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Reimagining extension careers: Extension for the future

¹Vasave Pratik Jerma, ²P Ganesh Kumar, ³V Jyothi and ⁴Sahaja Deva

¹M.Sc. Student, Sri Venkateswara Agricultural College, Tirupati, ANGRAU, Andhra Pradesh, India

^{2,3}Associate Professor, Department of Agricultural Extension Education, S.V. Agricultural College, Tirupati, Andhra Pradesh, India

⁴Scientist, Department of Agronomy, Regional Agricultural Research Station, Tirupati, Andhra Pradesh, India

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Corresponding Author: Vasave Pratik Jerma

Abstract

Agricultural extension systems face growing pressure from climate change, resource degradation, market volatility, rapid technological change and shifting socio-economic conditions of farming communities. Traditionally centred on technology transfer and farmer training, extension now requires a more integrated and multidimensional approach. Modern extension services integrate technology transfer with advisory, organisational and facilitation roles, providing location-specific guidance and enabling access to inputs, credit, insurance, markets and government schemes. Support for Farmer Interest Groups, Self-Help Groups and Farmer Producer Organisations enhances aggregation, value addition and income resilience. Emerging roles such as digital extension product management, climate information services, FPO incubation and agri-investment advisory are expanding the professional boundaries of agricultural extension. This review synthesises evidence on the transformation of extension from a narrow delivery system to a strategic ecosystem facilitation platform, identifies critical gaps in current extension models and outlines new career pathways for extension professionals in India.

Keywords: Agricultural extension, value chain, farmer producer organisations, digital extension, climate information services, ecosystem facilitation

Introduction

Agricultural extension has traditionally served as a bridge between scientific research and farming communities through technology transfer, training and advisory services. This approach played a key role in the success of the Green Revolution, significantly improving agricultural productivity and national food security. However, agriculture has since undergone major changes due to globalisation, technological progress, climate change and social transformation. Farmers today face multiple challenges including climate variability, market uncertainty, natural resource degradation, rising input costs and declining farm sizes.

At the same time, new opportunities have emerged through digital agriculture, agri-business development, value chain integration and collective institutions such as Farmer Producer Organisations (FPOs). In response, agricultural extension is evolving from a narrow technology transfer model to a broader knowledge management and ecosystem facilitation approach. Despite this evolution, a critical gap exists in the literature: there is limited systematic documentation of the emerging career pathways and professional competencies that extension professionals need to remain relevant in this transformed landscape. This review addresses that gap by synthesising evidence on the functional transformation of extension and mapping the new professional roles that are reshaping the extension career in India.

1. Traditional Extension Professions

Agricultural extension in India has experienced substantial transformation over the decades, evolving from a centrally administered, technology-transfer-oriented approach to a more decentralised and farmer-centric system. India hosts one of the largest agricultural research and extension frameworks globally, with the Indian Council of Agricultural Research (ICAR) functioning as the apex institution in collaboration with State Agricultural Universities (SAUs) under the National Agricultural Research System (NARS). Formal extension commenced in the 1950s through the Community Development Programme and the National Extension Service, laying the foundation for Green Revolution-era programmes such as the Intensive Agricultural District Programme (IADP), High Yielding Varieties Programme (HYVP) and the Training and Visit (T and V) system, which sought to professionalise extension services but was eventually discontinued due to rigidity and high costs.

A major paradigm shift occurred with the establishment of the Agricultural Technology Management Agency (ATMA) in 1998, which emphasised decentralisation, inter-institutional convergence and farmer participation, though implementation outcomes remained uneven across states. Subsequently, the National Mission on Agricultural Extension and Technology (NMAET) sought to integrate extension with information and communication technologies,

mechanisation, seed systems and plant protection services. Contemporary agricultural extension in India is characterised by institutional pluralism involving public agencies, private input suppliers, NGOs and digital platforms. Public expenditure on agricultural research, education, extension and training remains approximately 0.7 per cent of agricultural GDP, with a disproportionately larger share allocated to research compared to extension, underscoring long-standing underfunding of frontline extension services (ICRIER, 2018) [31].

