Developing a robust soil health indicator selection framework

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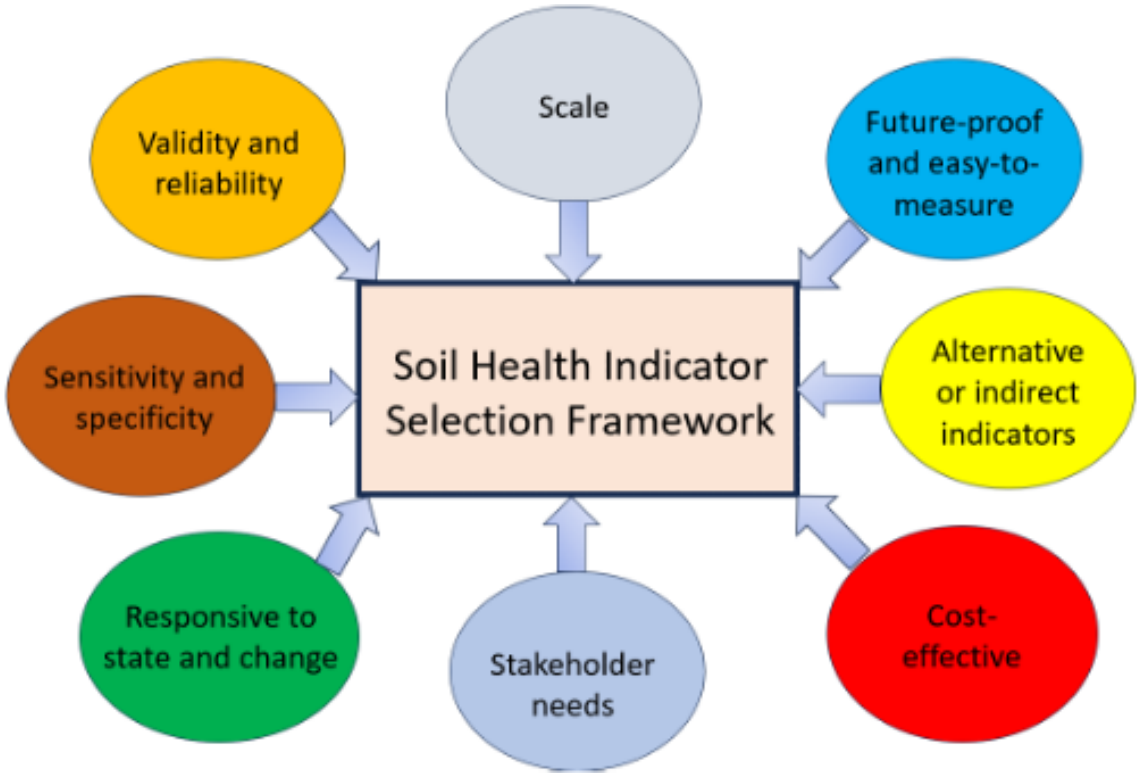

Figure 1: Soil Health Indicator Selection Framework for AI4SoilHealth

The EU Soil Health Monitoring Law proposes twelve main soil indicators for reporting soil health. There is a need to ensure that these indicators and other subsequent measures are robust for their purpose

Effective soil health indicators must measure both the state and change of the soil metric over time.

Since there is no single indicator for soil health, a robust framework for selecting indicators using agreed-upon criteria is needed[1,2]. A summary of the selection framework criteria is discussed below and summarized in ***Figure 1.*** This framework is based on synthesizing accepted and tested methods to assess current indicators and provide a basis for selecting new ones in the future. Selected indicators will be dependent on their ability to assess soil ecosystem functions and services[3].

Targeted context-specific indicators responsive to state and change

Soil health indicators must be relevant to the context of study and their response to state and change[1] to address specific, targeted questions. Indicators must be easy to interpret and identify temporal variation. They should have a strong connection to soil functions, threats, or ecosystem services and can be gathered across various habitats (e.g., forestry, agriculture) and specific soil types (e.g., peats, bare soil)[3].

Indicator sensitivity and specificity

Indicators must address the question of interest and be sensitive enough to determine the state and detect change over time. Statistical methods can be used to determine sensitivity and power analysis can be used to determine how many samples are required to determine a level of change. Some soil health indicators have large uncertainty[1,2], which renders them ineffective since too many samples might be required to detect the response. Indicators should not be selected if they have high spatial or temporal variability or high uncertainty from sampling error.

