Food and Agriculture Organization of the United Nations

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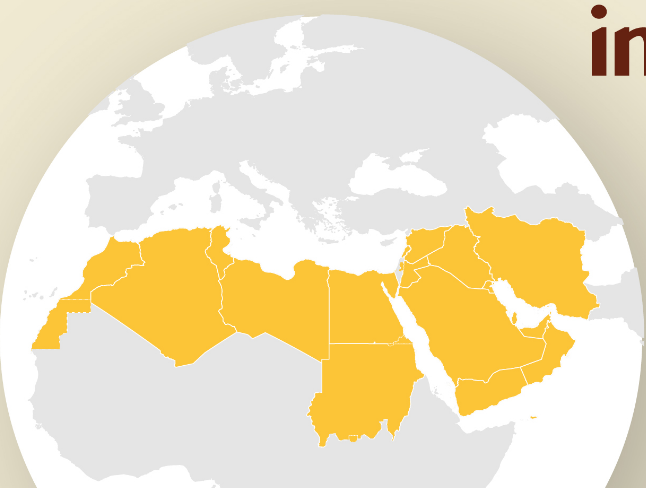
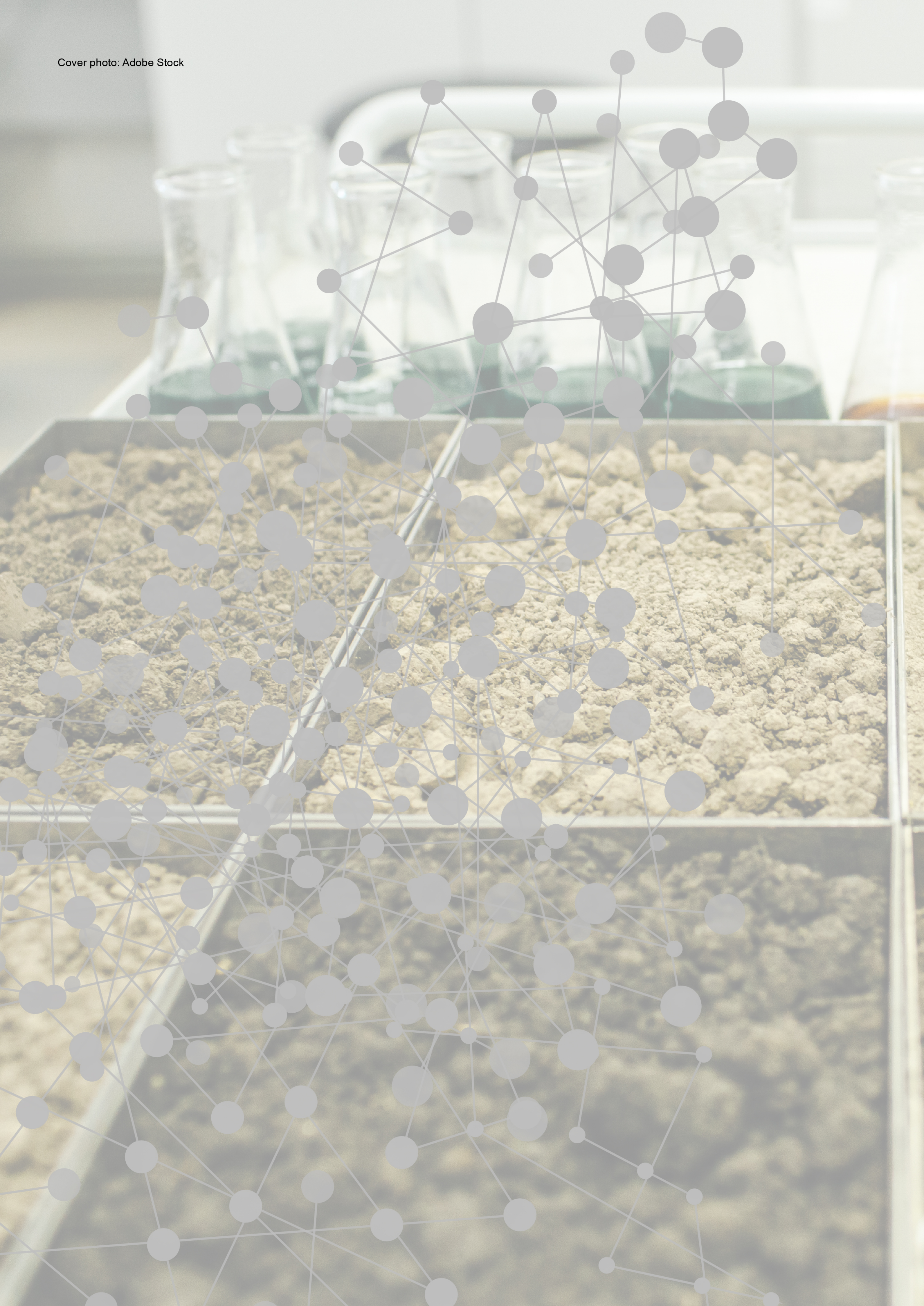
Regional assessment of soil laboratories capacities and needs

in the Near East and North Africa region



GLOBAL SOIL PARTNERSHIP



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REGIONAL ASSESSMENT OF SOIL LABORATORIES CAPACITIES AND NEEDS IN THE NEAR EAST AND NORTH AFRICA REGION

Mohammed Salih Dafalla and Lucrezia Caon

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Foreword

Soil degradation is a real threat to the production capacity of agricultural land in all the Near East and North Africa (NENA) countries and remains a major limitation to the reliable food supply in the region. Over the years, those governments have become increasingly aware of the role of soil in their economies and ecosystems, recognizing it as a fragile resource that needs to be preserved. Nevertheless, there is still a need to build the individual and institutional capacities necessary to plan, design, and implement impactful soil management programmes at a national and regional level, and to integrate them into water and land programmes.

The availability of reliable and harmonized soil data remains a challenge that affects decision-making at a national and local level, and the implementation of coordinated actions to practice of sustainable soil management in the region. Recognizing the challenge, the Food and Agriculture Organization of the United Nations (FAO) Regional Office for Near East and North Africa (FAO RNE) and the Global Soil Partnership (GSP) implemented a Technical Cooperation Programme (TCP) project from October 2020 to April 2023 to assess the capacities and needs of 34 soil laboratories under the ministries of agriculture from ten countries in the NENA region. By generating data, laboratories play a role that affects the entire decision-making process on soil management. Providing support to soil laboratories indirectly supports farmers, extension services and policy makers, and strengthens national databases for country reporting to international agreements such as the Sustainable Development Goals.

This report summarizes the main findings from the TCP project on soil laboratories, focusing on the political, financial and infrastructural constraints common to the soil laboratories assessed. This is in addition to training and procurement requests, which are discussed in more detail in the national soil laboratory assessment reports produced under the project.

Regional strategies can be developed to promote technical and scientific cooperation between countries and laboratories, and to aid in the establishment of international capacity building programmes on the topic. However, national governments are called upon to act in support of their soil laboratories. Urgent actions need to be taken to ensure safe working environments and conditions, the execution of accurate and precise soil analyses and lastly, to enable soil laboratories to meet national demands on soil analysis.

Through this project, FAO has opened the discussion on data quality and harmonization in the region. It is our hope that all relevant stakeholders and countries involved will use the findings and recommendations of this report to protect, sustainably manage and restore soils of the NENA region to maintain and increase food security, and increase resilience to climate change for the sustainable development and health of today's and future generations.

Abdulhakim Elwaer
Assistant Director-General
Regional Representative for the Near East and North Africa

Acronyms and abbreviations

AAS	atomic absorption spectrometry
CEC	cation exchange capacity
CRM	certified reference material
EC	electrical conductivity
FAORNE	FAO Regional Office for Near East and North Africa
GLOSOLAN	Global Soil Laboratory Network
GSP	Global Soil Partnership
NASOLAN	National Soil Laboratory Network
NENA	Near East and North Africa
NGO	non-governmental organization
PT	proficiency test
SDG	Sustainable Development Goal
SOPs	standard operating procedures
SPE	saturated paste extract
SSM	sustainable soil management
QA/QC	quality assurance/quality control

1. INTRODUCTION

The TCP/RAB/3802 project on Capacity development for the sustainable management of soil resources in the NENA region to achieve the Sustainable Development Goals (SDGs) was formulated to address the need to raise awareness on the importance of soils in the NENA region and to conserve and manage them sustainably. Soil degradation is a growing threat in the NENA region, as recalled by the first joint meeting of Arab Ministers of Agriculture and Water, who called for the establishment of "a sustainable regional mechanism to build individual and institutional capacities necessary to plan, design, and implement water and land management programmes efficiently" (page 2, Cairo Declaration of the Arab Ministers of Agriculture and Ministers of Water, 2019).[1]

Because of the impossibility of implementing activities in the Islamic Republic of Iran and Egypt, the project ultimately involved ten countries in the NENA region: Iraq, Jordan, Lebanon, Morocco, Oman, Palestine, the Sudan, the Syrian Arab Republic, Tunisia and Yemen. The project started on 21 October 2020 and will end on 30 April 2023. The total budget allocated to the project was USD 400 000. The project objectives were in line with the Food and Agriculture Organization of the United Nations (FAO)'s strategic framework and the countries´ programming frameworks.

The project had three expected outputs:

- Output 1: A better understanding of soil characteristics and challenges, with enhanced management practices.
- Output 2: Strengthened national capacities for the implementation of normative tools on sustainable soil management.
- Output 3: Strengthened regional and inter-regional collaboration on sustainable soil management (SSM).

Soil laboratory activities contributed to the achievement of Output 2. In this regard, the project aimed to build the capacity of national reference laboratories in the Global Soil Laboratory Network (GLOSOLAN) through the delivery of training tailored to the specific needs of each laboratory. The decision to invest in national reference laboratories refers to the leading role that these laboratories should play in their country. Indeed, national reference laboratories should lead the establishment of their National Soil Laboratory Network (NASOLAN) and the organization of national training and meetings so that the knowledge and skills acquired in GLOSOLAN can be passed on to other laboratories (see Terms of Reference).

However, in some cases, more than one beneficiary laboratory per country was identified due to political reasons and the administrative arrangement. The identification of beneficiary laboratories to the project was ultimately remitted to the national governments.

Beneficiary laboratories to the project were:

- Iraq:
  - Soil Chemical Analysis Laboratory, Soil and Water Resources Centre, Directorate of Agricultural Research, Ministry of Science and Technology (SCHAL-Wat);

[1] https://www.aoad.org/Cairo%20DeclarationFinal.pdf

- Soil and Water Analysis Laboratory (SWAL-Wasit), Wasit Agriculture Directorate, Ministry of Agriculture;
- The Central Laboratory of Soil and Water Analysis (CLASW-Dhi), Dhi_Qar Agriculture directorate, Ministry of Agriculture;
- Soil Research Department Laboratories, Ministry of Agriculture (SRDL), Abu Graib);
- Central Laboratory in Directorate of Agriculture in Karbala (CLDAK), Ministry of Agriculture;
- Soil and Water Resources Centre (SWRC), Sab' Abkar, National Centre for Water Resources, Ministry of Water Resources; and
- The Soil and Water Laboratories (SWLN), Nineveh Directorate of Agriculture, Ministry of Agriculture.