2. Extension Services Provided

Agricultural extension performs multiple interlinked functions, including technology transfer, capacity building and context-specific advisory services to enhance farm productivity and resilience. It facilitates farmers' access to quality inputs, institutional credit, insurance and government schemes, thereby strengthening economic security. Extension also promotes collective action through farmer organisations such as FIGs, SHGs and FPOs, improving market access and value addition. Continuous monitoring and feedback ensure adaptive learning, linking field-level experiences with research and policy refinement.

2.1 Technology Transfer and Capacity Building

Technology transfer and capacity building constitute the core functions of agricultural extension systems. Extension facilitates the adoption of improved crop varieties suited to specific agro-climatic conditions and promotes sustainable practices such as Integrated Pest Management (IPM) and Integrated Nutrient Management (INM). Capacity-building efforts include training on seed treatment, water-efficient irrigation methods and post-harvest management delivered through demonstrations, farmer field schools and hands-on trainings by KVKs and ATMA. Over time, extension approaches have shifted from top-down technology dissemination to participatory learning frameworks that emphasise experiential learning and local knowledge systems (Swanson and Rajalahti, 2010; Anderson and Feder, 2007; ICAR, 2011) [3, 29, 54].

2.2 Advisory and Decision Support

Farmers receive timely, location-specific advisories related to weather forecasts, irrigation scheduling, nutrient management and pest control through mobile-based platforms, WhatsApp groups and Kisan Call Centres. The integration of agro-meteorological data, remote sensing and artificial intelligence into decision-support systems enhances risk assessment and farm-level planning. Extension personnel play a crucial role in translating complex scientific and digital information into actionable, context-specific recommendations, thereby strengthening farmers' adaptive capacity (Glendenning *et al.*, 2010; FAO, 2019; Meera, Jhamtani and Rao, 2004) [18, 24, 37].

2.3 Access Facilitation: Inputs, Credit, Insurance and Schemes

Extension services link farmers with certified seed suppliers, formal credit institutions, crop insurance schemes such as the Pradhan Mantri Fasal Bima Yojana (PMFBY) and central and state government programmes, reducing farmers' dependence on informal sources of finance and inputs. This

facilitative role strengthens financial inclusion, enhances risk management and supports informed production and investment decisions at the farm level (Feder, Willett and Zijp, 2001; World Bank, 2012; Government of India, 2020) [22, 25, 61].

2.4 Organisation Development: FIGs, SHGs and FPOs

Extension agencies support the formation of Farmer Interest Groups (FIGs), Self-Help Groups (SHGs) and Farmer Producer Organisations (FPOs) through leadership development, governance training, financial literacy and business planning support. Well-functioning farmer organisations enable collective procurement of inputs, shared access to extension and financial services, aggregation of produce and improved market participation. Extension interventions play a critical role in transforming these groups into sustainable, farmer-owned institutions capable of engaging with markets and value chains (NABARD, 2015; Trebbin, 2014; Singh, Singh and Singh, 2019) [42, 50, 56].

2.5 Market Linkage and Value Addition

Farmers are trained in grading, packaging, quality standards and basic processing techniques to enhance value addition and reduce post-harvest losses. Extension services promote market linkage mechanisms such as the electronic National Agriculture Market (e-NAM), buyer-seller meets, contract farming and direct marketing channels. These interventions improve price realisation, reduce transaction costs and strengthen farmers' integration into value chains, shifting extension beyond production-centric approaches toward agribusiness and income-oriented outcomes (BIRTHAL *et al.*, 2017; Kumar *et al.*, 2020; FAO, 2016) [7, 15, 35].

