Participatory Soil Health Assessment in SUNRISE

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1. Background

This document outlines the indicators selected for the participatory soil health assessment implemented in the SUNRISE Living Labs (LLs) that identified *Soil Health* as one of their priority sub-themes. The participatory assessment complements the agroecological interview and the laboratory soil analyses, with an explicit focus on co-testing and co-evaluating the effects of management practices and innovations under real farm conditions. By actively involving farmers and other stakeholders in the assessment, the approach combines scientific soil assessment tests with learning about soil processes, strengthens motivation to improve soil management, and enables broader and more transparent monitoring.

The assessment framework is designed to capture both the baseline state of soil health (the current state) and its changes over time. Indicators were drawn from established soil testing protocols (see references in each test) and selected to provide an integrated representation of soil chemical, biological, and physical properties. The aim is to generate robust and comparable datasets across LLs while maintaining methodological consistency.

The SUNRISE LLs, that identified Soil Health as a priority sub-theme, are expected to conduct the participatory soil health assessment in:

- the parcel where the innovation/new management will be applied, prior to its implementation (including replications as outlined for each test),
- a comparable control parcel (see Chapter 3), and
- repeated again toward the end of the project (2027).

The following section presents the general information to be collected and the set of participatory health tests to be carried out. The complete assessment takes approximately 1.5 hours for each replicate. For the assessment of one farm (2 parcels including replicates), 1 full day should be scheduled. It is most efficient, timewise, to start with the infiltration test (Test 7) and continue with Soil Test 1 while the water is infiltrating, checking progress from time to time. Afterwards, the remaining tests can be carried out in the given order.

For living labs comprising more than five farms, we expect to carry out the full participatory soil health assessment on at least five farms (one parcel with agroecological innovation plus a corresponding control parcel per farm, see chapter 3) including the mentioned replicates (Chapter 2). On the remaining farms/parcels, a reduced version (Chapter 4) of the assessment can be conducted. We further expect that on each farm performing the Participatory Soil Health Assessment, the land manager is present for at least one replicate of each test. The remaining replicates may be carried out by the LL coordinator or another instructed SUNRISE team member.

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The information presented below is currently being integrated into a smartphone app to be guide through the process and to enter the data obtained. The purpose of this document is to familiarize yourself with the content and to provide feedback and/ or ask questions.

2. Conducting the Participatory Soil Health Assessment

General Information

- Parcel name (Country/LivingLab-Farm-Parcel-Replicate): _____
- Date & time & GPS coordinates: _____
- Current land use in parcel (choose one):
  Arable / Flower strip / Meadow / Pasture / Horticulture / Lawn / Urban green space / Permanent crop / Other
- Since when is the parcel used in this way?: _____
- Current crop (select all that apply):
  Vegetable / Cereal / Root crops / Leguminous / Ornamental plant / Wildflower / Tree / Shrub / Grass / Bare / Other
- Current degree of soil cover:
  0% / 20% / 40% / 60% / 80% / 100%
- Winter cover:
  Covered with plants (e.g. cultivated plants / meadow / weeds) / Mulch (incl. manure / compost / crop residues) / Bare / Other
- Management practices (select all that apply):
  tillage / no-till / strip-till / mulching / grazing / controlled traffic / mixed cropping / crop rotation / cover crops / nurse crops / agroforestry / flower strips / mineral fertilizers / organic fertilizers / synthetic pesticides / approved organic pesticides / biocontrol / herbicides / surface irrigation / drip irrigation / other
- Date of last soil tillage or other soil disturbance: _____
- Slope:
  Flat / Slope / Hollow / Hilltop
  Slope inclination (%): _____
- Known issues (select all that apply):
  Waterlogging / Compaction / Erosion / Disturbed growth / Wheel tracks / Drought stress / Rodent and mole damage / Trampling / None / Other

