



Towards Securing the Future of Farming

Healthy soils, efficient water use, diversified production systems, and empowered farmers are the pillars of a resilient agricultural future. Strengthening these through long-term investments and coordinated policies will ensure sustainable food systems, improved rural livelihoods, and environmentally responsible agricultural development.

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Indian agriculture stands at a decisive turning point. Achieving national food security remains one of Independent India's greatest accomplishments, but the conditions under which the next generation will farm are fundamentally different. Rising temperatures, unpredictable monsoons, groundwater depletion, deteriorating soil health, shrinking and fragmented holdings, biodiversity loss,

volatile markets and changing food preferences are reshaping the agricultural landscape. Securing the future of farming, therefore, will require more than increasing production. It will require an agricultural system that is productive, profitable, climate-resilient, nutritionally responsive and ecologically regenerative. Over the next two decades, Indian agricultural policy must bring these objectives together.

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This vision lies at the heart of 'Healthy Farms, Healthy Planet'. Agriculture and allied activities continue to support nearly 46 per cent of India's workforce while contributing almost one-fifth of the national income at current prices. This difference between employment and economic contribution reflects the continuing challenge of low labour productivity and inadequate farm incomes. At the same time, livestock, fisheries and horticulture are becoming increasingly important drivers of agricultural growth, demonstrating that the future of farming will be more diversified than the cereal-centred production system of the past.

Redefining Agricultural Progress

Agricultural success has traditionally been measured through output and yield per hectare. These indicators remain essential, but India must now pursue resilient productivity, stable and profitable output

per unit of land, water, nutrient, energy, labour and greenhouse-gas emissions. Agricultural performance should, therefore, be assessed through farm income, yield stability, soil organic carbon, groundwater balance, water productivity, nutrient-use efficiency, post-harvest losses, dietary diversity, women's participation and climate vulnerability. A system that produces slightly less in a favourable year but remains productive during droughts and heatwaves may be more valuable over time.

Sustainable intensification seeks to maintain or raise output while using resources more efficiently and reducing environmental damage. Diversification, integrated crop management, conservation agriculture and agroforestry can simultaneously enhance productivity and ecosystem services when adapted to local conditions. The farm of the future must be judged not only by one season's harvest, but by its capacity to produce reliably for decades.

Climate Resilience as the Organising Principle

Climate change has already become a significant threat to agricultural production and rural livelihoods. Without adequate adaptation measures, rainfed rice yields may decline by around 20 per cent, while wheat yields could decrease by nearly 19.3 per cent by 2050. More than 300 predominantly agricultural districts have already been classified as highly or very highly vulnerable (ICAR, 2025). Rising temperatures, erratic rainfall, floods, prolonged dry spells, and emerging pests are creating additional uncertainty, while the IPCC warns that climate-related hazards will increasingly affect crops, water resources, livestock, and food security across Asia.

Every major agricultural investment should therefore pass a climate-resilience test. Crop improvement must prioritise tolerance to heat, drought, submergence, salinity and emerging pests. Irrigation, warehouses, rural roads, electricity networks and cold chains should be planned for future climatic conditions rather than historical averages. District Agricultural Contingency Plans should become dynamic systems linked with local weather, advisories, seed reserves and emergency credit. Crop insurance must also move from post-disaster compensation towards integrated risk management, supported by remote sensing, reliable ground data and accessible grievance mechanisms.

SHIFTS FOR THE FUTURE



**From input-intensive
to resource-smart
farming**



**From isolated technology
to integrated solutions**



**From quantity focus
to quality, nutrition
and value**



**From fragmented
effort to inclusive
institutions**



**From short-term gains
to long-term resilience
and sustainability**



Soil as National Productive Infrastructure

Soil is agriculture's most fundamental productive asset. Healthy soils store water, supply nutrients, support biodiversity, and help crops withstand environmental stress. Degraded soils weaken these functions, increasing dependence on irrigation, chemical fertilisers, and pesticides. Soil organic matter is particularly important for maintaining soil aggregation, water retention, nutrient cycling and microbial activity. Its depletion reduces productivity as well as input-use efficiency (Lal, 2020).

Restoring soil health should, therefore, be treated as an investment in national productive infrastructure. Soil Health Cards should evolve from periodic diagnostic reports into field-specific management tools based on soil characteristics, cropping sequence, yield targets, locally available organic resources, and climatic conditions. Their recommendations should address not only nutrient application but also the restoration of soil organic matter.

