



SUSTAINABLE FOOD SYSTEMS

An Agenda for Climate-risked Times

The state of Indian soils and
ways to measure and improve
them

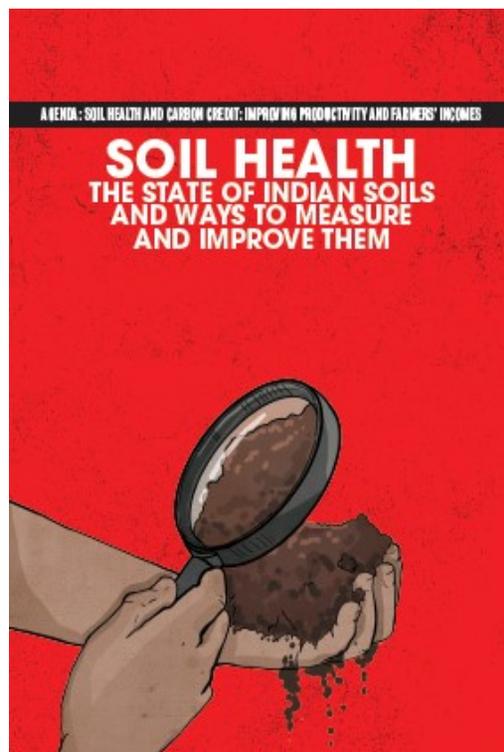
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Presentation overview

- Soil health and its measurement
- India's soil health status as per Soil Health Card Scheme
- Linkages between soil health and chemical fertilizer usage
- Improving soil organic carbon
- Gaps and challenges



[Link to download](#)



What is soil health?

- Capacity of soil to sustain the productivity, diversity, and environmental services of terrestrial ecosystems; Linked to **soil fertility**, which is linked to **crop productivity**
- **Functions of a healthy soil** (examples)
 - Medium for plant growth
 - Regulating hydrological and nutrient cycles
 - Maintaining biological activities
 - Store carbon
- **Crucial components of overall soil health:** physical, chemical and biological health
- **Threats to soil health** (e.g.): intensive agricultural practices, changes in land use patterns, deforestation and soil erosion



Soil health measurement

Soil parameters

- **pH and Electrical conductivity**
- **Chemical parameters**
 - Macronutrients (e.g., N, P, K)
 - Micronutrients (E.g., Cu, Mn, B)
- **Biological parameters**
 - E.g, microbial biomass, soil respiration, earthworm population
- **Physical parameters**
 - E.g., water holding capacity, bulk density, aggregate stability

Chemical parameters	Physical parameters	Biological parameters
<p><u>SHC-India</u> Macronutrients: Nitrogen, phosphorus, potassium, organic carbon. Micronutrients: Sulphur, iron, zinc, copper, manganese and boron Electrical conductivity and pH</p> <p><u>FAO's GLOSOLAN</u> (in addition to SHC-India) Total soluble salt content Microelements: Chlorine molybdenum, nickel</p> <p><u>USDA's NRCS</u> Reaction carbon, pH, phosphorus, soil nitrate, electrical conductivity</p>	<p><u>FAO's GLOSOLAN</u> Aggregate stability, coarse fragments, particle-size distribution, water retention curve, porosity, hydraulic conductivity, soil moisture content, soil crusts</p> <p><u>USDA's NRCS</u> Aggregate stability, slaking, bulk density, soil structures and macropores, available water capacity, infiltration</p>	<p><u>FAO's GLOSOLAN</u> Soil microbial biomass, soil respiration, enzyme activity, soil mesofauna, earthworm populations</p> <p><u>USDA's NRCS</u> Particulate organic matter, soil respiration, soil enzymes, potentially mineralizable nitrogen, earthworms</p>

Sources: FAO-GLOSOLAN, 'Standard Operating Procedures'7; USDA-NRSC, 'Cropland in Field Soil Health Assessment Guide'; Soil Health Card Scheme Dashboard, Ministry of Agriculture and Farmers Welfare

International bodies, Indian scientific community recommend integrating biological indicators and physical indicators for comprehensive assessment of soil health

