Soil Plays a Key Role in the Sustainability of Agricultural Systems

Eloá Moura Araujo1*, Glêvia Kamila Lima2 and Daniel G Strawn3
1Department of Soils and Agricultural Engineering, Federal University of Paraná, Curitiba, Paraná, Brazil
2Department of Agronomy, Federal Rural University of Pernambuco, Recife, Pernambuco, Brazil
3Department of Soil and Water Systems, University of Idaho, Moscow, Idaho, United States

*Corresponding Author: Eloá Moura Araújo, Department of Soils and Agricultural Engineering, Federal University of Paraná, Curitiba, Paraná, Brazil.

Received: July 19, 2019; Published: August 28, 2019

Abstract

Soil is a complex, dynamic, multiphase system that comprises the surface of the Earth’s crust, providing the essential nutrients, water and physical support needed for plant growth responsible for production of food, fiber and energy. Soils also are important for filtering, purification, (re)cycling, storage and transformation of elements and chemicals; climate regulation and carbon sequestration; control of erosion; habitats for living creatures; gene pools; source of raw materials; archaeological heritage, and source of multiple cultural and leisure services. In the face of the growing population, agricultural systems are becoming more intensive and utilizing more of Earth’s arable land. Thus, maintaining soil health is critical to the development of sustainable agrosystems, ecosystem services, and worldwide sustainability. As such, major efforts to better understand, model and quantify the services provided by soils to facilitate better management are underway. But, to achieve healthy soil and sustainable ecosystems, better integration and education of all sectors of society is required. The aim of this paper is to review the importance of soil properties, functions and services to educate and encourage broader participation of improving soil health and creating more sustainable ecosystems and better agricultural practices.

Keywords: Soil Functions; Ecosystem Services; Economic Viability; Population Growth

Introduction

The term soil comes from Latin Solum and denotes support, base, surface [1]. Soil is located in the upper portion of the earth’s crust, and is considered the epidermis of the Earth, and thus exchanges matter and energy with the surrounding environment (atmosphere, surface water, organisms, and subsurface) [2]. Soil is the product of the interaction of environmental factors such as climate and organisms with parental material and relief over time; occurring weathering reactions, and the pedogenesis [3,4]. Soil is the central interface between the atmosphere, hydrosphere, lithosphere and biosphere, and is a continuous, open, dynamic and complex three dimensional system [5,6].

The soil system has properties and processes originated from the interrelationships that occurred during its genesis and evolution [4,7]. Such properties and processes are reflected in multiple functions performed by the soils, resulting in ecosystem services that generate environmental, social and economic benefits to communities [7,8]. Thus, the soil provides several ecosystem services that are vital to support living beings and society [5,8,9].

Given the relationship between soil functions and ecosystem services, a conceptual understanding to distinguish these terms is needed [8]. Soil functions are products of the multiple complex interactions of natural processes occurring within soils and are the basis for the functioning of terrestrial ecosystems and development of life on earth. Ecosystem services are the direct and indirect contributions and
Soil Plays a Key Role in the Sustainability of Agricultural Systems

benefits of ecosystem processes and components to human wellbeing, defined based on the human perception, and can alter according to the social context [8,10,11]. Soil functions and ecosystem services as well as examples of both are presented in table 1.

<table>
<thead>
<tr>
<th>Ecosystem services</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Provision services, provision of food, water, fiber, wood, energy (bioenergy), biologic products;</td>
</tr>
<tr>
<td>2) Regulation services, climatic and erosion regulation, control of floods and diseases;</td>
</tr>
<tr>
<td>3) Support services, soil formation, water and nutrients cycling, production of atmospheric oxygen, provision of habitats;</td>
</tr>
<tr>
<td>4) Cultural services, benefits recreation, ecotourism, educational, aesthetic and spiritual;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>I) Natural support for plants growth;</td>
</tr>
<tr>
<td>II) Production of food, forage, fiber; wood and bioenergy;</td>
</tr>
<tr>
<td>III) Storage, filtering and transformation of components (carbon and nutrients);</td>
</tr>
<tr>
<td>IV) Water cycling: water purification, plant available water, water infiltration and groundwater recharge;</td>
</tr>
<tr>
<td>V) Nutrient cycling and recycling: storage of nutrients, availability of nutrients to plants;</td>
</tr>
<tr>
<td>VI) Retention, filtering and buffering of organic compounds: pollutants, pesticides and antibiotics;</td>
</tr>
<tr>
<td>VII) Retention, filtering and buffering of inorganic compounds: potentially toxic elements and trace elements;</td>
</tr>
<tr>
<td>VIII) Habitat for living being and genetic resources pool;</td>
</tr>
<tr>
<td>IX) Storage and capture of carbon: soil organic matter, soil microorganisms;</td>
</tr>
<tr>
<td>X) Release and sequester gases from the atmosphere;</td>
</tr>
<tr>
<td>XI) Degradation of pollutants;</td>
</tr>
<tr>
<td>XII) Acidity buffering;</td>
</tr>
<tr>
<td>XIII) Resource raw materials, crafts and cosmetics</td>
</tr>
<tr>
<td>XIV) Engineering medium;</td>
</tr>
<tr>
<td>XV) Archiving cultural;</td>
</tr>
</tbody>
</table>

Table 1: Soil functions and some relevant ecosystem services.
Adapted from: Duru., et al. (2015); European Commission (2006); Millennium Ecosystem Assessment (2005); Weil and Brady (2017).

