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Changing Ground: Handling Tensions between Production Ethics and Environmental Ethics of Agricultural Soils

Jan Diek van Mansvelt [1], Paul C. Struik [2,*], Arie Bos [3], Willem Daub [4], Diederick Sprangers [5], Mara van den Berg [6], Marieke Vingerhoets [7] and Kees Zoeteman [8]

1. Down2Earth Foundation, 1399 HS Muiderberg, The Netherlands; jandiek@vanmansvelt.nl
2. Centre for Crop Systems Analysis, Department of Plant Sciences, Wageningen University and Research, P.O. Box 430, 6700 AK Wageningen, The Netherlands
3. General Practitioner and Freelance Medical Writer, 1067 TD Amsterdam, The Netherlands; arieb25@planet.nl
4. Independent Researcher, 1862 DC Bergen, The Netherlands; willemdaub@gmail.com
5. Genethics Foundation, 6522 DP Nijmegen, The Netherlands; d.sprangers@genethica.nl
6. Wij.land, 1396 HJ Abcoude, The Netherlands; mjvandenberg@live.nl
7. Independent Researcher, 3971 GN Driebergen-Rijsenburg, The Netherlands; marieke.vingerhoets@protonmail.com
8. Het PON & Telos Institute, Tilburg University, 5038 ED Tilburg, The Netherlands; bcjzoeteman@gmail.com

* Correspondence: paul.struik@wur.nl; Tel.: +31-(0)-317-484246; Fax: +31-(0)-317-485572

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Abstract: Soils are an essential element in sustainable food systems and vital for ecosystem services. Soils are degrading, because of urbanization, poor soil management, depletion and mining, over-use of inputs and impacts of climate change. Poor soil management resulted from short-term yield maximization caused by changes in land tenure, property rights and land use. We argue for soil protection based on the concept of *soil telos* defined as the combined purposefulness in agricultural production and terrestrial ecosystem optimization. It includes the right of mankind to use soils, provided norms and values are respected based on the soil's usefulness, its natural purposefulness and its right to be protected (including its physical, chemical and biological cycles). Finding a sustainable balance between these values and rights on the one hand and the need to use living soils for agricultural production on the other hand requires a new approach to soil management based on widely accepted norm- and value-driven decisions on unavoidable trade-offs. Reconciling *man-made telos* and *natural telos*, requires (i) empowering the soil to achieve its *man-made telos* (e.g., by restoring degraded soils); (ii) empowering the soil to achieve its *natural telos* (e.g., by restoring water courses); (iii) raising awareness about the need to reconcile these two *teloi* (e.g., by acknowledging rights of soils); and (iv) monitoring tools to assess successful reconciliation (e.g., by evaluating soil health).

Keywords: food system; right of nature; soil ethics; soil health; sustainable soil management; telos

1. Introduction

Soils encompass the cover of the earth reaching from mountain tops to ocean depths and consist of minerals, organic matter, water and air; at the same time soils are living ecosystems involving a wide range of micro-, meso- and macro-flora and -fauna, such as bacteria, algae, fungi, nematodes and other microorganisms, as well as arthropods, earthworms and mammals. Quality of soils and of agricultural soils in particular therefore involves all aspects of the physical, chemical and biological fertility. The combined aspects of soil quality provide an identity to the soil ("terroir") and consequently also to products produced on that soil. This is acknowledged through the protected designation of origin of wines, cheeses and other products originating from a particular soil and its crops or vegetation.

Together with climate change and reduced availability of fresh water for agriculture, soil or land degradation is one of the most important threats agriculture has to face [1].

World-wide, soil fertility is being lost, i.e., agricultural land is degrading, as is demonstrated by the rapid increase in the area of degraded lands [1–4], and the related decline in agricultural production [5]. Land degradation is ubiquitous and strongly enhanced by increased population density, urbanization, changes in diet, changes in land use and climate change [2]. Land degradation is especially rapid in fragile environments, such as the Dry Arc, the temperate dry regions that run from Morocco through Northern Africa and Western Asia into China, where climate change will be more intense than elsewhere and where the amount of water available per inhabitant is frighteningly low and declining [5]. Land degradation results in multiple stress factors in fragile environments, for example through interactions between drought, heat, aluminum toxicity, acidification, salinization and loss of organic matter [3].

Soils have been managed for a long time. The well-known Terra Preta in Amazonia is a marvelous example of engineering of soils by pre-Colombian tribes with long-lasting beneficial effects that deserve to be copied in other parts of the world where soil quality is deteriorating [6]. In line with the above, the 68th UN General Assembly declared 2015 the International Year of Soils (IYS) [7] and the Food and Agriculture Organization of the United Nations was assigned to implement the IYS 2015. This task had to be done within the framework of a Global Soil Partnership, and in collaboration with Governments and the Secretariat of the United Nations Convention to Combat Desertification. The IYS 2015 had six objectives [8], which can be paraphrased as:

- To make sure that the general public and decision makers are fully aware of the importance of soils for the survival of humanity;
- To educate the general public on the significance of soils in relation to diverse and topical developmental goals, such as food security, poverty alleviation, climate change adaptation and mitigation, essential ecosystem services, and sustainable development;
- To help design and implement effective policies and related actions to manage soil resources in a sustainable way and to protect and conserve them for future generations;
- To enhance investing in activities that support sustainable soil management, aiming at developing and maintaining healthy soils for use by a diverse group of actors (e.g., farmers, foresters and nature conservationists);
- To strengthen any soil-related initiatives that can be interlinked with the United Nations Sustainable Development Goals and the UN Post-2015 agenda;
- To support rapidly enhancing the capacity to collect information on soil quality and to monitor changes therein, at different scales (global, regional and national).

