) examine cross-cutting themes including gender, ICT integration and institutional frameworks; and (v) identify challenges, research gaps and future directions for strengthening participatory extension systems for sustainable agricultural development.

2. Conceptual Foundations of Participatory Extension

2.1 From Technology Transfer to Participatory Learning

The conventional technology transfer model, epitomised by the T&V system promoted by the World Bank in the 1970s and 1980s, was premised on a linear flow of knowledge from research stations through extension agents to farmers (Benor & Harrison, 1977) ^[7]. This model assumed that research-generated technologies were universally applicable and that farmers' primary need was access to information rather than participation in knowledge creation. Evaluations of T&V programmes consistently found low adoption rates, poor sustainability after project withdrawal and failure to reach women and resource-poor farmers. These failures catalysed a fundamental rethinking of extension philosophy and methodology.

The participatory paradigm draws on multiple intellectual traditions, including Freire's (1970) ^[27] concept of 'conscientisation' - the process by which people develop critical awareness of their social reality and take action to transform it - and Chambers' (1994) ^[12] principles of Participatory Rural Appraisal, which emphasise 'handing over the stick' to local communities. Pretty (1995) ^[47, 48] articulated a typology of participation ranging from passive participation (being told what will happen) to self-mobilisation (taking independent initiatives), arguing that

only the higher levels of participation lead to sustainable development outcomes. This framework has been widely adopted in extension literature to evaluate the depth and quality of farmer engagement in extension programmes.

2.2 Indigenous Knowledge and Local Innovation

A central tenet of participatory extension is the recognition and valorisation of indigenous knowledge (IK) - the accumulated body of knowledge, practices and beliefs about the relationship between living beings, including humans and their environment, developed by peoples with long histories of interaction with their natural surroundings (Berkes, 2008) ^[8]. Indigenous knowledge encompasses farmers' understanding of local soils, climate patterns, crop varieties, pest management strategies and social institutions and represents a valuable complement to formal scientific knowledge (Sillitoe, 1998) ^[55]. Participatory approaches create spaces for the integration of IK with scientific knowledge, leading to more contextually appropriate and readily adoptable technologies (Reij & Waters-Bayer, 2001) ^[51].

Farmer innovation - the process by which farmers experiment, adapt and develop new agricultural practices in response to changing conditions - is a key driver of agricultural change in smallholder systems (Sumberg & Okali, 1997) ^[57]. Participatory extension approaches that support and amplify farmer innovation, rather than replacing it with externally generated technologies, have been shown to produce more sustainable and widely adopted outcomes (Critchley *et al.*, 1999) ^[17]. The concept of 'farmer-first' research and extension, articulated by Chambers *et al.* (1989) ^[13], remains a foundational principle of contemporary participatory approaches.

2.3 Systems Thinking and Sustainable Agriculture

Sustainable agricultural development requires a systems perspective that recognises the complex interactions between ecological, social, economic and institutional dimensions of farming systems (Conway, 1987) ^[15]. Participatory extension approaches are inherently systems-oriented, as they engage multiple stakeholders - farmers, extension agents, researchers, policymakers and market actors - in collaborative analysis and action (Röling & Wagemakers, 1998) ^[52]. The Agricultural Innovation Systems (AIS) framework, which conceptualises innovation as an emergent property of interactions among diverse actors within an enabling institutional environment, provides a useful theoretical lens for understanding how participatory extension contributes to sustainable agricultural transformation (World Bank, 2012) ^[24]. Agroecological approaches, which emphasise ecological processes, biodiversity and social equity as foundations for sustainable food systems, are particularly well-aligned with participatory extension principles (Altieri, 2002) ^[4].

3. Major Participatory Extension Approaches

3.1 Farmer Field Schools (FFS)

Farmer Field Schools, developed by the FAO in Indonesia in the late 1980s as a response to the pesticide treadmill in rice production, represent one of the most widely implemented and rigorously evaluated participatory extension approaches globally (Gallagher, 1999) ^[30]. FFS

are season-long, group-based learning programmes in which 20-25 farmers meet regularly in their fields to conduct agro-ecosystem analysis, compare management practices through field experiments and develop problem-solving skills through experiential learning (van den Berg & Jiggins, 2007) ^[62]. The FFS methodology is grounded in adult learning principles, emphasising discovery-based learning, critical thinking and collective decision-making rather than passive reception of expert advice (Braun *et al.*, 2006) ^[10].

