

# SOIL MONITORING SYSTEMS

## Challenges / recommendations towards harmonization

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- Differences in sampling strategies, designs and protocols make soil data difficult to compare across countries and with LUCAS Soil
- Countries do not want to change their protocols but could add new monitoring sites
- Harmonization options of soil monitoring systems and LUCAS Soil exist, such as developing transfer functions
- Major differences between a national soil monitoring system and LUCAS both on sampling strategy and measured soil properties can impact soil quality and soil health assessment

### INTRODUCTION

Soils are constantly evolving due to natural processes driven by factors such as climate and soil organisms, but also due to external pressures linked mainly to human activities. The evolution of soils makes it necessary to set up monitoring programs.

Since 20 years, several projects and initiatives (e.g. ENVASSO, Landmark, SOIL4EU) underlined the existing difficulties to compare and share data between national Soil Monitoring Systems (SMS), either due to technical issues (e.g. different sampling designs and protocols, analytical methods, data format, standards) but also due to lack of motivation (e.g. why share the data?, costs) and legal requirements. These difficulties pushed EU-JRC to develop its own monitoring system (LUCAS Soil) to report on the status of soils in Europe.

*How to combine the efforts of Member States in monitoring soils with the one developed by EU-JRC within the LUCAS Soil program?*

A questionnaire was designed and circulated to EJP SOIL partners to identify main differences between SMS and possible ways of harmonization.

### DIFFERENT SAMPLING STRATEGIES, DESIGNS AND PROTOCOLS BETWEEN SMS

A transversal analysis was made to identify similarities and differences between the 27 reported SMS (collected from 18 countries). Most SMS were developed and started in the nineties to monitor soil quality. Agriculture is the main land use investigated in our survey; forestry regularly has its own national SMS. The majority of SMS have at least 2 sampling campaigns (done or currently running) or more. The number of sites per country is highly variable but most have at least 1 site representing 300 km<sup>2</sup>. In the majority of SMS, the **monitoring sites were selected according to several criteria such as land use, soil type, main crop, climatic zone, but regular grids are also used**. On monitored sites, 50 to 60% of the countries also collect information on soil management and on the surroundings. The sampling protocol is quite variable as the sampling area ranges from less than 5 m<sup>2</sup> to 1 ha. The depths of sampling are also quite different as samples are taken according to soil horizons or just at one depth (0-20 or 0-30 cm) or at multiple depths (2 to 5).

## KEY MESSAGES FOR POLICY MAKERS

### *Recommendation 1:*

#### Maintain existing long-established Soil Monitoring Systems with extensive data

Several countries developed SMS in the nineties. Even if highly diverse in sampling strategies and protocols, existing data from different periods are extremely valuable. As countries are not willing to change their SMS, the possibilities to combine results of SMS and LUCAS Soil campaigns should be developed.

### *Recommendation 2:*

#### Support the harmonization of Soil Monitoring Systems and LUCAS with more resources

Funding is needed to support countries to add new monitoring sites in their SMS that should be in common with LUCAS to allow a better comparison in the future and develop transfer functions (see Table 1).

### *Recommendation 3:*

#### Improve the way data from Soil Monitoring Systems and LUCAS Soil are used

Data from national SMS and LUCAS Soil campaigns are not easily usable together. Care should be taken when using the LUCAS dataset, as it may not be representative of all land covers and soil types. Depending on the country, national datasets from SMS should be preferred to conduct soil quality and soil health assessments. Therefore, more work is needed to exploit the benefits from both data sources, e.g. by developing transfer functions (see Table 1).

## HARMONISATION WITH LUCAS SOIL

Considering harmonization with LUCAS Soil campaigns, apart from a few exceptions, the **countries do not want to change their protocols** (from the design to the analytical part). A majority of the countries would accept to **add new monitoring sites** (e.g. that could be in common with LUCAS) and are open to perform, with a proper budget, double sampling campaigns to account for differences in lab methods and an analysis to compare their results with LUCAS, which has now started with EJP SOIL budget. This will allow the development of validated transfer functions.

Several options towards harmonized SMS and LUCAS were discussed and are currently being tested within EJP SOIL WP6 (**Table 1**). The ambition is to improve the use of the existing data in EU countries and at EU level and also to benefit from the LUCAS campaigns to test harmonization options.



*National SMS sampling campaign in France  
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	Advantages	Limitations	EJP SOIL progresses
<b>Compare National and LUCAS datasets</b>	Can identify the main differences and similarities between national and EU datasets	Will require statistical skills to be tested and developed.	Test within EJP SOIL is ongoing and preliminary results are described in the paragraph below.
<b>Develop transfer functions for data produced with national and LUCAS sampling protocols and/or analytical methods</b>	Can improve the use of national and LUCAS datasets together.	Will require time and money for analysis and training (e.g. for sampling).	Tests within EJP SOIL are ongoing in collaboration with the LUCAS Soil programme. Taking the opportunity of LUCAS 2022 campaign, EJP SOIL partners are currently analysing soil samples collected by LUCAS samplers to compare several analytical methods. Some partners also sampled according to the LUCAS protocol in order to compare not only analytical methods but also sampling protocols. Results are expected in 2024.
<b>Identify and test statistical methods to combine national and LUCAS datasets or maps</b>		Will require statistical skills to develop and test appropriate methods.	Tests within EJP SOIL are ongoing, e.g. on data collected with different sampling strategies - included in EJP SOIL WP6 work programme.
<b>Develop framework for interpretation approaches</b>		Will require pedological and statistical skills to develop and test methods.	Tests within EJP SOIL are ongoing- included in EJP SOIL WP6 work programme and connected to SERENA project.

