The LDSF Field Manual

Land and Soil Health Assessments using the Land Degradation Surveillance Framework (LDSF)

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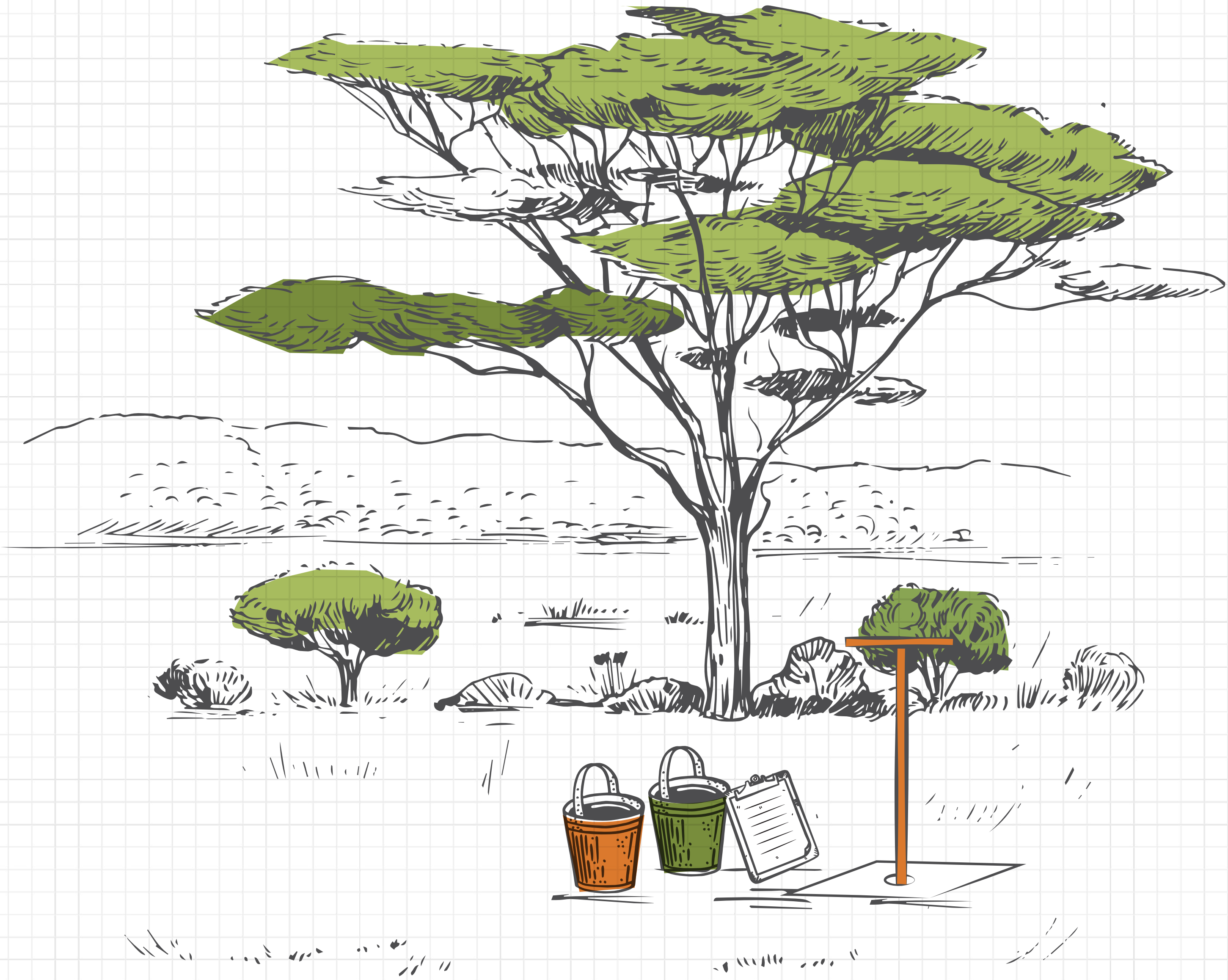

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What is the LDSF?

The Land Degradation Surveillance Framework (LDSF) is a comprehensive method developed by World Agroforestry (ICRAF) scientists, that provides a science-based field protocol for measuring land and soil characteristics, as well as vegetation composition and land degradation status over time.

LDSF was developed as a response to a lack of methods for systematic landscape-level assessment of soil and ecosystem health, using a robust and consistent indicator framework. The LDSF is designed to provide a biophysical baseline at landscape level, and a monitoring and evaluation framework for assessing processes of land degradation and the effectiveness of rehabilitation measures (recovery) over time. This is of particular importance for understanding land degradation processes, predicting changes in climate, prioritizing site-specific land management options and tracking the impact of interventions on the ground.

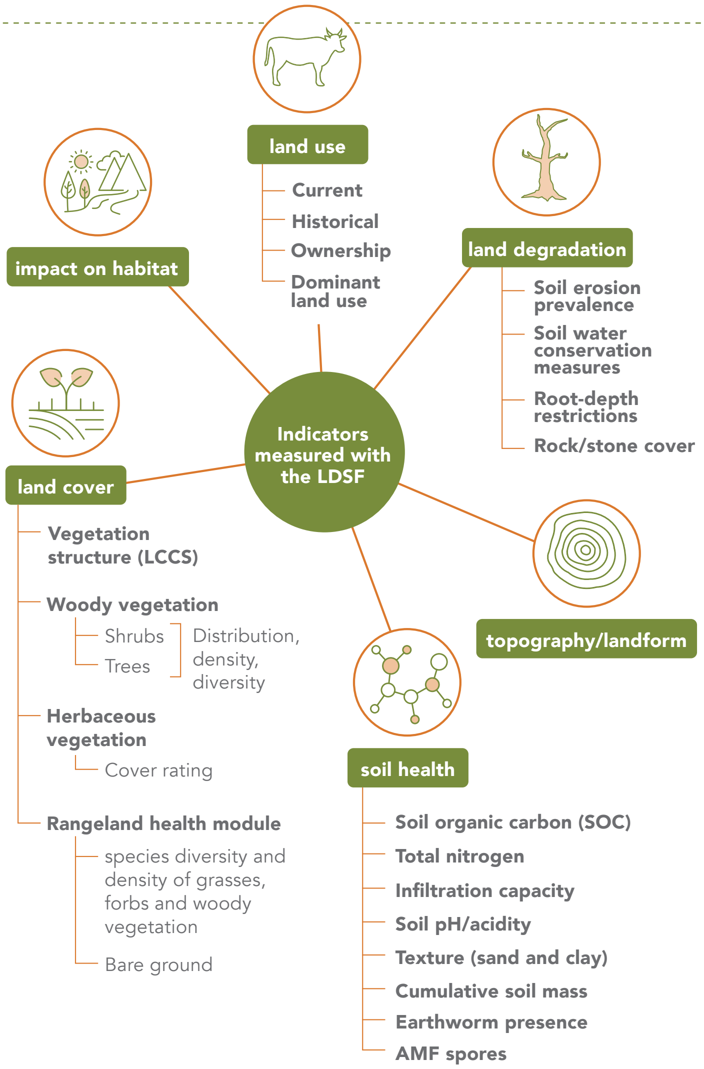
Implemented by a range of partners in over 40 countries since 2005, the LDSF provides a consistent set of indicators and field protocol to assess the health of an ecosystem. Indicators measured with the LDSF include vegetation cover and structure, tree, shrub and grass species diversity, current and historical land use, soil properties (soil organic carbon stocks for assessing climate change mitigation potential, total nitrogen, infiltration capacity, texture, etc.) and soil erosion prevalence.

