India’s Soil Health Crisis

This editorial is based on “Fixing India's soil crisis: Farmer awareness, tech can arrest degradation” which was published in Business Standard on 23/02/2025. The article brings into picture the adverse impact of India's skewed fertilizer policy, where excessive urea subsidies have led to a severe nutrient imbalance.

For Prelims: Fertiliser Consumption in India, Agroforestry, Soil organic carbon, Desertification and Land Degradation Atlas of India, Salinization, 2023 Himachal Pradesh floods, Soil Health Card Scheme, GM crops, High-yielding varieties, Nano Urea, Direct Seeded Rice (DSR) method , Happy Seeder technology.

For Mains: Role of Soil in Maintaining India’s Agricultural Prosperity, Key Factors Contributing to India's Soil Health Crisis.

India's soil health crisis stems from a **skewed fertilizer policy that heavily subsidizes urea, leading to excessive nitrogen application.** The current NPK ratio of **7.7:3.1:1 stands in stark contrast to the ideal 4:2:1 ratio**, reflecting a severe nutrient imbalance in agricultural soils. This over-reliance on nitrogen-based fertilizers, coupled with insufficient use of phosphorus, potassium, micronutrients, and organic manure, has triggered a **vicious cycle of declining soil productivity**.

As India aims to ensure food security for its growing population, addressing this soil health crisis through balanced nutrient management and policy reforms demands urgent attention.

What is the Role of Soil in Maintaining India’s Agricultural Prosperity?

- **Foundation of Food Security and Crop Productivity:** Soil is the primary medium for **plant growth**, directly influencing crop yields, nutrient absorption, and overall agricultural output.
    - The fertility of Indian soils sustains high productivity for staple crops like **rice, wheat, and pulses**, ensuring food security for 1.4 billion people.
    - Different soil types, such as **alluvial in the Indo-Gangetic plains and black soil in Maharashtra**, support diverse cropping patterns.
    - The **FAO Report** highlights that **95% of global food production relies on soil**, making its preservation crucial for India’s agricultural sustainability.
        - In **2022-23,** foodgrain production hit an all-time high of **329.7 million tonnes,** and oilseeds production reached 41.4 million tonnes.
- **Ensuring Nutrient Cycling and Soil Microbial Health:** Healthy soil functions as a **natural nutrient reservoir,** providing essential elements like **nitrogen, phosphorus, and potassium** for plant growth.
    - **Microbial activity in soil** plays a vital role in decomposing organic matter, fixing atmospheric nitrogen, and maintaining soil fertility. India’s organic farming movement,

including traditional techniques like **vermiculture and biofertilizers,** relies on **nutrient-rich soils.**
    - Without efficient nutrient cycling, agricultural productivity declines, increasing dependence on chemical fertilizers.
- **Water Retention and Drought Resilience:** Soil acts as a **natural sponge**, regulating **water infiltration, retention, and drainage**, ensuring stable crop growth.
    - High **organic matter content** in soil enhances **water-holding capacity,** reducing irrigation demand and making crops more resilient to erratic monsoons.
    - In drought-prone regions like **Rajasthan and Bundelkhand,** soil moisture conservation practices like **mulching and cover cropping** help maintain agricultural productivity.
        - Proper soil structure also prevents waterlogging and root diseases in high-rainfall areas.
- **Climate Change Mitigation and Carbon Sequestration:** Soil plays a crucial role in **absorbing and storing carbon**, helping mitigate climate change impacts on agriculture.
    - **Carbon-rich soils** act as a buffer against **extreme weather by stabilizing temperatures and preventing desertification.**
    - Practices like **agroforestry and conservation agriculture** enhance soil carbon sequestration, reducing greenhouse gas emissions.
        - The health of India's agricultural soils directly influences the country's ability to combat climate change and maintain long-term productivity.
    - Agricultural soils have the **technical potential to absorb 3–8 gigatons of CO_2 annually for 20–30 years,** helping bridge the gap between emission reductions and climate stabilization.
- **Biodiversity Conservation and Pest Control:** Healthy soils support a diverse ecosystem of **beneficial microorganisms, fungi, and insects** that contribute to **natural pest control.**
    - Soil-dwelling organisms, such as **earthworms and mycorrhizal fungi,** improve soil aeration and nutrient uptake for crops.
    - A balanced soil ecosystem reduces the **need for chemical pesticides,** making agriculture more sustainable and cost-effective. .
        - Also, a recent study found that farms with high soil biodiversity had **fewer pest outbreaks** than degraded soils.
- **Economic Stability and Rural Livelihoods:** Soil fertility directly influences agricultural income, as **healthy soils lead to higher crop yields and better market prices.**
    - About two-thirds of the Indian population is dependent on agriculture and soil health determines their economic stability and employment prospects.
    - **Fertile soil reduces input costs** by lowering dependency on fertilizers and pesticides, increasing farmers' profit margins.
        - Soil-based agro-industries, such as **organic farming and compost production,** also provide livelihood opportunities in rural India.

