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REVIEW

Effects of Agricultural Land Practices Management on Sustainable Crop Production

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Abstract
This study investigates effective soil management practices aimed at enhancing sustainable agricultural production and preventing soil degradation. Soil degradation remains a significant global challenge, threatening food security, ecosystem stability, and rural livelihoods. In this context, adopting well-planned soil conservation measures is essential to maintain long-term agricultural productivity. The research reviews various techniques, including contour farming, mulching, and the use of cover crops, conservation plowing, terracing, and agroforestry. The findings reveal that these methods collectively improve soil structure, increase water infiltration and moisture retention, enhance nutrient cycling, and promote biodiversity. For instance, mulching and cover crops protect the soil from erosion and temperature extremes; while terracing and contour farming reduce surface runoff and increase water availability for crops. Agroforestry not only stabilizes soils but also provides additional economic benefits through diversified farm outputs. These improvements contribute to higher crop and livestock yields, better resilience against climate variability, and overall ecosystem health. However, despite their proven benefits, the widespread implementation of these practices faces significant obstacles. High initial costs of adoption, limited access to skilled labor and technical expertise, and weak legislative and policy support remain major constraints. In many regions, farmers lack financial incentives and government-backed programs to encourage long-term conservation efforts. The study showed that increased financial and technical assistance to farmers, capacity-building programs to develop expertise, and the introduction of strong policy frameworks that promote these globally recognized soil conservation techniques. Addressing these challenges is vital for ensuring soil health, sustainable production, and food security for future generations.

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Statement of Sustainability: This study is designed with a strong commitment to sustainability, aiming to balance environmental, social, and economic considerations. Environmentally, the project minimizes waste, promotes resource efficiency, and supports the use of renewable materials where possible. Socially, it engages with the community, ensures inclusivity, and fosters long-term positive impacts on well-being. Economically, it encourages cost-effectiveness, supports local suppliers, and aims for financial viability beyond initial funding. By integrating these principles, the project contributes to the Sustainable Development Goals (SDGs) and ensures benefits for present and future generations.

1. Introduction

Agricultural soil is a fundamental resource for the continuation of human life, playing a vital role in agriculture, economic development, and environmental balance (Roussis et al., 2024). Proper soil management not only helps increase agricultural yields but also prevents degradation and misuse. Agricultural land plays a significant role, as the creation of alternative economic opportunities, improvement in crop quality, and sustainable land use can all help curb narcotic crop cultivation (Rounsevell, 1996). It was discovered that in place conservation techniques could increase grain yields by 200–1000 kg/ha. Over 90% of the research indicated that water conservation of 50 to 300 mm annually led to increased water productivity (Anantha et al., 2021). To increase agricultural yields, practices such as crop rotation, limited and efficient use of soil, and continuous soil cover with vegetation play a fundamental role in soil management and are essential parts of sustainable agricultural technology (Ejeta et al., 2025).

Although several obstacles exist in implementing such strategies on a wide scale, progress must be made in the development, improvement, and dissemination of soil conservation technologies (Bhan et al., 2014). The benefit of well-maintained and protected soil outweighs short-term gains in yields because, economically, healthy soil incurs lower degradation costs, resists erosion, and produces higher output (Figure 1). It also reduces the need for chemical pesticides and fertilizers (Moulin et al., 2019). Managing soil health is essential to increase carbon sequestration and reduce dependence on synthetic fertilizers. Carbon dioxide, directly linked to nitrous oxide and one of the main greenhouse gases, can be mitigated through soil conservation techniques that help reduce emissions into the environment (Lal, 2004). The process of managing soil in a way that prevents degradation, maintains fertility, and ensures long-term productivity is referred to as soil conservation (Kifle et al., 2022). This includes various methods aimed at preserving soil nutrients and preventing degradation. Historically, people have recognized the importance of soil management, employing techniques such as terracing and crop rotation (Montgomery, 2012).

