SOIL AND LAND HEALTH LABORATORY AT CIFOR-ICRAF: A GLOBAL LEADER

Soil and Land Health Assessments - to Assess Landscape Scale Variability

Why Soil Spectroscopy?

Over the past two decades, spectroscopy has played a significant role in transforming land and soil health assessments. The CIFOR-ICRAF Soil and Land Health Spectral Laboratory stands as a leading global facility, providing robust, cost-efficient, and rapid analysis of soil, plants, and agricultural inputs such as manure and fertilizers using dry spectral methods. It serves as the key reference laboratory for over 20 regional spectroscopy laboratories worldwide and is a crucial partner in the GLOSOLAN global spectral library initiative with the FAO.

CIFOR-ICRAF hosts a large geo-referenced spectral library to:

- Produce accurate soil maps.
- Accurate soil organic carbon assessments for MRV.
- Monitor and track monitor land degradation and soil health over time.
- Provide evidence-based reccomendations to farmers, pastoralists, policy maker and the global community on farmer-centered restoration practices.

Capacity Building and Technical Support

The Soils Theme builds capacity on the use of soil spectroscopy by supporting over 20 regional labs, run by national governments and private sector alike.

We also build capacity on data analytics using open source statistical software to analyze and predict soil properties using machine learning and AI.

We also build capacity on systematic field surveys for assessing soil health, land degradation and vegetation dynamics using the LDSF.

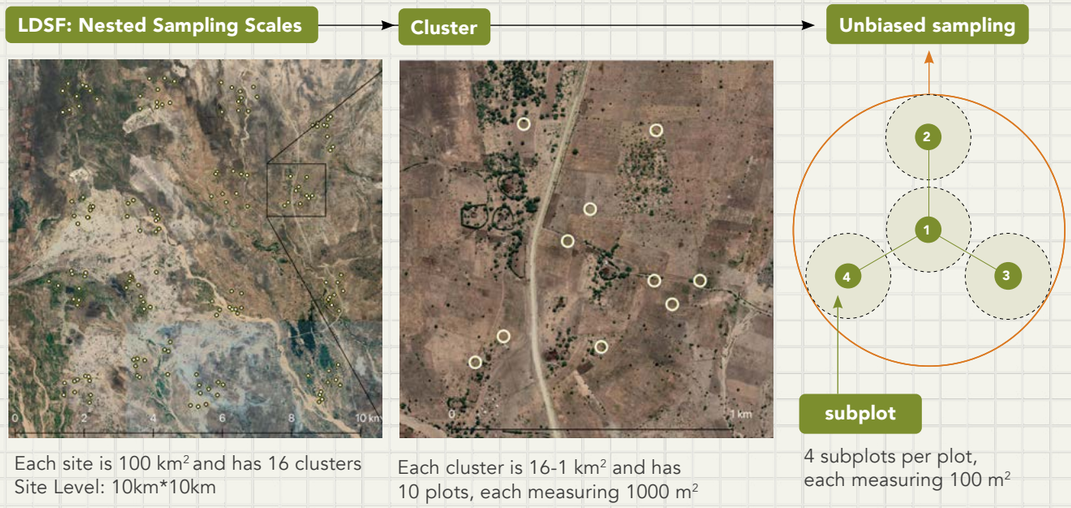
Samples Reception and Processing

CIFOR-ICRAF has developed and follows Standard Operating Procedures (SOPs) for each step in the Laboratory to ensure quality control. Soil samples are subjected to air drying, followed by crushing and sieving through a 2-mm sieve. All soil samples are logged and barcoded for long-term storage in the physical soil archive. A sub-sample is subsequently milled to achieve a particle size of less than 0.05mm. This process ensures representative sample.

The laboratory handles over 30,000 samples every year, and its operations are integrated into a Laboratory Information Management System (LIMS) with developed workflows incorporating quality analysis and control measures. These measures ensure seamless analysis of samples from sampling to the submission of results without compromising the integrity of the sample.

