Food and Agriculture Organization of the United Nations

GLOSOLAN
Soil spectroscopy training workshops

Unlocking the Science of Soil and Plant Diagnostics at CIFOR-ICRAF's State-of-the-Art Laboratory

Online webinars

Zampela Pittaki*, Dickens Ateku*,
Elvis Weullow*, Leigh Winowiecki

11/06/2024

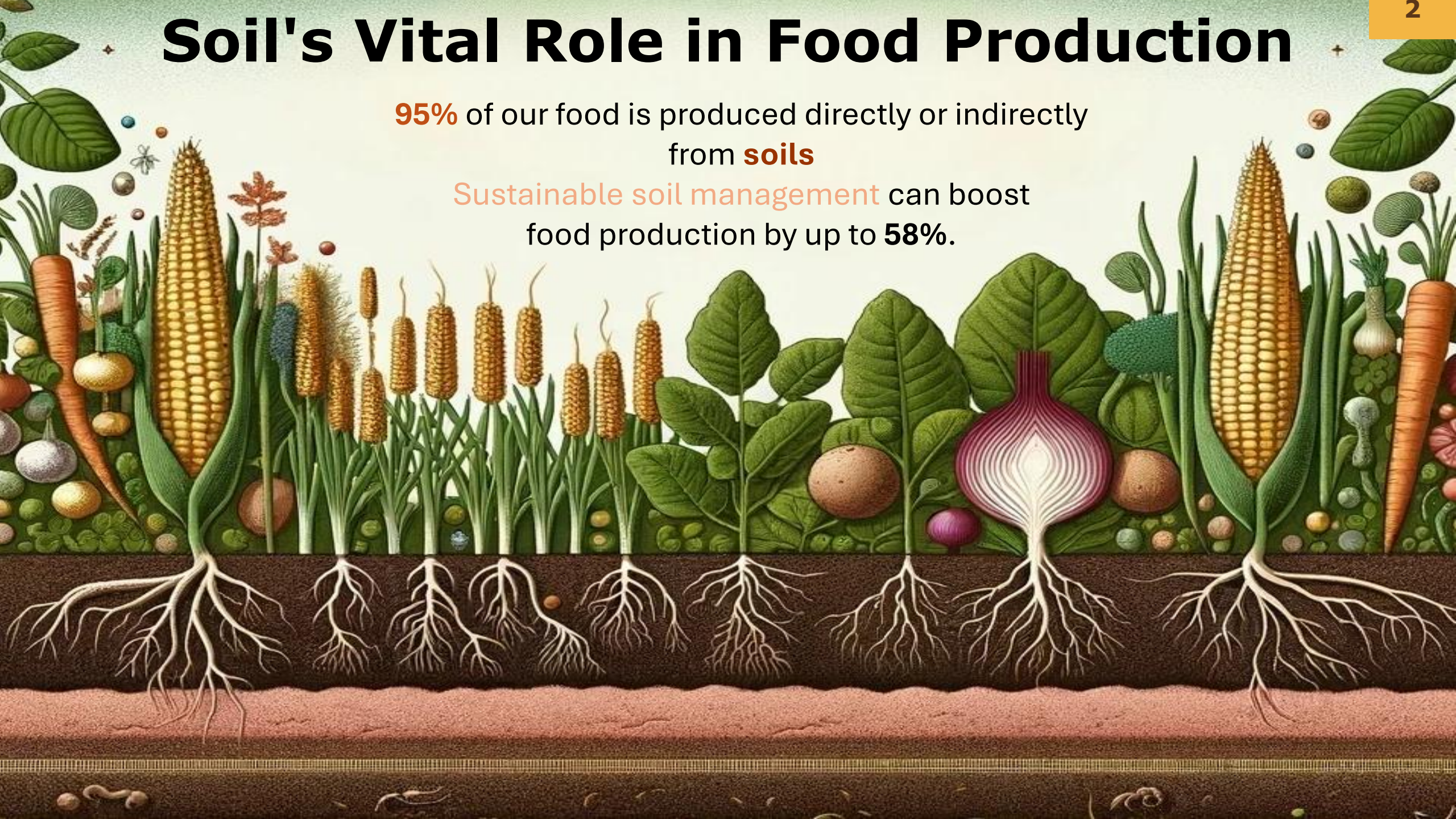
Kenya

GLOBAL SOIL PARTNERSHIP

Soil's Vital Role in Food Production

95% of our food is produced directly or indirectly from **soils**

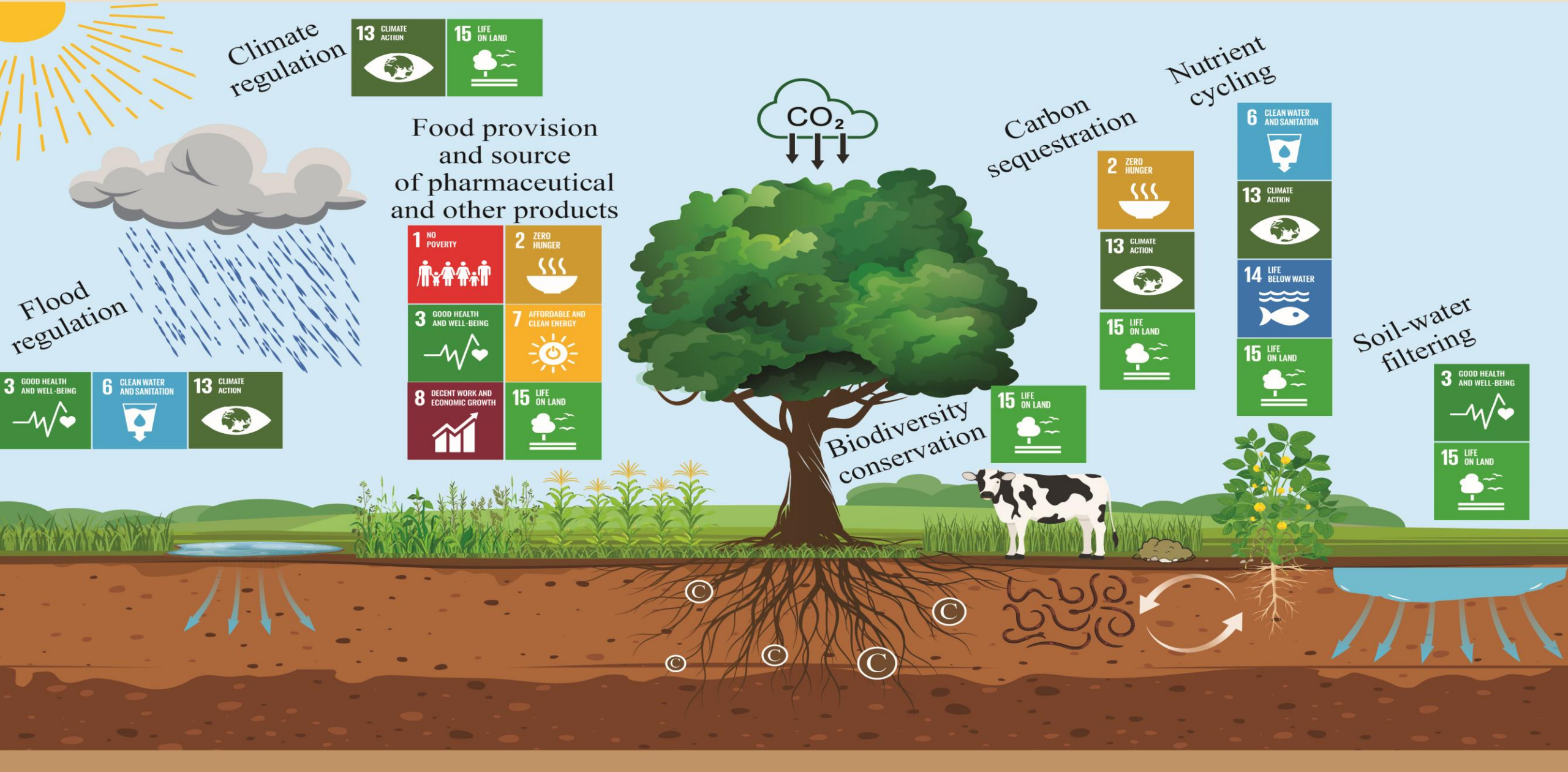
Sustainable soil management can boost food production by up to **58%**.



Healthy soil is the ability of the soil to sustain the productivity, diversity, and environmental services of terrestrial ecosystems.”

(Intergovernmental Technical Panel on Soils, 2020)

Soil health is the bedrock of sustainable development, grounding our aspirations for a better world through the achievement of the SDGs



>25% of the Earth's surface is degraded, impacting 3.2 billion people (GLO2, 2022; IPBES, 2018)

Most widespread form of degradation is the **Soil Erosion**

- Maintaining the status quo is not viable.
- We urgently require targeted investments in landscape restoration, beginning with the soil.
- These investments must be prioritized, tracked, and focused on the needs of farmers.

Photo: Kelvin Trautman

Landscapes are diverse

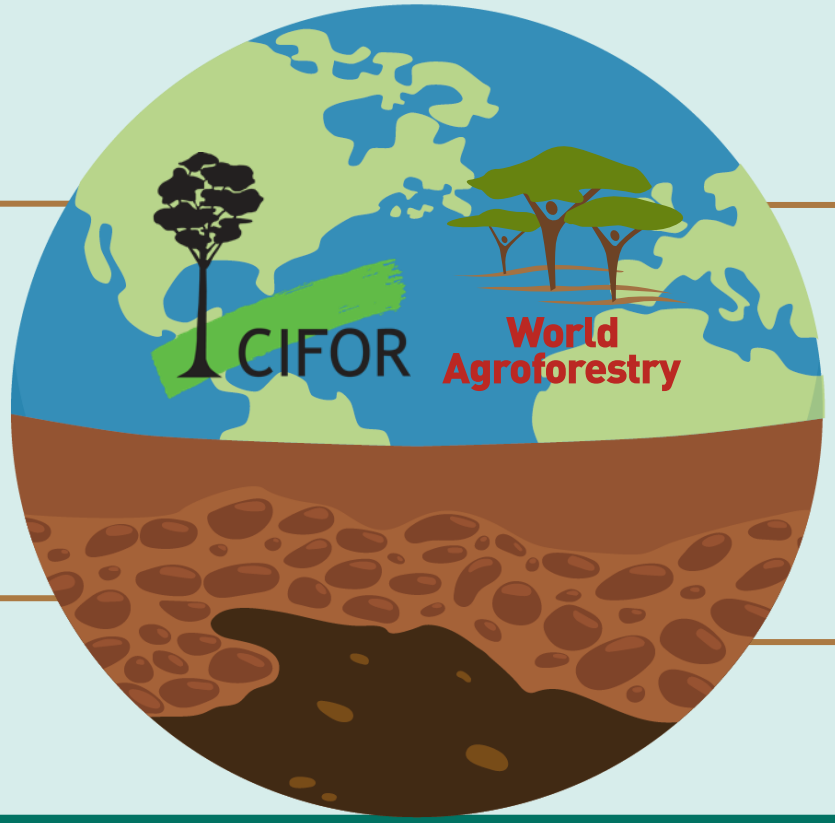
- This requires a sampling design to capture this variability.
- Soil analysis technologies that are cost-effective and robust.
- Data analytics that can assess the complex drivers of degradation.
- Frameworks that can track changes over time (performance of agricultural and restoration interventions).

Soil and Land Health Theme:

Four Main Objectives to address pressing global challenges, broken food systems, environmental degradation, accelerating climate change and biodiversity loss.

Science: Soil and land health monitoring over time including **soil organic carbon** accounting for climate change mitigation and adaptation.

Policy: To contribute to and inform **national & global agendas** on ecosystem restoration, food system transformation and soil health based on state-of-the-art science.



Innovation: Advance the development, application and **scaling of soil and land health assessments** using soil spectroscopy, soil biology, remote sensing, machine learning.

Scaling: Investing in learning to scale healthy soil practices and track changes overtime, incl opportunities to integrate soil health into policies.

From farm to lab to global landscapes

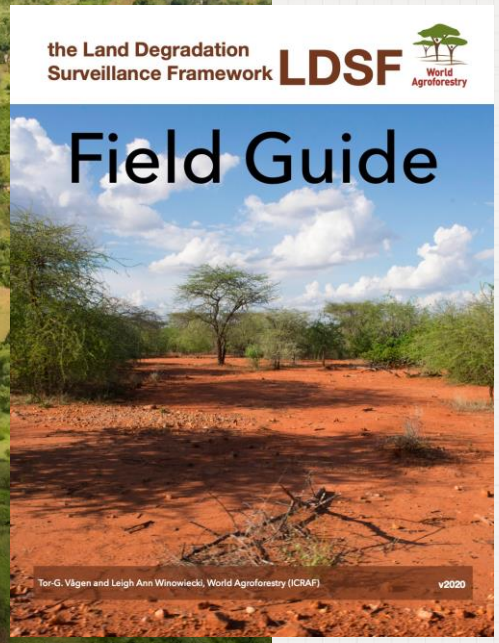
Geographic Scope of Soil and Land Health Theme Projects