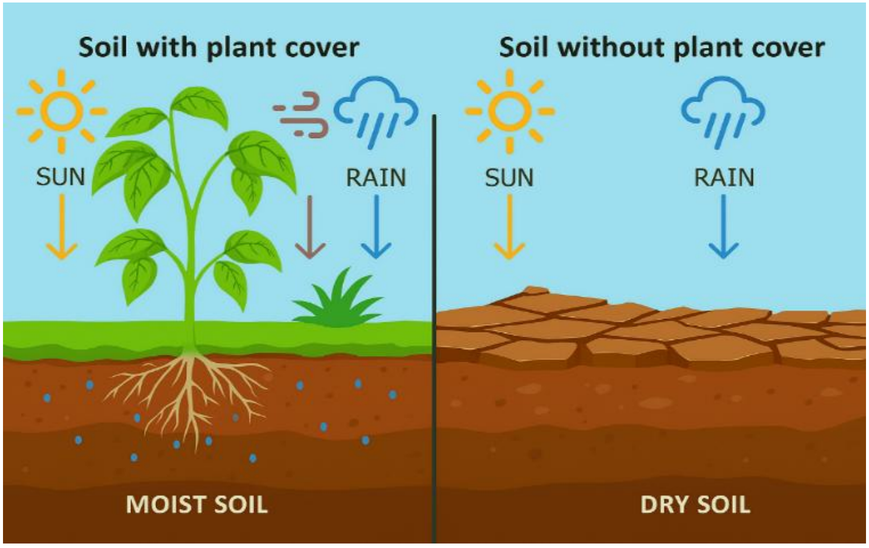

Figure 1. Impact of cover crops on soil degradation (Source: Cherlinka, 2020).

Crop rotation, terracing, contour farming, irrigation, and planting cover crops are methods that contribute significantly to soil protection and management. These practices strengthen soil structure, improve water retention, and reduce erosion. Farmers using these techniques can enhance their crops' resistance to environmental stress, maintain soil health, and reduce dependence on chemical inputs (Pimentel et al., 1995). Soil is a key component of agriculture, providing water, nutrients, and a stable medium for plant roots. Soil fertility, also known as soil health, is crucial for plant growth and agricultural productivity. Healthy soil contains a balanced mix of minerals, organic matter, water, and air, all of which support strong plant development. While nutrient content is one factor in soil fertility, others include structure, moisture retention, biological activity, and beneficial microorganisms (Brady, 1984). Sustainable crop production depends on the soil’s ability to provide adequate water and nutrients to support root development and ensure high yields. Soil health is vital for crop growth and overall food security. Compared to many other natural resources, soil takes a long time to form geologically, and its degradation can have long-lasting impacts on agricultural productivity (Lal, 2015). Modern agriculture faces significant challenges, including nutrient depletion, soil degradation, and climate change, that pose serious threats to soil health and management. Among the main causes of soil loss are erosion by wind and water, which strip away nutrient-rich topsoil. Factors such as reduced vegetation cover, monocropping, and overgrazing exacerbate this problem (Lal, 2001). When soil conservation techniques are repeatedly neglected, and soil is exploited continuously for crop production, fertility declines due to nutrient depletion (Schmidt and Tadesse, 2019). This leads to increased use of synthetic fertilizers, which over time alter the physical structure of soil and diminish its productivity (Abera and Wana, 2024). In addition, climate change affects rainfall patterns and increases extreme weather events, which cause soil particles to break apart, leading to further degradation. Climate change is thus a major threat to soil conservation and management (Shukla et al., 2019). Effective soil conservation techniques can enhance soil resilience and health, boosting agricultural productivity. Agroforestry, conservation plowing, and cover crops are practices that improve soil structure, reduce erosion, and increase water retention capacity. These approaches not only lead to higher yields on smaller land areas but also reduce chemical use and promote biodiversity, helping to sustain agricultural systems (Pretty, 2008).