Indicators sensitive to long-term management change are useful for determining soil health or degradation[3]. Commonly, metrics such as soil organic matter, carbon or soil pH have been monitored over time at local to national scales, but some indicators are less well established. The sensitivity of biological indicators is uncertain, their sensitivity to specific drivers or pressures can be harder to ascertain, and often supplementary measurements are required to measure activity occurring in the soil[4]. Indicators should be able to determine state and change in a consistent way over space and time and independent of the observer or laboratory used to determine them.

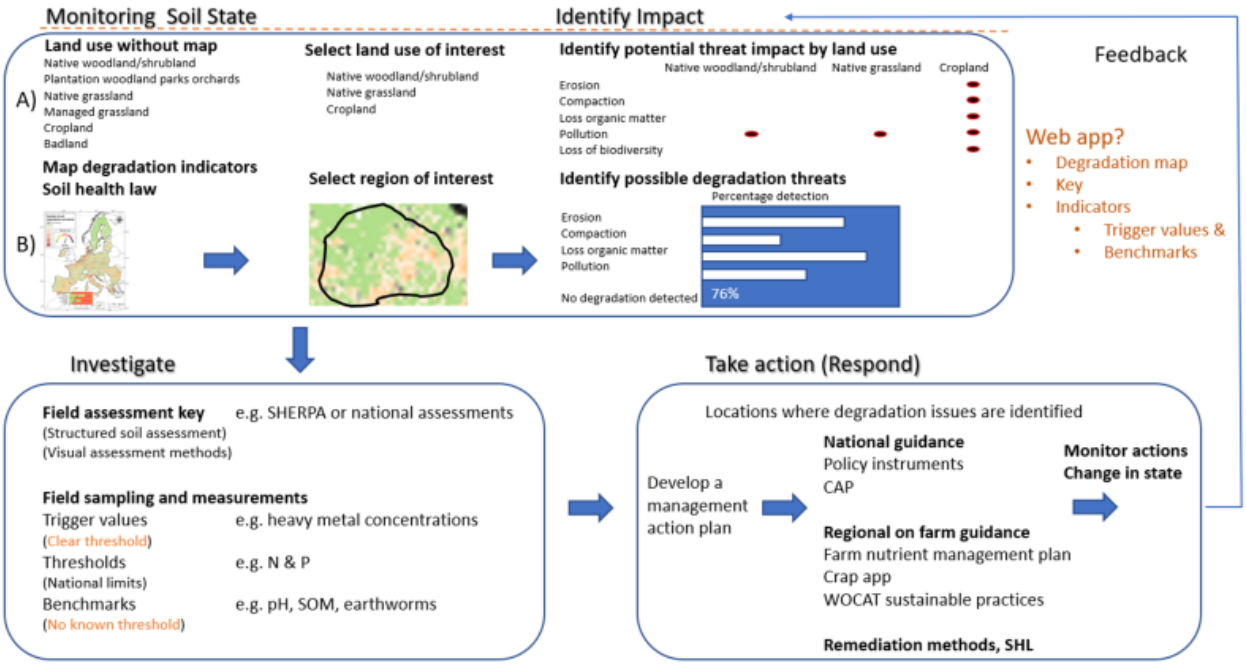

Figure 2: Flowchart for effective Soil Health Assessment in AI4SoilHealth.

Threshold, Trigger and Benchmark Values: What's most appropriate?

An assessment of indicators can be undertaken in different ways[7,8].

The first of these is through identified ***threshold values.*** These are determined through national policy and can be a single value or the critical limits of a range of values. These can be used in soil health assessments to better inform and examine the extent of soil degradation. ***Trigger values*** are thresholds that can provide a warning for further investigations. These are often used in conjunction with soil pollutants and heavy metal concentrations. ***Benchmark values*** can be used where there are no known thresholds accepted. These are obtained from the statistical distribution of the indicator sample population. Benchmarking can be a useful management tool and may guide a stakeholder to look for alternative practices. Finally, a change in a metric beyond certain values may indicate a function outside of a normal operating range.

Selecting easy-to-measure, future-proofed and cost-effective indicators

Indicators should usually be easy to measure and cost-effective, though some indicators may need to be selected because they are the most appropriate for addressing important questions[1,2]. Future-proofing selection is important to maintain utility. Some measurements offer exciting potential, but changes in techniques over 5–10-year time cycles may render them unsuitable to detect change over time. Simple, proven, robust measures such as pH are preferred for the long term.

Balancing the cost of monitoring with the benefit of improved decision-making and outcomes is critical. This may mean choosing between direct and indirect methods of soil health assessment. Data should be readily available or easily obtainable at a reasonable cost; establishing baseline measurements initially can be cost-effective, allowing repeat measurements to be scheduled[5].