- Jordan:
  - Soil and Water Laboratory (SWL), Amman;
  - Fertilizer Analysis Laboratory (FAL), Amman; and
  - Microbiology Laboratory (MB), Amman.

- Lebanon:
  - Lebanese Agricultural Research Institute, Fanar; and
  - Lebanese Agricultural Research Institute, Bekaa, Tel Amara.

- Morocco:
  - Laboratory of Soil, Water and Plant Analysis, Research Unit on the Environment and the Conservation of Natural Resources, Regional Centre for Agronomic Research of Rabat.

- Oman:
  - Soil and Water Laboratory, Seeb; and
  - Soil and Water Research Laboratory, Salalah, Dhofar.

- Palestine:
  - Nablus Central Laboratory, Nablus; and
  - Natural Resources Department Soil Laboratory, Soil Research Lab (SRL), Jenin camp.

- The Sudan:
  - Land and Water Research Centre Laboratory (LWRCL), Land Evaluation Research Section, Land and Water Research Centre, Agricultural Research Corporation, Wad Medani;
  - Soil Analysis Laboratories Unit (SALU), Land Evaluation Research Section, Land and Water Research Centre, Agricultural Research Corporation, Wad Medani;
  - Soil Water Management (SWM), Land Evaluation Research Section, Land and Water Research Centre, Agricultural Research Corporation, Wad Medani;
  - Dongola Soil Laboratory (DSL), Dongola Research Station. Agricultural Research Corporation;
  - Land, Water and Plant Nutrition Research Centre (LWPRC), Gedarif Research Station. Agricultural Research Corporation;
  - Hudeiba Research Station Laboratory (HuRSL), Hudeiba Research Station. Agricultural Research Corporation;

    - Laboratory of Kadugli Agricultural Station (LKAS), Kadugli Research Station, Agricultural Research Corporation;
    - Kassala and Gash Research Station Soil Laboratory (KGRSSL), Kassala and Gash Research Station, Agricultural Research Corporation;
    - Soba Soil Analysis Laboratory, Soba Research Station, Agricultural Research Corporation; and
    - Soil and Water Laboratory (SWE), Elobeid Research Station, Agricultural Research Corporation.

- The Syrian Arab Republic:
    - The Central Soil Laboratory (ANRR-lab1), Karahta, Rural Damascus;
    - Lattakia Soil Laboratory (ANRR-lab2), Lattakia;
    - Al-Swaida Soil Laboratory (ANRR-lab4), Alswaida; and
    - Aleppo Soil Laboratory (ANRR -lab8), Aleppo.

- Tunisia:
    - Central Laboratory of Soil Analysis, Tunisia.

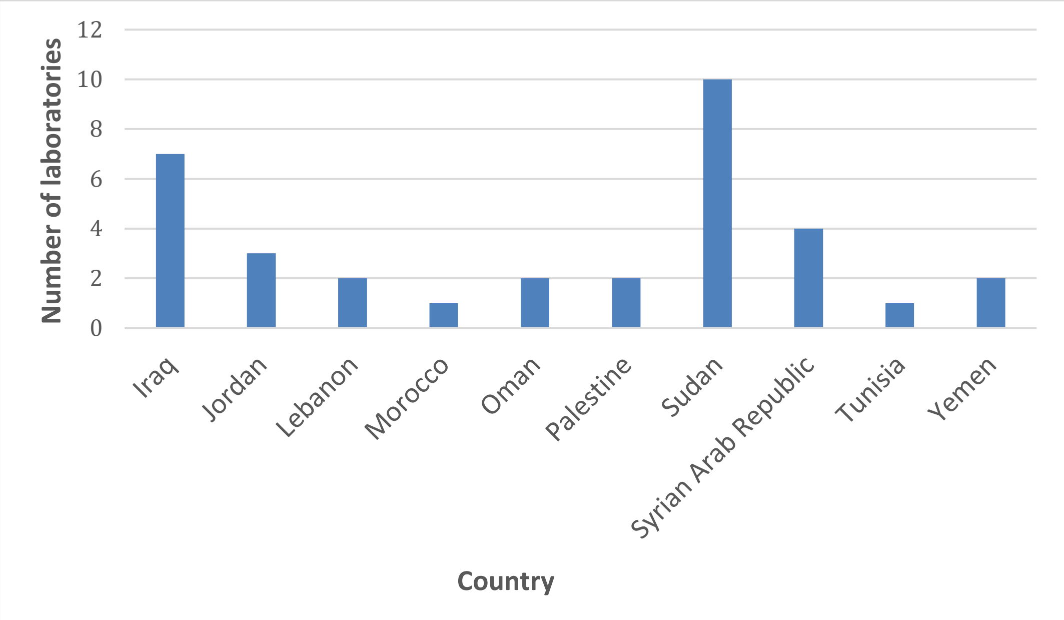
- Yemen:
    - Soil, Water and Plant Laboratory, Renewable Natural Resources Research Centre (RNRRC), Agricultural Research & Extension Authority (AREA), Dhamar; and
    - Soil and Water Laboratory, Agricultural Research & Extension Authority (AREA), Dhamar.

Following the carrying out of national assessments, training tailored to the beneficiary laboratories' needs and capacities was provided. Laboratory needs that could not be addressed through this project were also identified and brought to the attention of national governments for follow-up actions. This report discusses regional findings in the capacities and needs of soil laboratories and is based on the assessments of the national soil laboratories conducted during the project.

2. ASSESSMENT PROCEDURE

The capacities and needs of 34 soil laboratories were assessed (see Figure 1).

Figure 1. Number of beneficiary laboratories per country



Each beneficiary laboratory underwent a five-day assessment followed by five to twelve days of in-person or remote training. The laboratory assessment was crucial for building the capacity of laboratories in soil analysis, allowing for the generation of reliable data for decision-making at all levels. The assessment was also designed to investigate the financial and political conditions dictating the work by beneficiary laboratories and thereby explore ways to overcome any barriers preventing the generation of good quality data on soil and uphold the satisfactory performance and role of national reference laboratories.

The assessment started on 16 October 2021. Because of the large number of laboratories in the project, the assessment was carried out remotely, using the following tools:

- A structured, stratified questionnaire was used to assess the enabling environment, organization, infrastructure, and individuals of the laboratory (see Annex I).
- Virtual meetings and interviews were conducted with laboratory manager(s) and technician(s).
- Photos and videos were taken of the laboratories' units dedicated to the reception of soil samples, the storage of soil samples, and the storage of chemical reagents. Pictures and videos of the following were also collected:
    - laboratory benches;
    - analytical instruments with their manufacturing dates;
    - health and safety equipment (lab coats, sprinklers, laboratory's showers, firefighting equipment, etc.) and their manufacturing date;

- glassware;
- laboratory drainage system; and
- the waste and disposal area.

- Personal contact was maintained by emails, WhatsApp and other communication channels to allow for a faster communication when needed.
- The opinion of independent experts was sought as applicable. National soil data management consultants hired to look after the implementation of soil data management and mapping activities in the project were asked to visit the laboratories and to give an opinion on their status. The national focal points to the Global Soil Partnership (GSP) were also asked to do the same, as were the land and water officers at the FAO Country Offices.

3. MAIN FINDINGS

3.1. ORGANIZATIONAL SETUP

Beneficiary laboratories in all countries were affiliated to the Ministries of Agriculture. However, few laboratories in Iraq belonged to the Ministry of Water Resources and the Ministry of Science and Technology.

On average, 33 percent of the beneficiary laboratories had a surface area of less than 100 m^2 with the smallest measuring only 24 m^2. Six percent of the laboratories had a surface area of more than 600 m^2, with the largest measuring 1 500 m^2 (details are reported in Figure 2). Twenty-one percent of the laboratories had only one room, 25 percent had two rooms, and only 15 percent had more than ten rooms (see Figure 3). It is worth noting that in most laboratories some rooms were also used as offices.

Figure 2. Surface area in square metres (m^2) of the beneficiary laboratories to the project

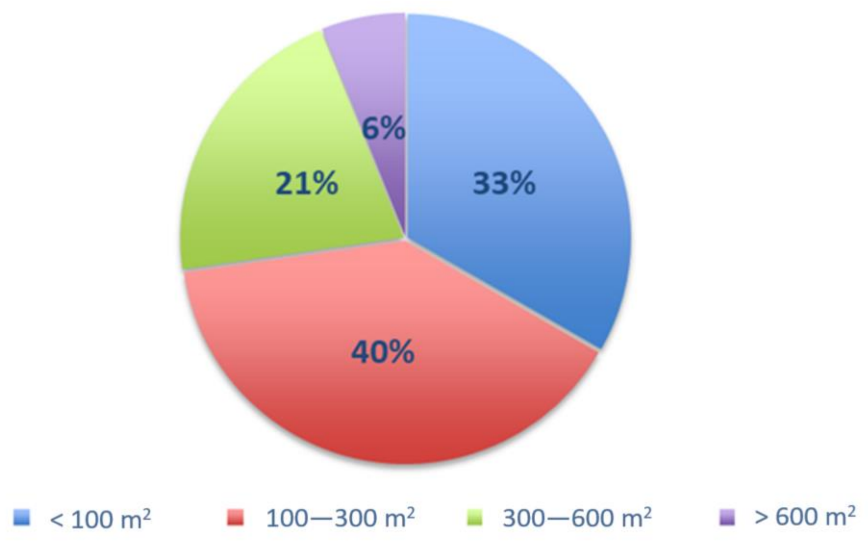
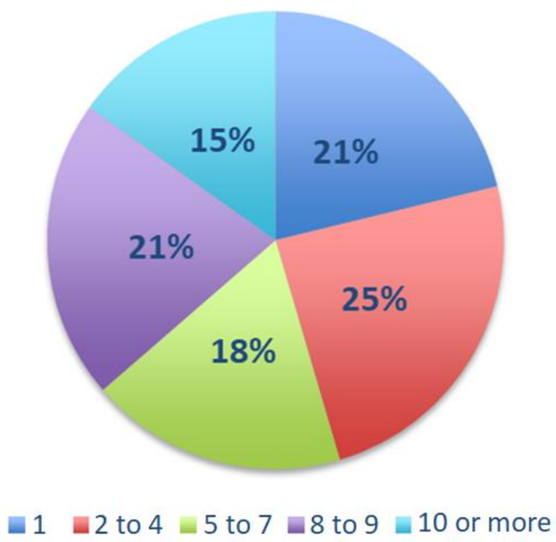
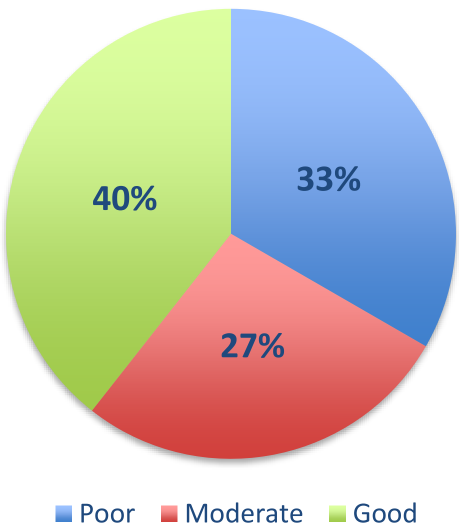


Figure 3. Number of rooms in beneficiary laboratories to the project



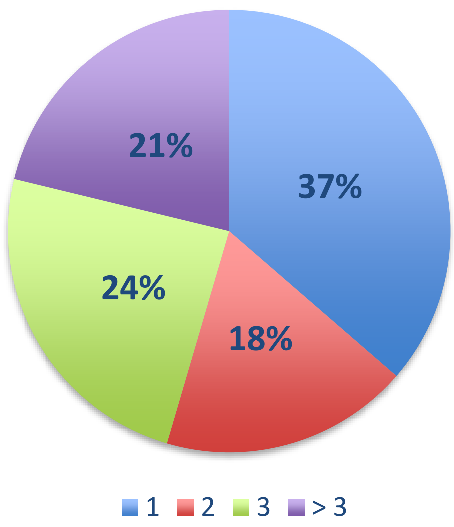
Sixty percent of the investigated laboratories were old and with infrastructure in a poor to moderate condition (see Figure 4). Because of political and economic instability, the need for maintenance is greater in Lebanon, Palestine, the Sudan, the Syrian Arab Republic, and Yemen. In countries like Iraq, Oman, Morocco, and Tunisia, laboratory infrastructures were considered good, partly due to the implementation of reconstruction activities in Iraq.

