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VIEWPOINT

Rights-of-Soil

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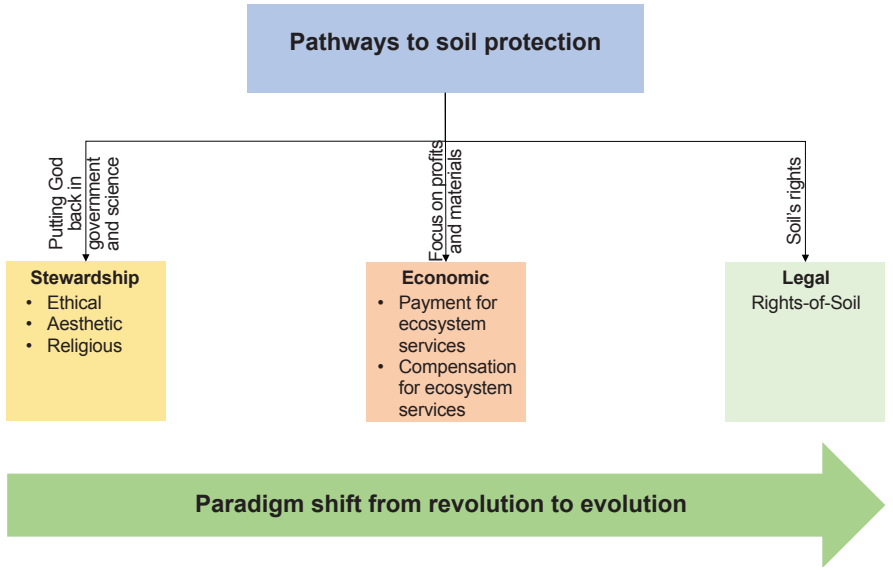
Soil is a finite and fragile resource. It is unequally distributed geographically and is prone to degradation and depletion because of the growing pressure to produce goods and ecosystem services for the rapidly increasing and progressively affluent human population. The global per capita arable land area was 0.37 ha (0.91 ac) in 1961 and is projected to be 0.17 ha (0.42 ac; and less than 0.14 ha [0.35 ac] in developing countries) by 2050 (Lal 2016). Productivity of the shrinking resource base is also being jeopardized by the ever increasing risks of soil degradation, already affecting 23% of the planet's land area (Bai et al. 2008), and the changing and uncertain climate. The anthropogenic climate change (ACC) has already caused global warming by 1°C (1.8°F) until 2017, and the global temperature is rising at the rate of 0.2°C (0.36°F) per decade (Ngo et al. 2019). As much as 75% of the Earth's land surface is already altered by humans, and 85% of the wetlands are lost (Ngo et al. 2019). Prime agricultural land is being encroached upon by urbanization, which has doubled between 1992 and 2018. Arable land area is also shrinking because of infrastructure development, especially in developing countries. For example, the paved road length is projected to increase by 25 × 10^6 km (1.56 × 10^7 mi) by 2050, with 90% of this expansion in developing countries (Ngo et al. 2019). Yet, the ever-shrinking soil resource is absolutely critical to advancing several Sustainable Development Goals (SDGs) of the United Nations, especially the SDGs 1, 2, 3, 6, 11, 13, and 15. Therefore, the need to protect and restore soil health and functionality is more now than ever before in human history.

There are three possible options of protecting the global soil resources (figure 1). The stewardship and incentivization options have been widely considered (Lal 2014) and are being attempted. A somewhat bold and innovative option is that of legal rights. Rights-of-Soil (RoS) implies that soil degradation, pollution, and depletion is a moral and ethical wrong that must be stopped. A similar concept is proposed for Rights-of-Nature or RoN (Chapron et al. 2019) and Rights-of-Lake Erie (Williams 2019). Just like the United Nations' Universal Declaration of Human Rights and the animal rights movement, RoS also implies that soil is a living entity; sustains life; and has a right to thrive, flourish, and be protected. Thus, the RoS is not based on economic benefits, but on protecting and restoring the soil for the greater good of the planet rather than just for the humanity. In this context, humanity is a part of nature, and it is in its own best interest that soil and its functionality are protected forever. Indeed, the RoS concept is more relevant during the Anthropocene than ever before, because of pervasive and persistent impact of humanity on the planet (Waters et al. 2016).

