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Crop Diversification in India: Agronomic Strategies for Sustainable and Profitable Farming Systems

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Crop diversification is an agronomic strategy for reducing dependence on a narrow range of crops while improving resource-use efficiency, resilience and farm income. It can be achieved through crop rotation, intercropping, sequential cropping, inclusion of legumes, integration of vegetables and oilseeds, and agroforestry. Recent Indian research indicates that diversified systems can improve soil health, reduce water use in selected settings, spread production and market risks, and increase system productivity when crop choice and management are matched to local conditions. A 2025 long-term study in Punjab reported that a legume-based maize–pea–spring groundnut system produced a 68.97% higher rice-equivalent yield than the rice–wheat system evaluated, alongside improved soil biological indicators and profitability. However, diversification is constrained by market access, procurement policies, seed availability, labour, mechanization, storage and price volatility. This article reviews agronomic approaches, recent evidence and implementation priorities for sustainable crop diversification in India, with attention to semi-arid regions such as Gujarat.

Keywords: crop diversification, cropping systems, legumes, resource-use efficiency, farm profitability, climate resilience

Introduction

Many Indian farming regions depend heavily on a limited number of crops and crop sequences. While specialization can support mechanization, procurement and established markets, it can also increase exposure to drought, price shocks, nutrient depletion, pest build-up and excessive demand for irrigation water. Crop diversification means increasing the number or variety of crops grown over time or space, including through rotations, intercropping, sequential cropping and the inclusion of high-value or perennial crops. Its purpose is not simply to grow more crops, but to design a cropping system that balances productivity, profitability, ecological health and risk. ICAR reviews highlight that diversification can support soil health, biodiversity, pest and disease-cycle disruption and resilience, while also noting that market incentives and infrastructure strongly influence adoption (Rautaray & Sucharita, 2023; Kumar *et al.,* 2025).

Major agronomic approaches to diversification

Crop rotation and legume integration

Rotating cereals with pulses, oilseeds or fodder crops can diversify rooting patterns, residue quality and nutrient demand. Legumes such as chickpea, mungbean, pigeonpea and cowpea can contribute biologically fixed nitrogen, break some cereal-associated pest and disease cycles, and provide protein-rich food or feed. Benefits depend on species, variety, crop duration, residue management

and the next crop's nutrient demand; biological nitrogen fixation does not eliminate the need for soil testing or balanced fertilization.

Intercropping and strip cropping

Intercropping combines two or more crops in the same field during part or all of their growing period. Cereal–legume, cotton–legume and millet–pulse combinations may use light, water and nutrients more complementarily than sole crops when row ratios and sowing dates are appropriate. The system should be selected using local evidence on land-equivalent ratio, total system yield, labour, harvesting compatibility and market value rather than relying on the yield of one crop alone.

Sequential cropping and short-duration crops

Short-duration varieties and crops can fit between major seasons and increase land-use intensity when water, temperature and planting windows permit. Examples include adding mungbean after wheat or incorporating vegetables, pulses or oilseeds into rice-based sequences. A 2025 study from eastern India found that rice–cauliflower–spinach–green gram recorded a higher rice-equivalent yield than the rice–wheat–green gram comparison system in that experiment; these results are location- and management-specific and should not be generalized without local validation (Shivani *et al*., 2025).

Diversification with vegetables, oilseeds and high-value crops

Vegetables, spices, oilseeds and selected horticultural crops can raise gross returns and improve dietary diversity, but often require more labour, perishability management, irrigation, quality inputs and reliable markets. A diversified farm should balance high-value crops with stable staples and pulses to avoid replacing production risk with market risk. Contract terms, grading, storage, transport and access to farmer producer organizations can influence profitability as much as yield.

Conservation agriculture and residue management

Diversification can be combined with reduced tillage, residue retention, mulching and suitable cover crops. These practices may improve soil cover, moisture conservation and soil biological activity, particularly where erosion or water stress is important. A 2024 study in the western Indo-Gangetic Plains found that diversified conservation-agriculture systems involving maize or soybean improved selected productivity and environmental indicators relative to rice-based comparisons, with outcomes dependent on the system and management package (Gora *et al*., 2024).

