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The Role of Soil Ecosystem Services in the Circular Bio-economy

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INTRODUCTION

Comprising both living and non-living materials that interact in different ways, soils constitute varied ecosystems. It is primarily focused on the development of pores, the stabilisation of pore structures, and the cycling of nutrients. The top 2-3 cm of the soil, which contains the majority of the organic content, is where soil organisms tend to gather. There could be other animals several miles below the surface of the ground. There have been reports of earthworms (*Lumbricus terrestris*) burrowing up to three metres (300 cm) underground in certain instances. The structure, aeration, drainage, and fertility of soil are all dependent on soil organisms. Their sizes range from microscopic cells that feed on organic debris as it breaks down to small animals that mostly eat other soil organisms. Additionally, they decompose the tissues of both plants and animals to release important elements and change them into forms that plants need. Seeds can grow in the environments found in soils. They facilitate the availability of water, nutrients, and heat so that plants can reach maturity. Together, these plants form an ecosystem with other plants and other things. Ecosystems provide a wide variety of processes and resources that are advantageous to humanity. These benefits, which are referred to as ecosystem services, are the result of interactions between plants, animals, and microorganisms and their surroundings. Soil's multifunctionality is determined by the diversity of its species and functional groups. Ecosystems of soil are made up of complex relationships between living organisms and their environment. Their vegetation diversity, the way biotic and abiotic processes interact, and the soil and climate characteristics set them apart. We refer to the benefits that individuals receive from soil ecological systems as "soil ecosystem services." Decision-making about public policy and land management from an ecosystem services viewpoint is characterised by a human-centered view of nature.

It addresses every benefit that people receive from the soil environment in detail. It is designed to enable the monetary or non-monetary valuation of ecosystem services that are both market-oriented and non-market. Think about how the decline of previous civilizations was caused by a lack of soil fertility to get an idea of the historical relevance of soil to humans.

Ecosystem services and soil functions

Life on Earth is made possible by the vital ecological services that soil offers. Through agriculture, medicine, water purification, and the provision of essential building materials, soils support human life. Soils regulate climate through the soil carbon cycle. Through landscapes and a feeling of place in our everyday lives, soils enrich culture. Ecosystem services are closely linked to soil functioning. A pool of biodiversity, comprising species, habitats, and genes, is found in soils. The production of biomass, including that from forestry and agriculture, is directly aided by soils. Water, chemicals, and nutrients are all stored, filtered, and transformed by the soil. In addition to being stores of prehistoric and geological relics, soils also operate as carbon sinks and sources of basic materials. Soils are vital to human life because they provide and manage a range of ecosystem services (ES). Soil has several advantages, including freshwater, cleaner air, and increased agricultural yield. It is also crucial for lowering poverty and halting climate change. These signify a few of the most pressing issues confronting our society. The kind, amount, and quality of soil ES are determined by the same environmental variables that dictate the characteristics and functions of soil. The MEA identified the several types of soil services that ecosystems offer: provisioning services, or material items like fibre, fuel, food, and feed; and maintenance services. regulating services (including water filtration, flood control, and temperature regulation); Cultural services, such as those related to recreation, spirituality, and aesthetics, as well as supporting services like habitat preservation and the preservation of a range of living organisms, form the foundation of all ecosystems and the services they provide.