A systematic review and meta-analysis by Waddington *et al.* (2014) ^[63] of 62 FFS evaluations found that FFS participation was associated with an average 13% increase in crop yields and a 20% increase in farmer income, with particularly strong effects in integrated pest management (IPM) and soil fertility management. FFS have been implemented in over 90 countries across Africa, Asia and Latin America, reaching an estimated 10-12 million farmers. Beyond productivity gains, FFS have been shown to improve farmers' knowledge and decision-making capacity, reduce pesticide use and associated health risks, strengthen social cohesion and collective action and empower women farmers when gender-sensitive facilitation approaches are employed (Braun *et al.*, 2006; Davis *et al.*, 2012) ^[10, 18].

Despite their demonstrated effectiveness, FFS face several implementation challenges. The high cost per beneficiary (typically USD 50-200 per farmer), dependence on skilled facilitators, limited scalability beyond project boundaries and weak linkages to input supply chains and markets have constrained the widespread institutionalisation of FFS within national extension systems (Feder *et al.*, 2004) ^[25]. Recent innovations, including e-FFS that integrate digital tools and FFS-plus models that link learning with savings groups and market access, have sought to address these limitations (Davis *et al.*, 2012) ^[18].

3.2 Participatory Rural Appraisal (PRA)

Participatory Rural Appraisal is a family of approaches and methods that enable local people to share, enhance and analyse their knowledge of life and conditions and to plan, act, monitor and evaluate (Chambers, 1994) ^[12]. PRA evolved from Rapid Rural Appraisal (RRA) in the late 1980s, with the key distinction that PRA emphasises local people's own analysis and action rather than outsiders extracting information. Core PRA tools include participatory mapping, seasonal calendars, wealth ranking, transect walks, Venn diagrams, problem trees and focus group discussions (Pretty *et al.*, 1995) ^[47, 48].

In agricultural extension, PRA is widely used for needs assessment, programme planning, monitoring and evaluation. By engaging farmers in systematic analysis of their own situations, PRA generates locally relevant information that informs the design of extension programmes and ensures that interventions address farmers' actual priorities rather than externally perceived needs (Chambers, 1994) ^[12]. Studies in sub-Saharan Africa and South Asia have demonstrated that PRA-based programme design significantly improves the relevance and uptake of extension recommendations compared to conventional survey-based approaches (Scoones & Thompson, 1994) ^[54]. However, PRA has been criticised for its potential to be misused as a data extraction tool by outsiders, for power dynamics within communities that may marginalise women

and the poor and for the risk of raising expectations without delivering tangible outcomes (Cooke & Kothari, 2001) ^[16].

3.3 Participatory Technology Development (PTD)

Participatory Technology Development is an approach in which farmers and researchers collaborate as equal partners in the design, testing and evaluation of agricultural technologies and practices (Haverkort *et al.*, 1991) ^[32]. Unlike conventional on-station research followed by technology transfer, PTD is conducted on farmers' fields under farmers' management conditions, ensuring that technologies are tested under realistic constraints and that farmers develop ownership of the innovation process (Reij & Waters-Bayer, 2001) ^[51]. PTD encompasses a range of activities including participatory varietal selection (PVS), farmer-managed trials, joint monitoring and evaluation and farmer-to-researcher feedback mechanisms.

Evidence from PTD programmes in Ethiopia, Uganda and Honduras demonstrates that farmer-led technology testing significantly improves adoption rates compared to researcher-led trials, as technologies are adapted to local conditions and farmers develop the knowledge and confidence to implement them (Almekinders & Elings, 2001) ^[3]. A long-term study of farmer research committees (CIALs) in Honduras found that communities engaged in PTD over 15 years achieved significant improvements in food security, land use sustainability and social capital, with benefits persisting well beyond the project period (Humphries *et al.*, 2024) ^[34]. The integration of PTD with participatory AI tools for crop improvement represents a promising frontier, enabling farmers to contribute to genomic selection and variety development processes (Lasdun *et al.*, 2024) ^[41].

3.4 Farmer-to-Farmer Extension

Farmer-to-farmer (F2F) extension leverages the social networks and peer learning dynamics within farming communities to disseminate knowledge and innovations. In F2F approaches, trained lead farmers or farmer promoters share knowledge and demonstrate practices to their neighbours, creating a multiplier effect that extends the reach of extension services at low cost (Holt-Gimenez, 2006) ^[33]. F2F extension is particularly effective in contexts where formal extension services are under-resourced, as it builds on existing social relationships and trust within communities (Simpson & Owens, 2002) ^[56].