Figure 4. Status of the infrastructure in beneficiary laboratories to the project



Overall, the surface area and the number of rooms in most laboratories were not sufficient to conduct a large variety of soil analysis and to operate according to health and safety standards. This was also confirmed by the large percentage of soil laboratories in poor to moderate conditions, which needed maintenance interventions. The number of departments and units within the soil laboratories varied depending on the type of services offered by the laboratory. The largest percentage of laboratories had one department (37 percent) while only 21 percent had more than three departments (see Figure 5).

Figure 5. Number of departments in beneficiary laboratories to the project



3.2. FINANCIAL SETUP

All beneficiary laboratories receive financial support from their governments through the allocation of an annual budget assigned based on laboratories' activities and needs. The annual budget request is prepared and revised by a specific administration and approved either by the Ministry of Agriculture or the Ministry of Science and Technology, and the Ministry of Water Resources in the case of Iraq. Depending on the country's economic situation and priorities, the budget is either completely or partially approved. In case of partial approval, priority is given to cover the cost of the most urgent activities and needs. Although laboratories provide analytical services to third parties, most are not allowed to have access and use of the additional funds, apart from laboratories in the Sudan and Yemen who are able to use the fees they charge to clients.

Because of the current grain and fertilizers crises, all the countries in the project are experiencing increasing concerns on food security that require their government to invest on extension services and soil laboratories. This situation is exacerbated especially in countries with economies heavily relying on agriculture, such as Jordan, Palestine, the Sudan, the Syrian Arab Republic, and Yemen. The long-term political and economic instability in Iraq, Lebanon, Palestine, the Sudan, the Syrian Arab Republic, and Yemen, have had a further and more pronounced negative impact on laboratories suppliers and equipment maintenance that is now requiring the government to make greater investments in the sector. Overall, the agricultural policies and strategies in all countries but Morocco and Jordan do not completely accommodate all agricultural concerns and do not clearly promote soil laboratories activities. Some regulations, such as those on permits and investment licenses for new agricultural lands (conversion of land use) and on the accreditation of exported fertilizers and agricultural commodities, do indirectly promote soil analysis. Nevertheless, there is no clearly formulated regulation or policy on soil analysis in all the countries under examination.

3.3. Laboratory staff

Details on laboratory staff are reported in Figure 6. Most laboratories have permanent staff, except in Lebanon where all staff have one-year fixed-term contracts and in Morocco, where more staff have temporary contracts than those with permanent contracts (Figure 7). Apart from Yemen and Tunisia, all laboratories have staff with doctoral degrees who normally work as laboratory managers or provide agricultural recommendations to farmers (Figure 8 and Figure 9). The number of technicians was considered sufficient in every country except Lebanon (Figure 10). It is worth noting that with the exception of Yemen, no beneficiary laboratories have any technician or engineer able to maintain instruments and equipment. In Yemen, due to being unable to access this service, some technicians taught themselves how to maintain their laboratory equipment. No country has a regular recruitment system in place and the lack of technicians limits the number of soil samples analysed annually.

Figure 6. Type of contract of laboratories' technicians and managers at the regional level

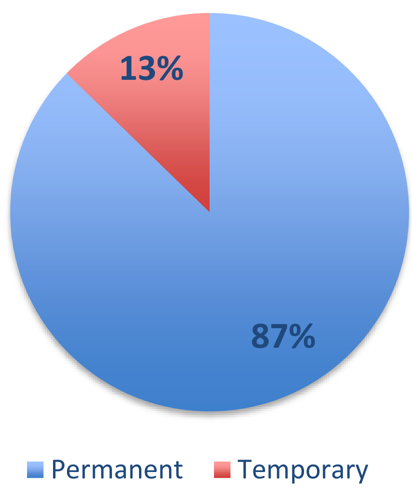


Figure 7. Type of contract of laboratories' technicians and managers at the country level

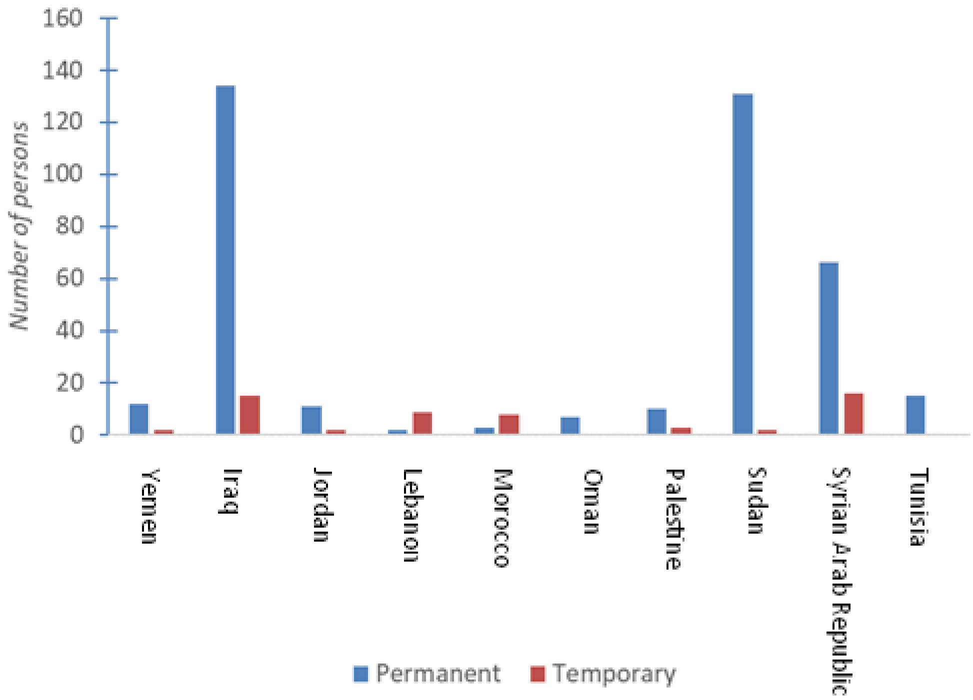


Figure 8. Academic qualification of staff in beneficiary laboratories to the project at the regional level

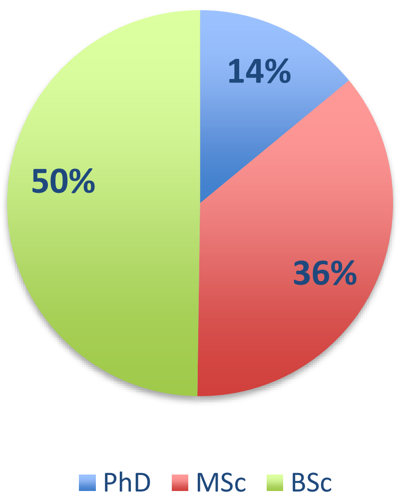


Figure 9. Academic qualification of staff in beneficiary laboratories to the project per country

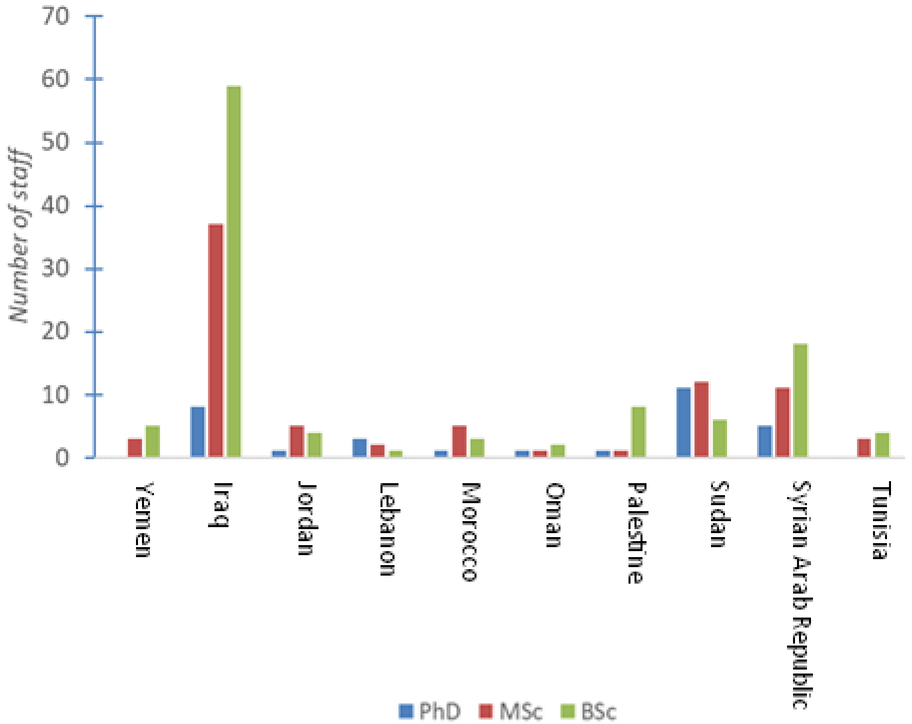
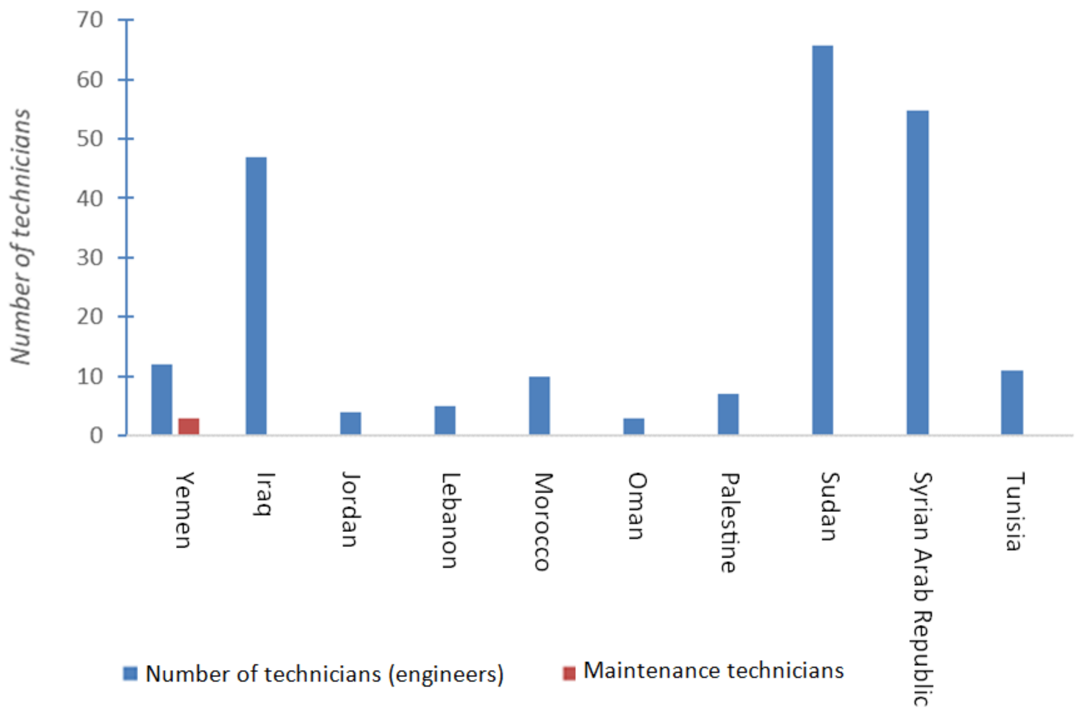


