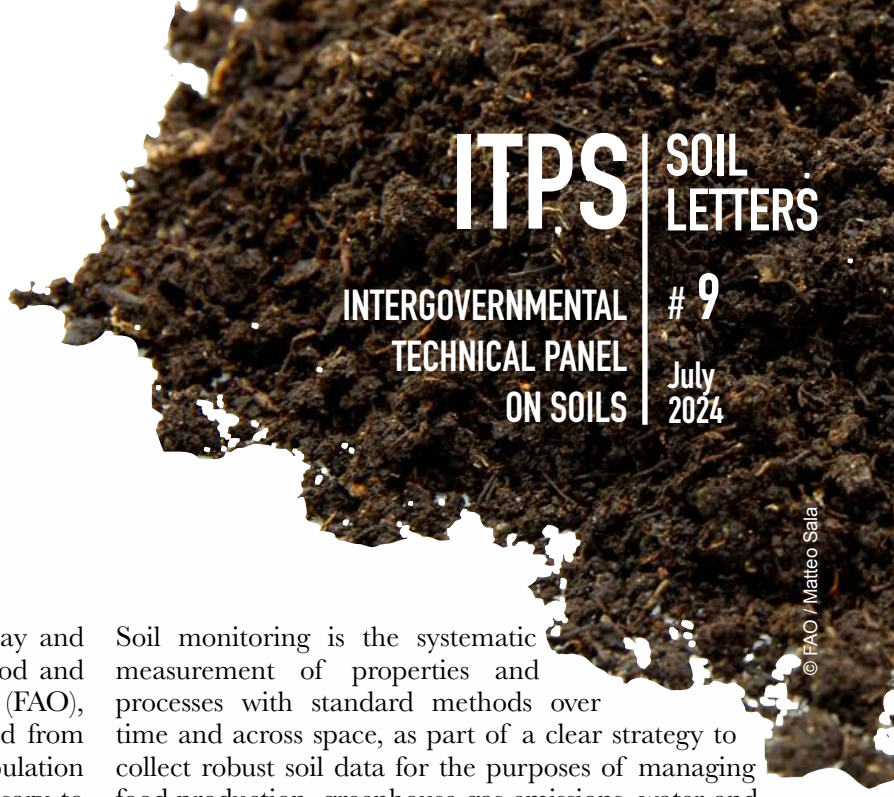
Food and Agriculture Organization of the United Nations

ITPS SOIL LETTERS

INTERGOVERNMENTAL TECHNICAL PANEL ON SOILS

9

July 2024



TIME TO ADDRESS GLOBAL SOIL MONITORING?

The population of the world is increasing every day and food supply is a serious issue. According to the Food and Agriculture Organization of the United Nations (FAO), more than 800 million people in the world suffered from malnutrition in 2021. Estimates indicate that if population growth remains in its current state, it will be necessary to increase global food production by 38 percent and 57 percent by 2025 and 2050, respectively. However, most of the suitable agricultural land is either already under cultivation (with little possibility of expanding the cultivated area) or unusable due to physical, chemical and biological degradation. Quantitative data regarding degradation are urgently needed to know the degree and extent of the effects of human activities on the land, so that studies can be prioritized and adequate policies and management responses can be developed to prevent further degradation of soils and restore degraded lands where possible.

Soil monitoring is the systematic measurement of properties and processes with standard methods over time and across space, as part of a clear strategy to collect robust soil data for the purposes of managing food production, greenhouse gas emissions, water and biodiversity protection, and others. Some soil characteristics (such as organic carbon, salinity or amounts of nutrients), vary spatially and temporally from farm scale to broader scales and are influenced by internal (intrinsic) factors and external factors such as soil management. To understand and forecast the effects of soil management on ecosystem services, it is necessary that each country sets up their soil system to quantify the changes of those characteristics.

