SOIL CONSERVATION SOCIETY OF INDIA

SOIL AND WATER CONSERVATION *Today*

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International Decade of Soils 2015-2024

FROM THE PRESIDENT'S DESK

Celebrating 73rd Foundation Day is a milestone in the journey of the Soil Conservation Society of India, New Delhi, an organization with a proud history stretching back to its registration in 1952-53. We must remember and honour the visionaries who laid its foundation and envisioned an India where the earth's resources are protected for future generations. From its beginnings in Hazaribagh to its national presence today, the society has been a driving force for natural resource management. Its legacy includes pioneering the watershed management approach, publishing vital research in the *Journal of Soil and Water Conservation*, and advocating for the creation of a dedicated Department of Land Resources.

Soil is a lifeline, and its health is directly linked to food security, climate resilience, and our overall survival. However, we continue to face significant challenges, including land degradation, erosion, and climate change. The society's contributions have been instrumental in addressing these issues. By advocating for integrated, bio-industrial watershed management and sustainable farming practices, we have helped to enhance land productivity, improve livelihoods, and combat rural poverty. We have brought together scientists, farmers, and policymakers to develop and implement solutions tailored to the needs of India's diverse agro-ecological regions. As we look ahead, our resolve must be stronger than ever. The society's future depends on our ability to embrace innovative, science-based solutions while remaining focused on the needs of our farmers and rural communities. Soil conservation is not the work of one person or organization; it is a collective responsibility. I call upon every member, partner, and citizen to join us in this crucial mission. Let us be inspired by the words of Franklin D. Roosevelt: "The nation that destroys its soil destroys itself". Our work is not just about preserving a resource, but about safeguarding the future of our nation. On the 73rd Foundation Day, let us reaffirm our commitment to protecting our soil—the foundation of our life, our food, and our future. Thank you.

The Intelligent Earth: AI's Role in Soil Science and Sustainability

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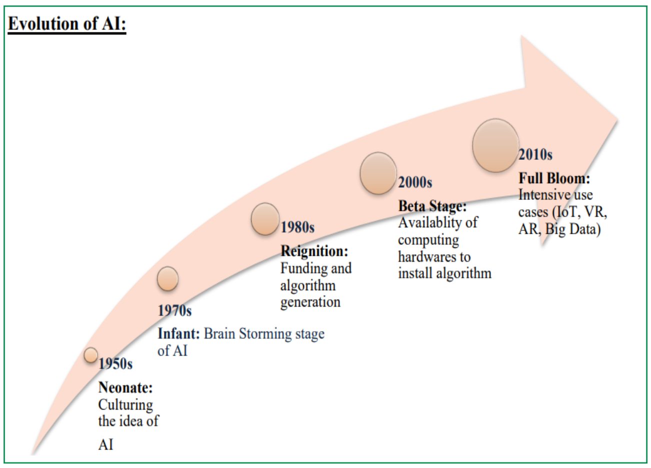
"The soil holds the memory of the land; AI gives us the language to understand it."

Soil, the "living skin of the Earth," is fundamental to terrestrial ecosystems, supporting plant life, regulating water flow, and storing carbon. However, global challenges like erosion, climate change, and increasing food demand necessitate urgent advancements in sustainable soil management. AI is revolutionizing soil management by processing vast quantities of soil-related data from diverse sources like sensors, satellite imaging, and remote sensing. This enables predictive modelling for soil parameters, nutrient levels, moisture content, and erosion, leading to enhanced land use planning, precision agriculture, and improved soil health diagnostics.



Applications of AI in Soil Science

AI's versatility is evident in:

- **Digital Soil Mapping (DSM):** Utilizes Machine Learning (ML) and spatial data to predict soil parameters, creating high-resolution maps crucial for land management.
- **Soil Fertility Assessment:** ML models (e.g., Random Forest) estimate soil fertility for optimized fertilization strategies.
- **Soil Moisture Prediction:** ML techniques, including Long Short-Term Memory (LSTM) networks, estimate soil moisture dynamics from time-series data.
- **Soil Erosion Modelling:** ML models analyze factors like rainfall and topography to predict erosion risk, guiding conservation practices.

