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Policy Brief
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A framework for setting soil health targets and thresholds in agricultural soils

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- Four approaches to setting soil health targets/thresholds identified and compared
- Case studies highlight the need for flexible, context-specific and data-driven approach
- Framework proposed for use in monitoring programs to support soil health

Introduction

Soil health, the current capacity of soils to provide ecosystem services (Faber et al., 2022), is at the centre of the European effort to reverse soil degradation (Panagos et al., 2022). Soil health is defined through soil indicators, which are assessed using targets (desirable values to reach) and/or thresholds (critical values not to overpass) (Fig. 1). The challenge is that targets and thresholds are highly site-, management- and climate-specific, and there is not yet a validated assessment system with that level of detail (EEA 2023). With policies worldwide being established to promote soil health, there is an urgent need for the development of a system to assess soils.

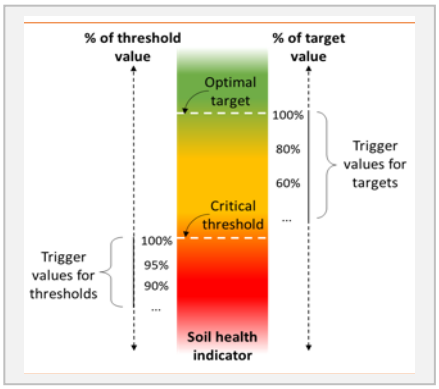

Figure 1. The difference between thresholds and targets for assessing soil health indicators.

We explored **four approaches to setting targets and thresholds** (Fig. 2). Based on stakeholder feedback of the approaches, collected in two webinars (EJP SOIL 2023) and case studies of three approaches (not including relative change; Fig. 3), we developed a framework (Fig. 4) that facilitates both choosing the most appropriate target/threshold method for a given context, and using targets and thresholds to promote soil health.

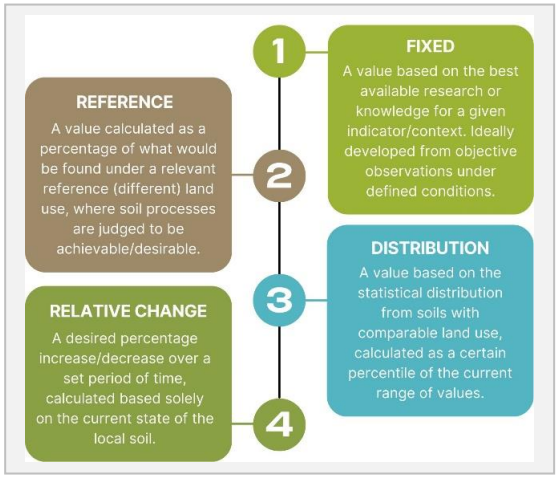

Figure 2. Descriptions of four different approaches to setting targets and thresholds for soil health indicators.

Comparison of Approaches

The four approaches were presented during two EJP SOIL Policy Forums (EJP SOIL 2023). In participant polls, the reference approach was identified as desirable, but relative change was considered the most feasible approach.

Using a **fixed value** would be the simplest approach, but these values are simply not available for many cases. The most significant drawback to the **reference** and **distribution** approaches is that assigning percentages or percentiles is arbitrary.

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The **reference** approach also requires a relevant situation, with a meaningful and achievable value, for comparison with an agriculturally managed soil. The **distribution** compares a population of soils with itself, so no separate reference required, but targets/thresholds are highly subjective and sensitive to soil degradation, which can skew distributions. At farm scale, **relative change** is simple: no stratification, no large data sets or references, and the choice of analytical techniques is open, assuming it is consistent over time. The weakness is that while it provides a fixed-term benchmark, it has no clear end point, and cannot provide explicit information on whether soil health status is good enough.

Case Studies

The fixed, reference and distribution approaches were explored in agricultural soils of Denmark, Italy and France (example for Denmark shown; Fig. 3), with soil organic carbon (SOC) as an example soil health indicator. Fixed values were taken from EEA (2023). Reference values were 50% (thresholds) and 80% (targets) of grassland SOC. Distribution thresholds/targets were set as the lowest/highest 12.5% quantile of the population. In Denmark, targets and thresholds from each approach had different total 'at-risk' land areas, but identified similar regions. This highlights that while quantiles and percentages are arbitrary, they can provide flexibility to tailor the identified area to unique aspects (i.e. intervention budget) of a given soil health assessment.