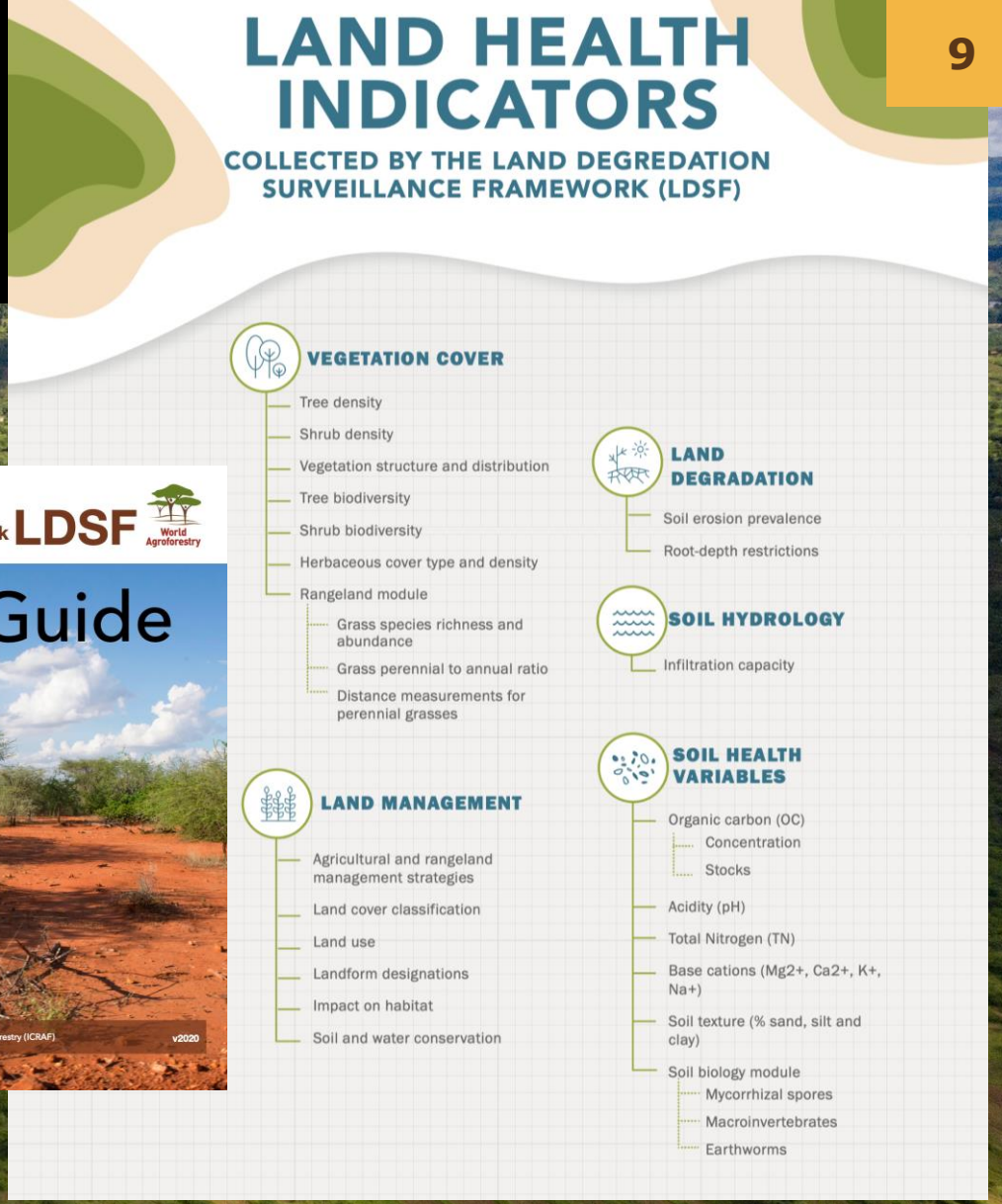
Contributing to
30 projects and leading 14 projects from 16 donors

- Projects led by Soils
- Projects where Soils Theme is Contributing
- Recently ended but still engaging

Understanding the multiple dimensions of soil health for ecosystem restoration, climate change and food & nutrition security

1) Application of a systematic sampling framework
2) Use of innovative methods for soil analysis
3) Coupled with statistical analysis to generate predictive maps





http://landscapeportal.org/blog/2015/03/25/the-land-degradation-surveillance-framework-ldsf/

Robust and rapid monitoring systems across diverse landscapes: The Land Degradation Surveillance Framework (LDSF)

http://landscapeportal.org/blog/2015/03/25/the-land-degradation-surveillance-framework-ldsf/

Data-driven network of LDSF sites (each site is 100 km^2, with 160 sampling plots). One systematic framework across multiple projects, donors, initiatives.

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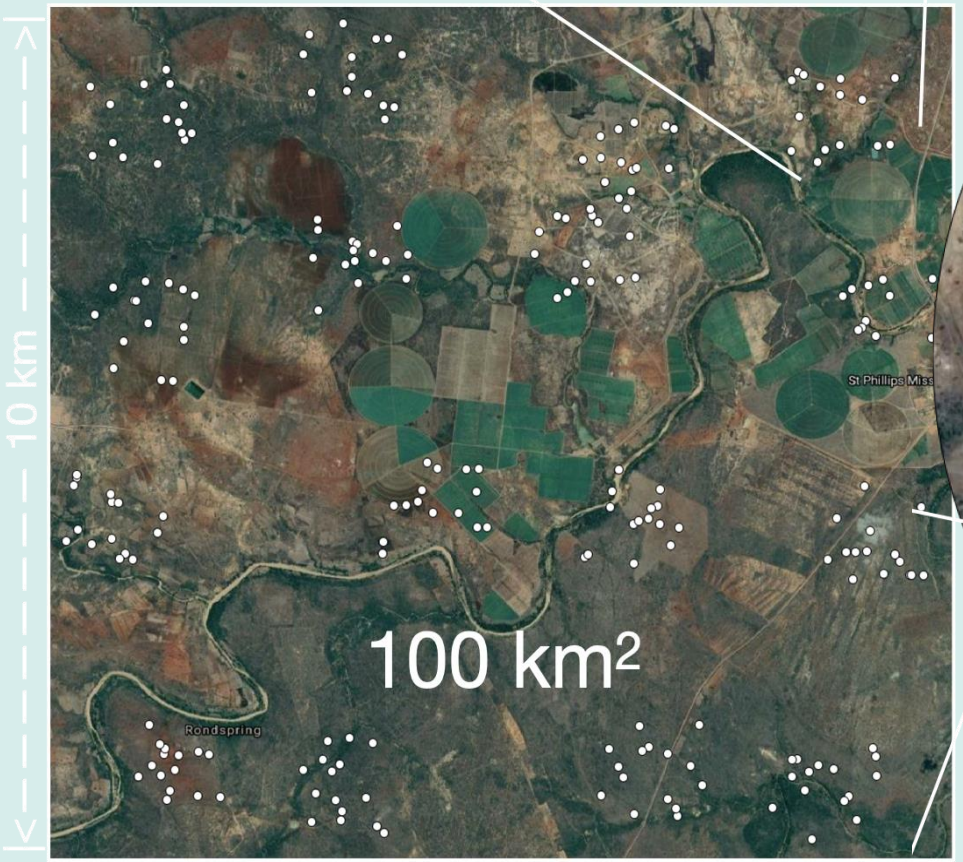
Resilient Landscapes

What makes the LDSF uniquely valuable?

- Consistently applied across landscapes and context
- Low-tech equipment
- Hierarchical sampling design
- Enabled by advancements in soil spectroscopy
- Multiple indicators of soil and land health measured at geo-referenced locations

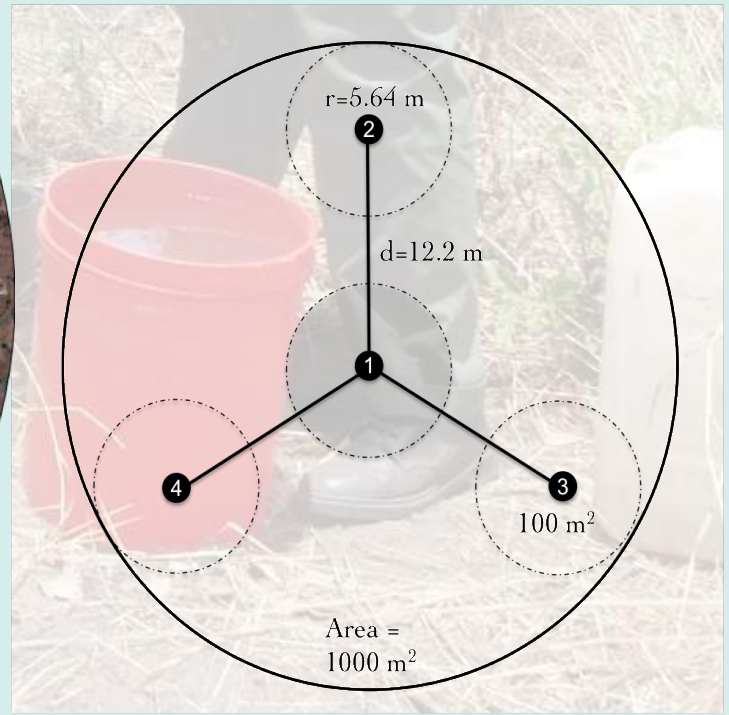
LDSF: Nested Sampling Scales



Site Level (10km * 10km)

Cluster Level 16-1km² per site

Unbiased sampling



Plot Level
10-1000m² per cluster

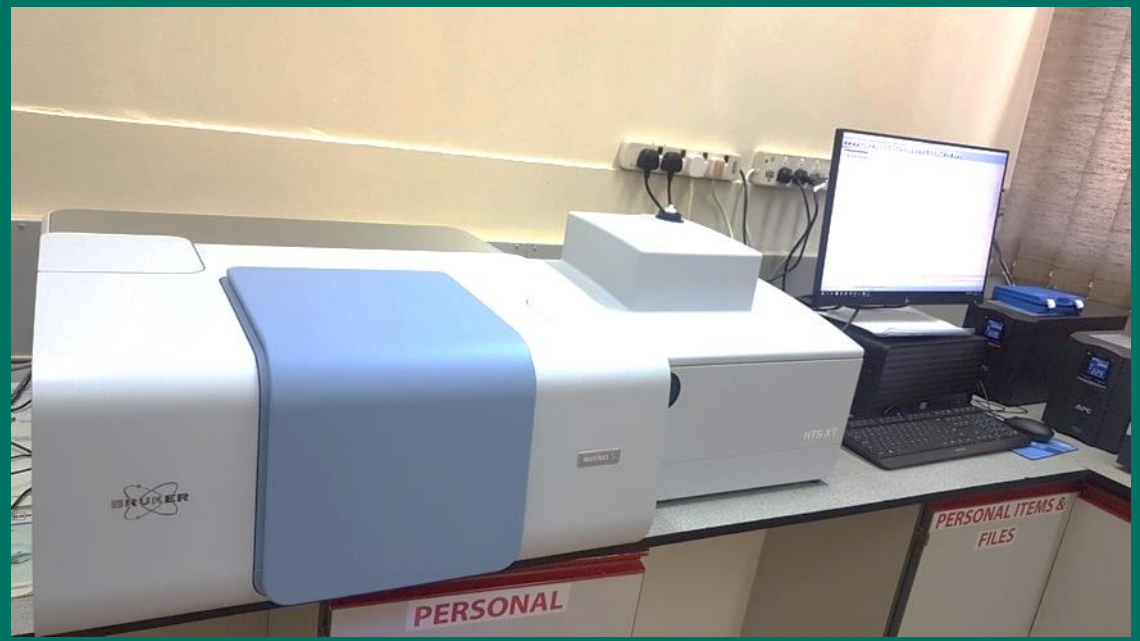
Soil sampling in the LDSF

- Soil samples are taken from each subplot (n=4) and composited at the plot level at two depths:
  - 160 topsoil (0-20 cm) samples per site
  - 160 subsoil (20-50 cm) samples per site
- All soil samples are analyzed using mid-infrared spectroscopy
- Reference soil samples (10%) are analyzed using wet chemistry for pH, **organic carbon & total nitrogen (using dry combustion)**, base cations, texture, etc).
- Predictions are made using the spectra and wet chemistry data 1) 70% for calibration model and 2) 30% for validation models.

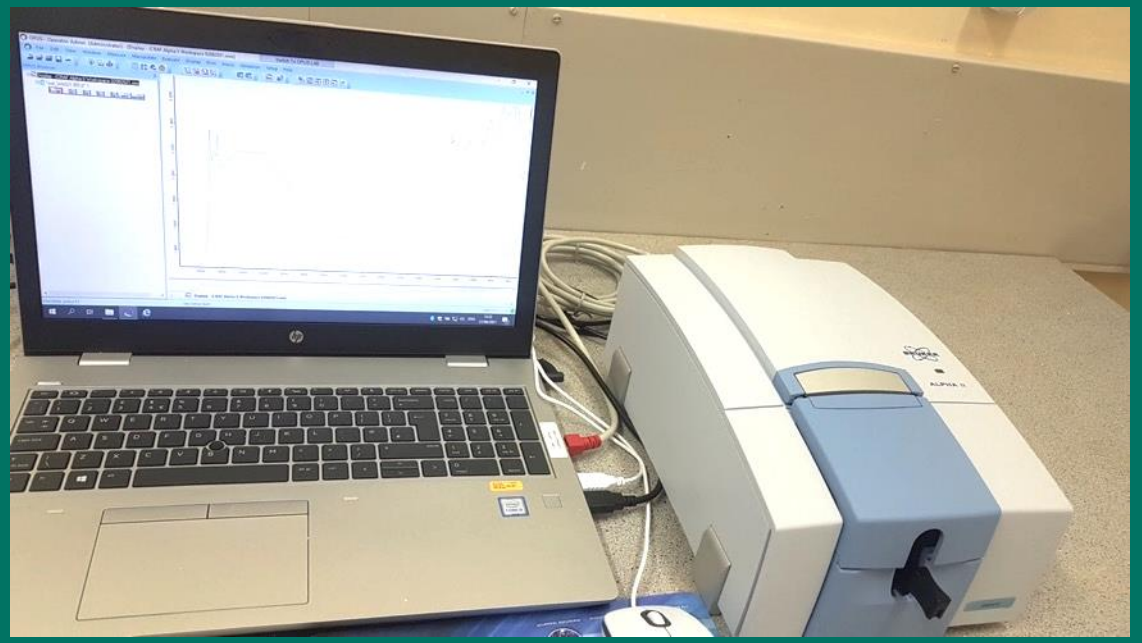
This landscape scale sampling is enabled by soil spectroscopy

(LDSF Field Guide:
https://www.cifor-icraf.org/knowledge/publication/25533/)

Advanced Spectral Analytics



The latest is the Bruker Invenios S FT-MIR

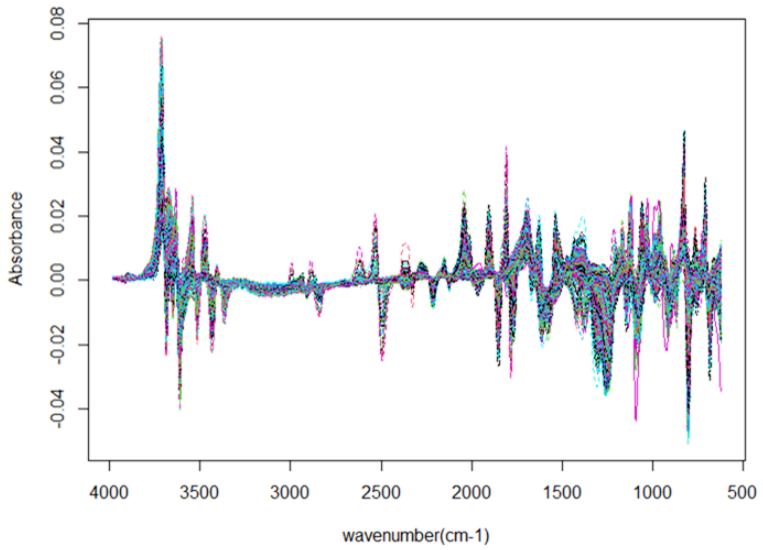


The Alpha II ZnSe FT-MIR

Visit our webpage to learn more about what we are doing: https://www.cifor-icraf.org/research/theme/soil-and-land-health/

Innovation: Advance the development, application and scaling of **soil spectroscopy, remote sensing, machine learning** for rapid and accurate assessments of soil health at scale.