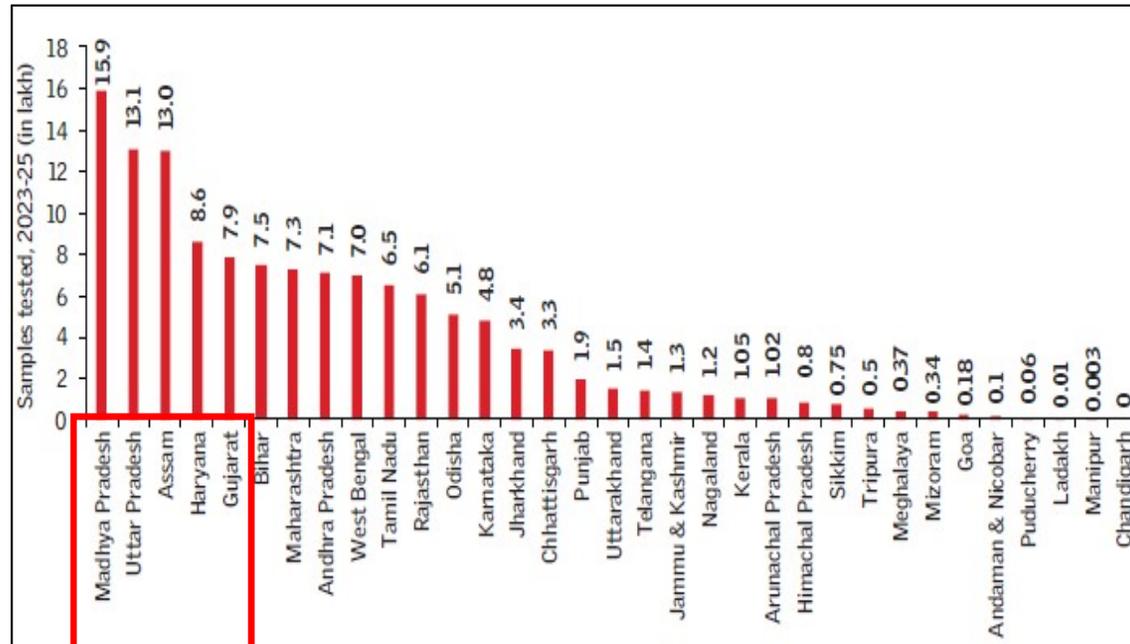


Soil Health Card Scheme

- **India's primary soil monitoring mechanism**
- Launched January 2015, under National Mission for Sustainable Agriculture; merged under Rashtriya Krishi Vikas Yojana since 2022-23 under Soil Health component
- Aims to provide farmers, through Soil Health Cards:
 - **Soil nutrient status** of their agricultural land
 - **Fertilizer use recommendations**
 - **Soil amendments** for long term fertility and crop productivity
- About **7.3 crore** soil samples tested under RKVY until March 2025; in 2025-26, (as on today), **73.7 lakh** (>seven million) tests done; SHC given
- During 2023-25: **1.3 crore** soil samples tested for different parameters
- Scheme based segregation of testing data in SHC portal (e.g., NMNF, PKVY)



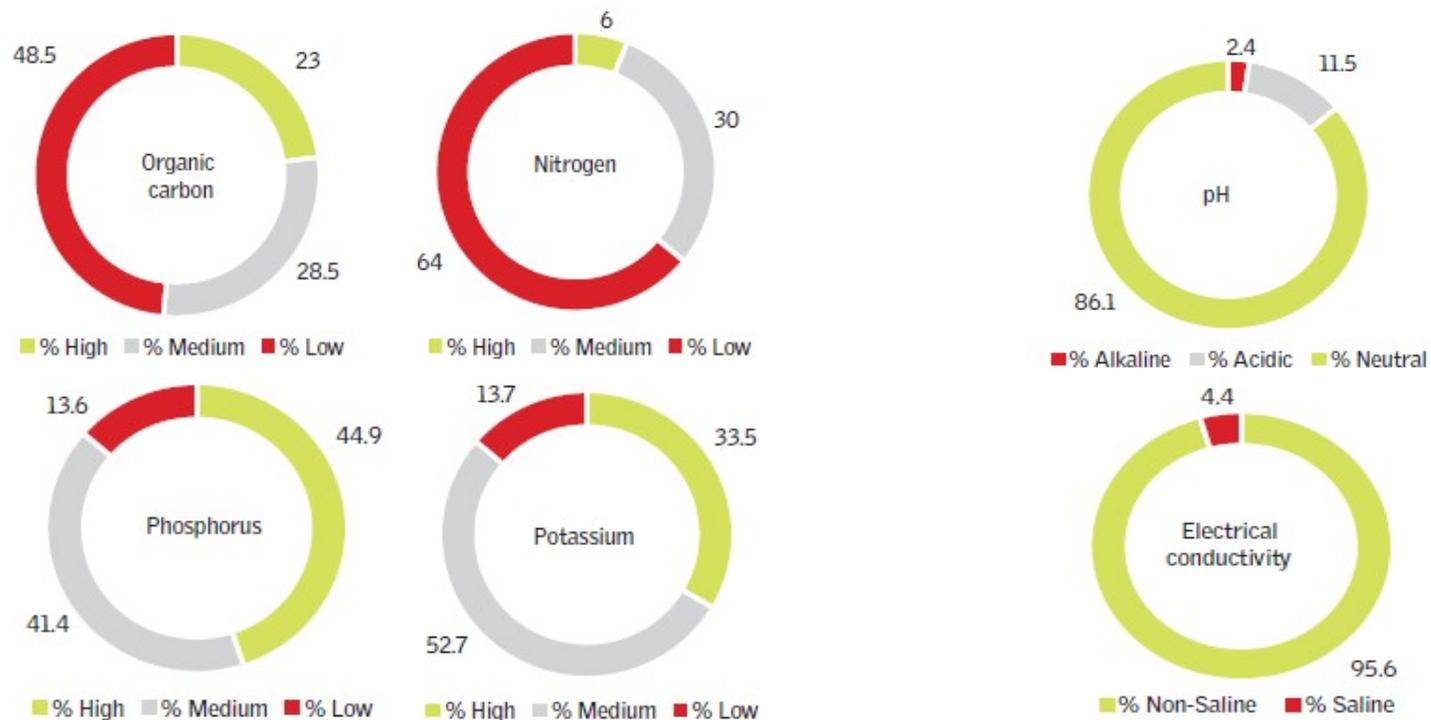
Samples tested across states under SHC scheme, 2023-25