itps INTERGOVERNMENTAL TECHNICAL PANEL ON SOILS

GLOBAL SOIL PARTNERSHIP

Some particular tasks and challenges in this area are the inclusion of a representative variety of undisturbed soils so that changes can be compared against those soils, and the use of comparable methods for monitoring and recording the changes of a set of common indicators of qualified data sets. Soil monitoring includes significant investments of equipment, technologies, and human resources. However, the return on investment is wide-ranging and can create advanced knowledge systems, reduce risks in decision-making, and increase the capacity to understand processes and forecast changes that compromise the ability of soils to produce food, perform other soil ecosystem functions and services, and protect the environment. The benefits include the early detection of soil degradation, the optimization of fertilizer use, and the improvement of agricultural productivity, site-specific suitability and protection of ecosystems. Not only do these benefits have a direct impact on the local and global economy by improving the efficiency of agricultural production, but they also contribute to their long-term environmental sustainability (Evangelista *et al.*, 2023). The information obtained from soil monitoring studies can be used in preparing thematic maps of soil characteristics such as salinity, fertility (including micro and macro elements, organic carbon and pH), and in assessing patterns and trends in these characteristics.

Some countries have already started soil monitoring programmes, but each country has different protocols (such as the density of observations, or periodicity) and characteristics (such as sampling depth, measured parameters, observation and analytical methods), which makes comparisons difficult, and emphasizes the need for harmonization where possible. For example, the European Union started such work in 2008 through the LUCAS soil data bank, which already has nearly 19 000 sampling points (Orgiazzi *et al.*, 2018). In England and Wales, a National Soil Inventory (NSI) was carried out on 6 600 points between 1978 and 1996 . Besides the original sampling, there was partial resampling in the mid-1990s and again in 2003, with around 40 percent of the original sampling points being resampled (Bellamy *et al.*, 2005). Since 1995, Poland has been conducting a national programme for the monitoring of chemical properties of arable soils, with five-year intervals to assess the contamination status of its arable soils. This long-term monitoring effort is essential for understanding the impacts of various factors on soil chemistry and taking appropriate measures to address any detected issues of contaminants.

In 1999, Japan initiated the *Soil survey program for monitoring soil function*, initially covering around 20 000 sites, although this was reduced to approximately 5 500 sites. In 2008, the National Soil Survey Program for Monitoring Soil Carbon Content and Soil Management was launched, which included an additional ~3 500 monitoring sites. These programmes aim to monitor soil health and management practices, to ensure sustainable use of soil resources.

In India, the soil health card scheme was initiated to serve as a soil monitoring system. Launched in February 2015, it stands as one of the flagship programmes of the Government of India. Oversight of these schemes falls under the purview of the Ministry of Agriculture Cooperation and Farmers' Welfare (AC&FW).

China's efforts to protect its agricultural lands, especially the black soil regions, are outlined in the National Black Soil

Protection Project Implementation Plan 2021–2025. This plan targets the evaluation of farmland quality within the black soil areas of the Inner Mongolia Autonomous Region and the provinces of Liaoning, Jilin, and Heilongjiang. It represents a critical step towards preserving soil quality and ensuring agricultural productivity in these regions.

In the Islamic Republic of Iran, monitoring of agricultural soils started in 2012, with 3 700 sampling sites being monitored, over a five-year-period, followed by a second monitoring campaign (Saadat, 2018; Rezaei *et al.*, 2020).

Australia launched the National Soil Monitoring Program (NSMP) in 2023, which focuses on monitoring national soil health indicators. The NSMP aims to enhance the understanding of soil conditions and trends across the country. It supplements the Australian National Soil Information System (ANSIS) by providing harmonized, publicly available data from across Australia, thus supporting better decision-making regarding soil management by landowners and policymakers. Between 1995 and 2001, New Zealand conducted two programmes aimed at monitoring soil quality. These initiatives were implemented with the aim of assessing sustainable land-use methods and obtaining valuable data for the purposes of state of the environment reporting (Sparling *et al.*, 2004).

