

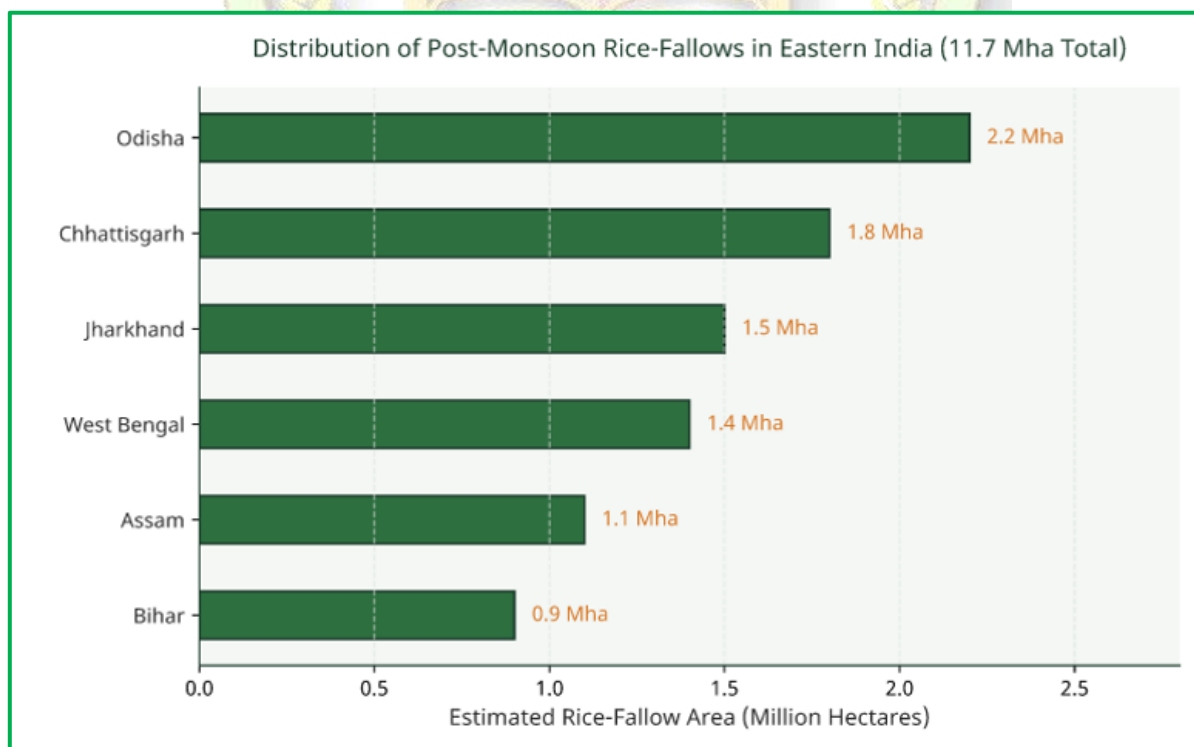
The Quiet Powerhouse Beneath the Soil: How Pulses Are Reviving India's Farmlands