2.6 Monitoring and Feedback

Regular field visits, farmer interactions, participatory assessments and feedback collection help track technology adoption, identify implementation constraints and evaluate socio-economic outcomes. Insights generated through monitoring and evaluation feed back into research prioritisation, programme redesign and policy formulation. Such feedback-driven systems enhance accountability, relevance and impact of extension interventions (Rivera and Sulaiman, 2009; Swanson, 2008; OECD, 2010) [44, 48, 53].

3. Changing Agricultural Scenarios and the Reorientation of Agricultural Extension

Agriculture globally and particularly in developing economies such as India, is undergoing rapid structural transformation driven by climate variability, digitalisation, market formalisation, producer collectivisation and emerging technologies. These shifts have fundamentally altered the risk landscape, information requirements and institutional expectations of farming systems. Consequently, agricultural extension has been compelled to reorient towards adaptive, data-driven and market-responsive roles that address complexity and uncertainty rather than solely productivity enhancement (Rivera and Sulaiman, 2009; Anderson and Feder, 2007) [3, 48].

3.1 Climate Variability and the Rise of Climate Information Services

Climate change has introduced unprecedented uncertainty

into agricultural production through erratic rainfall patterns, rising temperatures and changing pest-disease dynamics (IPCC, 2022) ^[33]. These changes have rendered blanket recommendations and fixed cropping calendars increasingly ineffective, particularly for small and marginal farmers who are highly climate-sensitive. Climate Information Services (CIS) have emerged as a critical extension domain, providing localised weather forecasts, seasonal climate outlooks and contingency advisories tailored to specific agro-ecological contexts (Hansen *et al.*, 2011; Vaughan and Dessai, 2014) ^[28, 58]. Extension professionals increasingly facilitate the adoption of climate-resilient crop varieties, water-efficient practices and diversified farming systems (Lipper *et al.*, 2014; FAO, 2018) ^[17, 36].

3.2 Digitalisation and Data-Driven Extension Systems

The digital transformation of agriculture has enabled the integration of farmer databases, satellite imagery, weather information and market intelligence into unified advisory platforms. In India, digital public infrastructure initiatives such as AgriStack represent a paradigm shift toward personalised, real-time and evidence-based extension services (Government of India, 2021; Birner *et al.*, 2021) ^[5, 26]. However, persistent challenges related to digital literacy and connectivity gaps limit the equitable reach of digital extension tools (Fabregas, Kremer and Schilbach, 2019) ^[14]. Digitalisation has also generated new professional domains within extension, including GIS-based advisory services, digital monitoring and evaluation and agricultural data stewardship (Aker, 2011) ^[1].

3.3 Value Chain Formalisation and Enterprise-Oriented Extension

Initiatives promoting micro-enterprises, food processing clusters and product branding have expanded the scope of extension beyond farm-level production advisory. Farmers and rural entrepreneurs increasingly require support in business planning, food safety compliance, quality standards, packaging and market positioning (Devaux *et al.*, 2018) ^[13]. This transition has driven the evolution of extension systems toward value chain facilitation and enterprise-oriented advisory services that integrate agronomic knowledge with management, finance and quality assurance (Swanson and Rajalahti, 2010) ^[54].

3.4 Producer Collectivisation and Institutional Extension Roles

The promotion of Farmer Producer Organisations (FPOs) reflects a structural shift toward collective action and market-oriented agriculture. While FPOs aim to improve farmers' bargaining power and income stability, their sustainability depends on robust governance systems, professional management and strong market linkages (Trebbin, 2014; Mukherjee *et al.*, 2019) ^[40, 56]. This evolving role signifies a departure from short-term training models toward long-term institutional handholding, enterprise incubation and organisational strengthening (Sulaiman and Hall, 2002) ^[51].

3.5 Emerging Technologies and Human-Machine Complementarity

Recent advances in artificial intelligence, drone-based remote sensing, IoT-enabled farm monitoring and digital

traceability systems have introduced new modalities of agricultural advisory characterised by enhanced precision and scalability (Wolfert *et al.*, 2017) ^[60]. Extension professionals remain critical intermediaries, validating AI-generated advisories, facilitating drone and sensor services and interpreting complex data outputs. This reinforces the concept of human-machine complementarity, wherein digital technologies augment but do not replace the experiential knowledge and contextual judgment of extension systems (Bronson and Knezevic, 2016) ^[8].

