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FROM THE PRESIDENT'S DESK

Effective soil health management requires a holistic and integrated approach, combining traditional knowledge with modern scientific techniques to achieve sustainable and productive agricultural systems. The key components for the effective soil health management are: soil testing and monitoring, organic matter management, crop rotation and diversity, conservation tillage, nutrient management, water management, erosion control, soil biota enhancement, pollution prevention, education and training. Regular soil testing and monitoring are crucial for determining nutrient level, pH, and other parameters, enabling informed decision-making regarding balanced fertilization to avoid nutrient imbalances and environmental pollution. Soil health is majorly determined by the soil structure, organic matter content, nutrient cycling, which can be enhanced by the practices like composting, diversified planting which enhances the soil structure, lower the incidence of soil-borne diseases, and sustain a diversified microbial community, addition of microbial inoculants, organic amendments such as compost, manure, or green manures improves the nutrient availability and increases the soil and plant health. To optimize fertilizer application, reduce waste and erosion, efficient irrigation methods like drip or sprinkler systems, water conservation practices such as rainwater harvesting, contour farming, and building terraces, contour farming, terracing and precision agriculture techniques are followed. Windbreaks to reduce wind speed and protect soil from wind erosion. Farmer education, research and development to support research, provide training and resources on innovative soil management techniques and their practical applications.

The intersection of soil health management and artificial intelligence (AI) represents a promising frontier in agricultural innovation, since it offers both the potential to enhance agricultural sustainability and productivity, as well as adapt to the climatic changes or resource constraints. This study is about Soil health management using AI, the foresaid theme involves leveraging advanced technologies to monitor, analyze and optimize soil conditions for sustainable agriculture. Since AI is often data driven, therefore the data from several sources, like as soil sensors, drone images, etc. could be utilized to analyze the current state of the soil and predict future ones. This is soil health management. Current AI tools are revolutionizing the execution of many routine tasks, opening intense debate over the implications for human employment in the future. Several researchers have examined the impact of AI on service industries, suggesting that the development of these technologies might lead to the obsolescence of certain job roles. However, it could also increase the demand for roles focused on management, decision-making, and the interpretation of complex analyses. Harnessing the power of artificial intelligence offers a transformative approach to both soil health management and ecosystem community. However, AI in soil health management faces certain challenges related to cost, accessibility, expertise, data quality, interpretability and system integration..

Artificial Intelligence and Machine Learning Driven Solutions for Sustainable Agriculture

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Agriculture life cycle starts from preparing the land for the crop followed by seed sowing, irrigation, weeding, fertilizer application, pest and disease management, harvesting, post-harvest processing, storage, and selling. Various AI techniques have the ability to alter and improve all the phases of the life cycle, some of which are now available and some still need to be worked on. In an ideal smart ecosystem, a farmer would be supervised by an artificially intelligent assistant that would recommend the most appropriate date and way to prepare the land based on the GIS and remote sensing data of that location. Using a block chain and recommender system enabled supply chain, farmer would acquire quality seeds to sow after land preparation. Scheduled weeding would be handled by low-cost smart weeding and fertigation devices. The identification of pest and disease with their corresponding control strategies may be handled by AI powered mobile applications. The yield prediction may be done by drone based smart application and the estimated yield will help in picking the appropriate market and buyer. Artificial intelligence (AI) is a scientific discipline focused on creating machines that replicate human cognitive abilities. Machine learning (ML) is a subset of artificial intelligence that enables machines to autonomously acquire knowledge from data without explicit programming.

Agriculture is perpetually compelled to yield greater outputs with limited resources. Artificial Intelligence and Machine Learning methodologies provide the ability to enhance resource efficiency through the analysis of agricultural data. It has transformed contemporary agriculture by anticipating numerous input parameters and projecting the post-harvest lifespan of a crop. This article examines several AI and ML approaches and their applications throughout different stages of the agricultural life cycle, and encompasses a wide array of agricultural domains that necessitate the application of AI and ML. It encompasses soil, irrigation, and disease management.