These objectives clearly underline that—besides the quality of water and air—soil quality is one of the three components of environmental quality. They also show that the concept of soil quality is complicated with many ramifications into diverse aspects of our livelihood. Bünemann et al. [9] defined soil quality as "the capacity of a soil to function within ecosystem and land-use boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health (including human health)". Nowadays, the concept of soil health has become popular, which goes beyond soil quality. The same authors [9] also indicated that soil health especially relates to ecological attributes, which impact the soil beyond soil quality as defined above and certainly beyond its capacity to support the productivity of a certain crop. These ecological attributes are closely connected to aspects of the soil biota, the diversity of these biota, the food web structure of the soil, the soil's activity, and the range of functions the soil performs [9]. In short, soils are vital and complex ecosystems with unique functions that deserve protection, proper management and respect.

There are not only economic and scientific reasons for respect for (the complexity and identity of) the soil. Many, if not all, old cultures considered soil as something holy, incorporated soil in their religion and made it an element of their normative reflections. In the Central Andes, for example, local people still worship Mother Earth (Pachamama) as the protector of soil fertility. In this region there is a very strong Virgin Mary/Pachamama syncretism, which has a direct influence on the way these people farm, as Pachamama presides over planting and harvesting. Normative reflections on how to manage the soil based on a God-centered belief system are also very influential elsewhere in the world, especially in relation to conservation agriculture (CA), i.e., a farming system that prevents loss of arable land while restoring soil fertility and regenerating degraded land. The worldwide movement Farming God's Way (FGW; later renamed into Foundations for Farming) is another example. There is a wide body of literature on conservation agriculture, its relation to belief systems and contested agronomy (see, e.g., [10]). CA is centered around three aspects of soil management: no tillage, mulching and crop rotation. To some extent, FGW claims the same benefits as CA, relabels the CA principles by making use of religious notions, biblical metaphors and symbols, but also entails the faith-based networks among its proponents [11]. FGW also tries to change the lens of the farmer, through which (s)he interprets and understands the world, i.e., tries to change the farmer's world view. Thus, FGW may result in adoption of sustainable and climate-robust cultural practices [11]. Characteristic in these belief systems is the transcendent nature of the thinking about soils, as opposed to the more reductionistic way of thinking common in Western culture.

In this paper, we reflect on how the UN-FAO's Year of the Soil "Healthy soils for a healthy life" [8] woke the world's awareness for the immense eroding and poisoning effect that our culture at large has on the health of the world's soil ecosystems: the basis of our nutrition and carbon and nitrogen cycles. This particularly applies to the present practices in agriculture that often harm the soil ecosystem, as is visible in soil compaction by heavy machinery, declines in pH by poor fertilization practices, killing of microorganisms by applying herbicides, fungicides and pesticides, disturbing the soil microbiome by deep ploughing, disrupting the water, nitrogen and carbon cycles, etc.

We explore what soils mean to humans; moreover, we examine whether awareness of the importance of soils can be converted into respect for (the intrinsic value of) this essential resource thus opening up a new route towards holistic soil management based on soil ethics. We investigate whether soils have some kind of 'telos', i.e., a meaning of their own, in congruence with our previous paper on the telos of crop plants and farm animals [12], which could help provide a basis for value-driven choices in soil management.

The paper has been compiled by the team of authors through an iterative process of literature research, writing of narratives, commenting on these narratives, debating on the various emerging views, and asking advice from key informants over a period of 2.5 years.

2. Threats to Soil Quality and Health

With increasing urbanization, more and more lands around urban areas have been stripped from vegetation and covered by mineralized materials, which resulted in increasing petrification of green lands, enhancing erosion and flooding. This changing land-use resulted from urbanization, including industry, airports, parking lots and highways, and relied on increased mining for raw materials [13]. Soil compaction by ever more heavy machinery needing ever more heavy tractors in agriculture can be seen as a type of petrification as well [14,15]. In addition to the petrification of the soils, soil condition was and is also influenced by solid-waste dumping, resulting in contamination with excess salts, acidity, heavy metals, pesticides, antibiotics and other toxic or disrupting substances [16,17].

All these influences resulted in losses of naturally available nutrients and of fertile soil ecosystems, which were by far not sufficiently compensated by new natural or cultural formation of both. Thus, soil degradation and desertification are the overall result of human land cultivation, as mentioned by the UN-FAO in its IYS declaration [8].

A much greater cause of desertification, also mentioned by UN-FAO's IYS, is modern, industrialized, chemicals- and mechanization-based agriculture, which is precisely the type of agriculture that FAO supported for more than half a century [18]. Agriculture, although it is dependent on soil quality, became the main soil eroding human activity worldwide [19–22]. To secure and restore a safe and sufficient food production and ecosystem functioning, a new appreciation of the value of soils and how to manage soils is needed. The discovery of highly fertile, anthropogenic soils in the Amazon (Terra Preta; Amazonian

Dark Earth) contributed significantly to the re-appreciation of soil-building agriculture and soil legacy [6].

In Table 1 (based on [23,24]), we distinguish three types of soil degradation (congruent with the three types of soil fertility: physical, chemical and biological) and provide an overview of the different causes of these types of degradation, the main degradation processes, as well as their impact on soil processes.

Table 1. Types of soil degradation, their causes, relevant degradation processes and their impact on soil processes (adapted from [23,24]; reproduced with permission from Annual Reviews, Inc., San Mateo, CA, USA).