Table 1. Analysis of the harmonisation's options

## ZOOM IN ON ONE HARMONISATION OPTION:

### COMPARING NATIONAL AND LUCAS MONITORING STRATEGIES AND DATASETS

To explore the technical options for further harmonization with LUCAS, the LUCAS Soil program was compared in more detail with the SMS of 10 countries (BE, DE, DK, EE, FI, FR, HU, IT, SE, and SK), looking at monitoring strategies, soil types and properties distribution.

The results showed clear differences in monitoring strategies between LUCAS and national SMS. Most of the countries showed a higher number of sampling points in national SMS compared with LUCAS, up to 100 times higher for some countries (i.e. Belgium). Compared to national SMS, sampling in cropland was overrepresented in the LUCAS sampling at the expense of woodlands.

Finally, LUCAS oversampled and/or under-sampled some soil types compared with the national SMS which better represented the soil type distribution in the countries. Sampling strategies (e.g. stratified random sampling or grid sampling) were different for several SMS and LUCAS. As LUCAS Soil campaigns were designed for specific purposes at EU scale (e.g. focus on cropland), statistical distributions at country level may be biased.

*Differences exist between each national soil monitoring system and LUCAS Soil on soil properties*

Results from soil properties measured by LUCAS and by national SMS were also compared (e.g. organic carbon, clay content and pH). Significant differences were observed depending on land cover (**Figure 1**). Consequently, an under or over-representation of land covers and soil types in the monitoring program can affect the reported results of soil health indicators, such as those suggested in the proposed Soil Monitoring Directive. This underlines the importance of a well-designed SMS and that reference and threshold values to evaluate soil health should be selected with care.

In order to harmonize national SMS with LUCAS datasets, **it is necessary to develop transfer functions for data collected with different laboratory methods, sampling protocols, for sampling design differences, etc.** Additionally, the findings highlight the importance of close collaboration between LUCAS Soil and National SMS to identify any gaps in soil information (such as for certain soil types and land covers) and ensure that the necessary steps are taken to allow harmonisation of the results of monitoring programs if desirable.

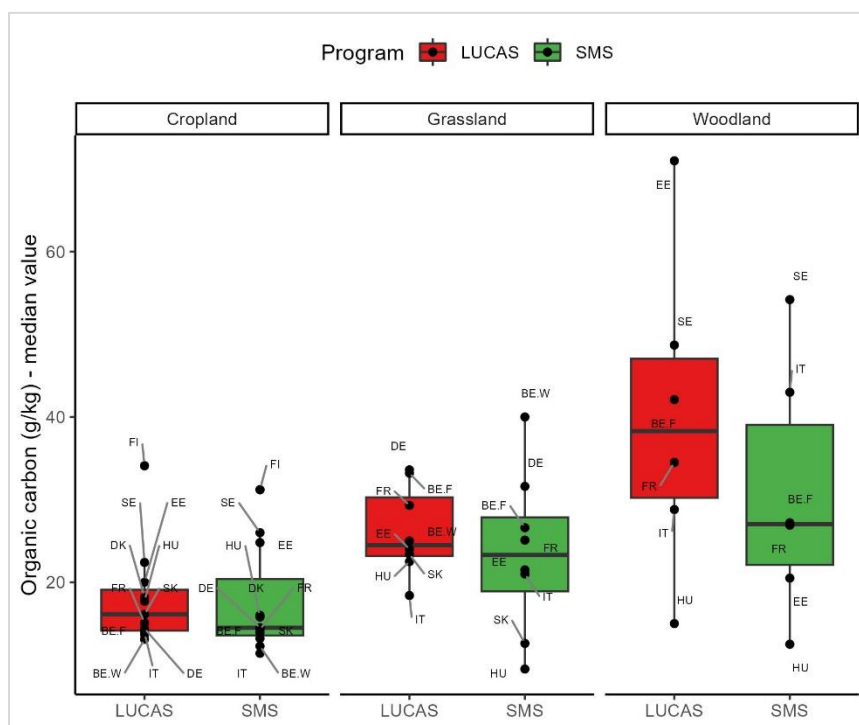


Figure 1. Comparison of measured soil Organic Carbon content between the LUCAS and national Soil Monitoring System (SMS) campaigns depending on land cover for ten countries (BE: Belgium with BE.F: Flanders and BE.W: Wallonia; DE: Germany; DK: Denmark; EE: Estonia; FI: Finland; FR: France; HU: Hungary; IT: Italy; SE: Sweden; and SK: Slovakia)

The report can be found on our webpage:



<https://ejpsoil.eu/>

**REFERENCE TO THE REPORT**

Bispo, A., Arrouays, D., Saby, N., Boulonne, L., & Fantappiè M. (2021). Proposal of methodological development for the LUCAS programme in accordance with national monitoring programmes. EJP SOIL. Deliverable 6.3

