Healthy Soil, Healthy City: The Secret Beneath Our Feet

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ABSTRACT

Soil health underpins agriculture, food security, and environmental sustainability by supporting plant growth and key ecosystem services. In urban areas, soils play a vital role in maintaining environmental quality, climate regulation, and human well-being. However, rapid urbanization and industrialization led to sealing and compaction, limiting gas exchange, thereby accelerating degradation. Urban land expansion is outpacing population growth, with a significant share of new urban areas replacing agricultural land, highlighting the need for integrated urban–rural planning. Healthy urban soils are essential for climate regulation, flood mitigation, biodiversity conservation, and achieving key Sustainable Development Goals. Restoration can be achieved through nature-based solutions, increased green and permeable spaces, composting, phytoremediation, and urban farming. Long-term sustainability requires coordinated stakeholder engagement and integration of initiatives like *Meri Maati Abhiyan*, *Bhoochetna* into urban planning frameworks to create resilient and livable cities.

INTRODUCTION

Urban population growth is concentrated in few countries, with over half of the global increase by 2050 occurring in seven nations, led by India. Towns remain crucial, which link rural and urban areas, while rural regions face ageing populations and youth migration (United Nations, 2025). A "healthy city," as defined by the World Health Organization (WHO, 1998), is one that continually improves its physical and social environments and community resources to support human well-being and development. Healthy soils drive essential functions such as decomposition, nutrient cycling, toxic buffering, flood control, and structural stability of urban vegetation, strengthening soil–plant–human linkages. Urban soils, however, often suffer from ecological dysbiosis *i.e.*, reduced biodiversity, shallow depth, structural degradation, high pH, and contamination, unlike natural soils, thereby impairing all ecosystem services (supporting, regulating, provisioning, and cultural) (Schroder *et al*., 2024). Soil health combines physical, biological, and chemical properties with environmental, agricultural, and socio-economic factors. Key features like organic carbon, structure, nutrients, pH, and biological activity support resilience and ecosystem functioning. It is influenced by management, climate, policies, and social factors, providing benefits such as better productivity, water quality, climate resilience, and food security. Therefore, sustainable development requires coordinated urban–rural planning and policy frameworks that treat soil health as a multifunctional system.

1. Key Benefits of Healthy Urban Soils

Healthy urban soils deliver vital environmental and social benefits by improving water infiltration, reducing runoff, and easing pressure on drainage systems, thereby minimizing flood risks. They naturally filter pollutants through microbial activity, support groundwater recharge, and store carbon, contributing to climate regulation. Additionally, organic-rich soils help mitigate the urban heat island effect and enhance biodiversity by sustaining vegetation, pollinators, and urban wildlife, promoting resilient and balanced city ecosystems (Smart Water Magazine, 2025).

2. Effects on Urban Soils

Urban agriculture supports food security and sustainability but is highly exposed to anthropogenic pressures that affect soil quality and food safety. Direct impacts include land-use change, where urbanization removes nutrient-rich topsoil, compacts layers, and reduces carbon and water movement; waste disposal, which introduces artificial materials rich in pollutants; soil sealing with concrete and asphalt, limiting root growth and biodiversity; and soil replacement using low-quality imported or recycled soils. Indirect impacts include the urban heat island effect, altered rainfall patterns, and pollutant deposition, which modify soil chemistry, microbial activity, and nutrient cycling (Pouyat *et al*., 2020). Additionally, invasive species disrupt soil structure and ecosystem functioning, further degrading urban soils

3. Urban Soil Constraints

Urban soils face multiple constraints that degrade their function and productivity. Soil compaction and sealing increase density, restrict root growth, and limit gas exchange while intensifying the urban heat island effect (Tyagi *et al*., 2021). Alkalinity, salt accumulation, and nitrate build-up disrupt nutrient balance and alter soil chemistry. Heavy metal and pollutant contamination (Polychlorinated Biphenyls- PCBs, Polycyclic Aromatic Hydrocarbons-PAHs) from waste and industrial activities pose risks to soil health, organisms, and human safety, often reducing enzyme activity. Altered microclimates in cities result in higher temperatures, vapor pressure deficits, and reduced vegetation causing moisture stress and lower plant productivity, while runoff can further raise soil pH. Disrupted nutrient cycling and reduced microbial activity result from low organic matter inputs. Additionally, artificial materials and debris in soils hinder root growth, water movement, and may release toxins, with compaction and pollution further worsening soil degradation (Choudhury and Meena, 2024).