What are the Key Factors Contributing to India's Soil Health Crisis?

- **Unsustainable Agricultural Practices:** Excessive use of **chemical fertilizers, pesticides, and monocropping** has degraded soil fertility and caused nutrient imbalances.
    - Intensive farming in states like **Punjab and Haryana**, driven by **MSP-backed wheat-rice cycles**, has led to severe soil degradation.
        - Additionally, **over-tillage and deep plowing** break down soil structure, reducing its ability to retain water and nutrients.
    - The **2022 State of India's Environment Report** found that **30% of India's land** faces degradation.
- **Declining Organic Carbon and Soil Microbial Life: Soil organic carbon (SOC)** is crucial for fertility, but **rapid depletion due to reduced organic matter incorporation has worsened soil health.**
    - Burning of crop residues, particularly in the **Indo-Gangetic belt,** eliminates organic matter instead of returning nutrients to the soil.
    - Over-reliance on **synthetic fertilizers disrupts microbial ecosystems,** leading to lower nutrient cycling.
        - Deforestation and encroachment for urbanization further strip soil of natural organic content.

    - The Soil Organic Carbon (SOC) content in India has come down to **0.3% from 1% in the past 70 years**
        - In states like Punjab, **only 6.9% of soils had high organic carbon**, and this percentage declined further in 2024-25..
- **Soil Erosion and Desertification:** Rampant **deforestation, overgrazing, and poor water management** contribute to severe soil erosion and land degradation, especially in semi-arid regions.
    - **Unsustainable mining and industrial activities also strip topsoil,** reducing land's agricultural potential.
    - According to the **Desertification and Land Degradation Atlas of India (SAC 2021),** the current extent of land degradation in India is **97.85 million hectares,** which represents approximately **29.77% of the country's total geographical area.**
- **Over Extraction and Salinization Due to Poor Irrigation Practices:** Unscientific irrigation, including **excessive groundwater extraction and flood irrigation**, leads to soil salinity, alkalinity, and waterlogging.
    - In states like **Punjab and Haryana,** continuous irrigation without proper drainage has caused **secondary salinization.**
        - Canal irrigation without proper management also leads to **waterlogging**, reducing soil aeration and microbial activity.
    - The total annual groundwater extraction for the entire country in 2022 **has been estimated as 239.16 bcm,** with agriculture being the predominant consumer of groundwater resources, accounting for about **87% of the total annual groundwater extraction.**
        - India's 6.7 Mha of salt-affected land results in a loss of 11.18 million tonnes of crops, valued at around **₹150.17 billion.**
- **Climate Change and Extreme Weather Events:** Unpredictable weather patterns, including **erratic monsoons and rising temperatures,** have worsened soil degradation through **droughts, floods, and heat stress.**
    - Intense rainfall events lead to runoff, washing away topsoil and depleting nutrients.
        - Rising temperatures accelerate soil carbon loss, reducing long-term sustainability of agriculture.
    - Due to climate change, high to very high soil erosion zones are projected to rise from 35.3% to **40.3% by the century's end.**
        - For instance, the **2023 Himachal Pradesh floods** led to significant topsoil loss in agricultural areas.
- **Pollution from Industrial and Urban Waste:** Unchecked dumping of **heavy metals, industrial effluents, and plastic waste** has led to toxic contamination of agricultural soils.
    - In peri-urban areas, **untreated sewage sludge and landfill leachates** degrade soil structure and introduce hazardous chemicals.
        - Groundwater pollution from landfills and chemical waste further affects soil chemistry.
    - **India's farmland** is heavily contaminated by heavy metals like **lead, cadmium, and arsenic.**
- **Lack of Effective Policy Implementation and Awareness:** Despite schemes like the **Soil Health Card (SHC) program,** adoption of sustainable practices remains low due to inadequate farmer awareness and follow-up.
    - For the **2024 fiscal year,** India allocated **one-ninth of its total agricultural budget to fertilizer subsidies**.
        - But **many farmers still lack access to real-time soil quality data**, limiting their ability to optimize fertilizer use.
    - Government subsidies on **urea encourage overuse**, despite recommendations for balanced fertilizer application.
        - The existing **NPK ratio of 7.7:3.1:1** deviates significantly from the ideal 4:2:1, highlighting a severe nutrient imbalance in soils.
- **Loss of Traditional Agroecological Practices:** Traditional organic farming methods, including green manure**, crop rotation, and agroforestry,** have declined due to the push for high-yield, chemical-dependent crops.
    - Indigenous soil management techniques, such a**s "Zaï pits" in Rajasthan and "Vermiculture" in the Northeast**, are being replaced by intensive, mechanized