***Krishnakumar S, Dr. Ipsita Kar, Dr. Anshuman Nayak and Vijay Sundar B**

College of Agriculture, OUAT, Bhubaneswar, Odisha, India

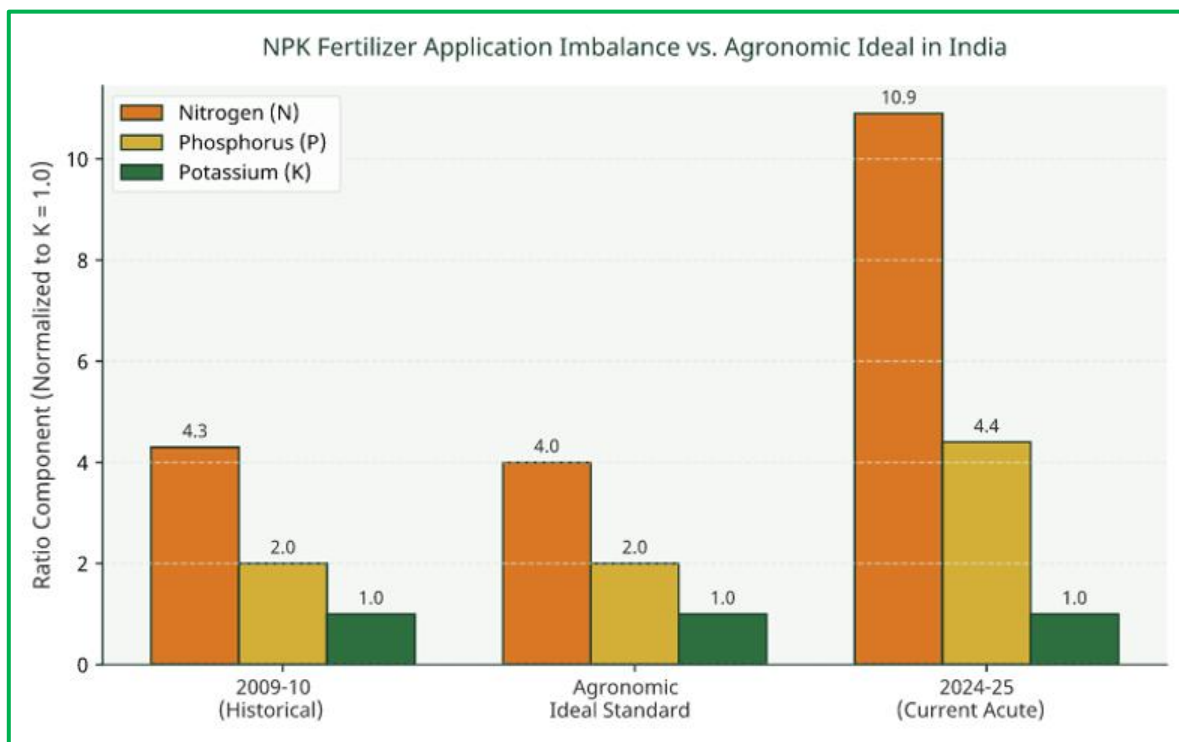
*Corresponding Author's email: krishnakumarsenthil2004@gmail.com

Walk through any intensively cropped belt of the Indo-Gangetic plains today and the soil tells a quiet, troubling story. Decades of rice-wheat monocropping, lopsided fertilizer use, and shrinking organic inputs have left fields that yield less for every kilogram of fertilizer poured into them. According to India's latest Soil Health Card cycle, nearly three-fourths of tested soil samples across the country now show organic carbon levels below 0.75 percent — well short of the 1.5 percent considered healthy for most agricultural soils. Fewer than one in ten samples register sufficient nitrogen, and the nutrient mix farmers are actually applying has drifted far from what crops need. Into this depleted landscape steps an unlikely hero: the humble pulse crop. Chickpea, pigeon pea, lentil, mungbean, urdbean and their leguminous cousins have spent millions of years perfecting a biochemical trick that no fertiliser factory can fully replicate — pulling nitrogen directly from the air and depositing it, free of cost, into the soil. They do this while feeding people protein, asking for little irrigation, and demanding far less synthetic input than the cereals that dominate Indian farming. Pulses are not a nostalgic throwback to 'traditional' agriculture; they are increasingly recognised as a frontline climate and soil-health technology. As India pushes a freshly approved ₹11,440-crore National Pulses Mission and the world braces for a food system that must feed more people with less land, water and chemical input, pulses sit at the exact intersection of nutritional security, environmental repair and farm profitability.



Current Status of Pulses: Where the World and India Stand Today

Globally, pulse consumption touched around 101 million tonnes in 2024, having grown at roughly 2 percent a year over the previous decade, with Asia and Africa driving most of that growth. The FAO projects global production will climb further, to about 125 million tonnes by 2032, lifting average per-capita consumption from 7 kg to 8.6 kg a year. India remains, by a wide margin, the world's largest pulse grower and consumer, contributing somewhere between a quarter and nearly a third of global production depending on the year and dataset, while farming roughly a third of the world's pulse area — a gap that points to persistently low per-hectare yields compared with countries such as Canada.



