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# Reimagining Agricultural Extension for the Sustainable Development Goals: Building Climate-Resilient, Digital and Farmer-Centric Agriculture

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Indian agriculture feeds more than 1.4 billion people and employs close to half the country's workforce, yet the sector still runs on the decisions of over 140 million operational holdings, most of them small and marginal. Every one of those decisions which seed to sow, when to irrigate, how to manage a pest outbreak, where to sell depends on information reaching the farmer in time and in a form that is usable. That is the quiet, unglamorous job of agricultural extension, and it has never mattered more. Three pressures are converging on the extension system at once. Food security concerns have sharpened as population growth, urbanisation and shrinking per-capita land holdings squeeze the margin for error. Climate change is rewriting the agronomic calendar, bringing erratic monsoons, heat stress and new pest pressures that older advisory packages were never designed for. And a digital wave smartphones, low-cost data, satellite feeds and now generative AI has given extension tools it could barely have imagined a generation ago. Sustainable agriculture is no longer a side conversation, it is the organising idea around which modern extension is being rebuilt. The United Nations 2030 Agenda gives this rebuilding a shared compass. The Sustainable Development Goals do not mention agricultural extension by name, but almost none of them can be met in a country like India without it. Extension is the connective tissue between research stations and real fields, between government schemes and the farmers they are meant to serve, and between climate science and the decisions taken on a half-acre plot tomorrow morning.

## Agricultural Extension: From Traditional to Smart

The story of Indian extension is really the story of successive attempts to close the gap between what science knows and what a farmer can act on. The earliest model, inherited from the colonial period and continued after Independence, was built around the community development programme and a generalist Village Level Worker. It gave way in the 1970s to the World Bank-supported Training and Visit system, which organised extension officers around fixed visit schedules and a top-down transfer-of-technology philosophy: scientists generated recommendations, and extension's job was to carry them, largely unchanged, to the field. That model reached its limits as farming systems diversified and farmers' own knowledge proved indispensable to making recommendations work locally. Participatory extension approaches, and later the Agricultural Technology Management Agency (ATMA) framework, tried to correct course by bringing farmers, Krishi Vigyan Kendras, State Agricultural Universities and line departments into a shared planning process rather than a one-way instruction chain.

The 2000s and 2010s added a further layer: information and communication technology. Kisan Call Centres, SMS-based advisories and, later, smartphone apps meant that a farmer no longer had to wait for an extension worker's visit to get an answer. Today the frontier has moved again, toward AI-enabled and data-driven systems capable of tailoring advice to a specific plot, using satellite and sensor data rather than generic, one-size-fits-all recommendations. Many scholars now describe the direction of travel as Agriculture 5.0 a phase in which artificial intelligence, robotics and big data work alongside, not instead of, human expertise and farmer knowledge.

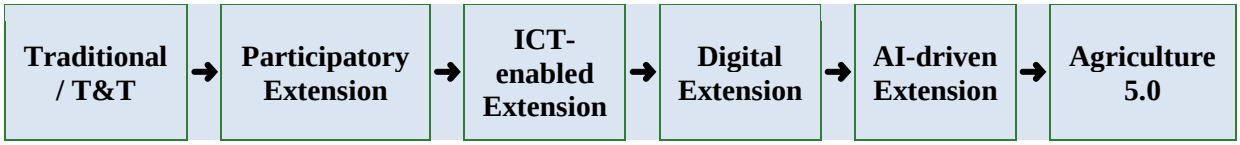


**Figure 1. Evolution of Agricultural Extension in India — from a top-down technology-transfer model toward a participatory, digitally enabled, AI-assisted system.**

## Agricultural Extension and the Sustainable Development Goals

Look closely at the 2030 Agenda and extension's fingerprints are on far more goals than the obvious ones of zero hunger and no poverty. Because extension shapes what farmers grow, how they grow it, who gets to make decisions on the farm, and how produce moves from field to market, it touches the economic, social and environmental dimensions of the SDGs simultaneously. On poverty and hunger (SDG 1 and SDG 2), extension advisory on improved practices, credit linkage and market access remains one of the most direct levers available for raising farm incomes and productivity among small and marginal holders. On gender equality (SDG 5), a systematic review of the literature on women's empowerment through agricultural extension found that capacity-building approaches targeted at women farmers rather than assuming information will trickle down within the household are central to closing the well-documented gender gap in access to advisory services and inputs.

