

ORGANIC WAYS TO CONSERVE THE SOIL UNDER CHANGING CLIMATE SCENARIO

Abstract

Soil loss, a great concern for long term agricultural sustainability can be addressed by opting non-intensive chemical free, eco-friendly organic farming approach. Conservation of soil is even most crucial in current scenario of changing climate not only for ensuring food security but also for healthy ecosystem development. Since ancient days, various organic inputs and practices have been utilized to effectively conserve the soil and its environment aiming sustainable agricultural productivity. These various soil conservation practices viz. mulching, cover cropping, manuring, intercropping, erosion resistance, biochar application etc. have the abilities to rejuvenate the soil health which due to continuous use of chemical bound intensive agriculture has lost its productivity potential. However, due to lack of awareness, poor extension works, negligence and other factors, soil degradation is still a major challenge that India as well as entire world is facing right now. Climate-resilient agriculture, application of remote sensing and other modern instruments, integration of different organic farming approaches, adequate extension programmes etc can tackle the challenge ahead and conserve the soil for fostering eco-system stability and agricultural sustainability.

Keywords: Agricultural Sustainability, Climate Change, Organic Farming, Soil Conservation, Soil Degradation.

Authors

Saikat Biswas

Faculty of Agriculture
Rural and Tribal Development
Ramakrishna Mission Vivekananda
Educational and Research Institute
Morabadi, Ranchi, Jharkhand, India.
sbsaikatbiswas27@gmail.com

Rupa Das

Faculty of Agriculture
Usha Martin University
Angara, Ranchi, Jharkhand, India.

I. INTRODUCTION

Soil is the consortium of all the essential microbes, nutrients and various other resources required for agriculture. However, with the goal of producing more and more food from a finite amount of land, excessive usage of chemical fertilisers, pesticides, synthetic chemicals, and other things has purposefully driven the farmers to forgo environmental safety. This situation is very grimier in African and Asian countries, especially in India which has the burden to ensure food security of world's largest population [1]. In India, although the green revolution first increased crop productivity, which had a significant impact on the agricultural sector, from the late 1990s onward it started to lose hope [2]. As a result of persistent soil health deterioration brought on by extensive and unscientific chemical-based agriculture, production rates have stagnated, revealing the true nature of the green revolution. In recent years, the use and cost of external inputs have both increased dramatically, endangering the agricultural market system and squeezing farmers, particularly those in small and marginal categories. Simultaneously, the output from agriculture is becoming very limited as the soil is losing its productive potential day by day. Today, soil loss is a major concern not only in India but also in the entire globe. It may be due to erosion, deforestation, urbanisation, climate change, excessive usage of chemicals, intensive agriculture, pest, disease, weed problems etc. The current status of soil loss and some initiatives to tackle this are shown in Table 1. It is true fact that loss of soil shows devastating impact on agriculture as soil is the treasure box of nutrients and beneficial micro-organisms (Fig 1).

By preventing or minimising soil erosion, compaction, and salinity, local efforts are made to maintain or increase the land's productive capacity, including soil, water, and vegetation, in degraded areas. By halting environmental deterioration and boosting crop output, soil conservation contributes to the long-term security of livelihoods. Additionally, it aids in avoiding soil pollution from causing the loss of the soil's topmost layer and fertility. Understanding the mechanisms and variables that affect soil erosion is crucial to putting control measures in place. This will help to manage soil erosion and promote soil conservation. Crop rotation, cover crops, planting windbreaks, and conservation tillage are examples of conservation approaches and management techniques that have been used for centuries to assure these. For the purpose of controlling soil erosion by avoiding or reducing soil particle detachment and transport in air or water, farming activities and soil management strategies are referred to as soil conservation practices.

Organic farming is a promising alternative of chemical based intensive agriculture. In order to increase crop growth and productivity as well as other related sectors, organic farming practices rely mostly on natural and organic inputs and goods [3]. Different organic farming inputs (manures, biofertilizers, crop residues, bio-stimulants, etc.) and management practices through eco-friendly soil conservation, play an important role in addressing various issues of soil degradation and enable the crop to grow well under climate change scenario. Understanding how organic farming protects the soil on a long-term basis is crucial and therefore, an effort is made in this chapter to highlight the detrimental effects of soil loss on agriculture and different soil conservation measures under organic farming.

Table 1: Current Status of Soil Loss

Current status of soil loss and some initiatives	
Global Soil Erosion	In many places of the world, soil erosion is still a significant problem. A third of the world's soils are thought to be moderately to severely deteriorated as a result of erosion, nitrogen loss, and other reasons. Soil erosion can result in decreased agricultural output, deteriorated water quality, more sediment in rivers and lakes, and a loss of ecosystem services.
Water and Wind Erosions	Both water and wind erosion which is brought on by precipitation and runoff as well as wind transporting away loose soil particles contribute to soil loss. While wind erosion occurs frequently in arid and semi-arid environments, water erosion is more common in humid climates.
Unscientific Agricultural Practices	Unsustainable farming methods including heavy tillage, monocultures, and overgrazing greatly increase soil erosion. Without taking suitable conservation measures, clearing land for cultivation may accelerate erosion rates.
Deforestation	Forest deterioration and deforestation make soils more susceptible to erosion. When trees are present, the soil is stabilised, and when they are gone, there may be more water runoff and soil erosion.
Urbanisation	Rapid urbanisation can result in more soil sealing (the covering of soil with impermeable surfaces like pavement), which decreases the soil's capacity to absorb water and raises the likelihood of runoff and erosion.
Climate Change	Increased rates of soil erosion may be brought on by changes in precipitation patterns and intensified rainfall events as a result of climate change.
Topsoil Loss	Topsoil, the soil's most fertile layer, is especially susceptible to erosion. The productivity of agriculture and the capacity of the soil to support plant development can both be affected by topsoil loss.
Conservation Efforts	To reduce soil erosion and degradation, several nations have put in place soil conservation techniques such as contour farming, terracing, agroforestry, and cover crops.
Research and Monitoring	It's essential to continue doing research and monitoring studies to determine the degree of soil erosion, pinpoint sensitive locations, and put conservation techniques into practice.
Global Initiatives	Groups like the Global Soil Partnership (GSP) and the Food and Agriculture Organisation of the United Nations (FAO) aim to spread knowledge on soil erosion and encourage sustainable soil management.
Awareness of Soil Health	A greater focus on sustainable land management practices has resulted from a deeper understanding of the value of soil health and conservation.