Source: Soil Health Card Dashboard, Ministry of Agriculture and Farmers Welfare



Macronutrient, pH and EC status of soil: National level



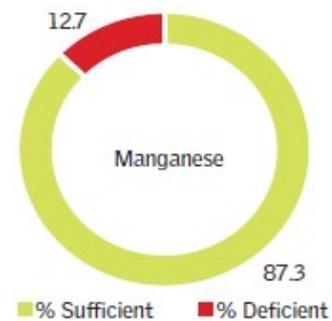
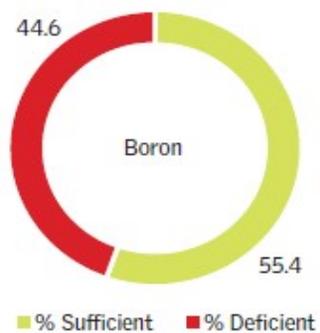
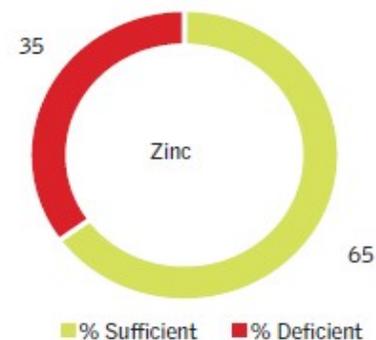
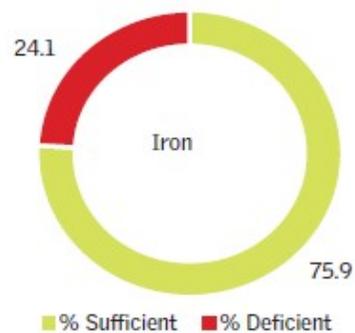
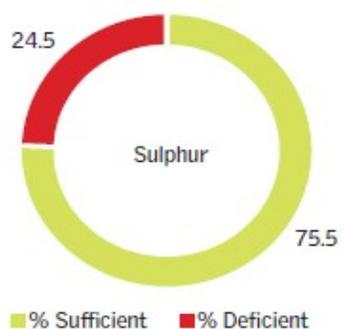
Majority of Indian soils **deficient in nitrogen (N) and organic carbon**; **Phosphorus (P) and potassium (K) levels better**

