

June 2024



Food and Agriculture
Organization of the
United Nations



E

Global Soil Partnership Plenary Assembly

Twelfth session

Hybrid, 3–5 June 2024

Progress of the GSP Technical Networks (GSPPA: XII/2024/9)

Executive summary

- The technical networks of the Global Soil Partnership (GSP) constitute the technical arms of the GSP, and all FAO Members can take an active part in them.
- The GSP Secretariat and the International Network of Soil Information Institutions (INSII) have successfully developed and implemented a country-driven approach to the development of global soil data products. The Global Soil Information System (GloSIS) Discovery Hub and the Map Service are available online including 36 map layers and four country-driven global maps.
- At the seventh meeting of the Global Soil Laboratory Network (GLOSOLAN), held in November 2023, new Chair and Vice Chairs of the network were elected by its members. Training activities have attracted around 2 000 participants in 2023. In-person regional workshops were organized in Eurasia and Sub-Saharan Africa. Regional proficiency tests (PTs) have been organized in Africa, Asia, Eurasia, and Near East and North Africa (NENA). Over 100 new laboratories registered in GLOSOLAN in 2023 and the network currently counts about 1 100 members.
- The International Network on Black Soils (INBS) organized two webinars on sustainable black soil management case studies from Argentina and China in November 2023 and February 2024, respectively, which were attended by over 600 participants. The network is now represented by 41 countries.
- The International Network on Salt Affected Soils (INSAS) has prepared the Global Status of Salt Affected Soils (GSAS) report with the support of over 300 experts from 73 countries. The GSAS report will be released during the 12th GSP Plenary Assembly.
- The International Network on Soil Fertility and Fertilizers (INSOILFER) was launched in July 2023. INSOILFER directly supports the implementation of the International Code of Conduct for the Sustainable Use and Management of Fertilizers. The governance, technical committees,

This document is printed in limited numbers to minimize the environmental impact of FAO's processes and contribute to climate neutrality. Delegates and observers are kindly requested to bring their copies to meetings and to avoid asking for additional copies. Most FAO meeting documents are available on the Internet at www.fao.org

and work plan were endorsed in the first meeting of the INSOILFER working groups, held in November 2023.

- The International Network on Soil Biodiversity (NETSOB) approved a technical concept note on the implementation of the Global Soil Biodiversity Observatory (GLOSOB) at the third annual meeting, held on January 16-18, 2024.
- The International Network on Soil Pollution (INSOP) has launched four working groups to assess, monitor, remediate, and increase awareness on soil pollution. The 3rd annual meeting of INSOP will be held in September 2024 in hybrid mode, in Adelaide, Australia, in collaboration with the Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (crcCARE) during the 2024 CleanUp conference to track the progress on the four INSOP working groups and their activities in the period 2023-2024.

Suggested actions by the GSP Plenary Assembly

The Plenary Assembly may wish to:

- welcome the efforts made by the GSP technical networks to advance the implementation of their work plans and encourage all members to continue contributing to the best of their ability to the development of key documents, products, and projects for sustainable soil management and conservation;
- invite FAO Members and GSP partners to nominate experts to contribute to the development of activities and products promoted by the GSP networks in response to the decisions of this Plenary Assembly and their work plans, as well as to contribute to the dissemination of information on the networks in their respective countries;
- invite resource partners to support the activities of the networks and to carry out field activities through specific projects on the various themes;
- invite FAO Members to establish national soil information systems in accordance with INSII guidelines and with the support of the GSP Secretariat; and
- encourage FAO Members and resource partners to join and support the development of GLOSOB for monitoring soil biodiversity and soil health.

Background

1. The Global Soil Partnership (GSP) has to date established seven technical networks that represent the operational arms to address the main areas of work and soil threats that the GSP is dealing with.
2. The networks have been launched at different times according to the needs and priorities of the GSP, with some existing since 2017 and the latest launched in 2023, so the number of members, progress and achievements differ between the networks. Likewise, the mobilization of resources by the different networks has been uneven, also affecting the delivery of activities and projects.
3. It is important to note that the International Network of Soil Information Institutions (INSII) is only composed of institutions that officially represent the country to produce soil data and information, so these institutions are officially nominated by the national focal points. Similarly, in the Global Soil Laboratory Network (GLOSOLAN), each country has a national reference laboratory officially nominated by the focal point, and other laboratories can join in their individual capacity. The rest of the technical networks are composed of experts in each subject area who join in their individual capacity and do not necessarily represent their country or institution.
4. This document summarizes, for each network, the status of membership, main activities and achievements since the last Plenary Assembly.