agriculture.
        - The marginalization of indigenous knowledge, particularly among small and tribal farmers, reduces resilience to soil degradation.
- **Impact of Genetically Modified (GM) Crops and High-Yield Varieties:** The introduction of **GM crops** **and** **high-yielding varieties** **(HYVs)** has intensified nutrient depletion, as these crops demand higher fertilizer inputs.
    - **Bt cotton,** for instance, has been linked to declining soil biodiversity in Maharashtra and Telangana.
        - The rapid expansion of HYVs has also led to loss of **traditional, resilient crop varieties that maintain better soil structure.**

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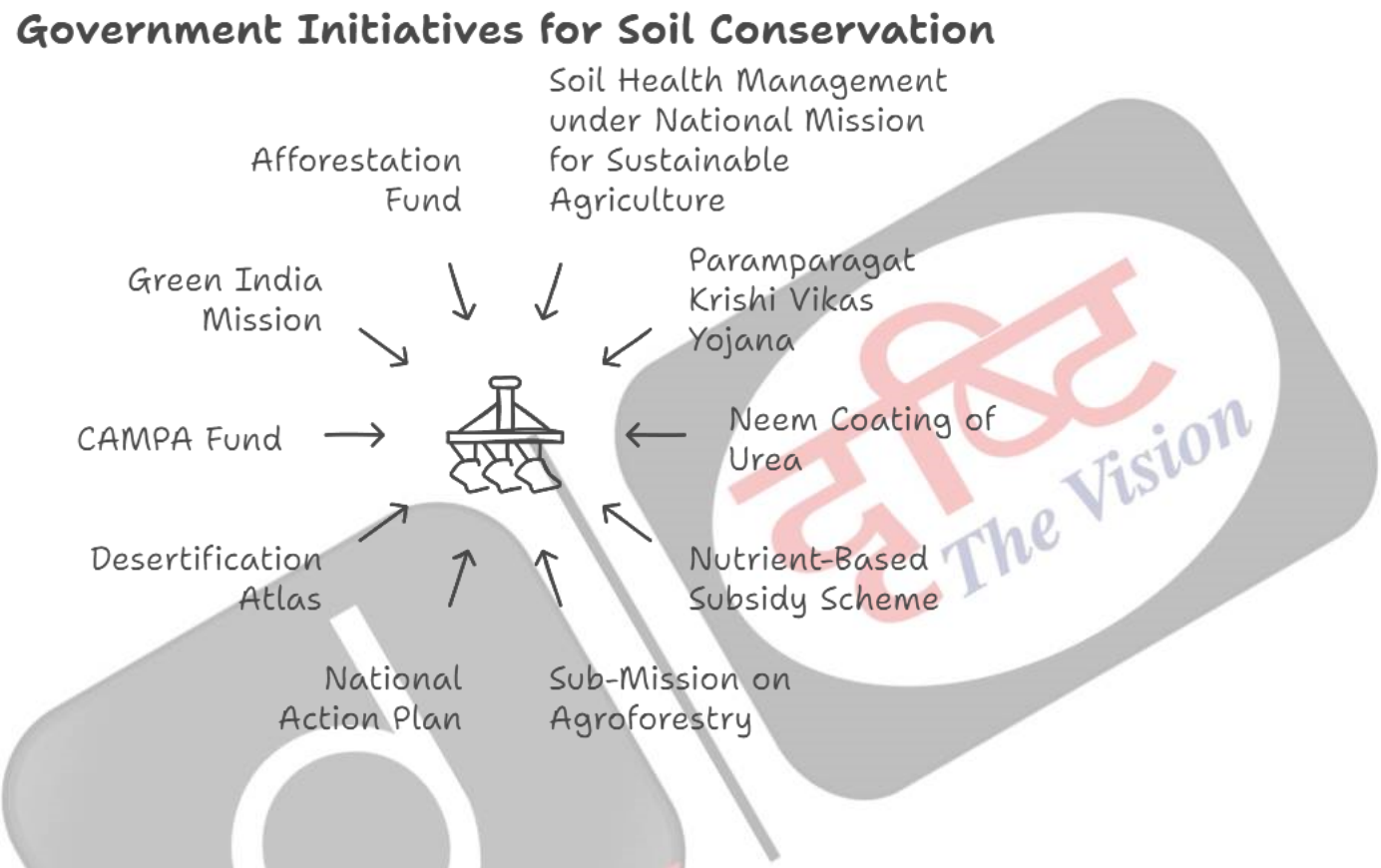