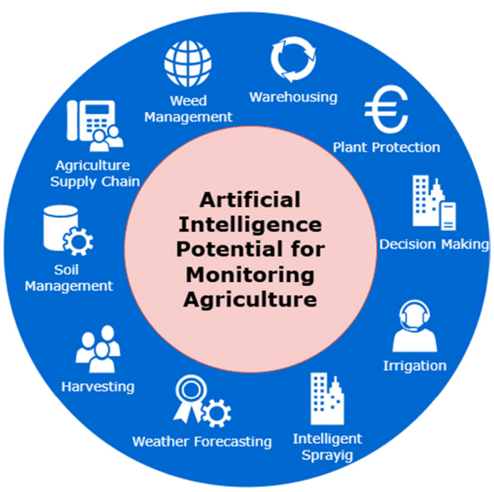
Major application of AI and ML in Agriculture

In the present scenario, AI and ML techniques are being exponentially applied in the various areas of the agricultural domain. These areas can be categorized into the following groups: soil and water management, crop health management, crop phenotyping, recommender-based systems for crops, semantic web and ontology driven expert systems for crops and Geo-AI. The applications of ML and AI based techniques on these areas are discussed hereunder.

- **Soil and irrigation management:** Soil and irrigation are the most viable components of agriculture. The soil and irrigation are the determinant factors for the optimum crop yield. In order to obtain enhanced crop yield and to maintain the soil properties, there is a requirement of appropriate knowledge about the soil resources.Real-time devices that can supervise soil moisture and water availability, and consequently regulate water costs, are crucial. This type of precision farming can eliminate waste and create valuable harvests, high productivity, and improved advantage.
- **Precision agriculture:** Artificial intelligence is employed in precision agriculture to enhance the utilisation of water, fertilisers, and pesticides. Real-time data on meteorological conditions, agricultural produce, and soil vitality is collected by sensors and satellites. AI subsequently analyses this data to deliver tailored recommendations, ensuring that farmers utilise the optimal amount of resources at the exact time and location necessary. Consequently, there is less waste, diminished costs, and increased output.
- **Weather forecasting and risk management:** Agriculturists encounter substantial risks due to the volatility of meteorological conditions. Artificial intelligence employs satellite imagery, real-time updates, and historical climate data to enhance the precision of weather forecasts. Consequently, farmers can more

effectively strategies for planting, irrigation, and harvesting. AI predicts threats such as storms, floods, and droughts, enabling farmers to prepare in advance.

- **Soil health monitoring:** Artificial intelligence facilitates the assessment and improvement of soil health, crucial for sustainable agriculture. It analyses soil composition, moisture levels, and nutrient concentrations utilising data from sensors, drones, and soil analyses. This supports farmers in selecting optimal crops and ascertaining precise quantities of water and fertilisers.
- **Sensors on crops and farm machinery:** Sensors can connected with various agricultural machines like combine harvesters, tractors, and other devices and it will let farmers for gathering of fresh of information about their crops and soil. Sensing technology makes farms more innovative and more linked through precision agriculture. This is simply one technique to boost the quality and quantity of agricultural products. The information acquired from sensors not only directly assists the farmers but also the agriculture company overall.
- **Environmentally safe pesticides:** The food and agriculture industries are focused on finding efficient and cheap option to synthetic pesticides. Natural pheromones-some compounds produced by animals that affect the natural behaviour of another animal of the same species-are now being used to disrupt the mating patterns of pests that eat fruit.