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Soil Tests

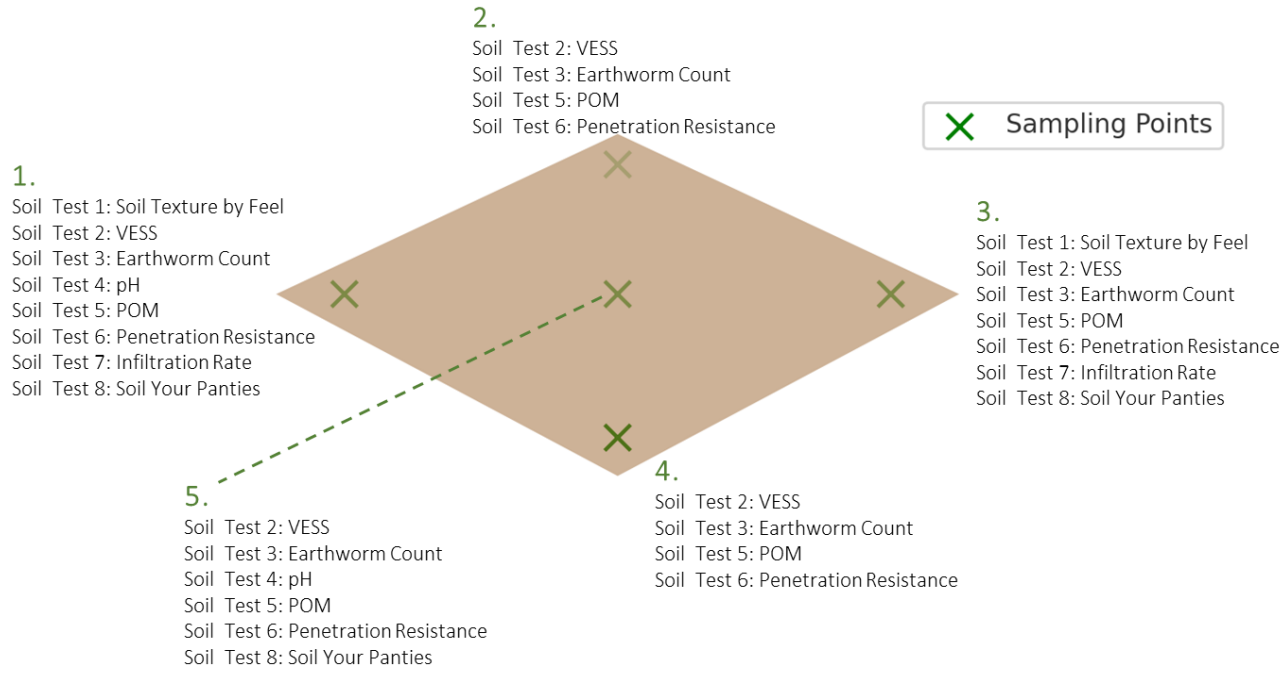

Figure 1 The five-point sampling scheme illustrated; due to repetitions, some locations require more tests than others.

Soil Test 1: Soil Texture by Feel

Purpose: to estimate soil texture (sand, silt, clay proportions) by hand, which influences many soil properties (water retention, nutrient supply, workability) and to get in first contact with the soil.

Material needs:

Provided by us: NA

Provided by land manager ***or AELL coordinator****:* digging spade, water (best in a spray bottle), tarp / bin bag /tray

Time estimated: 10 minutes

Location and repetitions: In two distant VESS spade tests per parcel (see Soil Test 2).

Step-by-step instruction:

1. Dig a hole of approximately one spade blade's depth and 20 cm on each side. It should be slightly wider than the spade. Try to keep one side of the hole as intact as possible to use it for the VESS spade test (Soil test 2). Place the excavated soil on a tarp or in a box for performing Earthworm counts (Soil Test 3).
2. Take a representative mix of the excavated soil (use a mix of soil from approximately 5- 20 cm depth, avoid the top layer with plant material, if present).
3. Perform the soil texture analysis as described in the diagram below.
   Info: "Gritty" feels like (parts) of sandpaper/ can feel individual kernels,
   "smooth" feels like wet flour or baby-powder.