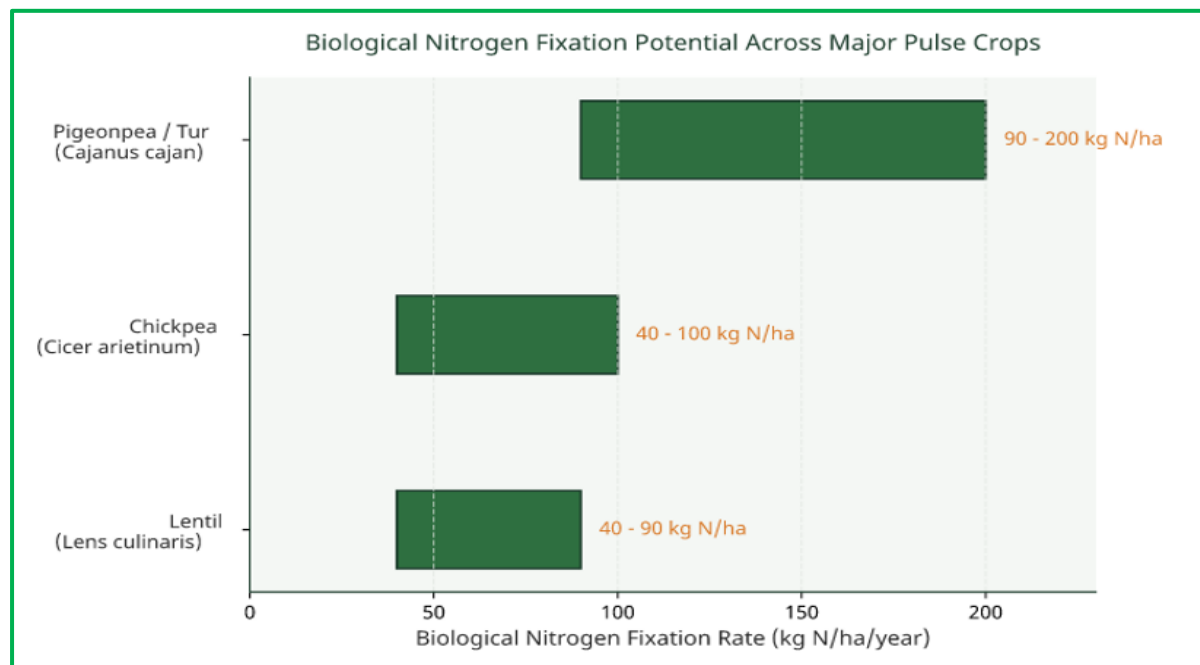
Domestically, India produced an estimated 252.38 lakh tonnes (about 25.2 million tonnes) of pulses in 2024-25 by the Third Advance Estimate, grown across roughly 30 million hectares. That figure masks a worrying Kharif-season slide: pulses sown during the monsoon season in 2024-25 totalled only about 6.9 million tonnes, the lowest in nine years and below the decade's average of 7.6 million tonnes, largely due to reduced acreage and erratic rainfall in producing belts. Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Gujarat, Karnataka, Jharkhand, Andhra Pradesh, Chhattisgarh and West Bengal between them account for the bulk of national output.

Why Soil Fertility Is Declining

India's soil crisis did not arrive overnight; it is the cumulative result of several decades of input choices. Heavily subsidised urea has pushed farmers toward nitrogen-only fertilisation, distorting the nutrient ratio applied to fields. The ideal NPK (nitrogen-phosphorus-potassium) ratio recommended by agronomists is roughly 4:2:1. India's actual applied ratio, which stood at a comparatively balanced 4.3:2:1 in 2009-10, had deteriorated to about 10.9:4.4:1 by 2024-25, with states such as Punjab showing some of the worst imbalances. This nitrogen-heavy regime comes at a steep efficiency cost: only about 35-40 percent of applied nitrogen fertiliser is actually taken up by crops, with the rest leaching into groundwater as nitrates or escaping as nitrous oxide, a potent greenhouse gas. Meanwhile, organic matter inputs have steadily declined as labour costs rose and residue burning became a shortcut. The result shows up directly in carbon stocks: roughly three-fourths of India's tested soils now carry organic carbon below the 0.75 percent threshold associated with healthy soil structure and microbial activity.