(Agriculture Parameters Monitors by Artificial Intelligence)

Need for AI and ML in agriculture

Agriculture is a labour-intensive occupation, and with increasing population and agricultural output demand, machine learning is being increasingly essential. AI significantly assists farmers in components, technologies, and applications. Predictive analytics and improved farm and crop management systems guarantee crop quality and supply. Through satellite photos and meteorological information, businesses determine acreage and track crop health in real-time. Businesses can use big data, AI, and ML technologies to anticipate pricing, calculate tomato output and yield and identify pest and disease infestations. They can advise farmers on demand levels, crop varieties to plant for the best profit, the usage of pesticides, and future pricing patterns. AI will be a potent instrument that can help organisations deal with the growing complexity of contemporary agriculture since it dramatically reduces the shortage of resources and labour. It is past time for large corporations to invest in this area. Many industries use AI technology to boost productivity and efficiency. AI technologies are helping people in every sector overcome conventional obstacles. Finance, transportation, healthcare, and agriculture are among the sectors that employ AI applications.

Advantage of AI and ML

Agriculture is becoming digitised and smarter, AI in agriculture is appearing in three primary categories which are agricultural robotics, soil & crop monitoring, and predictive analytics, Farmers are utilising sensors and soil sampling to collect data and this data is kept on-farm management systems that enable for better processing and analysis. Agricultural offer information on soil's strengths and weaknesses, the emphasis is on standardized the potential for healthy crop yield production and preventing faulty weak crops, the increase in AI technology has permitted agro-based businesses to run more efficiently.

Machine learning helps to propose seeds, the technique is also being applied in another areas such as automated machine adjustments (combine, planter down force, etc.), weather forecasting, disease or pest detection, image recognition, disease and pest movement, machine maintenance and break-down prediction, field accessibility or harvest advisory type projections, irrigation and water management, nutrient use and fertility recommendations, autonomous machines or robots.

Limitations

The lack of simple solutions that seamlessly incorporate and embed AI in agriculture is a significant barrier to the widespread adoption of AI in agriculture. The majority of farmers lack the time and digital skills to investigate AI solutions on their own. In order to seamlessly incorporate and embed AI within agriculture, these new AI solutions will need to be integrated into existing and legacy infrastructure and systems that farmers already use. Agriculture cannot wholly rely on AI because it cannot work outside its programming. Farmers, particularly those in rural areas, lack technical knowledge andare unawareof the existenceof such technologies. As more awareness is raised and technologies become more accessible to the average farmer, agriculture may become semiautonomous, with AI leading the way.

Future prospect

AI technologies are delivering innovative and precise solutions to major agricultural issues confronting farmers worldwide. AI will provide solutions for almost everything, from pest control to weather prediction to farm work assistance. AI will assist farmers in becoming agricultural scientists using data to optimise yields to individual rows of plants. AI companies are developing robots that can readily do various duties in farm settings. This robot is engineered to pick crops more quickly and thoroughly than humans can. These robots are taught to harvest and pack crops while checking crop quality and weeds. These robots can also overcome the difficulties faced by agricultural labour.

Conclusion

AI-enabled technologies use data like temperature, precipitation, wind speed, and solar radiation in combination with ML algorithms and images taken by satellites and drones to predict weather conditions, analyse crop sustainability, and evaluate farms for the presence of diseases or pests and inadequate plant nutrition. Farmers with Wi-Fi connectivity may use AI applications to acquire an AI-tailored agricultural plan. Using AI-driven solutions that boost output and income without reducing irreplaceable natural resources, farmers can fill the global requirement for higher food supply and profitability. Farmers can utilise AI to gather real-time insights from their fields, detecting regions that require irrigation, fertilisation, or pesticide treatment. Innovative farming technologies such as vertical agriculture may assist boost food output while utilising reduced resources.

Measuring Soil Carbon Sequestration

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Soil health is paramount for modern farmers who confront the challenges of food security, climate change, and environmental sustainability. A key component of this is soil carbon sequestration, a process that captures atmospheric carbon dioxide and stores it in the ground. This article explores the complexities and environmental benefits of soil carbon sequestration, the challenges in its implementation, and how Al-powered satellite data analytics can facilitate this crucial process.

