

CROP DIVERSIFICATION IN PUNJAB: PATHWAYS FROM RICE-WHEAT DEPENDENCE TO SUSTAINABLE AND PROFITABLE AGRICULTURE

Gorakh Singh

Head, P.G. Department of Geography, GSSDGS Khalsa College, Patiala.

ABSTRACT

Punjab has been the backbone of India's food security, but the state's agri-ecosystem has become increasingly dependent on the rice-wheat cropping system. While this has created a surplus of food grains, it has led to groundwater depletion, loss of biodiversity, soil degradation, and other ecological problems, as well as crop residue management issues. Crop diversification is, therefore, an important environmental and economic concern. This paper aims to assess the current state of Punjab's agriculture, with a specific focus on crop diversification. The paper uses government data, academic research, and policy documents to analyze the challenges and opportunities associated with crop diversification in the region. The discussion finds that paddy continues to dominate Punjab's cropping pattern in the country. The area under paddy was 32.43 lakh hectares in 2024-25, with a projected increase to 32.49 lakh hectares in 2025-26. As of 2025, the groundwater outlook in Punjab is not appropriate, with 156.36% of the annual groundwater availability being utilized – 111 of the 153 assessment blocks were overexploited. It is argued that diversification must be economically viable to incentivize farmers, offering alternatives with assured prices, procurement infrastructure, crop insurance, processing, and market linkages. The paper highlights potential substitute crops with better economic and ecological viability, ranging from maize, cotton, and pulses to oilseeds, horticulture, fodder, and livestock-based systems. It concludes that crop diversification must be gradual, responsive to market forces, and regionally appropriate to ensure economic security while maintaining food grain production and natural resource conservation.

Keywords: Crop diversification, Punjab agriculture, rice-wheat system, groundwater depletion, maize, cotton, pulses, sustainable agriculture, farm income, agricultural policies.

1. INTRODUCTION

Agriculture is the backbone of the rural economy in Punjab, contributing significantly to India's food-grain production. The state has emerged as one of the country's leading agricultural producers as a result of the green revolution, which was made possible by the adoption of high-yielding varieties, increased irrigation, fertilizer usage, mechanization, and government procurement. As a result, Punjab's farmers had begun to rely heavily on wheat and paddy.

The rice-wheat system, in comparison to other systems, offered farmers a more stable source of income, a well-established market for their produce, government-controlled minimum support price, a well-established supply chain of agricultural inputs, and heavy government assistance. As a result, there was little incentive for farmers to grow other crops with a lower risk of profit.

However, the state's natural environment has been damaged in the process. Apart from depleting soil productivity, the transition to the rice-wheat system resulted in water logging and a drop in groundwater levels in Punjab. According to ICAR, "out of the total 4.2 million hectares of cultivated area in Punjab, 96 percent were irrigated from groundwater. Thus,

irrigation is the major determinant of groundwater trends in the state. The Central Rice-Wheat Research Centre has reported that the groundwater levels in the central rice-wheat belt of Punjab were declining at an alarming rate during 2005-2020. Moreover, imbalanced use of fertilizers has resulted in major soil degradation in Punjab.”

Agriculture in Punjab is now in danger due to a lack of water. According to the Department of Water Management and Regulation, Punjab’s groundwater resources are being mined at an “alarming rate” and have dropped significantly since 2009. Punjab’s groundwater economy is in serious danger, as the 2025 assessment by the Government of India revealed. Of the 153 assessment blocks in Punjab, 111 were classified as “over-exploited” by the government.

Punjab’s government must promote crop diversification to improve the situation. This does not imply that rice and wheat should be completely eliminated, but it does mean that farmers should lessen their reliance on them. It will be critical to develop viable agricultural alternatives based on the state’s agro-climatic regions.