Type	Causes *	Degradation Process	Impact on Soil Processes
Physical	Deforestation	Breakdown of soil structure, aggregation and porosity	Reduction in infiltration capacity; Changes in soil-water retention characteristics
	Biomass burning	Crust formation and sealing of surface	Increase in rate, intensity and quantity of runoff
	Poor or excessive tillage or tillage under adverse conditions; Tillage up and down the slope; Excessive human, animal and machine traffic; Overgrazing	Compaction of surface and subsoil; Reduction in proportion and strength or stability of aggregates	Accelerated water and wind erosion; Increase in bulk density, resulting in poor porosity and poor infiltration; Water logging, resulting in anaerobiosis
Chemical	Irrigation with water of poor quality; Inadequate drainage	Salinization; Alkalization	Accumulation of base-forming cations
	Little or no use of fertilizers	Nutrient depletion/Soil mining	Decreased levels of macronutrients on exchange sites; Reduced soil organic matter content; Lower levels of nutrients in soil solution
	Excessive use of fertilizers	Acidification; Eutrophication	Leaching and runoff of nutrients to water sources
	Application of industrial or urban wastes	Contamination with heavy metals, other types of pollution/toxification	Excessive build-up of some heavy metals (such as Hg, Pb) or other elements (such as Al, Mn, Fe); Shifts in populations of soil-borne pathogens
Biological	Removal or burning of crop residues	Depletion of soil organic carbon	Reduction in N mineralization; Reduction in soil aggregation; Reduction in water retention and aeration
	Little or no use of organic inputs	Decline in abundance and diversity of soil biota	Shifts in species composition and diversity of favorable and harmful soil organisms
	Inadequate crop rotation, continuous cropping, monoculture	Loss of soil structure	Reduction in porosity and infiltration; Reduction in activity of favorable soil biota; Increase in harmful soil biota

* Not (always) one to one along the row.

From the above it is clear that soils, compared with other compartments of the environment, have their specific characteristics. Soils reflect the impact of human behavior on the environment over centuries. These legacy effects are essential for future soil fertility. It is also clear that soil fertility can only be maintained if organic matter is fed to the soils in order to create an active soil microbiome. This aspect alone already justifies a particular responsibility in the way we manage our soils. Thus, in this paper, we propose several concepts that can help design new strategies for sustainable soil management.

3. Soil as a System Component Deserves Respect

As was already realized in ancient agrarian societies, many scientists emphasize that soils are complex systems, but also part of a holistic reality and as such a component of an even more complex system. For sustainable soil management, it is essential that actors perceive the complexity of soils and are aware, using science-based data, of their importance as a vital component of a larger ecosystem. Caspari et al. [25] have emphasized the need for an awareness about the vital functions of soil and land. People whose livelihood depends on what soils allow them to produce will demonstrate a strong drive to protect and sustainably manage their land assets. The awareness of (and respect for) these vital functions should also become the norm among agronomists, politicians and decision makers. First of all, as Caspari et al. [25] pointed out, inaction in protecting this resource will entail tremendous costs and destructive consequences. Secondly, this awareness should be associated with respect for the complexity of the problems related to soil management and land degradation and, even more so, with respect for the complexity of a sustainable solution for land degradation. Thirdly, this respect should translate itself into the acknowledgement of the importance of a range of services that soil and land provide to mankind and therefore that soil management requires an ecosystem approach. Fourthly, these ecosystem services vary from place to place and are therefore case-specific. But with this variation there is also a cultural diversity, anchored in the histories of the communities making use of the land and the soils. This cultural diversity entails variation in local interpretations of land quality and soil quality and therefore variation in proper management. Consequently, there should be no global assessment of soil quality followed by a global instruction how to manage the soil best (see also [9]).

The respect for soils as valuable elements in ecosystems can be supported by detailed assessment of economic costs and benefits of land degradation, land restoration and land rehabilitation, as suggested by Keesstra et al. [26]. Such economic assessments will help securing returns on investment of existing or innovative profitable soil management practices. Keesstra et al. [26] therefore introduced four, partly complementary, concepts that are needed to support holistic decision-making regarding soil and land management, but at different levels of scale:

(i) systems thinking, essential for our understanding of the impact which sustainable use of the entire system may have on land management and land use changes;

(ii) connectivity to realize that land management and land use in one natural system may impact the behavior of a system with which it is spatially or geographically connected;

(iii) nature-based solutions, meaning that the specific characteristics and dynamics of a certain natural system are used to enhance solutions that are natural, resilient and sustainable.

(iv) regenerative economics, i.e., trying to manage land and soil in such a way that it will enhance its value instead of using it as a resource of which the value will degrade over time.

4. Towards Soil Ethics

Nature is a complex concept, with many diverse interpretations [27]. Views on nature very much depend on attitude towards and experience of nature, and on world view. These views therefore strongly vary among people with different beliefs and values, can be inconsistent and are certainly dynamic over time. Naturalness, a concept derived from nature, plays a significant role in discussions on ethics in many areas of societal debate (see e.g., [28]). Nowadays, natural is often seen as pristine, precious and ethically preferable above artificial.

In Western culture, the Enlightenment has been a major game changer in the world view at large and therefore also in the relation between humans and nature and between humans and soil. It caused an alienation from nature and a strong belief in science-based technology but this was also associated with a loss of respect for nature in general and for soil in particular. Chemical inputs that solved many short-term problems of low fertility, weeds and soil-borne pests and diseases degraded the soil. Soil was no longer seen as a fundamental part of the farm system, exchanging water and nutrients with plants and animals, and became an environment in which the crops merely anchored and a medium for uptake of externally applied resources such as water and nutrients. Similarly, changes in views on land ownership, and thus the right to exploit, strongly affected views on soil management with negative effects on long-term fertility [9].

Land area and soils—as existing natural resources—are integrated in a plethora of social constructs: views on privileges, rights and duties associated with ownership and propriety are very dynamic [29,30]. In modern times, privileges and rights have become dominant, duties are much less taken into account, and responsibilities are externalized to the public sector, and therefore soils have become a threatened resource.