Work has been recently undertaken to improve the Latin America and Caribbean Soil Information System (SISLAC) database, a regional initiative promoted by FAO's Latin America and the Caribbean Soil Partnership (ASLAC), to enhance its usability and scalability, and forms the basis for a soil monitoring system (Diaz-Guadarrama *et al.*, 2024). According to the authors, SISLAC includes data from 49 084 soil profiles distributed unevenly across the Latin America and the Caribbean, making it the region's largest soil database.

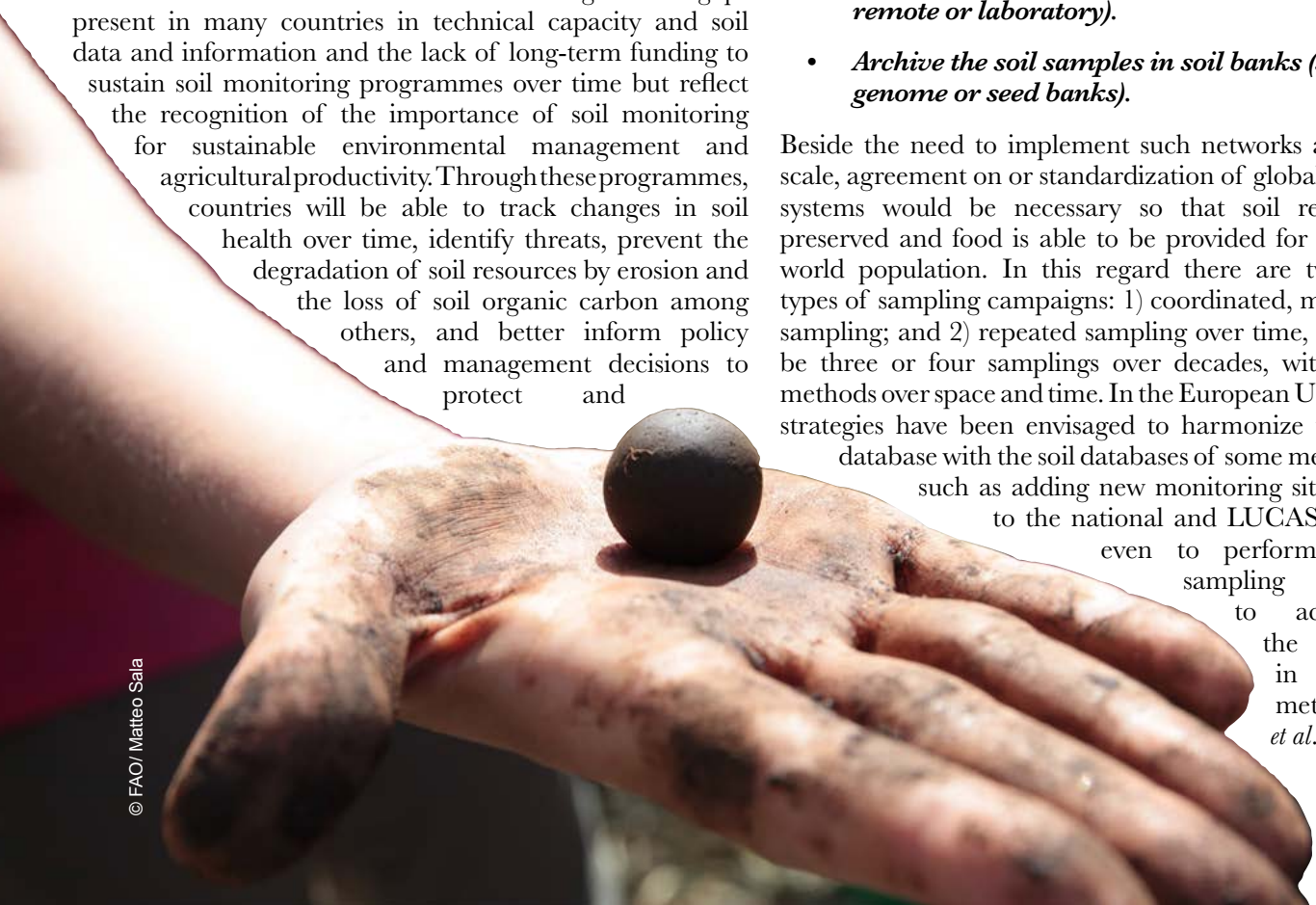
These initiatives demonstrate both the significant gaps present in many countries in technical capacity and soil data and information and the lack of long-term funding to sustain soil monitoring programmes over time but reflect the recognition of the importance of soil monitoring for sustainable environmental management and agricultural productivity. Through these programmes, countries will be able to track changes in soil health over time, identify threats, prevent the degradation of soil resources by erosion and the loss of soil organic carbon among others, and better inform policy and management decisions to protect and determine the most sustainable management practices for the benefit of future generations. Soil monitoring return on investment (ROI) has been demonstrated at field scale (Bennett *et al.*, 2021), and assessed at more regional scales (Kibblewhite, Chambers and Goulding, 2016).