II. SOIL DEGRADATION IN INDIA AND GOVERNMENT'S INITIATIVES

The frequency and kind of soil erosion and land degradation across the nation are not regularly identified by scientific survey or investigation. According to NAAS (2010) [4], the amount of soil erosion (soil loss greater than 10 tonnes per hectare per year) on the nation's cultivable land was 92.4 million hectares. The state wise soil degradation status in India is shown in Table 2.

The government is assisting in the reclamation of lands plagued by alkalinity, salinity, and acidity under the Reclamation of Problem Soils (RPS) sub-scheme of Rashtriya Krishi Vikas Yojana (RKVY). A total of Rs. 58.76 crore (central shares) was given to the states between 2016–17 and 2020–21, and 0.24 lakh ha of land was developed. In order to prevent and manage land degradation, the Indian Council of Agricultural Research has created site-specific bio-engineering soil and water conservation measures, watershed management interventions, soil reclamation measures for saline, alkali, waterlogged, and acid soils, selection of suitable crops, including agro-forestry interventions. In accordance with the formerly-existent Integrated Watershed Management Programme (IWMP), the Department of Land Resources approved 8214 watershed development projects from 2009–10 to 2014–15.

For the development of rainfed/degraded lands, IWMP was combined as the Watershed Development Component of the Pradhan Mantri Krishi Sinchayee Yojana (WDC-PMKSY) in 2015–16. A total of 7.60 lakh water harvesting structures were built or renovated between 2014–15 and 2021–22, bringing an additional 16.27 lakh ha under protected irrigation and assisting 35.62 lakh farmers. Under 'WDC-PMKSY-2.0' for the years 2021–2026, the Indian government has also approved a financial outlay of Rs. 8,134 crores with a physical target of 49.50 lakh hectares [5].

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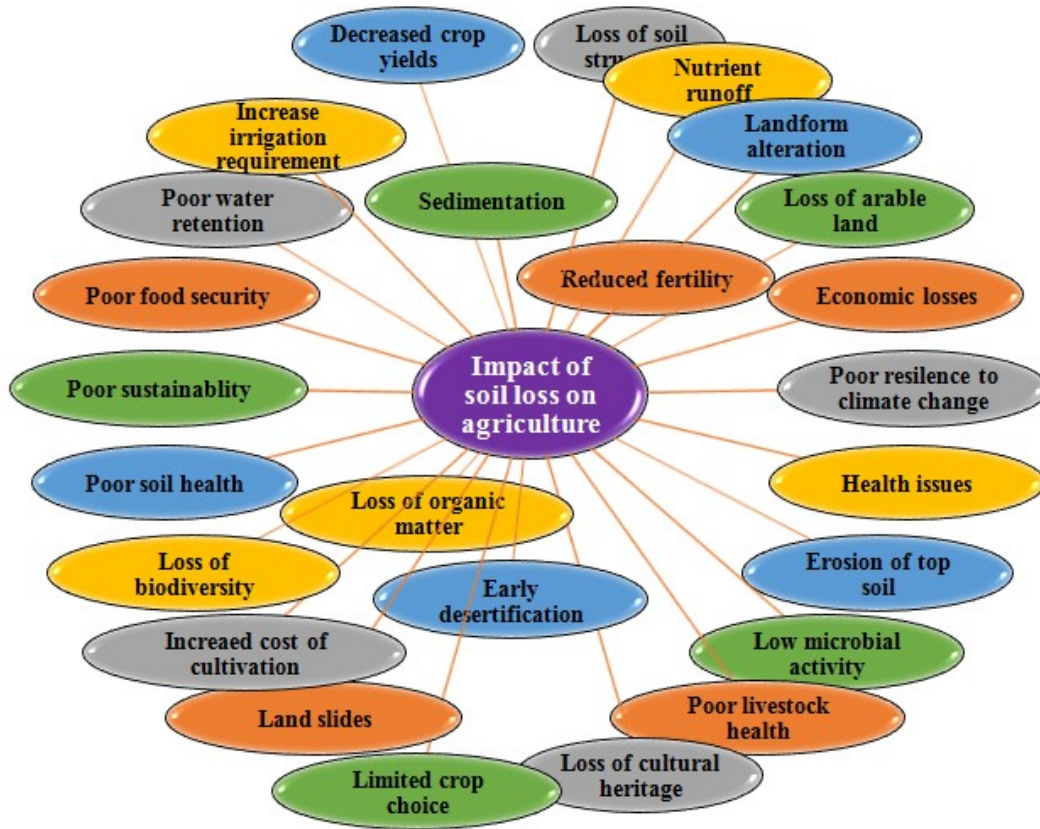