The German bishops of the Roman Catholic Church published a position paper on the threatened soil [31]. The paper has been summarized in English by Hansjürgens et al. [29]. They argued that soil conservation is an issue for normative reflection in many cultures and religions (see also Section 1).

For our discussion, it is essential to comment on the concept of sustainability in agriculture. Sustainability and sustainable development—and therefore sustainable land use and soil management—have become leading principles in environmental ethics, including soil ethics. Zoeteman and Tavenier have summarized the history of the concept of sustainable development and elaborated that the concept rooted in the combination of the environmentalist movements and the economic growth movement [32]. They also showed the important role Christian theologists played in the development of the eco-justice movement, i.e., the movement that links environmental protection to social justice. We try to apply the concepts of sustainable development and eco-justice to soil health. According to Daly [33], two obvious and operational principles of sustainability should be maintained for the management of renewable resources. These include that harvest rates should not exceed regeneration rates and waste emission rates should not exceed the natural capacity of the ecosystems to absorb or assimilate the waste emitted in them. Daly considered these so-called regenerative and assimilative capacities “natural capital”, which should be “consumed” in a sustainable way [33]. Neumayer [34] contends that there is a central question in the debate on sustainable development: can natural capital (e.g., soil fertility) be substituted by other forms of capital? Proponents of a relatively weak concept of sustainability consider such substitutability possible. Proponents of a relatively strong concept of sustainability regard natural capital non-substitutable. These different views have a huge impact on the arsenal of measures considered necessary to realize sustainability, but also determine which indicators are most suitable to assess sustainability gaps.

Elaborating on the man-nature interactions, humans are seen as actors that often behave as the self-aware, ego-centered directors that manage nature according to their needs for biophysical survival and cultural elevation. Their attitude to nature may vary between the extremes of dictator and servant [35]. Compared with animals, their offspring is very limited in number as is their material service to the biotope. Recent decades have shown with increasing flagrance how the dominant attitude, that of dictator, devastates nature and the environment, climate included [36].

Here the rights as part of the Rights of Nature, based on the ideas of the Global Alliance for the Rights of Nature, are at stake [37]. Darpö [38] has elaborated the wide variety of concepts underlying the Rights of Nature. These include (i) the legal-philosophical aspect that stresses that acknowledging Rights of Nature means a paradigm shift in our attitude towards nature, from an anthropocentric attitude towards an ecocentric one; (ii) environmental constitutionalism, acknowledging that Rights of Nature should be included in international and national laws or constitutions to realize long-lasting protection and conservation of nature; (iii) providing natural entities so-called legal personhood; (iv) protecting the rights of indigenous people to use natural resources, while preserving biodiversity. However, it is essential to realize that Nature can only have Rights when we ascribe and assign them to Nature, and—when violated—claim and enforce them for Nature. Carducci et al. [39] provide a strongly worded framework for the legal recognition of the Rights of Nature within the EU legislation and make a plea for an “EU Charter on Fundamental Rights of Nature”. Implementing such a charter would change our land use system and our agriculture profoundly.

If we consider soil as part of our natural resources and as a resource that is—at best—only partly renewable, we will need to manage soils in such a way that they will be maintained at the same quality level for future generations. This has become a leading principle in organic farming [40]. The opposite—soil degradation and soil mining—can be considered as mistreating the planet and a crime against the natural world [29,41], but unfortunately was common in past agricultural societies, including societies in the Middle East, Ancient Greece, the Roman Empire, Easter Island, Mesoamerica, etc. [42].

Moreover, in the view of Barros Souza and Cravias [43], the land is imprescriptible and man is a steward entrusted with responsible management of the soil, allowing every human being to profit from its primary goods, products and services [29]. Responsible management requires maintaining soil health with respect for the soil, its capacity to be fertile, its ecosystem services and services to humanity and to the life forms it contains.

Paul B. Thompson [44] goes a bit further in his book entitled "The Spirit of the Soil". He invites farmers and environmentalists to find a common ethic that combines the productionist ethic with the ethic of preserving everything in its original state. A heated debate followed and was summarized in the publication "Author meets critics" [45]. In the latter, Carolyn Raffensperger claims that developing ethics might not change behavior, at least not in a timely manner, and instead makes a plea for a new standard, that of the Respectful Person, to bolster the precautionary principle in such a way that one can ground sustainability in the law. She states that respect gives deference to uncertainty and honors those elements that cannot be commodified. Mora Campbell, however, argues in the same article that the views of agriculturalists and environmentalists cannot be combined. The "balance of nature", which will allow an effective combination of preservation and production, is a myth, she claims, but there is an ethical choice to be made to decide which of the many possible configurations of the physical, chemical and biotic community is to be preserved. Sustainability is a framework for raising key ethical questions, especially related to the long-term effects of our way of farming. Sustainability also entails a functional integrity of the soil system. This is demonstrated by the soil management in organic farming, which very much aims at continuously increasing organic matter content and associated physical, chemical and biological soil fertility.

An important claim from Thompson's book is that ethical reductionism, most likely, was more common among scientists active in the recent past than scientific reductionism.

The dichotomy in the ethics of Thompson or—as others put it—his hierarchically ordered two-tiered system of ethics is exactly reflected in the disconnect between the two teloi which we defined in Struik et al. [12] and which we tried to reconcile. In this paper we will try to do the same for the soil telos.

"Telos" (from the Greek word τέλος meaning "end", "completion", "goal", or "intent") within the framework of soil management can be considered as the end or goal of a soil. According to Aristotle [46], telos involves a natural strive for existence. In the case of a soil, this existence involves its natural behavior and development, allowing the soil to manifest itself in different, natural forms, while playing a significant role in natural cycles of carbon, nutrients, water, and living organisms.