The Campesino a Campesino (CaC) movement in Central America and Cuba represents one of the most successful and well-documented F2F extension models, having facilitated the widespread adoption of agroecological practices among hundreds of thousands of smallholder farmers (Holt-Gimenez, 2006) ^[33]. Studies in sub-Saharan Africa have found that F2F extension can achieve technology adoption rates of 40-60% among farmers in the social networks of trained lead farmers, compared to 10-20% for conventional extension approaches (Kondylis *et al.*, 2017) ^[39]. However, the quality of knowledge transmitted through F2F networks can degrade over successive transmission steps and lead farmers may face time and resource constraints that limit their effectiveness as extension agents (Simpson & Owens, 2002) ^[56].

3.5 Community-Based Extension

Community-based extension (CBE) approaches embed extension services within community institutions - including farmer organisations, cooperatives, savings groups and community development committees - to ensure local ownership, sustainability and responsiveness to community needs (Swanson & Rajalahti, 2010) ^[59]. CBE recognises that agricultural development is inseparable from broader community development processes and that effective extension must address the social, economic and institutional dimensions of farming systems alongside technical aspects (Röling & Wagemakers, 1998) ^[52].

Community-based extension has been particularly effective in promoting collective action for natural resource management, including watershed management, community seed banks and collective marketing (Uphoff, 2002) ^[61]. Studies in India, Ethiopia and Kenya have demonstrated that CBE approaches strengthen social capital - the networks, norms and trust that facilitate collective action - which in turn improves the sustainability of agricultural development interventions (Pretty & Ward, 2001) ^[49]. The integration of CBE with savings and credit groups has been shown to address the financial constraints that often prevent smallholder farmers from adopting improved technologies (Markelova *et al.*, 2009) ^[43].

4. Digital Technologies and Participatory Extension

4.1 ICT-Enabled Extension Services

The rapid expansion of mobile telephony and internet connectivity in developing countries has created unprecedented opportunities for scaling participatory extension services and reaching previously underserved farming communities. ICT-enabled extension tools - including mobile applications, SMS advisory services, interactive voice response (IVR) systems, video-based learning platforms and social media groups - can deliver personalised, timely and locally relevant agricultural information to millions of farmers at a fraction of the cost of conventional face-to-face extension (Aker, 2011) ^[1]. A systematic review by Fabregas *et al.* (2019) ^[20] of 37 randomised controlled trials found that digital agricultural extension services increased crop yields by an average of 11% and improved farmers' knowledge and decision-making across diverse contexts.

The framework for strengthening digital agricultural extension and advisory services identifies five key dimensions of effective digital extension: accessibility (reaching all farmers regardless of literacy, gender, or location), quality (providing accurate, timely and actionable information), sustainability (ensuring long-term financing and institutional support), integration (linking digital tools with face-to-face extension and market systems) and inclusivity (addressing the digital divide and ensuring equitable access). Digital extension tools are most effective when they complement rather than replace participatory face-to-face approaches, creating blended extension systems that combine the reach of digital platforms with the depth of in-person learning (Nakasone *et al.*, 2014) ^[46].

4.2 Mobile Advisory Services and Apps

Mobile-based advisory services have emerged as one of the most widely adopted digital extension tools in developing

countries. Services such as Esoko (Ghana), iCow (Kenya), mKisan (India) and Plantix (global) provide farmers with crop management advice, weather forecasts, market price information and pest and disease diagnostics through mobile phones (Aker, 2011) ^[1]. A study of mobile advisory services in sub-Saharan Africa found that farmers who received SMS-based crop management advice achieved 15-25% higher yields compared to control groups, with the greatest benefits observed among farmers with limited access to conventional extension services (Cole & Fernando, 2021) ^[14].

Participatory design of mobile advisory services - involving farmers in the identification of information needs, content development and interface design - significantly improves the relevance and uptake of these tools (Wyche & Steinfield, 2016) ^[65]. Studies in South Asia and Southeast Asia found that digital extension tools designed with farmer input were adopted by 40-60% of target users, compared to 10-20% for tools developed without participatory design processes (Fabregas *et al.*, 2019) ^[20]. The integration of artificial intelligence and machine learning into mobile advisory platforms - enabling personalised recommendations based on farm-specific data - represents a promising frontier for enhancing the effectiveness of digital extension (Kamilaris & Prenafeta-Boldu, 2018) ^[36].