Soil organic carbon sequestration

Soil organic carbon (SOC) sequestration is the process of transferring CO_2 from the atmosphere into the soil in the form of organic carbon. This process begins with photosynthesis, where plants convert atmospheric carbon dioxide into organic compounds. These compounds are then incorporated into the soil through plant residues and root exudates.

SOC is the carbon fraction of soil organic matter, derived not only from plants but also from animals and microorganisms. Another source of these compounds is the byproducts of animal and microbial activity. The process of carbon sequestration in soil continues as organic compounds are incorporated into the earth through dead plants or leaves. These materials eventually decompose and transform into SOC with the help of subterranean organisms. Since by increasing the soil organic carbon content, one can effectively lock away CO_2- a major greenhouse gas that traps heat in the atmosphere - from the air, SOC sequestration also turns out to be a natural way of mitigating climate change.

Soil carbon sequestration potential

Utilizing soil carbon sequestration for climate change mitigation holds immense potential. Today, farmers and agri-businesses can employ a variety of strategies to enhance this process:

Conservation tillage: Traditional tilling exposes organic matter in the soil to oxygen, which aids decomposition, releasing CO_2 and other greenhouse gases. Conservation tillage, on the other hand, involves minimal soil disturbance, which helps to retain soil carbon.

Crop rotation and diversification: This practice can enhance SOC levels by varying the amount and type of plant residues returned to the soil. Different crops have different root structures and growth patterns, which can influence soil carbon sequestration.

Cover cropping: Clover, beans, peas, and other cover crops planted after the main crop is harvested help carbon get into the ground year-round. These crops can be plowed under the ground as "green manure," adding more carbon to the soil.

Applying organic amendments: Compost and manure can significantly increase SOC levels and enhance erosion control measures like contour plowing and terracing. These amendments increase organic matter in the soil, which improves its structure and enhances its ability to absorb and retain water. For example, perennial crops, which do not die off every year, grow deep roots that help soils store more carbon. However, the potential for carbon sequestration in soil is influenced by local controls ecosystem processes such as rainfall infiltration, soil erosion and temperature, and sediment deposition. These factors can vary on local scales due to landscape heterogeneity, affecting SOC input and loss rates, and resulting in differences in SOC contents along topographic gradients. For example, slope position impacts soil moisture and nutrient levels, with subsequent impact on plant root growth that may have consequences for SOC. The potential for carbon sequestration in soil may be determined by understanding both the historic SOC stocks under natural vegetation prior to conversion to the uses and the influences of those land uses on carbon loss. Changes in land use and management that result in either increased inputs or decreased losses of SOC can reduce its deficit and enhance soil carbon sequestration.

How to measure carbon sequestration in soil

Measuring soil carbon sequestration is a crucial step for farmers and agri-businesses willing to reap financial benefits from their efforts. To do this, they need to employ careful sampling strategies and bring collected soil to a lab to determine its SOC content. This is not a simple task, as sampling requires a systematic approach to ensure that the samples are representative of the entire field. Once the samples reach the lab, they undergo a complex process to measure and verify the SOC content. This involves a variety of techniques and methodologies, as carbon levels can significantly vary both over time and across different field areas. For instance, the SOC content can differ between the topsoil and subsoil layers, and even within the same layer, it can vary depending on the soil type, climate, and management practices.

Based on the lab results, estimates of soil carbon sequestration are made in comparison to the baseline state. However, given the complexity of SOC dynamics, these estimates are often associated with a degree of uncertainty. To overcome this challenge, scientists use various change estimation models. Some of them simulate the processes involved in carbon cycling in soil, such as the decomposition of organic matter, carbon input from plant residues, and its loss through respiration. Others are based on already observed relationships between SOC and influencing factors and use statistical techniques to predict SOC changes on historical data.