Indian soil largely neutral pH and non-saline

Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare



Micronutrient status of soil: National level

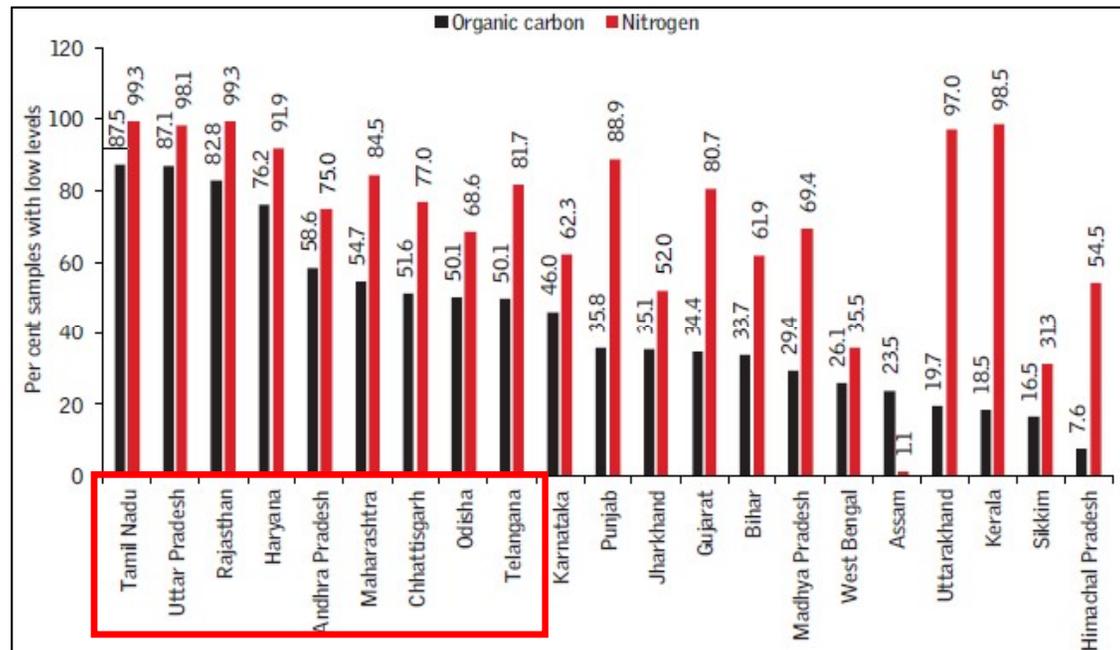


Notable deficiency in zinc and boron levels samples tested; others sufficient

Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare



Nutrient status of soil: State level



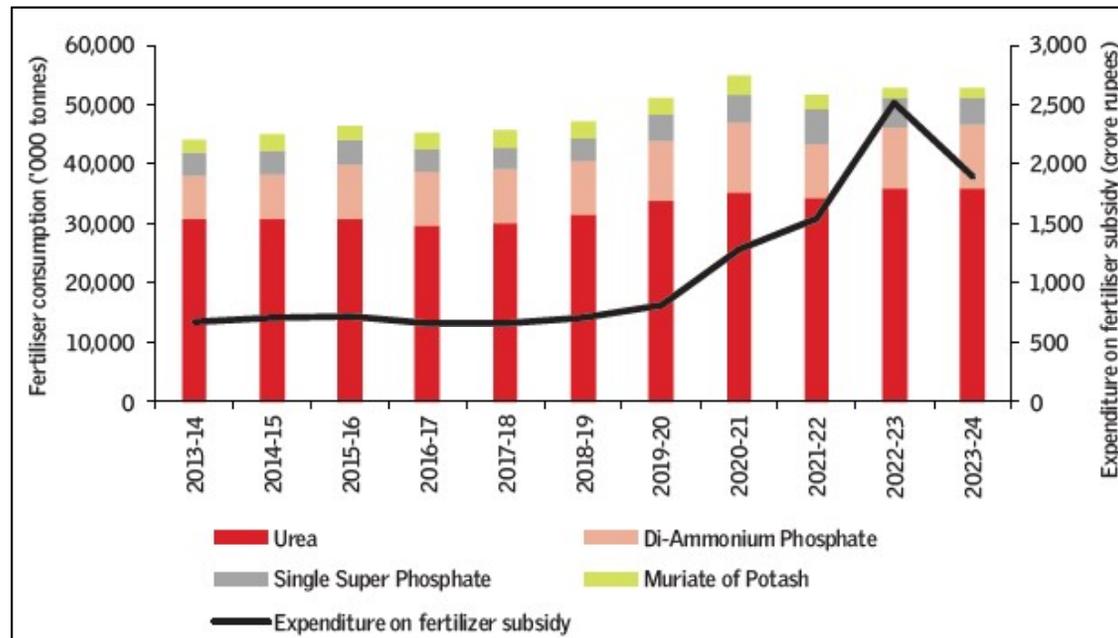
Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare

Organic carbon and nitrogen in agriculturally-relevant states, 2023-25

- >50 per cent samples in **nine states** with 'low' organic carbon
- >50 per cent samples in **18 states** with 'low' nitrogen