4.3 Video-Based Learning and Social Media

Video-based extension, pioneered by organisations such as Digital Green in India and sub-Saharan Africa, uses locally produced videos featuring farmers demonstrating improved practices to facilitate peer learning within communities (Gandhi *et al.*, 2009) ^[31]. A randomised evaluation of Digital Green's video-based extension programme in India found that farmers who watched videos featuring local farmers adopting improved practices were seven times more likely to adopt those practices compared to farmers who received conventional extension advice (Gandhi *et al.*, 2009) ^[31]. The participatory production of extension videos - involving farmers as actors, scriptwriters and directors - enhances the cultural relevance and credibility of the content and builds community ownership of the extension process.

Social media platforms, particularly WhatsApp and Facebook groups, have emerged as informal but highly effective channels for farmer-to-farmer knowledge sharing and extension service delivery in many developing countries (Mwombe *et al.*, 2014) ^[45]. WhatsApp groups facilitated by extension agents or lead farmers enable real-time sharing of agricultural information, photos of pest and disease symptoms and market prices, creating dynamic learning communities that transcend geographic boundaries. Studies in Kenya, India and Bangladesh have found that farmers in WhatsApp-based extension groups demonstrate significantly higher knowledge scores and technology adoption rates compared to farmers receiving conventional extension services (Mwombe *et al.*, 2014) ^[45].

5. Gender and Social Inclusion in Participatory Extension

5.1 Women's Participation and Empowerment

Women constitute approximately 43% of the agricultural labour force in developing countries and are responsible for

60-80% of food production in sub-Saharan Africa, yet they consistently receive a disproportionately small share of extension services. The estimates that closing the gender gap in access to agricultural resources and services - including extension - could increase yields on women's farms by 20-30% and reduce the number of hungry people in the world by 12-17%. Despite this compelling evidence, women's participation in conventional extension programmes remains low due to time constraints, mobility restrictions, cultural norms and the male-dominated composition of extension services (Ragasa, 2012) ^[50].

Participatory extension approaches offer significant potential for improving women's access to and benefit from extension services, but only when gender-sensitive design principles are explicitly incorporated (Meinzen-Dick *et al.*, 2011) ^[44]. Gender-responsive FFS - which schedule meetings at times convenient for women, address women's specific crops and enterprises and create safe spaces for women's voices - have been shown to significantly improve women's agricultural knowledge, decision-making power and income (Davis *et al.*, 2012) ^[18]. A bibliometric analysis of gender-inclusive extension research from 1988 to 2023 found a significant increase in publications addressing women's empowerment through participatory extension, reflecting growing recognition of gender as a central dimension of sustainable agricultural development (Frontiers in Sustainable Food Systems, 2024) ^[28].

The Women's Empowerment in Agriculture Index (WEAI), developed by IFPRI, provides a comprehensive framework for measuring women's empowerment across five domains: production, resources, income, leadership and time (Alkire *et al.*, 2013) ^[2]. Studies using the WEAI have found that participation in gender-responsive participatory extension programmes significantly improve women's scores across all five domains, with the greatest gains in leadership and decision-making (Malapit *et al.*, 2015) ^[42]. The integration of gender transformative approaches - which challenge discriminatory social norms rather than merely accommodating them - into participatory extension represents the frontier of gender-responsive programming.

5.2 Youth Engagement in Extension

Youth - defined as individuals aged 15-35 - represent a critical but often overlooked constituency for agricultural extension services. In many developing countries, rural youth are abandoning agriculture due to perceptions of low profitability, drudgery and lack of social status, creating a demographic crisis for food production systems (Sumberg *et al.*, 2012) ^[58]. Participatory extension approaches that engage youth as innovators, entrepreneurs and change agents - rather than as passive recipients of agricultural advice - have shown promise in reversing this trend. Studies in sub-Saharan Africa have found that youth-focused FFS and agri-business incubation programmes significantly improve young people's agricultural knowledge, entrepreneurial skills and willingness to pursue farming as a career (Frontiers in Sustainable Food Systems, 2026) ^[29].