This field manual describes the LDSF field survey methods and is designed to be used in training and as a reference in field during survey campaigns.

LDSF indicator framework

The LDSF enables **systematic and science-based assessment and monitoring of soil and ecosystem health at scale**, using a robust and consistent indicator framework that is:

- **Specific:** The indicator should accurately describe what is intended to be measured, and should not include multiple measurements in one indicator.
- **Measurable:** Regardless of who uses the indicator, consistent results should be obtained and tracked under the same conditions.
- **Attainable:** Collecting data for the indicator should be simple, straightforward, and cost-effective.
- **Relevant:** The indicator should be closely connected with each respective input, output or outcome.
- **Time-bound:** The indicator should include a specific time frame.

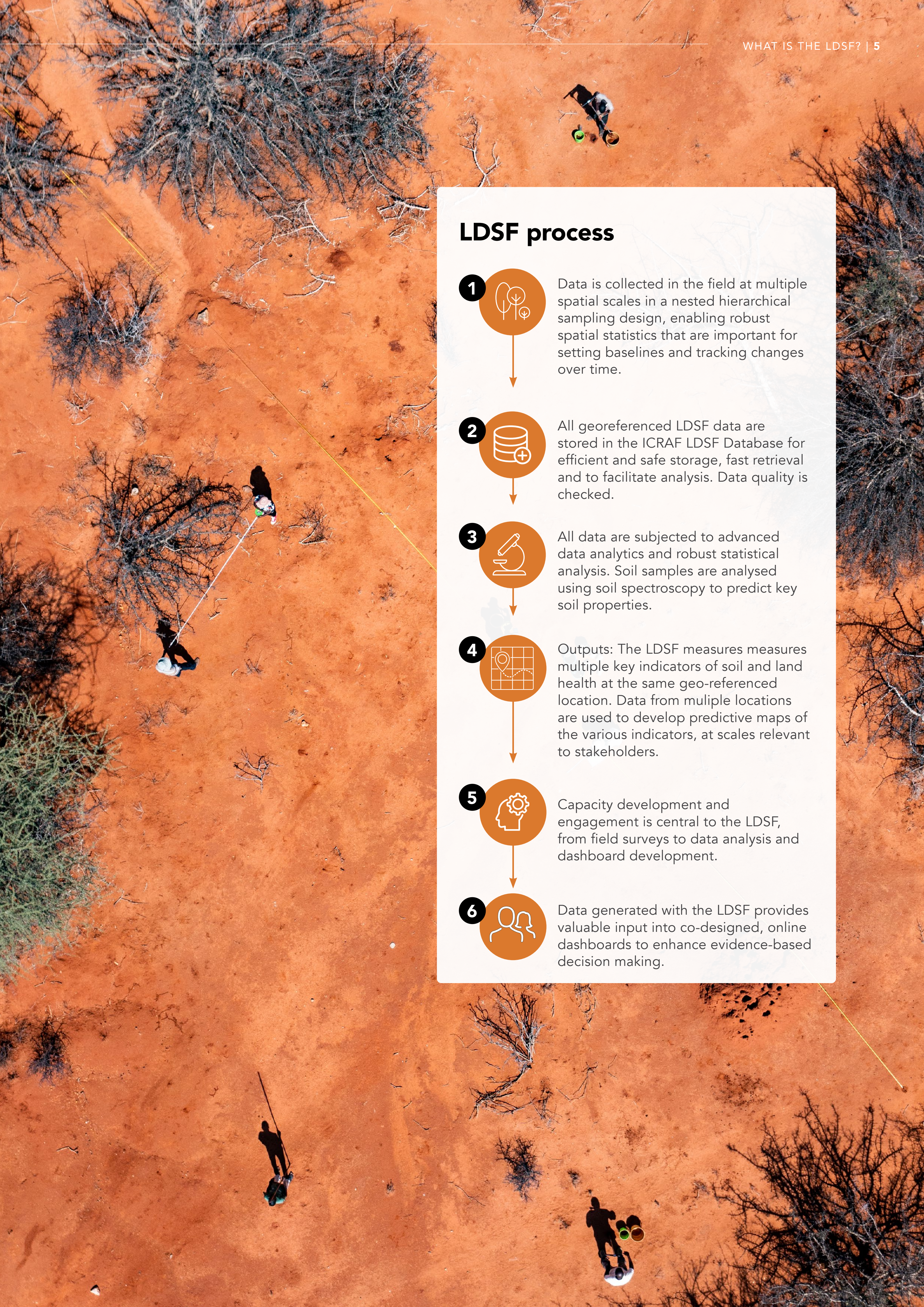


Value of the LDSF

The LDSF has been applied systematically across a wide range of ecosystems and land uses across the global tropics. It is now one of the largest geo-referenced databases of soil and land health indicators, globally.

The LDSF allows you to:

- Understand variability of ecological indicators
- Establish a biophysical baseline
- Quantify above and below ground carbon stocks
- Better understand drivers of land degradation
- Target land management interventions in landscapes and monitor
- Assess the impact of land management practices on key biophysical indicators
- Enable evidence-based decision making
- Improve crop/rangeland/climate models
- Provide evidence to decision and policy makers
- Communicate with farmers, communities, governements, donors and investors
- Implement spatial and temporal assessments and mapping of a range of soil and land health indicators
- Allows for consistent and robust tracking of interventions overtime.



LDSF process

1. Data is collected in the field at multiple spatial scales in a nested hierarchical sampling design, enabling robust spatial statistics that are important for setting baselines and tracking changes over time.

2. All georeferenced LDSF data are stored in the ICRAF LDSF Database for efficient and safe storage, fast retrieval and to facilitate analysis. Data quality is checked.

3. All data are subjected to advanced data analytics and robust statistical analysis. Soil samples are analysed using soil spectroscopy to predict key soil properties.

4. Outputs: The LDSF measures measures multiple key indicators of soil and land health at the same geo-referenced location. Data from muliple locations are used to develop predictive maps of the various indicators, at scales relevant to stakeholders.

5. Capacity development and engagement is central to the LDSF, from field surveys to data analysis and dashboard development.

6. Data generated with the LDSF provides valuable input into co-designed, online dashboards to enhance evidence-based decision making.

The LDSF sampling procedure

The LDSF is built around a hierarchical field survey and sampling protocol using **sites** that are 100 km^2 (10 x 10 km). LDSF sites may be selected at random across a region or watershed, or they may represent areas of planned activities (interventions) or special interest.

Each site is stratified into 16 (2.5 x 2.5 km) tiles. Within each tile, a 1km^2 cluster is generated. Each cluster consists of 10 sampling plots, each plot is 1000 m^2. Each plot consists of 4 sub-plots, each 100 m^2. Randomising the plots is important to minimise biases that may arise from convenience sampling. Randomisation procedures are normally implemented using customised programs or scripts, but can also be conducted in any spreadsheet program.

The LDSF uses a nested hierarchical sampling design that provides multiple perspectives needed to understand the complex nature of ecosystems. A nested hierarchical sampling design is useful for developing predictive models with global coverage, while maintaining local relevance.

By applying a multi-scale approach, the LDSF framework can be used to conduct robust statistical analysis and inference, including spatial assessments and predictive maps with a high level of accuracy. These outputs can in turn be used to improve the targeting and design of land management, including land restoration efforts, and to monitor the effectiveness of different practices in terms of meeting restoration targets and ensuring sustainability.