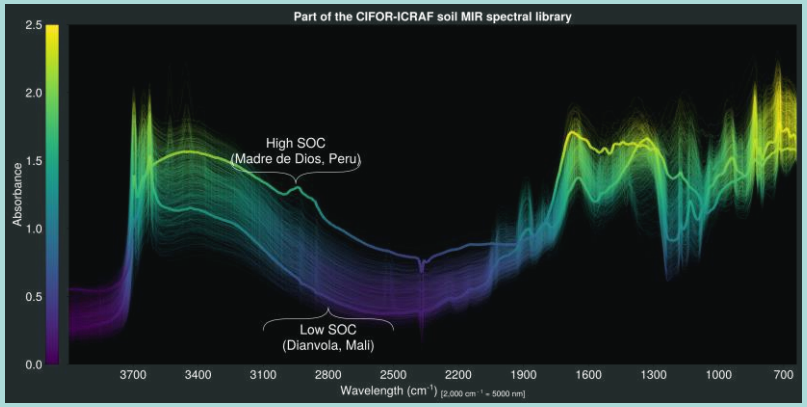
Shining a light on soil, plants, food & inputs

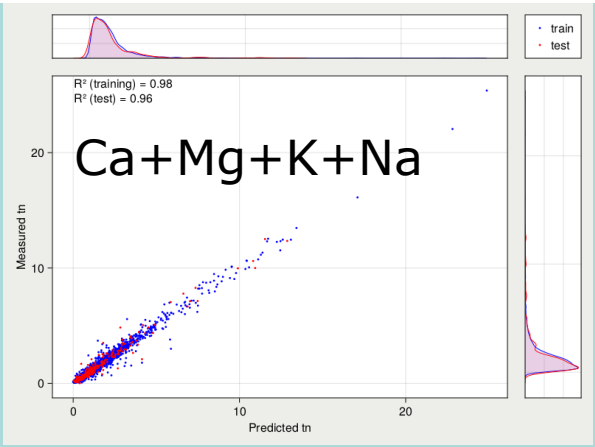


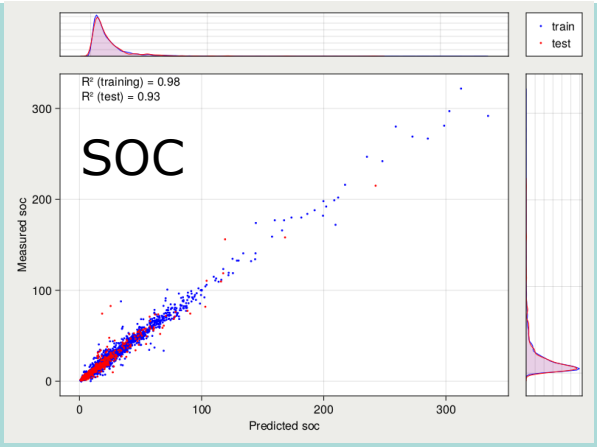
- Leading global lab for **accurate, cost-efficient** and rapid analysis of soil, plants and inputs using spectroscopy.
- Gold standard lab for FAO GLOSOLAN
- Analysing **20,000 soil samples annually**
- Over **200,000 geo-referenced** samples barcoded in our physical archive.

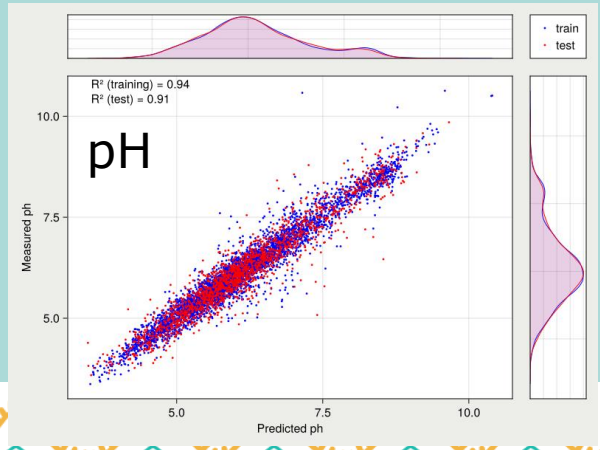
Innovation: Advance the development, application and scaling of **soil spectroscopy, remote sensing, machine learning** for rapid and accurate assessments of soil health at scale.

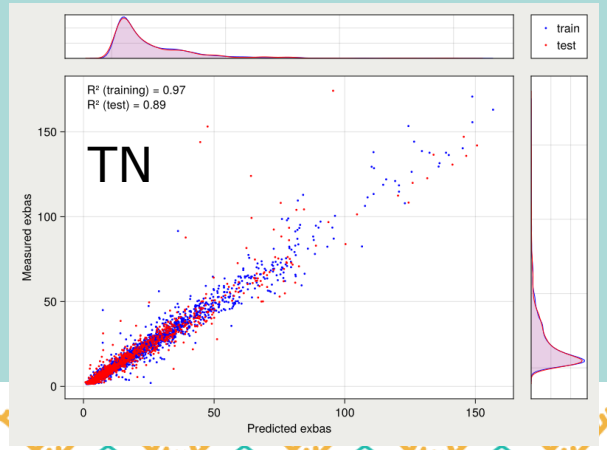
- 30 Countries
- N= 15,000 samples with reference samples
- Deep Learning Model
- >0.9 R2 on the validation for SOC, TN, Base cations, pH and texture











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Resilient Landscapes

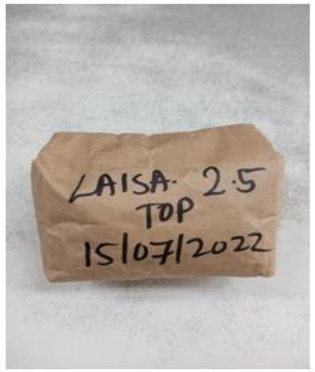
Sample Collection, Processing and Measurement Workflow

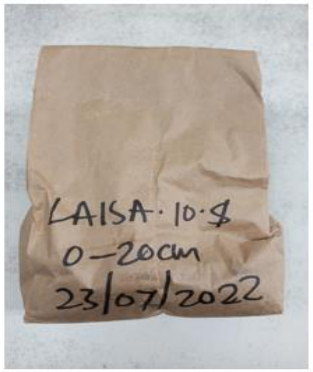
Field Sample Collection

At the field **Land Degradation Surveillance Framework (LDSF)** sampling protocol is used.
It provides **systematic baselines** of soil and ecosystem properties that allow for a **proper assessment of landscape** performance and prediction of change over time.

Labeling is critical!
Site, cluster, plot and depth code and date should be legibly recorded with a permanent marker on the outside of the soil sample bag. A paper label containing the same information (written with a permanent marker or pencil) should be placed inside the bag. Samples should be double-bagged.

A Standard (STD) and Cumulative Mass (CM) Labeled Soil Sample





Fresh wet samples are received at the sample reception and placed in the drying room facility.

Drying Room Facility

The drying room facility is fitted with;
1.Two heaters set at 40^{0}C to dry samples.
2.Dehumidifier to extract moisture released by the drying samples.

Work-Flows of Sample Handling

Sample handling

About 20,000 samples are handled in our laboratory every year and having a system in place to do this is very critical.

During sample handling ,maintaining the integrity of the sample is critical. It can be compromised **by cross contamination** or **sample mix up**.

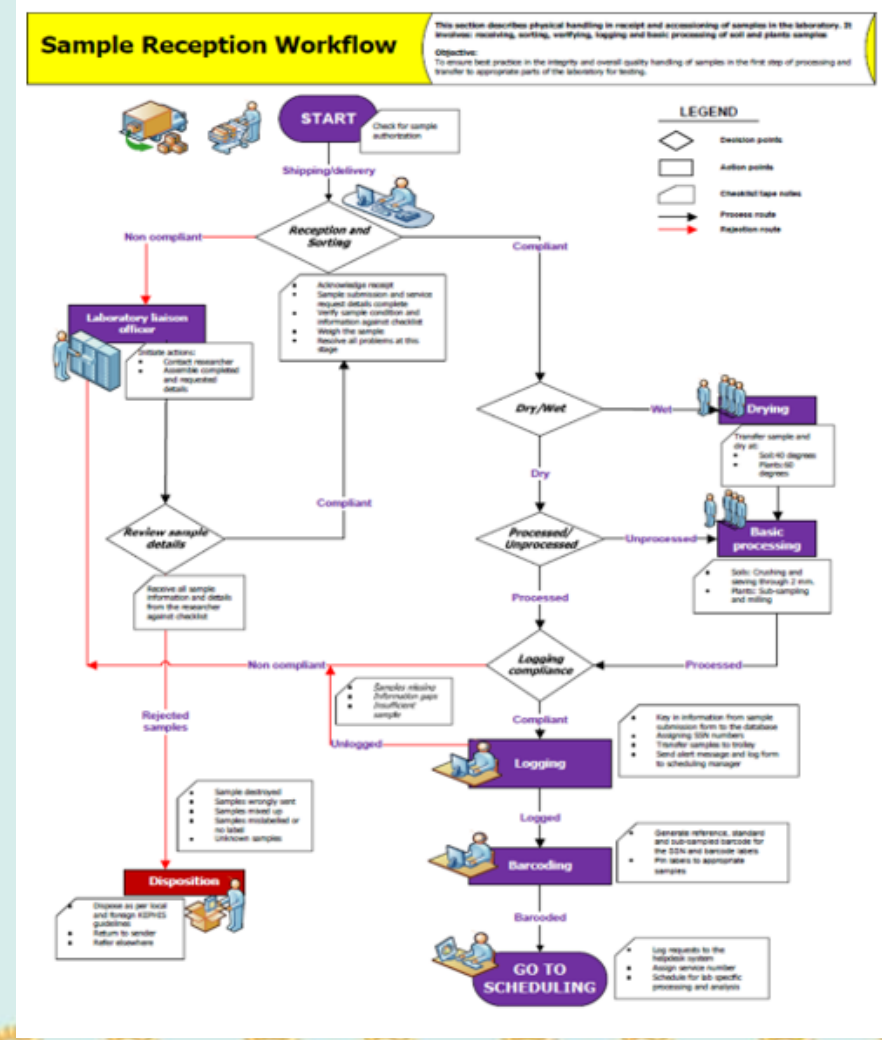
Systems put in place include;

1.Laboratory Information Management System (LIMS) - This is a software developed to provide solutions for laboratory operations including a structured workflow and support in data tracking, storage and retrieval.

2.Workflows with Quality Control checks – Step by step designated workstations with SOPs **From the field sampling, sample processing and measurement to data generation and analysis...!**

Examples of workflows include;

- ❑ Sample Reception Workflow
- ❑ InfraRed Spectroscopy Laboratory Workflow
- ❑ X-Ray Fluorescence Laboratory Workflow
- ❑ Data Generation and Management Workflow



The Laboratory Information Management System (LIMS) Workflow

Laboratory Information Management System (LIMS) - This is an online access software developed in CIFOR-ICRAF to provide solutions for laboratory operations including a structured workflow and support in data tracking, storage and retrieval.

Key Performance Indicators (KPI)

The CIFOR- ICRAF Soil-Plant Spectral Diagnostics Laboratory is a global leader is spectral data analytics.

We conduct accurate, cost-efficient and rapid analysis of soils, plants and agricultural inputs using dry spectral methods.

26	248672	160200	30
Number of countries	Number of spectra in the database	Number of samples logged in the archive	Number of instruments

[Link to the CIFOR-ICRAF Soil and Land Health Theme LIMS Soil -Plant Spectral Diagnostics Laboratory]

Features of LIMS

Features

Sample submission

Sample pricelist and analytical packages, receipt acknowledgement, registration and accessioning

Scheduling and Monitoring of Analyses

Sample tracking at processing, preparation and analysis work stations.

Spectral data

Raw binary data files from the instruments and conversion to processed excel (CSV or xls) files with peak intensities for extraction of soil functional properties

Advanced Instrumentation

Advanced infrared and x-ray spectrometers for rapid, low-cost, high-throughput spectral analyses.