Figure 10. Number of technicians in beneficiary countries to the project



3.4. Clients

Based on the information provided from questionnaires, the main clients to beneficiary laboratories in the region are:

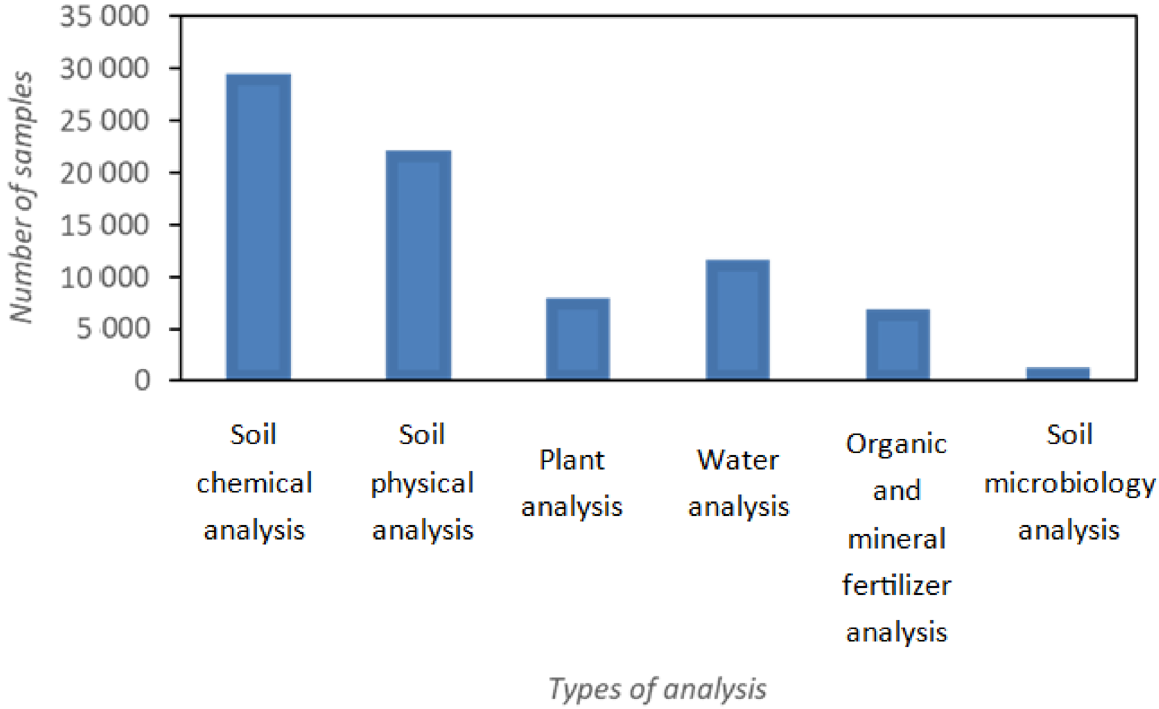
- governmental institutions and companies;
- private agricultural companies;
- fertilizer companies;
- international organizations like FAO and the International Fund for Agricultural Development (IFAD) and others;
- farmers;
- non-governmental organizations (NGOs); and
- universities (academics, researchers, and students).

Overall, soil laboratories are well distributed in the region. They are therefore in a position to properly support farmers' activities and gives them the potential to support the implementation of SSM practices and activities aimed at improving land productivity.

3.5. Type of analysis

Based on their competence, each beneficiary laboratory performs a different set of soil analyses and processes a different number of soil samples per year (see Figure 11). Beneficiary laboratories mostly analyse soil samples for chemical and physical properties and, to a small extent, conduct soil microbiology analysis. The majority of laboratories also perform plant, water, and fertilizer analysis

Figure 11. Number of samples per type of analysis processed in the region annually

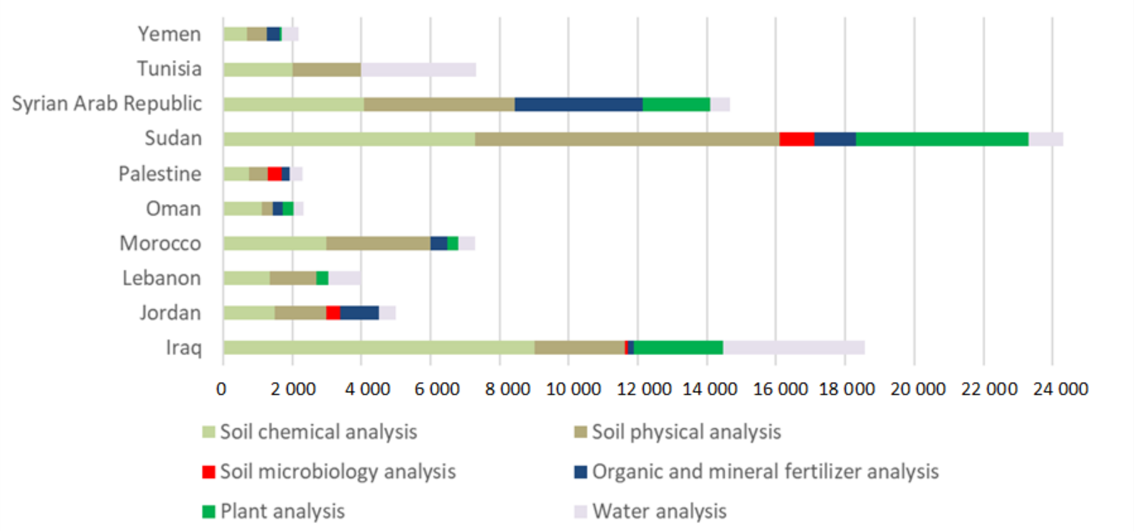


Soil researchers in all laboratories provide a basic interpretation of the results of soil, water, plant, and fertilizers analyses and provide recommendations to the farmers on request.

Details on the number of samples analysed by beneficiary laboratories in each country are reported in Figure 12. Information on the methods used to analyse major soil properties are reported as follows (together with information on the percentage of laboratories that use them in the region):

- **Organic carbon**: All laboratories use the Walkley and Black method. Information on the soil organic matter content is obtained by applying a correction factor of 1.72 to the results obtained with the Walkley and Black method.
- **pH reading**: Forty percent of laboratories read in soil:water suspension of 1:1, 1:2.5 and 1:5 (Yemen, Lebanon, Morocco and Tunisia) while Jordan, Oman and the Sudan read in saturated paste extract (SPE) (30 percent of laboratories). However, laboratories in Iraq, Palestine, and the Syrian Arab Republic read it in both soil–water suspension and SPE (30 percent of laboratories). In the case of the Syrian Arab Republic, pH is also read using potassium chloride (KCl).
- **Electrical conductivity (EC) reading**: Forty percent of laboratories read EC in a filtrate of soil–water suspension of 1:2.5 and 1:5. Thirty percent read in SPE and 30 percent read in both a soil–water suspension and in SPE (30 percent of laboratories).
- **Soluble cations and anions**: Beneficiary laboratories in all countries but Lebanon use the titration method to determine calcium, magnesium, carbonate and bicarbonate. Nevertheless, sodium and potassium are determined using flame photometer in all countries.
- **Inorganic carbon (percentage of calcium carbonate [$CaCO_3$])**: Laboratories in all countries but Jordan, Lebanon, and Palestine determine the percentage of $CaCO_3$ by the back titration method (70 percent);
- **Total nitrogen**: All laboratories use the Kjeldahl method.
- **Available phosphorus**: All laboratories use the Olsen Method.
- **Cation exchange capacity (CEC) and exchangeable cations**: All laboratories do extraction with ammonium acetate.
- **Micronutrients**: Micronutrients are determined by atomic absorption spectrometry (AAS) after extraction with DTPA (50 percent of laboratories) or acids (50 percent of laboratories).
- **Soil moisture**: All laboratories use gravimetric analysis.
- **Soil texture**: All laboratories use the hydrometer method.
- **Soil water retention curve**: This is only measured in the Sudan, Yemen, and Tunisia (30 percent of laboratories) using a pressure cooker.
- **Soil microbiology**: Only Jordan and Iraq (20 percent of laboratories) conduct soil microbiology analysis.

Figure 12. Number of samples analysed by each country annually

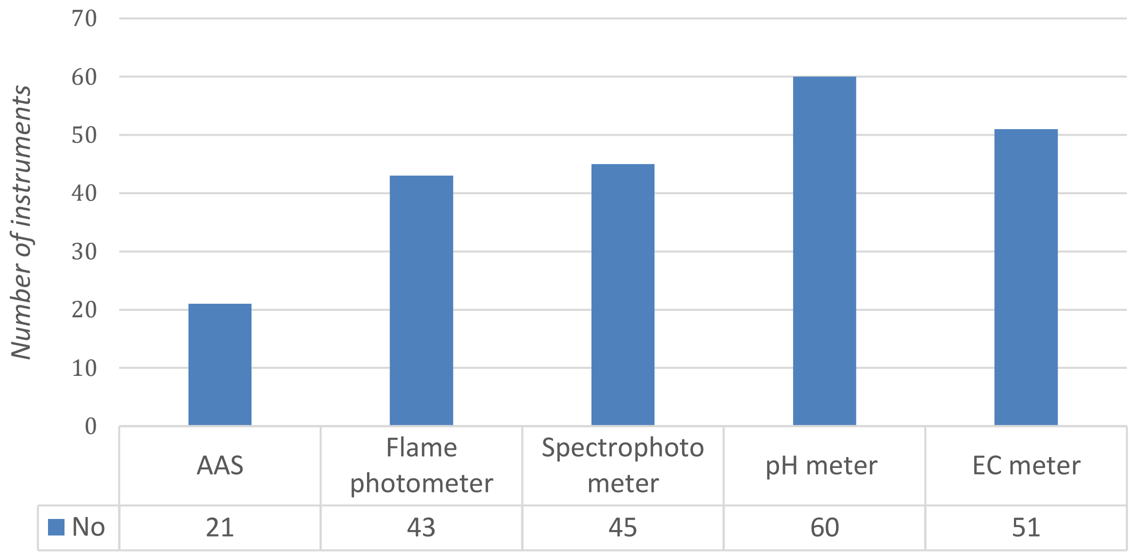


3.6. Laboratory equipment

Beneficiary laboratories have equipment and instruments for the chemical and physical analyses of soil, water, plants, and organic and mineral fertilizers, according to its purposes. The instruments are generally old and frequently malfunctioning. Maintenance services are offered by supply companies during the warranty period but no regular maintenance is performed and all labs but the ones from Yemen do not have any maintenance engineers or technicians. The laboratories request maintenance services from the appropriate companies when needed.

