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Soil and land management in a circular economy

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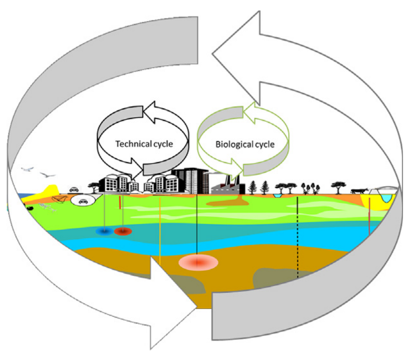
HIGHLIGHTS

- Soil as carrier of activities and landscape plays important roles in circular economy.
- Soil is scarce and non-renewable natural capital and its quality should be preserved.
- Increased use of biobased resources competes with land and soil for food production.
- Geo-energy may play an important role in the reduction of the use fossil fuels.

GRAPHICAL ABSTRACT



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ABSTRACT

This article elaborates the role of soil and land management in a circular economy. The circular economy is highly dependent on the functioning of soils and land for the production of food and other biomass; the storage, filtration and transformation of many substances including water, carbon, and nitrogen; the provision of fresh mineral resources and fossil fuels; and the use of their functions as the platform for nature and human activities. Resource demand is increasing as a result of the growing human population. In addition to the shrinking availability of resources resulting from their unsustainable use in the past, our planet's diminishing potential for resource production, due to a range of reasons, is leading to resource scarcity, especially in the case of depletable resources. As an economic system that focuses on maximizing the reuse of resources and products and minimizing their depreciation, the circular economy greatly influences, and depends on, soil and land management. The concise management of the resources, land and soil is thus necessary, to make a circular economy successful.

1. Introduction

In December 2015 the European Community introduced an action plan endorsing the circular economy called ‘Closing the loop’ (European Commission, 2015). The main aims of the action plan are to maintain the future provision of natural resources through their efficient use, including the reduction of resource use, the reuse of waste materials and the substitution of scarce resources as inputs with resources that are easily available and renewable.

The action plan has important interfaces with the EU 2020 strategy (European Commission, 2010) and its Roadmap to a Resource Efficient Europe (European Commission, 2011a), EU Biodiversity Strategy (European Commission, 2011b), the EU Soil strategy (European Commission, 2006), and European policy on agriculture (https://ec.europa.eu/agriculture/envir/cap_en) in terms of the better maintenance and management of natural resources.

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1.1. Circular economy

Within this paper we define the 'circular economy' as an economic system focused on maximizing the reuse of resources and products, and minimizing their depreciation. The circular system consists of two material cycles: (i) a technical cycle, and (ii) a biological cycle. The technical cycle relies on the use of mineral resources as production inputs, where products and their parts are designed and marketed in a way that they can be maintained and reused, maximizing their quality and their economic value. Within the biological cycle, resources used as production inputs have a biological origin, allowing for products to be safely discarded into the natural system once they reach their end of life. The system is meant to be both ecologically and economically restorative. (https://www.ellenmacarthurfoundation.org/circular-economy/overview/concept).

The circular economy may be viewed as a vehicle for organizing society to achieve the Sustainable Development Goals agreed upon by the United Nations. In this respect soil may play a crucial role (Keesstra et al., 2016).

In practice, cycles within a circular economy must not always be closed within the lifespan of one product cycle. Often remains from one product or process will be used as the resource material or energy input for another product or process, thereby reducing the dependence on unused resources and the production of waste. The organizational form of a circular economy would consist of a network, where, ideally, no fresh resources are taken up (consumed), and no waste is produced.

1.2. Why a circular economy

With growing world population, an expanding middle class and further urbanization, resource demand is constantly increasing. Additionally, the potential to produce and consume new resources cannot grow endlessly and may even decline as the Club of Rome stated already in 1972 in "The Limits to growth: a global challenge" (Meadows et al., 1972). This leads to resource scarcity, especially in the case of non-renewable and depletable resources such as minerals, fossil fuels and gravel.

The way soil is crucial for the circular economy can be analyzed from three different perspectives.

