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CHAPTER - 16

SUSTAINABLE SOIL AND WATER MANAGEMENT PRACTICES

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Introduction

The pillars of agricultural systems are soil and water, on which the world food production and stability of the ecosystems are built. Soil is a dynamic and living system which supports plants in a mechanical manner, stores and supplies important nutrients, supports a huge diversity of microorganisms and regulates important biogeochemical cycles. Water, on the other hand, is indispensable for sustaining plant life, as it plays a central role in physiological processes such as photosynthesis, transpiration, nutrient uptake, and cellular metabolism. Soil-water interaction is a very complex and interdependent process, which affects plant growth, crop productivity, and environmental sustainability. The capacity of soil to absorb and pass water, as well as its capacity to store nutrients, defines the effectiveness of crops in using the resources available. Thus, sustainable management of soil and water resources is not only a key to the agricultural productivity, but also to the ecological balance and long-term food security.

Over the past few decades, the world agricultural environment has experienced a tremendous transformation with the increasing population rate, urbanization, industrialization, and shifting food consumption trends. These have contributed to the high demand of food, fiber and fuel which has put a lot of strain to the natural resources. Simultaneously, there are new challenges that have been brought about by climate change such as erratic rainfall patterns, extended droughts, rising temperature, and the frequency of extreme weather events. These circumstances increase the susceptibility of agricultural systems, especially in those areas that are already susceptible to water shortages and soil erosion. This has led to massive environmental degradation due to over exploitation of land and water resources in the quest to achieve maximum short-term productivity. The health of the soils has been greatly compromised by unsustainable farming methods, which include excessive tillage, mono-cropping, overgrazing, and careless application of chemical fertilizers and pesticides. These activities interfere with the soil structure, decrease the contents of organic matter and lower the activity of microbes, which eventually results in low fertility and productivity.

Soil erosion is one of the most urgent problems related to the mismanagement of soils and is the process of the loss of the fertile topsoil layer by wind and water. This not only lowers the nutrient level and water retention of the soil but also leads to sedimentation of water bodies, which impacts on aquatic life and water quality. On the same note, inadequate irrigation methods, especially over-irrigation and poor drainage have resulted in issues like waterlogging and salinization of the soil. The accumulation of salinity in the root zone may seriously affect the growth of plants by interfering with their osmotic balance and nutrient uptake. Moreover, over-exploitation of groundwater to irrigate lands has led to the loss of aquifers, which reduces the water table and jeopardizes the sustainability of water resources. The disparity between the water demand and supply in most agricultural areas has been growing, and thus there is an urgent need to implement effective water management practices.

Sustainable soil and water management is an integrated and holistic method that seeks to solve these issues and at the same time provides the sustainability of agricultural systems in the long term. It involves the judicious use and conservation of soil and water resources in a manner that maintains their productivity, enhances resilience to environmental stresses, and minimizes negative impacts on the ecosystem. The strategy acknowledges the interdependence of soil, water, plants, and the environment, and the importance of coordinated management practices. Sustainable practices can greatly enhance the ability of the soil to retain water and nutrients by enhancing the soil structure, increasing the content of organic matter and improving the biological activity of the soil. This, further, results in better crop performance and less reliance on external inputs.

Current agricultural practices are more focused on integrating soil and water management practices as opposed to seeing them as two distinct entities. Conservation tillage, cover cropping, crop rotation and organic amendments are methods that aim at improving soil health and at the same time increasing the water infiltration and retention. The goal of efficient irrigation techniques such as drip and sprinkler irrigation is to maximize the use of water by applying the exact water level to the root zone of the plant, and minimizing evaporation and runoff losses. Rainwater harvesting, watershed management and use of mulches also help in conserving and effective use of water. These are not only enhancing efficiency in water use, but also alleviating the effects of climate variability by increasing the resilience of agriculture systems.