9.1 International Network of Soil Information Institutions (INSII)

5. The INSII facilitates the development of national soil information systems and country-driven soil data products to support evidence-based decision making by establishing the Global Soil Information System (GloSIS) and SoilSTAT.
6. The 9th INSII meeting was held from 7 to 9 November 2023. At the meeting, INSII members reviewed the progress and status on the implementation of relevant activities, GloSIS and its data products, and discussed the implementation of future activities. The meeting [report](#) is available online.
7. Progress made and main results achieved by the INSII in 2023 and first half of 2024 are as follows:
 - a) The Global Soil Nutrient and Soil Budget Map (GSNmap) is being developed in two phases: phase I dedicated to the soil nutrient and soil property maps and phase II to the soil nutrient budget maps. The capacity development programme to develop the GSNmap phase I has been completed. Six [regional online trainings on the preparation of the GSNmap](#) were organized for Africa, Asia, Eurasia, Latin America and the Caribbean, and the Near East and North Africa (NENA);
 - b) The following countries have submitted national GSNmap phase I maps: Armenia, Bhutan, Brazil, Colombia, Cuba, Ecuador, France, Ghana, Greece, Lesotho, Liberia, Mexico, Nigeria, Panama, Philippines, Senegal, Syrian Arab Republic (the), Thailand, and Türkiye;
 - c) After considering comments from participating countries and considering the time and data availability limitations, the launch of the first version of the GSNmap (Phase I and Phase II) has been postponed to World Soil Day 2024;

- d) The Liberian Soil Information System (LibSIS) was launched in August 2023 and fully integrated with GloSIS. Other 20 National Soil Information Systems are in the pipeline to be established or modernized during 2024 (13 in Asia and seven in the Caribbean);
 - e) Work for the integration of SISLAC (Soil Information System for Latin America and the Caribbean) into GloSIS has started and will be completed in 2024;
 - f) To date, more than 1 500 national experts from 122 countries have been trained on soil data management, digital soil mapping, and soil modelling as part of the training to prepare the various INSII products (GSOCmap, GSASmap, GSOCseq, GBSmap, and GSNmap);
 - g) An online training on developing sampling design specifically for digital soil mapping was held from 23 to 25 January 2024. It was attended by 118 participants representing 13 countries from the Asian region.
8. As stated in the new GSP Action Framework 2022–2030, INSII's role in the development and subsequently monitoring and reporting of key performance indicators will be central. A concept note delineating the main indicators, scope and methodology of the Global Soil Health Index and the Global Soil Health Dashboard is currently under development by the Working Group for the Indicator System of the GSP Action Framework (ISAF) and will be opened for review by the INSII upon completion.

9.2 Global Soil Laboratory Network (GLOSOLAN) and its initiative on soil spectroscopy (GLOSOLAN-Spec)

9. [GLOSOLAN](#) continues to expand, counting with around 1 100 members from 160 countries.
10. The [seventh GLOSOLAN meeting](#) was organized virtually in November 2023 to define its work plan for the year 2024 and to revise the network governance. The elected Chair is Mr Elh Moudi Moustapha Abdourahaman, from Niger, and the Vice-chair Ms Hanane Aroui Boukbida, from France.
11. The annual meetings of the Regional Soil Laboratory Networks for Africa ([AFRILAB](#)), Asia ([SEALNET](#)), Europe and Eurasia ([EUROSOLAN](#)), Latin America and the Caribbean ([LATSOLAN](#)), NENA ([NENALAB](#)), and the Pacific ([ASPAC](#)) were successfully convened in virtual modality between September and October 2023 to revise the networks' work plans and governance.
12. The GSP focal points were invited to the meetings and requested to encourage soil laboratories in their countries to register with GLOSOLAN, to establish National Soil Laboratory Networks ([NASOLANs](#)) and to develop specific work plans according to GLOSOLAN priorities.
13. The main results of GLOSOLAN in 2023 and in the first half of 2024 were as follows:
 - a) The standard operating procedures (SOPs) on [pH](#), [soil organic carbon by Walkley and Black](#), and [soil respiration rate](#) were revised and republished.
 - b) Four training workshops on the [implementation of the GLOSOLAN SOPs](#), [soil spectroscopy](#), [quality control in the laboratory](#), and [laboratory health and safety](#) were organized in English and Spanish. These trainings were delivered by five trainers from three different countries and attended by around 2 000 participants.
 - c) A [regional in-person training session](#) on quality control and soil analysis was organized for the members of AFRILAB in Dakar (Senegal) from 23 to 27 October 2023. Over

70 soil laboratories technicians from 40 sub-Saharan countries participated in the training.

- d) A [regional in-person training for the members of LATSOLAN](#) was organized in Chile (Santiago and Chillán) from 8 to 11 April 2024. The event gathered representatives of national reference laboratories from about 25 countries in the Caribbean, Central America, and South America, and focused on soil spectroscopy, the determination of soil chemical, physical, and biological parameters, and quality control practices.
 - e) Regional Proficiency Tests (PTs) to assess the analytical performance of the laboratories when implementing the GLOSOLAN SOPs were organized in Eurasia, focused on soil organic carbon using various methods and involving over 20 laboratories from seven countries, in sub-Saharan Africa and NENA, involving around 90 soil laboratories from 45 countries, and in Asia focusing on soil organic carbon, pH, available phosphorus, total nitrogen, moisture content, and particle size distribution.
 - f) Two national soil laboratory networks were launched: the Honduras Soil Laboratory Network (HONSOLAN) on 11 January 2024, and the Zambia Soil Laboratory Network (ZASOLAN) on 15 February 2024, within the framework of NASOLANs.
14. The [GLOSOLAN initiative on soil spectroscopy \(GLOSOLAN-Spec\)](#) proposes an extension of its mandate to cover soil spectroscopy not only from laboratories, but also using proximal and remote platforms, with the aim of facilitating the acquisition of diverse soil data from various sources and platforms.