4. Approaches of Soil Management

Soil health management requires integrated and holistic practices to achieve sustainable agricultural productivity. Crop-related practices such as cover cropping, crop rotation, and Pre-Monsoon Dry Sowing (PMDS) help maintain soil cover, improve organic matter, enhance nitrogen availability, conserve moisture, and reduce erosion, weeds, and pests.

Soil amendments like Jeevamrutham, bio-slurry, tank silt, mulching, biochar, and phosphate-solubilising bacteria (PSB) improve soil fertility, structure, microbial activity, nutrient availability, and carbon storage while reducing dependence on chemical inputs.

Tech-based practices, including crop residue management and zero tillage, enhance soil organic matter, moisture retention, and structure while reducing pollution and input costs.

Sustainable systems such as Direct Seeded Rice (DSR), Sloping Agriculture Land Technology (SALT), and natural farming promote water efficiency, reduce erosion, improve soil fertility, and minimize chemical use, ensuring long-term soil health and agricultural sustainability (Council on Energy, Environment and Water, 2023).

5. Restoration of the health of Urban Soils

Achieving sustainable urban resilience requires a coordinated and multi-dimensional approach, placing green infrastructure at the center of degraded land rehabilitation (Dwijendra *et al.*, 2025). It involves four interconnected pillars: technology and innovation, policy and governance, public awareness and education, and infrastructure development. Technological approaches such as smart green infrastructure, nature-based solutions, and data-driven planning enhance ecosystem restoration and support informed decision-making. Strong policies, adequate budget allocation, regulatory support, and inter-agency coordination ensure effective and accountable implementation of resilience strategies. Public awareness, university-led research, and community participation build social responsibility and promote long-term sustainability. Infrastructure measures, including green spaces, sustainable drainage systems, and active land restoration, improve soil health, biodiversity, microclimate regulation, and flood control thereby helps in achieving sustainable urban resilience.

6. Urban Soil Rehabilitation Strategies

Restoring urban soil health requires integrated strategies addressing physical, chemical, and biological degradation. Phytoremediation and bioremediation use plants and microorganisms to remove or transform contaminants in a cost-effective, eco-friendly manner. Soil amendments such as compost, biochar, and lime improve structure, fertility, pH balance, and reduce contaminant bioavailability, while green infrastructure (green roofs, rain gardens, permeable pavements) limits soil sealing, manages stormwater, and enhances biodiversity. Soil aeration, decompaction, and erosion control further restore infiltration, root growth, and soil stability, making integrated management essential (Ghosh, 2024).

A circular resource recovery model links water reclamation with urban soils and agriculture, where treated wastewater provides reclaimed water, biosolids, nutrients, and energy. Reused water supports irrigation, while biosolids and nutrients improve soil fertility and reduce dependence on synthetic inputs. Energy recovery (biogas) lowers emissions, demonstrating how urban waste can be transformed into resources to enhance soil restoration, water reuse, and sustainable urban resilience (Kumar and Hundal, 2016). The fig. 1 highlights that improving soil health requires coordinated action among multiple stakeholders. Governments frame policies and scale programs, while civil society and communities support grassroots implementation. Researchers provide scientific innovations, farmers drive sustainable practices, and the private sector supports innovation and market linkages. Urban gardening and peri-urban farming systems further strengthen local engagement and food systems. Overall, such collaboration integrates policy and practice to sustain soil health.