5. Introducing the Concept of Soil Telos

Free trade and open competition on the world food market creates a situation in which soil management is mainly driven by the need to increase economic efficiency [47,48]. An agriculture that is both socially inclusive and sustainable, however, requires a balance between and an integration of actions that respond to environmental, social and economic concerns (see, e.g., [49–52]). Sustainable and ethically just soil management makes it necessary that stakeholders are conscious of and knowledgeable in those concerns and let moral considerations play a role in soil management, based on generally accepted norms and rules. This will have to involve a drastic change in land use and soil management as the carrying capacity of the soil has already been surpassed [53].

Soil management should be carried out in such a way that the soil does not lose its value, i.e., we need to manage the soil in such a way that it will maintain, or preferably increase, its capacity, based on regeneration and maintenance of soil health, to deliver its services, including delivery of water, nutrients, ecosystem services, and related enabling factors for life. For that we want to introduce the utility part of the concept of “soil telos”, congruent to our earlier concept of telos of crop plants and farm animals. This element in the soil telos allows all men to use their right to benefit from this resource, taking into account certain norms and values and based on social justice for all current and future humans [48]. Maintaining soil health will allow the production of healthy food for people and healthy feed for animals.

But we argue there is also another part of the concept of soil telos, the intrinsic, non-utility part. In a previous paper, we analyzed the extent to which man shows respect for the farm animals and crop plants that produce food and other products for mankind, and whether man provides adequate care for them in return [12]. Concerns regarding this respect are justified, since farm animals and crop plants have become completely dependent on humans for their survival. However, those animals and plants, together with humans, depend for their survival on fertile soils. Is a similar need for care and respect justified for soils? To answer our question about roots of and reasons for respecting soils, we explore the concept of telos as we did with plants and animals [12]. In the latter study, we argued that from a biocentric, custodian position, farm animals and crop plants—as species, and therein as a specimen—possess a telos, a sense and meaning of their own. This entails some species-specific, biotic purpose, adding complementary elements to the well-known man-made telos, which is their perceived useful purpose for human use.

Based on both forms of telos, we deemed that farm animals and crops have ethical value and deserve human respect in the various ways we manage them. Otherwise, cultivation devolves into radical suppression. The more man domesticates animals or plants without the mentioned respect, the more both must sacrifice their natural telos to perform the telos imposed on them by man.

However, we also realized that man can create conditions that respect both forms of telos, by enabling the animals or plants he cultivates, to realize the essentials of their own, species-specific, natural biotope purpose in harmony with the objectives imposed by man. In other words, both forms of telos can be reconciled if man fulfils his ethical duty to support farm animals and crop plants in, for example, completing their biotope service, their production cycle and their flock service, in the time they produce food for mankind in the framework of mutual respect. Finally, we formulated some guidelines to give meaning to and operationalize the concept of telos. Thus, we shed a “New Enlightenment 2000” light on our connections with those two domains of nature [54]. Can the same be done for soils?

6. The Man-Made Telos of a Soil

Agriculture was up until the early decades of the 20th century basically about “building” land (land-bouw in Dutch). “Building land” here means making the soils more fertile for better harvests in the future [19–21,44,55–58].

A deep respect for the soil, as a living ecosystem, even a kind of being or entity (“terroir”, “our family’s land”, “Genius Loci”) was somehow present in the educated farmer’s basic notions. It is reflected in the value consumers give to local produce sold at farmers markets. A growing demand for local traceability of farm products indicates a renewed interest in farm and farmland identity. Some even scale it up to the identity, integrity and health of the entire farm [59].

As for soil tillage techniques, ploughing was only about opening the soil—Mother Earth—for restoring the balance between air, water and physical structures and for removing unwanted plants or crop residues. It originally was not about turning the soils upside down to bring fresh soil layers up and put worn-out top soils down as is sometimes done through deep-ploughing (see Table 1). Wearing soils out conflicted with the common intrinsic respect for soils. This ethic refers to soils from lands that were owned by people in families' history. Therein the challenging task of the farmer was to upgrade the soil's capacities for all its fertility functions, like water retention, carbon and minerals storage. It was literally a way of cultivating, of upgrading, "upbringing" the soils [60,61].

Manuring was basically about feeding the soil ecosystem by adding organic substrate for the soil's organisms (insects, worms, fungi, bacteria, etc.), in order to fill the soil-storehouse for the future crops to feed on, according to those specific crops' instantaneous demands. Soil was a plant-fiber (humus) based storehouse that prevented water evaporation as well as its leaching, losing nutrients, and thus soil erosion altogether [20,21].

Crop residues and animal manure were ideally mixed in order to rebalance the C/N ratio of manure down to soil compatible ratios. Composting was managed in order to facilitate the mentioned rebalancing and at the same time to store the local nutrient mix on the farm, for optimal soil manuring times in the seasonal crop growth cycle. Manure and compost were well-respected entities, referred to as "the gold of the farmer" [55,62], not a waste product with a negative value.

Thereby crops were familiar, well respected and trusted companions for the farmers. The latter selected the best crops' best seeds in an effort to upgrade them in their capacities to perform under the farm's and farming region's conditions. Thus, there were ever so many farm- and region-adapted varieties of all relevant species. Their experiential knowledge told them that crops were clever entities, "invisibly" feeding the next years' soils with their root exudates and residues, while at the same time, visibly, feeding themselves from the soil fertility that was built in by previous crops and manuring in the years before. Today we can specify in more detail the interconnections of crop-roots, and their cooperation with bacteria, mycorrhizas, earthworms, etc. [63].