9.3 International Network of Black Soils (INBS)

15. The [International Network of Black Soils \(INBS\)](#) was established in 2017. The network aims to provide a platform for knowledge sharing for countries with black soils to discuss common issues related to the conservation and sustainable management of these soils and the need to foster technical exchanges and cooperation. INBS is currently composed of 41 countries.
16. The main results of INBS in 2023 and first half of 2024 are as follows:
- a) Two webinars on Sustainable Black Soil Management, case studies from Argentina and China were organized on 24 November 2023 and 6 February 2024, respectively. Black soil experts shared successful management practices to improve the health of black soils in these two countries with more than 600 participants from around the world.
 - b) INBS experts collaborated with the Intergovernmental Technical Panel on Soils (ITPS) for the publication of the ITPS Letter "[A call to protect the world's food basket soils: black soils](#)" (see GSPPA: XI/2023/4).
 - c) Co-organized the black soil session at the International Union of Soil Sciences (IUSS) Centennial, held from 19 to 21 May 2024.

9.4 International Network of Salt Affected Soils (INSAS)

17. The [International Network of Salt Affected Soils \(INSAS\)](#) was established in 2019. The network aims to facilitate the sustainable and productive use of salt affected soils (SAS) for current and future generations. The network is currently composed of 815 members from 125 countries.
18. The main results of INSAS in 2023 and the first half of 2024 are as follows:
- a) Since 2021, over 300 INSAS experts from 73 countries have been involved in the preparation of the Global Status of Salt-affected Soils report. The report has counted with the support of 43 co-authors from 17 countries, 94 respondents from 53 countries

to the [Questionnaire on the Status of salt-affected soils](#), and 205 contributors from 39 countries who provided their national reports. The release of the GSAS report is scheduled during the 12th Plenary Assembly of the GSP.

- b) On 21 November 2023, INSAS held an interactive webinar “[Health of salt-affected soil](#)” with a panel of leading SAS experts to discuss the concept of soil health and its connection to sustainable soil management, the importance of natural habitats with SAS for global biodiversity as well as the indicators of soil health and sustainable soil management of SAS. There were 1 150 participants (from 115 countries) registered to the webinar, 500 unique attendees (from 80 countries) and 310 constant attendees.
 - c) On 13 February 2024, the webinar “[eHALOPH and the economic uses of salt-tolerant plants](#)” was organized. More than 390 participants from 92 countries registered for the webinar, with 196 unique attendees and 160 constant attendees.
 - d) On 10 December 2023, INSAS, jointly with the Global Framework on Water Scarcity in Agriculture (WASAG), the Dutch Ministry of Agriculture, Nature and Food Quality, the Wageningen University Research (WUR), the Vrije Universiteit Amsterdam (VU), and the International Center for Biosaline Agriculture (ICBA) organized a high-level session at the 2023 UN Climate Change Conference (Dubai) for Promoting the declaration of 2028 as the “[Year of Saline Agriculture](#)”, showcasing the transformative power of saline agriculture towards developing more climate-resilient, sustainable farming systems and healthy ecosystems in salt-affected areas.
19. From 27 to 31 May 2024, the 3rd annual meeting of INSAS is to be held in Valencia, Spain. In addition to the INSAS technical session, a workshop on SAS management, trainings and field trips have been organized to develop capacities and share knowledge on sustainable management of SAS.

9.5 International Network on Soil Fertility and Fertilizers (INSOILFER) including the International Network on Fertilizer Analysis (INFA) and the implementation of the International Code of Conduct for the Sustainable Use and Management of Fertilizers

20. Following the main recommendation of the Global Symposium on Soils for Nutrition organized in 2022, the [International Network on Soil Fertility and Fertilizers](#) (INSOILFER) was launched in July 2023 to contribute to the implementation of the International Code of Conduct for the Sustainable Use and Management of Fertilizers, particularly addressing the underuse, misuse and overuse of fertilizers.
21. [The International Code of Conduct for the sustainable use and management of fertilizers](#) (hereafter “the Fertilizer Code”) was endorsed by the 41st Session of the FAO Conference in June 2019. Since then, the Fertilizer Code has been translated and disseminated in FAO’s six official languages.
22. Although the emergency of the fertilizer crisis of 2022 has passed its peak, there are still after-effects such as soil fertility loss and vulnerable producers. The adoption and implementation of the Fertilizer Code therefore remains of high importance.
23. INSOILFER is formed by 260 members and 186 laboratories from 80 countries. The network operates with three [working groups](#) (WG): WG1- Soil nutrient monitoring, WG2 - Soil fertility and fertilizer management, and WG3 - Fertilizer safety and quality assessment.