Although the assessment looked at all the equipment present in the laboratories, this report focuses on the availability of the five most relevant pieces of equipment used to conduct basic routine soil analysis. These are the atomic absorption spectrometer (AAS), the flame photometer, the spectrophotometer, the pH meter, and the EC meter. Details on the availability of this equipment in the region is reported in Figure 13.

Figure 13. Number of pieces of the five most relevant equipment to conduct basic routine soil analysis in the region



Equipment-specific remarks:[2]

- **AAS**: Apart from the Sudan, all countries have at least one AAS. The countries with the highest number of AASs are Iraq (six) and the Syrian Arab Republic (six).
- **Flame photometer**: All countries have at least one flame photometer. The countries with the highest number of flame photometers are Iraq (12), the Sudan (ten), and the Syrian Arab Republic (seven).
- **Spectrophotometer**: All countries have at least two spectrophotometers. The countries with the highest number of spectrophotometers are Iraq (13), the Sudan (ten) and the Syrian Arab Republic (seven).
- **pH meter**: All countries have at least two pH meters. The countries with the highest number of pH meters are Iraq (20), the Sudan (ten), and the Syrian Arab Republic (ten).
- **EC meter**: All countries have at least one EC meter. The countries with the highest number of EC meters are Iraq (17), the Sudan (nine), and the Syrian Arab Republic (seven).

3.7. Procurement system

In all beneficiary countries, the decision to replace or buy new devices is based on the efficiency and accuracy of the available devices in comparison with readings of reference samples, regardless of the age of the device. The procurement system follows the standard international procedure:

- **Step 1**: An internal consultation on the instruments needed by the laboratories in terms of number and technical specifications.

[2] It is important to note that Iraq, the Sudan and the Syrian Arab Republic are also the countries with the largest number of laboratories in the project.

- **Step 2**: The preparation and revision of the technical specifications by an internal committee, including the laboratory's managers.
- **Step 3**: The documents for launching a call for tender are revised and approved by the head of the laboratory and endorsed by the Ministry of Agriculture.
- **Step 4**: Publishing the call for tender to the accredited supply companies, who provide their offers based on the technical specification. Note that the technical specifications always include warranty, guarantees, installation, and the eventual provision of training and regular maintenance during the warranty period.
- **Step 5**: Awarding the tender to the best offering vendor. The winning offer is identified based on the quality of the offer and the lowest price.
- **Step 6**: The purchase order is approved by the committee.

It is worth mentioning that the purchasing of new devices is controlled and linked to the annual budget authorized by the Ministry. The economic crisis being experienced by countries like Lebanon, Palestine, the Syrian Arab Republic, the Sudan, and Yemen is having serious negative impacts on the maintenance and purchasing of new instruments and on the replacement of old ones. Ultimately, this condition affects the quality of the analysis and the quantity of samples that each laboratory can analyse each year.

3.8. Staff training

Overall, soil experts and researchers in all the beneficiary laboratories have a good working knowledge of, and experience in soil, water, plant, and fertilizer analyses, results interpretation, and provision of agricultural recommendations to the farmers due to their formal education. Apart from in the Sudan and Yemen, where most of the technicians only have a secondary school education, all soil experts and researchers across the beneficiary laboratories hold Bachelor (BSc), Master (MSc) or doctoral (PhD) degrees.

Laboratories in Jordan, Palestine, the Syrian Arab Republic, and Tunisia provide regular training to their staff, although this does not happen in other countries. In all countries, soil experts, researchers and technicians provide training to university students and researchers. All laboratories, except those in Tunisia and the Syrian Arab Republic, do not have any training programme on health and safety and quality assurance and quality control.

3.9. Laboratory management system

In all countries, the head of the laboratory is responsible for monitoring and supervising the whole soil analysis process, from sample reception to the delivery of results and their interpretation. Recommendations on soil fertility management are provided upon request in all countries apart from Lebanon, Palestine, and the Syrian Arab Republic. Soil samples are registered at entry in record books or digitally. In all countries but Tunisia (which only use hard form), results of the analysis are recorded in hard and digital forms using a computer program and are delivered in digital and hard forms to the clients. Laboratories follow written standard operating procedures (SOP) in English, in addition to the SOPs produced by the International Center for Agricultural Research in the Dry Areas (ICARDA) in

Arabic. Standard operating procedures in English are based on the United States Department of Agriculture (USDA) system and ICARDA. The reports for the clients are signed by the head of the laboratory.

3.10. Drainage and waste management system

In all countries, laboratory waste management is very poor although some national laws or legislation exist in Jordan, Morocco, Tunisia, and Lebanon. However, these are not well implemented. Overall, the laboratories do not adopt any specific waste management system. Analysed soil samples are either disposed of in the general waste or taken to specific places outside the laboratory but without any special treatment, while reagents are poured down the sink. Laboratories' drainage systems are not isolated from the public drainage system. As an example, the drainage system in the Sudan is an aseptic tank connected to surface groundwater, with the subsequent environmental pollution and human health risks.

3.11 Quality assurance/quality control (QA/QC)

Quality assurance (QA) and quality control (QC) procedures are in place in Jordan, Morocco, Palestine, and the Syrian Arab Republic and moderately implemented in Iraq. In those countries, certified reference materials (CRMs), standard reagents and blank samples are used as QC tools. In Lebanon, Oman, the Sudan, Tunisia, and Yemen, all laboratories have weak QA/QC procedures and standard reagents, internal control samples and blank samples are used for quality checks. The countries with the weakest QA/QC are Lebanon, Oman, the Sudan, and Yemen. However, the national reference laboratories to GLOSOLAN in Lebanon, Iraq, Jordan, Morocco, the Sudan, the Syrian Arab Republic, Tunisia, and Yemen participated in the proficiency test (PT) organized by GLOSOLAN in 2022. The laboratory in Palestine attempted to participate but could not get the samples due to customs procedures. Oman did not participate in the GLOSOLAN PT 2022.

3.12 Health and safety

The health and safety system in beneficiary laboratories varies with the country. The system is relatively good in Oman; moderate in Iraq, the Syrian Arab Republic, and Tunisia; weak in Jordan, Lebanon, Morocco, Palestine, and the Sudan; and poor in Yemen. Laboratories in the Syrian Arab Republic do not have first aid kits. Laboratories in Oman, Palestine, and the Syrian Arab Republic do not have internal showers. Although some laboratories have ventilation systems, these are not well distributed in the lab space. It is worth mentioning that in some the Sudanese and Syrian laboratories, laboratory heads and managers consider the opening of windows and the turning on of the air conditioners as a health and safety measure to compensate for the absence of a ventilation system. Overall, most laboratories have protective cupboards. The majority of beneficiary laboratories have fire extinguishers. Overall, laboratories in the region have weak health and safety systems.

4. Strengths of the beneficiary laboratories

During the assessment, beneficiary laboratories shared the following strengths:

- Overall, laboratories are well distributed on the national territory, allowing them to serve farmers in several agroecological zones.
- Laboratory technicians and managers have extensive experience in soil analysis and in the analysis of the soil types that are dominant in their countries.
- Laboratories are characterized by having qualified and committed staff and technicians.
- Laboratories have well established administration systems; and
- Most of the beneficiary laboratories have a well-established laboratory management system.

5. Laboratory issues

During the assessment, it was found that most or all beneficiary laboratories share the following issues:

- All laboratories suffer from a lack of equipment, consumables and (in some cases) technicians. Technicians are needed, especially in Lebanon and in some laboratories in the Sudan, where all the work is done by the laboratory manager. This situation is affecting the ability of the laboratories to satisfy the national demand for soil analysis.
- The absence of a regular recruitment system results in a knowledge and skills-sharing gap between generations. Often, the retirement of a specialized technician results in the inability of the laboratory to continue with some analyses.
- The lack of regular training and skills-improving programmes put laboratory technicians and managers in the position of having to work by self-learning, increasing the risk of making errors when implementing new procedures or being non-compliant with international standards. The establishment of staff laboratory mobility programmes could help laboratory technicians and managers to increase their knowledge and eventually acquire international experience.
- Overall, laboratories have old instruments and equipment in need of maintenance or being replaced. The absence of maintenance technicians exacerbates the situation in countries with limited financial resources or access to after-sale and maintenance services by manufacturers or vendors. The absence of a regular maintenance system also extends to the laboratory infrastructure.
- Beneficiary laboratories suffer from financial constraints and inadequate direct cash incentives that limit their ability to take immediate action on the reparation of malfunctioning equipment, the procurement of consumables and the recruitment of additional technicians when needed. Because of the frequent malfunctioning of instruments able to provide information on a large set of soil parameters at once (for example, AAS), this point is particularly serious.
- Most of the beneficiary laboratories have unstable electrical power supplies which limit the number of soil samples that can be analysed in a day.
- All laboratories have very poor waste management and drainage systems.

- Overall, laboratories have weak health and safety systems that therefore increase the risk of accidents for laboratory technicians and managers.
- Laboratories that have weak QA/QC procedures, meaning that the quality of results of the analysis cannot be guaranteed.

6. Laboratory needs

During the national assessments, laboratories' needs were divided into three categories:

1. needs to be addressed through the project (mainly related to training);
2. needs to be addressed through a second phase of the project (related to training and procurement); and
3. needs to be addressed with the support of the government.

In general, beneficiary laboratories in all countries were trained on:

- soil samples collection and storage;
- preparation of soil samples for different routine soil analyses;
- preparation of standard solutions;
- implementation of GLOSOLAN's SOPs for the analysis of chemical and physical soil parameters. If GLOSOLAN SOPs were not available, training was provided on the implementation of SOPs released by ICARDA and national institutions;
- pH (soil–water suspension or SPE);
- electrical conductivity (EC) (SPE and soil–water suspension);
- soluble cations and anions (Ca, Mg, Na, K, CO_3, HCO_3, and Cl);
- available P by Olsen Method;
- analysis of total nitrogen;
- total and organic carbon analysis by Walkley and Black method and the calculation of organic matter from total carbon;
- management and disposal of chemicals;
- soil moisture content analysis;
- soil texture analysis;
- QA/QC for soil analysis;
- calibration of laboratory equipment;
- internal quality control;
- external quality control (proficiency testing);
- soil report writing;
- interpretation of soil results and provision of recommendation; and
- health and safety.