Cattle were held to use grasslands, often communal ones, for human nutrition: ruminants were able to convert the low protein fibers, with their unique rumen-microflora, into high protein products, milk and meat. Their urine was very low in N and their manure quite high in carbon, as long as the protein in their feed was low (mostly crop residues from cereals). Thus, there was no serious cereal competition between man and cattle as there is these days. By feeding them more plant protein to have more protein in their milk and meat, that natural capacity diminishes and N-emission in urine and feces increases [64].

Like what was said in the crops section, here even more the partnership of the farmer with his varied livestock, his cattle and his horses, was intensely experienced. Partnership here was intensified to friendship or even brotherhood [12]. Heavy duty work was carried out with draught animals (horses, oxen, buffalos, camels, donkeys) but these were replaced by tractors and utility vehicles. This also changed the need to grow certain crops (e.g., oats for horse feed) or the possibilities to grow certain crops (e.g., crops that required deep ploughing to restore soil health).

It may be clear that the above representation of farming history takes an optimist, idealized view, as not all the world's farmers and agronomists share(d), or manage(d) to live up to, those ideals. Socio-economic market constraints brought them astray, and increasingly do so these days. However, if socio-economic conditions would allow them, most people involved in agriculture, then and today, would agree with the notions mentioned here. Externalizing costs of farming to other sectors in society, to other agricultural systems elsewhere in the world, or to later generations is both unsustainable and unethical [48].

The authors take the stance that increasing physical, chemical, and biological soil fertility, is an intrinsic objective of any sustainable agriculture. Man-made telos entails that the soil has an intrinsic, moral value, because the soil is capable of providing productivity and ecosystem services for mankind. This telos can only be fulfilled if farmers perform all the cultural practices required to support the soil processes that lead to the right soil quality and soil health to enhance crop productivity and health, and animal productivity and health, while contributing to the continuous cycling of water, nutrients and carbon in such a way that physical, chemical and biological soil fertility can be maintained or preferably improved. The soil therefore deserves our respect, and society also owes respect to those farmers who manage to improve their soils.

7. The Natural Telos of a Soil

In Struik et al. [12], we elaborated on the farmers' relationship with livestock and crops, to see how it reflects their mutual intrinsic goals or intentions ("telos"), asking ourselves how these could be matched by farmers, research and society. In that study we proposed that in nature, plants and animals have a double utility purpose. The first one is to survive and create offspring. The second one is to provide nourishment for the partners in the ecosystem they live in, from and for. As a clear indication thereof, we mentioned the large offspring surplus in animals and the immense seed surplus in plants. In both domains, acute overpopulation of the species would occur if "others" would not be fed with, or would feed on, that offspring. Respectful growing, harvesting and breeding plants and animals by farmers contributes to feeding the human population as well as to elevating or upgrading the species. This in order to create more quality or stature of the species in its relevant agro-ecosystem, its environment and its landscape.

Do soils also have their beings' own purpose, their natural telos in the sense as used in our previous paper on the telos of plants and animals? In the case of soil, we can perhaps call it purposefulness, but there is more to it. What is the essence of the soil? Lennox [65] used the term *causa finalis*, the end or purpose: the final cause of a change or movement of a thing is that for the sake of which the thing is what it is. For a seed, it might be an adult plant. For a soil it is to provide a rich and healthy medium to grow a crop or to maintain a natural vegetation and play a significant role in maintaining cycles of carbon, nutrients and water, while supporting diversity above and below ground. However, the soil's purpose is also to carry us: It is the ground on which we stand, live and work. It is also the source of building materials for human culture. Aristotle used the term *entelechy* for a non-perceptible principle in organisms leading to full actualization of what was merely potential. In his book "The Magic of Findhorn", Paul Hawken [66] described how intimate and spiritual the relations between men, soils and plants can become, to the well-being of all creatures involved.

Soils might perhaps be qualified as mothers, which would fit with the old notion of "Mother Earth" (Gaia in Greek, Terra in Latin, Pachamama in Western South America). Therein the whole fertile earth's soils are the primeval mother. Wherever on Earth, under the sun, "she" nourishes the whole food, feed and fiber chain—if people treat the soils appropriately. In line with this cooperative perspective on nature, altruism therein becomes increasingly discovered [67–69]. Biological sciences often use metaphors and concepts that are anthropomorphic; it is not difficult to extrapolate this to the soil ecosystem in all its aspects. Buchen stressed this [70] by illustrating that the soil microbiome is at the basis of the plant microbiome which has a direct influence on the human microbiome when eaten.

Based on one's own observations, one can see the livestock as, so to say, "generously offering us" their offspring, and the crops as immensely generous in offering us masses of seeds and fibers, and the soils as offering themselves unrestrictedly, completely, in feeding the vegetation. Soils even, in a sense, 'die' (metaphorically) by delivering their own structures' minerals and proteins in making them available for the crops' feeding themselves. They do so according to each crop's specific demands, as expressed by the crop's mycorrhizas, and then revive in integrating the residues of all crops and livestock in composting processes, on surface or in compost heaps. The soil's substance disappears into the plants, thence into animals and humans, and comes back in the form of manure and compost. The "invisible" soil-ecosystem's mostly microscopic animals and plants, although largely out of sight and minute of size, contribute to the soil's revival. A process that is more than "just" a revival, but actually an ongoing upgrading, as soils get more fertile by integrating organic matter.

The notion of living, dying and reviving soils is particularly important for our perception of desertification. Today's world-wide desertification, so disastrous for our climate and for our food production in itself, is not irreversible (see for example [71–74]). Deserts can be made fertile again by those who want to do so.

Thus, we define the natural telos of a soil as the balanced state in which all physical, chemical and biological processes can thrive and its natural services can be fulfilled in order to play its own role in the ecosystem. This is juxtaposed to the 'man-made' telos of a soil, being its use for our own survival.