24. The former International Network on Fertilizer Analysis (INFA) now constitutes the INSOILFER WG3 and continues its work on measuring and monitoring the quality and safety of organic and inorganic fertilizers and building capacity of its members on fertilizer analysis.
25. The [First Meeting of the Working Groups](#) of INSOILFER was conducted on 27-29 November 2023. The main outcome of the meeting was the establishment of the governance. Dr George Ndzana is the new INSOILFER Chair. Dr Ranjan Bhattacharyya, Dr Noura Mohamed Salah, and Dr Wesley Feldman were elected as INSOILFER Vice-Chairs and leads of the three WG, respectively. A technical taskforce for each WG was also formed and the initial work plan endorsed.
26. The webinar on “[Soil health as a prerequisite for crop production: The relevance of organic fertilizers](#)” was held on 30 January 2024. This webinar is part of INSOILFER's efforts to building capacity on sustainable soil management, organic fertilizers use efficiency, quality assessments of organic amendments, and integrated approaches advocating for balanced fertilization plans. This event attracted the attention of over 260 participants from 123 countries.
27. INSOILFER is currently harmonizing the following standard operating protocols (SOPs) for the determination of the quality and safety of organic and inorganic fertilizers:
 - The SOP for the analysis of total nitrogen concentration by Kjeldahl methodology is in the process of peer review and publication.
 - SOPs for the determination of heavy metal content in mineral fertilizers are under edition and publication.
 - SOPs for the determination of total nitrogen by the combustion method, total phosphorus by acid digestion, total potassium by the water-soluble method, total phosphorus by the ammonium vanadomolybdate absorptiometric method, and total phosphorus by the quinoline soluble gravimetric method are under harmonization.
28. In preparation for the launch of the first global Proficiency Test (PT) on the analysis of the quality of fertilizers, information was collected on customs procedures for the import and export of fertilizer samples.

9.6 International Network on Soil Biodiversity (NETSOB)

29. The [International Network on Soil Biodiversity \(NETSOB\)](#) was established in 2021 with the aim of promoting the sustainable use and conservation of soil biodiversity. The network is currently composed of 1 015 members from 129 countries. Membership in the network grew by 14 percent in 2023.
30. The Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) at its 15th session (COP15) adopted the Plan of Action 2020–2030 for the International Initiative for the Conservation and Sustainable Use of Soil Biodiversity as an instrument for supporting the implementation of the Kunming-Montreal Global Biodiversity Framework, on a voluntary basis and in accordance with national circumstances and priorities ([Decision 15/28. Biodiversity and agriculture](#)). The parties invited FAO, including through the framework of the GSP, to facilitate the implementation of the plan of action, involving parties, including their ministries of agriculture and environment at the national level, as appropriate. To this end, NETSOB has taken the facilitation role to implement the actions of this important initiative. NETSOB has produced a concept note in partial fulfilment of the initiative and is working within FAO and CBD to organize activities at COP16 in 2024.

31. The main results of NETSOB in 2023 and first half of 2024 are as follows:

- a) A webinar on the [Results from the 2022 global survey to assess the status of soil biodiversity initiatives and efforts](#) was held on November 17, 2023, with over 300 registrants;
- b) A synthesis of the survey findings has been written and reviewed by the NETSOB board. It is planned for peer-review publication in 2024. Additionally, results of the survey along with a review of recent literature indicating regional and international efforts to assess and monitor soil biodiversity will be published in a special edition of the journal *Soil Organisms*;
- c) NETSOB has contributed to the harmonization and development of the GLOSOLAN SOPs on microbial biomass and microbial enzyme activity;
- d) A [call for contributions](#) on current best practices to conserve soil biodiversity yielded 40 case studies and 20 chapter contributions. To date, nine high-quality case studies have been revised and are under publication. A revised call for contributions with a specific questionnaire will be launched in mid-2024;
- e) A draft of the theory and a formula for the economic valuation of soil biodiversity and an analysis of policies related to soil biodiversity have been developed. These documents will be finalized and published in a series of papers in the *Soil Organisms* special issue;
- f) The [3rd NETSOB Annual Meeting](#) was held on January 16-17, 2024. At the meeting, a new governance was defined. Dr Brajesh Singh has been elected as new Chair and Dr George Brown, Dr Zoe Lindo, Dr Gian Luca Bagnara, and Dr Rosalina Gonzalez continue to serve as Vice-chairs over each of the four working groups;
- g) The concept note for the Global Soil Biodiversity Observatory (GLOSOP) has been approved by the NETSOB in an in-person board meeting held in January 2024 and by the ITPS in March 2024 (see annex 1). The concept note was shared with the NETSOB members during the 3rd meeting and further disseminated during the IUSS centennial in May 2024;
- h) NETSOB will collaborate with the Soil Biodiversity Observatory Network (SoilBON) to collect biodiversity measurements and build capacity in five pilot countries.