Fig 1: Impact of Soil Loss on Agriculture

Table 2: State-Wise Soil Degradation Status in India

State	Area ('000 ha)	State	Area ('000 ha)
Andhra Pradesh (including Telangana)	8093	Gujarat	984
Arunachal Pradesh	666	Haryana	306
Assam	3248	Himachal Pradesh	982
Bihar	851	Jammu & Kashmir	1369
Chhattisgarh	3733	Jharkhand	3219
Delhi	28	Karnataka	7522
Goa	1	Kerala	490
Madhya Pradesh	12262	Mizoram	-
Maharashtra	8799	Nagaland	46
Manipur	122	Orissa	2227
Meghalaya	302	Punjab	229
Rajasthan	19029	Uttar Pradesh	13075
Sikkim	45	Uttarakhand	1018
Tamil Nadu	2308	West Bengal	1332
Tripura	109	Total	92400

Source: NAAS (2010) [4]

III. IMPORTANCE OF SOIL CONSERVATION

Numerous factors make soil conservation important, including the fact that healthy soil is the basis for both productive ecosystems and human well-being. The following are some major arguments in favour of soil conservation:

- 1. Sustainable Agriculture:** For the production of nourishing and bountiful crops, healthy soils are essential. Soil conservation supports sustainable agricultural practices that can feed a growing world population by minimising soil erosion, preserving soil fertility, and fostering soil structure.
- 2. Erosion Control:** The loss of fertile topsoil due to soil erosion, which is frequently brought on by wind and water, lowers the productivity and nutrient content of the land. By reducing erosion, soil conservation practices protect priceless soil resources.
- 3.** Healthy soils foster a variety of plant and microbial life, which in turn promotes biodiversity and wholesome ecosystems.
- 4. Water Quality:** Groundwater and surface water bodies are protected from pollution by the soil, which serves as a natural filter. Soils that are preserved help to clean up water supplies and lessen the chance of water pollution.
- 5.** Healthy soils are essential for carbon sequestration, which store carbon dioxide from the atmosphere and helps to slow down global warming. The potential for carbon sequestration can be improved through soil conservation techniques.
- 6.** Resilient landscapes that are better able to withstand climate-related problems like floods, droughts, and extreme weather events are made possible in part through soil conservation.
- 7. Food Security:** In order to maintain a steady and secure food supply in an era of rapidly expanding global population, soil conservation is essential. For the production of food that is sustainable, productive and healthy soils are required.
- 8. Economic Sustainability:** Fertile soils are essential for agricultural output and rural economies. Through the preservation of productive lands and a decrease in the demand for expensive inputs, soil conservation practices help ensure long-term economic sustainability.
- 9. Land Use Efficiency:** Maintaining and growing crops on conserved soils uses fewer resources. This results in better resource management, waste reduction, and efficient land use.
- 10. Indigenous and Cultural Values:** There are strong relationships between many civilizations and indigenous communities and the land. Conservation of soil honours these cultural ideals and guarantee the survival of natural ecosystems for next generations.

- 11. Education and Research:** In order to better comprehend the complex interrelationships between soils, plants, and ecosystems, soil conservation promotes research and teaching regarding sustainable land management techniques.
- 12. Desertification Prevention:** Deforestation, overgrazing, and erosion all contribute to the process of desertification, which causes fertile land to become arid and unproductive [6].
- 13. Healthy soils support leisure activities like gardening, hiking, and outdoor sports.** They also have aesthetic value. Beautiful scenery and well-kept parks enhance the wellbeing of a community.
- 14. Local Economies:** Soil conservation can stimulate rural economies by supporting eco-friendly practices that draw tourists, such as agro-ecotourism and sustainable tourism.
- 15. Ecosystem Services:** Healthy soils offer a range of ecosystem services, including nitrogen cycling, water retention, and the support of helpful microbes that are essential for the wellbeing of ecosystems.

Soil conservation is essentially an important practice for preserving the health of our planet's ecosystems and safeguarding the welfare of both present and future generations. It supports environmentally sound farming practices, environmental stability, and the health of both natural and artificially created landscapes.

IV. HISTORY OF SOIL CONSERVATION

The development of agriculture and human cultures is entwined with the history of soil preservation. A summary of significant historical developments in soil conservation is given below:

- 1. Historic Civilizations:** Early agricultural communities understood how crucial soil fertility was to generating food. Crop rotation, organic waste recycling, and irrigation were methods used by ancient civilizations in Mesopotamia, Egypt, and the Indus Valley to increase soil fertility.
- 2. Indigenous Wisdom:** Based on their traditional knowledge, indigenous societies all over the world managed their lands sustainably. To stop soil erosion and preserve the health of the soil, these techniques included terracing, agroforestry, and shifting agriculture.
- 3. Dust Bowl Era (1930s–1940s):** During the Great Depression in the United States, the Dust bowl brought to light the disastrous effects of soil erosion brought on by ineffective land management techniques. Massive dust storms caused by intense ploughing of delicate grassland soils combined with severe droughts drove thousands of people from their homes and seriously harmed the environment and agriculture.
- 4. Establishment of Agencies for Soil Conservation:** Governments all throughout the world started establishing soil conservation agencies in reaction to the Dust bowl. In an effort to combat soil erosion and advance environmentally friendly land management

techniques, the United States created the Soil Conservation Service (now the Natural Resources Conservation Service) in 1935.

5. **Green Revolution (1950s–1960s):** The Green revolution used irrigation, fertilisers, and high-yield crop types to boost agricultural production. While it increased food production, it also raised issues with soil erosion, water pollution, and the disappearance of conventional farming methods.
6. **Techniques for Soil Conservation:** Different soil conservation approaches have been adopted globally over time. These included no-till farming, contour farming, terracing, cover crops, agroforestry, and the use of organic amendments to improve soil fertility and structure.
7. **Movements for Conservation Today:** Environmental awareness and conservation movements gained traction in the second half of the 20th century. The preservation of natural resources, particularly soil, was the focus of groups like the World Wildlife Fund (WWF) and The Nature Conservancy.