2. OBJECTIVES OF THE STUDY

The major objectives of this paper are:

1. To examine the evolution and present status of crop specialization in Punjab.
2. To assess the environmental and economic rationale for crop diversification.
3. To analyse recent trends in paddy and alternative crops.
4. To identify the major constraints preventing farmers from adopting diversified cropping systems.
5. To evaluate recent government initiatives aimed at diversification.
6. To suggest a practical policy framework for sustainable crop diversification in Punjab.

3. METHODOLOGY

The study is based on secondary data and a review of recent literature. Information has been compiled from government publications, official groundwater assessments, agricultural research institutions, recent academic studies and contemporary policy reports.

Particular emphasis has been placed on recent evidence available up to 2026. The analysis combines quantitative indicators such as crop area, groundwater extraction and diversification indices with qualitative assessment of farmer incentives, markets, procurement and environmental sustainability.

A 2024 study by researchers associated with Punjab Agricultural University found that Punjab had a Herfindahl Index of 0.80 and a Crop Diversification Index of 0.24 in 2020–21, indicating substantial specialization. The combined share of wheat and paddy in gross cropped area had increased from 74.38% in 2001–02 to 85.33% in 2020–21.

4. EVOLUTION OF CROP SPECIALIZATION IN PUNJAB

Punjab’s cropping pattern underwent a significant shift following the introduction of the Green Revolution. Prior to the Green Revolution, a diverse range of crops such as cereals, pulses, oilseeds, cotton, and other crops were cultivated in the region. The production of high-yielding wheat varieties along with the introduction of irrigation methods initially changed wheat production for the better. Thereafter, paddy became increasingly widespread due to guaranteed procurement, relatively high yields, and suitability for mechanized farming.

As a result, the cropping pattern in Punjab has become extremely skewed towards these two cereals. In fact, according to recent statistics, wheat and paddy account for over 85% of the Gross Cropped Area (GCA) in Punjab for the 2020-21 agricultural year.

Such a decision to specialize in wheat and paddy seems economically sound for individual farmers. When comparing the potential benefits of cultivating wheat and paddy alongside other crops, one would consider multiple factors besides potential profits, such as price risks, procurement security, ease of sale, availability of related inputs, technical feasibility, and crop failure risks. In this regard, wheat and paddy seem to be the most viable options due to the established supporting complex. Therefore, it is essential to improve the entire agricultural sector and consider the needs of the entire farming sector, not only those of wheat and paddy producers.

5. CURRENT STATUS: RECENT DATA

Recent evidence demonstrates that the rice–wheat system remains highly resilient despite repeated diversification programmes.

Table 1. Selected recent indicators of Punjab agriculture and diversification

Indicator	Recent figure	Significance
Paddy area, 2024–25	32.43 lakh ha	Demonstrates continued paddy dominance
Paddy area, 2025–26	About 32.49 lakh ha	Near-record level
Maize area, 2025–26	94,000 ha	Identified as a major diversification crop
Sugarcane area, 2025–26	95,000 ha	Potential alternative to paddy
Cotton area, 2025–26	1.19 lakh ha	Important crop in south-western Punjab
Proposed additional diversification from paddy	1.30 lakh ha	Government diversification target
DSR area, Kharif 2025	2.93 lakh acres	Water-saving approach within rice cultivation
Punjab groundwater extraction, 2025	26.27 BCM	Indicates severe resource pressure
Stage of groundwater extraction, 2025	156.36%	Above sustainable extraction level
Over-exploited groundwater blocks	111/153	72.55% of assessment blocks

Source: Government of India, CGWB and recent reports on Punjab agriculture.

The data suggest that while overall environmental pressures were rising, farmers still found paddy production to be a relatively lucrative option despite the potential alternatives available to them. As such, the observed trend is best explained by the specific incentives for farmers to produce rice rather than any inherent preference for specialization over diversification.

6. ENVIRONMENTAL RATIONALE FOR CROP DIVERSIFICATION

6.1 Groundwater depletion

Groundwater is perhaps the best argument for diversification in Punjab. Paddy requires a large amount of groundwater for its irrigation, and the cropping pattern promoted in the state has been historically groundwater-intensive.