9.7 International Network on Soil Pollution (INSOP)

32. The [International Network on Soil Pollution \(INSOP\)](#) was established in 2022 with the aim to stop soil pollution and achieve the global goal of zero pollution. The network has 400 new members since 2023 and now consists of 1 100 members from more than 110 countries.

33. The [second annual meeting of INSOP](#) was held online from 13 to 16 June 2023. The meeting had the following outcomes:

- a) the progress made by the network since its launch in April 2022 was reviewed;
- b) the priorities for the network were discussed and agreed;
- c) the work plan for 2023 and 2024 was endorsed; and
- d) INSOP leaders for the four working groups were elected.

34. The main results of INSOP in 2023 and first half of 2024 are as follows:

- a) INSOP, together with its partners Instituto Ekos Brasil (EKOS) and the Network for Industrially Contaminated Land in Europe (NICOLE) and Latin America (NICOLE Latam) have carried out a pilot project titled '*Risk assessment of heavy metals contamination of cocoa in Ecuador and Trinidad and Tobago and identification of sustainable management practices for soil pollution management*'. The outputs of the project were a methodology and checklist for risk assessment and the design of a conceptual site model for Trinidad and Tobago. The results of the project were presented at the [NICOLE Latam Annual Conference](#) held on August 23, 2023 in Sao Paulo, Brazil. The project attracted the attention of other countries, such as Brazil, and the private sector, and therefore it will be extended to a second phase where a detailed investigation will be carried out and ecosystem-based solutions will be applied in Trinidad and Tobago and Brazil.
- b) Collaboration was established with GLOSOLAN and INSOILFER to review SOPs on soil contaminants and develop new SOPs for determining heavy metals in fertilizers.
- c) On 16 November 2023, the [Assessment working group meeting](#) was organized focusing on the development of the SOP for determining the residue of pesticides in the soil and soil pollutant threshold values. More than 300 members from 93 countries registered for the meeting, in which 96 members from 52 countries actively participated.
- d) On 29 November 2023, the [Monitoring working group meeting](#) was organized focusing on updating the national legal instruments for the prevention, monitoring and remediation of soil pollution worldwide. More than 250 members from 82 countries registered for the meeting, in which 86 members from 50 countries actively participated.
- e) On 14 December 2023, the [Food Quality working group meeting](#) was organized focusing on launching a soil pollution educational module as part of the Global Soil Doctors Programme. More than 350 members from 90 countries registered for the meeting, in which 98 members from 65 countries actively participated.
- f) On 17 January 2024, the [Remediation working group meeting](#) was organized focusing on presenting the INSOP remediation checklist action plan and exchanging knowledge on sustainable remediation. More than 400 members from 100 countries registered for the meeting, in which 110 members from 77 countries actively participated.
- g) The Assessment, Mapping, Monitoring and Communicating Soil Pollution technical manual is under finalization and will be published at the end of 2024.

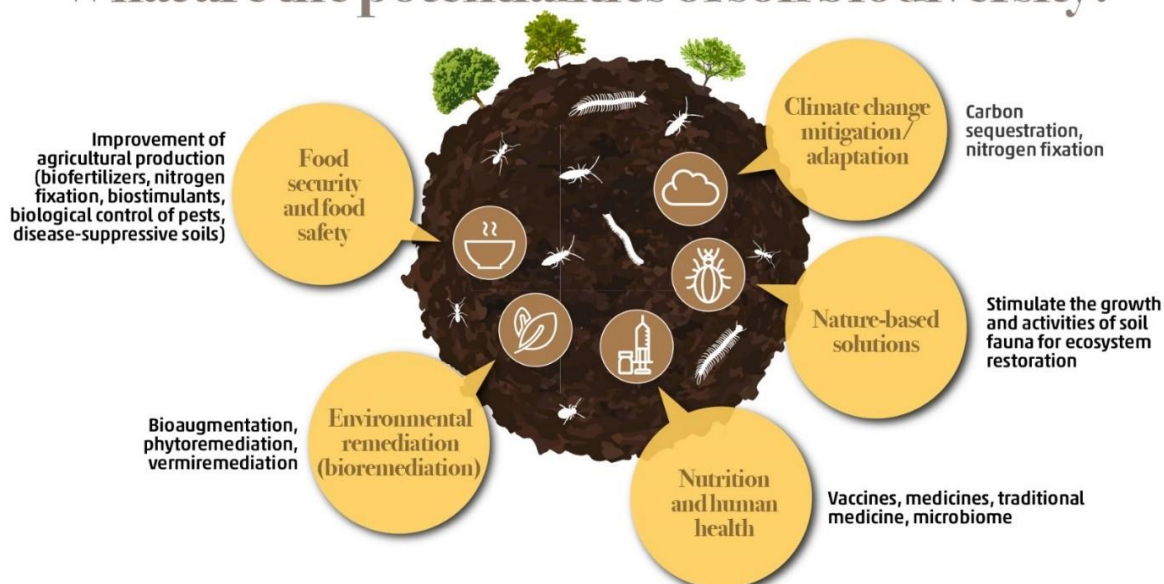
Annex I. Concept note: Global Soil Biodiversity Observatory

Background

Our well-being and the livelihood of all human societies are tightly connected with soil biodiversity and the ecosystem services it provides. The fundamental role of soils in global biogeochemical cycles, the functioning of terrestrial ecosystems for food, fuel, and fibre production, the filtration, degradation and immobilization of contaminants, and in climate change adaptation and mitigation all underpin the importance of promoting conservation, restoration, and sustainable activities around this precious resource.