The provision of ecosystem services depends on complex biological, physical and chemical soil properties and their interaction with crops and management techniques [14,15]. The United Nations (UN) Sustainable Development Goals explicitly identify soil resources as being of crucial importance for sustainable development and food security, contributing directly to the goals of “no poverty”, “zero hunger”, “clean water and sanitation” and “life on land”; and indirectly to the remaining goals [16]. To achieve the goals, the UN promotes the protection of soil resources to achieve the zero land degradation by 2030 [17-19]. Land degradation is caused by erosion, contamination, salinization, desertification, and acidification. Protection of soil resources will create healthy soil1.

Perception of farmers about ecosystem services provided by soil

The importance of ecosystem services for alleviating poverty and achieving the UN Global Sustainable Development Goals has been increasingly considered in scientific research and policy making [19]. However, more attention must be given to one of the most important actors in a sustainable agricultural system: the farmers.

1“Soil health, also referred to as soil quality, is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans” (USDA NRCS).

Citation: Eloá Moura Araujo, et al. “Soil Plays a Key Role in the Sustainability of Agricultural Systems”. EC Agriculture 5.9 (2019): 545-549.
Soil Plays a Key Role in the Sustainability of Agricultural Systems

Through interviews carried out in Germany, Dietze., et al. (2019) observed that farmers were knowledgeable about all ecosystem services without calling them by this name. They use at least a very similar understanding of socio-ecological benchmarking in their management decisions. Farmers recognized various factors that have an influence on ecosystem services, as well as their interactions. But, for some services, farmers don't know how their agricultural practices can influence on them.

In the study of Dietze., et al. (2019), “Food” was seen as the most important ecosystem service for farmers because it is the basis of farmers' income. While “Buffering and Mediation of Nutrient Release” were ranked as the second most important ecosystem service. Farmers considered “biomass as renewable energy” as a critical service, being in competition with the provision of food and fodder.

Baude., et al. (2019) identified an intensification of biomass production from 1750 till today in Europe. The intensification has likely led to a decline in the capacity of the landscape to provide other ecosystem functions, especially regulation of groundwater quantity and quality and a decline of the capacity of the landscape to protect the soil against soil erosion. Intensification also leads to a decrease in biodiversity [20], which results in decreased soil resilience when faced with land use changes stressors [21,22].

Although agricultural production and climate regulation are highly interlinked, farmers do not seem to consider “climate regulation” as a very important soil service. Farmers had only a limited understanding of how they could consider “climate regulation” in their agricultural practices [15]. This indicates how the knowledge of farmers about several ecosystem services and their environmental and economic benefits is still limited.

Soil threats and the economic trade-offs

Soil health is facing many threats worldwide [23,24]. Intensification and competing uses of soils for cropping, pasture, forestry, and urbanization are increasingly impacting the provision of life-supporting services, such as food production, clean water for drinking, flood mitigation, and habitat for plants and animals [23]. Soil erosion is one of the main processes of land degradation and major threat to agricultural soil productivity [18,25]. A global soil erosion assessment carried out by Borrelli., et al. (2017) estimated 35.9 Pg yr⁻¹ of soil eroded in 2012, and estimations carried out by Panagos., et al. (2019) for the European Union suggest that soil loss due only to crop harvesting removes an average of 14.7 million t yr⁻¹ per harvest for the period 2000 - 2016.

Farmers are aware of the risk of losing soil, but they do not see erosion as a threat to production capacity of their soils [15]. An explanation for this could be that farmers are already partially implementing soil conservation measures like crop rotation and reduced tillage. However, despite current conservation efforts, soil erosion caused by water reduces global agri-food production by 33.7 million tones, incurring a global annual cost of eight billion US dollars to the global gross domestic product [27].

Globally, 10 to 20% of land is degraded, 52% of agricultural land worldwide is moderately or severely affected by soil degradation, and worldwide 75 billion of tons of arable lands are lost annually as a result of degradation [28]. Much of this degradation stems from management to optimize production and profit. However, sustainable management of soils can have economic returns; it is estimated that 75.6 trillion US dollars can be obtained from the adoption of sustainable practices, as well as the economic rates of return of invested capital can be 12 to 40% from the implementation such practices [28].

A major challenge for society is to improve agricultural production to achieve the increasing demand for food [24] without compromising environmental quality [29]. Any discussion about best management practices in the agriculture sector should consider, at least, the following four dimensions: agricultural practices; sustainable development; agricultural policies; and costs-benefits relations [29]. In some cases, the costs-benefits relations may be a constraint towards implementing best practices, however, there are several examples where the adoption of sustainable approaches is more profitable [29]. Anyway, preserving high-quality soils should be recognized as a policy target that surpasses the sole need for balancing economic interests [16,30].

Citation: Eloá Moura Araujo, et al. “Soil Plays a Key Role in the Sustainability of Agricultural Systems”. EC Agriculture 5.9 (2019): 545-549.
Conclusion

Besides the multiple ecosystem services delivered by soil, globally, the health of soils is under threat and soil degradation is reducing ecosystem services. Most of the soil degradation causes are provoked by mismanagement that leads to erosion, deforestation, compaction and sealing, pollution, salinization, urbanization and desertification. Pressures on soils and ecosystems have increased dramatically in the past century, resulting in high rates of degradation and loss of biodiversity, compromising billions of people and threatening the future sustainability of the whole planet. The alterations are fast, often not linear, and multi-causal, thus complicating mitigation strategies. To overcome these problems, sustainable management plans must be adopted that preserve and protect soil resources and optimizes ecosystem services. The plans need to include soils and its services in policy and decision-making programs.

Bibliography


Citation: Eloá Moura Araujo, et al. “Soil Plays a Key Role in the Sustainability of Agricultural Systems”. EC Agriculture 5.9 (2019): 545-549.
Soil Plays a Key Role in the Sustainability of Agricultural Systems


30. USDA NRCS. Soil Health.

Volume 5 Issue 9 September 2019
©All rights reserved by Eloá Moura Araujo., et al.