Despite evidence of the benefits of soil conservation practices, limited large-scale adoption persists due to economic, technical, and policy-related constraints. Therefore, the objective of this research is to evaluate the effectiveness of different soil conservation and land management practices in promoting sustainable crop production while preventing soil degradation.

2. Current Status

2.1. Cover Crops and Their Role in Sustainable Soil Management

Cover crops refer to the cultivation of specific plants such as legumes, grasses, and clovers either between rows of cash crops or after the harvest of a main crop. These plants serve three primary functions: a) increase soil organic matter; b) prevent soil degradation; and c) contribute to the nutrient cycling process. According to Sharma et al. (2018), the basic cover crops and their benefits are described in Table 1.

Table 1. Classification of cover crops by season and type with associated benefits.

Parameter	Category	Representative Crops	Primary Benefits	References
Weather conditions	Winter cover crops	Winter rye, brassicas, hairy vetch, red clover, oats	Controls erosion; fixes nitrogen; improves soil organic matter and soil structure	Moncada et al. (2010)
	Summer cover crops	Buckwheat, sorghum–Sudan grass, cowpea, Sunn hemp	Increases soil organic matter; enhances soil microbes; suppresses weeds; reduces erosion	Blanco-Canqui et al. (2012); Creamer et al. (2000)
Type of cover crops	Legumes	Hairy vetch, peas, red clover, crimson clover, beans	Fix nitrogen; prevent erosion; increase organic matter; support insects and pollinators	Clark et al. (2008)
	Non-legumes	Wheat, oats, barley, annual ryegrass, brassicas, mustards, buckwheat	Prevent erosion; scavenge nutrients; suppress weeds; provide ground cover	Clark et al. (2008)

Source: Sharma et al. (2018).

In addition, cover crops enhance water infiltration into the soil, suppress weed growth, and help control the population of harmful insects. Leguminous crops, particularly mung beans, beans, chickpeas, clover, and alfalfa, can fix atmospheric nitrogen into the soil (Snapp et al., 2005). They also promote the formation of soil aggregates, which improve water retention capacity and eliminate compacted soil layers, thereby enhancing soil structure. Such practices are especially effective in areas with continuous rainfall, where soil erosion is a major contributing factor to soil degradation. The root systems of cover crops help stabilize soil and reduce sediment displacement (Creamer, 1996).

2.2. Conservation Tillage for Sustainable Crop Production

When compared to conventional tillage, conservation tillage includes various techniques such as no-till, reduced tillage, and strip-till that minimize soil disturbance (Table 2). These methods help protect the soil from physical damage by reducing surface cracking and compaction. As a result, they prevent soil erosion caused by wind and water (Lal, 2020). Conservation of tillage improves water absorption at the soil surface, helps reduce water loss, and enhances water retention for crops. Crop residues left on the soil surface, including those from cover crops, further increase water infiltration (Kour, 2021). This approach is essential for preventing soil degradation. It mitigates the effects of water runoff and wind erosion (Blanco et al., 2008). Additionally, conservation tillage increases organic matter through the decomposition of crop residues, which enhances soil fertility and creates favorable conditions for plant growth (Derpsch et al., 2010). In some cases, conservation tillage may also reduce pest and disease pressure by improving subsoil conditions, which in turn supports better root development and limits pest proliferation (Liebman et al., 1993).

2.3. Terracing Importance for Erosion Control

In mountainous regions, terracing prevents soil erosion and surface runoff (Figure 2). By slowing down water flow, terraces minimize water loss and protect the soil from both wind and water erosion (Lal, 2001). Terraces are also effective for water storage and ensure efficient distribution of moisture to crop fields. This technique plays a critical role in water management in arid and semi-arid regions (Brown et al., 1997). Terracing enhances soil fertility by conserving water and stabilizing soil, ultimately increasing crop yields. It offers long-term benefits to farmers by improving productivity and land quality (FAO, 1997). Moreover, terraces contribute to efficient land use, particularly in hilly areas, where they prevent land degradation and support sustainable agricultural development (Critchley et al., 2013).