Balanced fertilisation should follow the principles of applying the right source, right rate, right time, and right place. Although mineral fertilisers will continue to play a vital role in Indian agriculture, their efficiency can be significantly improved by integrating them with legumes, green manures, compost, crop residues, livestock manure, and biofertilisers. Reduced tillage, residue retention, and diversified crop rotations can increase soil organic carbon and sustain productivity when adopted as part of an integrated package.

Natural, organic, regenerative and conventional farming systems should be evaluated scientifically on the basis of productivity, cost, labour requirements, profitability, and environmental impact rather than being viewed as competing ideologies.

Producing Greater Value from Every Drop

Water will increasingly determine the geography and economics of Indian agriculture. Irrigation has significantly strengthened food security, but excessive groundwater extraction, water-intensive cropping patterns, subsidised electricity, and inefficient irrigation practices have created severe water stress in many regions. Future policy must therefore shift from expanding water extraction to maximising value from every unit of water used.

An integrated approach combining watershed restoration, rainwater harvesting, groundwater recharge, micro-irrigation, laser land levelling, precise irrigation scheduling, and drought-tolerant crop varieties should become the foundation of water management. In rice cultivation, alternate wetting and drying can substantially reduce water use without compromising yields when implemented correctly, although excessive drying may reduce productivity. Crop choices must also reflect local water availability. Water-stressed regions should be encouraged to diversify towards pulses, oilseeds, millets, fodder crops, maize, and suitable horticultural crops through access to quality seed, reliable markets, processing facilities, crop insurance, and transitional support. Solar irrigation under PM-KUSUM can reduce dependence on diesel and improve farm incomes, but it should be accompanied by groundwater monitoring and incentives that encourage efficient water use.

Diversifying Farms for Nutrition and Resilience

India's future food security must combine calories with nutrition. Diversification towards pulses, millets, oilseeds, fruits, vegetables, livestock and fisheries can improve diets, raise farm income and strengthen ecological resilience. Rotations and integrated systems can interrupt pest cycles, support pollinators, improve nutrient cycling and spread climatic and market risks.

A synthesis of 98 meta-analyses found that agricultural diversification generally enhances biodiversity, pollination, pest regulation, soil fertility, and water regulation without reducing crop yields. However, farmers diversify only when alternative production systems are economically viable. Irrigation infrastructure, roads, remunerative prices, market access, processing facilities, and institutional support strongly influence the adoption of high-value crops in India. Diversification must therefore be supported by improved crop varieties, sound agronomic management, affordable credit, insurance, price support, storage, processing, and efficient marketing systems.

Pulses and millets can be linked more closely with public nutrition programmes; oilseeds with decentralised processing; and horticulture with grading, packhouses, cold storage and transport. Integrated crop–livestock–fish–tree systems are especially valuable in rainfed and smallholder regions because they recycle nutrients, generate year-round employment and reduce dependence on a single commodity.





Climate-Ready Science and Seed Systems

The farm of the future will require crops that combine high productivity with tolerance to heat, drought, submergence, salinity and emerging pests, while meeting demands for nutrition, mechanisation, storage and processing. Public breeding must remain central because many crops, regions and traits important to smallholders may not attract sufficient private investment.

Modern breeding tools, including genomic selection, speed breeding, advanced phenotyping, and participatory varietal selection, can significantly shorten breeding cycles. Community seed systems can conserve locally adapted genetic diversity, while formal seed systems ensure varietal purity, quality, and rapid multiplication. Success should be measured not only by the number of varieties released but also by seed availability, local adaptation, and farmer adoption.

Agricultural research must also move beyond isolated commodity-based approaches. Even the most resilient variety cannot realise its full potential without appropriate soil, nutrient, water, and market management. Research funding should therefore prioritise integrated farming-system solutions and reward institutions for improvements in farm profitability, resilience, and resource-use efficiency.

Inclusive and Responsible Digital Agriculture

Artificial intelligence, satellites, drones, sensors, mobile platforms, and automated weather systems can

support pest surveillance, irrigation, credit, insurance, yield forecasting, and market coordination (Fig. 2). The Digital Agriculture Mission, including AgriStack, the Krishi Decision Support System, and soil mapping, provides a strong foundation for data-driven agricultural services (Department of Agriculture and Farmers Welfare, 2024). However, digitalization must remain farmer centred.