The other important aspect of sustainable soil and water management is that it helps in protecting the environment and mitigating climate change. The healthy soils serve as major carbon sinks, which trap the carbon dioxide in the atmosphere and, in this way, decrease the level of greenhouse gases. Organic matter incorporation, less tillage, and agroforestry practices increase the storage of carbon in the soil, which is part of the efforts to mitigate climate change. Moreover, sustainable management practices contribute towards conservation of biodiversity by ensuring that soils, insects and other organisms that are vital in the operation of the ecosystem are not disturbed. The health of aquatic ecosystems and the availability of clean water to support various uses is also promoted by protection of water resources through less pollution, efficient use and better management.

Moreover, sustainable soil and water management is closely connected with the concepts of climate-smart agriculture, which aims at raising agricultural productivity, improving climate change resilience and minimizing greenhouse gas emissions. Farmers can be more productive and reduce environmental effects by implementing integrated and resource-efficient practices. This also contributes to socio-economic sustainability by boosting farm incomes, lowering input expenses, and boosting livelihood security among farming communities.

Basic Ideas of Soil and Water Sustainability

Soil Health and Soil Quality

Soil health is an inclusive term that indicates the capacity of soil to be a living system that is dynamic and capable of supporting the productivity of plants, sustainability of the environment, and human and animal life. It includes physical characteristics including soil structure, soil texture, and porosity; chemical characteristics of soil including nutrient availability, pH and cation exchange capacity; and biological characteristics including microbial biomass and enzyme activity. A healthy soil is one that has a stable structure that will facilitate water penetration and aeration thus minimizing surface runoff and erosion. High content of organic matter enhances nutrient retention and a rich microbial community, which is crucial in nutrient cycling and disease suppression. Soil quality, also known as soil health, is more concerned with the ability of the soil to do certain functions. The goal of sustainable management practices is to improve the health and quality of soils, which will guarantee long-term productivity and ecological balance. Healthy soils are the key to efficient water consumption, climate resilience, and sustainable agriculture.

Water Use Efficiency (WUE)

Water Use Efficiency (WUE) is a very important parameter in sustainable agriculture that is the ratio of crop yield to the amount of water used by the crop through transpiration and evaporation. Enhancement of WUE is especially essential in arid and semi-arid areas where there is a shortage of water resources. Effective irrigation techniques like drip and sprinkler irrigation systems are used to ensure water reaches the root zone, and there is minimum waste through evaporation and runoff. The soil management practices such as mulching and conservation tilling also contribute greatly towards the reduction of water loss and soil moisture. Also, WUE can be further improved by the choice of the drought-resistant varieties of crops and the optimization of the planting time. The development of precision agriculture, such as sensors and remote sensing technologies, enables real-time tracking of soil moisture and crop water needs, which can be more effectively managed with regard to water. WUE can be used to not only conserve water resources, but also enhance crop productivity and sustainability.

Soil–Water–Plant Relationship

The relationship between soil, water and plant is an essential principle which determines the growth and yield of crops in agricultural systems. Soil is a storehouse where water and nutrients are stored and can be availed to the plants through their root systems. Water availability in the soil is influenced by soil texture, structure, and organic matter content that determine the water retention and movement. Water and dissolved nutrients are absorbed by plants and are vital in physiological processes like photosynthesis, transpiration, and growth. The water supply to the plants and the demand of the water is of critical importance; lack of water and surplus can adversely affect the crop performance. The management of this relationship is most effectively achieved by ensuring that the soil moisture is at the optimum level during the crop growth period, so that the plants get sufficient water without leading to waterlogging or loss of nutrients. Knowledge of such interactions can help farmers to implement proper irrigation and soil management techniques, which results in a high productivity and efficiency of resources utilization.