Each cluster is 1 km^2 and has 10 plots, each measuring 1000 m^2

4 subplots per plot, each measuring 100 m^2

In each plot, we describe and record basic plot characteristics, including:

- plot centre-point coordinates
- altitude
- slope
- landform and topographic position
- vegetation structure
- dominant land use, land ownership, etc.
- soil infiltration capacity (measured in 3 out of 10 plots per cluster)
- herbaceous and woody cover using ratings
- detailed rangeland health module (optional)

In each subplot, we:

- collect soil samples (both top- and subsoil) using an auger and record auger depth restrictions
- measure and identify at species level all trees and shrubs
- record and classify visible soil erosion
- assess herbaceous and woody cover using ratings

Preparing for the field

Proper preparation before going to the field is critical to ensure a successful field sampling campaign, and for the safety and wellbeing of the field team. Prior to any field campaign, it is recommended that you complete the following:

Have a good understanding of the area to be surveyed, including its topography, climate and vegetation characteristics, accessibility, and security situation. You can source pre-existing information about an area through maps (topographical, geological, soils and/or vegetation), satellite images and/or historical aerial photographs, long-term weather station data, government statistics, census data etc.

Undertake a **reconnaissance survey** when conducting field campaigns in new areas, in order to establish local contacts and assess arrangements.

Plan your timeframe. Ideally, a 4- to 5-person field team can complete 10 sampling plots per day; this includes completing 3 infiltration tests per cluster.

Obtain permission from the land owner(s) to sample a given area, and make sure that he/she understands what you are doing. Informing local government officers and community leaders about your activities is also a good idea.

Load coordinates of sampling locations into the GPS units before leaving for the field. If possible, load local maps into the unit to aid in navigation in the field.

Do a thorough equipment check before leaving for the field (see Appendix 1 for an equipment list). This includes making sure you have enough water to complete the infiltration tests.

Safety tips:

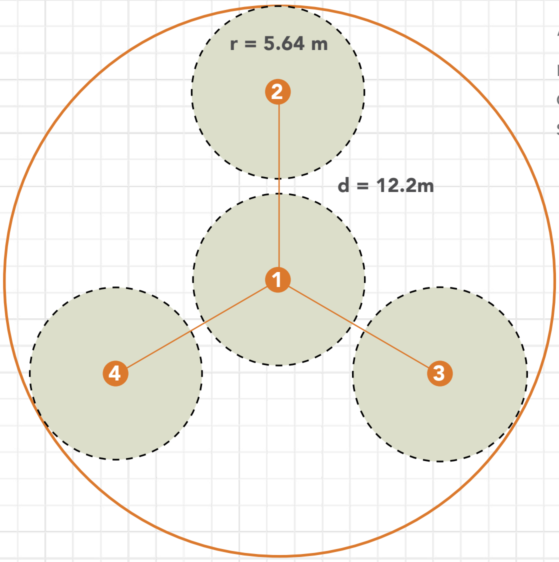
- Avoid any areas where you might be placing the field team at any risk of harm or injury. Always carry an emergency first aid kit.
- At least one member should be properly trained in first aid. Identify emergency evacuation routes and nearest hospitals in case of emergency.
- Be sure someone knows where the team will be operating. Carry a satellite phone, where necessary.


field clipboard
buckets
auger
hand shovel
measuring tape
jerrycan of water
sampling plate
clinometer
GPS unit
hammer
infiltration ring
stopwatch
ruler
block of wood

Setting up the plot

1 Radial-arm plot layout

Navigate to the center of subplot 1 using the GPS. Once you arrive, use a measuring tape to measure and mark the center of each remaining subplots: measure the distance (12.2 m) from the center of subplot 1 down-slope to the center of subplot (2) (or south if flat). Mark the centre of each subplot with buckets. Subplots 3 and 4 should be offset 120 and 240 degrees from the center of subplot 1, respectively.



'r' is the subplot radius, 'd' is the distance between subplot center-points.

The dashed circles represent 100 m^2 subplots.

1000 m^2 radial-arm plot layout

2 Electronic field data entry

In the LDSF, databases and electronic data entry are used for direct data entry in the field, though paper back-up is still advised. These systems increase efficiency and reduce potential errors in the data capture process.

Teams should upload their completed LDSF electronic forms to the server based in Nairobi, Kenya daily.

Open Data Kit
The Open Data Kit (www.opendatakit.org) software is a free and efficient method for field data collection. The form can be uploaded on smartphones or GPS units compatible with Android. An Open Data Kit application for LDSF field data entries has been developed.

Note: Data management is key to rigorous and reproducible assessments of soil and ecosystem health.

Field measurements: Plot-level

Georeferencing

Initially, georeference the centre of the plot by letting the GPS average the position for at least 5 minutes. Store this as a waypoint in the GPS, and record the **easting** (longitude), **northing** (latitude), **elevation** and **position error** on the field recording sheet.

Slope

Stand in the centre of the plot and take an **up-slope** sighting. Use a clinometer to measure the site in degrees, and then repeat the process in the **down-slope** direction. Often the downslope measurement is toward subplot 2.

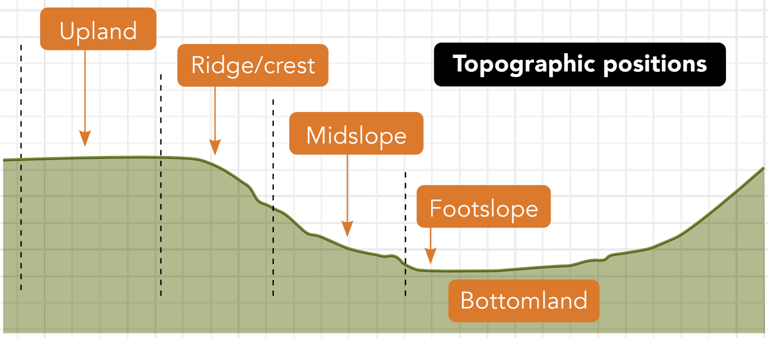
Note:

- Ensure that you sight to a location that is at the same height as the observer's eye level.
- In steep terrain (slope >25 degrees), use the following formula to calculate the distance from the centre point to the other subplots:

  slope distance = horizontal distance/cos(Slope)

Topographic position

To complete the section describing topographic position, **visually inspect the area surrounding the plot** and select the appropriate categories provided on the field recording sheet.



Land cover classification

Land cover is recorded in all plots using a simplified version of the FAO Land Cover Classification System (LCCS) (www.africover.org). Furthermore, scores are made of "impact on habitat", adapted from Royal Botanic Gardens in Kew (www.kew.org).

The LCCS further differentiates primary land cover systems on the basis of dominant vegetation life form (tree, shrub, herbaceous), vegetation cover, leaf phenology and morphology, and spatial and floristic aspects.

Note: The questions in the field recording sheet (see Appendix 2) are designed to guide you through the classification process.

Vegetation structure classification*

Type	Description
Forest	A continuous stand of trees, their crowns interlocking
Woodland	An open stand of trees with a canopy cover of 40% or more. The field layer is usually dominated by grasses.
Bushland	A mix of trees and shrubs with a canopy cover of 40% ore more
Thicket	A closed stand of bushes and climbers usually between 2 and 7 m tall
Shrubland	An open or closed stand of shrubs up to 3 m tall
Grassland	Land covered with grasses and other herbs, either without woody vegetation or with less than 10% woody cover
Wooded grassland	Land covered with grasses and other herbs, with woody vegetation covering between 10 and 40% of the ground
Cropland	Cultivated land (or land being prepared for cultivation, if sampling during the dry season) with annual or perennial crops
Mangrove	Open or closed stands of trees or bushing occurring on shores between low and high water mark
Freshwater aquatic	Herbaceous freshwater swamp and aquatic vegetation/wetland
Halophytic	Saline and brackish swamp vegetation
Distinct/restricted	Formation of distinct physiognomy (vegetative formations) but restricted distribution (e.g., bamboo, inselbergs, etc.)
Other	

Impact on habitat

This is a score of observed disturbance or impact from 0 to 3, with 0 meaning none and 3 meaning severe. The impacts are scored by category.

