What is soil health? How to assess it?

Soil health is a widely used term in discussions about sustainable agriculture and soil management to describe the general condition of the soil. In this context, soil health emerged in the early 2000s and, today, has linkages to the emerging "One Health" concept, in which the health of humans, animals, and the environment are all connected.

According to the NRCS (USDA), soil health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. Soil health encompasses scales, stakeholders, functions, and assessment tools relevant to soil quality and fertility and shares some of the policy dimensions of soil security. There is a broad understanding that soils not only support crops but also underpin other essential ecosystem services, such as climate regulation, nutrient cycling, flood regulation, carbon sequestration, water purification, and habitats for microorganisms. This understanding manifests the importance of proper soil management to be sustainable for future generations. Lehmann et al. (2020) state that several other related concepts to soil health (national scale) exist, including soil fertility (local scale), quality (regional scale), and security (global level) (Figure 1).

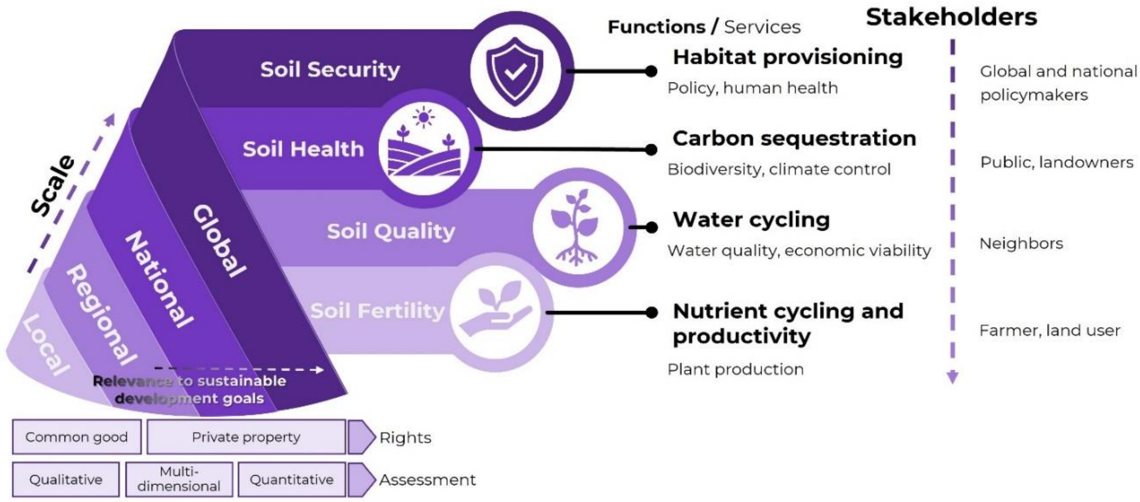


Figure 1. Relevant spatial scales, functions, ecosystem services, and stakeholders of soil security, health, quality, and fertility. The concepts also differ in the view of soil rights and assessments. Source: Adapted from Lehman et al. (2020).

Soil health is a concept that encloses ecological soil attributes associated with the soil microbiome and the range of functions it performs. Moreover, soil health encompasses the living and dynamic nature of the soil. One teaspoon of soil contains more living microorganisms than people in the world. Typically, there are 100 billion bacteria in 5-7 grams of soil. Without this "biological diversity," no terrestrial life on Earth would exist. Farming practices that minimize soil disturbance, maximize soil cover, biodiversity, and continuous living roots, and make the most efficient use of external inputs are practices that follow soil health and conservation agriculture principles (Figure 2). Considering the context of the geographic location is as important as the other principles since climate patterns, soil type, landscape, and land-use change across space. Contemplating local markets, supply chains, and agricultural suitability are also essential aspects to contextualize when implementing farming practices that pursue soil health principles.

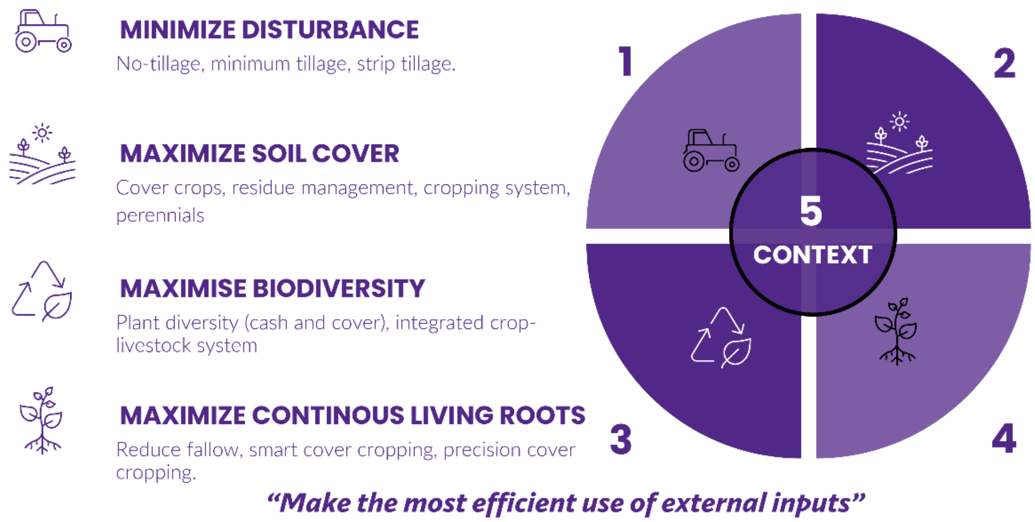


Figure 2. Soil health and conservation agriculture principles.