What Measures India Can Adopt for Soil Health Restoration and Conservation?

- **Promoting Integrated Nutrient Management (INM) for Balanced Fertilization:** India must shift from excessive chemical fertilizer use to **Integrated Nutrient Management**, combining organic manure, biofertilizers, and judicious synthetic inputs.
    - Promoting **Nano Urea** and organic alternatives can help to reduce fertilizer overuse.
    - **Soil Health Cards (SHC) and Paramparagat Krishi Vikas Yojana (PKVY)** should be linked to encourage bio-fertilizer adoption.
        - Large-scale **composting units** in rural areas can enhance organic carbon levels in degraded soils.
- **Expanding Agroforestry and Perennial Crop Systems:** Integrating **trees with agriculture** through **National Agroforestry Policy (NAP)** enhances soil organic carbon, prevents erosion, and boosts farm income.
    - Crops like **alley-cropped millet and legume plantations** can rejuvenate degraded lands while maintaining productivity.
    - Agroforestry, already **popular in Karnataka and Odisha**, should be scaled up nationwide.
    - Linking **Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)**

for soil conservation works can support large-scale afforestation on degraded farmlands.

- **Encouraging Zero-Tillage and Conservation Agriculture:** Shifting to **zero-tillage farming** reduces soil erosion, enhances microbial activity, and conserves moisture, especially in wheat-rice cropping systems.
    - **Happy Seeder technology in Punjab and Haryana** has successfully reduced stubble burning while improving soil health.
    - **Direct Seeded Rice (DSR) method** in paddy farming lowers groundwater usage and preserves soil structure.
    - Conservation agriculture, backed by the **National Mission for Sustainable Agriculture (NMSA)**, must be expanded to semi-arid regions.
        - **Brazil's success in no-till soybean farming** can be adapted to India's pulse and cereal cultivation.
- **Restoring Degraded Lands Through Agroecological Approaches:** Soil restoration efforts must adopt **agroecology-based models**, incorporating natural ecosystems to improve soil structure and fertility.
    - Encouraging **intercropping and crop rotation** with nitrogen-fixing plants like pulses and legumes can naturally replenish nutrients.
    - Reviving techniques like Rajasthan's **Zaï pit technique** can successfully reverse soil erosion.
    - These approaches should be mainstreamed through **Watershed Development Component (WDC-PMKSY)** under **Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)** .
- **Implementing Controlled Irrigation and Preventing Salinization:** Over-irrigation has led to **soil salinity and waterlogging** in the Indo-Gangetic plains; adopting **drip and sprinkler irrigation** can mitigate these effects.
    - Micro-irrigation techniques under **Pradhan Mantri Krishi Sinchayee Yojana** can be promoted to a wider extent to conserve soil moisture while reducing erosion.
    - Conjunctive use of **rainwater harvesting and surface water irrigation** will prevent groundwater depletion.
        - Using **salt-tolerant crop varieties** in saline-affected areas (as done in **coastal Gujarat**) can restore productivity.
- **Strengthening Soil Biodiversity and Microbial Rejuvenation:** Enhancing **soil microbial diversity** through **bioinoculants, vermiculture, and mycorrhizal fungi** can improve soil fertility and plant resilience.
    - **Integrated Farming Systems (IFS)** that combine livestock, cropping, and fish farming ensure natural nutrient cycling.
    - **Decomposers like Pusa Bio-Decomposer (IARI innovation)** must be widely adopted for organic residue recycling.
    - Soil-friendly techniques, such as **Fukuoka's natural farming**, have shown promising results.