Soil Organic Matter (SOM)

One of the most important components of soil health is soil organic matter (SOM), which is important in ensuring the soil is fertile, structurally sound, and has the capacity to retain water. It is composed of plant and animal remains that are decomposed, microbial biomass, and humus, which all lead to better physical, chemical, and biological characteristics of soil. SOM improves soil aggregation, which results in improved aeration and root penetration, as well as water and nutrient retention of the soil. It is a storehouse of vital nutrients, which are released slowly by microbial degradation. Composting, green manuring, use of crop residues, and minimized tillage are good practices that increase the level of SOM. Increased SOM also enhances resilience of the soil to environmental stresses like drought and heavy rainfall. Also, SOM is an important part of carbon sequestration, which can alleviate climate change. SOM preservation and improvement is thus a pillar of sustainable soil and water management.

Soil Erosion and Degradation

Agricultural sustainability is seriously threatened by soil erosion and degradation, which causes loss of fertile topsoil, decreased productivity and degradation of the environment. Erosion is caused by the effect of water and wind especially in places where the vegetation cover is poor, there is poor land management, or where the slope is steep. Top soil erosion leads to the loss of vital nutrients and organic matter, which adversely impact on soil fertility and structure. Other processes that contribute to soil degradation are compaction, salinization, and loss of nutrients, which further diminish the quality of soil. To manage erosion and avoid degradation, sustainable land management practices are necessary. Contour farming, terracing, strip cropping, and cover crops are some of the techniques used to reduce soil loss by limiting the surface runoff and covering the soil surface. The preservation of vegetation cover and conservation practices do not only conserve soil resources but also increase water retention and stability of the entire ecosystem.

Integrated Resource Management

Integrated resource management is the coordination of soil, water and other inputs in agriculture to come up with sustainable and efficient production systems. This strategy focuses on the interaction of various management practices such as irrigation, nutrient management, crop choice, and conservation methods. Combining these elements, farmers will be able to optimize resource utilization, decrease environmental effects, and increase productivity. To illustrate, effective irrigation techniques coupled with appropriate nutrient control will guarantee plants get the right amount of water and nutrients at the appropriate time, enhancing growth and production. Integrated methods also take into account the relationships between soil health, water availability, and climate factors, which allow more robust farming systems. Integrated resource management practices are necessary to tackle the problem of resource scarcity, climate change, and environmental degradation, which in the long run will help to achieve sustainable agriculture and long-term food security.

Sustainable Soil Management Practices
Conservation Tillage

Conservation tillage is a sustainable soil management method that causes minimal disturbance of the soil to maintain the soil structure, minimize soil erosion, and improve the health of the soil. Contrary to traditional tillage where the work entails heavy plowing and soil inversion, conservation tillage incorporates techniques like no-till, reduced tillage and strip tillage. These practices ensure that there are crop residues that cover the soil surface and this gives a protective cover that minimizes the effects of raindrops and wind hence preventing soil erosion. Cultivating the soil with conservation tillage also enhances the organic carbon content of the soil by minimizing oxidation and enhancing the build-up of organic matter. It also increases the water penetration and retention, which increases the availability of more moisture to crops. These advantages over time result in better soil fertility, enhanced root growth and higher crop yields. Even though conservation tillage may need some changes in equipment and management practices in the beginning, it has long-term benefits to sustainable agriculture and environmental protection.

Crop Rotation and Diversification

Crop rotation and diversification are essential practices for maintaining soil fertility and breaking pest and disease cycles. By alternating different crops in a sequence, farmers can improve nutrient balance in the soil and reduce the build-up of specific pests and pathogens associated with mono-cropping. For example, a rotation system involving *Oryza sativa* (rice) and *Triticum aestivum* (wheat) is widely practiced and helps maintain soil productivity.

Incorporating legumes into the rotation, such as pulses, enhances nitrogen availability through biological nitrogen fixation, reducing the need for synthetic fertilizers. Crop diversification, which involves growing multiple crop species simultaneously or in sequence, further improves soil health by increasing biodiversity and resilience. These practices contribute to sustainable soil management by enhancing nutrient cycling, improving soil structure, and reducing environmental risks. They also provide economic benefits by diversifying farm income and reducing dependency on a single crop.