Success Stories and Government Efforts in India

India is increasingly adopting AI in soil science, driven by government initiatives and tech innovation. A key step was the Soil Health Card (SHC) Scheme (2015). AI, integrated by companies like CropIn and AgNext with organizations like ICAR, helped interpret massive soil data from satellite imagery and ML algorithms to identify nutrient deficiencies and forecast soil needs. By 2023, over 228 million SHCs were issued, leading to reported benefits in AI-supported areas: a 10% increase in yield and a 20% reduction in fertilizer use.

- **Agripilot.ai (2025):** A Microsoft and Agriculture Development Trust partnership in Maharashtra, resulting in a 40% increase in agricultural yields and a 50% decrease in production expenses.
- **Project Mitti Didi (PepsiCo India):** Women in Uttar Pradesh were trained to use portable soil-testing tools, empowering them and providing employment. The initiative also facilitated bank loans and buy-back guarantees for thousands of potato growers and providing field-specific recommendations.
- **Precision Irrigation:** AI systems in Uttar Pradesh have led to significant water savings and increased legume output for pea producers.
- **ISRO:** Uses satellite data and AI to categorize over 120 million hectares of land for precise fertilizer recommendations.

Government Initiatives in India

The Indian government is actively pursuing the integration of AI into soil science to modernize agriculture and promote sustainable practices.

- The **Soil Health Card (SHC) Scheme (2015)**, bolstered by AI technologies and partnerships with ICAR, ISRO, and agritech startups, effectively handles vast soil sample data to provide region-specific recommendations for maximizing fertilizer use and boosting output.
- The **National e-Governance Plan in Agriculture (NeGPA)** and the **Digital India project** have accelerated digital transformation by promoting the use of IoT devices and AI-based smartphone applications for real-time soil diagnostics and monitoring, delivering updates directly to farmers' phones in local languages.

AI Model Types and Algorithms in Soil Science

Task	Model Type	Common Algorithms
Soil type classification	Supervised Learning	Decision Trees, SVM, k-NN
Moisture prediction	Regression	Linear Regression, XGBoost
Soil health diagnosis	Deep Learning	CNN (for image data), RNN
Text analysis of reports	NLP	BERT, GPT-based summarization

- **NITI Aayog's "AI for All" initiative** (2018) designated agriculture as a priority area for AI application, including land use planning, crop compatibility evaluations, and soil fertility analysis.
- ISRO continues to map and categorize Indian land using satellite imagery and ML algorithms, providing crucial insights for precision agriculture.
- The government-supported **AgriStack project** aims to create a centralized database of soil data, land records, and farmer profiles, with AI being essential for analyzing this data and providing tailored advice.
- Funding programs through **MeitY** and platforms like the **National AI Portal** support AI research in agriculture, fostering creativity and collaboration.

Issues with AI Adoption in Farming

Despite potential, AI adoption faces significant hurdles in rural India:

- **Infrastructure and Connectivity:** Limited internet access in rural areas.
- **Cost and Investment Considerations:** High initial cost for small-scale farmers.
- **Data Privacy and Ethics:** Concerns about misuse of farmer data.
- **Lack of Awareness and Training:** Farmers' unfamiliarity with AI and complex data interpretation.

Overcoming Barriers to AI Adoption in Farming

A multi-pronged approach is needed:

- **Empowering Farmers with AI Tools:** User-friendly mobile apps and software provide real-time data and tailored advice.
- **Education and Training Programs:** Specialized programs to teach farmers how to confidently use AI tools.
- **Collaborative AI Communities:** Online forums and partnerships for sharing experiences and knowledge.

Conclusion

Artificial Intelligence is emerging as a cornerstone of a smarter, more sustainable future for agriculture. By transforming complex data into actionable insights, AI enhances soil management, supports water conservation, and facilitates climate adaptation. Despite challenges such as limited infrastructure, high costs, data privacy concerns, and the need for farmer education, sustained investment in training, robust governmental backing, and international cooperation are essential for AI to meaningfully strengthen the resilience of the global food supply. ■

Soil Conservation Society of India (SCSI), New Delhi Celebrated 73rd Foundation Day of SCSI

The Soil Conservation Society of India (SCSI) celebrated its 73rd Foundation Day on September 20, 2025, in the conference room of its headquarters. On this occasion Dr. Suraj Bhan memorial lecture was organized under the esteemed chairmanship of Dr. TBS Rajput, President of SCSI, saw an enthusiastic gathering of over 65 society members.