© FAO/ Matteo Sala

Some good practices that every soil monitoring strategy should adopt are as follows:

- ***Establish a minimum set of indicators (physical, chemical, and biological) to monitor in relation to those reflected in local or global soil governance instruments.***
- ***Determine the period of monitoring for each indicator, depending on their rate of change in time.***
- ***Ensure resources are available for the long-term maintenance of the monitoring (beyond the duration of political mandates).***
- ***Establish systems to handle the data (either field, remote or laboratory).***
- ***Archive the soil samples in soil banks (similar to genome or seed banks).***

Beside the need to implement such networks at a country scale, agreement on or standardization of global monitoring systems would be necessary so that soil resources are preserved and food is able to be provided for the growing world population. In this regard there are two valuable types of sampling campaigns: 1) coordinated, multi-country sampling; and 2) repeated sampling over time, which could be three or four samplings over decades, with consistent methods over space and time. In the European Union, several strategies have been envisaged to harmonize the LUCAS database with the soil databases of some member states, such as adding new monitoring sites (common to the national and LUCAS systems) or even to perform sequential sampling campaigns to account for the differences in laboratory methods (Bispo *et al.*, 2021).


© FAO/ Matteo Sala

Coordinated and consistent soil monitoring efforts and the high quality information that is provided by such efforts can contribute to the Sustainable Development Goals (SDGs), in particular SDG 2: *End hunger, achieve food security and improved nutrition and promote sustainable* agriculture and SDG 15: *Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss*, by protecting natural resources from further degradation and preserving soil´s ecosystem functions.

The specific SDG indicators that are directly obtained from coordinated and consistent soil monitoring efforts organized through an international network are as follows:

- **INDICATOR 2.4.1**
  Proportion of agricultural area under productive and sustainable agriculture.
- **INDICATOR 15.1.2**
  Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type.
- **INDICATOR 15.2.1**
  Progress towards sustainable forest management.
- **INDICATOR 15.3.1**
  Proportion of the total land area that is degraded.
- **INDICATOR 15.4.1**
  Coverage by protected areas of important sites for mountain biodiversity.
- **INDICATOR 15.9.1**
  Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020.

Each country needs to officially launch their National Soil Action Plan to address priorities in soil monitoring programmes and ensure long-term soil security. Existing Global Soil Partnership (GSP) international technical networks, such as the Global Network for Soil Information Systems (GLOSIS), the International Network on Soil Pollution (INSOP), the International Network on Soil Biodiversity (NETSOB) and the Global Soil Laboratory Network (GLOSOLAN), already work with harmonized methods, thus improving the quality of soil data.

Furthermore, donors and international organisations (including the GSP, the International Union of Soil Sciences, and others) should seek and establish long-term funding to help countries or regions sustain soil monitoring programmes over time.

Establishing national and global soil information systems relates closely to the objectives of a global soil monitoring system. Through their ongoing work, the GSP aims to establish a framework for the estimation of agricultural soil health through the determination of the impacts of the different soil threats. In implementing standardized soil monitoring globally, it enables informed decision-making and aids sustainable soil management practices, safeguarding the foundation of life on Earth for generations to come, and ensuring food security and environmental stability for all.