The 2025 assessment of the national groundwater status placed Punjab in an extremely critical position. The state’s stage of groundwater utilization stood at 156.36%, and over 72% of its assessment blocks were categorized as over-exploited.

This has serious implications for the sustainability of agriculture in the state. Further depletion of groundwater may lead to decreased well discharge and an increased need for

deeper wells, requiring more energy to pump out water, and creating uncertainty about water availability.

The 2026 study conducted on the water footprint of 240 farmers, which used farm-level data, arrived at a water footprint of 1,308.2 cubic meters of water per tonne of paddy. The study also reported lower water footprints for wheat and maize and proposed that diversification towards maize along with improved irrigation and nutrient management practices could offer groundwater sustainability.

6.2 Soil degradation

The continuous cultivation of the same crops can lead to problems such as nutrient imbalances, decrease in soil organic matter and poor aggregation. Multi-nutrient deficiencies coupled with low organic carbon were reported in intensively cultivated soils of Punjab by ICAR.

Recent studies undertaken in Punjab have shown that the system of growing diverse crops such as maize, basmati rice, cowpea, mungbean and berseem is better compared to growing only rice and wheat. The study found that diversified systems had more favourable structure, water holding capacity and hydraulic conductivity.

6.3 Crop-residue management

Rice production generates substantial amounts of straw as a by-product. The short window between paddy harvest and wheat sowing has led to the widespread practice of stubble burning. Growing different crops with shorter duration and less residue would ease the paddy-wheat calendar.

Crop diversification, however, should not be the only option to deal with the problem of stubble burning. Other measures like cultivating shorter duration varieties of rice, promoting direct seeded rice, mechanization for residue management and developing alternate markets for rice straw will also help.

7. ECONOMIC RATIONALE FOR DIVERSIFICATION

Environmental sustainability alone is insufficient to persuade farmers to change crops. Farmers need an economically credible alternative.

The rice–wheat system has several advantages:

- assured procurement for major crops;
- relatively predictable prices;
- established input markets;
- extensive mechanization;
- easy access to credit;
- established transport and storage networks; and
- relatively familiar production technology.

By contrast, many alternative crops face uncertain markets and inadequate processing facilities. Therefore, the opportunity cost of diversification can be high.

A 2025 study examining crop-diversification incentives in Punjab and Haryana found that existing incentives may be insufficient to generate the desired shift from paddy to alternatives such as maize and cotton. Its estimates suggested that, under existing incentive structures,

only around 17–20% of paddy area might shift to less water-intensive maize or cotton in Punjab, below a 30% policy target.

This finding is important because it demonstrates that the problem is not simply a lack of government schemes. The financial difference between the existing system and alternatives must be sufficiently attractive to compensate farmers for risk.

8. MAJOR CROPS WITH DIVERSIFICATION POTENTIAL

8.1 Maize

Maize is one of the alternative options to paddy as it needs less irrigation as compared to paddy. It has various industrial uses like poultry, starch, ethanol, and industrial processing.

The Punjab government's 2025-26 budget aims to promote alternative crops in the state and maize is one of them. The government has already allocated 94,000 hectares for growing maize and wants to cultivate an additional 60,000 hectares of land.

The Punjab government's 2026-27 budget proposed to expand the maize diversification program from six to 16 districts. They want to incentivize farmers by giving a subsidy of ₹17,500 per hectare (₹7,000 per acre) by allocating 20,000 hectares for promoting maize cultivation in place of paddy. The major challenge before the government is to ensure the procurement of surplus maize along with industry linkages, feed mills, storage, and processing facilities.

8.2 Cotton

Cotton is ideally suited for the south-western Punjab, say, researchers, as the groundwater in the area is not as good and water logging is a problem. It used to be a major crop in this region but due to several challenges it failed to thrive. Challenges include pests, poor prices and competition from other crops.