4. Current Status and Emerging Demands in Agricultural Extension

Agricultural extension in India has undergone significant transformation in response to shifting development priorities. Contemporary literature indicates a shift toward knowledge facilitation, capacity building, climate adaptation support, gender mainstreaming, entrepreneurship development, market linkage facilitation and the application of digital technologies (Anderson and Feder, 2007; Glendenning *et al.*, 2010) ^[3, 24]. The extension landscape has also become increasingly pluralistic, with private agribusinesses, NGOs, FPOs, ICT platforms and agri-tech startups complementing public extension systems (Swanson, 2006; Davis, 2008) ^[9, 52]. Despite these advancements, persistent challenges remain, including reliance on conventional pedagogies, limited field applicability of research, gender disparities and inadequate recognition of indigenous knowledge systems (Rivera and Sulaiman, 2009) ^[48]. Climate variability has further heightened production risks, underscoring the need for adaptive and resilient extension models. Future extension professionals must therefore acquire competencies in digital literacy, climate-resilient agriculture, monitoring, evaluation, accountability and learning (MEAL), gender and social inclusion and agripreneurship.

5. New Career Pathways in Agricultural Extension

Conventional linear technology-transfer models are increasingly complemented by pluralistic, data-driven and market-oriented advisory roles that integrate agronomy, climate science, finance and institutional coordination. Recent literature highlights the need for extension systems to evolve from information dissemination mechanisms to innovation brokerage and ecosystem facilitation platforms (Swanson and Rajalahti, 2010; Davis and Sulaiman, 2014; FAO, 2022) ^[10, 20, 54].

5.1 Digital Extension Product Management

Digital Extension Product Managers develop and manage farmer-facing advisory systems such as mobile applications, IVR services, chatbots and decision-support dashboards. Acting as intermediaries between technology developers, researchers and field institutions, they ensure advisories are agronomically valid, localised and user-centric. Evidence suggests that adoption improves when services emphasise local languages, voice-based interfaces and feedback mechanisms (Aker *et al.*, 2016; Baumüller, 2018; World Bank, 2021) ^[2, 4, 65].

5.2 Climate Information Services Specialists

Climate Information Services specialists translate climate and agro-meteorological data into timely, actionable

advisories aligned with farmers' operational decisions. Studies show higher uptake when advisories are localised, repeatedly delivered through multiple channels and synchronised with cropping calendars, particularly in climate-vulnerable regions (Hansen *et al.*, 2011; Vaughan and Dessai, 2014; Roudier *et al.*, 2016) ^[28, 58].

5.3 CFO-on-Call for Farmer Producer Organisations

Many FPOs face early-stage failure due to weak financial management and limited access to professional expertise. The CFO-on-Call model provides shared, part-time financial services across multiple FPOs, improving bookkeeping, compliance, credit access and investment readiness. Research indicates that professional financial advisory support significantly enhances FPO sustainability and market performance (Trebbin and Hassler, 2012; NABARD, 2018; Murray and Shukla, 2020) ^[41, 43, 57].

5.4 PM-FME Cluster Facilitation and Micro-Processing Support

Cluster facilitators under the PM-FME and ODOP frameworks support micro food processing enterprises in technology adoption, regulatory compliance, branding and market linkage development. By enabling institutional convergence and value-chain coordination, these facilitators reduce post-harvest losses, promote local value addition and generate rural employment (FAO, 2017; MoFPI, 2021; Dev and Rao, 2022) ^[12, 16, 39].

5.5 Monitoring, Evaluation and Learning (MEL) Specialists

MEL specialists support a shift from activity-based monitoring to outcome and impact-oriented evaluation in extension and rural development programmes. Using theory-driven frameworks, mixed methods and data analytics, MEL actors generate evidence on adoption, income change, resilience and inclusion while informing adaptive programme design (OECD, 2019; World Bank, 2020) ^[45, 64].