Table 2. Differences between conservation and conventional tillage.

Parameters	Conservation Tillage	Conventional Tillage
Tillage operation	Minimum soil disturbance	Requires intensive tillage (more than four times per year)
Crop residue	Leaves more than 30% (≈1,000 lb/ac) on the surface	Crop residues are incorporated into the soil
Soil organic matter (SOM)	Increase SOM sequestration in surface soil	Increase SOM loss from surface soil
Greenhouse gas emission	Reduce greenhouse gas emissions such as CO_2	Increases greenhouse gas emissions
Erosion	Reduce soil loss from wind and water erosion	High risk of soil loss from wind and water erosion
Soil water storage	Increase infiltration and reduce evaporation	More soil water loss from evaporation and poor infiltration
Water body pollution	Minimum water body pollution with sediment load and field-applied chemicals	High risk of water body pollution
Aggregate stability	Increase soil aggregate stability	Lower soil aggregate stability
Labor and fuel	Low fuel use and labor cost	High fuel use and labor costs due to more trips over the field
Tillage equipment	Direct seed drills costlier than conventional drills	Machinery is widely available
Weed control	Reliance on herbicides during fallow	Tillage used to control weeds
Crop management	Information on new crop management strategies evolving	Relatively more information on crop management strategies
Germination	Potential for slower germination	Well-tilled and clean seeding facilitates germination and plant establishment.
Fertilizer	May initially require more nitrogen	The initial nitrogen requirement does not increase

Source: Bista et al. (2017).

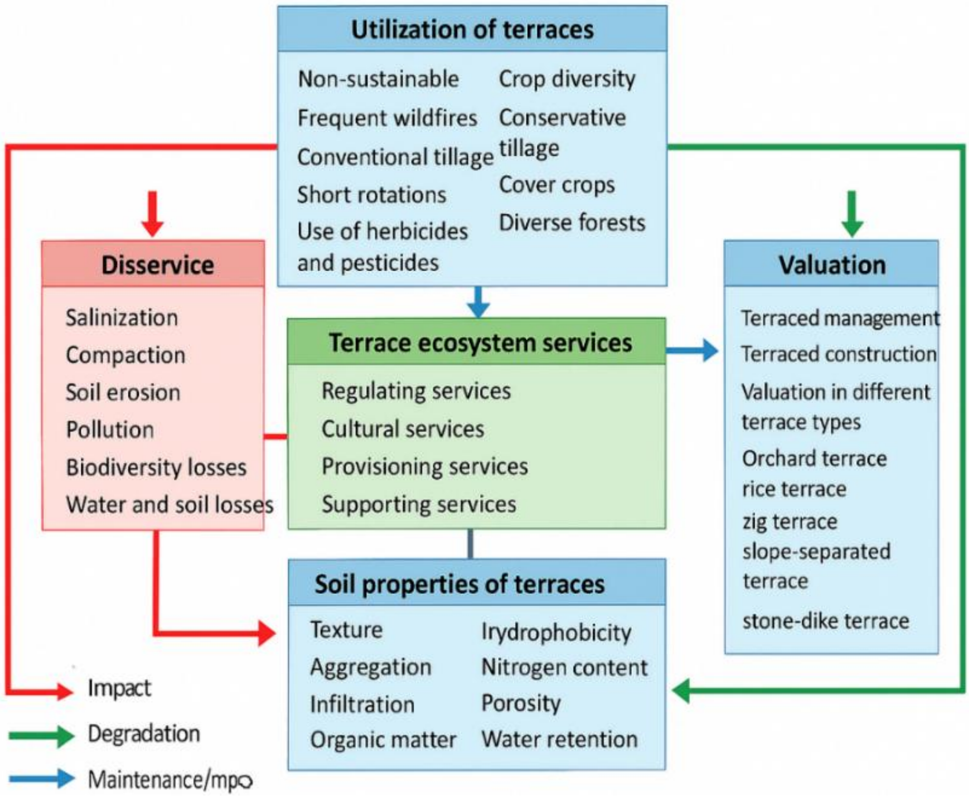

Figure 2. Indicated the role and utilization of terracing for soil quality and degradation (Source: Deng et al., 2021).