(i) Planetary boundaries. Coined by Rockström et al. (2009), an approach for addressing ecological boundaries on a global scale which has gained wide recognition is the 'planetary boundaries' framework, which can be seen as a description of the carrying capacity of the Earth. Planetary boundaries define constraints on biophysical processes under which humans can safely operate, and above which 'dangerous' levels are approached that may lead to disastrous consequences for humanity. To stay within the identified boundaries the overload of biogeochemical cycles, environmental pollution, and biodiversity loss must be reduced.

(ii) Integration within the social system. The second aspect concerns the integration of resource provisioning within a circular economy into the current societal system. For instance, the extraction of mineral resources within the technical cycle exerts pressure on the natural environment. Such activities have critical impacts on the landscape (especially open pit mining), biodiversity, and the quality of soil, waterbodies and air. Similarly the provisioning of bioresources to feed into the biological cycle competes with agricultural production of food and feed and can have severe consequences on society and the environment (Schneider et al., 2015; Vieira et al., 2016).

(iii) Land management. Land itself is a finite and shrinking resource, which has been put under further stress through land degradation. This affects its role within the biogeochemical cycles and other ecological functions, including its function as a provider of resources, and physical space for nature and human activities. These are some reasons as to why, EU policies with targets looking towards 2020 take into account the direct and indirect impact of land management on land use in the EU and globally (e.g. through land-use change indicators, Bos et al., 2016). Currently the rate of land take is on track with the EU's aim to achieve no net land take by 2050 (European Commission, 2011b).

In the waste phase of products negative effects are caused through disposal of resource residues in soil, water and air. The increasing environmental stress caused by the extraction of mineral resources, land use and degradation, (e.g. the production of biomass, or urbanization), the disposal of waste materials, and land and resource scarcity, are all important drivers for adopting a circular economy, stimulating the efficient use of resources and prevention of problematic residue production. In Europe the efficient use of resources is also a political spearhead, in the sense that it is necessary for improving the security of resource supply.

2. The role of soils and land in a circular economy

In this paper we define soil as "the solid part of the earth including liquid and gaseous compounds and organisms therein" in line with the definition used in legislative documents by various countries (Römbke et al., 2005). Here we include the top layer as well as the deeper layers of the soil. Soil performs a large number of vital functions, such as the production of food and other biomass products, and the storage, filtration and transformation of substances including water, carbon, and nitrogen. It has a role as a habitat and gene pool, serves as a platform for human activities, landscape and heritage sites and acts as a provider of raw materials, including fossil fuels and minerals.

Essentially, soil can be considered as a non-renewable resource, as the formation of top soil and the recovery of soil (and groundwater) quality are extremely slow processes.

In this context, the role of soils in a circular economy is especially important in terms of the contribution to the delivery of provisioning services and regulation and maintenance services as defined in de Common International Classification of Ecosystem Services (CICES) (www.cices.eu). It should be acknowledged here that soil is a scarce natural resource and an inseparable part of the soil-water-sediment-system. Practices are being developed to manage soil in such a way that desired services are enhanced without leading to irreversible damage to other services (Otte et al., 2012). The conceptualization and reification of soil ecosystem services provides an opportunity for equipping policy makers with insights on the societal functions that soils fulfill (Breure et al., 2012). For instance, the application of the ecosystem services concept can be useful and illustrating how the use of natural processes to solve societal challenges may reduce the dependence of technical solutions, thereby reducing the application of mineral resources and fossil fuel.

2.1. The role of regulation & maintenance services of the soil in the circular economy

2.1.1. Natural cycles

The increase in resource demand is leading towards increasing pressure and exhaustion of natural capital. This pressure negatively affects the functioning of ecosystems, with consequences for biodiversity and the services provided by ecosystems, such as climate change adaptation and mitigation, degradation of pollutants, prevention of erosion, and soil fertility. The restoration of ecosystems recovers the functioning of degraded soils to improve natural cycles. Soil plays key roles in the water and nutrient cycles through its influence on biological, chemical and physical processes that take place within the soil environmental compartment. It contains a significant portion of the freshwater stock, and large amounts of fossil fuels and soil organic carbon, which are