Water-use advisory under initiatives such as micro-irrigation promotion and groundwater-friendly cropping choices connects extension to clean water and sanitation (SDG 6), while support for farmer-owned enterprises and Farmer Producer Organizations builds the kind of decent, dignified rural work envisaged under SDG 8. Extension messaging on input-use efficiency, integrated pest management and reduced post-harvest loss speaks directly to responsible consumption and production (SDG 12), and climate-smart agriculture advisory covering everything from drought-tolerant varieties to residue management is now one of the clearest on-ground expressions of climate action (SDG 13) available to a farming household. Extension work on soil health, agroforestry and watershed management supports life on land (SDG 15), and the entire architecture of modern extension public research institutions, private agri-tech, cooperatives, NGOs and farmer collectives working together is itself a small-scale demonstration of the partnerships that SDG 17 asks the world to build.

**Table 1. Illustrative Linkages Between Agricultural Extension Functions and Selected SDGs**

| SDG | Extension Function | Illustrative Mechanism |
|---|---|---|
| SDG 1 – No Poverty | Income-enhancing advisory | Improved-practice advisory, credit and input linkage for smallholders |
| SDG 2 – Zero Hunger | Productivity and nutrition advisory | Balanced fertiliser use, crop diversification, nutri-garden promotion |
| SDG 5 – Gender Equality | Women-focused capacity building | Targeted training for women farmers and self-help groups |
| SDG 6 – Clean Water | Water-efficient advisory | Micro-irrigation promotion, groundwater-friendly cropping advice |
| SDG 8 – Decent Work | Enterprise and FPO support | Capacity building of Farmer Producer Organizations and agri-entrepreneurs |
| SDG 12 – | Input-use efficiency advisory | Integrated pest/nutrient management, |

| SDG | Extension Function | Illustrative Mechanism |
|---|---|---|
| Responsible Consumption | | post-harvest loss reduction |
| SDG 13 – Climate Action | Climate-smart agriculture advisory | Climate-Smart Villages, weather-based advisories, resilient varieties |
| SDG 15 – Life on Land | Natural resource management advisory | Soil health cards, agroforestry, watershed-based farming systems |
| SDG 17 – Partnerships | Multi-stakeholder platforms | ICAR–SAU–KVK–NGO–agri-tech convergence in extension delivery |

## The Digital Revolution in Agricultural Extension

The most visible change in extension over the last decade has been the shift of advisory from the field visit to the handset. The Kisan Call Centre scheme, running on the toll-free number 1800-180-1551 since 2004, answers farmer queries in twenty-two local languages through agents drawn from agricultural graduate and postgraduate backgrounds. The mKisan portal built on top of it allows central and state agencies to push crop, weather and market advisories directly to farmers' phones by SMS in their preferred language and crop interest. Beyond messaging, a wider stack of digital tools is now part of the extension toolkit. Artificial intelligence is being used for crop and pest image recognition, yield prediction and personalised advisory, chatbots and voice-based assistants are beginning to offer round-the-clock query resolution in regional languages, drones are used for aerial crop monitoring and targeted spraying, and remote sensing and GIS feed into geospatial decision-support systems such as the Krishi Decision Support System, which brings together satellite, weather, soil and water data at district and sub-district level. The Internet of Things, through low-cost soil-moisture and weather sensors, is starting to make precision agriculture viable even on small holdings, particularly where it is bundled into a shared or cooperative service rather than sold to individual farmers.