As the demand for finite soil and other natural resources increases, there is a growing need for innovative and bold institutional arrangements to protect these resources. Thus, recognizing and granting legal RoS can be similar to those enacted for RoN in Bolivia, Columbia, Ecuador, India, New Zealand, and the United States (Chapron et al. 2019). The Indian state of Uttarakhand has announced the rights for the Ganges and Yamuna Rivers (O'Donnell 2017). Similar concepts for legal rights are being discussed for some rivers in Australia (O'Donnell and Talbot-Jones 2018). Just as for rivers and other ecosystems (e.g., forests, mountains, lakes, and landscapes), soils must also have rights to exist, flourish, and be protected and restored. This would imply recognizing soil as an entity that has legal rights. Thus, communities would be authorized to bring litigation on behalf of soil against those who pollute, erode, deplete, degrade, or desertify soils. This does not imply that human use of soil is immoral, unethical, or illegal. Rather, land use and soil management practices which degrade, destroy, and pollute soil would be prohibited through legally binding proclamations. The concept of granting legal rights to nonhuman entities was first proposed in the early

Figure 1

Pathways to protecting soil (and nature) from inappropriate anthropogenic activities.



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1900s (Salmond and Williams 1902) and later in the 1970s (Stone 1972).

Therefore, the objective of this feature article is to address the concept of RoS so that human misuse that degrades and destroys soil health and functions may be declared unacceptable. However, the societal value of soil may be conceptually different.

RIGHTS-OF-SOIL AND PLANETARY BOUNDARIES

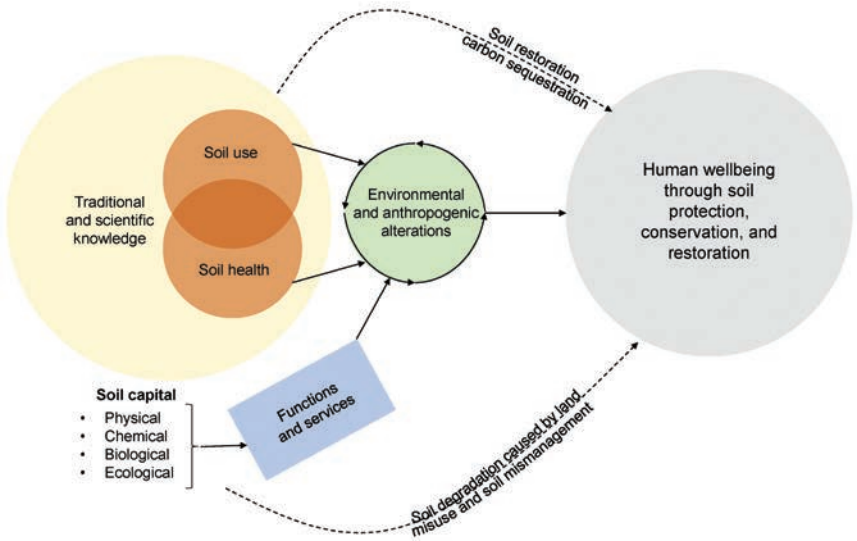
Just as anthropogenic activities that breach planetary boundaries are discouraged (Rockström et al. 2009), similarly identifying and quantifying soil boundaries that must not be breached would protect soil resources and encourage adoption of soil protective and restorative measures. Transgressing key soil thresholds (e.g., topsoil depth, soil organic carbon [SOC] concentration, and rate of soil erosion) could jeopardize soil health, undermine its capacity to support life, and thus, must be legally discouraged and banned to protect soil's self-regulating capacity or resilience. Thus, legal boundaries of soil as a natural body (Chapron et al. 2017) must be respected, and human-soil relations carefully considered and objectively assessed. The strategy is to promote soil as a living entity and support harmonic relation between soil and people, such as that between nature and people (Pascual et al. 2017).