So far, our elaboration on the natural telos of soils in agricultural use. Therein soils appear as biodiverse ecosystems, with all nature's kingdoms as well as minerals, water, air and organic matter involved as eco-partners, each in its own ratio, according to nature's laws.

At the end of this section, we summarize the characteristics of soils that constitute the natural telos.

- A soil is able to fulfil its natural telos when it demonstrates the capacity to capture and process within several years the natural and man-made products that have accumulated or have been added during the crop cycles and fallow periods or during the use and rest periods of the vegetation (as for example for grasslands and range lands).
- The soil should do so in such a way that it can contribute to the maintenance of the water, nutrient and carbon cycles as under natural conditions and accumulate organic matter, while offering home to micro-, meso- and macro-flora and -fauna, providing the ecosystem services to the best of its ability and supporting the development aboveground and belowground of rich, functional networks and food webs towards a balanced and desirable ecosystem that is also in balance with the surrounding ecosystems (e.g., water bodies).
- Aboveground diversity and belowground diversity interact and together create a similar or improved soil fertility compared with previous years.
- Making maximum use of this soil fertility [combined health], the natural telos should also be able to express the "terroir", the identity that is associated with the natural telos and developed into the local culture of soil management and land use, thus maintaining and enriching the soil's legacy in which the events of ages have solidified and have created a unique and morally valuable identity.

In the next section, we will focus more on the telos question this paper is about: how to reconcile the two forms of soil telos.

8. Reconciling the Two Soil Teloi: Guidelines for Operationalization

In this section, we will compare the man-made soil telos with natural soil telos, assess where they are in conflict with or congruent to each other, how we can reconcile the two teloi, if necessary, and come up with suggestions what kinds of actions operationalize this reconciliation.

The man-made telos entails the notion that soils have a moral value, because they support crop and animal productivity and provide ecosystem services. This utility telos is imposed by mankind and requires cultural practices carried out by farmers to enable the soils to perform their tasks at the time and at the level demanded by men. To optimize the soil's ability to serve mankind, both short-term (e.g., releasing nutrients, holding water) and long-term (e.g., maintaining balanced legacy effects) objectives need to be achieved, for which proper soil management (soil tillage, manuring, etc.) is required.

The natural telos entails the notion that a soil should be in a state of a natural balance with its environment (both aboveground and belowground) in which all physical, chemical and biological processes can thrive in such a way that the soil's natural services can be fulfilled in order to play its own role in the ecosystem, not only at present but also in the future. For that it also needs to reach a state of development in which it is resilient, robust and, most of all, very much alive.

It is important to realize that, to some extent, the man-made telos works against the natural telos. Exploiting the capacity of soils to deliver carbon, nutrients and water by growing crops or grazing cattle, automatically means that we extract essential elements from the soil, often more than are replenished by natural processes, at the same time cause shifts in bacterial, fungal and nematode communities and affect the ecosystem services soils can perform. Maximizing the man-made telos goes at the expense of the natural telos. This effect is stronger when exploitation coincides with soil degradation, but then both the long-term man-made telos and the short- and long-term natural telos are affected.

In fact, under responsible stewardship of farmers, the difference between the two teloi does not have to be so large, at least not on the long term, because both the man-made telos and the natural telos benefit from maintaining or even enhancing the physical, chemical and biological soil fertility, resulting in high soil quality and maximum soil health. It is the short-term profit taking that has induced land degradation and thereby created a discrepancy between man-made telos and natural telos of soils. Changes in land use, mechanization and the upscaling in agricultural production have imposed stresses on the soil that cause partly irreversible damage, such as soil erosion, soil compaction and soil contamination (Table 1).

Operational guidelines set out to reconcile both teloi are therefore mainly to prevent irreversible change and to provide opportunities for soil improvement.

Reconciling *man-made* or *utility telos* and *natural* or *intrinsic telos* requires (i) empowering the soil to achieve its *man-made telos* (e.g., by restoring degraded soils), (ii) empowering the soil to achieve its *natural telos* (e.g., by restoring water courses), (iii) raising awareness about the need to reconcile these two *teloi* (e.g., by acknowledging rights of soils), and (iv) monitoring tools to assess successful reconciliation (e.g., by evaluating soil health).

We list examples of guidelines in soil and landscape management that can be taken to reconcile the two teloi. The guidelines are divided into four groups.

1. Empowering the soil to achieve its *man-made telos* in a sustainable way:
    a. Restoring degenerated, desertified and eroded soils by planting trees, shrubs, crops and other vegetation. The loss of soils and of soil quality is often enhanced by or directly associated with the loss of vegetation growing on it. Plants reduce the impact of destructive forces (such as heavy rain), help keeping the nutrient cycles intact, support soil microorganisms and directly influence the fungal and bacterial composition of the soil in terms of species diversity and species abundance, thereby significantly affecting soil health. Replanting a suitable vegetation on degenerated or desertified soils greatly helps restoring the soils, as has been shown by the organization Commonland [75]. This is an eco-justice approach to realize the utility telos.
    b. Introducing agricultural policies that protect soil health and fertility and restore degraded soils. This is probably one of the most effective, yet at the same time one of the most elusive ways to promote sustainable land use. Agricultural policies can be very effective in enhancing soil quality, including soil fertility and soil health. However, agricultural policies have significantly contributed to the current decline in soil quality, in many different ways. Changes in land tenure and the feminization of agriculture world-wide are also crucial factors. For a sustainable impact of policies, trade-offs, social justice and moral choices require balanced choices on long-term objectives and effective instruments to reach those objectives [48]. Such choices require a societal debate on norms and values with all stakeholders involved, including farmers, conservationists, agrochemical industry, breeding companies and others. This is a social-justice approach to realize the utility telos.
    c. Introducing financial instruments to make products from soil-protecting agriculture cheaper than those from soil-degrading agriculture. Financial instruments are essential and effective tools in many policies, including the agricultural policies mentioned under b. Financial incentives determine whether a farmer can afford to farm based on soil conservation techniques and whether the consumer can afford to buy his products. Again, this is a social-justice approach to realize the utility telos.