There are also hybrid models that combine elements of process-based and empirical models. These models leverage the strengths of both approaches, providing more accurate and reliable estimates of the effects of soil carbon sequestration. Since businesses want to know possible profits before engaging in any new venture, they can forecast the amount of sequestered SOC using modern AI-powered satellite analytics solutions. For that, they need to take soil samples so that the analytics model could use them as a baseline. After a certain period of time the longer, the better for more noticeable changes the user will need to take only 10% of the initial samples again to validate the model. This approach significantly reduces the time and cost associated with soil sampling, making it a more feasible option for businesses.

The tribal-inhabited aspirational district Ri-Bhoi, Meghalaya is still continues to use traditional farming practices such as *jhumming* and mono-cropping. The land and soil are continually damaged as a result of the farming community's lack of awareness about soil health, causing reduction in crop yields. A comprehensive approach to manage soil organic carbon is essential to improve soil health and crop output. Soil resource mapping can be a better idea for predicting spatial variability of soil organic carbon. Therefore, the College of Post Graduate Studies in Agricultural Sciences, Umiam is attempting to study the discrete dataset of SOC, compare the different geo-statistical models, and mapping the SOC using the best model among employed models.

SOC management and modern technologies

Modern technologies, particularly AI-powered satellite data analytics, are playing a pivotal role in overcoming the challenges of measuring soil carbon sequestration. Satellite images provide high-resolution data on SOC levels across large geographical areas. AI models analyze historical and current data to predict changes in SOC levels based on various factors such as land use, climate, and management practices. And then the insights provided by AI-powered satellite analytics can guide farmers toward more sustainable and carbon-efficient practices. On a larger scale, reliable data on soil health and carbon sequestration can inform policy decisions promoting sequestration practices that mitigate climate change. The advances in technologies have also led to the introduction of a carbon market as a way to stimulate SOC sequestration.

Joint Celebration of World Day for Glaciers & World Water Day at SCSI Headquarters

The Soil Conservation Society of India (SCSI) organized a joint celebration of the World Day for Glaciers and World Water Day on March 21, 2025 at the SCSI Headquarters, NASC Complex, New Delhi. The event was conducted in hybrid mode, allowing both physical and virtual participation from members across the country.

The occasion was graced by Dr. J.K. Singh, Former Dean, GBPUA&T, Pantnagar, as the Chief Guest, and Sh. Surender Makhija Senior VP & Strategic Advisor at Jain Irrigation Systems Ltd. as the Guest of Honor. The event was held under the chairmanship of Dr. T.B.S. Rajput, President, SCSI, who highlighted the importance of glacier conservation and sustainable water management in the context of climate change and food security.

At the outset, Dr. T.B.S. Rajput, President, SCSI, warmly welcomed all members who could attend the program at the headquarters. He emphasized the crucial role of water in agricultural production systems, highlighting the increasing challenge of reduced availability and deteriorating quality of water resources. He stressed the collective responsibility of efficient water management in agriculture to achieve the national goal of "Per Drop More Crop," as envisioned by Hon'ble Prime Minister of India. President, SCSI further appealed to the members to raise awareness, particularly among young children, about the vital importance of water in sustaining life.

President, SCSI presented various climate change mitigation strategies and adaptation technologies that are essential for sustaining food production in the country amidst increasing climate uncertainties. He emphasized the need for adopting climate-smart agricultural practices to meet the growing demands of the ever-increasing population. Before opening the house for discussions, he introduced the distinguished speakers, Prof. J.K. Singh and Mr. Surender Makhija, and invited them to share their insights on the occasion.

Dr. J.K. Singh emphasized the significance of glaciers as a crucial freshwater resource and discussed the themes of previous World Water Day celebrations, focusing on water conservation, sustainable usage, and climate resilience. He stressed the urgent need for collaborative efforts in preserving water resources, mitigating glacier retreat, and enhancing public awareness about water security challenges.