Among a wide range of soil properties (i.e., physical, chemical, biological, and ecological; figure 2), protecting, restoring, and sustaining SOC stock is critical because of its numerous ecosystem services (Schjønning et al. 2018). It is essential that soil's self-regulating capacity or resiliency is protected and enhanced to strengthen the provisioning of goods and services (figure 3). Thus, legal boundaries of soil as a natural body (Chapron et al. 2017) must be respected. Some key soil properties, whose threshold limits must be defined so that these are not to be breached, are outlined in table 1.

The fact that as much as one-third of global soil resources are degraded, to a varying intensity, by a range of processes (Oldeman 1994; Bai et al. 2008), indicates that soil resources are taken for granted and thus abused and misused. Some soils are already extinct, and

Figure 2

Processes affecting the natural capital and the societal value of soil.



others are endangered (Wallace 1994; Ditzler 2003; Tennesen 2014; Bockheim and Hartemink 2017). As a component of managed ecosystems, some soils are endangered, and must be protected against land misuse and soil mismanagement that breach the "soil boundaries." Because soil has always been taken for granted, the "dirt" is no longer as common a commodity as it used to be (Yang 2003) prior to the Industrial Revolution.

Threshold limits of SOC and other key soil properties would depend on land use, climate, terrain, and the human dimensions. Once the threshold limits of key soil properties are agreed upon, these must not be transgressed. In addition to the agronomic consideration, threshold limits may also depend on the "societal value" of soil for diverse purposes, such as mitigation of climate change (Liu and Lal 2014). Of the total value of the world's ecosystem services and natural capital of US$16 trillion to US$54 trillion (an average of US$33 trillion y^{-1}) in 1995 (Costanza et al. 1997) and US$46 trillion in 2007 (Costanza et al. 2014), annual societal value of soil for all ecosystem services and natural capital may also be outside the normal market range. The loss of ecosystem services from 1997 to 2011 because of land use change, and the attendant soil degradation, was estimated at US$4.3 trillion to US$20.2 trillion y^{-1} (Costanza et al. 2014).

TRANSLATING ENVIRONMENTAL CONSTITUTIONALISM FOR RIGHTS-OF-SOIL INTO A PRACTICAL REALITY

There are a few examples of rights-based strategies to protect soil and nature. However, most of these initiatives are anthropocentric rather than eco-centric. Political, economic, social, and cultural rather than ecological values of natural capital have historically been considered to merit legal protection of ecosystems. The so-called "rights approach" (Brei 2013) can be adopted to addresses soil issues through the concept of legal and moral rights of soil. For example, the Ecuadorian constitution of 2008 has adopted an eco-centric approach and recognized enforceable rights of nature (Akchurin 2015; Kotzé and Calzadilla 2017). Legislation with regards to the "Rights of Mother Earth" also exist in Bolivia (Calzadilla and Kotzé 2018). This approach is indicative of the humanity's duties towards natural environment in general and protection of the soil resources in particular (Brei 2013).

There is a growing interest in ushering a paradigm shift toward environmental constitutionalism. Thus, as many as 75% of the world constitutions make some reference to environmental rights (Boyd 2017). Accordingly, humans must grant legal rights to nature (i.e., soil, trees, mountains, rivers, lakes, oceans, and atmosphere) and

Figure 3

Soil organic carbon (SOC) effects on physical, biological, chemical and ecological components of soil health. WSA = water stable aggregation. MWD = mean weight diameter. PAWC = plant-available water capacity. NPP = net primary productivity. ACC = anthropogenic climate change. MBC = microbial biomass carbon. CEC = cation exchange capacity.