Fertilizer consumption and subsidy

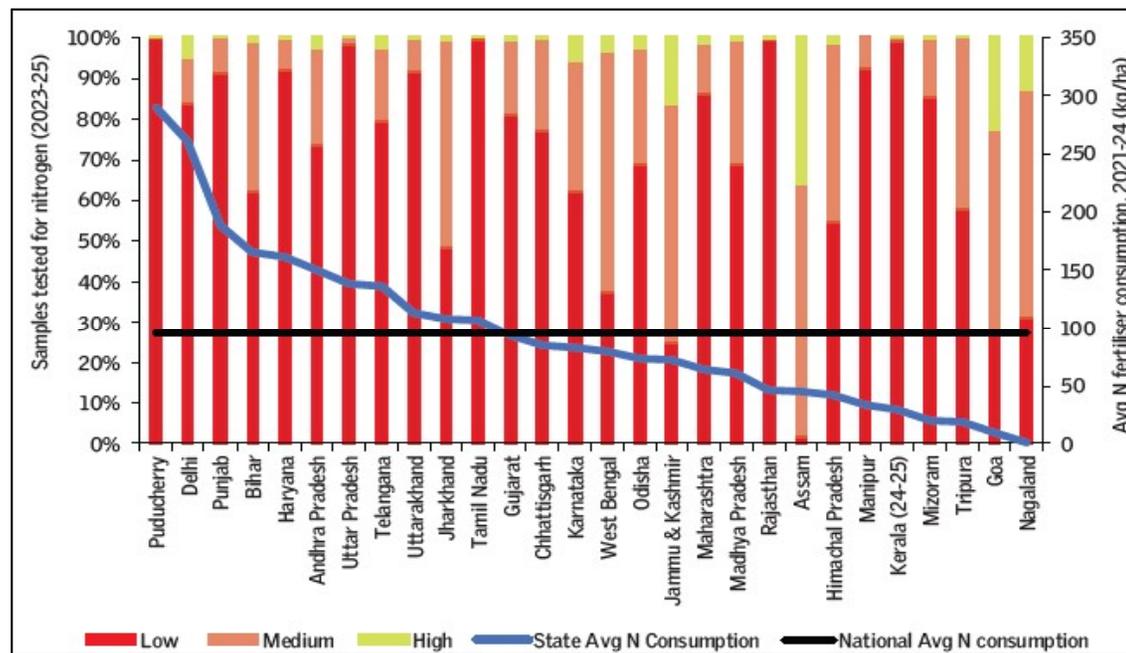


Source: Fertilizer Statistics, The Fertilizer Association of India (yearly reports 2020-24)

- Between 2013-14 and 2023-24, fertilizer consumption rose by **19.5%**
- Government spending on fertilizer subsidy rise by **180.5%** at same time
- Fertilizer consumption skewed towards **urea**; **68%** of total consumption
- **Heaviest subsidy** for urea sale