2.4. Agroforestry and Sustainable Agricultural Production

One of the key benefits of agroforestry is its role in preventing soil erosion (Figure 3). The roots of trees and shrubs help stabilize the soil and improve its structure, thereby reducing erosion caused by wind and water (Nair, 2021). Agroforestry systems also enhance water storage capacity. Tree roots absorb and retain moisture in the soil, reducing water loss and providing essential water for crops (Jose, 2009). An important objective of agroforestry is to increase plant diversity.

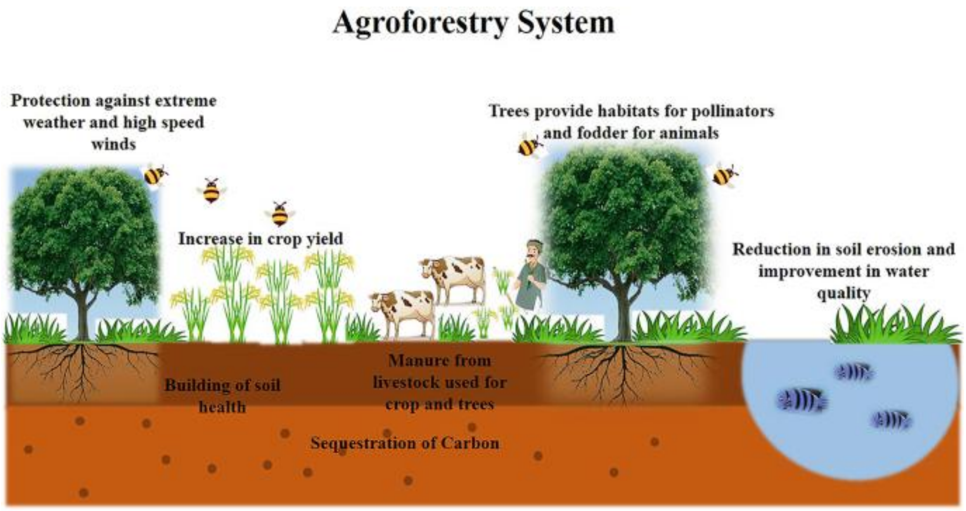

Figure 3. Role of agroforestry in sustainable agricultural production (Source: Yadav et al., 2024).

The integration of trees and various plant species adds ecological diversity to the farming system, helping reduce pests and diseases. This mixed planting system increases the resilience of crops against climate-related stress and natural disasters (Scherr et al., 2007). Trees and other plants used in agroforestry increase soil fertility by contributing organic matter and improving soil structure, which supports better nutrient uptake. This approach offers a long-term solution for enhancing soil productivity. Agroforestry can also increase crop yields by creating favorable conditions such as shade, windbreaks, and moisture conservation, particularly in climate-stressed areas (Leakey, 1996).

2.5. Mulches for Sustainable Crops Production

Mulching is an effective method for weed suppression and improving soil health. Mulch refers to the presence of plant residues or cover crop materials spread over the soil surface. This layer enhances water absorption, improves soil quality, prevents erosion, regulates soil temperature, reduces surface runoff, and inhibits weed growth. Organic and inorganic mulches initially differ in origin, living or non-living plant materials, and can later be categorized into synthetic and organic types. Mulching is especially important in arid and semi-arid regions, as it protects the soil from water evaporation and direct sunlight (Alyokhin et al., 2020). According to El-Beltagi et al. (2022), Mulching is a long-standing agricultural method that can help address this problem

Table 3. Influence of mulches on the relationship between climate change, drought types, and their controls.