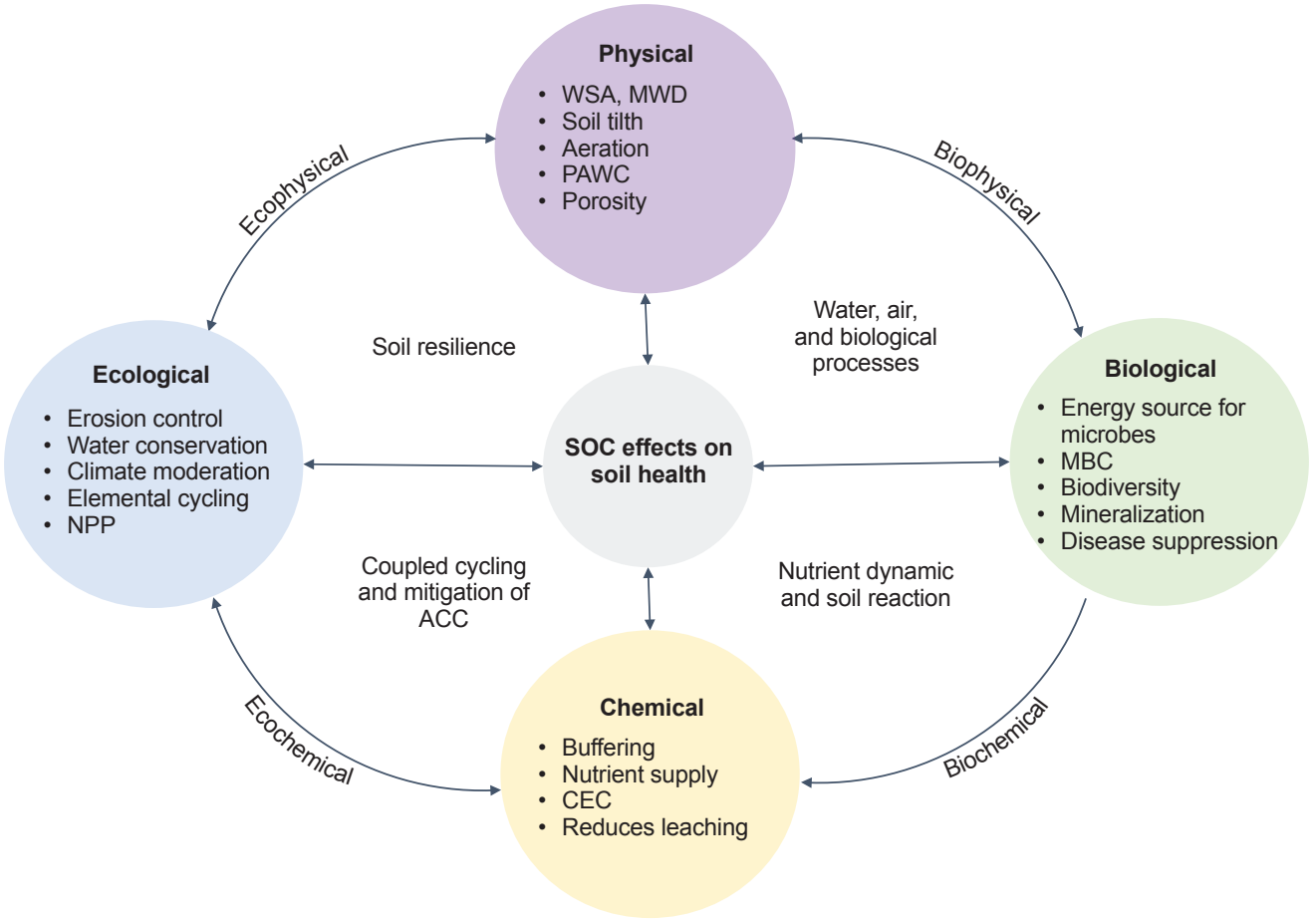


Table 1

Example of key soil properties of identification of threshold limits.

Soil parameters	Critical properties
Physical	Bulk density, aggregation, pore size distribution, available water capacity, effective rooting depth, infiltrability, heat capacity, erodibility, soil erosion rate, penetration resistance
Chemical	pH, electrical conductivity, cation exchange capacity, nutrient reserves, carbonates/bicarbonates
Biological	Soil organic carbon, microbial biomass carbon, enzyme activity, respiration quotient
Ecological	Potential erosion risks, gaseous flux

Notes: Soil organic carbon (SOC) concentration and stock is a key property that affects all parameters and the attendant soil processes. Rather than concentration/stock of SOC per se, the ratio of clay:SOC may be a better index for some specific processes (e.g., C saturation, aggregate stability).

all natural objects for the sake of what they are and not for their economic or material values. There is also a discussion regarding the aspirational Universal Declaration on the Rights of Mother Earth (Margil 2014). Thus, there are movements regarding the legal rights of trees (Stone 1972), forests (Joppa et al. 2008), biodiversity (Mace et al. 2018), rivers (O'Donnell and Talbot-Jones 2018), and lakes (Daley 2019). The exact nature of RoS will obviously require objective deliberations based on strengthening of the scientific knowledge of soil restorative processes, along with that of different theories of rights (Van Duffel 2012) and of the judicial processes (Berns 1982). Just as animals have rights (Jamieson 2008), so must soils as an integral part of nature

to follow the path of sustainable development (Kauffman and Martin 2017).