Despite substantial advances in the knowledge of soil biodiversity and its functions, only around one percent of soil organisms have been identified so far. Soil biodiversity loss is one of the greatest threats in many regions of the world and is likely underestimated due to the lack of data. Data on soil biodiversity and its status at local, national, continental and global levels is therefore key to understanding the impact of human activities on ecosystem functions and services and to inform protection and restoration actions and policies.

What are the potentialities of soil biodiversity?



Although protection of aboveground biodiversity has been promoted for decades, little attention has been given to belowground biodiversity. A few regional and national initiatives specifically address soil biodiversity, while others evaluate indirect links to soil biota. However, those assessments target different soil taxa and often use different metrics. Harmonized measurements of soil biodiversity need to be a priority for soil surveys and soil sampling and mapping efforts to better understand and value soil biodiversity's contribution to soil health. Furthermore, considering its importance to ecosystem services provisioning, monitoring soil biodiversity is a critical component for assessing land use sustainability and the long-term maintenance of global soil health. Therefore, standardized guidelines and protocols for assessing soil biodiversity need to be developed and included in soil survey description manuals, as well as in long-term monitoring programmes of soil/environmental quality and the provisioning of ecosystem services from soils.

The Global Soil Biodiversity Observatory

As part of the post-2020 [Plan of Action of the International Initiative for the Conservation and Sustainable Use of Soil Biodiversity](#), adopted at the 2022 Conference of the Parties to the Convention on Biological Diversity (CBD COP15), the Food and Agriculture Organization of the United Nations (FAO) was mandated to implement a [global soil biodiversity and ecosystem function monitoring framework](#). This initiative aligns with past and recent efforts of the FAO's Global Soil Partnership (GSP) and its recently created International Network on Soil Biodiversity (NETSOB), as well as those from other international initiatives such as the Global Soil Biodiversity Initiative (GSBI) and the global Soil Biodiversity Observation Network (SoilBON). Through these initiatives, participating countries are therefore encouraged to improve their knowledge of soil biodiversity and implement sound policies and actions to prioritize soil biodiversity in National Reports and National Biodiversity Strategies and Action Plans (NBSAPs).

The Global Soil Biodiversity Observatory (GLOSOB) aims to be the global source of standardized reference data and information on soil biodiversity. The goal is to guide evidence-based decision-making, be the key provider of technical knowledge for measuring, mapping, and monitoring soil biodiversity in a harmonized way. The outcome will be to provide insight to soil biodiversity conservation and restoration practices for sustainable agriculture. GLOSOB priorities are to: a) improve knowledge on soil biodiversity; b) address soil biodiversity information gaps; and c) develop/strengthen national capacities to monitor, protect and sustainably manage soil biodiversity. GLOSOB includes monitoring soil biodiversity on managed lands and natural ecosystems.

GLOSOB intends to coordinate with and complement existing soil local, national, and international biodiversity initiatives where possible. This includes GSBI, SoilBON, The Global Initiative of Crop Microbiome and Sustainable Agriculture, and other similar networks and initiatives. GLOSOB follows a country-driven approach that is adapted to country capabilities through a tiered approach.

GLOSOB will be developed in four phases, an implementation phase, a planning phase, an execution phase, and a maintenance phase:

- 1) The first phase is the implementation of GLOSOB *per-se*, following a three-tiered voluntary participation, involving various levels of assessment of essential biological variables (EBVs; Guerra et al., 2020). The specific variables measured at each tier, harmonized methods, and how they are collected are determined in the implementation phase, with the assistance of NETSOB steering group.
- 2) The second phase will be the planning of the observatory for each country. This will involve countries, communities, and Indigenous Peoples determining participation tier, allocating resources, signing agreements, assessing training and/or capacity building needs, and establishing sampling strategies. Where requested, GSP technical networks or partners can help build capacity in planning steps.
- 3) The third phase will be the execution phase where sample collection according to the national sampling strategy and biodiversity measurements at the appropriate tier will commence. Capacity building on interpreting soil biodiversity measurements will be implemented.
- 4) The fourth phase will be the maintenance phase. Data will be compiled, analyzed, and interpreted for reports and for guiding policy. Capacity to advance to the next tier will commence. Initiatives to conserve and protect soil biodiversity can be enacted.