Nitrogen fertilizer consumption and soil nitrogen levels

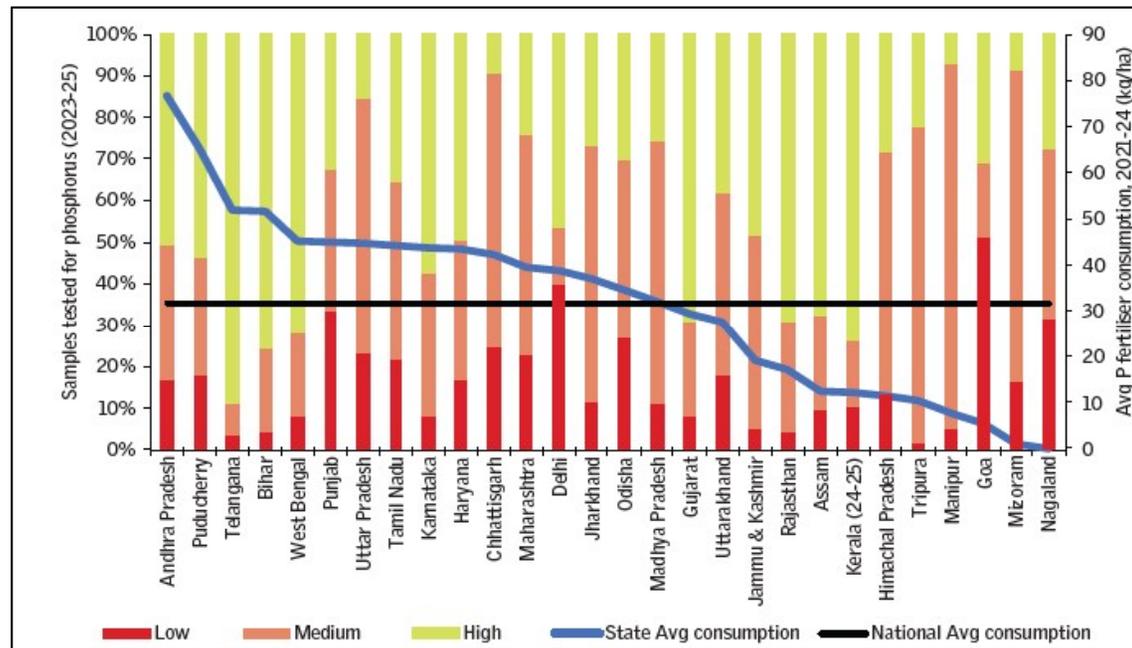


Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare; Fertilizer Statistics, The Fertilizer Association of India (yearly reports 2020-24)

- National avg of nitrogen (N) fertilizer consumption: **95.5 kg/ha for 2021-24**
 - 12 states/UTs above avg; 16 below
- 11/12 have >50% soil samples with 'low' N;
- 11/16 had > 50% soil samples with 'low' N levels



Phosphorus fertilizer consumption and soil phosphorus levels

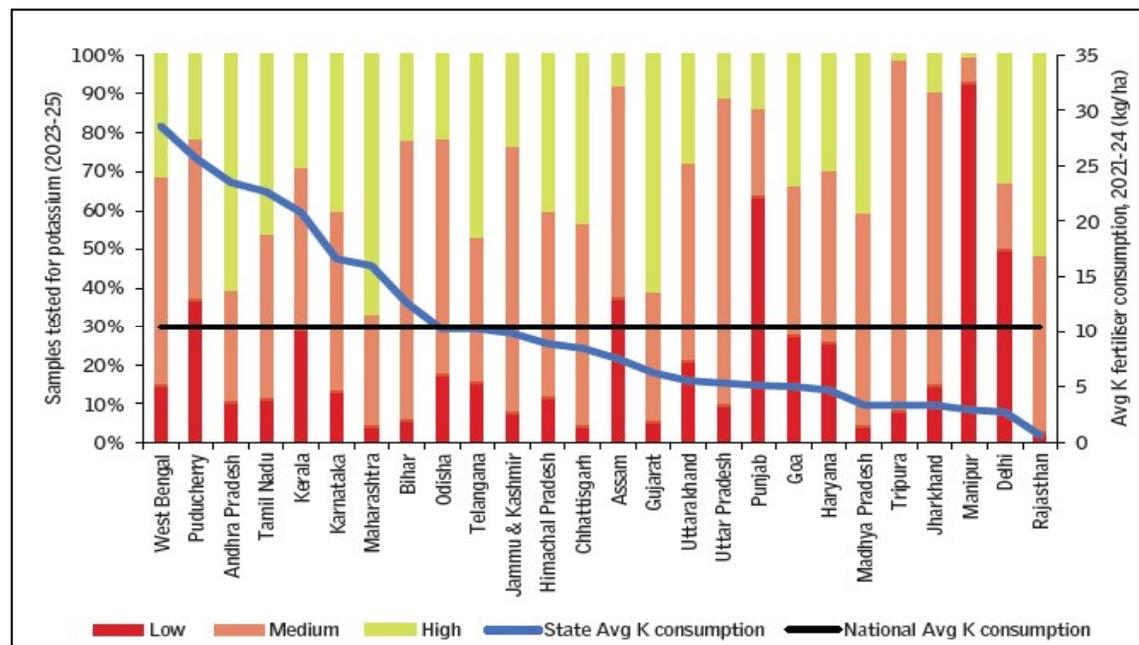


Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare; Fertilizer Statistics, The Fertilizer Association of India (yearly reports 2020-24)

- National avg of phosphorus (P) fertilizer consumption: **31.7 kg/ha for 2021-24**
 - 16 states/UTs above avg; 12 below
- None have >50% samples with 'low' P levels
- 1/12 has >50% samples with 'low' P levels