To revive the crop there is a need to develop new varieties of seeds, improved pest control measures, extension services, insurance coverage and linkages to textile industries.

8.3 Pulses

Pulses such as mungbean and other legumes have an advantage over paddy in terms of lower water requirement and rotation-crop benefits to the soil. Moreover, boosting production in Punjab will also help in addressing India's need to reduce its dependence on imports. But for that to happen, procurement and market forces need to be bolstered for growers to take up more area under these crops.

8.4 Oilseeds

Oilseeds represent another promising diversification opportunity. India remains heavily dependent on imports to meet edible-oil demand, creating a strategic rationale for expanding domestic oilseed cultivation.

Punjab can consider suitable oilseed crops in agro-climatically appropriate areas, provided farmers receive remunerative prices, quality seed and efficient marketing arrangements.

8.5 Horticulture

Vegetables, fruits, spices and other high-value horticultural crops can generate higher returns per unit of land than conventional cereals in suitable locations. A 2024 study on Punjab's diversification prospects concluded that high-value crops provide important avenues for increasing agricultural profitability while reducing excessive cereal specialization.

The major limitation is perishability. Horticultural diversification therefore requires cold chains, grading, storage, processing and organized retail markets.

8.6 Fodder and livestock integration

Punjab has a strong dairy sector. Diversification into fodder crops can be integrated with dairy farming, producing income from both crop and livestock activities.

Such systems can improve nutrient cycling and reduce dependence on purchased feed. Research on diversified cropping systems in Punjab has also highlighted the potential benefits of integrating crops, legumes, green manure and livestock.

9. GOVERNMENT INITIATIVES AND EMERGING POLICY DIRECTION

Punjab has introduced several measures aimed at reducing paddy dependence.

The state's 2025–26 diversification plan identified maize, sugarcane and cotton as major kharif alternatives. The plan proposed increasing their combined area by approximately 1.30 lakh hectares.

Another approach has been to make rice cultivation itself less water-intensive. During Kharif 2025, approximately 2.93 lakh acres were reported under direct-seeded rice, supported by an incentive of ₹1,500 per acre. The government has also promoted shorter-duration rice varieties, including PR-126, to increase the interval available for residue management and wheat establishment.

These measures demonstrate that diversification and sustainable rice cultivation should not be viewed as mutually exclusive. A realistic strategy should combine:

1. partial replacement of paddy with alternative crops;
2. water-saving rice technologies;
3. shorter-duration varieties;
4. better residue management; and
5. stronger alternative-crop markets.

The Economic Survey 2025–26 similarly advocates a calibrated approach in which farmers are offered financially attractive alternatives to a portion of rice and wheat acreage rather than relying on abrupt changes to existing procurement arrangements.

10. MAJOR CONSTRAINTS TO CROP DIVERSIFICATION

10.1 Procurement and price risk

The biggest constraint is the difference in market certainty between paddy/wheat and alternative crops. A farmer may earn a potentially higher return from an alternative crop, but if the crop cannot be sold at harvest, expected profitability becomes less meaningful.

10.2 Lack of processing infrastructure

Diversification requires a complete value chain. Maize requires feed and industrial processing; cotton requires ginning and textile linkages; fruits and vegetables require cold storage and processing; pulses and oilseeds require cleaning, grading and processing facilities.

10.3 Small and fragmented holdings

Small farms may find diversification riskier because a crop failure can have a large effect on household income. Collective farming, farmer-producer organizations and cooperative marketing can help reduce this risk.

10.4 Established machinery and knowledge

Punjab's agricultural machinery, labour arrangements and farmer knowledge have been developed around rice and wheat. Moving toward different crops can require new machinery and technical knowledge.

10.5 Policy uncertainty

Farmers make decisions based on expectations about future prices, procurement and government support. Frequent changes in policies can discourage investment in alternative crops.