The project was successful in training 227 laboratory technicians and managers. Because of security or logistic reasons (such as long VISA application times, and the impossibility to find some vaccines required to enter the country), the training sessions were conducted in person in Jordan, Morocco, Oman, the Sudan, and Tunisia and online in Iraq, Lebanon, Palestine, the Syrian Arab Republic, and Yemen. Following the conclusion of the assessment, all laboratories were given the opportunity to comment on the training programme before the start of the training. Training videos on the implementation of some SOPs were recorded during the training in Iraq, Oman, and the Sudan. These will be made available on the GLOSOLAN website in 2023.

At the end of the training, an assessment of its quality and pertinence was carried out. All trainees said that they were very satisfied with the training and the trainer. However, they requested that future training should be for a longer period of time, less intensive, and in person. Time was a constraint, especially for trainees in Jordan, the Syrian Arab Republic, and the Sudan that attended a five-day intensive training. The project budget allocated to training activities dictated their duration, modality, and number of trainees. In this regard, the training duration and modality was adapted to the number of trainees, which was higher than expected in almost all countries. This was due to the request of the government to increase the number of beneficiary laboratories to the project from one to a maximum of ten. It should be noted that, in case of in-person training, the project and the FAO Country Offices had to cover unplanned travel and accommodation costs resulting from the participation of trainees from laboratories other than the national reference laboratory. In a few cases (for example Oman), the country's government co-financed the event, allowing for the organization of an extensive (14 days), in-person training with a high number of trainees from each beneficiary laboratory.

Additional training was also requested on topics like soil microbiology, fertilizer analysis, and the maintenance of laboratory equipment. Trainees also suggested future projects to include visits to soil laboratories located abroad.

Figure 14. Training in Lebanon (online)

Figure 15. Training in Oman (in person)

Figure 16. Training in the Sudan (in person)

Figure 17. Training in Jordan (in person)

The project was also successful in identifying those actions that require the direct intervention of the national governments as these go beyond the mandate and possibilities of FAO:

- There is a need to establish regular national training programmes and national and international exchange programmes aiming at building the capacity of laboratory technicians, managers and researchers in soil analysis and good laboratory practices.
- There is a need to formulate and implement laws and regulations for the management of soil laboratories' waste and the disposal of expired chemicals. The same applies to the drainage systems, which should be regulated in order to limit water and environmental pollution, as well as to reduce the risk and exposure of people to toxic substances.
- There is a need to establish policies and regulations on the minimum data quality required for decision-making on soil management. This would ensure and encourage the government and the private sector to engage and promote soil analysis.
- There is a need to issue permanent maintenance contracts for regular checking and repairing of analytical instruments.
- There is a need to establish policies and regulations on health and safety, and to invest in the installation of health and safety equipment in soil laboratories.

7. Conclusions and recommendations

The project successfully assessed the capacities and needs of 34 laboratories in Jordan, Morocco, Lebanon, Republic of Iraq, the Sudan, Tunisia, Yemen, Palestine, Oman, and the Syrian Arab Republic. Two-hundred and twenty-seven laboratory technicians and managers were trained on the implementation of standard operating procedures (including the calibration and maintenance of the soil laboratory equipment), good laboratory practices (including quality assurance and quality control and the writing of laboratory reports), and health and safety. Training was successful although implemented with some limitations related to the availability of budget and time, and the ability of the trainer to travel to the different beneficiary countries in the project.

National soil laboratory assessments provide detailed information on each beneficiary laboratory's specific needs in terms of training and procurement. Training requests that could not be addressed through this project were included as recommended activities for future projects. Activities that require the direct intervention of the government were also identified. Through this report, aspects common to laboratories in all beneficiary countries were identified.

Overall, the lack of political and financial support, equipment and consumables, and the instability of the electrical power supply in many countries affect the ability of laboratories to meet national demands on soil analysis. This is exacerbated by the lack of technicians and the absence of regular training programmes, which also have an impact on the implementation of quality assurance and quality control procedures and on the overall quality of the data produced by the laboratories. The presence of poor legal frameworks and regulations on the laboratory's waste management system, the laboratory's drainage system, and the implementation of health and safety measures increase the risk for accidents and the exposure of soil laboratory's personnel to toxic substances as well as the risk of release into the local environment.

National governments need to invest in solutions to these issues, define minimum data quality standards and promote the implementation of internationally recognized SOPs, such as those released by GLOSOLAN, which also contribute to the national, regional and global harmonization of data on soils. National reference laboratories to GLOSOLAN should be particularly supported because of their leading role in training, advising, assessing, and monitoring soil laboratories' activities in their countries. In this regard, they should be supported (financially, politically and economically) and in some cases, they should receive the clearance of the governance to establish National Soil Laboratory Networks and to organize national proficiency tests, training, and meetings.

It is recommended that this project's outputs are used to formulate national or regional projects capable of addressing the training and procurement requests highlighted in the national soil laboratory assessments. Regional findings can be used to promote the implementation of coordinated actions among countries and facilitated by the endorsement of an international declaration on sustainable soil management for the region. Ultimately, the execution of soil laboratory assessments like the one conducted under the project is recommended for other countries and regions, as it has the potential to stimulate financial resource mobilization and policy actions.

ANNEX I. QUESTIONNAIRE FOR MANAGERS

TCP 3802 RAB
Soil laboratory capacity and need assessment

A: General information

1. Country______
2. Official soil laboratory name:____
2. Soil laboratory short name or acronym ____
3. Full address of the soil laboratory ____
____
4. Manager of the soil laboratory (surname, forename)______________________________________
5. Manager of the soil laboratory (email)______________________________________
6. Location of the laboratory (place and coordinate if possible)___________________________

B: Enabling environment

1. Is there a national policy promoting soil analysis or defining how soil analysis should be conducted (such as the use of a specific method)?

- ☐ Yes
- ☐ No

1.1 If yes please specify: ____

2. Are there national/local laws/regulations that promote soil analysis?

- ☐ Yes
- ☐ No

2.1. If yes please specify: ____

3. Does your laboratory receive any financial support from the government?

- ☐ Yes
- ☐ No

3.1. If yes, how?

- ☐ Money
- ☐ In kind
- ☐ Other

3.2. Is this financial support provided on a regular basis?

- ☐ Yes, please specify ___________
- ☐ No

4. To whom is the laboratory affiliated
(e.g. Ministry of Agriculture, Higher Council, Standalone etc.) ? ___________________________

C: Individuals: Soil laboratory staff

1. Number of employees with a permanent contract _______
2. Number of employees with a temporary contract _______
3. Number of soil experts/specialists/researchers

PhD _______
MSc _______
BSc _______

4. Number of technicians _______

4.1 What is the highest qualification of the technicians?

- ☐ Secondary schools
- ☐ Diploma
- ☐ BSc

4.2. Is the number of technicians enough?

- ☐ Yes
- ☐ No

5. Percentage of employees who received a formal education on analytical work_____

6. Percentage of employees who were trained to perform analytical work_____

7. Percentage of employees who were educated, trained or having experience in soil analyses_____

6. Does your lab have a training programme to regularly improve the skills of the employees?

- ☐ Yes
- ☐ No

6.1. If yes, how often is training provided? _________________

7. Is there a technician specialized in equipment/instruments maintenance?

- ☐ Yes
- ☐ No

7.1 If Yes, does she/he have regular training?

- ☐ Yes
- ☐ No

8. Is there an incentive system for managers/technicians for executing the analyses?

- ☐ Yes, please explain_________
- ☐ No

9. Does your laboratory provide training for others?

- ☐ Yes
- ☐ No

9.1. If yes, who are the beneficiaries from the training? _________________

D: Infrastructure of the soil laboratory

1. What is the area of the laboratory (m^2) _______

2. How many rooms are there in the laboratory? _______

3. How many divisions/departments are there in the laboratory? _______

4. Do you have a sample reception area?
   - ☐ Yes
   - ☐ No

5. List the available instruments and number

Item	Number	Use (such as C analysis)

6. Do you have a cold room (constant temperature of 4 °C) to store samples?
   - ☐ Yes
   - ☐ No

6.1. If no, please specify where you store samples and the approximate temperature of the storing place: ____

7. What do you store samples in?
   - ☐ Sealed glass
   - ☐ Plastic containers
   - ☐ Other, please specify

8. How do you store the dried, sieved soil samples?
   - ☐ At room temperature
   - ☐ In a dark room

9. Does the soil laboratory have one or more rooms that are dedicated to the storage of reagents? If yes, are they organized by groups (acids, bases, flammable, highly toxic compounds and compressed gases) and are these sections labelled accordingly and properly?
   - ☐ Yes, please describe__________
   - ☐ No

10. Do all chemicals/reagents have labels indicating the receipt, and the opening/disposal dates?
   - ☐ Yes
   - ☐ No

11. Does the soil laboratory have a system to check the receipt and opening dates of chemicals/reagents?

- ☐ Yes
- ☐ No

12. How often do you monitor and record the temperature and humidity in the sensitive areas (balance room, analytical room) of the soil laboratory?

- ☐ Hourly
- ☐ Daily
- ☐ Not regularly
- ☐ Never
- ☐ Other (please specify)

13. Does the soil laboratory have a room dedicated to the preparation of soil samples?

- ☐ Yes
- ☐ No

14. Does the soil laboratory have an analytical room dedicated to the storage and use of balances?

- ☐ Yes
- ☐ No

15. Does the soil laboratory have a specific area dedicated to glassware cleaning?

- ☐ Yes
- ☐ No

16. What is the quality of the water used in the soil laboratory?

- ☐ De-ionized water
- ☐ Distilled water
- ☐ Double distilled water
- ☐ Other (please specify)

17. How often is the EC of the de-ionised/distilled water tested?

- ☐ Hourly
- ☐ Daily
- ☐ Not regularly
- ☐ Never
- ☐ Other (please specify)

E: Clients of the soil laboratory:

1. Which institutions or organizations have a direct or indirect link to your lab for supporting decisions or accreditation or quality control? ____________________

2. Who are the main clients of the soil laboratory? (Tick all that apply.)

- ☐ Government departments
- ☐ Research institutions [e.g., universities, governmental research centres]
- ☐ NGOs
- ☐ Fertiliser companies
- ☐ Land users (farmers)
- ☐ Other, please specify ___________________

3. Who collects the soil samples?

- ☐ Team from the laboratory

- ☐ Team from authorized institutions
- ☐ Clients
- ☐ Other, please specify

3. Do the clients request advice on which soil tests to use?
   - ☐ Yes
   - ☐ No
4. How are results reported to the clients?
   - ☐ Hard copy
   - ☐ Electronically
   - ☐ Both
   - ☐ Other (please specify)
5. Who signs the result reports? ________________________________
6. Does the soil laboratory provide an interpretation of the analyses?
   - ☐ Yes
   - ☐ No
   - ☐ Upon request of the client
7. Is there a charge for these services?
   - ☐ Yes
   - ☐ No

F: Analyses performed by the laboratory

1. Which types of soil analyses does your laboratory provide?
   - ☐ Soil (chemical)
   - ☐ Soil (physical)
   - ☐ Soil (biological)
   - ☐ Organic fertilizer
   - ☐ Mineral fertilizers
   - ☐ Soil conditioner/polymers
   - ☐ Plant
   - ☐ Water
   - ☐ Other (please specify)
2. Specify the analyses performed.