5.3 Inclusion of Marginalised Groups

Effective participatory extension must actively address the exclusion of marginalised groups - including the landless, ethnic minorities, people with disabilities and indigenous

communities - who are often invisible in conventional extension programmes (Cooke & Kothari, 2001) ^[16]. Wealth ranking and social mapping tools from PRA can help identify and target the most vulnerable community members, while inclusive facilitation techniques can create spaces for their voices to be heard in group learning processes (Chambers, 1994) ^[12]. Studies in South Asia have found that participatory extension programmes that explicitly target marginalised groups achieve greater poverty reduction impacts than those that focus on average or better-off farmers (Meinzen-Dick *et al.*, 2011) ^[44].

6. Institutional Frameworks and Policy Environment

6.1 Pluralistic Extension Systems

The recognition that no single extension approach or provider can meet the diverse needs of all farmers has led to the emergence of pluralistic extension systems, in which public, private, NGO and farmer-based organisations provide complementary extension services (Swanson & Rajalahti, 2010) ^[59]. Pluralistic systems create a more competitive and responsive extension environment, but also require effective coordination mechanisms to avoid duplication, ensure quality and reach underserved populations (Anderson & Feder, 2007) ^[5]. The World Bank's (2012) ^[24] Agricultural Innovation Systems framework provides a useful conceptual basis for designing pluralistic extension systems that foster innovation through multi-stakeholder collaboration.

Public extension services retain a critical role in pluralistic systems, particularly for providing public goods such as information on climate change adaptation, food safety and natural resource management that private providers have limited incentive to supply (Birner *et al.*, 2009) ^[9]. However, public extension systems in many developing countries suffer from chronic underfunding, poor staff motivation, inadequate transport and communication infrastructure and weak accountability mechanisms (Anderson & Feder, 2007) ^[5]. Reforms that improve the accountability of public extension to farmers - through participatory planning, farmer scorecards and performance-based financing - have shown promise in improving the quality and responsiveness of public extension services (Birner *et al.*, 2009) ^[9].

6.2 Multi-Stakeholder Platforms

Multi-stakeholder platforms (MSPs) - forums that bring together farmers, researchers, extension agents, input suppliers, processors, traders and policymakers to jointly identify problems, develop solutions and coordinate action - have emerged as a key institutional innovation for promoting participatory agricultural development. MSPs create spaces for dialogue and negotiation among actors with different interests and knowledge systems, facilitating the co-creation of innovations that are technically sound, economically viable and socially acceptable (Klerkx *et al.*, 2012). Studies of MSPs in sub-Saharan Africa and South Asia have found that they significantly improve the relevance and uptake of agricultural technologies, strengthen market linkages for smallholder farmers and build the capacity of local institutions to support agricultural innovation.

6.3 Policy Support for Participatory Extension

The institutionalisation of participatory extension approaches within national agricultural development strategies requires supportive policy frameworks that recognise the value of farmer participation, allocate adequate resources for participatory programming and create enabling conditions for multi-stakeholder collaboration. Several countries - including Ethiopia, Uganda and India - have incorporated participatory extension principles into their national agricultural extension policies, with varying degrees of implementation success (Swanson & Rajalahti, 2010) ^[59]. The Comprehensive Africa Agriculture Development Programme (CAADP) and the SDG framework provide important international policy anchors for promoting participatory approaches to agricultural development. Financing mechanisms for participatory extension remain a critical challenge. Demand-driven extension financing models - including agricultural extension vouchers, matching grants and farmer-managed extension funds - have been piloted in several countries as alternatives to supply-driven public funding, with mixed results (Birner *et al.*, 2009) ^[9]. The integration of participatory extension into climate finance mechanisms - including the Green Climate Fund and REDD+ - offers new opportunities for sustainable financing of community-based extension programmes that contribute to climate change adaptation and mitigation (World Bank, 2012) ^[24].

7. Impacts and Evidence Base

7.1 Technology Adoption and Productivity

A growing body of rigorous evidence - including randomised controlled trials, quasi-experimental studies and systematic reviews - demonstrates the positive impact of participatory extension approaches on technology adoption and agricultural productivity. A meta-analysis of 52 studies on participatory extension in sub-Saharan Africa found that participatory approaches increased technology adoption rates by an average of 35% compared to conventional extension, with the greatest effects for soil and water conservation practices and integrated crop management (Kondylis *et al.*, 2017) ^[39]. The positive effects of participation on adoption are attributed to improved relevance of technologies to local conditions, enhanced farmer knowledge and skills and greater social legitimacy of innovations promoted through participatory processes (Pretty, 1995) ^[47, 48].