Video tutorial: https://www.youtube.com/watch?v=W0osjN0t-Ho

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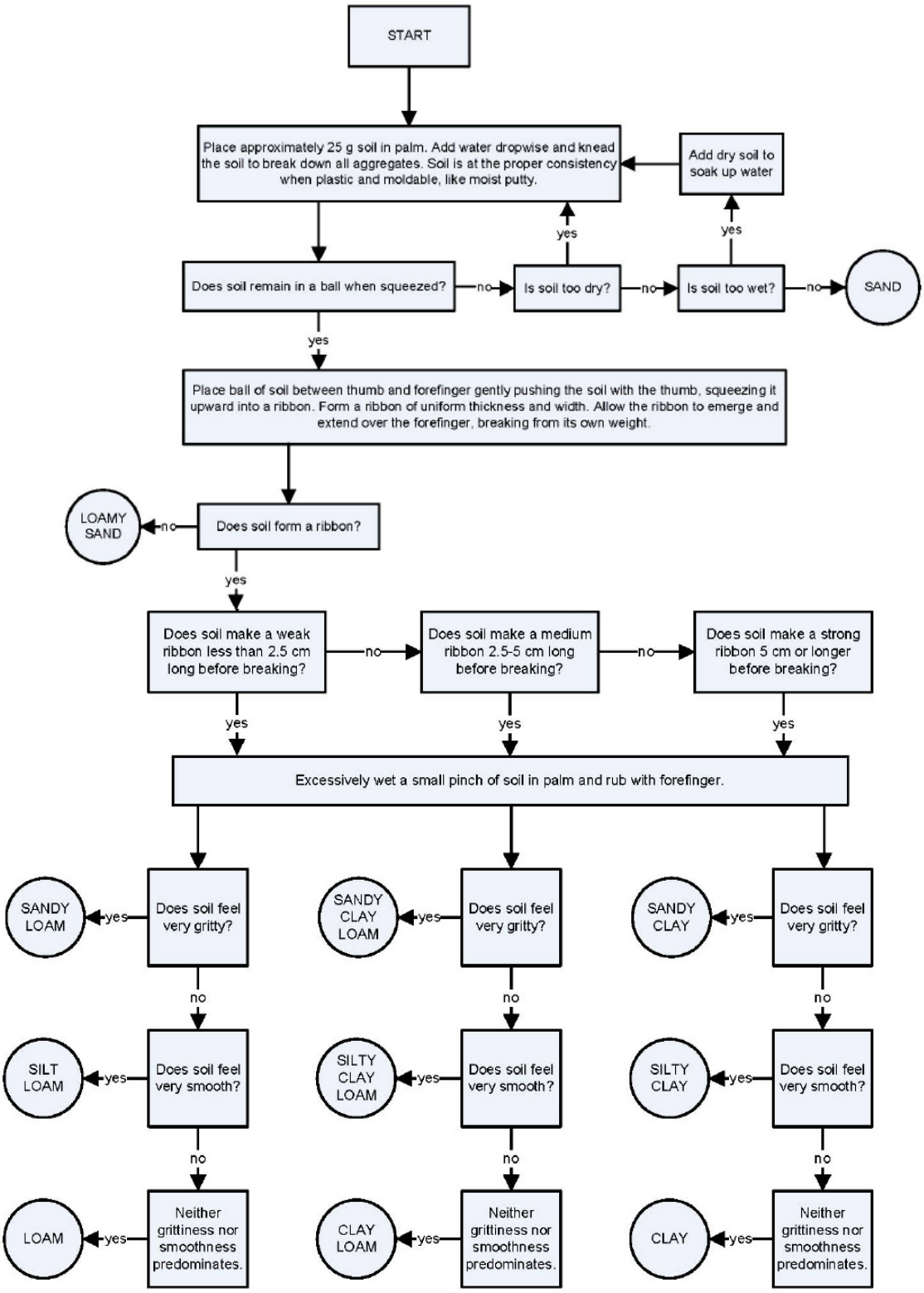

Figure 1 Soil texture by feel instruction. https://www.nrcs.usda.gov/sites/default/files/2022-11/texture-by-feel.pdf

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Form

- Current soil moisture:
  Dry / Slightly moist / Wet
- Final soil texture: sand / loamy sand / sandy loam / silty loam / loam / sandy clay loam / silty clay loam / clay loam / sandy clay / silty clay / clay

Soil Test 2: VESS (Visual Evaluation of Soil Structure)

Purpose: to assess soil structure quality, rooting conditions, and porosity by examining soil aggregates and layers, key factors affecting most soil functions.

Material needs:

Provided by us: VESS score chart

Provided by land manager or AELL coordinator: digging spade, ruler, tarp / bin bag /tray, camera (on phone)

Time estimated: 20 minutes (in the beginning it might take longer)

Location and repetitions: 5 spots per parcel. In a five-point sampling scheme (center + corners, minimum 1m from the edge of parcel)

Step-by-step instruction:

1. In case, you did the Soil Test 1, skip directly to point 2. Otherwise, dig a hole of approximately one spade blade's depth and 20 cm in length. It should be slightly wider than the spade. Try to keep one side of the hole as intact as possible to use it for the spade test. Place the excavated soil on a tarp or in a box to put it back later.
2. Excavate an intact block of soil from the intact edge of the hole as follows: Insert the spade vertically on either side of the block to be excavated (one side being the left intact edge from step 1). Alternatively, you can cut slits into the sides of the block with a knife. If the soil is sticky or heavily covered, stabilise the soil surface with your feet when pulling out the spade.
3. Then insert the spade vertically into the soil at a distance of approx.10 cm from the hole, parallel to the left-intact edge. Separate the soil tile from the remaining soil volume by pushing the spade slightly forward with your shoulder.
4. Use the spade like a lever and carefully lift the sample out of the hole. Stabilise the block with your hand, or use a second spade in front of the soil block and tip the block onto it. Place the block on a plastic tarp.
5. Open the block in the middle and push both sides by hand like opening a book to reveal undisturbed areas. Place a meter rule next to the block and take a picture.
6. Distinguish soil layers by watching out for changes in colour, soil type, structure, etc. Use your hands to separate the layers into their natural components (the aggregates, see explanation and example images) and note whether you need a lot or a little force to do so. With the form, you will be guided step by step through the description of the layers. Beware, in case you have a clayey or sandy soil (see results from Soil test 1), the possible answers change!