Drought Type	Drivers (Climate Change Factors)	Major Impacts	Role of Mulches in Control
Meteorological Drought	Precipitation deficit - Temperature anomalies (warming)	Reduced infiltration, runoff, and groundwater recharge - Increased evaporation and transpiration	Improve soil infiltration and water retention - Reduce soil temperature fluctuations - Minimize direct soil evaporation
Hydrological Drought	Reduced streamflow, inflow to reservoirs, lakes, and ponds - Lower groundwater levels, ground subsidence, and deeper pumping	Shrinking wetlands - Decline in aquatic and terrestrial habitats	Promote groundwater recharge through better infiltration - Maintain soil moisture balance - Slow surface runoff and erosion
Agricultural Drought	Soil water or moisture deficiency	Plant stress - Reduced crop yield - Decline in wildlife food resources	Conserve soil moisture for a longer duration - Improve soil structure and organic matter - Enhance crop resilience to water stress
Socio-economic Drought	Indirect impacts of meteorological, hydrological, and agricultural drought	Social: Food insecurity, migration, livelihood loss. Economic: Decline in farm income, higher irrigation costs. Environmental: Land degradation, biodiversity loss	Reduce yield loss through improved water-use efficiency - Lower irrigation demand and production costs - Support sustainable ecosystem functions

2.6. Contour Farming

Contour farming is a proven technique for reducing soil erosion, conserving moisture, and increasing crop yields. It is particularly effective in semi-hilly areas to reduce surface runoff and prevent soil degradation (Figures 4 and 5). In arid and semi-arid regions, this technique can significantly improve crop production by retaining soil moisture. Contour farming involves planting crops perpendicular to the slope, allowing more water to infiltrate the soil. Normally, farming is conducted in the direction of the slope, which reduces water absorption and increases erosion. Contour farming, however, reverses this by planting against the slope, thereby reducing runoff and erosion (Madhu, 2022).

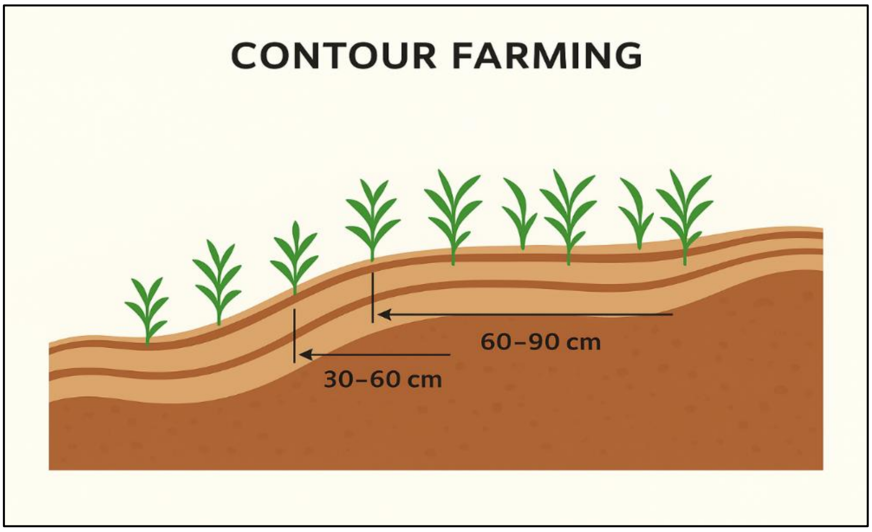

Figure 4. Show the structure and space of contour for sustainable crops production.

Figure 5. Lush green crop rows are planted in smooth, curved patterns across a hillside, illustrating contour farming to reduce soil erosion and conserve water.