Dr. S.S. Grewal, Bhu Ratana Awardee delivered Dr. Suraj Bhan memorial lecture. He highlighted challenges and opportunities for India's land and water resources management due to climate change. It is important for agriculture sector to adapt measure to mitigate the effects of climate changes particularly for food and water security. It is predicted that billons of people particularly in developing countries shall face shortage of water, food and health risk and life. According to IPCC 2023, 3.3 to 3.6 billion people live in the highly vulnerable ecosystems with considerable development constraints to fight climate change. He also emphasized that soil carbon credit and trading for climate change has emerged as a prominent tool to reduce green house

emissions. Various attempts are being made by the Ministry of Forest, Environment and Climate Change, and Ministry of Agriculture and Farmers Welfare of Government of India which mainly deals with climate change. The Ministry of Agriculture and Farmer Welfare (2023) prepared draft green credit programme implementation rules. As per this draft, the National Mission for Sustainable Agriculture (NMSA) is one of the nine missions outlined under National Action Plan on Climate Change. The soil carbon trading is now carried out under NMSA. Punjab and Haryana are central to India's rice-wheat production system, vital for national food security and agricultural exports. However, this intensive system faces increasing stress due to groundwater depletion, stubble burning, soil degradation, and climate vulnerability. Agriculture practices account for about 20% India's total emission and majority of which comes from crop residue burning or agriculture biomass burning. This attracted the attention of several companies dealing with soil carbon trading based on elimination of residue burning but incorporation in soil

to increase tradable soil carbon. There are challenges in soil carbon trading but opportunities are also promising which needs to be capitalized for making agriculture a sustainable enterprise.

The event underscored SCSI's ongoing commitment to soil and water conservation, highlighting the society's significant role in promoting sustainable agricultural practices for the betterment of India's natural resources and rural communities.

Smart Compost Monitoring and Evaluation: Transforming Waste into Gold

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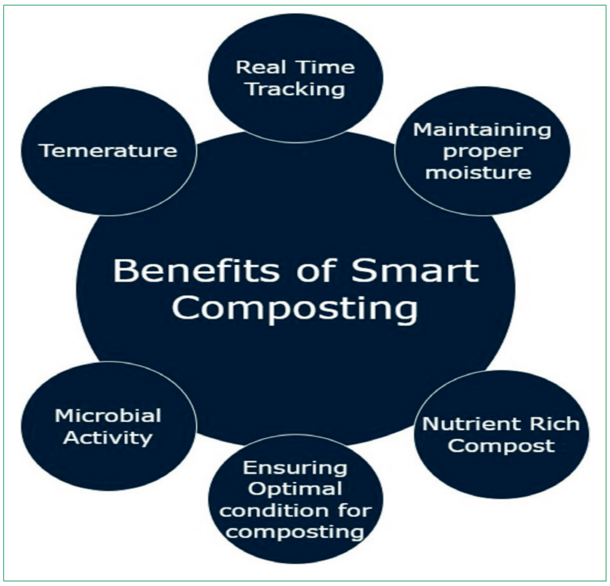
Composting has long been recognised as an essential method for recycling organic waste and enriching soil. While traditional methods rely on manual observation and periodic testing, digital sensors are revolutionising how composting is monitored and optimised. Smart compost monitoring is a revolutionary approach that leverages cutting-edge technology to simplify and enhance composting.

Need for Smart Composting

Composting is a science: it requires precise balance in moisture, temperature, and microbial activity to produce nutrient-rich compost efficiently. Without proper monitoring, compost piles can become too dry, too wet, or even anaerobic, leading to foul odours and inefficient decomposition. Smart compost monitoring provides real-time tracking, ensuring conditions remain optimal throughout the process.