PAYMENT FOR ECOSYSTEM SERVICES

One of the strategies of protecting/restoring soil health and its functionality is through payments for ecosystem services (PESs) or compensation for ecosystem services (CESs) (figure 1) (Bremer et al. 2014), which is highly contested and a debated concept (Wunder 2005; Wunder et al. 2008; McAfee and Shapiro 2010; Dempsey and Robertson 2012; Muradian et al. 2017). This is an economic option to promote adoption of conservation-effective measures that protect and restore finite soil resources. Whereas the true value of soil and other natural bodies may be out-of-the-range of payment (Costanza et al. 1997), rewarding land managers compensates them for their commitment to protect and restore soil (Liu and Lal 2014).

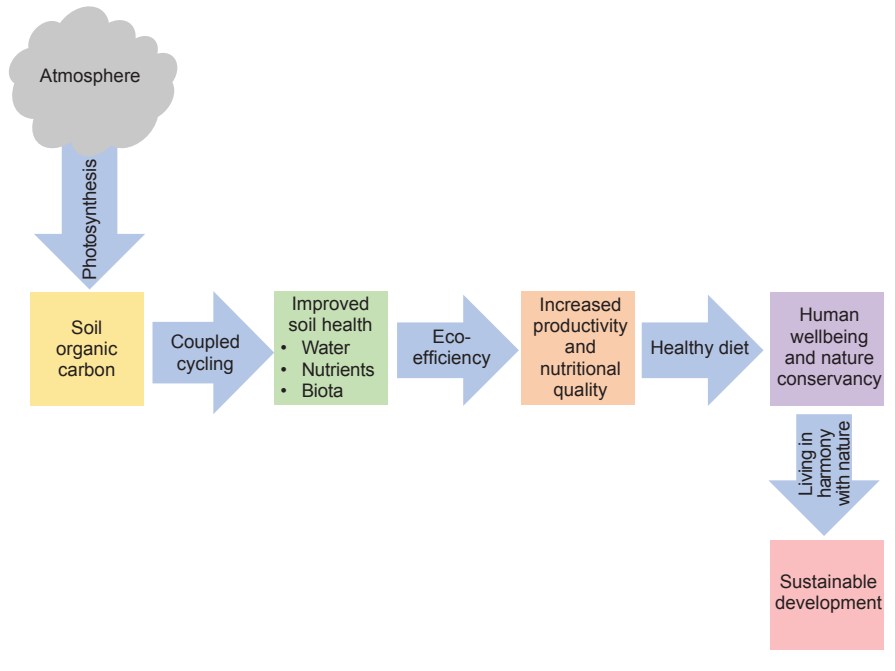
THE NEED FOR A PARADIGM SHIFT: FROM REVOLUTION TO EVOLUTION

There is a time for revolutionary ideas, such as the Green Revolution that was ushered in by Norman Borlaug during the 1960s and that saved hundreds of millions from starvation. It was a timely intervention that effectively addressed the need of the time. Exactly half a century later, however, we must revisit the global issues of the present era, especially those with regards to soil degradation, climate change, pollution/eutrophication of water, and extinction of species, etc. Presently, soils are being eroded, salinized, and depleted; forests logged and burnt; hilltops levelled for fossil fuel and minerals; wetlands drained; rivers contaminated; atmosphere polluted; and the environment desecrated in the name of development. The resource scarcity and environmental pollution thus created are the cause of conflicts, civil unrest, and eco-violence, especially in poor countries (Homer-Dixon and Blitt 1998). We are nearing the time of reconciling the need of advancing food and nutritional security of the growing and increasingly affluent human population with the absolute necessity of restoring degraded soils and improving the environment. Sustainable development and management of natural resources, especially those that cross national borders (e.g., rivers, fisheries, minerals, fossil fuel, wildlife, and climate), provide opportunities for cooperation, prudent governance, and peaceful coexistence in harmony with nature (Bruch et al. 2016). In the western economies, increase in wealth from fossil fuels accelerated the emission of greenhouse gases (GHGs), which were/are exacerbated by deforestation and unsustainable land use and soil management practices (Robinson 2018). There are several opportunities of bringing about the much needed paradigm shift, including the symbiosis of science and spirituality (Singh and Kaur 2006). However, efforts must be made to ensure that the connection between science and spirituality is not volatile (Knight 2004).