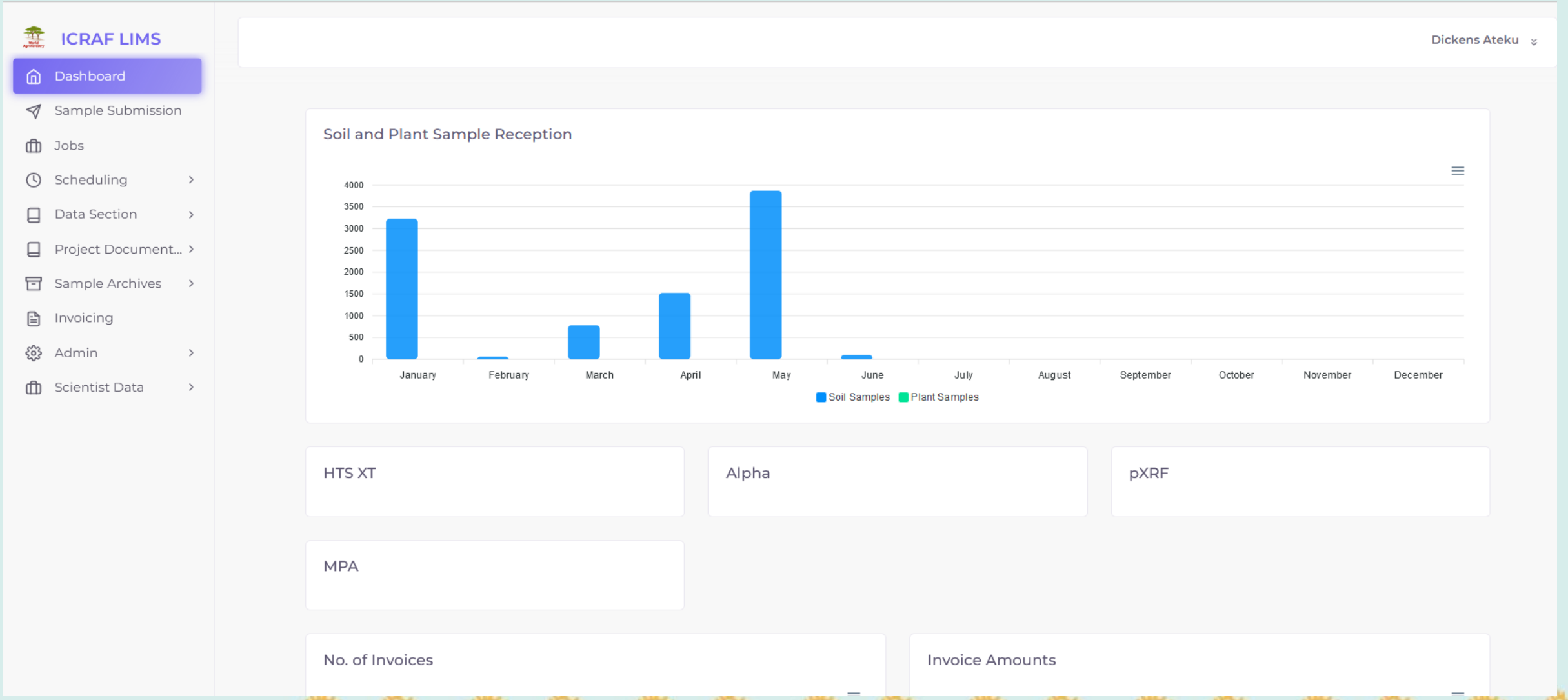
Spectral Predictions

Data analytics based on the spectral library to develop robust spectral calibration and validation models of key functional soil properties.

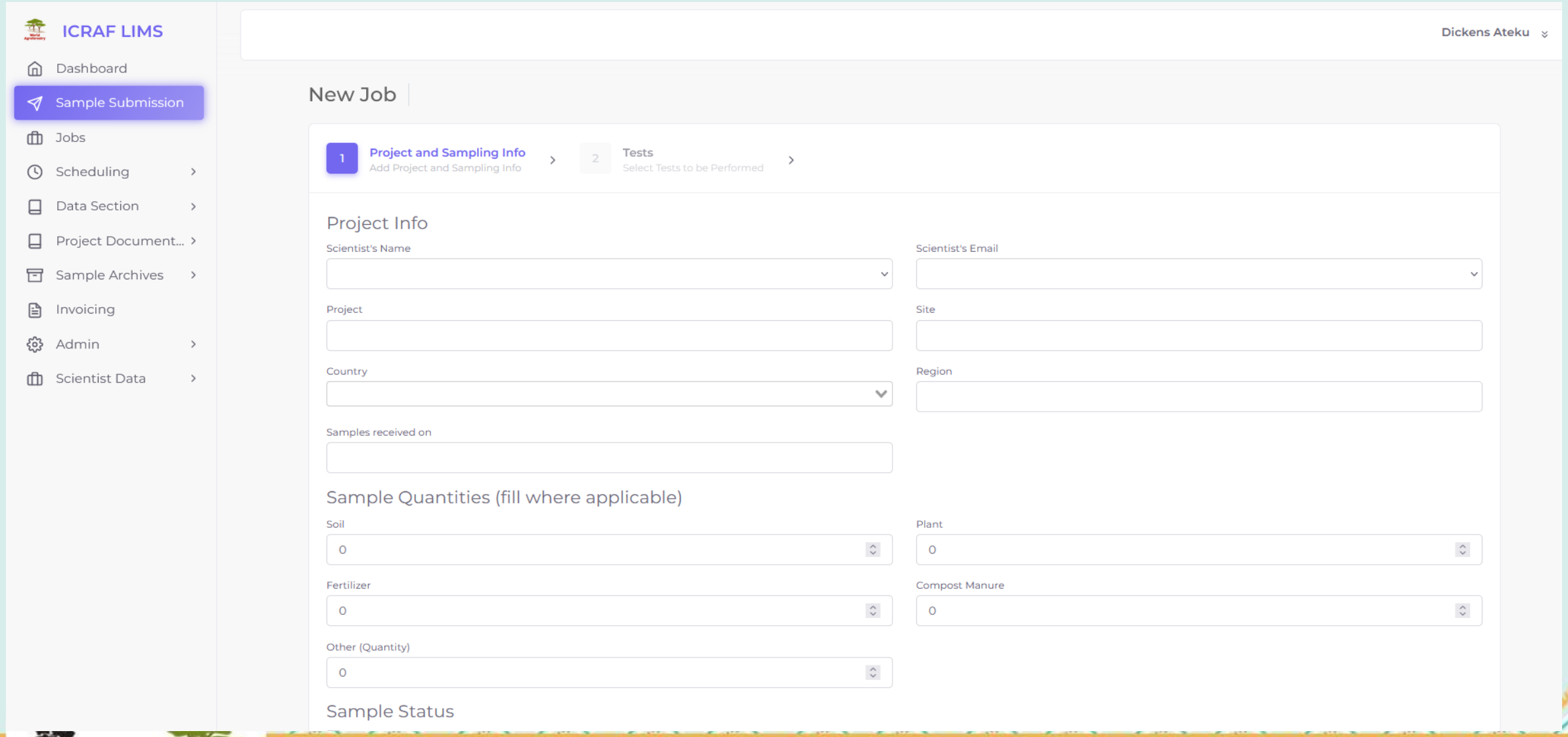
Archived Soil Sample Curation

Valuable physical repository for systematically collected samples with associated data on location and actual sample weights at CIFOR-ICRAF physical soil archives.

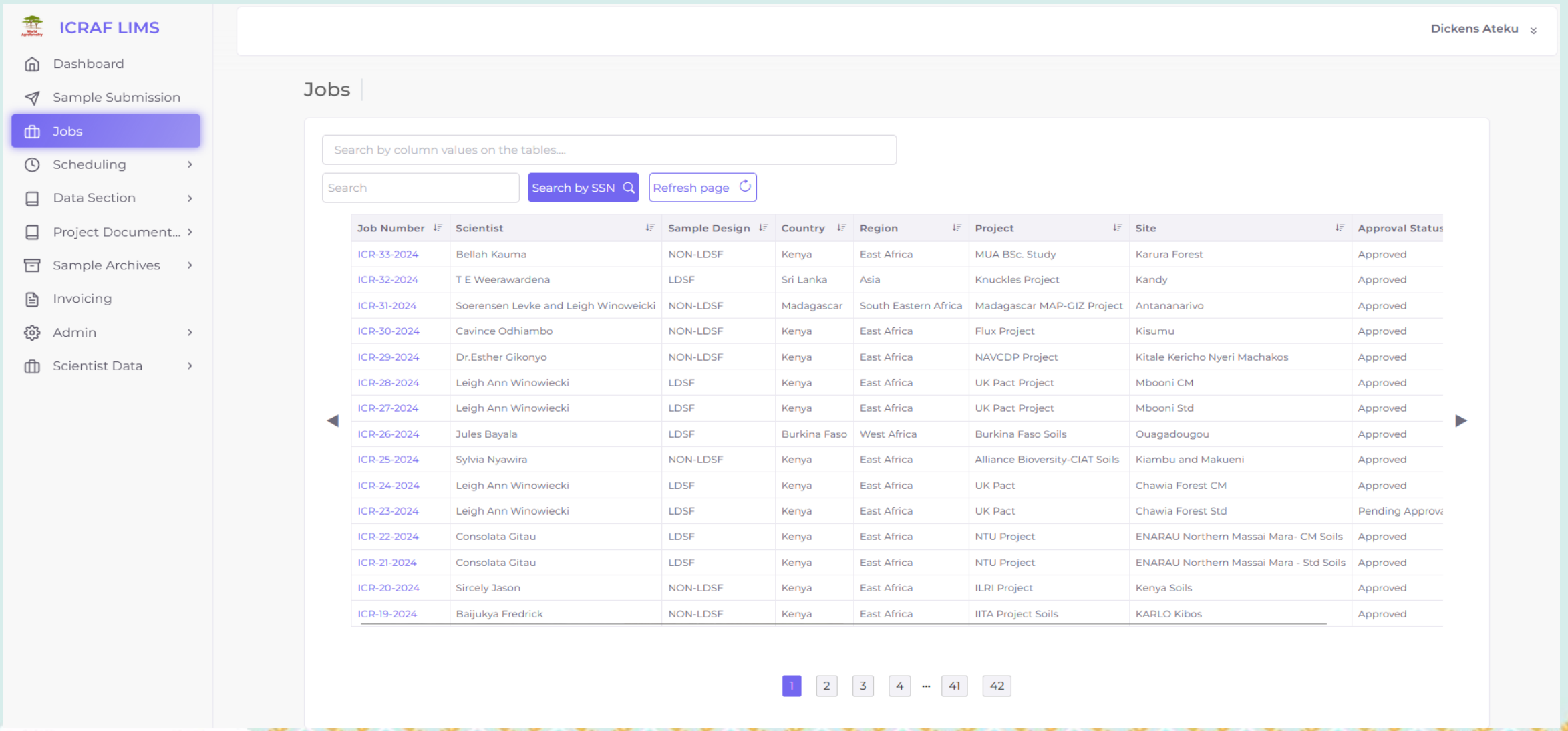
LIMS Dashboard



Sample Submission



Jobs on LIMS



Job Number	Scientist	Sample Design	Country	Region	Project	Site	Approval Status
ICR-33-2024	Bellah Kauma	NON-LDSF	Kenya	East Africa	MUA BSc. Study	Karura Forest	Approved
ICR-32-2024	T E Weerawardena	LDSF	Sri Lanka	Asia	Knuckles Project	Kandy	Approved
ICR-31-2024	Soerensen Levke and Leigh Winoweicki	NON-LDSF	Madagascar	South Eastern Africa	Madagascar MAP-GIZ Project	Antananarivo	Approved
ICR-30-2024	Cavince Odhiambo	NON-LDSF	Kenya	East Africa	Flux Project	Kisumu	Approved
ICR-29-2024	Dr.Esther Gikonyo	NON-LDSF	Kenya	East Africa	NAVCDP Project	Kitale Kericho Nyeri Machakos	Approved
ICR-28-2024	Leigh Ann Winowiecki	LDSF	Kenya	East Africa	UK Pact Project	Mbooni CM	Approved
ICR-27-2024	Leigh Ann Winowiecki	LDSF	Kenya	East Africa	UK Pact Project	Mbooni Std	Approved
ICR-26-2024	Jules Bayala	LDSF	Burkina Faso	West Africa	Burkina Faso Soils	Ouagadougou	Approved
ICR-25-2024	Sylvia Nyawira	NON-LDSF	Kenya	East Africa	Alliance Bioversity-CIAT Soils	Kiambu and Makueni	Approved
ICR-24-2024	Leigh Ann Winowiecki	LDSF	Kenya	East Africa	UK Pact	Chawia Forest CM	Approved
ICR-23-2024	Leigh Ann Winowiecki	LDSF	Kenya	East Africa	UK Pact	Chawia Forest Std	Pending Approva
ICR-22-2024	Consolata Gitau	LDSF	Kenya	East Africa	NTU Project	ENARAU Northern Massai Mara- CM Soils	Approved
ICR-21-2024	Consolata Gitau	LDSF	Kenya	East Africa	NTU Project	ENARAU Northern Massai Mara - Std Soils	Approved
ICR-20-2024	Sircely Jason	NON-LDSF	Kenya	East Africa	ILRI Project	Kenya Soils	Approved
ICR-19-2024	Baijukya Fredrick	NON-LDSF	Kenya	East Africa	IITA Project Soils	KARLO Kibos	Approved