Agriculture research organisations all over the world focus on investigating soil deterioration, erosion, and sustainable land management techniques. Best practices for preserving soil health have been developed as a result of this research.

8. **Worldwide Recognition:** The International Year of Soils was declared by the UN in 2015 to increase public awareness of the value of soil preservation for long-term sustainability and food security.

Recent years have seen a shift in emphasis towards sustainable agriculture, which places an emphasis on all-encompassing methods of land management. Agroecological, regenerative, and organic farming ideologies place a priority on soil health, biodiversity, and long-term sustainability.

9. **Soil and Climate Change:** Carbon sequestration by soil has drawn attention to the importance of soil in reducing climate change. Conservation and soil health practices are now understood to be crucial elements of measures for climate adaptation and mitigation.

Technology and innovation have made it possible to monitor and manage soil health and erosion more effectively. Examples of this include precision agriculture, remote sensing, and data analytics.

Through history, efforts to conserve soil resources for future generations have expanded from regional traditional practices to worldwide initiatives. Today, soil conservation is still a key element of environmental protection, food security, and sustainable land management.

V. PRESENT STATUS OF SOIL CONSERVATION

1. **Awareness and Education:** The importance of soil conservation practices has been brought to the attention of farmers and communities by a number of government

agencies, non-governmental organisations (NGOs), and agricultural extension services through awareness campaigns, workshops, and training programmes.

In India, the Soil Health Card (SHC) programme has been put in place to give farmers information about the condition of their soil and suggestions for effective nutrient management. This programme attempts to increase agricultural output and soil health.

2. **Initiatives by the Government:** To encourage soil conservation and sustainable agriculture, the Indian government has launched a number of programmes, including the Paramparagat Krishi Vikas Yojana (PKVY) for organic farming and the National Mission for Sustainable Agriculture (NMSA) for improving soil health and productivity.
3. **Organic Farming:** Soil health and conservation are given first priority in organic agricultural methods, which are gaining popularity. Farmers are implementing organic farming practices such as crop rotation, cover crops, and decreased tillage to increase soil fertility and decrease soil erosion.
4. **Erosion Control:** To reduce soil loss brought on by water and wind in areas prone to soil erosion, techniques including contour farming, terracing, and planting windbreaks are being adopted.
5. **Technology Integration:** To monitor and manage soil health, erosion, and fertility, technology is being employed, including remote sensing, GIS, and soil sensors. These resources aid farmers in making well-informed choices on their land management techniques.
6. **Research and Innovation:** Agricultural research institutions are working to create innovative methods for conserving soil, drought-tolerant plants, and sustainable land-management strategies that can improve the productivity and health of the soil.
7. **Collaboration:** The adoption of soil conservation practices is being pushed by cooperation between government organisations, non-governmental organisations, farmers' associations, and research institutions. These coordinated efforts aid in overcoming obstacles and guarantee a more comprehensive approach to managing soil health.

The use of chemical fertilisers and pesticides, changing weather patterns, growing urbanisation, and other issues continue to be problems despite advances. These difficulties nevertheless have an effect on conservation efforts and soil health.

VI. DIFFERENT ORGANIC WAYS OF SOIL CONSERVATION

Implementing practices that maintain or improve soil health and fertility while reducing erosion, nitrogen depletion, and other types of degradation constitutes soil conservation through organic approaches. Organic farming and gardening place an emphasis on methods that are sustainable and complement natural processes. These natural/organic techniques enable resilient farming systems that support long-term food production and environmental wellbeing while also preserving the health of the soil. The efficacy of these

techniques can change based on the environment, the climate, and the particular crops used. Some effective organic ways to conserve soil are mentioned hereunder:

1. A more sustainable approach to land use and soil conservation can be achieved through holistic management, which focuses on the entire ecosystem, including social and economic elements.
2. Aerating the soil on a regular basis enhances water infiltration and root penetration. This can be done either manually through cultivating or by promoting earthworm activity.
3. **Agroecology:** The application of ecological concepts to agriculture takes into account the interactions between organisms and their surroundings in order to design systems that are both resilient and fruitful.
4. **Agroforestry:** Adding trees, shrubs, or other woody plants to agricultural systems can improve soil stability, lessen wind and water erosion, and add more organic matter.
5. **Application of Biochar:** The soil's ability to hold water, retain nutrients, and support microbial activity can all be enhanced by adding biochar, a type of charcoal made from organic materials through controlled pyrolysis.
6. **Apps for Soil Monitoring:** Using technology and apps to keep track of soil conditions and get management advice in real time.
7. Aquaculture that has been integrated with crop production can assist recycle nutrients, enhance water management, and increase soil fertility.
8. **Barriers against Soil Erosion:** In regions where soil movement is a problem, building physical barriers like silt fences, rock walls, and straw wattles can stop erosion.
9. **Beekeeping and Pollinator Conservation:** Promoting native plant habitats and pollinator support through beekeeping helps to maintain a healthy soil environment.
10. **Biodynamic Farming:** A method for boosting soil vitality, microbial activity, and plant health by fusing organic techniques with lunar and cosmic rhythms.
11. **Bokashi Composting:** A fermentation-based composting process that decomposes organic materials and enriches the soil with good bacteria.
12. **Bund Cultivation:** By creating soil embankments or bunds across fields, water is retained and soil erosion is decreased.
13. **Climate-Adaptive Farming:** Soil conservation is aided by adapting farming methods to the changing climate's patterns, such as altered rainfall and temperature.
14. **Community Gardens:** Establishing and promoting community gardens strengthens ties within the neighbourhood, expands access to fresh produce, and raises awareness of organic soil protection.
15. **Community Supported Agriculture (CSA):** Consumers can interact directly with regional farmers who practice organic soil protection by joining or starting CSAs.
16. **Companion Animals:** Including animals in agricultural systems, such as hens, ducks, or goats, can help control weeds, pests, and crop residues while promoting nutrient cycling.
17. **Composting:** Making compost from organic waste materials such as kitchen scraps, yard trash, and animal manure enhances soil structure, stimulates microbial activity, and replenishes nutrients in the soil in a slow-release form. Promoting urban composting prevents organic waste from being dumped in landfills and offers a nearby supply of nutrient-rich soil amendments. Setting up public composting facilities promotes ethical disposal of organic waste and improves the soil in the area.
18. **Conservation Tillage:** By eliminating ploughing and other heavy machinery, reduced or no-till farming reduces soil disturbance while maintaining the soil's organic matter content, helps preserve soil structure and lessen erosion [7].