11. POLICY RECOMMENDATIONS

11.1 Guarantee income, not merely subsidies

Temporary subsidies can encourage initial adoption but may not generate permanent diversification. Farmers need a predictable income mechanism. Price-deficiency payments, assured procurement or long-term contracts for selected alternative crops could provide greater confidence.

11.2 Develop crop-specific procurement networks

Procurement should be expanded beyond rice and wheat in selected diversification zones. Maize, pulses, oilseeds and cotton should receive stronger institutional market support where agro-climatically appropriate.

11.3 Establish diversification clusters

Instead of encouraging every farmer to grow every alternative crop, Punjab should develop district- and block-level specialization.

For example:

- maize clusters near feed and starch industries;
- cotton clusters in suitable south-western areas;
- horticulture clusters near processing and cold-chain infrastructure;
- pulse and oilseed clusters in suitable agro-climatic zones.

11.4 Link farmers with processing industries

The government should encourage private investment in food processing, maize-based industries, edible-oil processing, cotton ginning, fruit and vegetable processing and livestock feed.

11.5 Promote Farmer Producer Organizations

Farmer Producer Organizations can aggregate produce, reduce marketing costs, improve bargaining power and make processing and contract arrangements more feasible.

11.6 Expand crop insurance

Diversification increases perceived risk. Crop insurance should therefore cover alternative crops adequately and provide timely settlement. Insurance products should be designed around the specific climatic and market risks of Punjab.

11.7 Reward water conservation

Instead of supporting only the output of crops, agricultural policy should increasingly reward conservation of natural resources. Farmers adopting water-saving technologies or replacing paddy with less water-intensive crops could receive payments linked to measurable water savings.

11.8 Use remote sensing and digital monitoring

Recent studies show that the technology of using satellites and machine learning to identify various crops and assess water-saving measures is now in reach. A 2025 study in Punjab, which used both satellite and ground measurements from 1,400 fields, provides a potential solution at scale for monitoring such practices as DSR and irrigation. These technologies can be used to validate claims of crop diversification while also targeting incentives and monitoring groundwater use and crop adoption.

11.9 Protect food security through gradual diversification

Punjab is a region of strategic importance for food security; hence, the process of diversification has to be evolutionary. High-yielding regions have to be encouraged to produce more wheat and rice. On the other hand, areas facing acute groundwater depletion have to be incentivized to adopt less-water intensive crops.

12. A PROPOSED DIVERSIFICATION FRAMEWORK FOR PUNJAB

A sustainable strategy can be organized into three phases.

Phase I: 2026–2030 — Risk reduction

The immediate objective should be to make diversification economically safe.

- Identify high groundwater-stress blocks.
- Provide enhanced incentives for alternative crops.
- Expand maize, pulses, oilseeds and cotton in suitable areas.
- Strengthen procurement.
- Promote DSR and short-duration rice varieties.
- Develop crop-specific insurance.

Phase II: 2030–2035 — Market transformation

The second phase should shift from subsidy-driven diversification to market-driven diversification.

- Establish processing clusters.
- Expand cold storage and logistics.
- Build farmer-industry contracts.
- Strengthen Farmer Producer Organizations.
- Develop export-oriented horticulture and value chains.

- Promote livestock-integrated systems.

Phase III: Beyond 2035 — Sustainable agricultural landscape

The long-term objective should be an agricultural system in which crop selection is determined by profitability, agro-climatic suitability and resource sustainability rather than by a single dominant procurement model.

13. DISCUSSION

The first important lesson that Punjab offers for dealing with the crisis is that crop diversification is not an agronomical issue. Farmers are not interested in cultivating other crops than paddy and wheat because they have no access to alternate cropping systems. It is an institutional issue.

Paddy and wheat have an institutionalised ecology that includes procurement and MSP, storage and transportation, agro-processing, credit and extension, and machinery and cultivator skills. Hence, other crops could not overcome the dominance of these two by virtue of their lower water footprints.