Job Details

Job Details | Jobs > Job Details

Job #ICR-31-2024

Country:
Madagascar

Region:
South Eastern Africa

Site:
Antananarivo

Scientist:
Soerensen Levke and Leigh Winoweicki

Created By:
Dickens Ateku

Created:
17 May 2024

Sampling Design:
Non LDSF

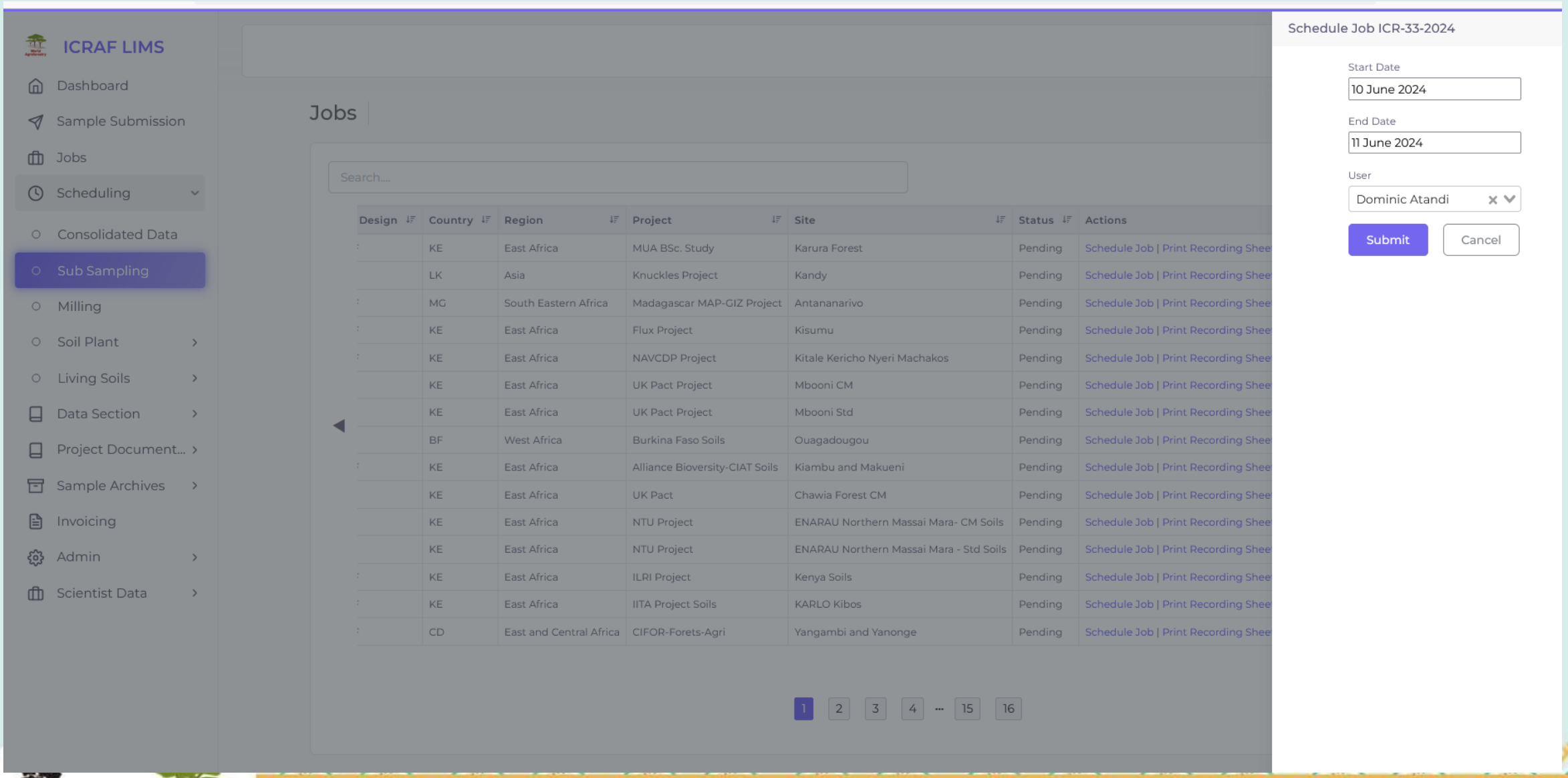
Total Samples:
400

Samples received on:
2024-05-16

Tests

- Sub Sampling - Pending
- Milling - Pending
- Soil Sample processing - Pending
- Mid Infrared Spectroscopy (MIR) using the HTs XT for soils/plants/ manure/compost/fertilizers - In Progress
- Wet Chemistry Soil Analysis Soil Option 1 - Pending
- Mid Infrared Soil/Plant/Manure/Compost and fertilizer Prediction per sample functional property predicted - Pending
- CN analysis at Iso-Analytical Laboratory in UK - Pending
- Export permit per package - Pending
- Courier charges to Iso-Analytical Laboratory UK per package - Pending
- Exported sample packaging container costs - Pending
- Import permit per package - Pending
- Archiving storage charges - Pending
- Soil pH - Pending

Scheduling on LIMS



Uploading of Data Generated from Instruments on LIMS

ICRAF LIMS

Dickens Ateku

- Dashboard
- Sample Submission
- Jobs
- Scheduling
- Data Section
  - Consolidated Instru...
  - Version One Instru...
  - Version Two Instru...
- Project Document...
- Sample Archives
- Invoicing
- Admin
- Scientist Data

CIFOR-ICRAF Soil Plant Spectral Diagnostics Laboratory Full Sample Analysis

Alpha ZnSe_FTMIR_Alpha_I

Alpha ZnSe_FTMIR_Alpha_II

HTs XT_FTMIR_Invenio-S

MPA_FTNIR

pXRF

Wet Chem Reference Analysis

CIFOR-ICRAF Living Soils Laboratory Full Sample Analysis

Actinomycetes

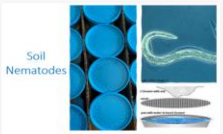
AMF colonization in plants roots

Arbuscular Mycorrhiza Fungi

Bacteria

Bacteria: Fungi ratio

Fungi analysis



Nematodes

Soil Aggregates

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Global Landscapes Forum

Resilient Landscapes

Uploading Infrared Spectral Files (OPUS) on LIMS

ICRAF LIMS

- Dashboard
- Sample Submission
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- Project Document...
- Sample Archives
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- Scientist Data

Dickens Ateku

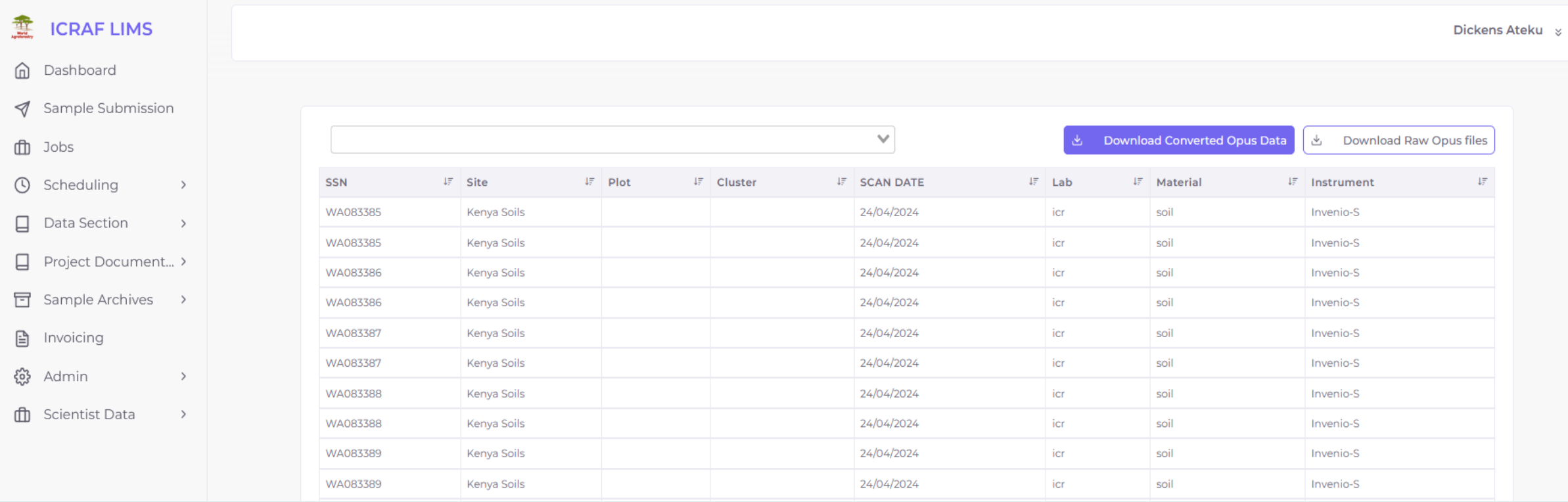
HTs XT_FTMIR_Invenio-S Jobs

Search....

Country	Region	Project	Site	Actions	Upload Status	Actions to Update data upload status
KE	East Africa	MUA BSc. Study	Karura Forest	Upload Job Data | View Data	Incomplete	Update upload status
MG	South Eastern Africa	Madagascar MAP-GIZ Project	Antananarivo	Upload Job Data | View Data	Incomplete	Update upload status
KE	East Africa	UK Pact Project	Mbooni CM	Upload Job Data | View Data	Incomplete	Update upload status
KE	East Africa	UK Pact Project	Mbooni Std	Upload Job Data | View Data	Incomplete	Update upload status
BF	West Africa	Burkina Faso Soils	Ouagadougou	Upload Job Data | View Data	Incomplete	Update upload status
KE	East Africa	Alliance Bioversity-CIAT Soils	Kiambu and Makueni	Upload Job Data | View Data	Incomplete	Update upload status
KE	East Africa	UK Pact	Chawia Forest CM	Upload Job Data | View Data	Incomplete	Update upload status
KE	East Africa	UK Pact	Chawia Forest Std	Upload Job Data | View Data	Incomplete	Update upload status
KE	East Africa	NTU Project	ENARAU Northern Massai Mara- CM Soils	Upload Job Data | View Data	Incomplete	Update upload status
KE	East Africa	NTU Project	ENARAU Northern Massai Mara - Std Soils	Upload Job Data | View Data	Incomplete	Update upload status
KE	East Africa	ILRI Project	Kenya Soils	Upload Job Data | View Data	Complete	Update upload status
KE	East Africa	IITA Project Soils	KARLO Kibos	Upload Job Data | View Data	Complete	Update upload status
CD	East Africa and Central	CIFOR-Forets-Agri	Yangambi and Yanonge	Upload Job Data | View Data	Incomplete	Update upload status
ET	East Africa	Ethiopia MAP GIZ Project	Ethiopia soils	Upload Job Data | View Data	Complete	Update upload status
ET	East Africa	Ethiopia CYMMIT Samples Project	Ethiopia Soils	Upload Job Data | View Data	Incomplete	Update upload status

1 2 3 4 ... 11 12

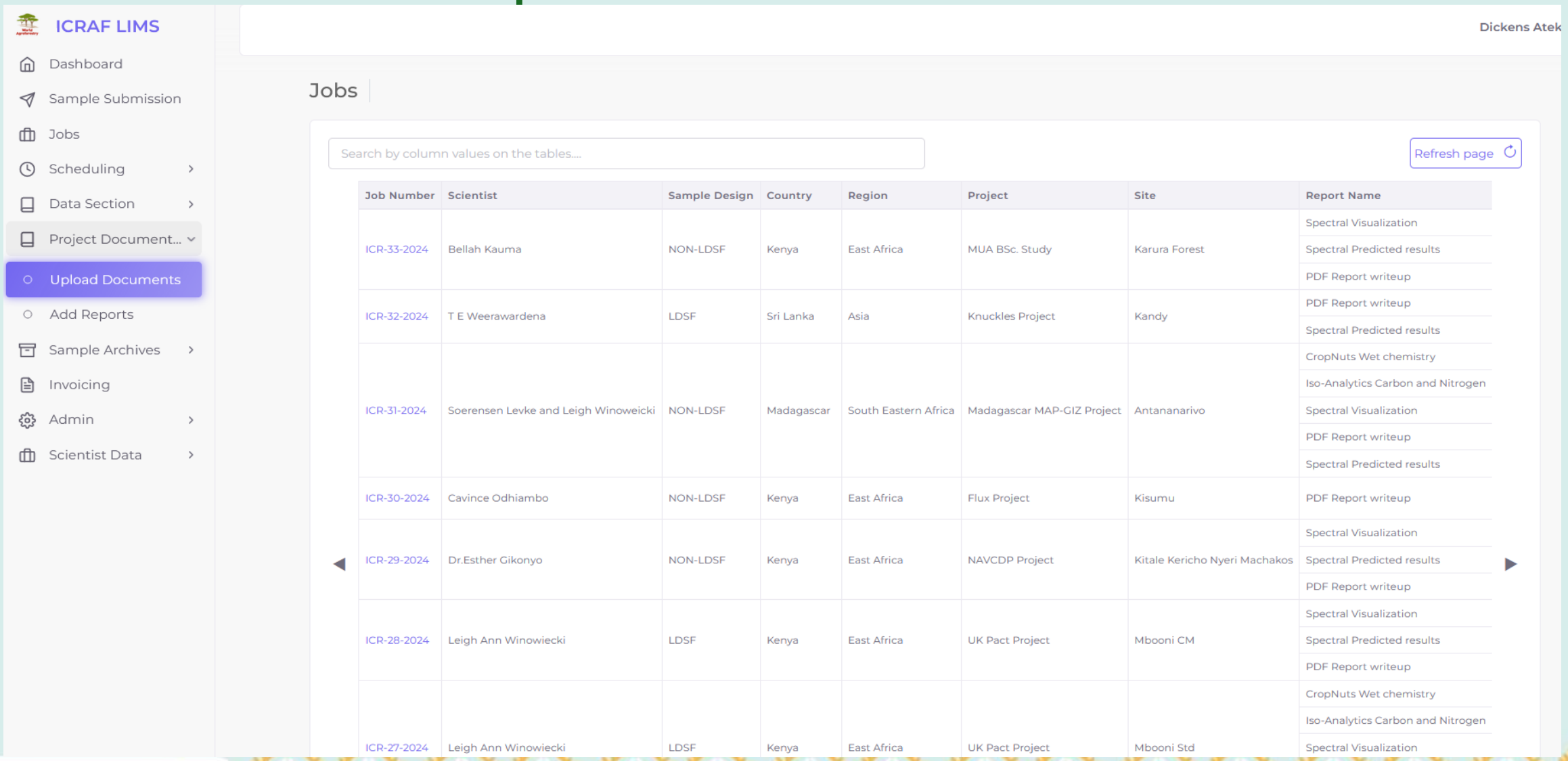
Uploading Infrared Spectral Files (OPUS) on LIMS



SSN	Site	Plot	Cluster	SCAN DATE	Lab	Material	Instrument
WA083385	Kenya Soils			24/04/2024	icr	soil	Invenio-S
WA083385	Kenya Soils			24/04/2024	icr	soil	Invenio-S
WA083386	Kenya Soils			24/04/2024	icr	soil	Invenio-S
WA083386	Kenya Soils			24/04/2024	icr	soil	Invenio-S
WA083387	Kenya Soils			24/04/2024	icr	soil	Invenio-S
WA083387	Kenya Soils			24/04/2024	icr	soil	Invenio-S
WA083388	Kenya Soils			24/04/2024	icr	soil	Invenio-S
WA083388	Kenya Soils			24/04/2024	icr	soil	Invenio-S
WA083389	Kenya Soils			24/04/2024	icr	soil	Invenio-S
WA083389	Kenya Soils			24/04/2024	icr	soil	Invenio-S