Using alternative or indirect indicators of soil health Surrogate metrics, such as the area of bare soil, can indicate risk to soil health and prove useful. However, these should only be selected if they provide appropriate understanding across one or more soil functions[2]. When measurement of a specific soil indicator is considered too expensive or difficult to gather, pedotransfer functions can provide proximate value(s) using metrics such as carbon and texture[3].

Other considerations:

Scale and Stakeholders Different indicators might be needed at different scales. Visual assessment of soil can be useful at the local scale to inform stakeholders about soil structure and degradation. Stakeholder needs will be crucial in identifying which indicators are appropriate(6). Indicators need to be continually reassessed to determine if they address an important question and whether they provide benefit now or in the future.

AI4SoilHealth approach to soil health assessment

While AI4SoilHealth will provide a pan-EU assessment, outcomes are most useful when they can also be interpreted locally. Different ways of approaching assessment are described below and in ***Figure 2.***

In the first box monitoring the soil state, AI4SoilHealth is developing digital tools to interrogate data across scales which will be useful for the concept of soil management districts in the future.

A region of interest could be selected, and the number of soil degradation indicators determined that need to be addressed to improve soil health. Alternatively, a stakeholder could select the relevant land use(s) and be able to identify the various threats associated with that land use in the region.

In the second box investigate the region of interest, this might include using a simple field assessment key, or more detailed sampling investigation. Samples from national survey or those collected locally might be interpreted by thresholds, trigger values or benchmarks. Depending on what is found, response action may be required. Action can be undertaken using national guidance, regional or farming guidance or by including practices proposed by the Soil Monitoring Law.

Monitoring any actions will be crucial for determining success. The development of this soil health indicator selection framework and assessment approach will be helpful for working towards meeting the eight European Union (EU) Mission Board targets. This will provide a platform for choosing future indicators aligning with and supporting the implementation of the Soil Monitoring Law.

References

1. Merrington, G., Fishwick, S., Barraclough, D., Morris, J., Preedy, N., Boucard, T., Reeve, M., Smith, P. and Fang, C., 2006: The development and use of soil quality indicators for assessing the role of soil in environmental interactions. Report to UK SIC, SC030265, Environment Agency.
2. Bone, J., Barraclough, D., Eggleton, P., Head, M., Jones, D.T., Voulvoulis, N., 2014. Prioritising soil quality assessment through the screening of sites: the use of publicly collected data. Land Degradation & Development 25, pp. 251–266.
3. Bünemann E. K., Bongiorno, G., Bai, Z., Creamer, R.E., De Deyn, G., de Goede, L., Geissen, V., Kuyper, T.W., Mader, P., Pulleman, M., Sukkel, W., van Groenigen, J.W., and Brussard, L. 2018: Soil quality — a critical review, Soil Biology and Biochemistry 120, pp.105-125 (https://doi. org/10.1016/j.soilbio.2018.01.030).
4. Morvan, X., Saby, N.P.A., Arrouays, D., Le Bas, C., Jones, R.J.A., Verheijen, F.G.A., Bellamy, P.H., Stephens, M., Kibblewhite, M.G., 2008: Soil monitoring in Europe: a review of existing systems and requirements for harmonisation. The Science of the Total Environment 391, pp.1–12.
5. Black, H., Bellamy, P., Creamer, R., Elston, D., Emmett, B., Frogbrook, Z., Hudson, G., Jordan, C., Lark, M., Lilly, A. and Marchant, B., 2008: Design and operation of a UK soil monitoring network.
6. Campbell, G. A., Lilly, A., Corstanje, R., Mayr, T. R., & Black, H. I. J. (2017) Are existing soils data meeting the needs of stakeholders in Europe? An analysis of practical use from policy to field. Land Use Policy, 69, 211- 223. [https://doi.org/10.1016/j. landusepol.2017.09.016]

7. Baritz, R., Amelung, W., Antoni, V., Boardman, J., Horn, R., Prokop, G., Römbke, J., Romkens, P., Steinhoff- Knopp, B., Swartjes, F., Trombetti, M., de Vries, W. 2021: Soil monitoring in Europe: Indicators and thresholds for soil quality assessments. EEA ETC/ULS Report | 2021.
8. Matson, A., Fantappiè, M., Campbell, G.A., Miranda- Vélez, J.F., Faber, J.H., Carvalho Gomes, L., Hessel, R., Lana, M., Mocali, S., Smith, P., Robinson, D., Bispo, A., van Egmond, F., Keestra, S., Saby, N.P.A., Smreczak, B., Froger, C., Suleymanov, A., Chenu, C. (in press): A framework for setting soil health targets and thresholds in agricultural soils, in press.

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