Any crop diversification initiative needs to replicate, at a lesser scale, the ecology that rice and wheat have created for themselves if it has to withstand the competition these crops enjoy through their extensive backup systems.

The latest evidence of the failure of such diversification efforts in Punjab is provided by the area under paddy this year, which was estimated at 32.43 lakh hectares as of 2024-25. The rise has been equally worrying as far as the early paddy crops of 2026 are concerned. For the fiscal year 2025, the groundwater utilisation in Punjab was at 156.36%. This means that the groundwater extraction in the state exceeded the annual exploitable groundwater by a huge margin.

This puts the policymakers in a dilemma whether to sacrifice the state's economic growth or its ecological future. The answer to this question lies in the strategy of designing cropping patterns that will help make Punjab switch from less eco-friendly crops like paddy to more eco-friendly ones by making the right interventions.

CONCLUSION

Crop diversification is one of the most contentious policy issues in Punjab. The rice–wheat system has contributed immensely to India's food security, but at what cost to the environment? The most recent groundwater assessment paints a bleak picture, with extraction at 156.36% of annual extractable groundwater in Punjab as of 2025, and 111 of 153 assessment blocks classified as over-exploited.

Meanwhile, the latest data on paddy area indicate that diversification will not happen unless farmers are given viable alternatives, as the area under paddy remained broadly stable at around 32.43 lakh hectares in 2024-25 and close to a record high since.

It is clear that crop diversification will happen only when farmers have access to reliable alternatives beyond paddy. Maize, cotton, pulses, oilseeds, horticulture, fodder along with livestock, dairy and poultry offer such an attractive portfolio, provided there is procurement, processing, insurance, infrastructure and assured markets.

Punjab needs to pursue a farmer-centric, water-conservation and market-driven crop diversification strategy that promotes alternative crops to rice and wheat without totally eliminating them. It is a matter of choice between “sacrificing” rice and wheat and “sticking” to them, and finding ways that allow farmers to continue growing them alongside other

water-conserving strategic crops by adopting site-specific methods. By combining diversification with water-saving techniques for rice with allied activities, value addition and enhanced farmers' organizations, Punjab can achieve conservation of its natural resources while ensuring farm livelihoods.

The way forward for Punjab is to shift from the narrow perspective of production of food grains to a more holistic approach that emphasizes on production of diverse crops for diverse markets while conserving water, soil, manpower, enhancing farm income, nutritional security and creating employment.

REFERENCES

1. Government of India. Lok Sabha: Groundwater Exploitation in Punjab, 2026. Data from the 2025 Dynamic Ground Water Resources assessment.
2. Central Ground Water Board. Ground Water Resources of Punjab – 2024. Government of India.
3. Indian Council of Agricultural Research (ICAR). Punjab: Natural Resource Management and Agricultural Profile.
4. Singh, A. & Kataria, P. (2026). "Sustainable Crop Production in Water-Scarce Regions: Water Footprint and Economic Water Productivity in Indian Punjab." *Water and Environment Journal*.
5. Singh, S. & Kaur, P. (2024/2025). "Prospects of Crop Diversification through High Value Crops in Punjab." *Journal of Agricultural Development and Policy*, 34(1), 49–59.
6. Gupta, D. & Mitra, A. (2025). "Unwatering the fields: analyzing incentives for crop diversification amid groundwater crisis in India."
7. Shah, A. et al. (2025). "Machine Learning for Sustainable Rice Production: Region-Scale Monitoring of Water-Saving Practices in Punjab, India."
8. Government of India. Economic Survey 2025–26, Chapter 6: Agriculture and Food Management.
9. Commission for Air Quality Management. Comprehensive Plan for Crop Diversification and Stubble-Burning Management, 2026.
10. Recent Punjab agricultural research on diversified cropping systems and soil quality.