**Based on White (1983)*

Vegetation structure and land use categories

Using the following table, record the dominant land use for the plot. This is different to vegetation structure.

Case description	Is the plot cultivated?	Structure of the vegetation[1]	Land use[2]
Eucalyptus plantation	Yes	woodland	woodlot
Leucaena luecocoephala plantation	Yes	woodland/shrubland/bushland*	woodlot
Citrus plantation	Yes	woodland/shrubland/bushland*	perennial crop
Mango plantation	Yes	woodland/shrubland/bushland*	perennial crop
Palm tree plantation	Yes	woodland/shrubland/bushland*	perennial crop
Castor plantation	Yes	cropland	annual or perennial crop (dependent on variety)
Banana plantation	Yes	cropland	perennial crop
Grape plantation	Yes	shrubland	perennial crop
Tea plantation	Yes	shrubland	perennial crop
Cotton plantation	Yes	shrubland	perennial crop
Agricultural field where annual crops are planted and grown during the wet season, but visited during the dry season when no crops are currently present.	Yes	cropland	annual crop
Agricultural field that is fallow and has been so for more than one year	No	grassland/wooded grassland/ shrubland*	fallow
Cowpea field with no trees	Yes	cropland	annual crop
Cowpea field with scattered trees	Yes	cropland	annual agroforestry
Paddy field	Yes	cropland	annual crop
Grasses present with no trees or shrubs	No	grassland	rangeland pasture
Grassland with few trees	No	wooded grassland	rangeland pasture

Note: If a plot is cultivated, the following agricultural questions need to be considered:

Management of crops cultivated in the last 12 months

- Was crop rotation practiced in the last 12 months?
- Was intercropping practiced in the last 12 months?
- Was farmyard manure applied to any of the crops in the last 12 months?
- Was inorganic fertiliser used on any of the crops in the last 12 months?

Agricultural practices: fallowing and burning

- Is fallowing (leaving part of the land uncultivated for one or more seasons) being practiced on this plot?
- Number of years in which fallowing has been practiced on this plot
- Is burning practiced on this plot?
- How often is burning practiced on this plot?

Land ownership

Land ownership is recorded as private, communal or government.

*1. See all vegetation structures on previous page. 2. LDSF options for land use include: annual crop, perennial crop, annual agroforestry, perennial agroforestry, fallow, woodlot, protected area, pasture rangeland, natural vegetation, and other. Note: a woodlot is a tree plantation grown for timber. * Depending on presence and height of woody vegetation.*

Rangeland health

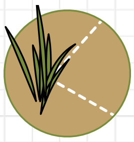
The LDSF rangeland module aims to assess the health of a rangeland and can be applied in each LDSF plot (1000 m^2) in both the dry and wet seasons.

The rangeland health assessments are conducted using the transect method. A stick/pin is placed every 2 m along two 28 m transects (one N-S and E-W). At each point the nearest annual grass, perennial grass, forb and woody vegetation is identified.

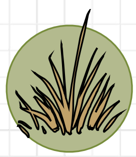
Key rangeland indicators that are measured include:

Rangelands are important ecosystems and can harbour a high biodiversity of grass species and high soil organic carbon (SOC) content. There is a real need to collect systematic data on rangeland health to assess degradation status, productivity and biodiversity measures.

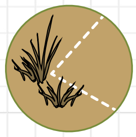
Nearest perennial grass species



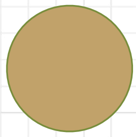
Distance to nearest perennial grass



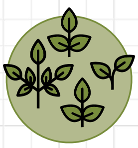
Nearest annual grass species



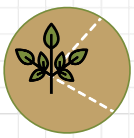
Distance to nearest annual grass



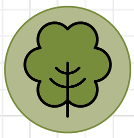
Bare ground



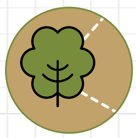
Nearest forb species



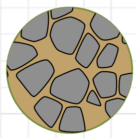
Distance to nearest forb



Nearest woody plant species (<1.5 m height)

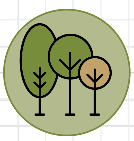


Distance to nearest woody plant

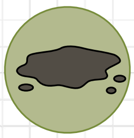


Rock cover

Prescence of leaf litter



Point under canopy



Presence of dung

Soil infiltration capacity

Soil infiltration capacity measurements are the most time consuming aspect of the field measurements, so these should be set as soon as possible. A minimum of **three infiltration measurements** should be conducted per cluster. Allocate these randomly to the different plots in the cluster. We usually recommend to use Plot 1 as the reference plot and to conduct infiltration there.

These data will be used to plot **infiltration rates of water into soil** and to calculate the saturated hydraulic conductivity. By repeating measurements across the landscape, we will be able to assess the effects of land management and vegetation types on soil hydrological properties.

Why do we use single-ring infiltration testing?

The LDSF emphasises landscape level measurements–in other words, measurements are repeated many times across large areas (landscapes). The approach is to collect a statistical sample of the landscapes being surveyed and to develop models based on these data. The single-ring infiltration test is a robust method for calculating infiltration rates. While double-ring tests may also be used, they are often too time consuming and require very large quantities of water, not allowing for repeated measurements across a landscape.

You will need:

- ☐ an infiltration ring with a 17 cm diameter and ~20 cm in height.
- ☐ a ruler
- ☐ a hammer and block of wood
- ☐ approximately 25 litres of water
- ☐ a small cup for scooping water
- ☐ a timer
- ☐ an infiltration form

How to measure infiltration

1. Place the infiltration ring at the center of subplot 1. Using the hammer, drive the ring at least 2 cm into the soil, taking care to not disturb the soil surface. Make sure that the beveled end of the ring is inserted into the ground, and that the infiltration ring is level.

2. Place and stabilise the ruler inside the ring.

3. Fill the infiltration ring with water, pouring slowly so as not to disturb the soil surface. Continue pre-wetting for 15 minutes. Ensure that the ring does not leak! If it leaks, remove the ring and place it elsewhere. If there is floating litter inside the ring, you can remove it to allow for accurate readings on the ruler.

4. To start the test, fill the ring to the the start level. The start level should be easy to read on the ruler and at the top of the ring (i.e., 16 or 17 cm). When pouring the water, be sure not to disturb the soil surface.

5. Start the timer and record the exact start level (in cm) on the infiltration form.

6. Record the end level of the water on the ruler at the end of each time interval, refilling the ring back to the start level to proceed with the test. Do not stop the timer; let the time run continuously.

Note:

- Never allow the ring to empty completely.
- Always be sure you can clearly read the end level on the ruler.
- This may mean you need to reduce the time interval if infiltration is fast (e.g., take a measurement every two minutes). Likewise, if infiltration is too slow, you may need to increase the time intervals to be able to read the drop in water level. Record these changes on the infiltration form.

Field measurements: Subplot level

Note: The complete list of site characteristics to be recorded in each subplot can be found in the field recording sheet in Appendix 2.

Soil surface characterisation

In each subplot (n= 4 per plot), percent rock/stone/gravel cover on the soil surface is recorded. Signs of visible erosion are also recorded and classified (rill, gully or sheet–as illustrated below).