Biological Nitrogen Fixation: The Engine Room of Soil Renewal

The single most important reason pulses matter for soil health is a partnership that predates agriculture itself: the symbiosis between leguminous roots and Rhizobium bacteria. When a pulse seed germinates, specific strains of Rhizobium recognise chemical signals released by the root and colonise root hairs, triggering the plant to form specialised swellings called root nodules. Inside these nodules, the bacteria convert atmospheric nitrogen gas into ammonia using an enzyme called nitrogenase. In exchange for this fixed nitrogen, the plant supplies the bacteria with carbohydrates from photosynthesis.



DID YOU KNOW?

A well-nodulated pigeon pea crop, with its long duration and deep root system, can leave behind enough residual nitrogen to meaningfully reduce though rarely fully eliminate the fertilizer nitrogen requirement of the cereal crop that follows it in rotation.

Field studies using isotope-based methods show chickpea typically derives 50-80 percent of its nitrogen from fixation, translating to roughly 40-100 kg of fixed nitrogen per hectare depending on rainfall, inoculation and cultivar. Globally, the FAO notes that grain and forage legumes can, under favourable conditions, fix up to 350 kg of nitrogen per hectare per year. A long-term trial in West Bengal recorded nitrogen savings of 42.6-48.4 kg N/ha when lentil, chickpea and grasspea were inoculated, directly cutting the fertiliser bill for succeeding crops.

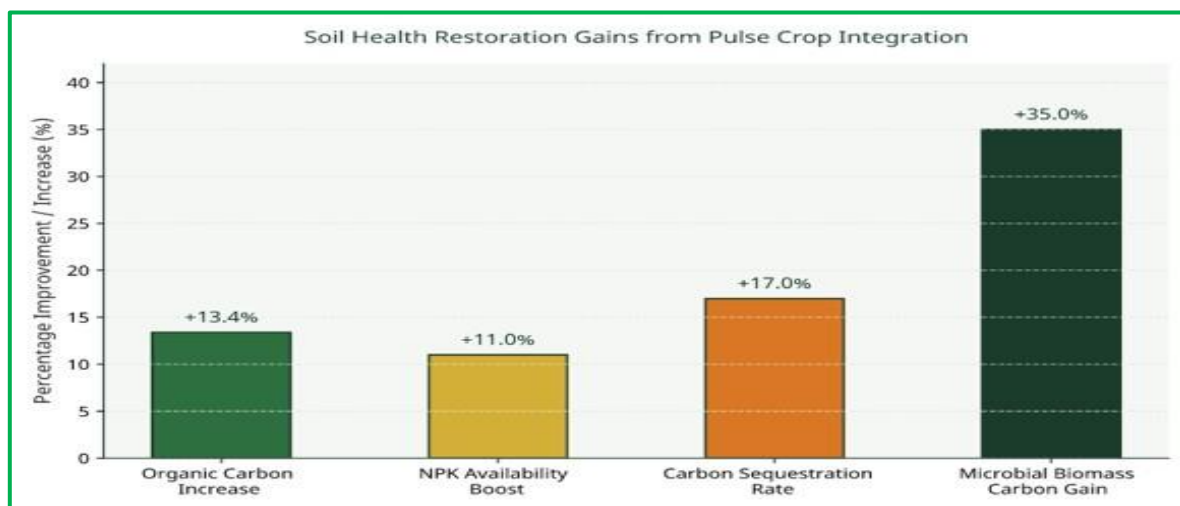
Improvement in Soil Physical, Chemical, and Biological Properties

- **Physical Scaffolding:** Their fibrous root systems, combined with leaf litter and root turnover, promote the formation of stable soil aggregates — clusters of soil particles bound together by organic glues that improve structure, lower bulk density, and raise water-holding capacity.
- **Chemical Enrichment:** Incorporating legumes into cereal-based cropping sequences raises soil organic carbon by 6.3 to 13.4 percent compared with continuous cereal monocropping, while root exudates solubilise bound phosphorus and release potassium and micronutrients.
- **Biological Activity:** Soils under legume cultivation carry over 11 percent higher available NPK and 16-17 percent greater carbon sequestration than soils under continuous cereal monoculture, driven by enhanced microbial activity and rhizosphere enzyme functions.