Cover Cropping

Cover cropping involves the cultivation of specific crops primarily to protect and improve the soil rather than for harvest. Cover crops such as *Trifolium spp.* and *Vicia spp.* play a crucial role in preventing soil erosion by providing ground cover that reduces the impact of wind and water. They also contribute to soil fertility by adding organic matter and, in the case of legumes, fixing atmospheric nitrogen. Cover crops improve soil structure by enhancing aggregation and porosity, which facilitates better water infiltration and root growth. Additionally, they suppress weeds, reduce soil temperature fluctuations, and support beneficial soil microorganisms. When incorporated into the soil, cover crops act as green manure, further enriching soil organic matter. This practice is an integral component of sustainable agriculture, promoting long-term soil health and reducing the need for external inputs.

Organic Amendments

The use of organic amendments is a key strategy for improving soil fertility and water retention capacity. Materials such as compost, farmyard manure, green manure, and biochar are added to the soil to enhance its physical, chemical, and biological properties. These amendments increase soil organic matter content, which improves soil structure, aeration, and moisture-holding capacity. They also provide a slow and steady release of essential nutrients, supporting plant growth and reducing reliance on chemical fertilizers. Biochar, in particular, has gained attention for its ability to improve soil fertility and sequester carbon, contributing to climate change mitigation. The application of organic amendments supports the activity of soil microorganisms, which play a vital role in nutrient cycling and soil health. Regular use of these materials helps maintain soil productivity and sustainability over the long term.

Agroforestry Systems

Agroforestry systems involve the integration of trees with crops and/or livestock in a single land-use system, providing multiple ecological and economic benefits. Trees contribute to improved soil structure through their extensive root systems, which enhance soil stability and reduce erosion. They also increase organic matter through leaf litter and root turnover, enriching soil fertility. Agroforestry systems improve water management by enhancing infiltration, reducing runoff, and maintaining soil moisture. Additionally, they promote biodiversity by providing habitats for various organisms and supporting ecological balance.

These systems can also offer additional sources of income through timber, fruits, and other tree products. By combining agricultural and forestry practices, agroforestry represents a sustainable approach to land management that enhances productivity while conserving natural resources.

Soil Salinity Management

Soil salinity is a significant challenge in irrigated agriculture, particularly in arid and semi-arid regions where evaporation rates are high. Excessive accumulation of soluble salts in the soil can negatively affect plant growth by disrupting water uptake and causing ion toxicity. Sustainable management of soil salinity involves practices such as leaching, where excess salts are washed away from the root zone using adequate irrigation. The use of salt-tolerant crops, such as *Hordeum vulgare* (barley), is another effective strategy for maintaining productivity under saline conditions. Improved drainage systems are essential to prevent waterlogging and salt build-up. Additionally, the application of organic amendments can help improve soil structure and reduce the impact of salinity. Managing soil salinity is crucial for maintaining soil health and ensuring sustainable agricultural production in affected regions.

Sustainable Water Management Practices

Sustainable water management is a critical component of modern agriculture, particularly in regions facing water scarcity, erratic rainfall, and increasing demand for food production. Efficient use and conservation of water resources not only enhance crop productivity but also ensure long-term environmental sustainability. Sustainable practices focus on optimizing water use, minimizing losses, and maintaining soil moisture balance to support healthy plant growth. These approaches integrate traditional knowledge with modern technologies to improve water use efficiency, reduce wastage, and protect natural water resources. Proper water management also plays a vital role in preventing soil degradation, salinization, and nutrient leaching, thereby contributing to overall agricultural sustainability.