Tip: Keep in mind that after an eroded field has been cultivated, it is generally difficult to determine whether the soil losses resulted from sheet or rill erosion.

Signs of erosion

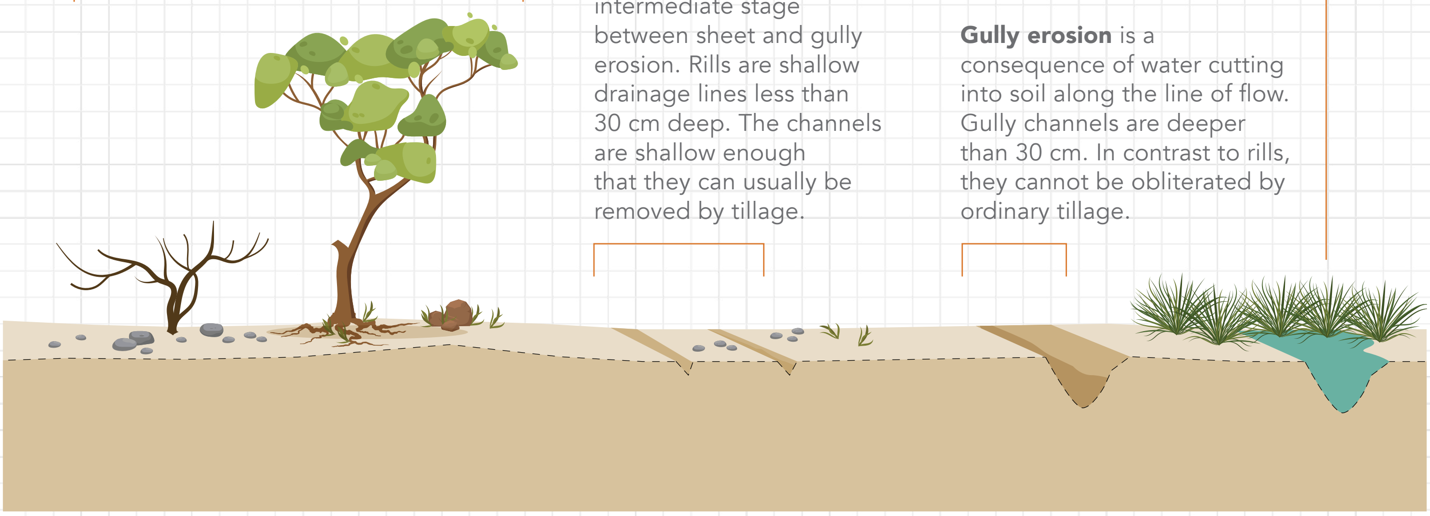
Soil-water conservation measures

- conservation tillage
- contour farming
- windbreaks
- crop rotation
- planting of cover crops
- buffer strips
- integrated pest management
- stone/earth bunds (fanya juu)
- planting pits
- grassed waterways
- dams
- contour ditches
- retention reservoirs

Sheet erosion is the uniform removal of soils in thin layers. Overgrazed and cultivated soils are most vulnerable to sheet erosion, and signs of sheet erosion include: bare areas, water puddling on the surface as soon as rain falls, visible grass roots, exposed tree roots, and exposed subsoil or stony soils.

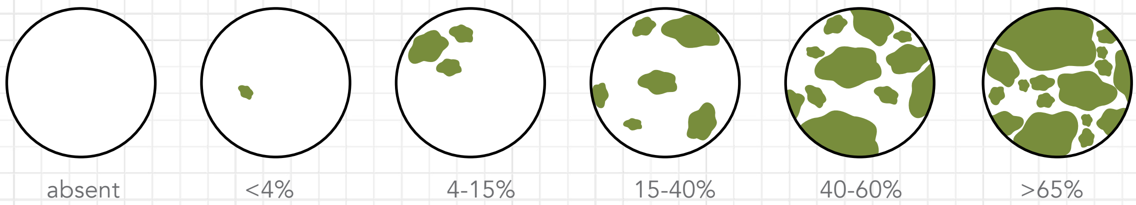
Rill erosion is the intermediate stage between sheet and gully erosion. Rills are shallow drainage lines less than 30 cm deep. The channels are shallow enough that they can usually be removed by tillage.

Gully erosion is a consequence of water cutting into soil along the line of flow. Gully channels are deeper than 30 cm. In contrast to rills, they cannot be obliterated by ordinary tillage.



Vegetation measurements

In each subplot, count each shrub and tree and enter these data in the field form. Woody and herbaceous cover ratings are made using a Braun-Blanquet (Braun-Blanquet, 1928) vegetation rating scale from 0 (bare) to 5 (>65% cover). The LDSF cover ratings are as follows:



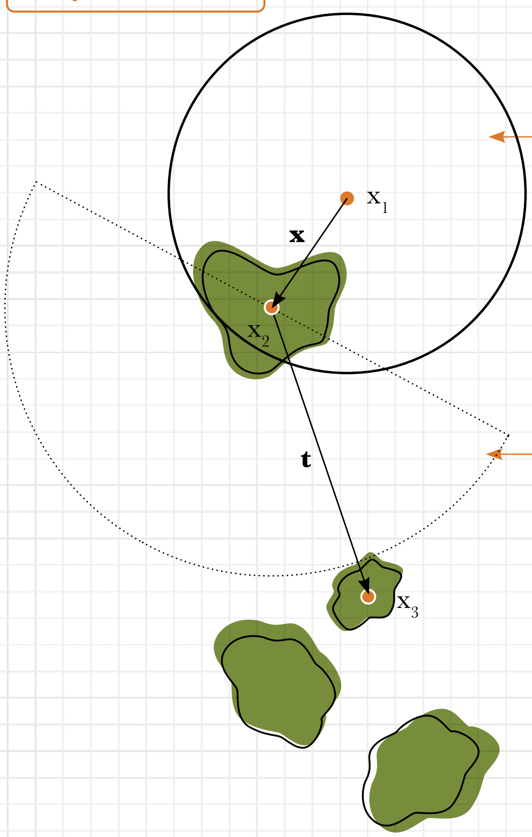
Determining vegetation distribution

To determine vegetation distribution, tree and shrub distance-based measurements are carried out using the **T-square method** (Krebs, 1989), as illustrated below. The T-square method is one of the most robust distance methods for sampling woody plant communities, particularly in forests but also in rangelands. The advantage of the T-square method over other commonly used distance methods (such as the point-centred quarter method) is that it is less prone to bias where plants are not randomly distributed.

Shrubs and trees

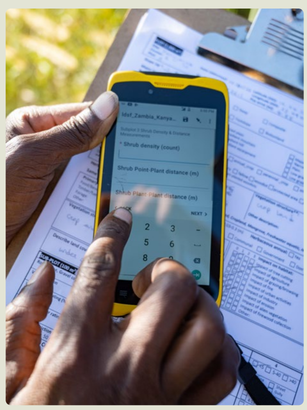
Shrubs are woody vegetation that are between 1.5 and 3 m tall. Trees are woody vegetation that are greater than 3 m tall.

T-square method



1. Standing at the center of each subplot, record the distance ‘x’ from the subplot center point (x_1) to the nearest tree or shrub (x_2). This is the point to plant distance.

2. Next, measure the distance ‘t’ to its nearest neighbouring plant (x_3). Stand at that plant with your back to the centre point and make a T with your arms; then record the distance to the nearest plant in front of your arms. This is the plant to plant distance. You will do this for trees and shrubs in each subplot. Also note that this plant can fall outside the subplot or even outside the plot.