Pulses in Cropping Systems: Rotation as Restoration

The real power of pulses is often realised not as a standalone crop but as a deliberate partner within a rotation:

- 1. Rice–Chickpea:** Chickpea grown after rice exploits residual soil moisture in the post-monsoon season, breaking disease and pest cycles while adding nitrogen.
- 2. Rice–Greengram:** Short-duration mungbean fitted into the gap between two rice crops utilizes India's 11.7 million hectares of rice-fallow land, especially across eastern states like Odisha, Chhattisgarh, Jharkhand, and West Bengal.
- 3. Wheat–Lentil:** Replacing a second wheat crop with lentil cuts nitrogen fertiliser demand while diversifying farm income.
- 4. Cotton–Pigeonpea:** Long-duration pigeon pea intercropped with cotton improves soil structure in compacted belts while drawing on deep subsoil moisture.

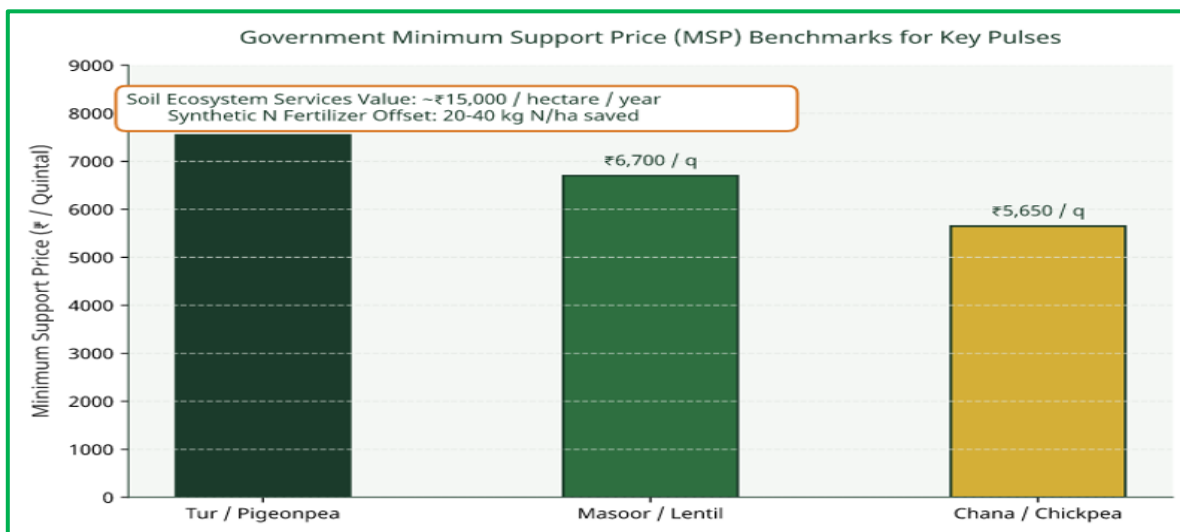


Climate-Smart Agriculture: Pulses as a Mitigation Tool

Indian agriculture contributes around 16 percent of the country's total greenhouse gas emissions, with roughly three-quarters of nitrogen-related emissions traced to agricultural sources. Pulses attack this problem by needing far less synthetic nitrogen and by sequestering more carbon in the soil. The 16-17 percent higher carbon sequestration observed under legume cultivation represents a meaningful natural climate solution. Pulses also demand roughly 25 percent less irrigation water than non-legume crops, offering crucial resilience against falling groundwater tables. Breeding programmes by ICAR and IIPR have released short-duration, drought- and heat-tolerant varieties such as Pusa Arhar 16 and JG 14 for dry regions, supported by over 2,661 stress-tolerant crop varieties released between 2014 and 2024.