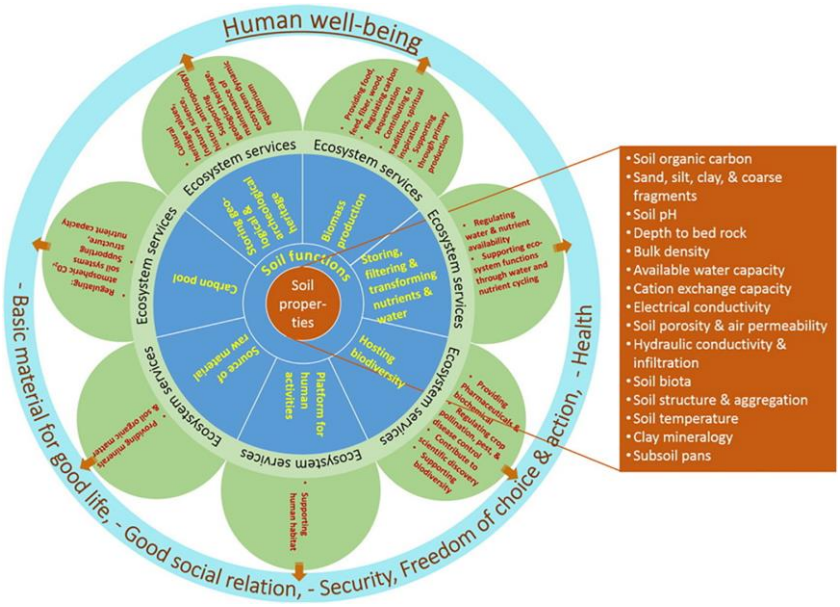

Figure 1: Linking soils to ecosystem services

The circular economy

The terms "creation, exploitation, preservation, and rejuvenation of natural assets" and "accompanying knowledge, technological advancements, and innovative thinking" refer to the bioeconomy. This facilitates the shift to a sustainable economy and the development of sustainable solutions (knowledge, products, and services) across all economic sectors. In order to achieve sustainable well-being in balance with the environment, a circular biobased economy provides a theoretical framework for rearranging and managing our food, manufacturing, well-being, and soil resources. The economy is growing as a result of changes in customer needs, technological advancements, environmental challenges, solutions, and circumstances and resource access. These components are driven by global dialogues, business, scientific, and technology initiatives, as well as the convergence of biological technology, nanotechnology, technological innovation, and cognition. The main force behind the circular bioeconomy is biodiversity, even if it also depends on cutting edge technology, creativity, and conventional knowledge. Ensuring the resilience and sustainability of our biological resources is crucial, as biodiversity affects the capacity of biological systems to adjust and transform in a dynamic environment. Through appropriate conservation laws and locally tailored market-based tools that encourage farmers, forest owners, and biobased companies to participate in biodiversity, we must acknowledge this crucial role. Because of its cross-cutting character, the economy offers a once-in-a-lifetime opportunity to achieve sustainable economic development while addressing interconnected societal challenges including the security of food and nutrition, the use of fossil fuels, the scarcity of natural resources, and climate change. It is widely understood that the world economy urgently has to change into a more environmentally sound, environmentally friendly system that depends on natural resources that use less resources or do not use fossil fuels, or what is known as the "bioeconomy." Using natural resources, processes, and ideals to generate products and provide solutions for all aspects of the economy is the bioeconomy. Economic sectors include engineering and construction, science, information and communication technology, agriculture, forests, fisheries, food, paper, textiles, and medicines. Commonplace products generated from microbes include biological materials, bioplastics, implantation devices, organic building materials, sweetener substitutes, natural pharmaceuticals, and biofuels.

The food industry, soil ecosystem services, and circular agriculture

All facets of life depend on soil ecosystem services since they facilitate the synthesis of ecosystem resources and products including energy sources, water storage and purification, and so forth. The "linear" structure of the current food production system has significant effects on the environment, society, and economy. In the absence of changes to the current unsustainable eating patterns, CO_2 emissions could double by 2050. A farming technique known as "circular agriculture" makes use of fresh scientific findings, technological advancements, and inventive methods while being environmentally benign. Diverse plant-livestock combinations, sustainable farming practises, water reuse, and wastewater recycling are given top priority in circular agriculture. The ecosystem's ability to support agriculture has been hampered by rising food demands, which has caused other services to deteriorate. The regular, valued commercial benefits that natural ecosystems provide are referred to as ecological services. Circular agriculture techniques are well adapted to small-scale, labor-intensive agriculture, which fosters gender-neutral local economic growth. The primary interconnected problems linked to farming practises are ecosystem transformation, global warming, diminishing biodiversity, excessive use of fertilisers, water scarcity, and overfishing in the ocean. The adoption of circular agricultural