5.6 Agri-Finance and Impact Advisory

Agri-finance and impact advisors design blended finance mechanisms and de-risking instruments that align farm profitability with climate and social outcomes. By integrating extension insights with financial structuring, they facilitate access to public, private and climate finance while improving investment viability in smallholder agriculture (IFAD, 2019; Ghosh *et al.*, 2021; OECD, 2021) ^[23, 32, 46].

6. Emerging Professional Pathways in Agricultural Extension

Traditional agricultural extension systems have largely emphasised technology dissemination and farmer training. Contemporary challenges such as climate change, market integration, institutional complexity and digitalisation have expanded the functional boundaries of extension. Recent literature highlights a shift from production-centric models to multidimensional extension systems encompassing institutional development, market facilitation, financial advisory and ecosystem coordination (Swanson and Rajalahti, 2010; Birner *et al.*, 2009; FAO, 2020) ^[6, 19, 54].

6.1 Agricultural Extension as Development Consulting

Extension professionals contribute to government initiatives, donor-funded programmes and development interventions by applying participatory approaches and socio-technical diagnostics to address productivity, equity and sustainability challenges (Rivera and Qamar, 2003; Swanson, Bentz and Sofranko, 1997) ^[47, 55]. Tools such as Participatory Rural Appraisal (PRA) and Farmer Field Schools enhance contextual relevance and scalability of development interventions, positioning extension professionals as development consultants with field-level credibility (Birner *et al.*, 2009; FAO, 2016) ^[6, 15].

6.2 Extension in FPO Strategy and Incubation

The rapid expansion of FPOs has created a new institutional mandate for extension systems. Literature emphasises that FPO performance depends on sustained capacity building, governance strengthening and market-oriented advisory — functions well aligned with extension expertise (NABARD, 2015; Trebbin and Hassler, 2012) ^[42, 57]. Extension supports leadership development, enterprise planning, financial literacy and market linkage facilitation, enabling FPOs to transition from input-focused collectives to viable agribusiness entities (World Bank, 2018) ^[63].

6.3 Role of Extension in Development Programmes

Agricultural extension is widely recognised as a critical intermediary in development programmes, translating policy objectives into field-level outcomes (Anderson and Feder, 2007; FAO, 2020) ^[3, 19]. Extension plays an operational role in farmer training, climate-resilient agriculture, digital advisory services and FPO promotion. Extension systems also contribute to monitoring, evaluation and learning by documenting impacts and facilitating feedback loops among stakeholders (OECD, 2019) ^[45].

6.4 Agricultural Extension as Agri-Investment Advisory

Agricultural extension is increasingly recognised as an important enabler of investment readiness among smallholder farming enterprises, particularly with the growth of agricultural value chains, Farmer Producer Organisations (FPOs) and agribusiness models. Sulaiman and Hall (2002) ^[51] emphasised the need for extension systems to move beyond conventional technology dissemination towards broader support for farmers' economic and organisational needs. In India, the expansion of FPOs has increased the demand for support in business planning, financial management, credit access, working-capital assessment and investment appraisal (NABARD, 2018; World Bank, 2018) ^[43, 63]. Klerkx *et al.* (2012) ^[34] highlighted the evolving role of extension as an innovation-brokering function that facilitates linkages among farmers, markets, financial institutions and other stakeholders. With the increasing use of blended-finance mechanisms for smallholder agriculture and agri-SMEs, extension institutions can potentially connect farmer organisations with financial and business-support services (IFAD, 2019; OECD, 2021) ^[32, 46]. This expanded role requires competencies in financial literacy, market intelligence, enterprise development and business facilitation.