Economic Benefits

The financial case for pulses rests on lower input costs rather than blockbuster yields. Because a substantial share of their nitrogen requirement is self-supplied through fixation, farmers spend less on urea and other nitrogenous fertilisers for the pulse crop and succeeding cereals.



Lower irrigation requirements compound these savings in water-scarce regions. Government price support has strengthened the income case further. For 2024-25, Minimum Support Prices for tur, masoor, and chana were substantially raised. The Atmanirbharta in Pulses Mission removed previous procurement caps, allowing NAFED and NCCF to procure these crops from registered farmers at MSP for four years, structurally de-risking pulse cultivation relative to assured cereals.

Environmental Benefits

- **Reduced Nitrate Leaching:** Because so little of the nitrogen they need comes from synthetic sources, fields under pulses contribute far less to nitrate leaching, protecting groundwater quality.
- **Biodiversity Support:** Diversifying monoculture landscapes supports greater above- and below-ground biodiversity, from pollinators drawn to flowering pulse crops to rich microbial communities.
- **High Protein Water Efficiency:** Producing a gram of protein from pulses requires only a fraction of the water needed for milk, eggs, chicken, or beef.

Future Technologies: Where Pulse Agronomy Is Heading

- **Precision Nutrient Management:** IoT soil-moisture and nutrient sensors and AI-based advisory platforms are enabling farmers to apply precise field inputs rather than flat doses.
- **Advanced Biofertilizers:** Rhizobium and co-inoculant formulations combining nitrogen-fixers with phosphate-solubilising bacteria deliver yield increases of 10-35 percent.
- **Genomic Selection:** Marker-assisted breeding is accelerating the release of disease-resistant, climate-resilient cultivars supported by the National Mission on High-Yielding Seeds.

Recommendations for Farmers

1. **Inoculate Seed:** Treat pulse seed with a recommended, crop-specific Rhizobium/PGPR inoculant before every sowing.
2. **Soil Testing:** Get soil tested through the Soil Health Card scheme and apply fertiliser based on actual nutrient gaps.
3. **Crop Rotation:** Include at least one pulse crop in every two- to three-year rotation cycle.
4. **Utilize Rice Fallows:** Grow short-duration pulses like mungbean, urdbean, or lentil using residual moisture in rice-fallow periods.
5. **Adopt Line Sowing & IPM:** Sow in lines rather than broadcasting, practise integrated nutrient management, and manage pests promptly.
6. **Secure Pricing:** Register with NAFED, NCCF, or state agencies to access MSP for tur, urad, and masoor.

Conclusion

Pulses occupy an unusual position in Indian agriculture: a crop that is simultaneously a dietary necessity, an economic opportunity, and a soil-restoration technology with no equivalent among cereals. Every hectare sown to chickpea, pigeon pea, lentil, or gram is a hectare quietly rebuilding organic carbon, fixing nitrogen for free, feeding soil microbes, and asking for less water and less synthetic fertiliser. At a moment when India's Soil Health Card data paint a worrying picture of depleted soils, and when the National Pulses Mission has set an ambitious production target backed by budgetary commitment, the alignment between policy, science and farm-level need has rarely been clearer. Realising this promise requires Rhizobium inoculant reaching the right farmer at the right time, rice-fallow land being brought into cultivation, and soil-test-based nutrient management replacing reflexive urea use. But the underlying biology has already done its part for millions of years. The task now is simply to give it room to work — one rotation, one inoculated seed, and one hectare of revived soil at a time.

References

1. Hazra, K. K., Nath, C. P., Singh, U., Praharaj, C. S., Kumar, N., Singh, S. S., & Singh, N. P. (2019). Diversification of maize-wheat cropping system with legumes and integrated nutrient management increases soil aggregation and carbon sequestration. *Geoderma*, 353, 308-319.
2. Venkatesh, M. S., Hazra, K. K., Ghosh, P. K., Praharaj, C. S., & Kumar, N. (2013). Long-term effect of pulses and nutrient management on soil carbon sequestration in Indo-Gangetic plains of India. *Canadian Journal of Soil Science*, 93(1), 127-136.