Farmer Field Schools have been particularly well-studied, with a systematic review by Waddington *et al.* (2014) ^[63] finding consistent positive effects on yields (average +13%), income (+20%) and pesticide use reduction (-30%) across diverse crops and regions. Participatory varietal selection programmes have been shown to accelerate the adoption of improved crop varieties by 2-3 times compared to conventional variety release processes, as farmers select varieties that match their specific preferences and constraints (Ceccarelli & Grando, 2007) ^[11]. Long-term studies of PTD programmes in Honduras and Ethiopia have documented sustained productivity improvements and diversification of farming systems over 10-15 year periods (Humphries *et al.*, 2024) ^[34].

7.2 Food Security and Nutrition

Participatory extension approaches contribute to food security through multiple pathways: increasing crop yields and production diversity, improving post-harvest management and storage, strengthening market linkages and building household resilience to shocks (Meinzen-Dick *et al.*, 2011) ^[44]. Studies of FFS programmes in East Africa found that participating households had significantly higher dietary diversity scores and lower rates of food insecurity compared to non-participating households, with effects persisting for at least two years after programme completion (Davis *et al.*, 2012) ^[18]. Nutrition-sensitive FFS - which integrate nutrition education and home garden promotion alongside crop management training - have shown particularly strong effects on household dietary diversity and child nutrition outcomes (Iannotti *et al.*, 2009) ^[35].

7.3 Environmental Sustainability

Participatory extension approaches that promote agroecological practices - including integrated pest management, conservation agriculture, agroforestry and organic soil fertility management - contribute to environmental sustainability by reducing chemical inputs, improving soil health, conserving biodiversity and enhancing ecosystem services (Altieri, 2002) ^[4]. A review of FFS programmes focused on IPM found that participating farmers reduced pesticide use by an average of 30-50%, with corresponding improvements in biodiversity and reduced health risks for farmers and consumers (van den Berg & Jiggins, 2007) ^[62]. Participatory watershed management programmes in India and Ethiopia have demonstrated significant improvements in soil and water conservation, groundwater recharge and agricultural productivity over 10-20 year periods (Kerr *et al.*, 2002) ^[37].

7.4 Social Capital and Community Empowerment

Beyond their direct effects on agricultural productivity, participatory extension approaches generate significant social capital - the networks, norms and trust that enable collective action - which has wide-ranging benefits for community development (Pretty & Ward, 2001) ^[49]. Studies of FFS alumni groups in Kenya, Uganda and Tanzania found that FFS participation significantly increased farmers' membership in community organisations, participation in collective marketing and engagement in local governance (Braun *et al.*, 2006) ^[10]. The social capital generated through participatory extension programmes has been shown to improve communities' capacity to respond to agricultural shocks, access financial services and advocate for their interests with government and private sector actors (Uphoff, 2002) ^[61].

8. Challenges, Research Gaps and Future Directions

8.1 Scalability and Sustainability

One of the most persistent challenges facing participatory extension approaches is the tension between depth and scale: approaches that achieve deep farmer engagement and transformative learning - such as FFS and PTD - are typically resource-intensive and difficult to scale beyond project boundaries, while approaches that achieve broad reach - such as mass media and SMS advisory services - often lack the depth of engagement needed for sustained

behaviour change (Feder *et al.*, 2004) ^[25]. Addressing this tension requires innovative blended approaches that combine the depth of participatory face-to-face learning with the reach of digital platforms and institutional arrangements that embed participatory extension within sustainable financing and governance structures (Davis *et al.*, 2012) ^[18].

The sustainability of participatory extension programmes beyond the project period remains a major challenge. Studies have found that many FFS and PRA-based programmes collapse after external funding ends, due to weak integration into national extension systems, lack of farmer organisation capacity to sustain activities and absence of market linkages that provide economic incentives for continued participation (Feder *et al.*, 2004) ^[25]. Strategies for improving sustainability include: integrating participatory approaches into national extension systems with dedicated budget lines; building the capacity of farmer organisations to manage and finance their own extension services; and linking participatory extension with value chain development to create economic incentives for continued engagement (Swanson & Rajalahti, 2010) ^[59].