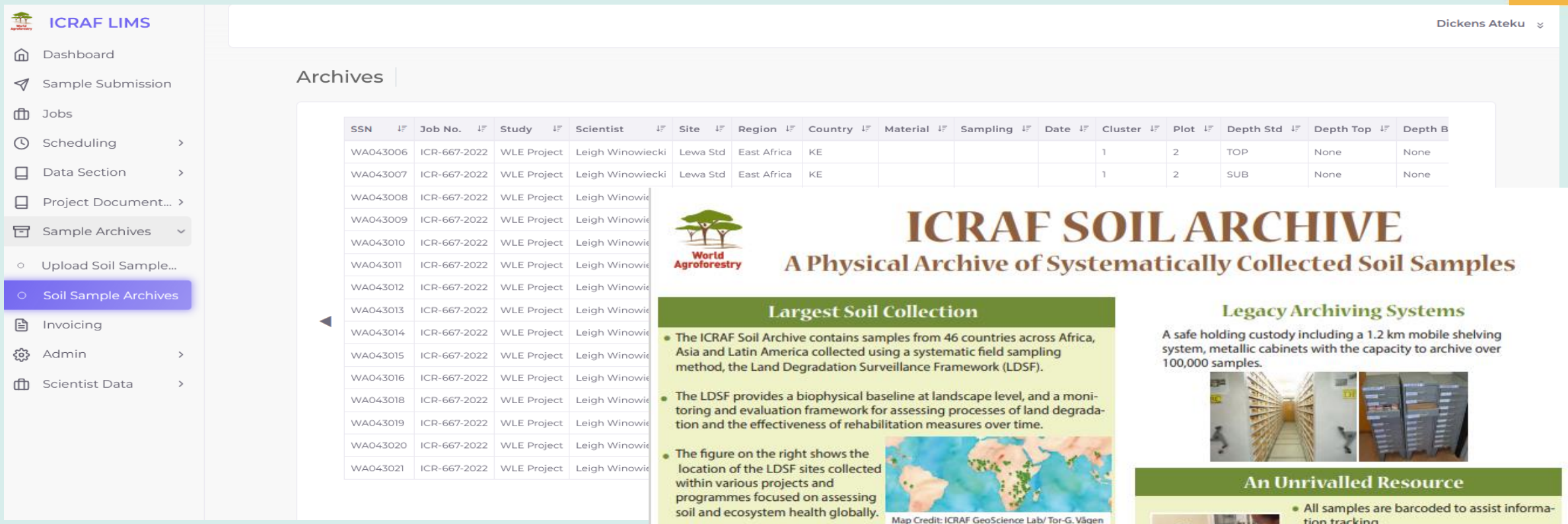
- Converted spectral data can be downloaded (CSV)
- The spectral files (OPUS) can be downloaded

Upload Documents on LIMS

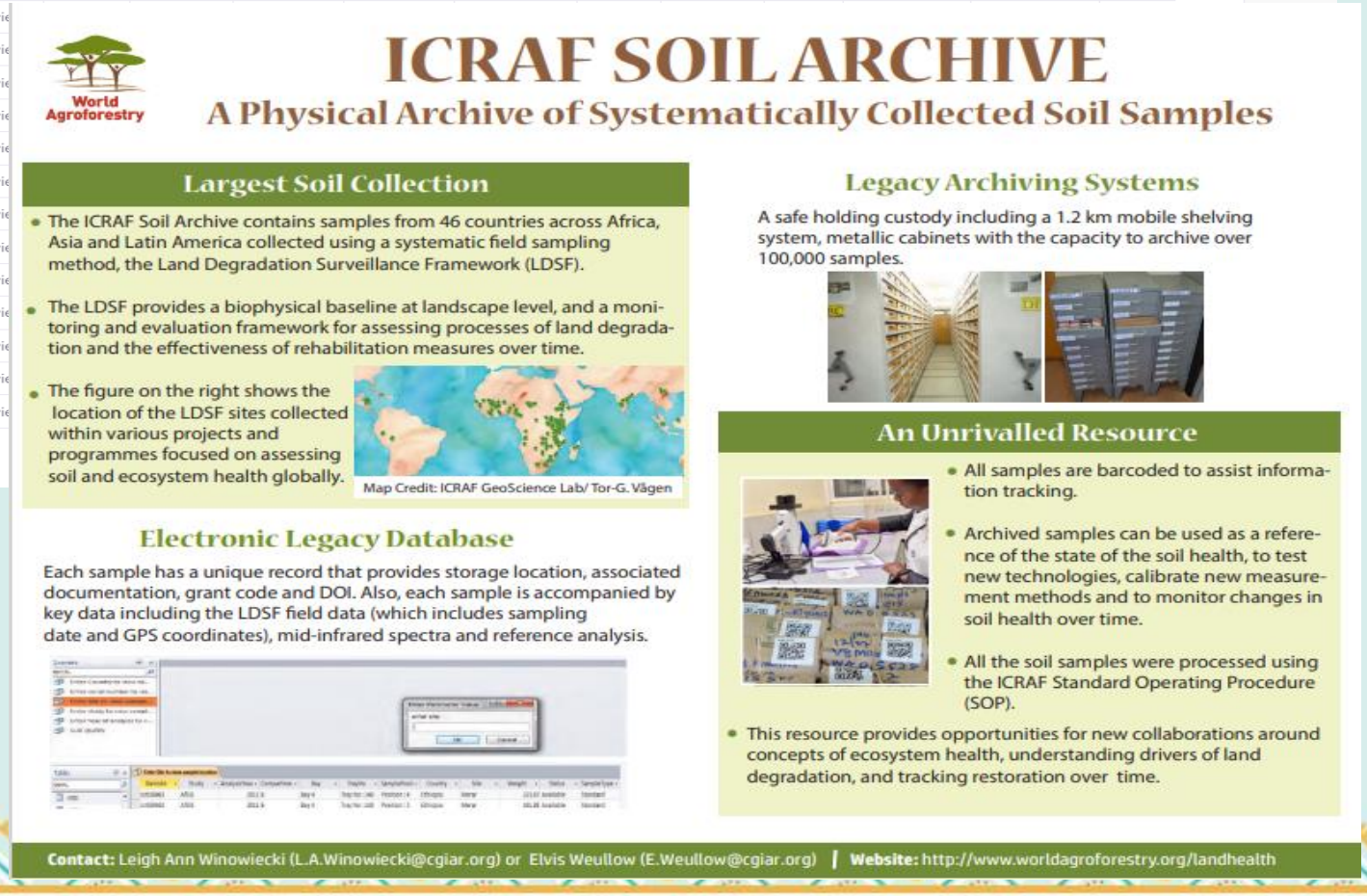


Job Number	Scientist	Sample Design	Country	Region	Project	Site	Report Name
ICR-33-2024	Bellah Kauma	NON-LDSF	Kenya	East Africa	MUA BSc. Study	Karura Forest	Spectral Visualization
							Spectral Predicted results
							PDF Report writeup
ICR-32-2024	T E Weerawardena	LDSF	Sri Lanka	Asia	Knuckles Project	Kandy	PDF Report writeup
							Spectral Predicted results
ICR-31-2024	Soerensen Levke and Leigh Winoweicki	NON-LDSF	Madagascar	South Eastern Africa	Madagascar MAP-GIZ Project	Antananarivo	CropNuts Wet chemistry
							Iso-Analytics Carbon and Nitrogen
							Spectral Visualization
							PDF Report writeup
							Spectral Predicted results
ICR-30-2024	Cavince Odhiambo	NON-LDSF	Kenya	East Africa	Flux Project	Kisumu	PDF Report writeup
ICR-29-2024	Dr.Esther Gikonyo	NON-LDSF	Kenya	East Africa	NAVCDP Project	Kitale Kericho Nyeri Machakos	Spectral Visualization
							Spectral Predicted results
							PDF Report writeup
ICR-28-2024	Leigh Ann Winowiecki	LDSF	Kenya	East Africa	UK Pact Project	Mbooni CM	Spectral Visualization
							Spectral Predicted results
							PDF Report writeup
ICR-27-2024	Leigh Ann Winowiecki	LDSF	Kenya	East Africa	UK Pact Project	Mbooni Std	CropNuts Wet chemistry
							Iso-Analytics Carbon and Nitrogen
							Spectral Visualization

LIMS Archives



SSN	Job No.	Study	Scientist	Site	Region	Country	Material	Sampling	Date	Cluster	Plot	Depth Std	Depth Top	Depth B
WA043006	ICR-667-2022	WLE Project	Leigh Winowiecki	Lewa Std	East Africa	KE				1	2	TOP	None	None
WA043007	ICR-667-2022	WLE Project	Leigh Winowiecki	Lewa Std	East Africa	KE				1	2	SUB	None	None
WA043008	ICR-667-2022	WLE Project	Leigh Winowie											
WA043009	ICR-667-2022	WLE Project	Leigh Winowie											
WA043010	ICR-667-2022	WLE Project	Leigh Winowie											
WA043011	ICR-667-2022	WLE Project	Leigh Winowie											
WA043012	ICR-667-2022	WLE Project	Leigh Winowie											
WA043013	ICR-667-2022	WLE Project	Leigh Winowie											
WA043014	ICR-667-2022	WLE Project	Leigh Winowie											
WA043015	ICR-667-2022	WLE Project	Leigh Winowie											
WA043016	ICR-667-2022	WLE Project	Leigh Winowie											
WA043018	ICR-667-2022	WLE Project	Leigh Winowie											
WA043019	ICR-667-2022	WLE Project	Leigh Winowie											
WA043020	ICR-667-2022	WLE Project	Leigh Winowie											
WA043021	ICR-667-2022	WLE Project	Leigh Winowie											

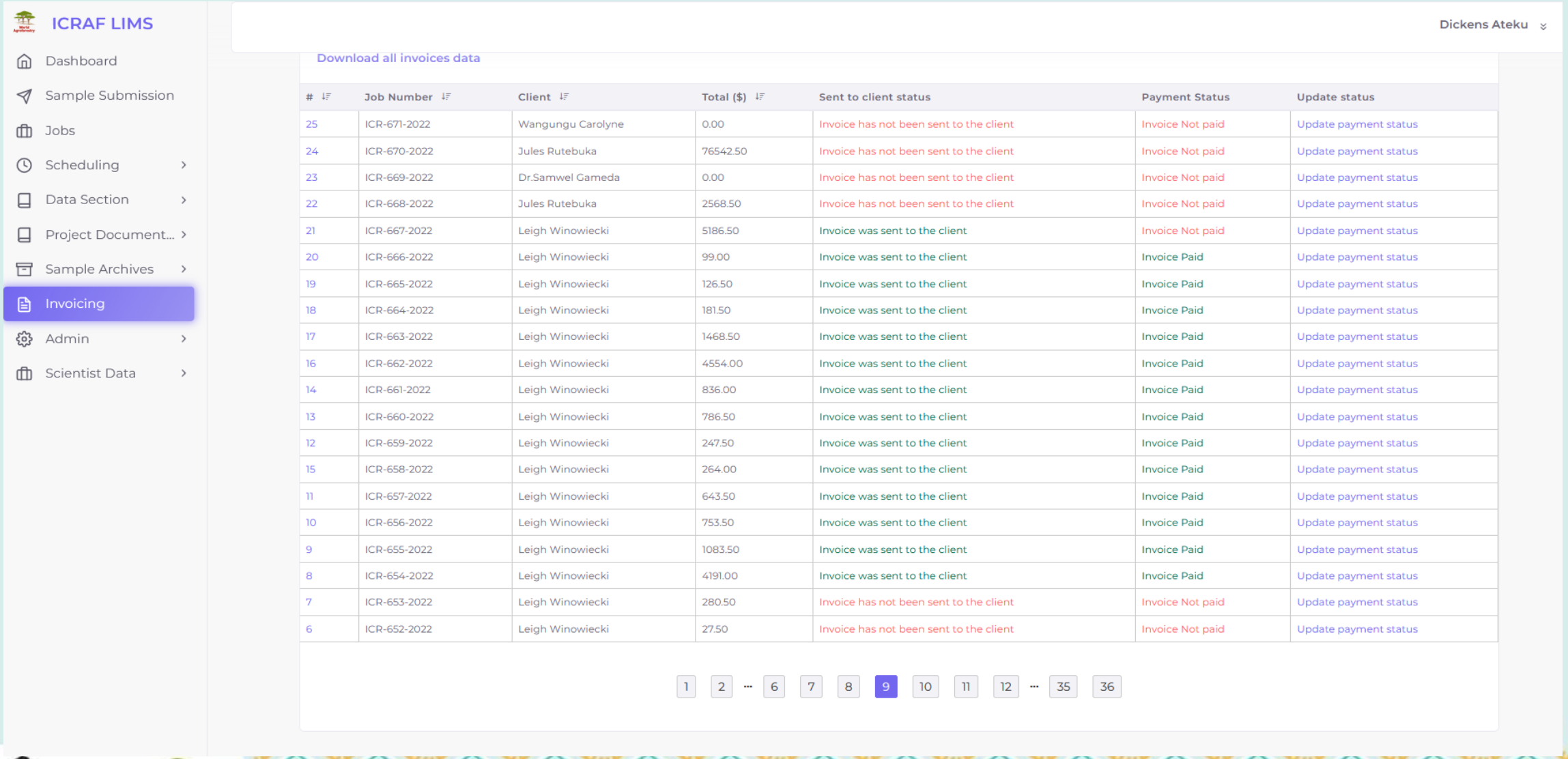


- We have **150,000 soil samples** archived in the facility

  All archived samples are bar-code-enabled to assist in research samples information tracking and data entry error prevention in the LIMS.

- The sample disposition ,archiving and disposal workflow is in place to guide coordination of all the operations involved.