The goal of soil health and conservation agriculture principles is not the restoration of the native, pre-agricultural ecology and its biological functions. Instead, it aims to harness ecological processes inherent in nature and integrate them into an agricultural system, thereby enhancing the overall health of the farming system through reliance on biological interactions and ecosystem services. To achieve this, researchers have proposed the use of farming practices such as minimum tillage (no-tillage, strip tillage), cover cropping, crop rotation, nutrient management, and crop-livestock integration, among others. Overall, these practices will also increase the resilience of agriculture to weather variability, water infiltration, nutrient cycling, soil aggregation, soil biodiversity, and economic stability and security through improved soil health (Figure 3).

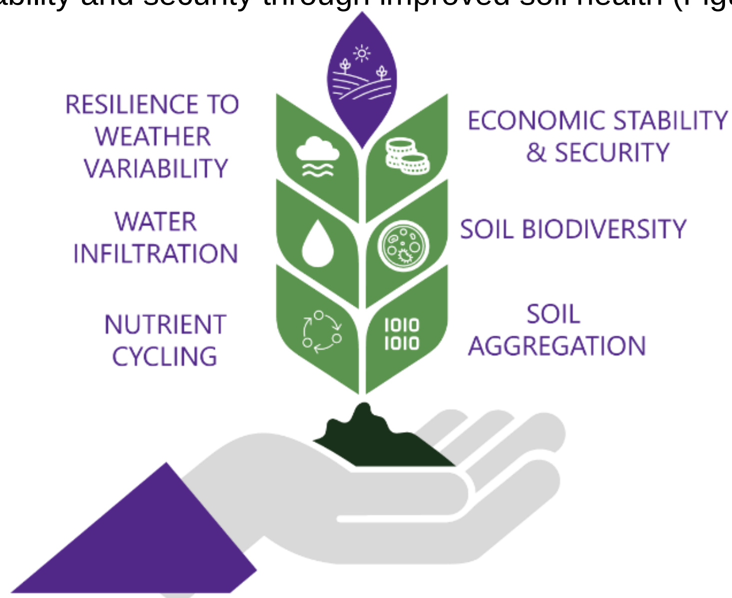
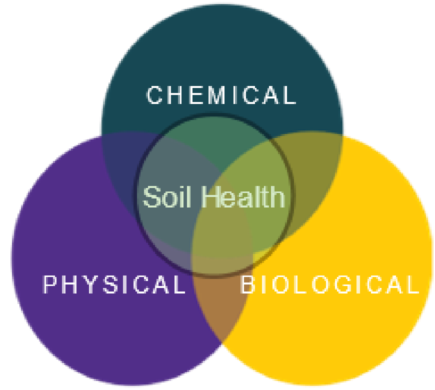


Figure 3. Soil health benefits.

Soil Health Assessment



A soil health assessment determines how soils perform all of the functions and how those functions are being preserved for the future. While crop yield is one outcome of soil health, it incorporates other soil functions that affect nutrient efficiency, water quality, and climate resilience. Soil health indicators include biological, physical, and chemical properties (Figure 4). These properties result from soil-forming processes, such as geological parent material, time, slope, orientation, depth, climate, and organisms. On the other hand, management practices affect dynamic properties, such as nutrient levels, moisture, pH, land cover, bulk density, aggregation, and porosity. Some soil properties, such as temperature, bulk density, and aggregation, can be both inherent and dynamic. Overall, soil health indicators are measurable properties that allow interpretation on a relative scale by monitoring changes over time in relation to standard reference values. Standard values can be soils from native ecosystems or non-degraded souls. However, using reference values from a standard reference soil may not represent the optimal value a managed system can achieve after undergoing management. Soil health indicators should be management-sensitive, time-sensitive, interpretable, and valuable.

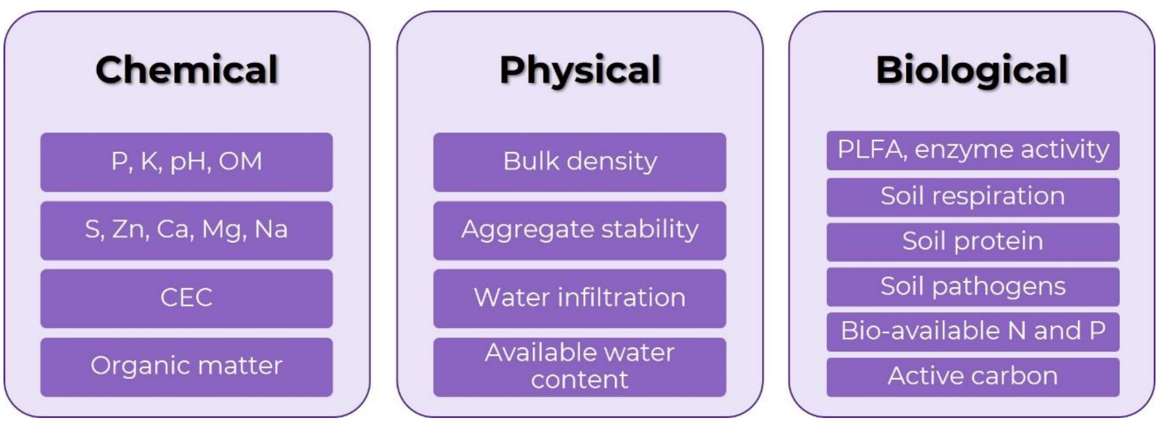


Figure 4. Soil health indicators. *PLFA: phospholipid fatty acid analysis.

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Glossary:

- Atmosphere: The envelope of gases surrounding the Earth or another planet.
- Lithosphere: The rocky shell of a terrestrial planet.
- Hydrosphere: The combined mass of water found on, under, and above the surface of a planet.
- Biosphere: The zone of life on Earth. The sum of all ecosystems.

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