6.5 Strategic Ecosystem Building

Contemporary scholarship conceptualises agricultural extension as a strategic ecosystem builder that connects farmers with research, markets, finance, institutions and digital infrastructure (Klerkx *et al.*, 2012) ^[34]. Extension increasingly performs an innovation-brokering function by facilitating knowledge exchange, stakeholder coordination and linkages among farmers, researchers, private enterprises and government agencies. Such linkages strengthen research–extension–farmer interactions and support the co-development and adoption of locally relevant agricultural innovations (Hall *et al.*, 2006; Klerkx *et al.*, 2012) ^[27, 34]. Extension also contributes to value-chain integration by helping farmers access market information, inputs, services and collective marketing opportunities.

Furthermore, effective coordination among extension agencies and other rural institutions can improve access to government programmes, financial services and technological resources. In the context of climate change, extension plays an important role in strengthening farmers' adaptive capacity through climate information, sustainable production practices, crop diversification, resource-conserving technologies and adaptive farm planning (FAO, 2020; IPCC, 2022) ^[19, 33]. Thus, the contemporary extension system is evolving from a technology-transfer mechanism into a multidimensional platform for innovation, institutional coordination, market integration and climate-resilient agricultural development.

6.6 Role of extension in entrepreneurship development

Agricultural extension plays a pivotal role in fostering entrepreneurship among farmers by bridging the gap between technical knowledge and market-oriented enterprise. Extension functionaries act as facilitators, encouraging farmers to move beyond subsistence-oriented production towards commercial and value-added activities such as processing, packaging and direct marketing. Through training programmes, demonstrations and exposure visits, extension agencies strengthen farmers' capacities in business planning, financial literacy, record keeping and risk management, which are important competencies for successful agri-entrepreneurship (FAO, 2017; OECD, 2021) ^[16, 46]. Extension also facilitates farmers' access to institutional credit, government schemes and support programmes that can provide financial assistance for establishing and expanding agri-enterprises (NABARD, 2018) ^[43].

By linking farmers with Farmer Producer Organisations, Self-Help Groups and cooperatives, extension can promote collective entrepreneurship and strengthen farmers' access to inputs, markets and services (World Bank, 2018) ^[63]. Extension personnel also disseminate market information, price trends and information on emerging value-added opportunities, thereby supporting informed enterprise decisions (Klerkx *et al.*, 2012) ^[34]. Convergence with programmes such as the Pradhan Mantri Formalisation of Micro Food Processing Enterprises (PMFME) scheme further creates opportunities for small-scale agricultural enterprises to access credit-linked support, capacity building and formalisation services (MoFPI, 2021) ^[39]. Overall, extension serves as an important institutional bridge that can transform farmers' entrepreneurial potential into viable agri-

business ventures, contributing to income diversification, employment generation and livelihood security.

Conclusion

Agricultural extension has evolved from a narrowly defined technology transfer mechanism into a multidimensional system central to sustainable agricultural and rural development. While traditional extension approaches played a decisive role in achieving food security during the Green Revolution, they are increasingly inadequate in addressing contemporary challenges shaped by climate variability, market integration, digitalisation and institutional complexity. Modern agriculture demands extension systems that are adaptive, participatory and systems-oriented rather than linear and prescriptive.

In India, extension today operates within a pluralistic landscape involving public institutions, private actors, NGOs, digital platforms and farmer collectives. Its functional scope has expanded to include climate information services, digital advisory systems, financial and investment facilitation, organisational development of FPOs, market linkage support and monitoring, evaluation and learning. Extension professionals now act as knowledge brokers, institutional facilitators and ecosystem builders who connect farmers with research, markets, finance and technology.

Despite notable progress, persistent constraints such as inadequate funding, human resource shortages, uneven digital inclusion and limited institutional coordination continue to undermine extension effectiveness. Addressing these gaps requires reimagining extension as a strategic public good supported by sustained investment, professional capacity building and accountability mechanisms. Strengthening extension's role in innovation systems, climate resilience and inclusive agribusiness development will be critical for enhancing farm livelihoods and ensuring the long-term sustainability of Indian agriculture.

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