Invoicing on LIMS



#	Job Number	Client	Total ($)	Sent to client status	Payment Status	Update status
25	ICR-671-2022	Wangungu Carolyne	0.00	Invoice has not been sent to the client	Invoice Not paid	Update payment status
24	ICR-670-2022	Jules Rutebuka	76542.50	Invoice has not been sent to the client	Invoice Not paid	Update payment status
23	ICR-669-2022	Dr.Samwel Gameda	0.00	Invoice has not been sent to the client	Invoice Not paid	Update payment status
22	ICR-668-2022	Jules Rutebuka	2568.50	Invoice has not been sent to the client	Invoice Not paid	Update payment status
21	ICR-667-2022	Leigh Winowiecki	5186.50	Invoice was sent to the client	Invoice Not paid	Update payment status
20	ICR-666-2022	Leigh Winowiecki	99.00	Invoice was sent to the client	Invoice Paid	Update payment status
19	ICR-665-2022	Leigh Winowiecki	126.50	Invoice was sent to the client	Invoice Paid	Update payment status
18	ICR-664-2022	Leigh Winowiecki	181.50	Invoice was sent to the client	Invoice Paid	Update payment status
17	ICR-663-2022	Leigh Winowiecki	1468.50	Invoice was sent to the client	Invoice Paid	Update payment status
16	ICR-662-2022	Leigh Winowiecki	4554.00	Invoice was sent to the client	Invoice Paid	Update payment status
14	ICR-661-2022	Leigh Winowiecki	836.00	Invoice was sent to the client	Invoice Paid	Update payment status
13	ICR-660-2022	Leigh Winowiecki	786.50	Invoice was sent to the client	Invoice Paid	Update payment status
12	ICR-659-2022	Leigh Winowiecki	247.50	Invoice was sent to the client	Invoice Paid	Update payment status
15	ICR-658-2022	Leigh Winowiecki	264.00	Invoice was sent to the client	Invoice Paid	Update payment status
11	ICR-657-2022	Leigh Winowiecki	643.50	Invoice was sent to the client	Invoice Paid	Update payment status
10	ICR-656-2022	Leigh Winowiecki	753.50	Invoice was sent to the client	Invoice Paid	Update payment status
9	ICR-655-2022	Leigh Winowiecki	1083.50	Invoice was sent to the client	Invoice Paid	Update payment status
8	ICR-654-2022	Leigh Winowiecki	4191.00	Invoice was sent to the client	Invoice Paid	Update payment status
7	ICR-653-2022	Leigh Winowiecki	280.50	Invoice has not been sent to the client	Invoice Not paid	Update payment status
6	ICR-652-2022	Leigh Winowiecki	27.50	Invoice has not been sent to the client	Invoice Not paid	Update payment status

Standard Operating Procedures (SOPs) to ensure quality control And tutorials for building capacity

Online SOPs

- http://worldagroforestry.org/sd/landhealth/soil-plant-spectral-diagnostics-laboratory/sops

- Having SOPs and tutorials are key for capacity building for scaling soil health assessments and soil spectroscopy
- From sample preparation to instrument set up to spectral processing

Online videos for soil processing

- https://worldagroforestry.org/output/video-ldsf-soil-sample-processing-protocol

• Sample loading and presentation

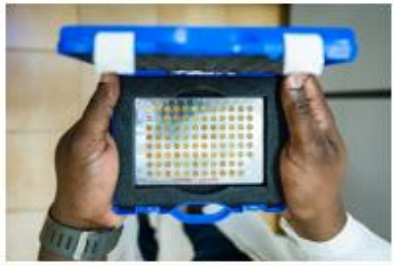
QR & Bar Codes labelled sample packs

The QR & Bar Codes generated by LIMS

Samples arranged on wooden trays sequentially placed on trolley and shelves

RM 200 Restch machine for grinding 2mm sieved soils to < 0.05 mm

HTS-XT Aluminium Sample Microplate



Alpha ZnSe - Drift Aluminium Sample Cups

MPA Sample Petri Dishes

	SSN	Job No	cluster	plot	depth	Study	Scientist	Site	Region	Country	Material	Sampling
1	WA049119	ICR-685-2022	1	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
2	WA049120	ICR-685-2022	1	1	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
3	WA049139	ICR-685-2022	2	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
4	WA049140	ICR-685-2022	2	1	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
5	WA049159	ICR-685-2022	3	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
6	WA049160	ICR-685-2022	3	1	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
7	WA049177	ICR-685-2022	4	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
8	WA049178	ICR-685-2022	4	1	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
9	WA049195	ICR-685-2022	5	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
10	WA049196	ICR-685-2022	5	1	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
11	WA049215	ICR-685-2022	6	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
12	WA049216	ICR-685-2022	6	1	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
13	WA049235	ICR-685-2022	7	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
14	WA049236	ICR-685-2022	7	1	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
15	WA049255	ICR-685-2022	8	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
16	WA049256	ICR-685-2022	8	1	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
17	WA049275	ICR-685-2022	9	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
18	WA049276	ICR-685-2022	9	1	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
19	WA049299	ICR-685-2022	10	6	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
20	WA049300	ICR-685-2022	10	6	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
21	WA049307	ICR-685-2022	11	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
22	WA049308	ICR-685-2022	11	1	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
23	WA049323	ICR-685-2022	12	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
24	WA049324	ICR-685-2022	12	1	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
25	WA049341	ICR-685-2022	13	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
26	WA049342	ICR-685-2022	13	1	SUB	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF
27	WA049357	ICR-685-2022	14	1	TOP	SLU-Dryland Transform Project	Leigh Winowiecki	Rupa Std	East Africa	Uganda	Std Soil	LDSF

Login Form

Plate No..... **SSN**.....
Study.....
Date of loading..... **Loaded & recorded by**.....
Comment.....

	1	2	3	4	5	6	7	8	9	10	11	12
A	Background.											
B	Blank											
C	Mua std											
D	Mua std											
E	Katumani											
F	Katumani											
G	HBCCS											White Sd.
H	HBCCS											White Sd

Date of scanning..... Initial time of scanning.....
Signal Check Amplitude..... Signal Check Position.....
Recorded by.....
Comment.....

Site:_____ Moisture start:_____ Sample type:_____
Date_____ Moisture End:_____ No.of Samples:___
Std Signal:White Sand Loaded by:_____
Std Signal:_____ Recorded by:_____
Amplitude:Au Ref

Cup No	SSN	QRcode	Scan
1	WA022743		_____
2	WA022744		_____
3	WA022745		_____
4	WA022746		_____
5	WA022747		_____

Recording Sheets

[Video link of soil grinding using Restch RM200,HTS-XT Aluminium microplate sample loading and MPA petri dish sample loading]

Capacity Development

CIFOR - ICRAF has for the last 23 years invested in scaling up spectroscopy technology across the globe through offering :

- Laboratory setup based on ICRAF SOPs and Instrument setup methods.
- Training on, sample log-in, sample processing, and handling in the laboratory.
- Training in Laboratory workflow and LIMS systems.
- Training in Data Processing and Analysis Training based on robust MLA.
- Training on Sample Archiving and Disposal.

GLOSOLAN
GLOBAL SOIL LABORATORY NETWORK

Consistent and harmonized instrument methods and SOPs are needed to generate high-quality spectral data outputs!

Global Spectral Lab Network

Country	Lab/Institution
Mauritius	Mauritius Sugarcane Research Institute(NARS)
Cameroon	IITA; ICRAF
Cote D'Ivoire	CNRA; ICRAF:AfricaRice
Ethiopia	ATA/NSTC (5) (NARS); Mekelle University; SARI(NARS),OCP Ethiopia
Ghana	CSRIO-SRI (NARS)
Rwanda	RAB(NARS)
Kenya	KARLO; One Acre Fund; CNLS, ICRAF, Natural State
Madagascar	Antananarivo University(collaborative).
Malawi	CARS/ DARTS (NARS)
Mali	IER(NARS)
Morocco	Mohammed Vi Polytechnic /OCP (in progress)
Mozambique	IAMM (NARS)
Nigeria	Obafemi Awolowo University; IITA; IAR; FDMA&RD (6)(NARS)
South Africa	KwaZulu-Natal Dept of Agriculture, ARC(NARS)
Tanzania	SARI (NARS); Min of Agriculture (4); Sokoine University
Outside Africa	Australia (CSIRO); China (YPC); India (CIMMYT; ISSS-ICAR); Peru (IIAP); UK (Rothamsted Research Institute), Sri Lanka MOI-DEA

2019-2024 Scaling Soil Spectroscopy

Year	Cap Dev Activity	Country/Institution
2019	Spectroscopy Training and Lab Setup	India , Andhra Pradesh-Achyra Ranga University
2020	Spectroscopy Training and Lab Setup	Cote D'Ivoire-ICRAF Sinemantiali Cottoton and Cashew Nuts Board
2020	Spectroscopy Virtual Training and Lab Setup	Cote D'Ivoire-AfricaRice Centre -Bouake
2021	Spectroscopy Physical Training and Lab Setup	Cote D'Ivoire-AfricaRice Centre -Bouake
2021	Laser Diffraction Training	Kenya -CNLS-Nairobi
2021	Sample preparation Virtual Training	India AP RySS
2022	Spectroscopy Training and Lab Setup	Rwanda -RWASIS project
2022	Regional Spectroscopy Full Virtual Training(Sample and Data analysis	Virtual from Kenya HQ(2 Key trainings held and 1 With Instrument suppliers
2022	Spectroscopy Training and Lab Setup	Nigeria -Ministry of Agriculture (4Spectral Labs)
2022	Spectroscopy Training and Lab Setup	South Africa -ARC-Soils4Africa Project
2023	Spectroscopy Training and Lab Setup	Kenya - Natural State -Laikipia
2023	Regional Specroscopy Full Virtual Training(Sample analysis	Virtual from Kenya HQ(2 Key trainings held and
	and Data Analysis)	2 With Instrument suppliers)
2024	Regional Spectroscopy virtual training on data analysis and lab workflows	Virtual from Kenya HQ(2 Key trainings held and 1 With Instrument suppliers
2024	FAO GLOSOLAN Webinar	Virtual global presentation from Kenya
2024	Regional network engagement on concepts notes and proposals	Virtual meeting from HQ Kenya
2024	Spectroscopy Training and Lab Setup	KALRO NAVCDP Project
2024	Spectroscopy Training and Lab Setup	OCP Ethiopia
2024	Spectroscopy Training and Lab Setup	Srilanka GCF IUCN Project
2024	Spectroscopy Training and Lab Setup	iSDB Project in Senegal, Mali, Gambia, Guinea, SierraLeone

Global Spectral Lab Network

ICRAF is the Regional Champion Lab for SSA in the FAO-led GLOSOLAN:

Global Soil Spectroscopy Community Continues to Grow

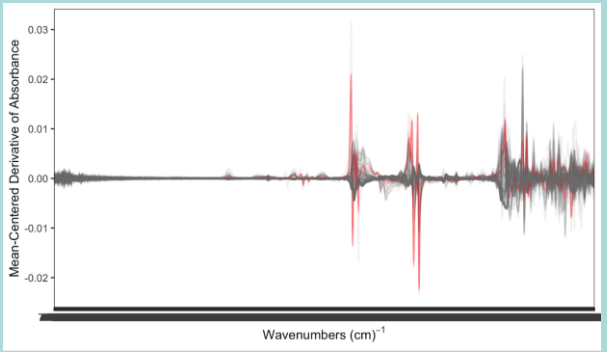
- Global community investing and scaling soil spectroscopy

New laboratory for spectral analysis of soils and plants in Côte d'Ivoire

ARC South Africa Physical spectroscopy training

Investing in the next generation: In 2023 we hosted 14 students

Soliver is mentored by Zampela to develop a biochar standard using spectroscopy



Received: 23 June 2023 | Revised: 9 November 2023 | Accepted: 19 December 2023
DOI: 10.1111/sum.13008