techniques may be aided by international collaborations and advantages, such as property rights, safe resource access, and water user organisations. These services were categorised into the following categories: pest control, biodiversity conservation, UV protection, climate stabilisation, taming of extreme weather, water and air purification, disaster mitigation, soil generation and conservation, pest control, soil protection, visual appeal, and thought stimulation. These categories have to do with agriculture and are either directly or indirectly mediated by the soils. The soil provides inputs for agriculture, many of which are unreported and unaccounted for. The main objective of plant agribusiness is to harvest common natural resources like sunshine, wind, and precipitation and transform them into useful necessities like plants. There are two distinct circular cycles in the agricultural industry: the technical and the biotic. Innovation in agro-processing that boosts farming productivity, lowers waste, and saves money is a prime illustration of how technology.

The potential challenges, limitations, or trade-offs associated with implementing circular bioeconomy strategies that rely on soil ecosystem services

While the circular bioeconomy strategies that rely on soil ecosystem services offer significant benefits, there are also potential challenges, limitations, and trade-offs that need to be considered. Some of these include:

Transition and Adoption Challenges: Land management methods, farmer behaviour, and legislative frameworks may need to be significantly altered to implement circular bioeconomy models that depend on soil ecosystem services. This change may be difficult, mainly when there is a lack of resources, technical expertise, and financial assistance. Social and cultural variables may also influence whether new techniques are adopted quickly or reluctantly.

Scale and Scope Limitations: To have a major effect, implementing circular bioeconomy initiatives often calls for a large-scale strategy. Scaling out these approaches across vast regions may be expensive and time-consuming. Maintaining uniformity and ensuring effective implementation across many landscapes with different soil types, climates, and socioeconomic circumstances may also be challenging.

Trade-offs between Production and Conservation Goals: Agricultural and conservation goals may need to be sacrificed in circular bioeconomy models that depend on soil ecosystem services. For instance, it would be necessary to take land away from conventional agriculture to expand agroforestry systems or restore degraded areas, which can result in a short-term decline in output levels. It may be challenging and needs careful planning to balance the requirement for increasing output with ecosystem protection and restoration.

Financial and Economic Considerations: It may be necessary to provide farmers and other stakeholders with financial resources and incentives to invest in circular bioeconomy methods that depend on soil ecosystem services. A lack of access to markets, credit, and money may constrain the adoption and expansion of these tactics. Additionally, it's essential to ensure that farmers and other stakeholders get a fair share of the economic gains from circular bioeconomy initiatives, taking into account both immediate profitability and long-term sustainability.

Monitoring and Evaluation: Evaluating the efficacy and effects of circular bioeconomy initiatives on soil ecosystem services might be challenging. Long-term monitoring and assessment are often necessary to measure changes in soil fertility, biodiversity, water control, and carbon sequestration. Accurate data collection may be resource-intensive, and establishing uniform monitoring procedures may call for cooperation among many parties. Overall, while implementing circular bioeconomy strategies that rely on soil

ecosystem services can bring multiple benefits, addressing these challenges, limitations, and trade-offs is essential to achieve their full potential. Integrated approaches involving multi-stakeholder collaborations, supportive policies, and capacity-building initiatives can help overcome these challenges and ensure the successful implementation of circular bioeconomy strategies in Africa and beyond.

CONCLUSIONS

The benefits of soil ecosystem service to people and the environment were examined, as well as their responsibilities in promoting the growth of sustainable bio- and circular economies. Many ecosystem services provided by soil are so essential to life that there is no limit to how valuable they are. Understanding the marginal costs associated with various human activities is critical to determining alternate management strategies for soil resources. Better characterization of the ecosystem services that the soil provides, particularly concerning the function of soil biodiversity, requires research. It's also essential to understand how different services offered by soil and other systems interact with one another and how affecting one service might affect the performance of others.

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