The common thread running through all of these tools is that they do not replace the human extension worker so much as extend her reach. NITI Aayog has projected that the AI-in-agriculture market in India could be worth around USD 2.6 billion by 2025, growing at over 22 per cent annually — a scale that only makes sense if these technologies are absorbed into, rather than substituted for, an advisory system that still depends on trust between farmer and adviser.

| | | |
|---|---|---|
| **AI Advisory** | **Mobile Apps / KCC** | **Weather Services** |
| **Drones & Remote Sensing** | **FARMER** | **GIS / IoT Sensors** |
| **Extension Professionals** | **Research Institutions (ICAR/SAU)** | **Government & FPOs** |

**Figure 2. The Digital Agriculture Ecosystem — how farmers, extension professionals, technology and institutions interact.**

## Emerging Innovations Reshaping Extension

Climate-smart agriculture has moved from a research concept to an extension delivery model in its own right. The Climate-Smart Village approach, piloted by the CGIAR Research Program on Climate Change, Agriculture and Food Security from 2011 in Haryana and Bihar and since scaled across Punjab and other states, brings farmers, researchers and local government together to co-select practices from laser land levelling to leaf-colour-chart-based nitrogen management suited to a specific village's climate risk profile.

Farmer Producer Organizations have become a second major channel for extension delivery, not just a marketing vehicle. Under the Central Sector Scheme for the Formation and Promotion of 10,000 FPOs, launched in 2020 with a budgetary outlay of about ₹6,865 crore, the target of forming 10,000 new FPOs was reached in 2025, with roughly thirty lakh farmers now linked to these organisations. Because FPOs aggregate demand for inputs, machinery and training, they have become natural nodes through which extension advisory, credit and market information can reach members more efficiently than through individual outreach.

Agri-tech startups and public-private partnerships fill much of the remaining gap. Companies now offer satellite-based advisory, digital marketplaces and app-based extension delivered in partnership with state departments, cooperatives and research institutions, while the government's Digital Agriculture Mission has signed memoranda of understanding with several private technology partners to pilot AI, blockchain and drone-based solutions. Taken together, these developments are what analysts increasingly describe as Agriculture 5.0 — an ecosystem in which public research, private technology and farmer collectives co-produce extension services rather than each working in isolation.

## Real Success Stories in Agricultural Extension

A handful of Indian initiatives illustrate how far extension has travelled from the single-message broadcast model. ITC's e-Choupal, launched in Madhya Pradesh's soybean belt in 2000, placed internet kiosks run by trained farmers called sanchalaks in villages so growers could check mandi and company prices, weather and best-practice information before deciding where to sell, the network grew to reach several million farmers across ten states and is widely cited as one of the earliest large-scale ICT interventions in Indian agriculture.

Digital Green took a different route, using locally produced, farmer-acted videos screened by trained community mediators rather than a purely technology-led approach. Independent randomised evaluations of its work in Bihar, conducted with the state's Jeevika livelihoods programme, found substantially higher adoption of recommended practices among farmers who viewed the videos compared with conventional government extension, at a cost per farmer well below that of traditional field-visit models. The approach has since scaled to reach several million smallholders across India and other countries.

The Kisan Call Centre and its mKisan messaging layer remain the largest single-window, government-run advisory channel, while the CGIAR Climate-Smart Village network in Haryana and Bihar continues to generate field-level evidence on water saving and emission reduction that is feeding into state agriculture department planning. Each of these initiatives, despite very different institutional models, shares a common feature: they treat the farmer as an active participant in generating and validating knowledge, not merely as its recipient.