19. **Construction Site Soil Protection:** To stop soil erosion, cover exposed construction site soil with mulch, erosion control tarps, or transient cover crops.
20. **Cover Cropping:** Planting cover crops like clover, legumes, or grasses during fallow times improves soil structure, provides organic matter, and fixes nitrogen in the soil while preventing soil erosion. Using techniques like cover crops and less tillage to promote soil carbon sequestration reduces climate change [8].
21. Creating terraces in sloped or mountainous places slows water flow, allowing it to permeate the soil rather than causing erosion.
22. **Crop Rotation:** Seasonal crop switching disrupts the cycles of pests and diseases, prevents nutrient imbalances, and preserves soil structure. The needs for nutrients and the effects on the soil are different for different plants.
23. Permaculture can result in more resilient and sustainable land use by stacking functions, maximising variety, and paying attention to natural patterns.
24. Designing vegetated areas to filter pollutants from stormwater runoff before they contaminate the soil.
25. **Ditch and Basin Systems:** Excavating ditches or building small basins can assist in capturing water, allowing it to permeate the earth and refuel groundwater. This works very well in dry areas.
26. **Diversity and Polyculture:** Planting multiple crops simultaneously rather than just one (monoculture) encourages healthy soil by increasing biodiversity and lowering the likelihood of pest and disease outbreaks.
27. **Dry Stone Walls:** By stabilising slopes and reducing water runoff, walls made of locally accessible stones help stop soil erosion.
28. **Eco-Friendly Packaging:** By decreasing waste pollution, compostable or biodegradable packaging for products promotes soil health.
29. **Education and Outreach:** Raising farmers' and local communities' awareness of organic soil conservation practices promotes the adoption of sustainable practices. Holding workshops or demonstrations on farms can inform people about the advantages of preserving organic soil and promote its adoption.
30. Establishing community seed libraries encourages the practice of conserving seeds and increases the genetic variety of the plants in the area.
31. **Ethical Wildcrafting:** Soil integrity and ecological balance are preserved by gathering wild plants for food and medicine in a responsible, sustainable manner.
32. Exploring perennial grain crops as alternatives to annual ones helps to lessen soil disturbance and boost soil carbon sequestration.
33. **Floodplain Restoration:** Restoring natural floodplain habitats helps increase the resilience of the ecosystem overall, improve water retention, and reduce erosion.
34. Grass waterways can be used to protect the soil from water erosion.
35. **Green Manure:** When some crops, such as certain legumes, are ploughed under as green manure, the soil is enriched with organic matter while simultaneously gaining nitrogen.
36. Hedgerows and living fences made of native plants can be planted to create habitat, wind protection, and erosion control.
37. **Holistic Orchard Management:** Supporting healthy soil and fruit production in orchards by using organic principles through techniques including optimum tree spacing, mulching, and encouraging beneficial insects.
38. **Hydroponic Organic Systems:** Making use of organic hydroponic techniques lessens the need for soil while still emphasising the growth of nutrient-rich plants.

