

## Strengthening SDG Outcomes through Soil Health Management and Soil Security Frameworks

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Soil is one of the most important natural resources that sustains life on Earth by supporting plant growth, regulating water, and maintaining ecological balance. It serves as a medium for nutrient cycling and acts as a habitat for a wide range of organisms. In the present scenario, soil has gained global importance due to its direct linkage with Sustainable Development Goals (SDGs), particularly those related to food security, climate change mitigation, and environmental sustainability (FAO 2020). However, increasing population pressure, intensive agricultural practices, and climate variability have led to soil degradation and increased vulnerability. Therefore, maintaining soil health and understanding soil vulnerability frameworks are essential for achieving sustainable development.



Fig 1: United Nations Sustainable Development Goals (SDGs) (Source: United Nations, 2015)

Table 1: Soil Health Indicators, Functions and SDG Linkages

Indicator Type	Parameters	Functional Role	Related SDGs
Physical	Bulk density, porosity, aggregation	Water retention, root growth	SDG 2, SDG 15
Chemical	pH, EC, macro & micronutrients	Nutrient availability	SDG 2
Biological	Microbial biomass C, enzymes	Nutrient cycling, soil fertility	SDG 13, SDG 15
Integrated	Soil Organic Carbon	Carbon sequestration, resilience	SDG 13

Source: Lal (2015)

## Soil Health: Concept and Indicators

Soil health refers to the ability of soil to function as a living system that sustains plants, animals and humans (Brady and Weil 2016). A healthy soil ensures productivity, enhances environmental quality and promotes biodiversity.

### Key Indicators of Soil Health:

- **Physical indicators:** Soil structure, texture, bulk density, porosity and water holding capacity influence root growth and water availability. Good structure improves aeration and reduces compaction.
- **Chemical indicators:** Soil pH, electrical conductivity, organic carbon and availability of essential nutrients (N, P, K and micronutrients) determine soil fertility and crop productivity.
- **Biological indicators:** Microbial biomass carbon, soil enzymes and biodiversity indicate biological activity and play a crucial role in nutrient cycling.

Soil organic carbon is a key component of soil health as it improves soil structure, enhances water retention and supports microbial activity (Lal 2015).

**Advanced concept:** Soil security is an emerging concept that integrates soil capability, condition, capital, connectivity, and codification to ensure long-term sustainability. It extends beyond soil health by incorporating governance and policy dimensions (McBratney et al. 2014).

## Soil Vulnerability Framework

Soil vulnerability refers to the susceptibility of soil to degradation due to environmental and anthropogenic factors. It helps identify areas at risk and guides appropriate management strategies.

### Major Types of Soil Vulnerability:

- **Erosion vulnerability:** Loss of fertile topsoil due to water and wind erosion, especially in hilly regions
- **Nutrient depletion:** Continuous cropping without replenishment reduces soil fertility
- **Climate vulnerability:** Variability in rainfall and temperature affects soil processes
- **Chemical degradation:** Excessive use of fertilizers and pesticides leads to salinity, acidity, and pollution

Globally, nearly 1–2 billion hectares of land are affected by soil degradation, and about 12 billion tons of fertile soil are lost annually due to erosion (FAO 2015; Lal 2015). In hilly regions like Himachal Pradesh, steep slopes and heavy rainfall increase the risk of soil erosion and degradation.

## Linkage Between Soil Health and SDGs

Soil health management plays a vital role in achieving several Sustainable Development Goals:

- **SDG 2 (Zero Hunger):** Healthy soils enhance crop productivity and ensure food security
- **SDG 13 (Climate Action):** Soils act as carbon sinks and help mitigate climate change (IPCC 2021)
- **SDG 15 (Life on Land):** Soil conservation prevents land degradation and supports biodiversity

Thus, maintaining soil health is essential for achieving global sustainability targets.

## Management Strategies for Improving Soil Health

Improving soil health and reducing vulnerability require integrated and sustainable approaches:

- **Integrated Nutrient Management (INM):** Balanced use of chemical fertilizers along with organic inputs such as FYM and compost
- **Organic amendments:** Use of green manure, crop residues and biofertilizers improves soil organic matter and microbial activity

- **Conservation agriculture:** Practices like minimum tillage, crop rotation and residue retention reduce soil erosion and improve soil structure
- **Soil testing:** Helps in scientific nutrient management and efficient fertilizer use
- **Agroforestry and cover cropping:** Enhance soil fertility, reduce erosion and improve biodiversity

These practices enhance soil resilience and long-term sustainability (ICAR 2019).

### Indian Perspective

In India, soil degradation is a major concern affecting agricultural productivity. A significant portion of land is affected by erosion, nutrient depletion, and salinity. In Himachal Pradesh, soil erosion due to slope and rainfall is a major issue. Adoption of soil conservation measures, organic farming, and improved nutrient management can significantly enhance soil health. Government initiatives such as the Soil Health Card Scheme have helped farmers adopt balanced fertilization practices and improve soil fertility (Government of India 2018).

### Conclusion

Soil health is the foundation of sustainable agriculture and environmental sustainability. Strengthening soil health management and understanding soil vulnerability frameworks are essential for achieving Sustainable Development Goals. Sustainable soil management is not only essential for present productivity but also for securing future generations. Integration of soil health with soil security frameworks and policy interventions is essential for long-term SDG outcomes..

### References

1. FAO. 2015. *Status of the World's Soil Resources*. FAO, Rome.
2. FAO. 2020. *State of Knowledge of Soil Biodiversity*. FAO, Rome.
3. Lal, R. 2015. Soil carbon sequestration and climate change. *Geoderma*, 123: 1–22.
4. Brady, N.C. and Weil, R.R. 2016. *The Nature and Properties of Soils* (15th Edition). Pearson Education.
5. IPCC. 2021. *Climate Change and Land*. IPCC, Geneva.
6. ICAR. 2019. *Handbook of Agriculture*. ICAR, New Delhi.
7. McBratney, A. et al. 2014. Soil security: A new concept for soil management. *Global Change Biology*.
8. Government of India. 2018. *Soil Health Card Scheme Guidelines*. Ministry of Agriculture.
9. United Nations. 2015. *Transforming our World: The 2030 Agenda for Sustainable Development*