Potassium fertilizer consumption and soil potassium levels

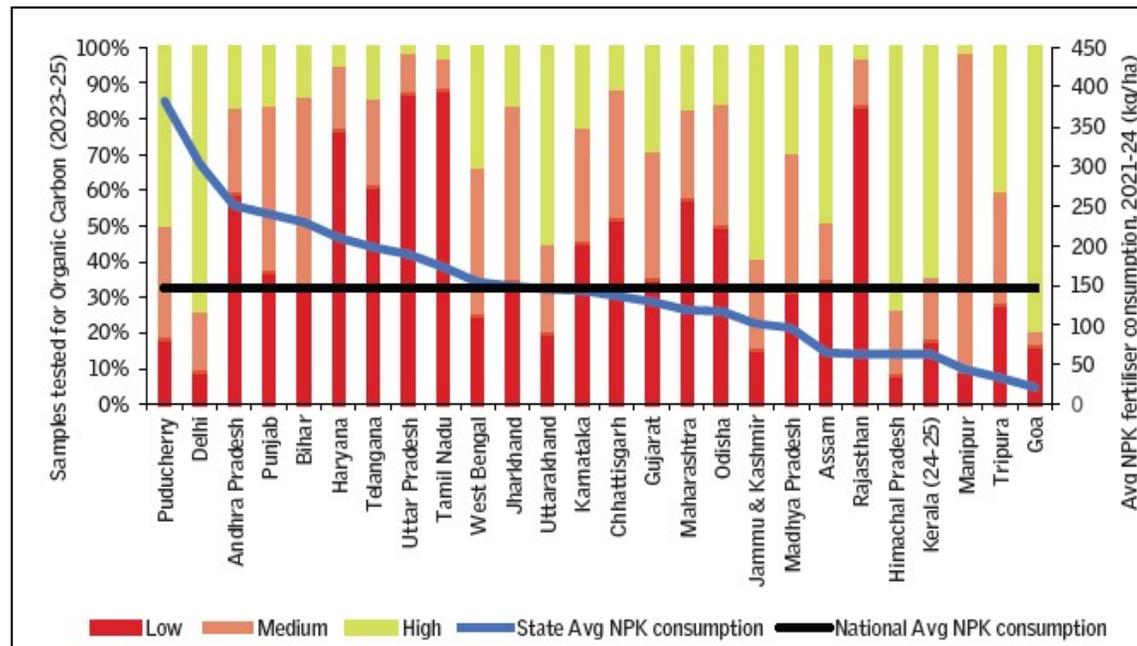


Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare; Fertilizer Statistics, The Fertilizer Association of India (yearly reports 2020-24)

- National avg of potassium (K) fertilizer consumption: **10.4 kg/ha for 2021-24**
 - 10 states/UTs above avg; 16 below
- None have >50% samples with 'low' K levels
- 3/16 has >50% samples with 'low' K levels



Total NPK fertilizer consumption and soil organic carbon levels



Source: Soil Health Card Nutrient Dashboard, Ministry of Agriculture and Farmers Welfare; Fertilizer Statistics, The Fertilizer Association of India (yearly reports 2020-24)

- National avg of NPK fertilizer consumption: **146.6 kg/ha for 2021-24**
 - 12 states/UTs above avg; 15 below
- 5/12 states have >50% samples with 'low' SOC;
- 2/12 have >50 per cent samples with 'high' SOC
- 5/15 states have >50% samples with 'low' SOC;
- 4/15 have > 50% samples with 'high' SOC



Correlation: fertilizer consumption and samples with low soil nutrient levels

N fertilizer and soil N

Moderately +ve correlation ($R=0.36$) between N consumption and samples with low soil N
Suggesting N fertilizer consumption **does not result** in corresponding improvement in soil N levels

P fertilizer and soil P

Almost no correlation ($R=-0.09$) between P consumption and samples with low soil P levels
Suggesting that P fertilizer consumption **does not seem to influence** soil P levels

K fertilizer and soil K

Weak negative correlation ($R=(-)0.21$) between total K fertilizer consumption and samples with low soil K
Suggesting that K fertilizer consumption **favourably influences** soil K levels