Soil and environmental restoration are slow processes that can only be realized at a generational scale of decades to centuries. Thus, this is the time to shift from revolution to evolution, not only for changing nature of the Christian right (Moen 2007), but for developing a philosophy and conceptual basis of RoS. Humanity is at a crossroads or the transition from human rights to those of nature in general and soil in particular. To be effective, these laws must not treat soil and other natural resources as property that can be abused, exploited, polluted, and degraded to get rich quick by cutting corners and making shortcuts. Rather than being the exploiter, humans should be an integral partner to pursue symbiotic relation of mutual coexistence (Borràs 2016). Humanity must recognize interconnectedness and work toward soil's right to be protected and restored while sustaining its vital biogeochemical and biogeophysical cycles. Thus, we must change from the anthropocentric to soil-centric approach in developing sustainable management systems (figure 4). Such an approach must be focused on the RoS based on the respect for soil with its own legal rights, a paradigm shift toward sustainable development. Global food habits are an important component of sustainable development. How we produce, process, transport, store, cook, and consume food affects all components of the environment: soil, water, atmosphere, terrain, biodiversity, etc. Therefore, consuming healthy food (plant-based diet) and producing it in a sustainable manner (using a soil-centric approach based on the concept of eco-intensification) are important to sustainable development.

Figure 4

Soil health and sustainable development.



RIGHTS-OF-SOIL FOR ADVANCING SUSTAINABLE DEVELOPMENT GOALS

Advancing several SDGs of the United Nations necessitate judicious management of soils of the world. Pertinent among these are SDG 1 (no poverty), 2 (no hunger), 3 (good health and wellbeing), 6 (clean water and sanitation), 13 (climate action), and 15 (life on land). There exists a strong interconnectivity between soil health and several of these SDGs. Soil and soil management has indirect impact on other SDGs including 5 (gender equality), 7 (affordable and clean energy), 8 (decent work and economic growth), 10 (reduced inequality), 11 (sustainable cities and communities), and 16 (peace, justice, and strong institutions). Despite the fact that soil matters in advancing most of the SDGs, the word soil neither directly appears in any of the 17 SDGs nor their specific targets. Perhaps the specific mention of the term "soil" was deemed to be unnecessary because of a broad understanding that none of the SDGs or targets can be realized without restoration and sustainable management of world soils. It is widely recognized that development may be more sustainable through implementation of RoN (Kauffman and Martin 2017). Being an integral part of nature, soil conservation and protection is critical to human wellbeing and existence.

CONCLUSIONS

The Anthropocene, the era since the beginning of agriculture, has pervasively and persistently altered Earth's environment and the life support system. Such a drastic impact warrants the need for an objective analysis of humanity's relation with nature to ensure that planet Earth remains habitable in perpetuity. Therefore, it is important to realize that humans are part of nature, and the latter is critical to human existence and wellbeing. It is in this context that the RoS to be protected, restored, and thrive are important to humanity and nature. However, RoS must be supported by enhanced awareness and change in global thinking. Similar to human rights, RoS must diffuse down to local communities, farmers, land managers, and policy makers. International laws and norms in support of RoS must be supported at domestic and local levels so that extractive practices of soil management can be replaced by sustainable and restorative systems. Soil scientists must work closely with policy makers to establish RoS in domestic and international laws and promote it globally as an emerging norm, especially through educational curricula from primary schools to graduate education, encompassing the education of judiciary and colleges of laws. The RoS must be based on integration of indigenous and spiritual concepts with scientific knowledge in order to formulate and implement appropriate policies. Further, there should be a strong link between RoS and SDGs, as both are intricately interconnected.

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