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Soil Conservation and Sustainable Soil Health Management Strengthen Agricultural Productivity, Climate Resilience and Food Security in India

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Recent Developments:

- The **nationwide Khet Bachao Abhiyan (1–30 June 2026)** was launched by the **Ministry of Agriculture & Farmers' Welfare**, ICAR and partner institutions to promote **soil-test-based nutrient management, balanced fertiliser application, natural farming and climate-resilient agriculture** through awareness campaigns and farmer outreach programmes.
- The **Soil Health Card Portal** has been further strengthened with digital soil maps, multilingual access, automated nutrient recommendations and integration with land records to improve scientific soil management.

About Soil:

Meaning and Characteristics:

- **Soil** is a dynamic natural body consisting of **minerals, organic matter, water, air and living organisms**, formed through long-term physical, chemical and biological processes.
- Soil develops distinct **soil horizons** due to additions, removals, transfers and transformations of materials over time, forming a complete **soil profile**.
- The major soil horizons are **O (Organic), A (Topsoil), E (Eluviation), B (Subsoil), C (Parent Material) and R (Bedrock)**.
- Healthy soil performs essential ecosystem functions by supporting plant growth, regulating water movement, recycling nutrients, storing carbon and filtering pollutants.

Soil Diversity in India:

Major Soil Types and Distribution:

- India's diverse **climate, geology, topography and vegetation** have produced a wide variety of soils that support region-specific agricultural systems.
- The major soil groups include **Alluvial, Black (Regur), Red, Laterite, Desert, Forest & Mountain, Saline & Alkaline and Peaty & Marshy soils**.
- Soil diversity enables **crop diversification, higher agricultural resilience and efficient utilisation of regional agro-climatic conditions**, thereby strengthening national food security.

Importance of Soil:

Agricultural and Economic Importance:

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- Soil forms the foundation of Indian agriculture, with nearly **59% of India's geographical area under cultivation**, while agriculture supports the livelihoods of a large share of the rural population.
- Healthy soils improve **crop productivity, nutrient-use efficiency, farm profitability and long-term agricultural sustainability**.
- Sustainable soil management directly contributes to **Sustainable Development Goal (SDG)-2 (Zero Hunger)** and **SDG-13 (Climate Action)**.

Ecological and Environmental Importance:

- Healthy soils function as natural reservoirs by **recharging groundwater, retaining moisture during dry periods and reducing surface runoff**, thereby strengthening water security.
- Soil serves as an important **carbon sink** by storing atmospheric carbon in the form of **Soil Organic Carbon (SOC)**, thereby mitigating climate change.
- Higher soil carbon improves **soil structure, fertility, moisture retention, nutrient availability and resilience against drought and climate variability**.
- Soil supports rich biodiversity, including **microorganisms, fungi, earthworms and beneficial insects**, which regulate nutrient cycling involving **nitrogen, phosphorus and sulphur**.

Major Challenges Affecting Soil Health:

Land Degradation and Soil Erosion:

- **Water erosion** and **wind erosion** remove fertile topsoil every year, significantly reducing agricultural productivity.
- Severe water erosion is observed in the **Himalayan Region, Western Ghats and Chambal Ravines**, resulting in large-scale land degradation.

Nutrient Imbalance and Soil Degradation:

- Excessive and imbalanced use of chemical fertilisers has caused widespread deficiencies of important micronutrients such as **Zinc, Boron and Iron**.
- Faulty irrigation practices, particularly excessive canal irrigation in **Punjab, Haryana and Western Uttar Pradesh**, have accelerated **soil salinisation and alkalinisation** through capillary action.

Urbanisation and Pollution:

- Rapid urbanisation has exposed soils to **industrial effluents, mining wastes, excessive agrochemicals, heavy metals and plastic pollution**.
- Declining **Soil Organic Carbon** due to continuous cultivation and residue burning has reduced soil fertility and weakened climate resilience.