Across all case studies (see Matson et al. unpublished data), three key issues affected the targets and thresholds:

- Degradation: to identify degradation potential of references/distributions, knowledge of soils, land-use history and management is needed
- Stratification: the unit of assessment (i.e. division by soil type, climate, management, etc,) should reflect the scale and purpose of assessment
- Data availability: the collection of sufficient, relevant, high-quality data is crucial to meet the needs of different contexts

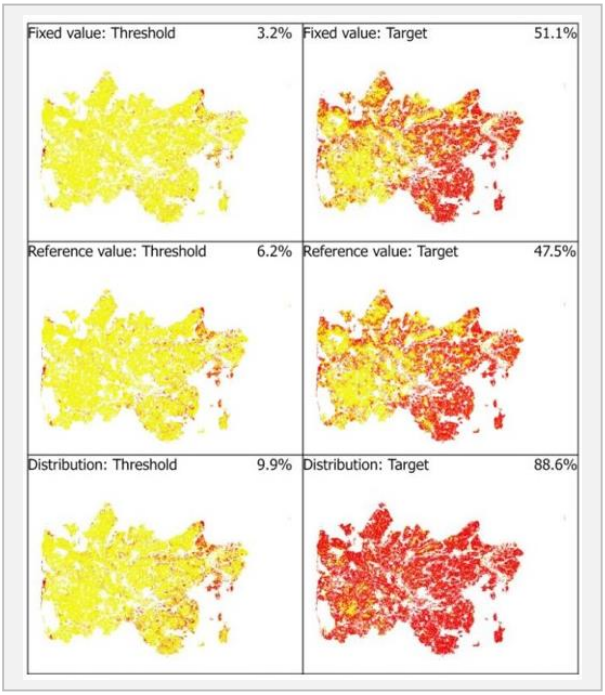

Figure 3. *Soils potentially at risk for carbon deficiency (shown in red and as a percentage of total agricultural area) in Denmark.*

Supporting Policy

Establishing systems to monitor the state and trends of soil health was among the four urgent actions proposed by the UN ITPS to tackle and reverse soil degradation (FAO and ITPS 2015). Soil monitoring is also included in the EU Soil Strategy for 2030 (Panagos et al. 2022) and required as part of the 2023 Soil Monitoring Directive (EU Commission 2023). Assessing soil data is an essential companion to soil monitoring. The proposed framework capitalizes on the strengths of the four approaches, to provide a flexible yet harmonized target/threshold and soil assessment system.

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KEY MESSAGES FOR POLICY MAKERS

Recommendation One: Plan soil health assessments jointly with relevant stakeholders

Each approach can provide meaningful targets/thresholds. The choice of approaches will strongly depend on data availability and context. While some aspects of context may be clear (i.e. ecosystem, soil threat, scale of assessment), stakeholders can further define i.e. required accuracy, user flexibility, time-scale or urgency, which will also inform the choice of approach.

Recommendation Two: Link the framework to a tiered soil health approach

While the proposed framework is relevant to any assessment, at any spatial scale, it is particularly well-suited for integration into tiered indicator assessments, providing the necessary link to logically trigger additional tiers.