GLOSOB structure and governance

Given the global scope and the necessary coordination with governments and existing networks and initiatives, the following functions are proposed to manage and coordinate GLOSOB:

The initiation phase will be driven by the GSP. Tiers, essential biological variables and how measurements are collected for GLOSOB will be advised by the NETSOB steering group.

The planning, execution, and maintenance phases will be driven by individual countries. GSP technical networks are available to advise and help build capacity where needed. Where possible, these phases can be executed by existing initiatives.

The GSP Secretariat will engage with country governments to determine their level of commitment. GSP programmes and technical working groups will work at local level to establish sites and collect soil biodiversity measurements.

What will GLOSOB evaluate and monitor?

Soil biodiversity (from microflora and microfauna to macrofauna) will be sampled, measured, and monitored using standardized methods (standard operating procedures, SOPs) defined by NETSOB and GLOSOLAN, which complement the EBVs established by other initiatives (e.g., SoilBON; Table 1). Where standard methods are inappropriate or inadequate, additional soil samples will be examined at a standard central laboratory to provide comparison.

Note: current soil biodiversity monitoring initiatives are encouraged to participate in NETSOB to ensure complementarity and cooperation between efforts.

Table 1. Essential Biodiversity Variables and Measurements proposed in GLOSOB for each tier. Advancement in tier adds additional EBVs to the previous tier.

Tier	Bioindicators [#]	How to Measure it
1	Enzymatic activity	Acid Phosphatase, N-acetylglucosamine, xylosidase, cellobiohydrolase, B-glucosidase
1	Aggregate Stability	Water stable soil aggregates
1	Nutrient Cycling	N mineralization (available & total), Total C, Organic C, Available P
1	Soil physical properties	Bulk density, pH, VSA, soil texture, CEC
1	Mesofauna	Abundance
1	Soil Biomass	SIR, Nematode
1	Soil Respiration	Soil respiration
1* 2	Population Abundance	16S, ITS, Nematode*
1* 2	Taxonomic Diversity	Mesofauna (order level), 16S, ITS, 18S sequencing, Nematode*
2	Intraspecific Genetic Diversity	16S, ITS, 18S sequencing
2	Litter Decomposition	Litterbags
2* 3	Mesofauna	Dry extraction*, COI barcoding
2* 3	Macrofauna	Hand sorting*, COI barcoding
3	Root Traits	Root scans, weight, total N
3	Functional Diversity	Shotgun sequencing, ITS (FunGuild)

[#] SoilBON Essential Biological Variables (Guerra et al., 2020)

* Measurements that span different tiers

Bold indicates harmonized SOPs already in GLOSOLAN

Participation in GLOSOB

There are three tiers of GLOSOB participation (Table 1). Participation tier should be determined at the country level in discussions between national experts and policy makers. Where requested, the GSP secretariat and its technical networks can provide training and guidance on national capacities.

The goals of each tier are:

- a. to provide a minimum number of EBVs necessary for a basic-level description of soil biodiversity and basic functions at a particular site. The maximum number of countries should be able to participate at the limited tier of GLOSOB and establish critical baseline data on soil biodiversity.
- b. to facilitate and build capacity and encourage countries to engage further.

Upon joining GLOSOB, participating countries should either directly participate at tier 3 or commit resources/plans to build capacity to get to tier 3. GSP technical networks and partner organizations can help countries build local capacity. Tiers 1 and 2 should be viewed as transition stages.

GLOSOLAN and NETSOB are currently developing and standardizing several soil biodiversity-related methods and will disseminate SOPs, training, and quality assurance for soil biodiversity measurements when ready. Where possible, countries are encouraged to use GLOSOB (GLOSOLAN) standard SOPs. In cases where GLOSOB standards are inappropriate, additional samples will be sent to approved laboratories to provide transfer function data as explained by SoilBON.

Locations for monitoring soil biodiversity will be determined by country or regional stakeholders. National sampling strategies can be provided through training GSP networks.

Each sampling location for monitoring sites for the GLOSOB should have the following minimum metadata: GPS coordinates, climate type, rainfall, temperature regimes, altitude, relief (slope/position), biome/ecoregion, main land use type (FAO classification), soil type (Order, preferably using WRB classification), records of past and current agricultural/forestry/pastoral management practices (if applicable), main native vegetation class, GSN maps, and land use history (preferably last 5 years, where applicable).

GLOSOB

GLOSOB will adapt to in-country ability to measure the different EBVs at each tier level. Different soil biodiversity groups (from microbes to macrofauna) will be sampled, measured, and monitored using standardized methods, where possible.

Countries are expected to identify soil biodiversity locations for monitoring. Soil biodiversity measurements should also become a standard in the revised FAO Guidelines for soil description as part of national soil surveys. Furthermore, soil health and monitoring activities and assessments of agricultural sustainability should include soil biodiversity measurements.

In countries or regions where soil biodiversity observatories or initiatives are planned or ongoing, it is recommended that GLOSOB complement and reinforce these efforts (country-level resources are committed to these efforts to collect GLOSOB measurements or to collect measurements to allow comparison).