VEGETATION MEASUREMENTS CONTINUED

Measuring biomass

For both trees and shrubs, measure the height of each individual plant using either the height pole or a clinometer.

TREES: For each tree in each subplot, measure the circumference at breast height (1.35m above ground level). Where a tree branches below this level, measure the main trunk or the diameters of all branches, and average these. For trees that are tilted, determine the 1.3 meter level from the down-slope direction and measure the diameter there.

SHRUBS: For each shrub in each subplot, measure the width and length.

Measuring biodiversity

Biodiversity of aboveground woody vegetation will be assessed. Record the species of each tree and shrub in each subplot, using the form in Appendix 2. If you do not know the scientific names of the shrubs or trees, record the common or local names. Trees and shrubs are measured separately.

Soil sampling

Two types of soil samples are collected at each plot: composite soil samples and cumulative mass soil samples.

Composite soil samples are a representative sample of the plot. Topsoil samples are collected at the center of each subplot (from 0-20 cm) and combined into one composite topsoil sample. The same is done for subsoil (20-50cm) samples.

Cumulative mass sampling is used to calculate **stocks** on a soil mass basis rather than using bulk density. The idea is to auger in 20 cm increments to 110cm, collecting ALL of the soil from each depth increment. The cumulative mass sample is collected from the **centre of the plot**. A sampling plate is used to easily capture any soil that falls out of the auger before transferring it to the bucket and to prevent collapse of the auger hole.

If you hit a restrictive layer when you are augering (known as auger depth restriction), record the depth of this restriction on the form for each subplot. If you do not have a restriction, enter 50 cm.

You will need:

- [ ] a soil auger marked at 20, 50, 80 and 110cm
- [ ] sturdy plastic or paper bags
- [ ] a mixing trowel
- [ ] a permanent marker
- [ ] labels
- [ ] buckets in different colours for topsoil and subsoil samples
- [ ] a sampling plate (for cumulative mass soil sampling only)

Labelling 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.

Cumulative mass soil sampling method

1 Press the sampling plate firmly onto the soil, so the plate is flush with the soil surface.

2 Place the auger in the centre of the hole in the plate and begin to auger straight down. Note: If the soil is very dry, it may be difficult to auger. Pre-wetting the soil before augering each increment may help.

Note: Depending on soil texture, a clay, combination or sand auger can be used, but use the same auger for the entire depth (profile). Changing augers may change the volume of the auger hole. Record auger diameter!

3 Be careful not to overfill the auger as this will distort the volume of the hole. To avoid this, empty the soil from the auger after every ~3 full turns.

4 Auger down to 20 cm, collecting ALL of the soil from the auger into the bucket. Be sure to collect any soil that has fallen onto the sampling plate.

5 Then transfer all of the soil to a clearly labelled plastic bag. The next samples to be collected are from 20-50, 50-80 and 80-110 cm.

Composite soil sampling method

1 Collect **topsoil (0-20 cm)** from the center of each subplot using an auger and put the sample in a labelled bucket.

2 Collect **subsoil (20-50 cm)** samples from the center of each subplot using an auger and put the sample in a labelled bucket. When augering the subsoil, ensure that no topsoil falls into the auger hole.

3 Pool (composite) all of the **topsoil** samples from each subplot into one bucket, and mix the soil thoroughly.

4 Pool (composite) all the **subsoil** samples from each subplot into one bucket, and mix the soil thoroughly.

5 Take a representative **~500g sub-sample of the topsoil** and place it in a labelled bag. Complete the same for the subsoil.

Note: There should be one bag of topsoil and one bag of subsoil for each plot. Auger depth restrictions are recorded (in cm) for each subplot, if they occur during sampling.

After the field

Air drying samples for analysis

After getting back from the field, the samples should be air-dried as follows:

- **Air-dry soil samples** by spreading a sample out as a thin layer into a shallow tray or by placing in shallow plastic bowls. Break up clods as far as possible to aid drying.
- **Drying** can be done in large room, a custom-made solar dryer, or a forced-air oven at 40° C.
- It is important to ensure that **no material from a sample is lost or discarded** as weights of soil fractions are to be recorded on processing. Contamination from dust, plaster or other potential contaminants should be avoided.
- **Drying time** depends on the samples and ambient conditions, but the samples should be thoroughly dry (i.e. constant weight).

Once air-dried, soil samples are either processed locally (weighed, sieved, coarse fragments weighed) or sent to ICRAF's Soil and Land Health Laboratory in Nairobi, where they are pre-processed and analysed using mid-infrared (MIR) spectroscopy to enable landscape scale analysis.

- Reference soil samples are analysed using traditional wet chemistry (pH, organic carbon, total nitrogen, base cations, etc)
- Predictions are made using the spectra
- Soil cumulative mass samples (0-20,20-50,50-80,80-110 cm) are analysed for carbon stock calculations

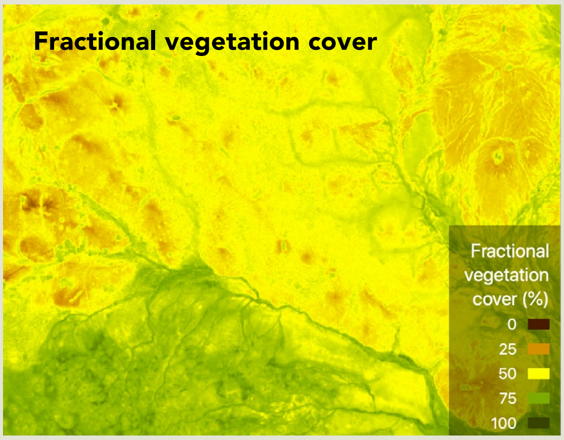
ICRAF's Soil Plant Spectral Diagnostics Laboratory leads advances in soil spectroscopy and hosts the largest systematic, georeferenced library of soil infrared spectra in the world. For more information, visit https://www.cifor-icraf.org/research/theme/soil-and-land-health/.

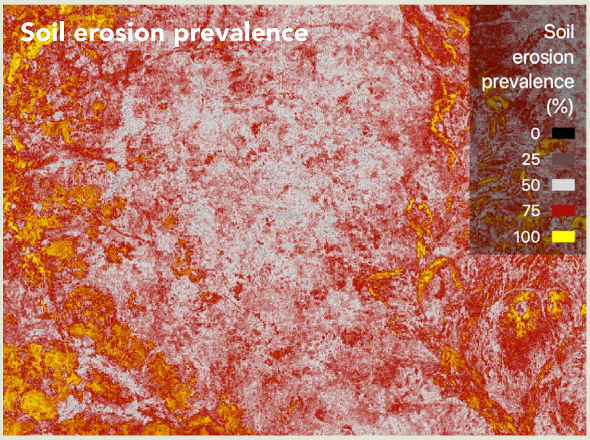
Field and laboratory data collected using the LDSF are stored in open source databases, hosted at ICRAF. All data are subjected to advanced data analytics and robust statistical analysis.