2.7. Crop Rotation

Crop rotation involves planting different types of crops sequentially in the same field. These crops have varying nutrient requirements, which helps maintain balanced soil fertility and prevents long-term degradation and erosion. Rotating crops improves soil structure and reduces compaction, thus minimizing damage caused by wind and water erosion. One key benefit of crop rotation is its ability to enhance plant resistance to pests and diseases. By alternating crops between seasons, the life cycles of specific pests and pathogens are disrupted, reducing the need for chemical treatments. This system creates optimal growing conditions, promotes organic soil matter, and minimizes water loss. Through improved nutrient cycling, soil conservation, and natural pest control, crop rotation increases both the quality and quantity of agricultural yields (Kathryn et al., 2020).

3. Mechanisms That Influence Agricultural Productivity

3.1. Enhancing Soil Fertility

Improving soil health will boost soil functions, which supports the notion that increasing soil organic carbon is necessary (Ţopa et al., 2025). Land degradation is a major factor in the low soil productivity of smallholder agricultural practices in developing countries (Cosmas et al., 2023). Farmers and policymakers can protect soil health, increase agricultural production, and guarantee the long-term sustainability of our food systems and environment by adopting sustainable soil management methods (Bommireddy et al., 2024). Soil fertility is a cornerstone of productive agriculture. Fertile soil is essential for achieving higher crop yields and efficient land use (Table 4). Productive soils support better plant growth, which in turn contributes to economic development. However, with proper soil fertility management, farmers can shift toward cultivating beneficial crops such as wheat, maize, and vegetables (Katharine et al., 2017)

3.2. Efficient Soil Water Management

Due to water scarcity and environmental pressures, agriculture must produce more with less water. This calls for smart water management, combining tillage, mulching, efficient irrigation, and regulated watering to boost water use efficiency and yields. Deficit irrigation is effective in dry areas, but the long-term regional impacts of these practices need further research for faster adoption (Halli et al., 2021). Water scarcity, climate change, and high demand threaten horticulture's sustainability. While efficient practices and technologies like mulching, improved irrigation, recycled water, IoT, and AI can boost water use efficiency, adoption is still limited. Greater research and application are needed to adapt, protect resources, and ensure long-term food security (Ferreira et al., 2024). Irrigation and water management are vital for modern agriculture, and with a growing global population, efficient and responsible water use is essential to ensure food security, safeguard the environment, and support future generations (Amanda, 2024).

Table 4. Mechanisms that affect maintainable agriculture production.

Mechanisms	Influence	Reference
Enhancing soil fertility	Organic farming approaches rely on managing soil organic matter to enhance the soil's chemical, biological, and physical properties in an effort to optimize crop health and yield.	Mekonen (2023)
	Cropping sequences that improve soil fertility boost the amount of nutrients available to crops, ensure that there are enough nutrients available, and promote the healthy growth and development of crops.	Hari Sudheer et al. (2022)
Efficient soil water management	Tillage, mulching, and better irrigation techniques can all be combined to increase yields and water use efficiency (WUE).	Halli et al. (2021)
	Modern agriculture depends on sustainable water management and effective irrigation. We can improve food security, safeguard the environment, and guarantee a robust future for future generations by implementing cutting-edge methods and ethical practices.	Amanda (2023)
Prevention of Soil Degradation	More accurate evaluation of land degradation and its effects across scales is made possible by developments in processing capacity, remote sensing, and ecological understanding.	Bindraban et al. (2012)
	It is crucial to use soil and water conservation techniques, such as biological (agroforestry and agricultural) and agronomic measures (contour farming, crop rotation, and cover crops, etc.), to reduce runoff and soil erosion and to sustainably improve soil and water quality, moisture conservation, and overall crop productivity.	Nithinkumar and Gairola (2023)
Soil Biodiversity and Ecosystem Conservation	Improve soil biodiversity, soil carbon storage, and soil quality (reduced tillage, cover crops, etc.). Promote soil health and soil's multiple functions.	Wittwer et al. (2017)
Crop rotation	Combat the environmental consequences of monocropping and lower the external costs of intensive agriculture.	Albizua et al. (2015)