Table 1: Efficient Irrigation Techniques

Irrigation Method	Description	Advantages
Drip irrigation	Water delivered directly to root zone	High water efficiency
Sprinkler irrigation	Simulates rainfall	Uniform distribution
Surface irrigation	Traditional method	Low cost
Subsurface irrigation	Water applied below soil surface	Reduced evaporation

Sustainable Water Management Practices (Continued)

Rainwater Harvesting

Rainwater harvesting is a highly effective and sustainable method for conserving water by collecting and storing rainfall for later use in irrigation. This practice reduces dependence on groundwater resources, which are increasingly being depleted due to excessive extraction. Rainwater can be collected from rooftops, farm fields, and natural catchment areas, and stored in ponds, tanks, or reservoirs for use during dry periods. In agricultural systems, harvested rainwater helps stabilize crop production by ensuring water availability during critical growth stages. Additionally, it contributes to groundwater recharge by allowing excess water to infiltrate into the soil. This practice also reduces surface runoff, thereby minimizing soil erosion and nutrient loss. Rainwater harvesting is particularly beneficial in arid and semi-arid regions, where rainfall is limited and erratic. Its integration into farming systems enhances water security, supports sustainable agriculture, and promotes efficient utilization of natural resources.

Deficit Irrigation

Deficit irrigation is a water-saving strategy that involves applying water below the full crop water requirement while minimizing yield reduction. This approach is based on the understanding that crops can tolerate mild water stress during certain growth stages without significant loss in productivity. By carefully managing the timing and quantity of irrigation, farmers can optimize water use efficiency and conserve limited water resources. Deficit irrigation is particularly useful in water-scarce regions, where maximizing the productivity of each unit of water is essential. It also helps reduce excessive vegetative growth, improve crop quality in some cases, and decrease the risk of waterlogging and nutrient leaching. However, successful implementation requires a thorough understanding of crop physiology, growth stages, and soil moisture dynamics. When applied correctly, deficit irrigation offers a practical balance between water conservation and crop yield, contributing to sustainable agricultural practices.

Wastewater Irrigation

The use of treated wastewater for irrigation is an innovative approach to addressing water scarcity while simultaneously recycling water resources. Treated wastewater often contains essential nutrients such as nitrogen and phosphorus, which can supplement fertilizer requirements and enhance crop growth. This practice reduces the demand for freshwater resources, making it particularly valuable in urban and peri-urban agriculture. However, careful management is essential to avoid potential risks associated with contaminants, pathogens, and heavy metals that may be present in inadequately treated wastewater. Proper treatment processes, monitoring, and adherence to safety guidelines are necessary to ensure that wastewater irrigation does not negatively impact soil health, crop quality, or human health. When managed effectively, wastewater irrigation can contribute to sustainable water use, nutrient recycling, and environmental conservation.

Soil Moisture Conservation Techniques

Soil moisture conservation techniques are essential for maintaining adequate water availability in the root zone and reducing water loss through evaporation and runoff. Practices such as mulching, contour farming, and terracing play a significant role in conserving soil moisture. Mulching involves covering the soil surface with organic or inorganic materials, which reduces evaporation, moderates soil temperature, and suppresses weed growth. Contour farming, practiced on sloped land, involves planting along contour lines to slow down water flow and increase infiltration. Terracing transforms steep slopes into flat steps, reducing runoff velocity and preventing soil erosion. These techniques not only enhance water retention but also improve soil structure and fertility over time. By maintaining optimal soil moisture conditions, these practices support healthy plant growth and increase resilience to drought conditions, making them integral components of sustainable water management.

Integrated Irrigation Management

Integrated irrigation management involves the strategic combination of irrigation practices with soil and crop management techniques to optimize water use and enhance agricultural sustainability. This approach considers factors such as soil type, crop requirements, climate conditions, and available water resources to design efficient irrigation systems. By integrating methods like drip irrigation, mulching, and proper nutrient management, farmers can reduce water losses and improve crop productivity. Advanced technologies, including soil moisture sensors and automated irrigation systems, further enhance the precision and efficiency of water application. Integrated irrigation management also emphasizes the importance of scheduling irrigation based on crop growth stages and environmental conditions. This holistic approach ensures that water is used judiciously, minimizing waste and environmental impact while maximizing agricultural output.