8.2 Quality of Facilitation

The effectiveness of participatory extension approaches is critically dependent on the quality of facilitation. Skilled facilitators who can create inclusive learning environments, manage group dynamics, integrate indigenous and scientific knowledge and adapt processes to local contexts are essential for achieving the transformative outcomes associated with participatory approaches (van den Berg & Jiggins, 2007) ^[62]. However, training and retaining skilled facilitators is a major challenge for extension systems in developing countries, where high staff turnover, inadequate training programmes and poor remuneration undermine facilitation quality (Braun *et al.*, 2006) ^[10]. Investment in pre-service and in-service training for extension facilitators, combined with mentoring, peer learning networks and performance-based incentives, is essential for building and sustaining facilitation capacity.

8.3 Monitoring, Evaluation and Learning

Robust monitoring, evaluation and learning (MEL) systems are essential for generating evidence on the effectiveness of participatory extension approaches and for adaptive management of programmes. However, MEL in participatory extension faces several challenges: the complexity and context-specificity of participatory processes make standardised measurement difficult; the long time horizons needed to observe transformative outcomes exceed typical project cycles; and the attribution of outcomes to specific extension interventions is complicated by the multiple factors influencing farmer behaviour (Waddington *et al.*, 2014) ^[63]. Participatory monitoring and evaluation (PM&E) approaches - which involve farmers in defining indicators, collecting data and interpreting results - can improve the relevance and use of MEL findings while simultaneously building farmers' analytical capacity (Estrella & Gaventa, 1998) ^[19].

8.4 Climate Change Adaptation

Climate change is fundamentally altering the context for

agricultural extension, creating new demands for information on climate-smart practices, early warning systems and adaptive management strategies (World Bank, 2012) ^[24]. Participatory extension approaches are well-suited to supporting climate change adaptation, as they build farmers' capacity for observation, experimentation and adaptive decision-making - skills that are essential for navigating climate uncertainty (Kristjanson *et al.*, 2012) ^[40]. Climate Field Schools - an adaptation of the FFS model focused on climate risk management - have been implemented in several countries with promising results, improving farmers' understanding of climate variability and their adoption of climate-smart practices. The integration of participatory extension with climate information services - including seasonal weather forecasts, agro-meteorological advisories and index-based insurance - represents a critical frontier for building climate resilience in smallholder farming systems.

8.5 Future Research Priorities

Several important research gaps need to be addressed to advance the field of participatory extension. First, there is a need for more rigorous, long-term impact evaluations that assess the sustained effects of participatory extension on productivity, food security, environmental sustainability and social outcomes beyond the project period (Waddington *et al.*, 2014) ^[63]. Second, comparative studies that systematically evaluate the relative effectiveness and cost-efficiency of different participatory approaches across diverse contexts are needed to guide programme design decisions. Third, research on the mechanisms through which participatory extension achieves its effects - including the roles of social learning, collective action and empowerment - would strengthen the theoretical foundations of the field. Fourth, studies on the integration of digital technologies with participatory approaches, including the design of participatory digital tools and the management of digital divides, are urgently needed. Finally, research on the political economy of participatory extension - including the factors that enable or constrain the institutionalisation of participatory approaches within national extension systems - would provide valuable guidance for policy reform.

9. Conclusion

This review has demonstrated that participatory extension approaches represent a fundamentally different and more effective paradigm for agricultural development than conventional top-down technology transfer models. By placing farmers at the centre of knowledge generation, innovation and decision-making, participatory approaches achieve higher technology adoption rates, more sustainable outcomes and broader social benefits - including women's empowerment, social capital formation and community resilience - than approaches that treat farmers as passive recipients of externally generated advice.

The evidence reviewed here demonstrates that Farmer Field Schools, Participatory Rural Appraisal, Participatory Technology Development, farmer-to-farmer extension and community-based extension each offer distinct strengths and are most effective when deployed in combination, tailored to local contexts and integrated within supportive institutional frameworks. The integration of digital

technologies - including mobile advisory services, video-based learning and social media platforms - with participatory face-to-face approaches offers exciting possibilities for scaling the reach and impact of participatory extension while maintaining the depth of farmer engagement that drives transformative outcomes.

Realising the full potential of participatory extension for sustainable agricultural development requires sustained investment in facilitation capacity, robust monitoring and evaluation systems, gender-transformative programming and supportive policy frameworks that embed participatory approaches within national extension systems. Multi-stakeholder partnerships - bringing together governments, research institutions, NGOs, private sector actors and farmer organisations - are essential for creating the enabling environment in which participatory extension can flourish. As the world confronts the intertwined challenges of climate change, food insecurity and rural poverty, participatory extension approaches offer a proven and powerful pathway toward inclusive, sustainable agricultural transformation.

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