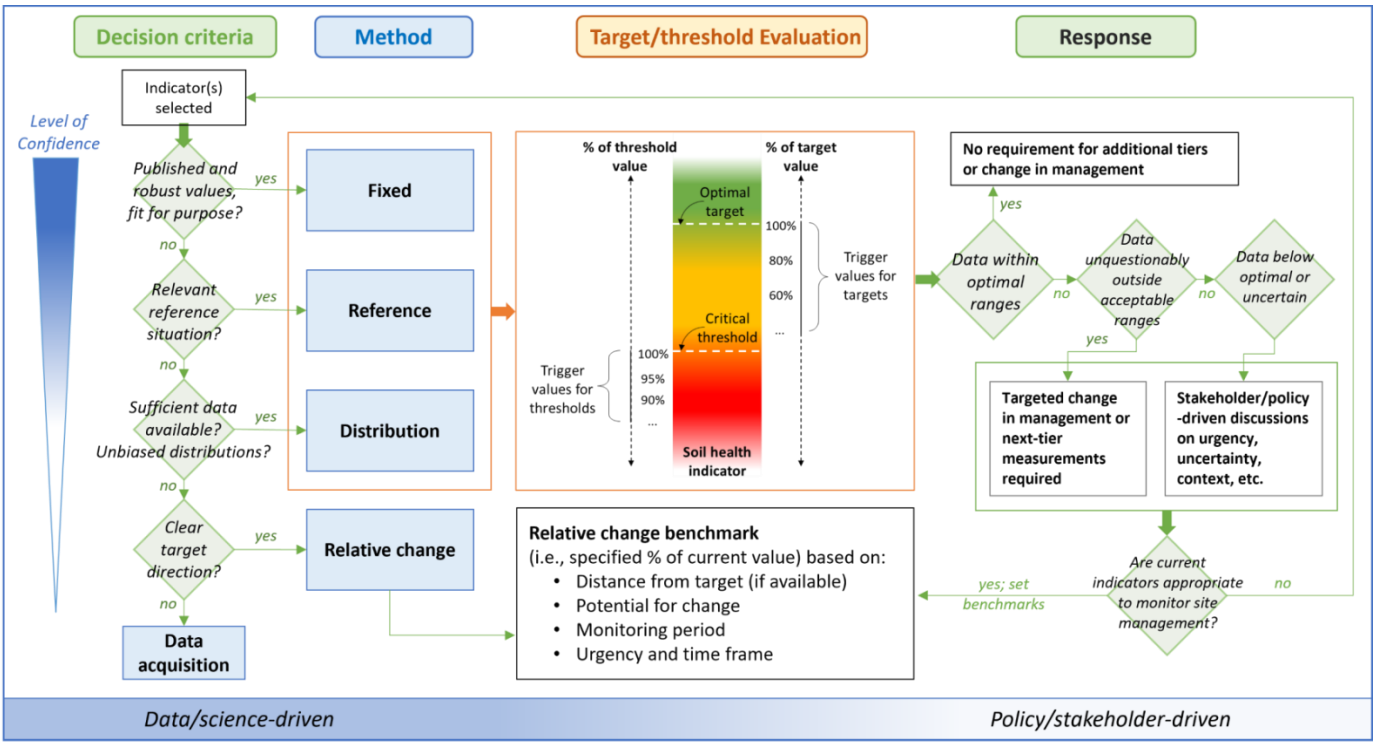

Figure 4. A framework for the selection/use of targets and thresholds for soil health indicators. The decision flowchart starts with the selection of a method, followed by an evaluation of data using trigger values (percentiles against which data is compared to assess how far it is from the target or threshold). Triggered responses may be changes in management or further data collection.

ASSESSMENT FRAMEWORK

We propose a framework (Fig. 4) to support the choice of target/threshold approach within the context of a soil health assessment. The suggested order starts with the simplest approach (research-based, fixed values), if there is sufficient knowledge for a *robust, fit for purpose* value. If not, the framework moves on to the reference approach, if a *relevant* situation exists. The popularity, simplicity and objectivity of this method, combined with the lower risk of a relevant reference being influenced by degraded soils, are why this approach is presented before the more subjective distribution approach.

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When a reference situation is not possible, the frameworks moves to distribution (given appropriate data) and finally to relative change, identified as the most feasible in the polls. When data is completely lacking, or there is uncertainty about the direction of desired change, a final option is to start with data collection until requirements are met for one of the four approaches.

Following the selection of an approach, the framework proposes the assessment of soil indicator data using percentiles, to normalize across multiple indicators and indicate how far soil data is from the target/threshold. These 'trigger values' address the question: "How good is good enough?" and would be decided by governance authorities and stakeholders, rather than science. Following this evaluation, if the current indicator(s) are insufficient to assess soil health, a next tier of indicators may be implemented in the potentially at-risk areas (by returning to the beginning of the framework flowchart) to acquire additional information. If the current indicator(s) are sufficient to assess soil health, management changes may then be implemented and a site may be monitored.

The relative change approach has a central place in the framework, as it can be chosen as the main target/threshold approach, or can be linked into one of the other approaches as the final step of the framework. The framework assumes that monitoring soil health improvement will take place using relative-change benchmarks. Using fixed-term benchmarks will ensure that soil health improvements are context-specific, accounting for the many differences that might affect soil processes and thus how quickly soil indicators will change.

By monitoring soil data against targets and thresholds over time, it will be possible to identify trends and assess the impacts of land use changes, management practices and even public policies. This can then guide the development of new/improved policies and practices that promote and protect soil health.

References

EJP SOIL webinars are available online at: https://ejpsoil.eu/science-to-policy/soil-health-indicators-webinar

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