- **Combating Soil Erosion Through Terracing and Grassland Regeneration:** Hilly and semi-arid regions require **terracing, check dams, and vegetative barriers** to prevent topsoil loss.
    - Encouraging **community-led watershed management** (as done in **Ralegan Siddhi, Maharashtra**) can restore eroded landscapes.
    - Grassland restoration efforts in **Gujarat's Banni Grasslands** provide a model for reviving degraded pasturelands.
        - Linking **Compensatory Afforestation (CAMPA funds)** with soil conservation projects can ensure sustainable land use.
- **Strengthening Policy Implementation and Farmer Awareness: Capacity-building initiatives** through Krishi Vigyan Kendras (KVKs) and **FPOs (Farmer Producer Organizations)** must be strengthened.
    - Linking **Soil Health Card Scheme** with **Direct Benefit Transfer (DBT)** can ensure customized fertilizer application for individual farms.
    - A strong policy push under the National Project on Soil Health and Fertility **sub-scheme of National Mission for Sustainable Agriculture (NMSA)** can coordinate state and central efforts effectively.
- **Preventing Industrial and Urban Soil Pollution:** Industrial effluents and **untreated urban waste** have led to toxic contamination of agricultural soils, especially near cities.
    - Implementing **strict soil quality monitoring** under the **CPCB guidelines** can prevent

heavy metal accumulation.
    - Promoting **phytoremediation (using plants to absorb toxins)** can rehabilitate contaminated soils in peri-urban areas.
    - Initiatives like **Tamil Nadu's innovative biochar projects** and **Kolkata's East Kolkata Wetlands-based agriculture** show how urban waste can be transformed into soil-enriching resources.
        - Linking **Smart Cities Mission** with urban soil restoration projects can ensure sustainable urban farming.
- **Encouraging Farmers to Adopt Regenerative and Natural Farming:** Regenerative farming techniques, such as **Zero Budget Natural Farming (ZBNF) and permaculture**, can enhance soil health while reducing external inputs.
    - **Andhra Pradesh** has demonstrated the feasibility of scaling regenerative practices.
    - Encouraging **cover cropping and mulching** can improve soil structure and prevent nutrient depletion.
    - Policy incentives under **National Mission for Organic Farming (NMOF)** should be expanded for wider adoption.

Conclusion:

India's soil health crisis threatens long-term agricultural sustainability, food security, and rural livelihoods and requires a collaborative approach that drives the **Food-Energy-Water Nexus.** It requires a shift from **chemical-intensive farming to balanced nutrient management, organic amendments, and climate-resilient practices**. Policy reforms, including rationalizing fertilizer subsidies and promoting agroecological approaches, are essential for restoring soil fertility. Strengthening farmer awareness and technological interventions like Soil Health Cards can drive sustainable soil management.

Drishti Mains Question:

"India's soil degradation crisis threatens agricultural productivity, ecological balance, and food security. Examine the major causes, consequences, and suggest strategic measures for sustainable soil management

UPSC Civil Services Examination Previous Year Question (PYQ)

Prelims:

Q. Consider the following statements: (2017)

The nation-wide 'Soil Health Card Scheme' aims at

1. expanding the cultivable area under irrigation.
2. enabling the banks to assess the quantum of loans to be granted to farmers on the basis of soil quality.
3. checking the overuse of fertilisers in farmlands.

Which of the above statements is/are correct?

(a) 1 and 2 only

(b) 3 only

(c) 2 and 3 only

(d) 1, 2 and 3

Ans: (b)

Mains:

Q. How far is the Integrated Farming System (IFS) helpful in sustaining agricultural production? **(2019)**