3.3. Prevention of Soil Degradation

Soil erosion is the dominant factor of soil degradation. Soil erosion can be reduced through several methods. Contour ploughing follows the land's natural slope, minimizing water erosion. Planting crops, especially leguminous cover crops, protects bare soil and enhances nitrogen content. No-till farming, which plants seeds without ploughing, also helps preserve soil structure (Alam, 2014). To prevent soil degradation and promote sustainable crop production, farmers can implement several strategies, including conservation tillage, crop rotation, cover cropping, and efficient irrigation (Bista et al., 2017). Professionals in the field should participate in development activities related to soil and water conservation so that personnel performing conservation operations in the field have the right direction and protocols (Flaviano, 2024).

3.4. Soil Biodiversity and Ecosystem Conservation

Soil biodiversity is crucial for the ecological intensification of agriculture because it enhances soil functions, sustainable crop production, and resilience to environmental shocks and disturbances (Tables 4 and 5). A detailed knowledge of mechanisms under field conditions is still required to inform ecological intensification strategies based on the beneficial effects of soil biodiversity on soil functions. This special issue's thirteen original studies explore how soil biodiversity, which includes nematodes, bacteria, fungi, collembolans, earthworms, and plant roots, affects soil functions such as water regulation, metal contaminant mitigation, nutrient cycling, soil C transformation, and soil structure maintenance. Water control, biological pest management, and metal pollution reduction (Amandine et al., 2024).

Table 5. Benefits of sustainable agriculture techniques.

Sustainable Agricultural Techniques	Benefit	Crop Yield	Reference
Conservation tillage and mulching	Increases soil moisture content	9% increase in rainfed wheat yield	Ziyou Su et al. (2007)
Conservation tillage and crop planting	Prevents soil degradation	12% increase in rainfed wheat yield	Rafael et al. (2021)
Crop residues	Increases soil moisture by 58%	Enhances maize yields	Govaerts et al. (2009)
Zero tillage and crop residues	Improves dry soil particle structure after 15 years		Somasundaram et al. (2019)
Reduced tillage combined with crop residues	Improves soil water retention	Higher soybean yield	Singh et al. (2016)
Zero tillage and crop residues	Increases soil moisture by 17%; enhances maize root biomass	Higher maize yield	Yadav et al. (2018)
Reduced tillage combined with crop residues	Increases soil organic carbon by 18%; enhances microbial carbon and dehydrogenase activity; increases soil NPK	26% increase in chickpea yield and 70% increase in mustard yield	Das et al. (2018)
Zero tillage with direct seeding of rice, followed by zero tillage and maize cultivation with crop residues	Increases soil organic carbon by 27%; improves secondary soil particles; enhances maize root biomass	Higher maize yield	Yang et al. (2018)

Source: Madhu (2022).

4. Conclusion

In conclusion, agricultural soil is not only a fundamental resource for the development of agriculture but also play a central role in the economic preparation of small-scale farmers. It is essential to take practical steps through proper soil management, environmental conservation, and economic development to combat scarcity. Conservation tillage is a key strategy for managing agricultural soils. It helps prevent soil degradation, reduces water loss, creates favorable conditions for plant growth, and enhances the level of organic matter in the soil, which collectively contributes to increased agricultural productivity. Similarly, terracing plays a foundational role in soil management. Terraces are not only necessary for agricultural advancement but are also critical for land conservation and sustainable agricultural production. Mulching is another highly beneficial practice in managing agricultural soils and improving crop yields. Mulches help retain soil moisture, regulate temperature, prevent erosion, enhance organic matter content, and create optimal conditions for plant growth, all of which are crucial for increasing crop productivity. Proper soil management contributes to poverty reduction and creates employment opportunities for youth, paving the way for healthy and sustainable development.

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Data Availability/Sharing: The datasets used and analyzed during the current study will be made available from the corresponding author upon a reasonable request.

Supplementary Information Availability: Not applicable.

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