In summary, GLOSOB is to be implemented and operationalized as follows:

Participation: Countries and institutions express their desire to become part of GLOSOB activities.

Essential measurements: Sampling and monitoring methods and tools for EBVs as defined by NETSOB and GLOSOLAN.

Tiered approach: national capacities are assessed within the country (GSP to assist where needed) to initiate and carry out soil biodiversity monitoring programs. Each country adopts a tier from the three tiers defined in GLOSOB based on the country's ability to include EBVs assessments. A national plan is developed to meet the EBVs for each tier and to upgrade tiers as resources are available and capabilities/capacities are developed.

Country-driven approach: the generation of soil biodiversity data/information will be decentralized, and preferably funded by participating countries. In some cases, extra-national funds can be used to help countries participate in GLOSOB, but the tier, sampling strategy, and data are owned by the recipient country.

Build capacities: develop national capacities to measure, map, monitor, and interpret soil biodiversity (equipment, technicians, land owners, policy makers, etc.).

Monitoring: identify and monitor soil biodiversity sampling locations in managed lands and natural ecosystems and establish National Soil Information and Monitoring Systems (including soil biodiversity indicators).

Mapping: map the distribution of soil biodiversity worldwide.

Sharing data/information: countries share and contribute data and information to GLOSOB following the revised GSP Global Soil Data Policy that will be updated to include soil biodiversity information.

Reporting: GSP will report on the global status of soil biodiversity and publish reports and policy briefs regularly.

Updating: mainstreaming of soil biodiversity into conventional soil surveys (modification/updating of the FAO's Guidelines for Soils Description).

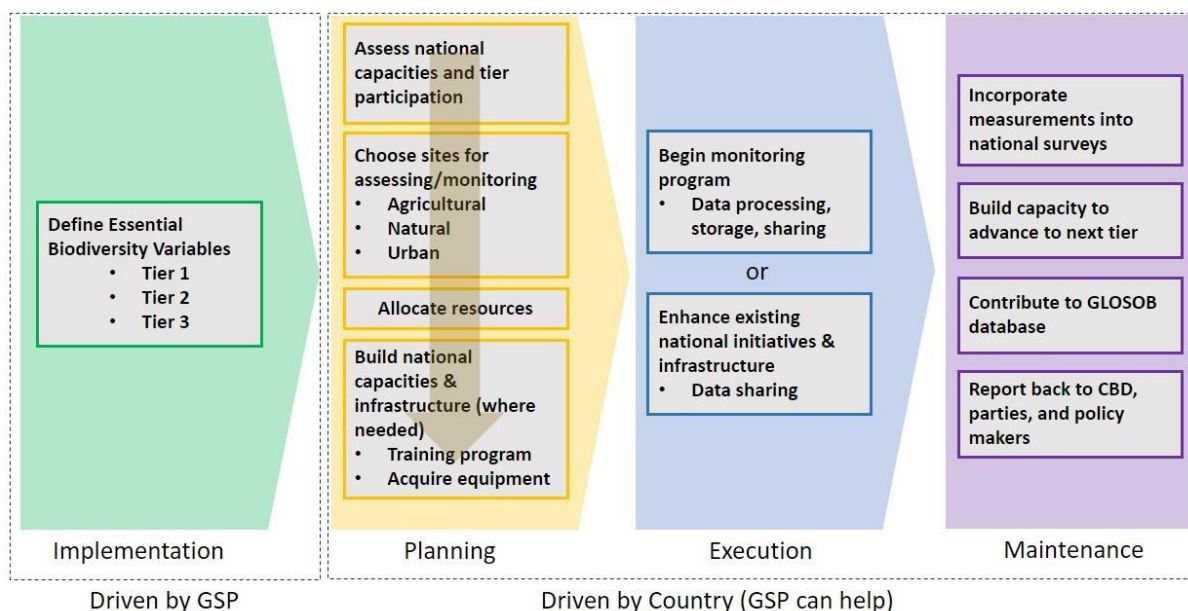


Figure 3. Plan of action for the Global Soil Biodiversity Observatory. Components of the four phases of the observatory (implementation, planning, execution, and maintenance) are outlined.

Information storage and access

The goal of GLOSOB is that each country manages a database where information can be easily entered, extracted, and visualized. Information should be easily imported where possible from current monitoring programs with compatible measurements. A biodiversity dashboard will be constructed with coordination from INSII to display key indicators for public accessibility for all stakeholders. Furthermore, a database will be constructed and housed within the GSP at FAO (GLOSI), including all variables, and be used to perform comparative analyses at global level, and improve understanding of the global drivers affecting soil biodiversity and functioning, or GLOSOB will coordinate with the Global Biodiversity Information Facility (GBIF) to house GLOSOB data. Although this is a country-driven decision, we recommend that each member country of GLOSOB establish a node with the GBIF, an international data infrastructure already funded by governments aimed at providing open access to data about Earth's biodiversity.