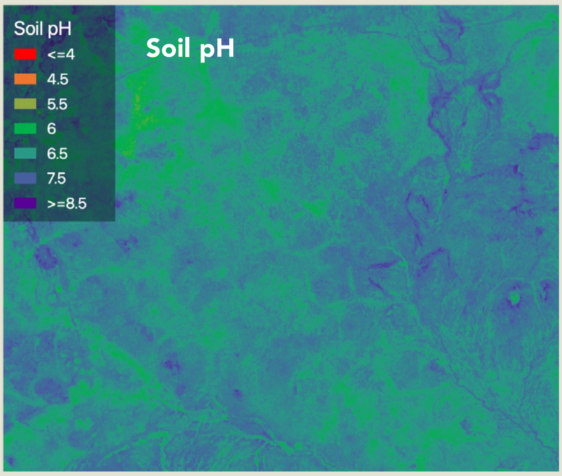
Predictive maps

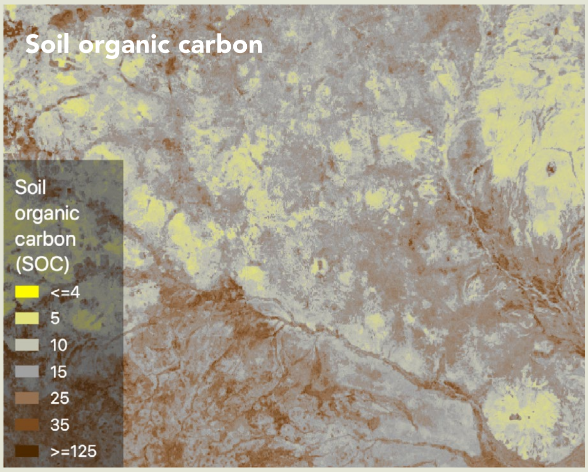
The LDSF provides on the ground evidence, generated through systematic data collection, that can form an invaluable tool for policy- and decision-makers.

Data from multiple global sites are used to create **predictive mapping** outputs at multiple spatial scales (see below), with fine-resolution maps produced at 5-10 m resolution or lower, high resolution maps at 20-30 m resolution, and moderate resolution maps at 250-500 m resolution. This enables you to zoom in to a specific area of your site and assess the possible indicators therein.









Appendix 1

LDSF field equipment check list

ITEM	QUANTITY	SOURCE	COMMENTS
Electronic equipment			
☐ Trimble TDC100, 4G (Android) (charged)	1-2		Ideally 2 GPS units in the field would be best. We use either the Trimble TDC100, 4G (Android) has proven to be quite rugged , though quite expensive.
☐ digital camera	1	There is a camera on the trimble GPS unit, so not always necessary	
Field forms			
☐ LDSF field forms (double-sided)	~180	Print	One form per plot, print 20 extra
☐ infiltration forms	~60	Print	One form for each infiltration measurement, print 12 extra
☐ field clipboard	2	Secure locally	-
☐ permanent markers	6	Secure locally	-
☐ pens	6	Secure locally	-
☐ certificates for hired labor	-	Supplied by LDSF	Template can be provided to translate into the local language.
☐ permits/introduction letters	-	-	-
Field equipment			
☐ 30 meter measuring tapes	2-3	Secure locally	-
☐ 5 meter stiff carpenter tape	2	Secure locally	-
☐ circumference tapes	3	Secure locally	Also called 'tailor tapes'
☐ clinometer (Suunto Clinometer)	1-2	-	For slope measurements and tree height measurements
☐ first aid kit	1	-	-
☐ range pole (1.5 meter each)	1	Secure locally	If not available, can be thin plastic PVC pipes to measure the shrub/tree height to ~ 4m
Infiltration			
☐ metal infiltration ring	2	Produce locally	-
☐ hammer	2	Secure locally	-
☐ stop watch or timer on phone	2	Secure locally	-
☐ ruler (30 cm)	2	Secure locally	-
☐ jerry cans of water (20L)	2	Secure locally	-
☐ umbrella	2	Secure locally	-
☐ block of wood	2	Source on site	-
☐ 20 L bucket	2	Secure locally	-
Soil sampling			
☐ combo auger (open)	2	Loan from LDSF	-
☐ coarse sand auger (closed)	1	Loan from LDSF	-
☐ cumulative soil mass sampling plate	1	Produce locally	-
☐ hand shovel	1	Secure locally	For mixing soil samples.
☐ red buckets (10L)	5	Secure locally	The exact color does not matter, just make sure you have 5 buckets of one color and 5 buckets of a different color.
☐ blue buckets (10L)	5	Secure locally	
☐ Large gunnia sacks (e.g., grain bags)	20	Secure locally	These will be used to transport and store soil samples until they reach the laboratory. Any strong, large bags will work.
☐ Soil sample bags (9*14 inch) or brown paper bags size 7	~1600	Secure locally	These are for the soil samples. All samples will be double-bagged.
☐ paper label tags	~800	Secure locally	These are paper labels to place inside soil sample bag in case marker on outside of bag rubs off.

Appendix 2

LDSF field form (plot and sub-plot)

PLOT (1,000 m²)

Site: **Date (ddmmyy):** **Latitude (DD):** **Longitude (DD):**
Cluster: **Elevation (m):** **Pos error (m):** **Country:**
Plot: **Name:**

Slope Up °: **Slope Down °:**
Major landform: ☐ Level ☐ Sloping ☐ Steep ☐ Composite
Position on topographic sequence: ☐ Upland ☐ Ridge/crest ☐ Midslope ☐ Footslope ☐ Bottomland

Landform designation:

☐ Medium gradient mountain	☐ Dissected plain	☐ Major depression
☐ Medium gradient hill	☐ High gradient mountain	☐ Narrow plateau
☐ Medium gradient escarpment	☐ High gradient hill	☐ Plain
☐ Ridges	☐ High gradient escarpment	☐ Low gradient mountain
☐ Mountainous highland	☐ Valley	☐ Low gradient hill

Plot bare > 10 months? ☐ Yes ☐ No
Plot regularly flooded? ☐ Yes ☐ No
Plot cultivated? ☐ Yes ☐ No

Dominant Land Use: ☐ annual crop ☐ perennial crop ☐ annual agroforestry ☐ perennial agroforestry ☐ fallow ☐ woodlot ☐ pasture rangeland

** Note that cultivated plots can include annual or perennial crops and even planted woodlots*

Vegetation types:

Trees	☐ Yes	☐ No
Shrubs	☐ Yes	☐ No
Graminoids	☐ Yes	☐ No
Forbs	☐ Yes	☐ No
Other	☐ Yes	☐ No

Woody leafe types:

Broadleaf:	☐ Yes	☐ No
Needle leaf:	☐ Yes	☐ No
Evergreen:	☐ Yes	☐ No
Deciduous:	☐ Yes	☐ No

Vegetation structure:**

Other description:

*** Forest, Woodland, Bushland, Thicket, Shrubland, Grassland, Wooded grassland, Cropland, Mangrove, Freshwater aquatic, Halophytic, Other*

Herbaceous height (m): ☐ 0.8-3.0 (m) ☐ 0.3-3.0 (m) ☐ 0.3-.0.8 (m) ☐ 0.03-0.3 (m) **Herbaceous annual:** ☐ Yes ☐ No
Same landuse since 1990: ☐ Yes ☐ No **Land ownership:** ☐ Private ☐ Communal ☐ Government ☐ Don't know

Primary current use:

Food/Beverage	☐ Yes	☐ No
Timber/fuelwo	☐ Yes	☐ No
Foragee	☐ Yes	☐ No
Other	☐ Yes	☐ No

Soil/water conservation measures:
Number of measures in plot:
☐ None ☐ Vegetative
☐ Structural ☐ Other