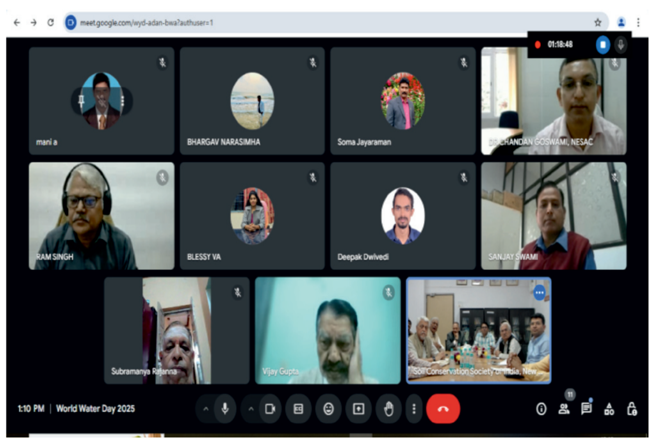
Mr. S. Makhija highlighted critical water challenges and solutions for sustainable agriculture. Climate change threatens crop yields with a 0.5°C rise reducing wheat yield by 0.45 tons/ha in India. Uneven rainfall and inefficient water use exacerbate scarcity, as seen in Maharashtra, where sugarcane covers only 5% of land but consumes 60% of irrigation water.

Drip irrigation boosts water productivity, increasing sugarcane yield from 2.5 kg/m^3 to 21 kg/m^3. Pipeline networks reduce losses, and wastewater recycling, like Israel's Shafdan plant treating 360,000 m^3/day, supports agriculture. Policy reforms, such as shifting crop planting periods and expanding micro-irrigation, are crucial.

He stressed that adopting efficient irrigation, policy shifts, and corporate initiatives are vital for sustainability. These measures will enhance food security and attract future generations towards the profession of farming.

Several SCSI members from Delhi-NCR attended the event in person, while many others from different regions joined virtually. The discussions revolved around the critical need for water conservation strategies and the impact of climate change on glaciers, emphasizing sustainable solutions for future generations.

The event concluded with a vote of thanks delivered by Dr. Mukesh Kumar, Secretary General, SCSI who expressed gratitude to all dignitaries, members, and participants for their valuable contributions.



Chhattisgarh Chapter of SCSI Organized Oath Taking Ceremony on World Water Day

Across the globe, individuals, organizations, and governments came together to observe World Water Day, a day dedicated to raising awareness about the importance of freshwater and advocating for sustainable management of water resources. World water day is marked on 22nd March every year. This year the theme was "Glacier Preservation". Often it is presented as "Celebration of World Water Day"; in fact it's not something to celebrate rather it is a concern to recall our oath reconfirm, our commitment to take care of our common mother "The Mother Earth". Our common mother is in ICU and we, the human being responsible because of our environment hostile lifestyle.

Oath on World Water Day was taken up by the members of the Chhattisgarh Chapter of Soil Conservation Society of India. The program was organized in the conference hall of Swami Vivekanand College of Agricultural Engineering, IGKV, Raipur. Chief Guest of the oath taking ceremony, Er. Shailendra Shukla, Chairman of the SCSI, CG Chapter presented deep and practical understanding/work pertaining to the watershed management. Sharing his vast experience in the field of natural resource management, Er Shukla calls for actions to take care of our mother earth. Dr Vinay K. Pandey, Executive member SCSI CG Chapter and Dean, Swami Vivekanand College of Agricultural Engineering, IGKV, Raipur shared some of his practical works in the field of watershed management. Dr M. P. Tripathi, Executive member SCSI CG Chapter, Senior Professor & Head, Department of Soil and Water Conservation Engineering, IGKV, Raipur shared his vast experience in the field of water management and watershed modelling. Dr Jitendra Sinha, Secretary, SCSI CG Chapter and Dean, BRSM College of Agricultural Engineering, Mungeli IGKV showed some of his innovative ideas relating to the natural resource management. He calls for care of "The Mother Earth". He showed his concern over the need for sensitization for water conservation especially amongst the highly literate society. He shared several examples of sensitivity towards respect and water conservation amongst the so called illiterate society. The program was organized in a sustainable manner as such no plastic bottles, no disposables used and no non-compostable garbage was created. The program was assisted by Dr Usha Yadav, SRF (Against), NHP-NRSC project, staff and students from the Department of Soil and Water Conservation Engineering, IGKV, Raipur.