Integrated Soil and Water Management Systems

Conservation Agriculture

Conservation agriculture is a sustainable farming system based on three core principles: minimal soil disturbance, permanent soil cover, and crop diversification. These principles work together to improve soil health, enhance water retention, and reduce erosion. Minimal soil disturbance, achieved through reduced or no-till practices, helps maintain soil structure and microbial activity. Permanent soil cover, using crop residues or cover crops, protects the soil from erosion and reduces evaporation. Crop diversification, through rotation or intercropping, improves soil fertility and breaks pest cycles. Conservation agriculture enhances the efficiency of both soil and water resources, making it a key strategy for sustainable agricultural production.

Climate-Smart Agriculture

Climate-smart agriculture focuses on increasing agricultural productivity while enhancing resilience to climate change and reducing greenhouse gas emissions. This approach integrates practices such as efficient water management, improved crop varieties, and sustainable soil management to adapt to changing climatic conditions. It emphasizes the use of drought-tolerant crops, efficient irrigation systems, and practices that enhance soil carbon sequestration. By addressing both mitigation and adaptation, climate-smart agriculture supports long-term sustainability and food security in the face of climate variability and extreme weather events.

Precision Agriculture

Precision agriculture utilizes advanced technologies such as sensors, GPS, and remote sensing to optimize the use of resources, including water, fertilizers, and pesticides. This approach allows for site-specific management, where inputs are applied based on the actual needs of different areas within a field. For water management, precision agriculture enables real-time monitoring of soil moisture and crop conditions, ensuring that irrigation is applied efficiently and only where needed. This reduces resource wastage, lowers production costs, and minimizes environmental impact. Precision agriculture represents a modern, technology-driven approach to sustainable farming.

Watershed Management

Watershed management involves the integrated management of land and water resources within a defined drainage area or watershed. The goal is to conserve soil, enhance water availability, and reduce erosion through coordinated interventions such as afforestation, contour bunding, check dams, and water harvesting structures. By managing the entire watershed, this approach ensures efficient use of water resources and improves groundwater recharge. It also supports sustainable livelihoods by enhancing agricultural productivity and reducing vulnerability to drought and floods. Watershed management is particularly effective in regions with uneven rainfall distribution and degraded land.

Integrated Farming Systems

Integrated farming systems combine multiple agricultural enterprises, such as crops, livestock, fisheries, and agroforestry, within a single farm. This approach enhances resource use efficiency by recycling nutrients and optimizing the use of water and land. For example, livestock waste can be used as manure to improve soil fertility, while crop residues can be used as animal feed. Integration of trees provides additional benefits such as shade, soil stabilization, and improved biodiversity. These systems reduce dependency on external inputs, increase farm resilience, and provide multiple sources of income. Integrated farming systems represent a holistic approach to sustainable agriculture, promoting environmental balance and economic viability.

Table 2: Benefits of Integration

Parameter	Conventional System	Sustainable Integrated System
Soil fertility	Declining	Improved
Water use efficiency	Low	High
Productivity	Variable	Stable
Environmental impact	High	Low

Examples, Future Prospects, and Conclusion

Examples of Sustainable Practices

Sustainable soil and water management practices are being successfully implemented across various cropping systems, demonstrating their effectiveness in improving productivity and conserving natural resources. In *Oryza sativa* (rice), the technique of alternate wetting and drying (AWD) has gained prominence as a water-saving irrigation method that reduces water use without significantly affecting yield. This practice also helps in lowering methane emissions, contributing to climate mitigation. In *Saccharum officinarum* (sugarcane), drip irrigation has been widely adopted to deliver water directly to the root zone, significantly improving water use efficiency and crop productivity while reducing wastage. Conservation agriculture practices in *Zea mays* (maize) systems, including minimal tillage and residue retention, have shown improvements in soil structure, organic carbon content, and moisture conservation.

Future Prospects

The future of sustainable soil and water management is closely linked with technological advancements and innovative approaches that enhance efficiency and adaptability. Artificial intelligence-based irrigation systems are expected to revolutionize water management by enabling precise, data-driven decision-making based on real-time soil moisture, weather conditions, and crop requirements. Remote sensing technologies, including satellite imaging and drones, are increasingly being used to monitor soil moisture levels, crop health, and water stress, allowing for timely interventions.