39. Implementing agricultural systems that resemble natural ecosystem, known as restoration agriculture, helps restore soil health, maintain wildlife, and produce food.
40. **Integrated Livestock Systems:** Including livestock in cropping systems can improve soil structure, lessen weed pressure, and help recycle nutrients through manure. Utilising rotational grazing and controlling livestock movement in a manner that resembles natural herd behaviour can reduce overgrazing and enhance soil structure.
41. **Intercropping:** Planting various crops adjacent to one another can have positive effects on both, such as lowered pest pressure and increased soil cover.
42. **IPM (Integrated Pest Management):** IPM lessens the need for chemical pesticides that can affect soil health by focusing on natural predators, crop rotations, and resistant plant cultivars.
43. **Livestock Integration:** Through trampling and manure deposition, integrating livestock with crop production, such as rotational grazing, can improve soil structure.
44. **Local Plant Types:** Plants with better health and more durable agricultural systems might result from selecting plant types that are tailored to the soil and climate of the area.
45. **Local Resource Management:** Utilising locally accessible resources for mulching and soil enhancement, such as agricultural byproducts and natural materials, lowers carbon footprint.
46. **Localised Seed Saving:** Replanting and saving seeds from productive crops promotes genetic variety and helps plants adapt to their environment.
47. **Mulching:** Covering the soil's surface with organic mulches like straw, leaves, or wood chips helps to retain moisture, control weed growth, maintain soil temperature, and reduce erosion. Controlling soil temperature using organic mulches helps avoid temperature extremes that could harm plants and soil microbes. Encouraging beneficial microbial activity and providing a continuous source of nutrients, letting organic mulch spontaneously decay on the soil surface [9].
48. Mycorrhizal fungi and rhizobacteria are two examples of beneficial microorganisms that can be applied to increase nitrogen uptake and total soil fertility.
49. **Natural Fertilisers:** Using compost, manure, bone meal, and rock phosphate as fertilisers in place of synthetic ones fills the soil with organic matter and vital nutrients.
50. Natural habitat restoration can help improve the general health of the ecosystem and promote soil conservation by reestablishing native plant groups and habitats in regions close to farms.
51. Neem oil, diatomaceous earth, and herbicides based on vinegar are examples of natural pesticides and herbicides that can be used to control weeds and pests without endangering the health of the soil.
52. **No-Plastic Farming:** Reducing the use of plastic in agricultural operations helps preserve healthy soil ecosystems and decreases pollution.
53. **Nutrient Cycling:** Using livestock to graze cover crops is one way to design farming systems that promote nutrient cycling within the ecosystem and preserve soil fertility. By enhancing nutrient cycling, preventing pests, and making the most of available space, companion planting can improve soil health.
54. Obtaining organic certification guarantees adherence to stringent organic standards and practices, fostering sustainable land management.
55. Offering local farmers and landowners customised advice on enhancing soil health through extension services for soil health.
56. **Organic Kitchen Gardens:** Growing fruits, vegetables, and herbs at home using organic methods enhances the health of the soil and encourages sustainable living.

57. Participating in regional land use planning projects that place an emphasis on sustainable development and soil preservation.
58. **Participation in the Community:** Promoting broader use of organic soil conservation techniques by interacting with neighbourhood groups, farms, and organisations to exchange information and resources.
59. **Perennial Crops:** Including perennial crops in agricultural systems, such as fruit trees, berries, and perennial herbs, provides long-lasting ground cover and reduces soil disturbance. Planting deep-rooted trees like comfrey or daikon radish can help loosen up compacted soil layers, boost nutrient cycling, and improve drainage.
60. **Plant Guilds:** Creating plant guilds or companion planting arrangements that complement one another improves the cycling of nutrients in the soil and increases plant resilience.
61. Planting natural plants in strips along the boundaries of fields or water bodies serves as a buffer by filtering out contaminants and reducing soil erosion brought on by water runoff.
62. Plants that create natural dyes can be grown in gardens, which promotes soil health and sustainable textile production.
63. Recycling brewery and winery wastes like spent grains and pomace into compost improves soil fertility. This is known as organic brewery and winery residue management.
64. Reforestation that restores soil health, controls erosion, and promotes biodiversity is known as restorative reforestation.
65. Regenerative agriculture focuses on restoring soil health, promoting biodiversity, and enhancing ecosystem function. It extends beyond employing organic farming techniques.
66. Regular soil testing enables the accurate and targeted application of organic amendments like gypsum, lime, wood ash, and volcanic rock dust by determining nutrient levels and pH. By incorporating biofertilizers into the soil, such as vermicompost and compost tea, the soil is enriched with helpful microbes that improve nutrient cycling and plant health.
67. Regularly assessing the condition of the soil and keeping tracks on changes over time enable management practices to be promptly modified.
68. **Rock Check Dams:** By scattering boulders or stones along watercourses, we can slow the flow of the water and stop gully erosion.
69. **Seaweed Fertilisation:** Adding trace minerals and compounds that encourage development to the soil through the use of seaweed extracts as a natural fertiliser.
70. **Seed Ball Planting:** To start vegetation development and soil recovery in damaged areas, seeds can be enclosed in seed balls, made of clay, compost, and seeds.
71. **Slope Stabilisation:** By diverting water flow and lowering runoff, practices including contour ploughing, strip cropping, and grassed streams can assist avoid soil erosion on inclined terrain.
72. **Soil Bioengineering:** Through the use of living plants in conjunction with engineering methods can stabilise slopes, manage erosion, and restore ecosystems.
73. **Soil Contouring:** Shaping the soil to follow its natural contours can reduce erosion and runoff while also encouraging water infiltration.
74. **Soil Erosion Mats:** Stabilising soil on slopes and preventing erosion can be accomplished by using erosion control mats composed of natural fibres like jute or coir.
75. **Soil Microbial Diversity:** Promoting a diverse population of soil microorganisms through good management practices aids in the cycling of nutrients and the general health of the soil.