Sampling Design

The Land Degradation Surveillance Framework (LDSF)



Each site is 100 km² and has 16 clusters
Site Level: 10km*10km

Each cluster is 16-1 km² and has
10 plots, each measuring 1000 m²

4 subplots per plot,
each measuring 100 m²

The LDSF was developed by ICRAF in response to the need for consistent in-field methods of assessing indicators of soil and land health in landscapes. The framework has been applied in projects across the global tropics and is currently one of the largest land health databases globally, with more than 30,000 observations. The LDSF is a systematic, unbiased sampling framework that assesses multiple indicators at the same geo-referenced location (see graphic below). Each LDSF site covers an area of 100 km². This approach enables robust statistical analysis for modeling and mapping land and soil health based on a network of LDSF sites. These ground observations are then combined with Earth Observation data to produce accurate maps of land cover change, land use, land degradation, and soil health.

Portable X-ray Fluorescence (pXRF) Laboratory

pXRF is a versatile analytical technique used to determine the elemental content in plants, soil, and compost manure samples. This technique enables rapid and simultaneous analysis of over 30 elements from sodium (Na) to uranium (U) on the periodic table within a five-minute time frame. Such capability allows for the comprehensive analysis of a large number of samples, providing valuable insights into heavy metal contamination or degradation in soil, nutrient assessment, and fertilizer quality evaluation.

Infrared Laboratory

The infrared analysis method offers a fast, cost-effective, and accurate approach to analyzing various properties in soils, plants, and inputs using near and mid-infrared spectroscopy. This technique involves shining light on the samples and capturing the diffuse reflected light within the near- or mid-infrared range. The resulting spectrum yields a fingerprint of the sample's composition.

Some of its advantages include high repeatability and precision. It is rapid and only takes approximately 30 seconds to scan a sample, enabling analysis of a significant number of samples in a single day.

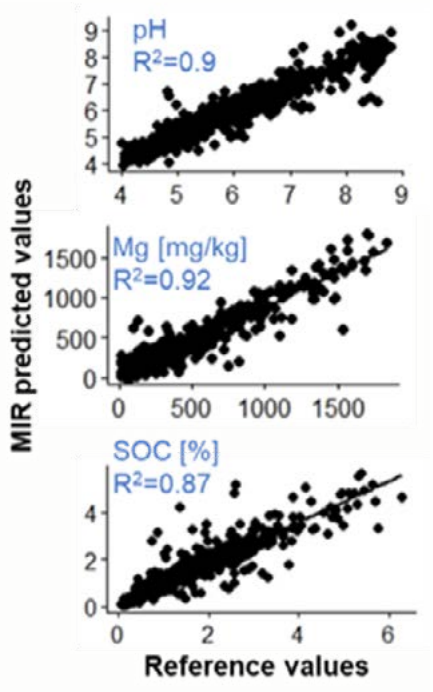
Advanced Data Analytics

CIFOR-ICRAF has the capacity to analyze soil spectral datasets and develop machine learning models to accurately predict multiple soil properties simultaneously. These advances allow for assessments that are consistent, cost- effective, and scalable.

CIFOR-ICRAF hosts over 200,000 mid-infrared spectra from systematically collected soil samples.

Our models have demonstrated exceptional accuracy in predicting soil parameters for samples obtained from regions not included in their development, affirming their reliability and effectiveness.

The use of soil spectroscopy requires skills in advanced data analytics. These large datasets are used to develop predictive models using machine learning techniques.



Examples of Applications

Monitoring soil health indicators including soil organic carbon (SOC): Monitoring soil health is critical for tracking the impact of land management, overtime. Furthermore, accurate assessments are critical for Measurement, Reporting, and Verification (MRV) of soil carbon, to improve the robustness of assessments.

Detection and monitoring of soil contaminants and pollutants: Soil spectroscopy and pXRF can identify and quantify various contaminants, including heavy metals. With this capability, environmental agencies and land managers can quickly identify contaminated areas.

Soil mapping: Predictive soil maps of key indicators are critical for informing and prioritizing investments, as well as understanding the spatial variability of indicators. CIFOR-ICRAF's extensive database, our maps achieve over 85% accuracy across multiple sensors (MODIS; Landsat 5, 7, 8, 9; Sentinel 2)."

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