REFERENCES

Bellamy, P.H., Loveland, P.J., Bradley, I. R., Murray Lark, R. & Kirk, G.J.D. 2005. Carbon losses from all soils across England and Wales 1978–2003. *Nature*, 437(7056): 245–248. https://www.nature.com/articles/nature04038

Bennett, J.M., Roberton, S.D., Ghahramani, A. & McKenzie, D.C. 2021. Operationalising soil security by making soil data useful: Digital soil mapping, assessment and return-on-investment. *Soil Security*, 4(1): 100010. https://doi.org/10.1016/j.soisec.2021.100010

Bispo, A., Arrouays, D., Saby, N., Boulonne, I. & Fantappiè, M. 2021. Deliverable 6.3. Proposal of methodological development for the LUCAS programme in accordance with national monitoring programmes. In: *EJP SOIL*. Brussels, EJP (European Joint Programme) SOIL & European Commission (EC). https://ejpsoil.eu/fileadmin/projects/ejpsoil/WP6/EJP_SOIL_Deliverable_6.3_Dec_2021_final.pdf

Díaz-Guadarrama, S., Varón-Ramírez, V.M., Lizarazo, I., Guevara, M., Angelini, M., Araujo-Carrillo, G.A., Argeñal, J. *et al.* 2024. Improving the Latin America and Caribbean Soil Information System database. *Earth System Science Data*, 16(3): 1229–1246. https://doi.org/10.5194/essd-16-1229-2024

Evangelista, S.J., Field, D.J., McBratney, A.B., Minasny, B., Ng, W., Padarian, J., Román Dobarco, M. & Wadoux, A.M.C. 2023. Soil security–strategizing a sustainable future for soil. In: D.L. Sparks, ed. *Advances in Agronomy*, Volume 183. Amsterdam, Elsevier.

Kibblewhite, M.G., Chambers, B.J., & Goulding, K.W.T. 2016. How good is the evidence to support investment in soil protection? *Soil Use and Management*, 32(S1): 172–182. https://doi.org/10.1111/sum.12236

Orgiazzi, A., Ballabio, C., Panagos, P., Jones, A. & Fernández-Ugalde, O. 2018. LUCAS Soil, the largest expandable soil dataset for Europe: a review. *European Journal of Soil Science*, 69(1): 140–153. https://doi.org/10.1111/ejss.12499

Rezaei, H., Saadat, S., Mirkhani, R., Bagheri, Y.R., Esmaeelnejad. L., Nouri Hosseini, M., Baybordi, A. *et al.* 2020. The state of soil organic carbon in agricultural lands of Iran with different agroecological conditions, International Journal of Environmental Analytical Chemistry, 102(16): 4623–4639. doi.org/10.1080/03067319.2020.1786547

Saadat, S. 2018. Soil quality monitoring in agricultural lands of Iran. Research Project report no: 2152. Karaj, Islamic Republic of Iran, Soil and Water Research Institute.

Sparling, G., Schipper, L., Bettjeman, W. & Hill, R. 2004. Soil quality monitoring in New Zealand: practical lessons from a 6-year trial. *Agriculture, Ecosystems & Environment*, 104(3): 523–534. https://doi.org/10.1016/j.agee.2004.01.021

© FAO/ Matteo Sala

The Intergovernmental Technical Panel on Soils (ITPS) is composed of 27 top soil experts representing all the regions of the world. ITPS members have a 3-year mandate and provide scientific and technical advice and guidance on global soil issues to the Global Soil Partnership primarily and to specific requests submitted by global or regional institutions. Created in 2013 at the first Plenary Assembly of the Global Soil Partnership held at FAO Headquarters, the ITPS advocates for addressing sustainable soil management in the different sustainable development agendas.

Global Soil Partnership (GSP)
Land and Water Division
GSP-secretariat@fao.org
www.fao.org/global-soil-partnership

Food and Agriculture Organization
of the United Nations
Rome, Italy