   d. Expanding the previous guideline results in empowering agricultural production systems that comply with the above recommendations, for example, by effective government support for non-eroding, non-poisoning soils and their collateral environment (taxation of harmful emissions); penalties for mining too much of the nutrients from the soil (e.g., affected by the crop rotation) and other types of soil degradation; and rewards for crop rotations and actions enhancing diversity of soil life. This is a combined eco-justice and social-justice approach to realize the utility telos.
   e. Another way to empower these agricultural production systems is by embedding them in the local communities and the local markets, thus enhancing the resilience of these production systems and supporting the "license to produce". This is, for example, demonstrated by the concept of Community Supported Agriculture (CSA) [76]. Another citizens' initiative was started in the village of Duiven (Netherlands), where inhabitants are aiming to buy an area of 100 hectares of existing agricultural land, sell 5 hectares of it for building ecological houses and use the income from this to realize regenerative agriculture on the remaining 95 hectares, including a food forest [77]. A stunning, although involuntary, example of the effectiveness of local markets in this respect is the political isolation of Cuba after the collapse of the Soviet Union, which has led to a large degree of food autonomy, with most of the farms in Cuba being organic [78] and the country ranking 9th out of 164 in the Sustainable Development Index [79]. This is a social-justice approach to realize the utility telos.

2. Empowering the soil to achieve its natural telos:
   a. Restoring natural water courses and systems in combination with adequate vegetation. Good water management is vital for living soils and their restoration and maintenance. An impressive, positive example of this is Sekem [80], the farm and associated community and institutions in Egypt, built in the middle of the desert, starting by digging a well. A negative example is the Aral Sea [81]: when the rivers feeding it were diverted for irrigation purposes, the Aral Sea (once the fourth largest lake in the world) dried up completely, leaving extremely salty and polluted soils behind and driving the population into unemployment and poverty. This is part of an eco-justice approach to realize the natural telos.
   b. Acknowledging, in line with this paper, that the improvement of soil (ecosystem) fertility contributes not only to the quality of the whole food chain but also to climate balancing and carbon sequestration. (cf. Section 8, references [71–74] and the Special Report of the International Panel on Climate Change on this topic [82]). This is also part of an eco-justice approach to realize the natural telos.
   c. Facilitating means of feeding the soils' ecosystems with crop residues (rich in carbon) and manure (enriched with carbon), in a way that facilitates the natural cycling and distribution of carbon, nitrogen, phosphorus, potassium, other minerals and organic matter. Natural cycles avoid imbalances of distribution, like eutrophication. This is part of an eco-justice approach to realize the natural telos.
   d. Screening the whole animal and plant production system for the input of toxins (pharmaceutics, animal health protection and plant protection products etc.) that harm the health of the soil ecosystem, with all its micro-, meso- and macrofauna and flora; and to remove or reduce these toxins. Today's screening is rather insufficient as for example can be seen from vanishing meadow birds, due to declining insect populations, but also disturbance of the balance of the soil ecosystem. In several places, citizen science groups have set up a system of toxin monitoring, but to reduce the soil contamination, new, strict policy rules

are required. Current policies, for instance, often do not take cumulative or even interactive effects of multiple toxins into account. This is a combination of an eco-justice and a Right of Nature approach to realize the natural telos.

3. Raising awareness about the need to reconcile the two types of teloi will benefit from:
    a. Reconsidering, in line with this paper, that soils should be given rights as part of nature [75], based on their natural telos and their man-made telos and acknowledging the pivotal role of soils in agriculture and ecosystems. These rights should be implemented in practice at all levels, in science, in politics, land management, nature conservation and agriculture at large (landscape, forestry etc.). This is part of a Right of Nature approach to reconcile the utility and intrinsic telos.
    b. Shifting the regulatory burden from non-polluting farmers (organic, biodynamic etc.) to polluting ones. This is an implementation of the "polluter pays principle", which is strongly supported in OECD and EU countries and is a fundamental principle in US environmental law. This is part of a social-justice approach to reconcile the two types of telos.
    c. Introducing and stimulating the use of the criterion 'embodied land' for the sustainable manufacturing of any product. All aspects of any manufacturing process on earth can be expressed in terms of the quantity of land needed to make a product. 'Embodied land' [83] is the sum of the land area used in a given period of time to (1) produce the energy and materials required for the manufacture of a given product, (2) manufacture the product and (3) restore the resources and supplies used up. This calculation is called the "MAXergy" method, because it is a tool to maximize the 'exergy' of any given product. Exergy is the work potential of a system containing energy and matter. When energy or matter (including land) is used in any way, its work potential (exergy) is reduced and must be restored if the process is to be sustainable. Expressing exergy as land area ("embodied land") will raise awareness of the need to reconcile the two soil teloi by emphasizing the quantities of land used, thus hopefully contributing to sustainable land use. This supports the realization of social justice in land use.
4. Providing monitoring tools for successful reconciliation requires:
    a. Making an inventory of monitoring tools for the quality assessment of soil ecosystems. Criteria defining the quality of soil ecosystems need to be established. The concept of the two soil teloi can support this. Next, assessment and monitoring methods need to be developed. This also supports the realization of eco-justice, Right of Nature and social justice in land use.

Further research will undoubtedly contribute to additional instruments to take better care of one of the most important natural resources we have and for which we should have respect, based on its utility telos for mankind and the moral value of its natural telos.

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