Technology is effective only when it solves real problems affordably, transparently, and in languages farmers understand. Farmers should retain control over their data through consent, correction, portability, and protection from unauthorised use. Digital tools should complement, not replace, human extension. A 'phygital' model combining satellite intelligence with local advisers, Krishi Vigyan Kendras, FPOs, and experienced cultivators offers an inclusive pathway, provided issues of privacy, data ownership, and digital skills are adequately addressed.

Creating an Institutional Scale for Smallholders

Most Indian farmers operate small or marginal holdings and cannot individually own every machine, warehouse, drone, or processing facility needed for competitive agriculture. The solution lies not in forced land consolidation but in institutional scale. Farmer Producer Organisations (FPOs), cooperatives, Self-Help Groups, water-user associations and modernised Primary Agricultural Credit Societies can aggregate inputs, machinery, finance, information, and produce. They strengthen bargaining power, support processing and branding, and enable direct market linkages.

The next phase of FPO development should focus on business viability, professional management, working capital, transparent governance, and member participation. Custom Hiring Centres can provide machinery and drones as shared services, while shared packhouses, warehouses, cold rooms, and testing facilities can reduce costs and improve the competitiveness of small farms

Building Circular and Low-Carbon Rural Economies

Farm income can rise not only through higher production but also by retaining more value after harvest. Drying, grading, storage, cooling, processing, packaging, and transport should be treated as integral to agricultural productivity. Decentralised infrastructure can reduce losses and help farmers secure better



INDIA'S MAJOR SOIL TYPES

Diverse Soils, Diverse Strength



Source: Ministry of Agriculture and Farmers Welfare

prices. Rural India should also promote circular bio-economies by converting crop residues, manure, and processing by-products into compost, animal feed, biochar, or biogas instead of causing pollution. Solar-powered cold stores, efficient pumps, renewable energy, and cleaner machinery can further reduce costs and emissions. NITI Aayog's long-term scenarios indicate that improved nutrient management, crop diversification, efficient energy use, and sustainable rice cultivation can reduce agricultural emissions while maintaining output growth (NITI Aayog, 2026). Carbon markets and payments for ecosystem services can provide additional income with transparent contracts and clear ownership. Soil restoration, groundwater recharge, biodiversity conservation, and residue recycling should also be recognized as valuable environmental services.

Placing Women and Rural Youth at the Centre

Agricultural transformation will remain incomplete unless women gain equitable access to land, finance, machinery, extension services, and leadership. Their contribution to crop production, livestock, post-harvest activities, and household nutrition remains substantial but often undervalued. Women-led producer organizations, seed groups, and food enterprises should receive targeted finance and market

support. Closing gender gaps can improve productivity, nutrition, and resilience (FAO, 2023).

Rural youth will remain engaged in farming only if it offers skilled and remunerative opportunities. Future villages will need drone operators, soil-health technicians, irrigation auditors, machinery-service providers, livestock advisers, and agricultural data stewards. Universities, vocational institutions, and Krishi Vigyan Kendras should combine scientific training with entrepreneurship and field apprenticeships.

Conclusion: A National Compact for Future Farming

This transformation cannot emerge from disconnected schemes. India needs a long-term agricultural compact with State- and district-specific pathways and measurable milestones. Public expenditure should gradually shift from input-based incentives towards investments in soil restoration, water conservation, diversification, research, extension, and risk reduction.

Procurement and minimum support systems should continue to safeguard food security while encouraging voluntary crop diversification. District transition plans should be based on local water resources, soil capability, climate vulnerability, infrastructure, and market opportunities. Public dashboards can track profitability, groundwater, soil health, input efficiency, post-harvest losses, resilience, and inclusion.

The Indian farm of 2047 should be productive yet sustainable, technologically advanced yet farmer-centred, and profitable by regenerating rather than depleting natural resources. Securing the future of farming is not merely an agricultural objective but a national development imperative. When healthy soils, secure water, capable farmers, responsible technologies, and fair markets reinforce one another, "Healthy Farms, Healthy Planet" can become the guiding principle of Indian agriculture over the next two decades. □