Technology Behind Smart Monitoring

Smart compost systems rely on sensor technology, wireless connectivity, and automated data processing to track key composting parameters. Digital sensors enable real-time



monitoring of critical composting parameters, ensuring efficiency, consistency, and high-quality results. Digital sensors play a crucial role in monitoring composting conditions to ensure efficient decomposition and high-quality compost. Some commonly used sensors are given hereunder:

1. Temperature Sensors: Measure heat levels to track microbial activity and ensure optimal composting conditions.
2. Moisture Sensors: Detect water content to prevent excessive dryness or waterlogging.
3. Gas Sensors: Monitor oxygen, carbon dioxide, and methane levels to assess aeration and decomposition efficiency.
4. pH Sensors: Help maintain the right acidity levels for microbial activity.
5. Odor Sensors: Identify volatile organic compounds that indicate improper composting.
6. Weight Sensors: Track compost mass changes to evaluate decomposition progress.

These sensors provide real-time data, helping users optimize composting conditions and reduce manual intervention. Data from these sensors is relayed to a centralised system, often accessible via smartphone apps or online dashboards, enabling users to make informed decisions about aeration, watering, and turning the compost.

Evaluation and Benefits

Smart monitoring optimizes composting efficiency, reduces manual labour, and improves compost quality by ensuring the right conditions at every stage. Farmers, gardeners, and waste management organizations can benefit significantly by integrating automated monitoring into their composting practices.

Digital Sensors for Composting Process Analysis

Composting is a biological process that transforms organic waste into nutrient-rich soil amendments. While traditional methods rely on manual observation and periodic testing, digital sensors are revolutionizing how composting is monitored and optimized.

Benefits of Sensor-Based Compost Analysis

By integrating digital sensors into composting systems, users can:

- **Improve Efficiency**: Automate monitoring, reducing the need for manual inspection.
- **Enhance Compost Quality**: Maintain optimal conditions for nutrient-rich compost production.
- **Reduce Waste and Odor Issues:** Prevent anaerobic conditions that lead to foul odours and slow decomposition.
- **Increase Sustainability**: Utilize data-driven methods to minimize resource wastage and maximize composting effectiveness.

How these sensors integrated into composting systems

Digital sensors are integrated into composting systems through a combination of hardware, software, and connectivity solutions to ensure efficient monitoring and optimization of the composting process:

1. **Sensor Placement in Composting Units:** Sensors such as temperature, moisture, gas, and pH sensors are strategically placed within compost piles or bins. They continuously collect data on key composting parameters to ensure optimal decomposition conditions.
2. **Data Collection & Transmission:** Sensors are connected to microcontrollers or IoT devices that gather real-time data. Wireless technologies like Wi-Fi, Bluetooth, or LoRaWAN enable remote monitoring and data transmission to cloud-based platforms.
3. **Automated Monitoring & Alerts:** The collected data is processed using digital signal processing (DSP) algorithms to filter noise and extract meaningful insights. If conditions deviate from optimal levels, automated alerts notify users to take corrective actions, such as adjusting moisture or aeration.
4. **Integration with Smart Composting Systems:** Some systems use machine learning models to predict compost maturity and optimize microbial activity. Cloud-based dashboards provide visual analytics, allowing users to track composting progress and make informed decisions.
5. **Remote Monitoring & Control:** Composting machines equipped with combined temperature and moisture sensors enable remote monitoring. Users can access real-time data via mobile apps or web interfaces, reducing manual intervention and improving efficiency.

By integrating these sensors, composting systems become more efficient, sustainable, and user-friendly, ensuring high-quality compost production while minimizing environmental impact.

Future of Smart Composting

With advancements in wireless technology, IoT, and AI-powered analytics, digital sensors are becoming more accessible to farmers, waste management organizations, and eco-conscious communities. The future of composting is smarter, more efficient, and environmentally friendly, reducing waste while enriching soil health. ■

Erosion: A global challenge for sustainability of soil and water resources

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Soil and water are two of the most critical natural resources that sustain life on earth. Soil provides essential nutrients for plants and supports a diverse community of organisms, while water is indispensable for both terrestrial and aquatic ecosystems. However, the degradation rate of these two natural resources is accelerated due to human activities like deforestation, intensive agriculture, monocropping, slope cultivation, shifting cultivation and conventional tillage practices. Climate change also plays a significant role in accelerating soil erosion. Water and wind are the main factors causing soil erosion, exacerbated by land slope, soil properties, and land use.