Conclusion

Sustainable soil and water management practices are fundamental to achieving long-term agricultural productivity, environmental conservation, and global food security. By maintaining soil health and optimizing water use, these practices ensure that natural resources are utilized efficiently without compromising their availability for future generations. Approaches such as conservation agriculture, precision farming, and climate-smart agriculture provide practical solutions to address the challenges of land degradation, water scarcity, and climate variability. The integration of scientific knowledge, technological innovations, and traditional farming practices enables the development of resilient agricultural systems that can sustain increasing food demands. As global pressures on natural resources continue to intensify, the adoption of sustainable soil and water management strategies becomes not just an option but a necessity. Ultimately, these practices pave the way for a more sustainable, productive, and environmentally balanced agricultural future.

References

1. Bouali Et-taibi, Mohamed Riduan Abid, El-Mahjoub Boufounas, Abdennabi Morchid, Safae Bourhnane, Tareq Abu Hamed, Driss Benhaddou, (2024). Enhancing water management in smart agriculture: A cloud and IoT-Based smart irrigation system, Results in Engineering, Volume 22, 2024, 102283, ISSN 2590-1230, https://doi.org/10.1016/j.rineng.2024.102283.
2. Salvatore Filippo Di Gennaro, Davide Cini, Andrea Berton, Alessandro Matese, (2024). Development of a low-cost smart irrigation system for sustainable water management in the Mediterranean region, Smart Agricultural Technology, Volume 9, 2024, 100629, ISSN 2772-3755, https://doi.org/10.1016/j.atech.2024.100629.
3. Rajiv Kumar Srivastava, Sanju Purohit, Edris Alam, Md Kamrul Islam, (2024). Advancements in soil management: Optimizing crop production through interdisciplinary approaches, Journal of Agriculture and Food Research, Volume 18, 2024, 101528, ISSN 2666-1543, https://doi.org/10.1016/j.jafr.2024.101528.
4. Ugo De Corato, Egidio Viola, Chetan Keswani, Tatiana Minkina, (2024). Impact of the sustainable agricultural practices for governing soil health from the perspective of a rising agri-based circular bioeconomy, Applied Soil Ecology, Volume 194, 2024, 105199, ISSN 0929-1393, https://doi.org/10.1016/j.apsoil.2023.105199.
5. Bhabani S. Das, Suhas P. Wani, Dinesh K. Benbi, Sekhar Muddu, Tapas Bhattacharyya, Biswapati Mandal, Priyabrata Santra, Debashis Chakraborty, Ranjan Bhattacharyya, Nirmalendu Basak, Nagarjuna N. Reddy, (2022). Soil health and its relationship with food security and human health to meet the sustainable development goals in India, Soil Security, Volume 8, 2022, 100071, ISSN 2667-0062, https://doi.org/10.1016/j.soisec.2022.100071.
6. D.S. Powlson, P.J. Gregory, W.R. Whalley, J.N. Quinton, D.W. Hopkins, A.P. Whitmore, P.R. Hirsch, K.W.T. Goulding, (2011). Soil management in relation to sustainable agriculture and ecosystem services, Food Policy, Volume 36, Supplement 1, 2011, Pages S72-S87, ISSN 0306-9192, https://doi.org/10.1016/j.foodpol.2010.11.025.
7. Filiberto Altobelli, Ronald Vargas, Giuseppe Corti, Carmelo Dazzi, Luca Montanarella, Alessandro Monteleone, Lucrezia Caon, Maria Grazia Piazza, Costanza Calzolari, Michele Munafò, Anna Benedetti, (2020). Improving soil and water conservation and ecosystem services by sustainable soil management practices: From a global to an Italian soil partnership, Italian Journal of Agronomy, Volume 15, Issue 4, 2020, 1765, ISSN 1125-4718, https://doi.org/10.4081/ija.2020.1765.