76. **Soil Solarization:** Controlling pests, diseases, and weed seeds that are carried by the soil can be accomplished by using plastic sheeting to trap heat and solar energy on the soil surface.
77. **Sylvi-Pasture:** By incorporating trees or shrubs with pastures for cattle to graze, it can increase soil nutrient cycling, provide shade, and lessen erosion.
78. Terraced planting is used in vineyards to manage water flow, lessen soil erosion, and improve the quality of the grapes.
79. The use of beneficial insects like ladybirds or parasitoid wasps can help control pest populations without the need of chemical pesticides.
80. The use of organic textiles and fibres lessens the environmental impact of conventional textile production, which frequently uses methods that degrade the land.
81. **Urban Food Forests:** Establishing diversified, permanent food systems in cities can help cut down on food miles, boost regional biodiversity, and encourage soil preservation.
82. **Urban Gardening:** Applying organic techniques in urban settings, such as rooftop gardens and community plots, helps preserve soil and reasserts the connection between people and food production.
83. Using literature, art, and media to spread awareness of soil protection and its importance in daily life is known as soil-focused art and media.
84. Utilising methods like mulching, hand weeding, and flame weeding to control weeds without upsetting the soil's structure is known as organic weed management.
85. Utilising particular plants, such as sunflowers and willows, to absorb and detoxify contaminants in polluted soils is known as soil remediation.
86. Utilising rainwater gathering techniques, such as rain barrels or swales, lowers the danger of erosion and maintains soil moisture by retaining water on the property. Swales with plants that filter runoff water are known as biofiltration swales and they can be built to help with erosion control, pollution removal, and groundwater recharge. Using native plants when designing rain gardens helps control stormwater runoff, minimise soil erosion, and allow water to gradually percolate into the ground.
87. **Water Management:** Effective irrigation techniques, such as soaker hoses or drip irrigation, reduce soil erosion and water waste while ensuring that plants receive enough moisture. Designing systems that efficiently capture, store, and transfer water across landscapes promotes soil health and ecosystem resilience.
88. **Windbreaks:** Planting trees or shrubs as windbreaks along the edges of fields helps protect crops from wind erosion and prevent the loss of topsoil [10].
89. **Worm Farming:** Setting up worm farms or vermicomposting systems results in castings that are rich in nutrients and enhance soil fertility and structure.
90. **Zero-Waste Farming:** Aiming for zero waste in agriculture through waste reduction, resource optimisation, and organic material recycling back into the soil.

VII. BENEFITS OF SOIL CONSERVATION

Numerous benefits of soil conservation include improvements to agriculture, communities, and the planet's overall health. The following are some major benefits of conserving the soil:

1. The top layer of fertile soil rich in nutrients is preserved due to soil conservation as practices that stop soil erosion. Better crop yields and increased agricultural production result from this.

2. **Improved Water Quality:** Soil conservation helps keep rivers, lakes, and groundwater sources' water quality by reducing soil erosion. This lessens the number of pollutants that are transported into water bodies and sediment discharge.
3. A strong foundation for long-term agricultural output is provided by conserved soil, according to sustainable agriculture. Healthy soil promotes root development, water retention, and nutrient cycling, which results in crop growth that is resilient and sustainable.
4. **Reduced Soil Compaction:** By enhancing soil structure and porosity, soil conservation techniques lower the danger of soil compaction. Because roots can easily pierce looser dirt, plants can more quickly absorb water and nutrients.
5. **Improved Carbon Sequestration:** Strong soils absorb carbon dioxide from the air and store it, reducing climate change. Conservation of soil techniques can improve carbon storage, supporting attempts to lower greenhouse gas emissions.
6. **Increased Biodiversity:** Protecting soil encourages the development of a variety of habitats for plants, insects, and microbes. This promotes general biodiversity and strengthens ecosystems.
7. **Improved Water Management:** Terracing and contour ploughing, two soil conservation techniques, assist control water flow and minimise excessive runoff, lowering the risk of flooding and encouraging effective water use.
8. **Climate Change Resilience:** Protected soils are more resistant to climate-related problems including droughts and extreme weather occurrences. They are better able to resist times of water scarcity because they can retain more water.
9. **Controlling Soil Erosion:** Strategies for preventing soil erosion brought on by wind and water include using erosion barriers and growing cover crops.
10. **Cost Savings:** Farmers and landowners can save money on inputs like fertilisers and irrigation by avoiding erosion and maintaining soil health. Less energy and resources are needed to maintain productive soils.
11. **Local Ecosystem Health:** By providing habitats for beneficial species that support plant development, nutrient cycling, and ecological balance, soil conservation helps to maintain the health of the local ecosystem.
12. **Food Security:** By ensuring that there is fertile land available for food production, soil conservation helps to contribute to global food security and lessens the need to convert additional natural areas to agriculture.
13. **Community Well-Being:** Soil conservation promotes the wellbeing of nearby communities by fostering the development of environmentally sound and visually beautiful landscapes. It promotes ecotourism, cultural events, and outdoor enjoyment.

14. Sustainability over the Long Term: Soil conservation practices encourage land stewardship and sustainable land management, assuring the agricultural land's sustained productivity for future generations.

15. Education and Public Awareness: Soil conservation programmes promote public understanding of the value of healthy soil, sustainable farming practices, and environmental responsibility. They promote responsible land management practices among people and groups.

More advantages than only soil preservation is provided by soil conservation. It benefits both current and future generations in terms of agriculture, ecosystems, water resources, reducing climate change, and overall quality of life.

VIII. CONSTRAINTS OF SOIL CONSERVATION

While there are many advantages to using soil conservation techniques, there are also drawbacks and restrictions that must be taken into account. These restrictions include, among others:

- 1. Site Specificity:** The soil type, climate, terrain, and vegetation of each site must be taken into consideration while designing soil conservation practices. What is effective in one setting might not be appropriate in another.
- 2. Initial Investment:** Some soil conservation techniques, like terracing or building erosion control structures, demand hefty initial labour, material, and equipment inputs.
- 3. Workforce and Skill Requirements:** Adequately implementing and maintaining soil conservation practices frequently calls for specialised labour that may not be easily accessible in all locations.
- 4. Limited Immediate Returns:** The advantages of soil conservation techniques may not be noticeable right away and may take some time to materialise. Farmers and landowners can be hesitant to spend money on strategies that don't produce quick financial gains.
- 5. Implementing soil conservation techniques may occasionally conflict with other uses of the property or development plans. It may be difficult to strike a balance between conservation and other economic or societal needs.**
- 6. Lack of Knowledge:** It's possible that many people, especially farmers and landowners, are unaware of the practices that can be used to conserve soil or completely comprehend its significance.
- 7. Focus on the Short Term:** Because of financial constraints and acute pressures, some landowners may place a higher priority on short-term gains than on long-term soil conservation activities.