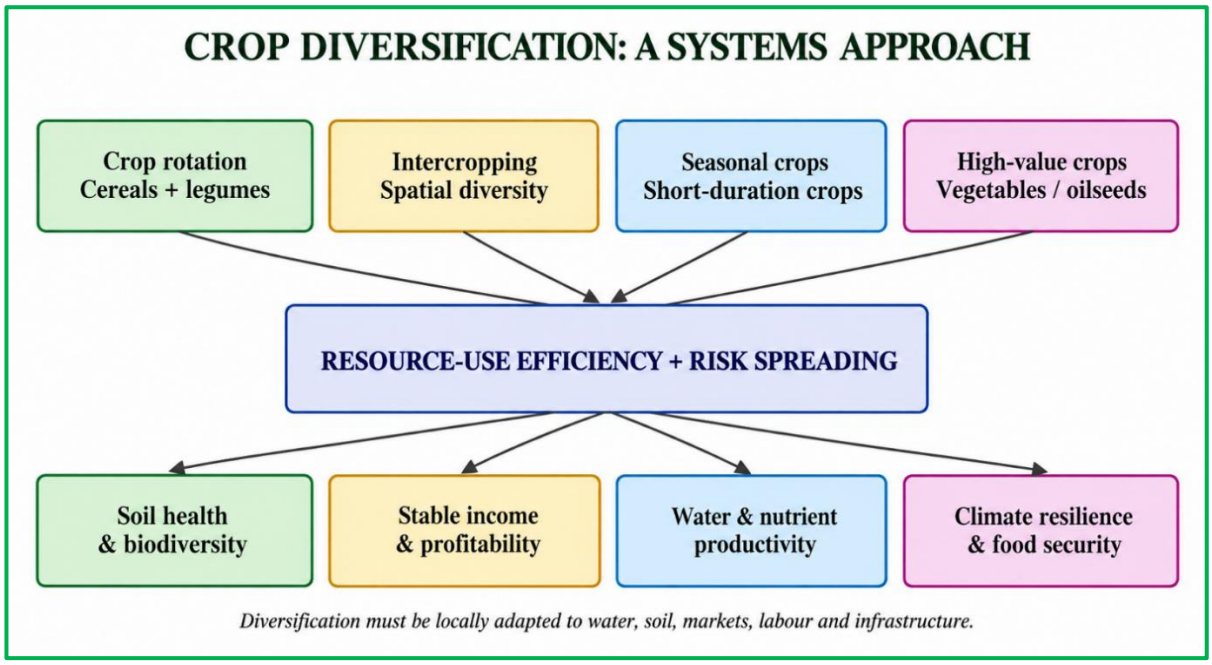


Figure 1. Conceptual framework showing how crop rotations, intercropping, seasonal crops and high-value crops can contribute to resource-use efficiency and resilience. Original illustration.

Recent evidence from Indian cropping systems

Recent studies support the potential of diversification but also demonstrate the importance of location-specific design. In a six-year experiment at Punjab Agricultural University, legume-integrated systems improved soil biological indicators and productivity; the maize–peas–spring groundnut sequence produced a rice-equivalent yield of 199.88 q/ha compared with 118.29 q/ha

under rice–wheat, a reported increase of 68.97%, and generated higher net returns under the study conditions (Walia *et al.,* 2025). In eastern India, a three-year rice-based cropping-system study reported high system productivity from sequences incorporating vegetables and green gram (Shivani *et al.,* 2025). These examples show that comparisons should include system yield, net returns, water use, labour, soil effects and price variability—not just the yield of an individual crop.

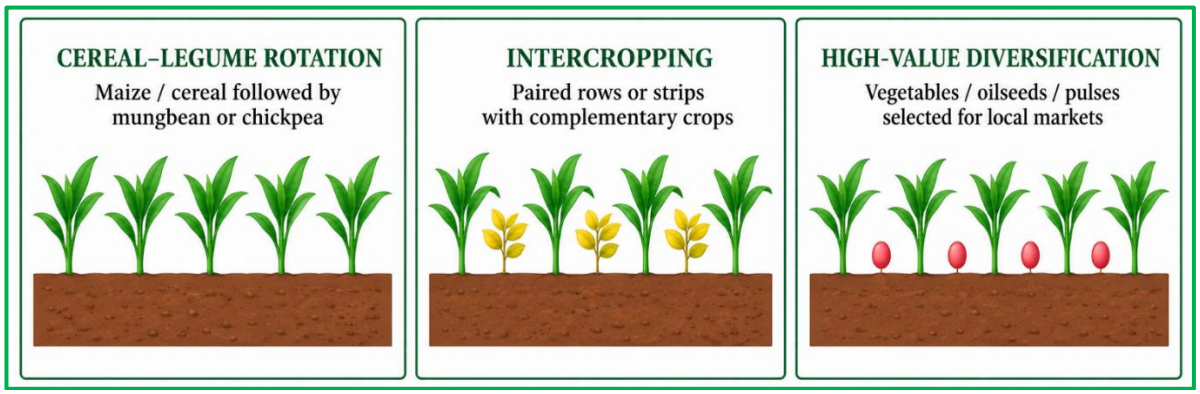


Figure 2. Coloured illustration of cereal–legume rotation, intercropping and high-value crop diversification. Original illustration.

