



## A simple definition of soil

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### ABSTRACT

This paper presents a simpler definition of soil that reflects three aspects: ontology (what), epistemology (how), and axiology (value), which are related to the construction of the definition. Soil is the loose mineral or organic material comprising three phases solid, liquid, and, gaseous, found on the surface of the earth (ontology), resulting from weathering processes through interactions of the lithosphere, atmosphere, hydrosphere, and biosphere (epistemology) serving as a habitat for micro and macro-organisms, plants, and animals, and ultimately supporting human life and civilization (axiology). This simple definition brings more attention to human soil interactions and build sustainable solutions for soil and civilization in the future.

A short article, 'Define soil' by McBratney and Hartemink published in the Soil Security Journal in March 2024 has offered a new paradigm in soil science. This article seemed to be the culmination of discourse about the future of soil science in papers entitled 'The future of soil science' and 'A soil science renaissance' (Hartemink, 2006; Hartemink and McBratney, 2008). For decades, soil science has primarily served the field of agriculture, as evidenced by the myriad definitions of soil since the early 1800s and expressed in two modern soil classification systems (van Es, 2017; Hartemink, 2016; IUSS Working Group WRB, 2022; Soil Survey Staff, 2022), even though many soil scientists realized that soil science served a broader scientific discipline.

The soil science community holds wide views on soils. They have been defined as: a three phase system by soil physicists; reactors of chemical properties and composition by soil chemists; stores and transformers of plant nutrients by soil fertility specialists; buffers and filters of water by hydrogeologists; a natural resource that degrades and under threat by environmental soil scientists; a medium for small fauna by microbiologists and soil biologists; a storage tank and transformer for organics and inorganics by biogeochemists; a functional element in ecosystem services by ecological soil scientists; an element of the landscape by soil geomorphologists; objects of individual study by most pedologists; soil as a natural capital by ecological economists; soil as a building material by engineers; soil as an forgotten, unseen and underfoot element (by pedo pessimists) (Hartemink, 2016).

In an anthropogenic era marked by ecological destruction and linked societal crises, soil has emerged as the hidden foundation for resolving these crises. Soil, often overlooked, has become recognized as a crucial

issue, evolving into soil security, which underpins five vital aspects of human civilization: food security, water security, climate change mitigation, biodiversity protection, ecosystem service delivery, and energy sustainability (Koch et al., 2013). Soil scientists may bring more attention to human-soil interactions and build sustainable solutions for soil in the future (Krzywoszynska and Marchesi, 2020).

McBratney and Hartemink proposed two definitions of soil one shorter and one longer single-sentence definitions. Soil, in the shorter definition, is 'the layered material at the earth's surface, which has resulted from chemical and biological processes and physical organisation of minerals and organic matter, and which supports terrestrial ecosystems and humanity. Meanwhile, soil in the longer definition is 'the horizonated mixed solid, liquid and gaseous material at the earth's surface, resulting from chemical and biological processes and physical organisation of minerals and organic matter which interacts with the atmosphere, lithosphere and hydrosphere, and which operates within, and supports, terrestrial ecosystems including biodiversity, plants, animals, and humanity. The authors also requested that others create and share concise definitions also in a single sentence in order to achieve ultimately general consensus, acceptance, understanding and use (McBratney and Hartemink, 2024).

The definitions of soil can be framed in different ways, and an attempt is made to unravel the basis of these definitions based on what soils are, how they are formed, and how the definitions differ for different groups of soil scientists. There are approximately six aspects of soil that determines its definition: 1) material (organic, inorganic, clay, sand, etc.); 2) composition (threephase system: solid, liquid, gas); 3)

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origin (broken-down rocks, geology, diluvium, alluvium, etc.); 4) behaviour (dynamics, changes over time); 5) medium for properties and processes (carbon storage, water filtration); 6) functions (biomass production, carbon pool, building material) (Hartemink, 2016). However, creating a simple definition with detailed information on six aspects in a single sentence is complicated and difficult to understand, especially for the public.

Here we present a simpler definition of soil which reflects three aspects: ontology (what), epistemology (how), and axiology (value), and which are related to the construction of the definition. Science, both natural science and social science, has three components as pillars supporting the body of knowledge, namely ontology, epistemology and axiology. In short, ontology is about the what question (Smith, 2022), epistemology is about the how question (Wenning, 2009), and axiology is about the value question (Hart, 1971). A simple definition should be capable of summarizing a wide range of perspectives from soil scientists, and it should be able to explain at least three aspects of the pillars of knowledge as outlined in this paper. The sentence structure of the definition may vary, but it should still encompass ontology, epistemology, and axiology, either sequentially or non-sequentially.

Based on three above pillars, soil is the loose mineral or organic material comprising three phases solid, liquid, and, gaseous, found on the surface of the earth (ontology), resulting from weathering processes through interactions of the lithosphere, atmosphere, hydrosphere, and biosphere (epistemology) serving as a habitat for micro and macro-organisms, plants, and animals, and ultimately supporting human life and civilization (axiology).

Therefore, the definition of soil is 'the loose mineral or organic material comprising three phases solid, liquid, and gaseous, found on the surface of the earth, resulting from weathering processes through interactions of the lithosphere, atmosphere, hydrosphere, and biosphere serving as a habitat for micro and macro-organisms, plants, and animals, and ultimately supporting human life and civilization.'

In the author's opinion, the phrase '...resulting from weathering processes through interactions of the lithosphere, atmosphere, hydrosphere, and biosphere...' implicit describes the soil formation process, which is the basis of the soil science discipline according to Dokuchaev and Jenny. The term 'processes' implies the time factor (t) during weathering by climate (cl), organisms (o), and relief (r). Meanwhile, the distinction between mineral and organic refers to the parent material (p) as well as the final form, whether mineral soil or organic soil. This definition also emphasizes the value of soil, which not only medium for growth of plants but also serves as a habitat for micro and macro-organisms, plants and animals, and supports human life and civilization.

Certainly, the simple definition above can be expanded into three definitions of soils based on three aspects, providing more detailed information. In this paper, the authors have attempted to offer some options about it. *First*, the definition of soil in being or ontology is a natural body of loose mineral and organic materials comprising three phases—solid, liquid, and gaseous—found on the surface of the earth, differentiated into horizons of variable depth, differing from the material below in morphology, physical, chemical, and biological characteristics.

*Secondly*, the definition of soil in process or epistemology is product of weathering and reorganization of the earth's surface material such as rock, plant and animal residue, through interactions of the lithosphere, atmosphere, hydrosphere, and biosphere with unique physical, chemical, and biological process.

*Thirdly*, the definition of soil in value or axiology is the skin of the earth, serving as a habitat for micro and macro-organisms within its layers, plants and animals above its surface, and ultimately supporting human life and civilization.

We have attempted to create this simple definition to support soil security for better soil policy in the future (Koch et al., 2013) and to be adequate for bringing more attention to human-soil interactions and building sustainable solutions for soil in the future. However, improved definitions may continue to evolve dynamically, keeping pace with advancements in soil science and the evolving needs of society concerning soil.

## Author statement

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## CRediT authorship contribution statement

**Destika Cahyana:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Budi Mulyanto:** Supervision, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

No data was used for the research described in the article.

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