Major Government Initiatives:

National Missions and Soil Conservation Programmes:

- The **National Mission for Green India**, under the **National Action Plan on Climate Change (NAPCC)**, promotes afforestation and enhances natural carbon sinks, supporting India's **Nationally Determined Contributions (NDCs)**.
- The **National Mission for Sustainable Agriculture** promotes climate-resilient farming through improved **soil health, water-use efficiency and resource conservation**.
- The **National Mission on Natural Farming (2024)** encourages nature-based agriculture by increasing **Soil Organic Carbon**, reducing input costs and improving climate resilience.

Soil Health and Nutrient Management:

- The **Soil Health and Fertility Scheme (2015)** promotes scientific nutrient management through **Soil Health Cards**, balanced fertiliser application and farmer capacity building.
- The **Nutrient-Based Subsidy (NBS) Scheme** links subsidies for **Phosphatic and Potassic fertilisers** to nutrient content, encouraging balanced fertiliser use.
- **Neem-Coated Urea** improves nitrogen-use efficiency while reducing diversion of urea for non-agricultural purposes.
- **Direct Benefit Transfer (DBT)** in fertilisers uses **Aadhaar-enabled Point of Sale (PoS)** devices for beneficiary authentication and real-time fertiliser tracking.
- The **Integrated Fertiliser Management System (iFMS)** strengthens fertiliser logistics, monitoring and supply-chain efficiency.

Recent Digital and Technological Initiatives:

- The **Khet Bachao Abhiyan (2026)** promoted soil testing, balanced nutrient management, natural farming and climate-resilient agricultural practices through nationwide farmer awareness programmes.
- The **Nationwide Soil Resource Mapping Project** of **Soil and Land Use Survey of India (SLUSI)** prepares village-level soil maps using satellite imagery and field surveys for scientific land-use planning.
- **Agri Stack**, under the **Digital Agriculture Mission**, integrates farmer, land, crop and soil databases to provide location-specific agricultural advisories.

Role of Emerging Technologies:

Artificial Intelligence and Precision Agriculture:

- **Artificial Intelligence (AI)** integrates soil, weather and crop data to support scientific crop planning, nutrient management and precision farming.
- **Satellite imagery, remote sensing and geospatial technologies** enable early identification of nutrient deficiencies, moisture stress and soil degradation.
- **AI-based Krishi Decision Support System (KDSS)** improves decision-making through data-driven recommendations for irrigation, fertiliser application and crop management.
- **Agricultural robotics**, including autonomous tractors, robotic soil sampling systems and precision planting technologies developed by **ICAR-IARI** and other institutions, enhance resource-use efficiency and reduce production costs.

Way Forward:

Priority Areas for Sustainable Soil Management:

- Promote **Integrated Nutrient Management (INM)** by combining chemical fertilisers with organic manures, biofertilisers and crop residue recycling.
- Expand **soil-test-based fertiliser application**, precision agriculture and digital advisory systems across all agro-climatic regions.
- Strengthen watershed development, afforestation and conservation agriculture to minimise soil erosion and restore degraded lands.
- Enhance carbon farming, regenerative agriculture and payment mechanisms through **Carbon Credit Trading** to improve farmer income and climate resilience.
- Increase investment in soil research, geospatial monitoring and farmer awareness for long-term conservation of India's soil resources.

Value Addition for UPSC:

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Important Concepts and Institutional Linkages:

- **Soil Organic Carbon (SOC):** A key indicator of soil health, fertility and carbon sequestration.
- **Integrated Nutrient Management (INM):** Balanced use of chemical fertilisers, organic manures and biofertilisers to sustain soil productivity.
- **Land Degradation Neutrality (LDN):** India aims to restore degraded land while achieving sustainable land management under the **United Nations Convention to Combat Desertification (UNCCD)**.
- **National Action Plan on Climate Change (NAPCC):** Includes the **National Mission for Green India** and the **National Mission for Sustainable Agriculture**, both contributing to soil conservation.
- **GS Paper III Linkages:** Agriculture, Land Resources, Environment, Climate Change, Disaster Management, Science & Technology and Sustainable Development.
- **Keywords:** Soil Health, Soil Organic Carbon, Carbon Sequestration, Soil Health Card, Integrated Nutrient Management, Precision Agriculture, Agri Stack, Natural Farming, Land Degradation Neutrality, Climate-Smart Agriculture, Regenerative Agriculture, Soil Conservation.