ORIGINAL ARTICLE

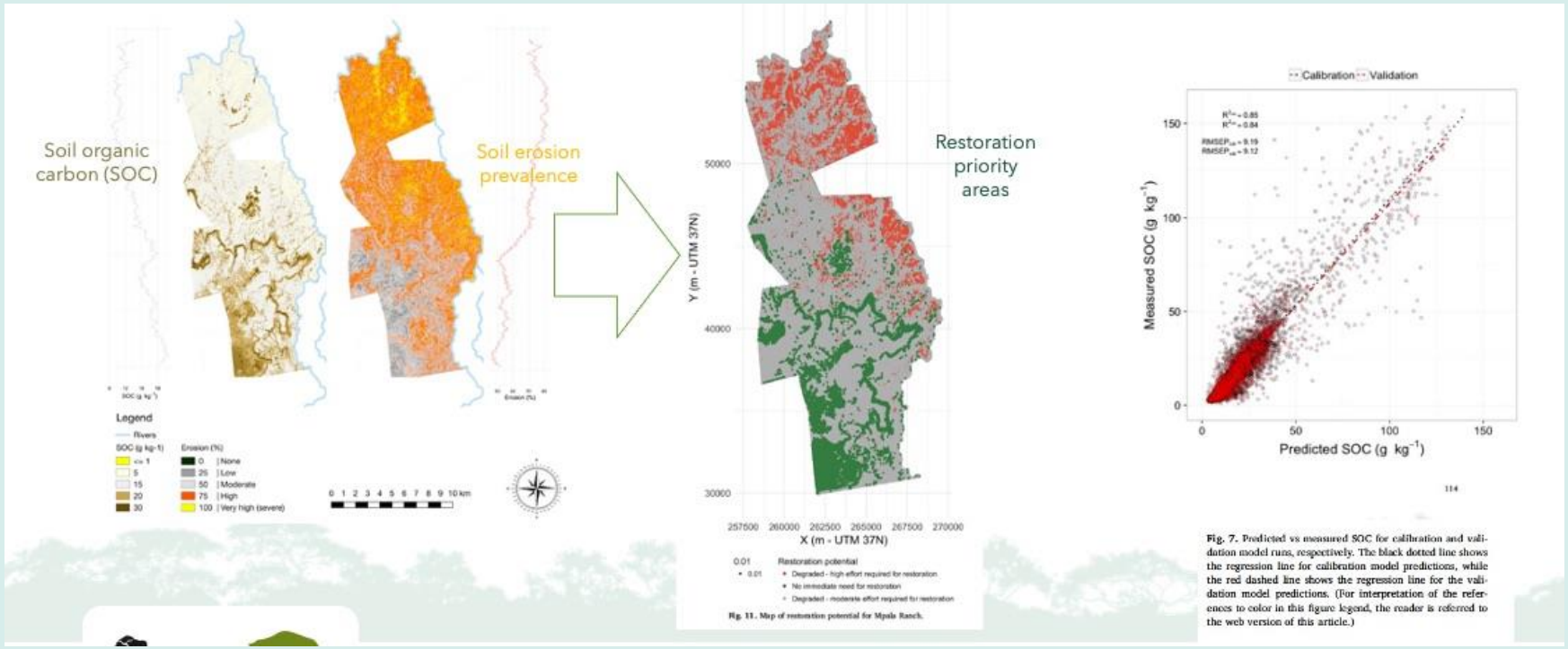
Soil Use and Management | WILEY

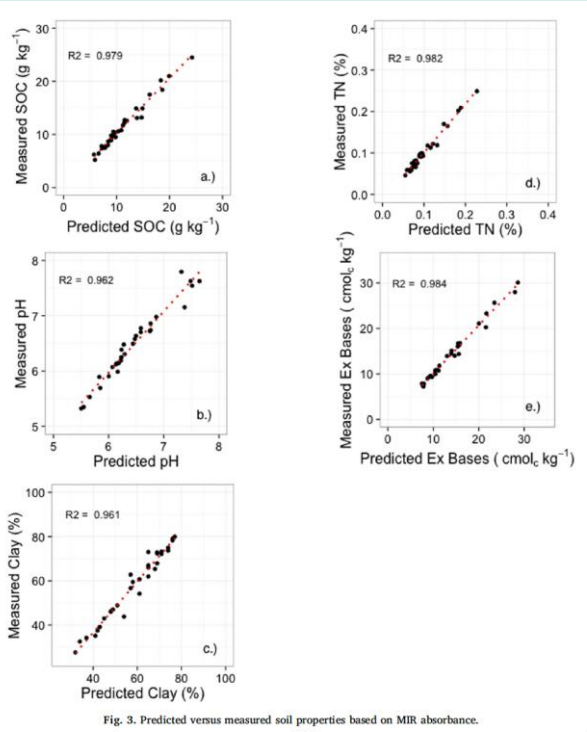
Effects of planting basins and farmyard manure addition on soil carbon and nitrogen pools under on-farm conditions in Makueni county of Kenya

Edith Kichamu-Wachira[1] | Zhihong Xu[1] | Kathryn Reardon-Smith[2] | Leigh Anne Winowiecki[3] | Gebiaw Ayele[4] | Duan Biggs[1,5] | Christine Magaju[3] | Sabah Taresh[1,6] | Shahla Hosseini-Bai[1] | Negar Omidvar[1]

Students are from: University of Nairobi, University of Bayreuth, Polytechnic University of Madrid, University of California, Berkeley/ Cornell, Kenyatta University, New York University, Griffith University, Kiambu National Polytechnic, Masinde Muliro University of Science and Technology

Assessing Restoration Potential in Kenya using spatially explicit maps of SOC and Erosion

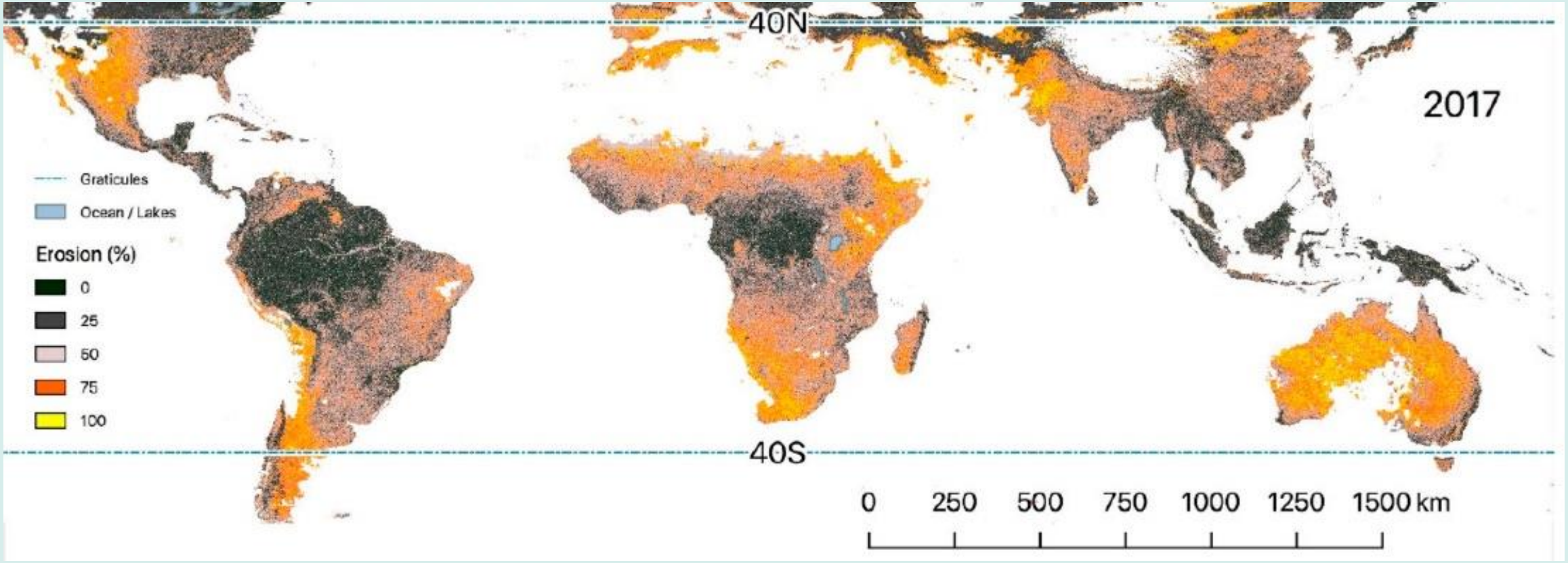




Winowiecki, LA., Vågen, T-G., Kinnaird, MF, TG. O'Brien. 2018. Application of systematic monitoring and mapping techniques: Assessing land restoration potential in semi-arid lands of Kenya. Geoderma. https://www.sciencedirect.com/science/article/pii/S001670611830510X

The ICRAF MIR database, which consisted of ca. 4000 soil MIR spectra with matching reference soil samples from 123 LDSF sites was used to develop the soil property prediction models.

Soil erosion is a key indicator of land degradation: Spatial assessments enable targeting and tracking over time and demonstrate the urgency

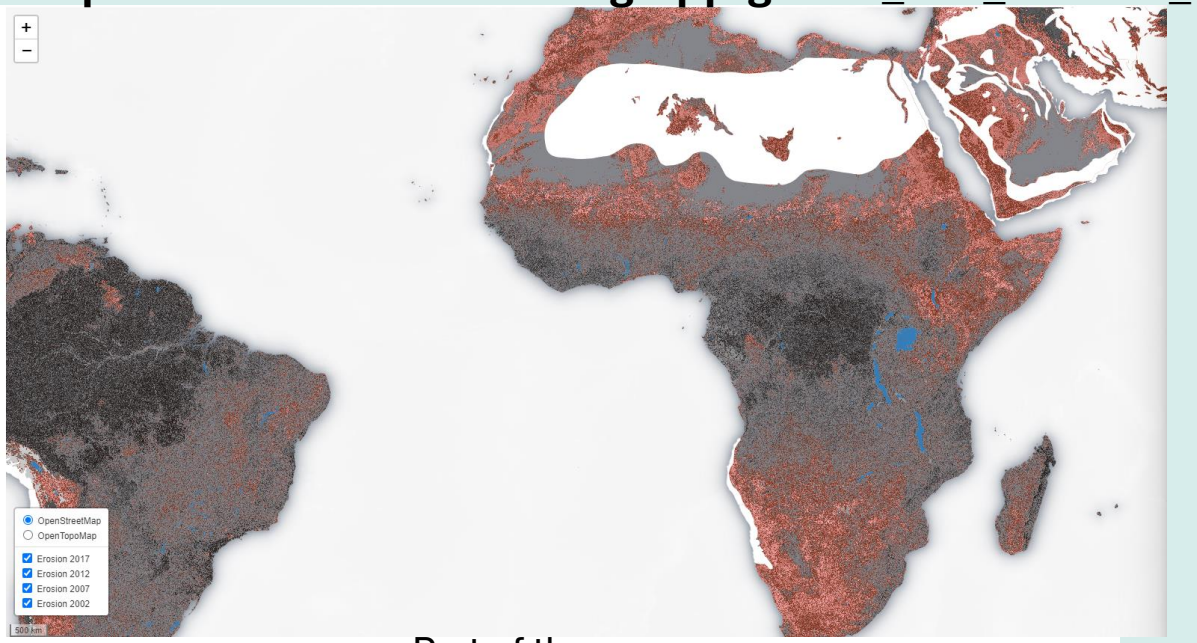


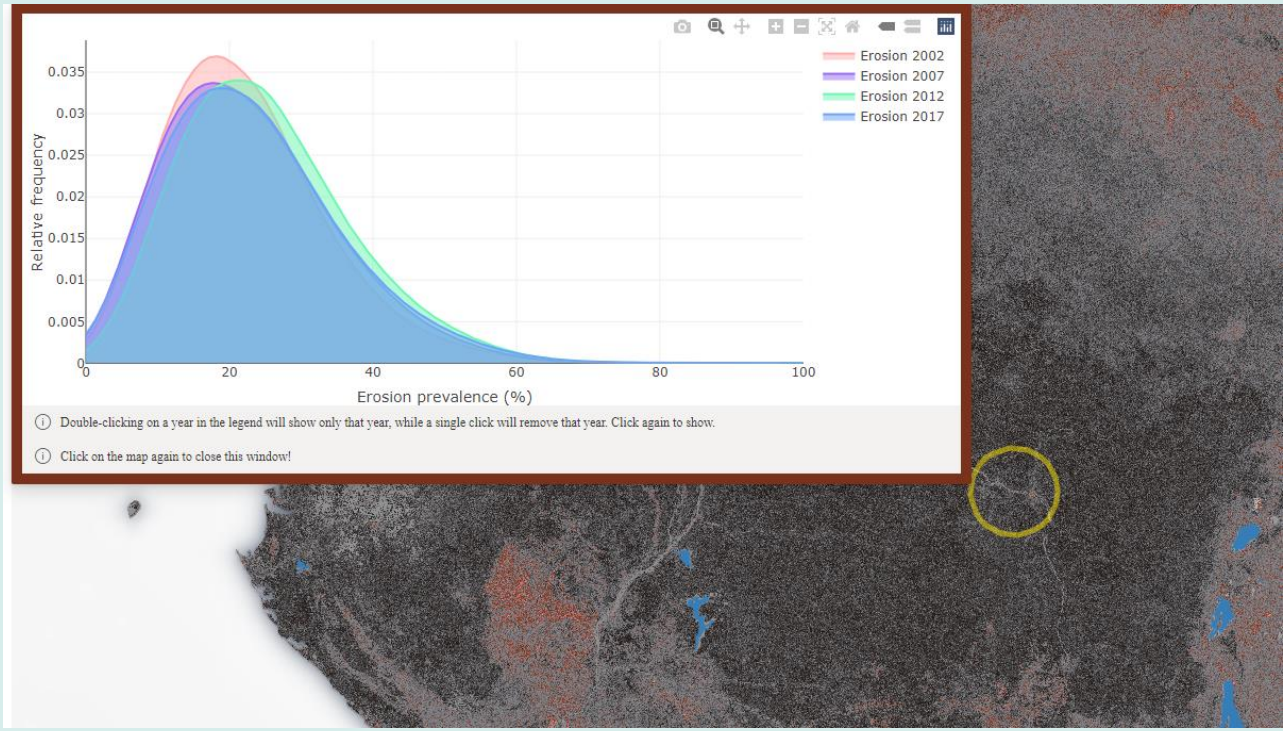
At the Global Level:
Vågen, T.-G.; Winowiecki, L.A. Predicting the Spatial Distribution and Severity of Soil Erosion in the Global Tropics using Satellite Remote Sensing. *Remote Sens.* **2019**, *11*, 1800. https://www.mdpi.com/2072-4292/11/15/1800

Global Soil Erosion Application: a combination of EO (MODIS platform) and field data collected using the LDSF

https://dashboards.icraf.org/app/global_soil_erosion_app

App development: Dr. Tor-G Vågen (t.vagen@cifor-icradf.org)





Part of the paper:
Vågen, T.-G.; Winowiecki, L.A. Predicting the Spatial Distribution and Severity of Soil Erosion in the Global Tropics using Satellite Remote Sensing. *Remote Sens.* **2019**, *11*, 1800. https://www.mdpi.com/2072-4292/11/15/1800

predict soil erosion prevalence at 500m resolution for the global tropics

Key Messages

1. CIFOR-ICRAF is a global leader in the assessment and monitoring of soil and land health at scale.

2. We have the tools and methods to measure and track changes in soil and land health at scales relevant to multiple stakeholders, including capturing the complex processes of degradation and restoration.

3. Investments in systematic field data collection, capacity development, databases, and data analytics are key.

4. The use of soil spectroscopy will play a key role in enabling landscape scale assessments

Thank you!

Check out CIFOR-ICRAF Soil and Land Health Webpage for videos, brochures, and more!!
https://worldagroforestry.org/landhealth
Video: The role of healthy soil for restoration:
http://worldagroforestry.org/output/healthy-soil-key-functioning-ecosystems
AlJaZeera Earthrise special: http://youtu.be/vFMSEHV7Ap4

cifor-icraf.org | globallandscapesforum.org | resilient-landscapes.org

CIFOR-ICRAF harnesses the power of trees, forests, and agroforestry landscapes to address the most pressing global challenges of our time – biodiversity loss, climate change, food security, livelihoods and inequity.

30 YEARS CIFOR

World Agroforestry

Global Landscapes Forum

Resilient Landscapes