0	1	2	3	**Impact on habitat:**
☐	☐	☐	☐	Impact of tree cutting
☐	☐	☐	☐	Impact of agriculture
☐	☐	☐	☐	Impact of grazing/browsing
☐	☐	☐	☐	Impact of fire
☐	☐	☐	☐	Impact of urban activities
☐	☐	☐	☐	Impact of industry
☐	☐	☐	☐	Impact of erosion
☐	☐	☐	☐	Impact of alien vegetation
☐	☐	☐	☐	Impact of firewood collection
☐	☐	☐	☐	Other

Vegetation strata description:

Land cover/use history description:

SUB-PLOT (100 m²)

SUB-PLOT (100 m²)	1	2	3	4
Rock/stone, Gravel cover (%)	☐ <5 ☐ 5-40 ☐ >40	☐ <5 ☐ 5-40 ☐ >40	☐ <5 ☐ 5-40 ☐ >40	☐ <5 ☐ 5-40 ☐ >40
Visible erosion	☐ None ☐ Sheet ☐ Rill ☐ Gully	☐ None ☐ Sheet ☐ Rill ☐ Gully	☐ None ☐ Sheet ☐ Rill ☐ Gully	☐ None ☐ Sheet ☐ Rill ☐ Gully
Woody cover rating (%)	☐ Absent ☐ 15-40 ☐ <4 ☐ 40-65 ☐ 4-15 ☐ >65	☐ Absent ☐ 15-40 ☐ <4 ☐ 40-65 ☐ 4-15 ☐ >65	☐ Absent ☐ 15-40 ☐ <4 ☐ 40-65 ☐ 4-15 ☐ >65	☐ Absent ☐ 15-40 ☐ <4 ☐ 40-65 ☐ 4-15 ☐ >65
Herbaceous cover rating (%)	☐ Absent ☐ 15-40 ☐ <4 ☐ 40-65 ☐ 4-15 ☐ >65	☐ Absent ☐ 15-40 ☐ <4 ☐ 40-65 ☐ 4-15 ☐ >65	☐ Absent ☐ 15-40 ☐ <4 ☐ 40-65 ☐ 4-15 ☐ >65	☐ Absent ☐ 15-40 ☐ <4 ☐ 40-65 ☐ 4-15 ☐ >65
Auger depth restriction (cm) (If no restriction, write 50cm)				

Notes – indicate if a Cumulative Soil Mass sample was taken (CM = depth) or if infiltration was conducted:

TREE AND SHRUB MEASUREMENTS - SUB-PLOT ($100M^2$)

Site: **Date:**

Cluster: **Plot:**

Density and Distance Measurements of Trees and Shrubs								
Subplot	1		2		3		4	
Description	**Shrubs** Suplot 1	**Trees** Subplot 1	**Shrubs** Suplot 2	**Trees** Subplot 2	**Shrubs** Suplot 3	**Trees** Subplot 3	**Shrubs** Suplot 4	**Trees** Subplot 4
Plant density								
Point-plant distance	m	m	m	m	m	m	m	m
Plant-plant distance	m	m	m	m	m	m	m	m

Tree and Shrub Measurement in each Subplot									
Subplot		1		2		3		4	
Description		**Shrubs** Suplot 1	**Trees** Subplot 1	**Shrubs** Suplot 2	**Trees** Subplot 2	**Shrubs** Suplot 3	**Trees** Subplot 3	**Shrubs** Suplot 4	**Trees** Subplot 4
1	Height	m	m	m	m	m	m	m	m
	Length	m	cm	m	cm	m	cm	m	cm
	Width	m	circumfrence	m	circumfrence	m	circumfrence	m	circumfrence
	Species								
2	Height	m	m	m	m	m	m	m	m
	Length	m	cm	m	cm	m	cm	m	cm
	Width	m	circumfrence	m	circumfrence	m	circumfrence	m	circumfrence
	Species								
3	Height	m	m	m	m	m	m	m	m
	Length	m	cm	m	cm	m	cm	m	cm
	Width	m	circumfrence	m	circumfrence	m	circumfrence	m	circumfrence
	Species								
4	Height	m	m	m	m	m	m	m	m
	Length	m	cm	m	cm	m	cm	m	cm
	Width	m	circumfrence	m	circumfrence	m	circumfrence	m	circumfrence
	Species								
5	Height	m	m	m	m	m	m	m	m
	Length	m	cm	m	cm	m	cm	m	cm
	Width	m	circumfrence	m	circumfrence	m	circumfrence	m	circumfrence
	Species								
6	Height	m	m	m	m	m	m	m	m
	Length	m	cm	m	cm	m	cm	m	cm
	Width	m	circumfrence	m	circumfrence	m	circumfrence	m	circumfrence
	Species								
7	Height	m	m	m	m	m	m	m	m
	Length	m	cm	m	cm	m	cm	m	cm
	Width	m	circumfrence	m	circumfrence	m	circumfrence	m	circumfrence
	Species								
8	Height	m	m	m	m	m	m	m	m
	Length	m	cm	m	cm	m	cm	m	cm
	Width	m	circumfrence	m	circumfrence	m	circumfrence	m	circumfrence
	Species								
9	Height	m	m	m	m	m	m	m	m
	Length	m	cm	m	cm	m	cm	m	cm
	Width	m	circumfrence	m	circumfrence	m	circumfrence	m	circumfrence
	Species								
10	Height	m	m	m	m	m	m	m	m
	Length	m	cm	m	cm	m	cm	m	cm
	Width	m	circumfrence	m	circumfrence	m	circumfrence	m	circumfrence
	Species								
11									
12									
13									
14									

Appendix 3 LDSF infiltration form

SITE:		**PLOT:**	
CLUSTER:		**DATE:**	

Start minute	End minute	Start level (cm)	End level (cm)
00:00:00	00:05:00		
00:05:00	00:10:00		
00:10:00	00:15:00		
00:15:00	00:20:00		
00:20:00	00:25:00		
00:25:00	00:30:00		
00:30:00	00:40:00		
00:40:00	00:50:00		
00:50:00	01:00:00		
01:00:00	01:10:00		
01:10:00	01:20:00		
01:20:00	01:30:00		
01:30:00	01:50:00		
01:50:00	02:10:00		
02:10:00	02:30:00		

Let the stopwatch run continuously. Record the end level & refill to the start level at the indicated time intervals.

Distance to closest tree (m):		**Tree species:**	
Distance to closest shrub (m):		**Shrub species:**	

Appendix 4 LDSF rangeland form

LDSF Rangeland Module 2022 v6

Site:					Plot:				Enumerator Name					
Cluster:					Date:		P = Perennial grass, A = Annual grass, F = Forb, W = Woody. Distance (Dist) in cm							

Distance on tape (m)	#	Under canopy (Y/N)	Bare Ground (Y/N)	Leaf litter (Y/N)	Dung (Y/N)	Rock (Y/N	Perennial grass (P) Annual grass (A) Forb (F) Woody (W) None (N) (P,A,F, W, N)	Nearest P spp	Dist P	Nearest A spp	Dist A	Nearest F spp	Dist F	Nearest W spp	Dist W	Comments
South to North Transect																
0 m	1															
2 m	2															
4 m	3															
6 m	4															
8 m	5															
10 m	6															
12 m	7															
14 m	8															
16 m	9															
18 m	10															
20 m	11															
22 m	12															
24 m	13															
26 m	14															
28 m	15															

If the point on the tape falls directly on a grass tuft or forb, distance is 0 cm.
If distance to nearest perennial (P), annual (A) or forb (F) is more than 100 cm, simply write >100 cm and add a comment that distance is more than 100 cm.

Contact details

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Landscape Portal http://landscapeportal.org

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

Soil and Land Health Theme: https://www.cifor-icraf.org/research/theme/soil-and-land-health/

World Agroforestry