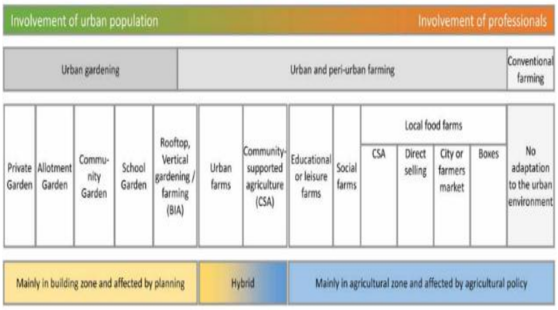

Figure 1. Stakeholders Driving Soil Health Innovation

7. Initiatives of Indian Government

Meri Maati Mera Desh (2023) promotes soil conservation through public participation and awareness activities, though its long-term impact relies on scientific monitoring and policy integration. *Meri Maati Abhiyan* strengthens multi-stakeholder coordination, integrates soil health into governance, and prioritizes soil security at the national level. *Bhoochetna,* focuses on soil test–based nutrient management, improving soil health, farmer capacity, and productivity with reduced input costs.

CONCLUSIONS

Urban soils are vital for sustainable and resilient cities but are increasingly degraded by rapid urbanization and anthropogenic pressures, leading to the loss of key ecosystem functions such as carbon storage, infiltration, nutrient cycling, and microbial activity. Targeted soil management can effectively restore these functions through integrated approaches, including nature-based solutions, green infrastructure, and circular resource use. Organic amendments play a crucial role, with biochar improving structural stability and carbon sequestration, compost balancing carbon and nitrogen, and biosolids enhancing nutrient availability; combined applications yield the best results. Strengthening urban soil health is therefore fundamental to supporting climate resilience, flood mitigation, and must be integrated into urban planning through coordinated policies, innovation, and stakeholder participation.

REFERENCES

Choudhury, N and Meena, S. 2024. Urban Soil Management Challenges and Solutions. Current Trendsch in Soil Science: Challenges and Innovations for Effective Ecosystem Management. ISBN: 978-93-5747-728-4. IIP Series. 14: 172-175.

Council on Energy, Environment and Water (CEEW). (2023). *Understanding carbon markets: Prospects for India and stakeholder perspectives*. New Delhi: Council on Energy, Environment and Water.

Dwijendra, N.K.A., Winastri K, D.A.K and Krishna K, D.N.M.B. 2025. Implementation of green infrastructure for rehabilitation of degraded lands in urban areas of Bali: Challenges and roles of universities. *Journal of Degraded and Mining Lands Management*. 12(4): 7887-7899.

Ghosh, S. 2024. Urban soil management and rehabilitation. In: Tripathi, S., Chauhan, A.R., Hota, R. and Naik, S.P. (eds.) *Modern Approaches in Soil Science*. 7. Stella International Publication: 255–280.

Kumar, K and Hundal, L.S. 2016. Soil in the city: Sustainably improving urban soils. *Journal of Environmental Quality*. 45(1): 2-8.

Pouyat, R. V., Day, S. D., Brown, S., Schwarz, K., Shaw, R. E., Szlavecz, K., Trammell, T. L. E and Yesilonis, I. D. 2020. Urban soils. In R. V. Pouyat, D. S. Page-Dumroese, T. Patel-Weynand, & L. H. Geiser (Eds.), *Forest and rangeland soils of the United States under changing conditions: A comprehensive science synthesis*. Springer. 127–144.

Schröder A, Schloter M, Roccotiello E, Weisser WW and Schulz S. 2024. Improving ecosystem services of urban soils – how to manage the microbiome of Technosols? *Frontiers in Environmental Science*. 12:1460099.

Smart Water Magazine. 2025. *Healthy soils for healthy cities: Restoring urban ground to prevent floods*. Smart Water Magazine.

Tyagi, A., Kumar, M., Bhan, S.C., Magotra, R and Sharma, Y. 2021. Review of urban heat Islands: monitoring, forecast and impacts. *VayuMandal*. *47*(2): 1-29.

United Nations, Department of Economic and Social Affairs, Population Division. 2025. *World urbanization prospects 2025: Summary of results*. New York: United Nations.

WHO. *Health Promotion Glossary*; WHO/HPR/HEP/98.1; World Health Organization: Geneva, Switzerland, 1998: https://www.who.int/publications/i/item/WHO-HPR-HEP-98.1 (accessed on 31 January 2026).