8. **Limited Government Support:** Soil conservation initiatives may not have enough support from the government in some areas due to policies, incentives, or money.
9. **Cultural Practices:** The adoption of innovative soil conservation techniques may be hampered by cultural norms or traditional agricultural practices.
10. **Technical Difficulties:** Some soil conservation techniques may call for highly specialised skills, instruments, or other resources that are not always readily available.
11. **Resistance to Change:** Despite the long-term benefits for soil health, people may be reluctant to change their traditional farming or land management practices.
12. **Maintenance Requirements:** To stay successful, some soil conservation techniques, such as erosion control structures, require routine maintenance. Their decline may be caused by poor upkeep.
13. Implementing soil conservation practices may be complicated by legal or administrative issues in places with complex land tenure or ownership structures.
14. **Scale Obstacles:** It can be challenging to scale up soil conservation activities to a regional or national level since there are so many different types of landscapes, stakeholders, and laws at play.
15. Results may not always match expectations since a number of factors can have an impact on how effective soil conservation practices are.

It's critical to identify these constraints and make efforts to overcome them through community engagement, education, governmental support, and the creation of workable solutions that are appropriate for individual locales. To get through these obstacles and encourage sustainable soil conservation, a comprehensive strategy that considers social, economic, and environmental aspects is essential.

IX. FUTURE SCOPE SOIL CONSERVATION IN INDIA

Given the country's varied landscapes, widespread agricultural practices, and the rising significance of sustainable land management, India's future potential for soil conservation is substantial. The following are some important future potential locations for soil conservation in India:

1. **Integration of Technology:** Remote sensing, GIS (Geographic Information System), and data analytics are examples of modern technology that can be used to more accurately monitor soil health, erosion trends, and land use changes. Targeted attempts at soil conservation can be made using this data.
2. **Digital Awareness Platforms:** In order to educate farmers, landowners, and communities on soil conservation practices, it is essential to make use of digital platforms, mobile apps, and online resources.

3. **Climate-Resilient Agriculture:** In the face of a changing climate, it is crucial to promote soil conservation techniques that improve climate resilience. This includes actions that reduce water consumption, stop soil erosion, and boost soil organic matter levels.
4. **Integrated Watershed Management:** Both rural and urban regions can benefit from adopting holistic methods to watershed management, which can increase water availability, lessen erosion, and improve soil fertility.
5. **Agroforestry and Permaculture:** By incorporating agroforestry and permaculture ideas into agricultural systems, it is possible to enhance ecosystem resilience, biodiversity, and soil health.
6. **Promotion of Organic Farming:** Since organic farming practices already place a high priority on soil conservation and health, the rising demand for organic produce presents a chance to boost this industry.
7. **Soil Health Cards:** The Soil Health Card effort of the Indian government may be expanded to offer farmers individualised recommendations, improving soil conservation techniques.
8. Building capacity can increase the adoption of soil conservation practices by funding training sessions, workshops, and educational initiatives for farmers, extension agents, and students.
9. **Support From Policies:** Policies that encourage sustainable land management and reward efforts to conserve soil can considerably accelerate transformation.
10. Continuous research into crop types, soil management techniques, and sustainable agriculture technologies can result in more effective soil conservation techniques.
11. **Urban Soil Management:** As cities become more populated, it is essential to manage soil deterioration through techniques like urban gardening, green infrastructure, and environmentally friendly building.
12. **Regions Prone to Soil Erosion:** By focusing on these areas with particular conservation measures, such as hilly areas and coastal regions, further degradation can be avoided.
13. **Integration of Indigenous Knowledge:** Traditional and indigenous information regarding sustainable land management techniques can be added to modern methods.
14. Sustainable land use planning can stop soil degradation and habitat loss by incorporating soil conservation concerns into urban and rural land use planning.
15. **Circular Economy:** The ideas of the circular economy are supported by practices that emphasise recycling organic waste, such as composting and utilising organic waste as soil amendments.

- 16. Collaborations and Partnerships:** Partnerships between governmental organisations, non-profit organisations, academic institutions, and commercial businesses can hasten the adoption of efficient soil conservation techniques.
- 17. Economic Incentives:** Creating financial rewards for farmers and landowners who use soil conservation techniques can promote their broad use.
- 18. Restoration of Degraded Land:** Rehabilitating degraded lands through habitat restoration, reforestation, and soil conservation techniques can aid in the recovery of an ecosystem.

Future opportunities for soil conservation in India are strongly related to the nation's general development, environmental sustainability, and food security. India may work towards maintaining its soil resources for the benefit of present and future generations by embracing innovative ways and incorporating a range of stakeholders.

X. CONCLUSION

Implementing organic strategies frequently needs thorough planning, adaption to regional conditions, and a comprehensive strategy for soil management. Combining several approaches can have a synergistic effect that improves soil sustainability, crop yield, and ecosystem resilience. These practices show the wide variety of organic techniques that may be used to protect soil, encourage sustainable agriculture, and create a more resilient and balanced ecosystem. It's crucial to modify these practices to meet the particular requirements and circumstances of each unique farming or gardening environment. Numerous techniques along with consideration for user's unique goals, climate, and soil characteristics are frequently necessary for successful soil conservation. Finding the best tactics for various contexts requires a combination of experimentation, observation, and adaptation. Depending on unique situation and aims, the efficacy of these practices may change. The long-term health and productivity of the soil must be prioritised while learning, adapting, and innovating continuously. Achieving long-term soil health and sustainability requires constant learning and adaptation. Each step we take on the path to soil conservation can make the world a healthier and more sustainable place.

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