Fig 1. Slope Cultivation without Proper Conservation Measures in Hilly Regions

A comprehensive study on the impact of water erosion on crop productivity revealed an annual loss of 13.4 million tons of cereals, oilseeds, and pulse crops. On the other hand, the nutrient concentrations in surface water bodies have increased dramatically over the past 50 years, primarily due to runoff and erosion from agricultural fields that are heavily fertilised. Eroded soil deposited in waterbodies reduces their storage capacity and contributes to nutrient pollution, ultimately leading to the scarcity of vital soil and water resources. The severity of erosion and water pollution is high in hilly and high-rainfall regions. Soil erosion has long been recognised as a threat to both agricultural productivity and the quality of surface water. However, the burgeoning population and its impact on every sphere of development, viz., agriculture, industry, and urbanisation, exert pressure on soil and water resources, leading to ever-increasing demands.

Impact of Soil erosion

Erosion intensity is often many times higher in agricultural lands compared to other land uses such as forests and grasslands, and it frequently exceeds the natural rate of soil formation. Although soil erosion is driven by both natural forces and human activities, its consequences are far-reaching, causing severe on-site and off-site impacts that pose significant threats to all forms of life.

1. Onsite effects:

- A significant onsite effect of soil erosion is soil health degradation primarily due to the loss of nutrient-rich and fertile topsoil from agricultural land.
- Organic matter is the crucial nutrient source for soil microorganism involved in nutrient cycling. Most of the soil physical properties such as bulk density, porosity, compaction and tilth are governed by the soil organic matter. However, erosion displaces this vital component from the field.
- Runoff strips finer silt and clay particles from the soil, resulting in reduced nutrient and water-holding capacity of soil.

Off-Site effects:

- The transported soil particles are deposited in water bodies, causing siltation problems.
- As a result of siltation, the storage capacity of the water bodies is significantly reduced.
- In India storage capacity of the reservoirs is reduced by 1-2 % annually due to such depositions, occurring at three to four times faster than originally anticipated.
- The nutrient rich sediments and runoff water promote eutrophication, a process wherein the higher level of nitrogen, phosphorus and organic carbon facilitate the growth of aquatic plants and algae degrading water quality.

Mitigation measures

Erosion mitigation measures should begin at induvial field level, and continue as a community mission. These measures can be classified into agronomic measures, mechanical/ engineering measures and bio engineering measures. Appropriate control measures can be employed based on slope and rainfall intensity. Erosion in fields with slopes of less than 2% can be effectively controlled by agronomical measures like intercropping, alley cropping, crop rotation, mulching and cover cropping. These practices help intercept falling raindrops and reduce their speed and impact on soil. In erosion prone areas, soil should never be left fallow, instead cover crops can be grown as green manure and later incorporated into the soil. Mulching between crop rows also serves the same purpose. Practices such as intercropping, alley cropping and crop rotation with different crops having varied canopy structures and root architectures enhances erosion control by improving ground cover and soil stability.

Erosion problem is more intensified in the fields with less than 8 % slope. In such areas, contour and graded bunds are advocated based on the annual rainfall. Contour bunds are constructed across the slope on the contour lines, help control erosion and promote in-situ moisture conservation in the regions receiving less than 600 mm of annual rainfall. In contrast, graded bunds are constructed with a slight gradient to drain the excess runoff water in the high rainfall regions. Steep slopes combined with high rainfall exacerbate the soil erosion in hilly areas. Therefore, on slopes with less than 33% slope, bench terraces are highly recommended. Bench terraces are the step like structures constructed on hill slopes to break the length of the slope into smaller segments, thereby reducing the velocity off running water and minimizing erosion.