Total NPK fertilizer and soil organic carbon

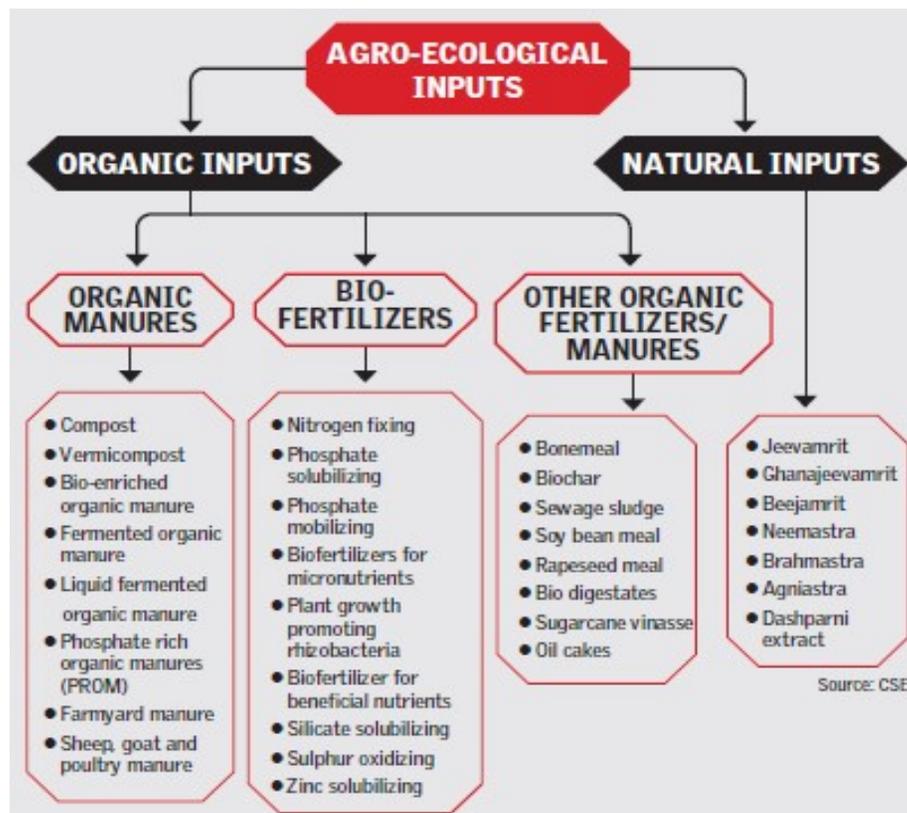
Moderately +ve correlation ($R=0.47$) between avg NPK consumption and samples with low soil organic carbon
Suggesting NPK fertilizer consumption **does not result** in corresponding improvement in soil organic carbon levels



Improving soil organic carbon



Agro-ecological inputs for improved soil health



- Diverse organic and natural amendments being used to support soil health improvement
- **Biochar, an emerging soil amendment** produced by pyrolysis of biomass;
 - Can enhance fertility, retain moisture, serve as long-term carbon sink
- Pilot projects showing positive impact



Experiments on natural inputs and organic farming

Experimental finding	Location/context	Impacts on Soil Organic Carbon (SOC)
Organic vs inorganic	Dehradun Doon University, ICAR-Indian Institute of Soil and Water Conservation and Bhomya Foundation	SOC much higher in organic farm than inorganic farm at two depths tested in Dehradun.
Integrated amendments	Haryana Agricultural University	Treatments combining chemical fertilizers with organic amendments (biogas slurry and vermicompost) resulted in higher SOC, compared to treatments using only chemical fertilizers
Long-term organic farming	ICAR-IARI, New Delhi (since 2009)	All treatments involving organic amendments increased SOC compared to control. Farmyard manure + crop residue treatment resulted in the highest SOC (up to 2.17%)
Natural farming systems	University of Horticultural Sciences, Karnataka	SOC across five crops consistently higher under natural and organic farming practices compared to the package of practice and farmers' practice (which used chemical fertilizers)
Natural farming inputs	Himachal Pradesh Krishi Vishwavidyalaya	Treatments combining natural farming inputs like ghanjeevamrit, jeevamrit and mulching led to higher SOC compared to the control treatment

Multiple field experiments demonstrate that treatments incorporating organic/natural amendments significantly **outperform** treatments relying solely on chemical fertilizers in increasing SOC



Gaps and Challenges

Soil health assessment

- **Limited indicator parameters:** Focus on chemical parameters; no physical/biological parameters
- **Lack of facilities for soil testing** leading to operational challenges with implementation
- **Minimal data update across different schemes;** gaps in comprehensive data integration, monitoring

Fertilizer subsidy and application policy

- **Skewed fertilizer consumption;** heavy subsidy on urea encourages overuse; imbalanced fertilizer use
- **Limited role of fertilizer use on improving soil nutrient levels**

Standards, programme implementation and outreach

- **Non-standardized biochar production:** Lack of standardization hinders adoption by farmers
- **Limited scale of organic farming schemes:** Total area under schemes remains limited (59.75 lakh hectare as of December 2024), indicating a gap in scaling up



Thank you

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Nutrient status of soil: District level

5/20 AEZs – covering parts of Punjab, Haryana, Rajasthan, Bihar, Uttar Pradesh, Gujarat, Karnataka and Tamil Nadu– **>75 per cent** samples have tested 'low' in organic carbon in **more than 50 per cent** of their districts

AEZs within **Himalayan ecosystem** and the **Western Ghats** have **more than 50 per cent districts with >75 per cent** samples testing 'high' in organic carbon

47/109 districts (43 per cent) had **>50 per cent** samples with 'low' levels of organic carbon;
83/109 (85 districts) had **>50 per cent** samples with 'low' nitrogen