Soil parameter	**Measured (Y/N)**	**Number of soil samples analysed per year**
pH in H_2O		
pH in KCl		
pH in $CaCl_2$		
Other pH		
Electrical conductivity (EC)		
Soluble Ca^{++}		

Soil parameter	Measured (Y/N)	Number of soil samples analysed per year
Soluble Mg^{++}		
Soluble Na^{+}		
Soluble K^{+}		
Soluble CO_3^{--}		
Soluble HCO_3		
Soluble Cl^{-}		
Soluble SO_4^{--}		
Total carbon		
Organic carbon		
Inorganic carbon (CO_3)		
Organic matter		
Dissolved organic matter		
Particulate organic matter		
Total nitrogen		
$N\text{-}NO_3$ and $N\text{-}NH_4$		
Available P by Olsen		
Available P by Bray and Kurtz		
Available P by other method		
CEC in NH_4O-Ac		
CEC by other methods		
Exchangeable K in NH_4O-Ac		
Exchangeable K by other methods		
Exchangeable Ca in NH_4O-Ac		
Exchangeable Ca by other methods		
Exchangeable Mg in NH_4O-Ac		

Soil parameter	Measured (Y/N)	Number of soil samples analysed per year
Exchangeable Mg by other methods		
Exchangeable Na in NH_4O-Ac		
Exchangeable Na by other methods		
Exchangeable acidity		
Al		
Micro elements		
Al-Fe in oxalate		
Texture analysis		
Water retention curve		
Soil moisture content		
Dry bulk density		
Particle density		
Hydraulic conductivity		
Microbial biomass		
Other microbiology analysis		
Other, please specify		

3. Does the laboratory perform analyses that are useful for soil classification?

- Yes
- No

3.1. If Yes, please state the average number of samples per year: _____________________

4. Are laboratory results used for digital soil mapping? If yes, are data provided to the government for the preparation of national maps?____

5. Does the laboratory perform analyses useful for fertilizer recommendations?

- Yes
- No

5.1. If yes, please state the average number of analyses per year: _______________-

6. Do you follow a standard in soil pre-treatment?

- ISO 11464

- None
- Other (please specify)

G. Analytical procedures

1. Does the soil laboratory have and use any standard operating procedures (SOPs)?
(Standard operating procedures are written documents that present the details of analytical or administrative procedures.)
   - Yes
   - No
   - Existing but not used

2. Are the analytical SOPs available in the rooms where the analytical tests are conducted?
   - Yes
   - No

3. In which language are the SOPs written? _______________

4. Does a maintenance log book exist for each instrument (such as balance or spectrometer)?
(A maintenance log book is a record of all the maintenance operations done by the laboratory personnel or by private companies on a given instrument.)
   - Yes
   - No

5. Is a result log book available near each instrument (balance, spectrometer, etc.)?
(A result log book is a record of all the results obtained on a given instrument.)
   - Yes
   - No

6. How often are the instruments in the soil laboratory calibrated?
   - Every day
   - Every week
   - Every month
   - Every three months
   - Every six months
   - Every year
   - Other, please specify

H. Quality control

1. How many samples do you usually have in an analytical batch?
(A batch is a set of samples which are processed/analysed at the same time.) ______________

2. Are blank samples of the extracting solution included in each analytical batch?
(A blank solution is a solution that contains all extracting reagents but was not used for any extraction. It is usually used to calibrate instruments and to check for instrument stability during analysis.)
   - Yes
   - No

3. Are internal control samples used in the soil laboratory?
(An internal control is a reference soil sample, of known analytical characteristics, available in large quantities (several kilos), and which is analysed in each batch of samples, to check the quality of the results.)

- ☐ Yes
- ☐ No

4. If used, how many internal control samples are used for each analytical batch? ___________

5. Are quality control samples used in the soil laboratory?

- ☐ Yes
- ☐ No

6. If used, which material is used as quality control samples?

- ☐ Certified reference material (CRM)*
- ☐ Internal reference material (IRM)**
- ☐ Standard reagent***
- ☐ Other, please specify

** Certified reference materials (CRMs): A reference material whose property values (such as purity or concentration) are established and certified in accordance with metrological principles using established, international best practice protocols. CRMs are used to calibrate the measurement process and they all have common characteristics: 1) assigned values are accompanied by an uncertainty statement; and 2) information is given on the methods used to assign values.*

*** Internal reference material (IRM): A reference material prepared in the respective laboratory to use as an internal control sample for monitoring precision of the lab results in each batch of analysis.*

**** Standard reagent: It can be a certified material if there is a certificate showing the purity, concentration, and traceability.*

7. Are the data obtained from internal control used to track the soil laboratory performance?

- ☐ Yes, performance is tracked every day
- ☐ Yes, performance is tracked every week
- ☐ Yes, performance is tracked every month
- ☐ Yes, performance is tracked every three months
- ☐ Yes, performance is tracked every six months
- ☐ Yes, performance is tracked every year
- ☐ No
- ☐ Other, please specify

8. What are the acceptance limits used to consider the analysis of an "internal control sample" or "quality control sample" reproducible?

- ☐ 5 percent
- ☐ 10 percent
- ☐ 15 percent
- ☐ Other, please specify

9. When results from "internal control samples" or "quality control samples" fall out of the acceptance limits, what happens next?

- The batch of samples is reanalysed
- The analytical data near the control are reanalysed
- The analytical data is corrected
- No consequence is drawn

I: Soil laboratory certification

1. Does the soil laboratory participate in proficiency tests or inter-laboratory comparisons? *(Proficiency testing or an inter-laboratory comparison compares the measured results obtained by different laboratories by sending soil samples to different laboratories. The results reported by each laboratory are then compared to a reference value.)*

- Yes
- No

2. If yes, at which level does the proficiency test/inter-laboratory comparison occur?

- National
- International
- Other, please specify

3. If applicable, how often does the soil laboratory participate in proficiency tests / inter-laboratory comparisons?

- Once every two to five years
- Once per year
- Two to four times per year
- Over five times per year
- Other, please specify

4. Did the laboratory ever organize a national proficiency test?

- Yes, please specify_________
- No

5. Is the laboratory equipped and laboratory technicians trained on the preparation of soil samples for a proficiency test?

- Yes
- No

6. Is the soil laboratory certified?

- Yes, under ISO 17025
- Yes, under ISO 9000
- No
- Other, please specify

7. Do you have a data library?

- Yes
- No

J: Health and safety

1. Is there a first aid kit in the laboratory?
    - Yes
    - No

2. Are there internal lab showers?
    - Yes
    - No

2.1. If yes, how many?

3. Are there ventilation equipment?
    - Yes
    - No

3.1. If yes, please specify: ______________

3.2. If yes, is it eventually distributed? ______________

3.3 If yes, how many? ______________

4. Are there protective cupboards?
    - Yes
    - No

4.1. If yes, how many? ______________

5. Is there firefight equipment?
    - Yes
    - No

5.1. If yes, please specify: ______________

6. Is there a drainage system?
    - Yes
    - No

6.1. If yes, is the drainage system isolated from the public one?
    - Yes
    - No

7. Is there a system for soil waste management?
    - Yes
    - No

8. How is soil waste managed?
    - Dumping at specific place with treatment
    - Dumping at specific place without treatment
    - Dumping at any place
    - Other specify

9. Is there a law to regulate the laboratory's waste management in the country?

- ☐ Yes, please specify: ____________________
- ☐ No

10. Is the legislation and collection system around laboratory's waste management appropriate and sufficient?

- ☐ Yes
- ☐ No, please specify: ___________________

11. Do you have a system for managing your expired chemicals?

- ☐ Yes
- ☐ No

12. What are the main constraints faced by the laboratory?

- ☐ Unavailability of certain Instruments
- ☐ Obsolete/old instruments
- ☐ Financial resources
- ☐ Capacity of technicians
- ☐ Other, please specify___________

13. What could your laboratory do to improve?____

ANNEX II. QUESTIONNAIRE FOR TECHNICIANS

TCP 3802 RAB
Soil Laboratory Capacity and Need Assessment
(Technicians)

General information

1. Country of the soil laboratory ____
2. Official soil laboratory name____
3. Soil laboratory short name or acronym ____
4. Full address of the soil laboratory _______________________________________
5. Name of the technician ___________________________________
6. Age ___________________________________
6. Division/department ___________________________________
7. Location of the laboratory (place and coordinates if possible) _____________________

A: Job and education

1. Job position: _________
2. Do you have a permanent contract?
   - ☐ Yes
   - ☐ No

2.1 If no, what is the type of your contract? ___________________________________

3. What is your highest education?
   - ☐ Secondary school
   - ☐ Diploma
   - ☐ BSc
   - ☐ Other, please specify ___________________________________

4. What is your mandate?
   - ☐ Sample collection
   - ☐ Sample receiving
   - ☐ Sample preparation
   - ☐ Soil analyses
   - ☐ Result preparation
   - ☐ Result interpretation
   - ☐ Other, please specify ___________________________________

5. Is there regular recruitment?
   - ☐ Yes
   - ☐ No

5.1. If yes, please specify the basis for new recruitment ___________________________________

B: Analyses performed by the technician

1. Which type of soil analyses do you perform?
   - ☐ Soil (chemical)
   - ☐ Soil (physical)
   - ☐ Soil (biological)
   - ☐ Organic fertilizer
   - ☐ Mineral fertilizers
   - ☐ Soil conditioner/polymers
   - ☐ Plant
   - ☐ Water
   - ☐ Other (please specify)

2. Specify the analyses performed.

Soil parameter	**Time required (hrs)**	**Number of soil samples analysed per year**
pH in H_2O		
pH in KCl		
pH in $CaCl_2$		
Other pH		
Electrical conductivity (EC)		
Soluble Ca^{++}		
Soluble Mg^{++}		
Soluble Na^{+}		
Soluble K^{+}		
Soluble CO_3^{--}		
Soluble HCO_3		
Soluble Cl^{-}		
Soluble SO_4^{--}		
Total carbon		
Organic carbon		
Inorganic carbon (CO_3)		
Organic matter		

Soil parameter	Time required (hrs)	Number of soil samples analysed per year
Dissolved organic matter		
Particulate organic matter		
Total nitrogen		
$N\text{-}NO_3$ and $N\text{-}NH_4$		
Available P by Olsen		
Available P by Bray and Kurtz		
Available P by other method		
CEC in NH_4O-Ac		
CEC by other methods		
Exchangeable K in NH_4O-Ac		
Exchangeable K by other methods		
Exchangeable Ca in NH_4O-Ac		
Exchangeable Ca by other methods		
Exchangeable Mg in NH_4O-Ac		
Exchangeable Mg by other methods		
Exchangeable Na in NH_4O-Ac		
Exchangeable Na by other methods		
Exchangeable acidity		
Al		
Micro elements		

Soil parameter	Time required (hrs)	Number of soil samples analysed per year
Al-Fe in oxalate		
Texture analysis		
Water retention curve		
Soil moisture content		
Dry bulk density		
Particle density		
Hydraulic conductivity		
Microbial biomass		
Other microbiology analysis		
Other, please specify		

3. Do you follow a standard in soil pre-treatment?
   - ☐ ISO 11464
   - ☐ None
   - ☐ Other (please specify)

C: Training

1. Do you have a regular training programme?
   - ☐ Yes
   - ☐ No

2. Who provides the training?
   - ☐ Government institutions
   - ☐ Supply companies
   - ☐ Other, please specify: ____________________________________

3. Is there an incentive system for executing the analyses?
   - ☐ Yes, please explain (money, promotion, etc)
   - ☐ No

4. Do you provide training for others?
   - ☐ Yes
   - ☐ No

4.1 If yes please specify: ____

D. Analytical procedures

1. Does the soil laboratory have and use any standard operating procedures (SOPs)?
(Standard operating procedures are written documents that present the details of analytical or administrative procedures).