In plantations, excavating trenches are the most effective erosion control measures. These trenches also function as a micro scale in-situ water harvesting structures. Depending on the shape and excavation patterns trenches are classified as contour, graded, staggered and half moon trenches. Stone bunds also recommended for tea plantations for stabilizing the slope and control erosion. Developmental and agricultural activities should be strictly prohibited on lands with slopes more than 33%, as they are the most vulnerable land form to soil erosion. These lands should be retained as forest to stabilize soil, regulate water flow, and support ecosystem health. Wherever the forests areas have been encroached for other activities, afforestation must be carried out with native tree species to sustain the rich biodiversity of the region. In addition to the erosion control measures, nutrient enrichment of water resources can be minimised by optimizing the use of chemical fertilizers in combination with organic manures, based on the nutrient status of the soil.

Conclusions

Land and water are the richest natural resources that becomes non-renewable in the short period. Over exploitation and improper management of these natural resources will leads to degradation, pollution and reduced productivity. Therefore, adaptation of suitable soil and water conservation measures across various land use systems by all stake holders is need of the hour. Lands with more than 33% slope should never be converted from forest land use to any other purpose. Quantity of nutrient applied to be decided based on available nutrients through soil testing which will reduce the soil and water pollution. The sustainable management of soil and water resources necessitates a holistic and collaborative approach among scientists, farmers, policymakers, and the general public. ■

5G Innovation and Training Lab

Prof. Sanjay-Swami
Dean, College of Agriculture, Central Agricultural University, Pasighat, Arunachal Pradesh

The 5G Innovation and Training Lab, the first of its kind in Arunachal Pradesh, has been established at the College of Agriculture, CAU (Imphal), Pasighat with support from the North Eastern Council (NEC) and AMTRON. It serves as a cutting-edge platform to harness the power of 5G technology, IoT, AI, and digital tools for advancing agriculture, education, and rural development in the North Eastern Himalayan region.

Highlights

- **First 5G Agri Lab** in the state, enabling future-ready agricultural solutions.
- A hub for **digital empowerment** of farmers, students, and rural communities.
- Integration of **research, training, and extension** for sustainable hill agriculture.

Location: College of Agriculture, CAU (Imphal), Pasighat

Focus: Digital Agriculture • Skill Development • Innovation • Community Empowerment

Key Activities

Skill Development & Training

- Hands-on training for students and youth on IoT, drones, robotics, and sensor-based agriculture.
- Capacity building programs on digital agriculture, ICT tools, and smart farming practices.

Research & Development

- Development of **5G-enabled agriculture use cases** such as precision farming, crop monitoring, automated irrigation, and livestock health tracking.
- Collaborative projects integrating **AI, machine learning, and remote sensing** for hill agriculture.

Innovation & Entrepreneurship

- Supporting rural youth and farm women through digital tools for agri-business, value addition, and market access.
- Providing incubation support for start-ups in agri-tech and digital solutions.

Technology Demonstrations

- Showcasing **live demonstrations** of drones, smart sensors, and real-time monitoring systems in agriculture.
- Exposure visits and industry collaborations to link students with cutting-edge technologies. ■

33rd NATIONAL CONFERENCE on Land and Water Management for Ecological Restoration and Agricultural Sustainability

At Punjab Agricultural University, Ludhiana, Punjab, December 08-10, 2025

Organized by
Soil Conservation Society of India -Punjab Chapter
and
Punjab Agricultural University, Ludhiana

CONFERENCE THEMES

1: Achieving Land Degradation Neutrality through Innovations
2: Innovative Water Resource Management
3: Food and Nutritional Security through Climate Resilient Sustainable Agriculture
4: Digital Innovations for Land and Water Management
5: Renewable Energy Integration for Sustainable Land and Water Management
6: Farmers' Centric Resource Management Policies

IMPORTANT DATES

Last date of abstract submission	31.10.2025
Intimation of acceptance of abstracts	07.11.2025
Submission of full-length papers	15.11.2025
Last date of registration (Without late fees)	21.11.2025

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CONFERENCE UPDATES

Information details of the conference and updates shall also be available on the website of Punjab Agriculture University (www.pau.edu) and SCSI (www.scsi.org.in).

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