**Table 2. Selected Extension Innovations and Their Approach**

| Initiative | Lead Actor(s) | Core Approach |
|---|---|---|
| e-Choupal | ITC Limited | Village internet kiosks run by farmer sanchalaks for price discovery and advisory |
| Digital Green | Digital Green Trust, with state livelihood missions | Locally produced farmer-to-farmer video, screened through community groups |
| Kisan Call Centre / mKisan | Ministry of Agriculture & Farmers Welfare | Toll-free multilingual call advisory plus SMS-based push advisory |
| Climate-Smart Villages | CGIAR–CCAFS with state agriculture departments | Community co-selection of locally suited climate-resilient practices |
| Farmer Producer Organizations | SFAC, NABARD, NCDC and state agencies | Farmer-owned aggregation for inputs, credit, extension and marketing |

## Challenges on the Ground

None of this progress is evenly distributed. The digital divide remains the most persistent constraint: smartphone ownership, reliable connectivity and comfort with digital interfaces vary sharply by region, landholding size, age and, most consistently, gender. Extension systems built primarily around mobile apps risk reinforcing existing inequities rather than closing them if they are not deliberately designed for low-literacy, low-connectivity users.

Capacity building of the extension workforce itself has not kept pace with the tools now available to it. Many field-level functionaries were trained under an older, transfer-of-technology model and need structured reskilling in data interpretation, digital tool use and participatory facilitation. Infrastructure gaps patchy rural broadband, inconsistent electricity, and uneven last-mile device access continue to limit how far ICT-based advisory can travel beyond well-connected districts. Policy support and funding, while improving under missions such as the Digital Agriculture Mission, still need to be matched by sustained state-level investment in extension staffing, which has historically been under-resourced relative to research.

**Table 3. Challenges Facing Modern Extension and Practical Responses**

| Challenge | Practical Response |
|---|---|
| Digital divide across region, gender and landholding size | Blended delivery combining voice, video and in-person facilitation, not app-only advisory |
| Extension workforce skill gaps | Structured reskilling of field staff in data use, digital tools and participatory methods |
| Rural connectivity and infrastructure gaps | Shared village-level access points, offline-capable tools, community facilitators |
| Uneven policy and funding support at state level | Convergence of central missions with sustained state extension budgets and staffing |
| Data privacy and farmer trust in digital platforms | Transparent data-governance frameworks under the Digital Public Infrastructure |

## The Road Ahead

The next phase of extension is likely to be defined by personalisation. Generative AI tools capable of holding a conversation in a farmer's own language, referencing local soil and weather data, and explaining recommendations in plain terms could make advisory genuinely responsive to an individual plot rather than a district-wide average provided the underlying data and language models are built for Indian agro-ecological and linguistic diversity rather than adapted from elsewhere as an afterthought. Climate intelligence seasonal forecasting, early-warning systems and locally calibrated risk advisories will need to become a standard extension offering rather than a specialised add-on, given how directly climate variability now affects cropping decisions. Youth engagement and women's empowerment are equally central to this future: bringing agriculture-educated young people into extension roles, and deliberately designing advisory and FPO leadership pathways for women farmers, will determine whether digital extension closes long-standing participation gaps or simply digitises them.


**Figure 3. Future Roadmap for Agricultural Extension, 2026–2035**

## Conclusion

Agricultural extension has quietly become one of the most important levers India has for reconciling productivity with sustainability, and technology with trust. It has moved from a system that pushed a single recommendation to millions of farmers, toward one capable of listening through data, through farmer feedback, through community video and through call

centres answering in twenty-two languages before it speaks. That shift matters because the Sustainable Development Goals cannot be achieved through policy alone, they require millions of individual decisions on millions of individual farms to move in a common direction. Extension is where that alignment happens, or fails to happen. Digital tools, climate-smart practices and farmer institutions such as FPOs have given the system unprecedented reach and precision, but its enduring strength still lies in the same place it always has: a relationship of trust between the person giving advice and the person acting on it. Getting that balance right — technology in service of trust, not in place of it is what will determine whether Indian agriculture's next transformation is as inclusive as it is smart.

> ***"The Sustainable Development Goals will be met, or missed, one farm decision at a time — and extension is where that decision gets its best information."***

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