Table 1. Illustrative diversification options for Indian farming systems

Existing system / context	Potential diversification option	Key planning consideration
Rice–wheat in irrigated areas	Maize, pulses, oilseeds, fodder or selected vegetables	Assess water availability, machinery, procurement and market access
Rainfed cereal systems	Millet–pulse rotation, intercropping, oilseeds and fodder crops	Choose drought-adapted crops and conserve soil moisture
Cotton-based systems	Cotton with suitable legumes or rotational pulses/oilseeds	Check competition, harvesting operations and local pest complexes
Rice fallows	Lentil, chickpea, pea or rapeseed where residual moisture permits	Use suitable short-duration cultivars and minimum-tillage options
Small farms near markets	Seasonal vegetables, spices, pulses and staggered planting	Plan labour, perishability, grading and price risk
Semi-arid areas such as Gujarat	Groundnut–cereal/pulse rotations, millet–pulse systems and selected horticulture	Match crops to rainfall, irrigation quality and local market demand

Economic assessment: measuring profitability, not just yield

Diversification should be evaluated using gross returns, cultivation costs, net returns, benefit–cost ratio, labour demand, market risk and returns per unit of water or land. Rice-equivalent yield is useful for comparing systems with different crops, but it does not replace an economic analysis because market prices and production costs vary. A crop with high gross returns may have lower net returns if it requires expensive seed, pesticides, labour, irrigation or cold-chain services. Farmers should use multi-year price and yield scenarios, consider staggered planting and avoid concentrating the entire farm in a single perishable crop.

Environmental and agronomic benefits

Diversification can improve soil structure and nutrient cycling, reduce dependence on a single nutrient extraction pattern, support pollinators and soil organisms, and interrupt some pest, weed and pathogen cycles. Legumes may contribute nitrogen; deeper-rooted crops can explore different soil layers; and varied residue inputs can support soil organic matter. Environmental benefits are not automatic: poorly chosen crops may increase irrigation demand, fertilizer use or pesticide pressure. The complete system must be assessed for water productivity, nutrient balances, greenhouse-gas emissions and effects on biodiversity.

Constraints and pathways for wider adoption

Farmers may hesitate to diversify when established crops have assured procurement, input supply chains and known markets. Other barriers include limited seed availability, machinery designed for dominant crops, storage and processing gaps, lack of price information, labour shortages, credit constraints and uncertain buyer demand. Support should combine locally validated cropping-

system demonstrations with seed systems, extension services, custom-hiring centres, storage, processing, market linkages and crop insurance. Procurement and value-chain policies that create reliable demand for pulses, millets, oilseeds and other suitable crops can make diversification economically feasible.

Priorities for Gujarat and semi-arid regions

In Gujarat, crop diversification should reflect rainfall variability, groundwater conditions, soil type and the region's existing groundnut, cotton, cereal, pulse and horticultural systems. In rainfed areas, drought-adapted millets and pulses, suitable intercropping, residue retention and moisture-conservation practices may reduce risk. Where irrigation is available, crop choices should be screened for water productivity and profitability rather than yield alone. Groundnut-based rotations with cereals or pulses, and carefully selected vegetables or horticultural crops near viable markets, may offer options, but recommendations should be validated at district and farm level.

Conclusion

Crop diversification is a systems-level strategy to improve the resilience, productivity and profitability of Indian agriculture. Rotations, legume integration, intercropping, short-duration crops, vegetables, oilseeds and conservation-agriculture practices can deliver benefits when matched to local soil, water, labour and market conditions. Recent Indian studies show that diversified systems can improve system productivity and soil health, but no single sequence is universally superior. Successful adoption requires whole-system economic assessment, reliable markets, appropriate seed and machinery, farmer training and long-term monitoring of water, soil and climate outcomes.

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