Measuring Soil Erosion in Umsarang Micro-watershed of Meghalaya

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Soil erosion is a serious problem in today's era. It has destroyed ecosystems. Average rate of world soil erosion is around 12 to 15 t/ha/yr while in India, it is around 16.53 t/ha/yr. Average annual soil loss in North-East India is around 40.9 t/ha/yr. Meghalaya is a mountainous state with average elevation of 3000 ft. Major causes of soil erosion in Meghalaya are undulating topography, inhospitable terrain, incessant rains and harsh climatic conditions. For checking the increasing threat in the ecosystem and food security because of erosion, particularly in the mountainous region of North-East India, immediate action plans must be executed for soil and water conservation. These action plans can be best achieved by the soil erosion assessment in watershed level. Land and water are two of the most important and basic natural resources in a watershed. In fact, good quality land and water is a fundamental requirement not only to maintain the existing ecosystem in awatershed but also to endorse anthropological changes to suit human needs without causing imbalances to the system. Assessment of soil erosion is useful in planning and conservation works in a watershed and modelling can provide a quantitative and consistent approach to estimate soil erosion. However, there is a dearth of systematic information on soil erosivity in Umsarang micro-watershed in Ri-Bhoi district of Meghalaya. RS and GIS, in conjunction with the RUSLE Model, play a crucial role in determining the input parameters for soil erosion modelling and resource management. Hence, the School of Natural Research Management, CAU, Barapani is investigating the quantity of soil erosion in the Umsarang micro-watershed of Meghalaya to suggest the possible planning and management strategies for tackling the problem of erosion in the study area. The spatial erosion maps can serve as a useful reference for deriving planning and management strategies and provide the opportunity to develop a decision plan for soil erosion prevention and control for implementation of appropriate soil conservation practices in the Umsarang micro-watershed.

New Executive Council of SCSI (2025-27)

The Soil Conservation Society of India (SCSI), New Delhi conducted election for framing new Executive Council online in December 2024. The new Executive Council of SCSI to function during next three years (2025-27) is given below:

S. No	Name	Designation
1.	Dr. T.B.S. Rajput	President
2.	Er. Shamsher Singh	Sr. Vice-President
3.	Dr. Sanjay Arora	Vice-President
4.	Dr. N.K. Pareek	Vice-President
5.	Dr. Sanjay Swami	Vice-President
6.	Dr. Mukesh Kumar	Secretary General
7.	Dr. Vikas Sharma	Joint Secretary
8.	Dr. Rajesh Kumar Meena	Treasurer
9.	Dr. Susanta K De	Councillor
10.	Dr. AnshumanKohli	Councillor
11.	Dr. P.K Rai	Councillor
12.	Dr. Manmohanjit Singh	Councillor
13.	Dr. Rajan Bhatt	Councillor
14.	Dr. Nilay Borah	Councillor
15.	Dr. V Kasthuri Thilagam	Councillor
16.	Dr. U.P. Shahi	Councillor
17.	Dr. Rohitashw Kumar	Councillor
18.	Dr. B.S. Negi	Councillor
19.	Dr. Kishor D Gharde	Councillor
20.	Dr. Sonal Tripathi	Councillor
21.	Dr. Ranu Rani Sethi	Councillor
22.	Dr. Jitendra Sinha	Councillor
23.	Dr. K.K. Satapathy	Councillor
24.	Dr. Sanjay Arora	Chief Editor

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