- ☐ Yes
- ☐ No
- ☐ Existing but not used

2. Are the analytical SOPs available in the rooms where the analytical tests are conducted?

- ☐ Yes
- ☐ No

3. In which language are the SOPs written? _______________

4. Does a maintenance log book exist for each instrument (such as balance or spectrometer)?
(A maintenance log book is a record of all the maintenance operations done by the laboratory personnel or by private companies on a given instrument.)

- ☐ Yes
- ☐ No

5. Is a result log book available near each instrument (such as balance or spectrometer)?
(A result log book is a record of all the results obtained on a given instrument.)

- ☐ Yes
- ☐ No

6. How often are the instruments in the soil laboratory calibrated?

- ☐ Every day
- ☐ Every week
- ☐ Every month
- ☐ Every three months
- ☐ Every six months
- ☐ Every year
- ☐ Other, please specify

E. Quality control

1. How many samples do you usually have in an analytical batch? (A batch is a set of samples which are processed/analysed at the same time.) ______________

2. Are blank samples of the extracting solution included in each analytical batch?
(A blank solution is the solution that contains all extracting reagents but was not used for any extraction. It is usually used to calibrate instruments and to check for instrument stability during analysis.)

- ☐ Yes
- ☐ No

3. Are internal control samples used in the soil laboratory?
(An internal control is a reference soil sample of known analytical characteristics, available in large

quantities (several kilos), and which is analysed in each batch of samples, to check the quality of the results.)

- Yes
- No

4. If used, how many internal control samples are used for each analytical batch? ___________

5. Are quality control samples used in the soil laboratory?*

- Yes
- No

6. If used, which material is used as quality control samples?

- Certified reference material (CRM)*
- Internal reference material (IRM)**
- Standard reagent***
- Other, please specify

** Certified reference materials (CRMs): A reference material whose property values (such as purity or concentration) are established and certified in accordance with metrological principles using established, international best practice protocols. CRMs are used to calibrate the measurement process and they all have common characteristics: 1) assigned values are accompanied by an uncertainty statement; and 2) information is given on the methods used to assign values.*

*** Internal reference material (IRM): A reference material prepared in the respective laboratory to use as an internal control sample for monitoring precision of the lab results in each batch of analysis.*

**** Standard reagent: It can be a certified material if there is a certificate showing the purity, concentration, and traceability.*

7. Are the data obtained from internal control used to track the soil laboratory performance?

- Yes, performance is tracked every day
- Yes, performance is tracked every week
- Yes, performance is tracked every month
- Yes, performance is tracked every three months
- Yes, performance is tracked every six months
- Yes, performance is tracked every year
- No
- Other, please specify

8. What are the acceptance limits used to consider the analysis of an "internal control sample" or "quality control sample" reproducible?

- 5 percent
- 10 percent
- 15 percent
- Other, please specify

9. When results from "Internal control samples" or "Quality control samples" fall out of the acceptance limits:

- ☐ The batch of samples is reanalysed
- ☐ The analytical data near the control are reanalysed
- ☐ The analytical data is corrected
- ☐ No consequence is drawn

F: Health and safety

1. Is there a first aid box in the laboratory?

- ☐ Yes
- ☐ No

2. Are there internal lab showers?

- ☐ Yes
- ☐ No

2.1. If yes, how many? ______________

3. Are there ventilation equipment?

- ☐ Yes
- ☐ No

3.1. If yes please specify: ______________

3.2. If yes, is it eventually distributed? ______________

3.3 If yes, how many? ______________

4. Are there protective cupboards?

- ☐ Yes
- ☐ No

4.1. If yes, how many? ______________

5. Is there firefighting equipment?

- ☐ Yes
- ☐ No

5.1. If yes, please specify: ______________

6. Is there a drainage system?

- ☐ Yes
- ☐ No

6.1. If yes, is the drainage system isolated from the public one?

- ☐ Yes
- ☐ No

7. Is there a system for soil waste management?

- ☐ Yes
- ☐ No

8. How is soil waste managed?

- ☐ Dumping at specific place with treatment
- ☐ Dumping at specific place without treatment
- ☐ Dumping at any place
- ☐ Other, please specify

9. Is there a law to regulate laboratory's waste management in the country?

- ☐ If yes, please specify: ___________________________________
- ☐ No

10. Is the legislation and collection system around laboratory's waste management appropriate and sufficient?

- ☐ Yes
- ☐ No, please specify: ___________________

11. Do you have a system for managing your expired chemicals?

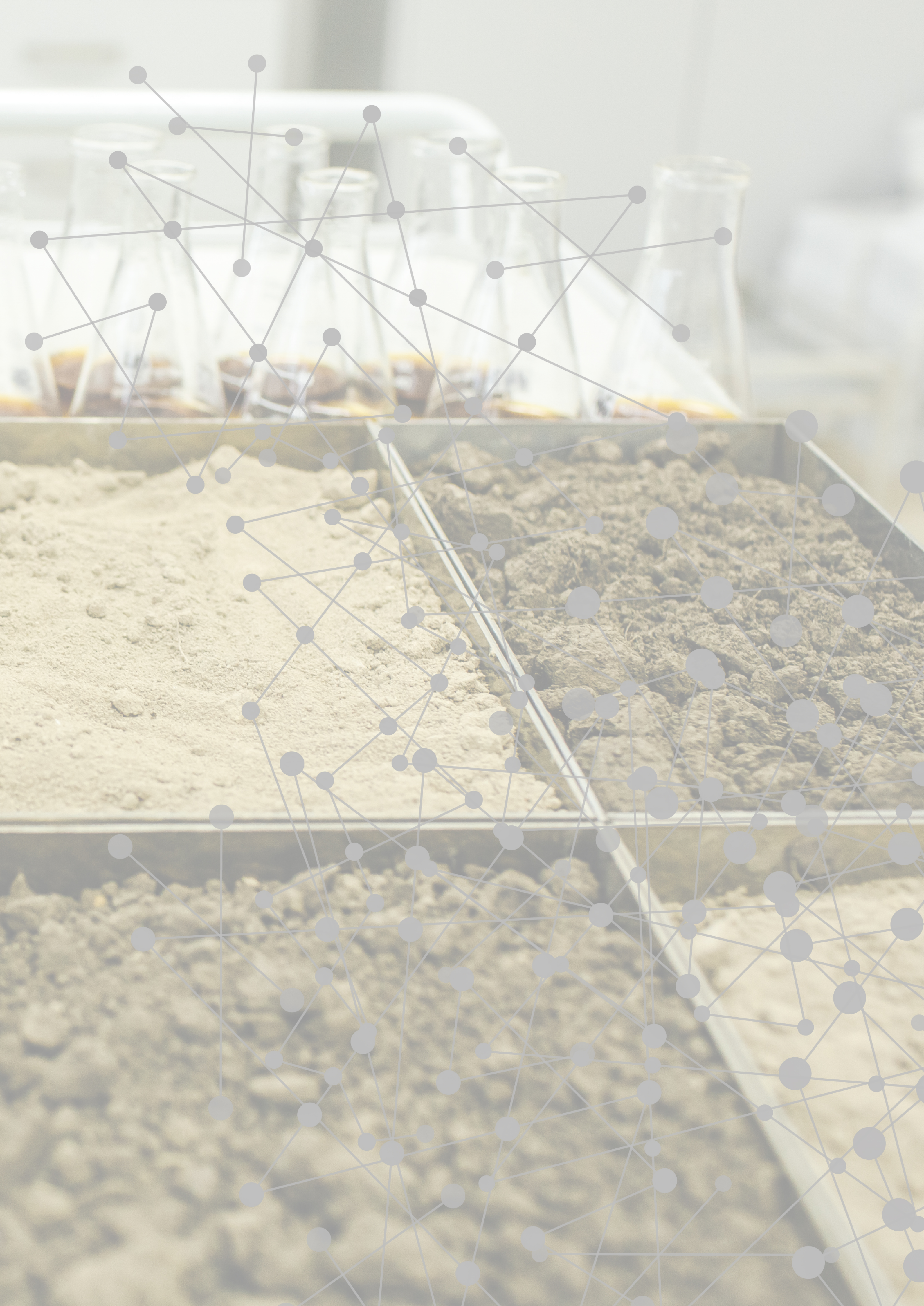
- ☐ Yes
- ☐ No

12. What are the main constraints faced by the laboratory?

- ☐ Unavailability of certain Instruments
- ☐ Obsolete/old instruments
- ☐ Financial resources
- ☐ Capacity of technicians
- ☐ Other, please specify

13. Do you recommend certain new innovative analytical instruments (such as ICP or radiospectrometers) ____________________

14. What could your laboratory do to improve?____



GLOBAL SOIL PARTNERSHIP

The Global Soil Partnership (GSP) is a globally recognized mechanism established in 2012. Our mission is to position soils in the Global Agenda through collective action. Our key objectives are to promote Sustainable Soil Management (SSM) and improve soil governance to guarantee healthy and productive soils, and support the provision of essential ecosystem services towards food security and improved nutrition, climate change adaptation and mitigation, and sustainable development.

GLOSOLAN
GLOBAL SOIL LABORATORY NETWORK

GLOSOLAN is a Global Soil Laboratory Network which aims to harmonize soil analysis methods and data so that soil information is comparable and interpretable across laboratories, countries and regions. Established in 2017, it facilitates networking and capacity development through cooperation and information sharing between soil laboratories with different levels of experience. Joining GLOSOLAN is a unique opportunity to invest in quality soil laboratory data for a sustainable and food secure world.

The Technical Cooperation Programme (TCP) was created to enable FAO to make its know-how and technical expertise available to member countries upon request. TCP PROJECT are subject to approval criteria that ensure relevance and sustainability of the assistance provided, while catalyzing results towards the achievement of the Sustainable Development Goals.

This project was implemented in: the Islamic Republic of Iran, Iraq, Jordan, Lebanon, Morocco, Oman, Palestine, the Sudan, the Syrian Arab Republic, Tunisia and Yemen.

Learn more at:
https://www.fao.org/technical-cooperation-programme/en/

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