Video tutorial: https://www.youtube.com/watch?v=y5x6Er-L-3E **Form**

- Soil surface description:
  Aggregates intact, easily recognisable, permeable surface /
  Aggregates partially washed out, surface still rough or uneven /
  Aggregates washed out, surface sealed, silted, or compacted, less permeable /

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Closed crust, deposited sediments, compacted, very poorly permeable /

- General sample observations:
  Rocks / Bad smell / Plow pan / Undecomposed residues / Straw mat / Difficulty digging / Rust stains / Plastic pieces / None
- Number of soil layers: _____
- Depth of layers (cm): _____

Record the following values for each layer separately:

- Aggregate size (mostly): <0.6 cm / <1 cm / 1-2 cm / 2-5 cm / 5-10 cm / >10 cm / a continuous block
- Aggregate form:
  All soil types but clayey or sandy: rounded / angular to rounded / angular / sharp-edged
  Clayey soil: rounded / angular to rounded / angular or sharp-edged / Very sharp-edged with conchoidal fracture
  Sandy soil: No aggregates, only individual grains / rounded / angular to rounded / angular or sharp-edged
- Aggregate porosity:
  Porous, many pores / few pores, macropores and cracks possible / dense, no pores or only individual macropores or cracks
- Aggregate stability:
  All soil types but clayey or sandy: disintegrates easily, flaky, crumbly, unstable/ little force, stable / great force, hard
  Clayey soil: Can be crushed with little force / Can be crushed with more force, but only with the fingers / Can only be crushed with a lot of force of the whole hand
  Sandy soil: Disintegrates by itself / Some cohesion, can be crushed with very little force / Can be crushed with little force, stable
- Root description:
  Many roots, evenly distributed, finely branched / Few roots, evenly distributed / Unevenly distributed, root-free zones, stunted roots, root clustering around aggregates/ none
- VESS score (see provided VESS score chart): _____

Soil Test 3: Earthworm Count

Purpose: to measure earthworm abundance as an indicator of biological activity, organic matter turnover, and soil health.
Material needs:
Provided by us: NA
Provided by land manager or AELL coordinator: digging spade
Time estimated: 10 minutes
Location and repetitions: In each VESS spade test (otherwise: 5 spots per parcel, in a five-point sampling scheme).

Step-by-step instruction:

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- If you have already performed Soil Test 2, use the excavated soil volume of the VESS spade test (Test 2) (20 × 20 × 30 cm) that you placed on a tarp or in a box.

1. Otherwise, dig a 20 × 20 × 30 cm hole and place the soil on a plastic tarp or in a box.

- Carefully separate the soil, break up aggregates and count all earthworms. It is important to break up all soil aggregates as earthworms can hide inside. However, try not to mix the upper soil (top 20 cm) with the lower soil, as we will need the upper soil for Soil Test 5.

2. Record the total number of earthworms found.
3. Note additional observations such as burrows or faeces.

Form

- Number of earthworms in 20 x20 x30 cm soil volume: _____
- Note other observations (ducts, faeces, etc.):

Soil Test 4: pH

Purpose: To determine soil acidity or alkalinity, which affects nutrient availability and plant growth.
Material needs:
Provided by us: pH indicator liquid, pH color scale
Provided by land manager or AELL coordinator: spoon, white saucer
Time estimated: 5 minutes
Location and repetitions: In the first three VESS spade tests per parcel (otherwise: 3 spots per parcel).

Step-by-step instruction:

1. Place a small amount of soil of the top 10 cm into the round depression of the measuring plate (or saucer).
2. Cover the soil with the color indicator and mix thoroughly.
3. Wait for about 2 minutes.
4. Slightly tilt the plate so that the liquid flows into the channel / along the outer edge of the saucer.
5. Compare the color of the liquid with the printed color scale.
6. Record the corresponding pH value.

Video tutorial: https://www.youtube.com/watch?v=pHKBRuYgiok (enable auto-translation)

Form

- Final soil pH value: _____

Soil Test 5: POM (Particulate Organic Matter)

Purpose: to estimate the amount of easily decomposable organic matter, an important source of energy for soil organisms and a driver of soil fertility.
Material needs:
Provided by us: plastic bottle with 2 mm holes, 250-micron mesh bag, pre-weighed cloth, tube (e.g. cut-open plastic bottle) and rubber bands to mount cloth on.

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Provided by land manager or AELL coordinator: bucket, water (approx. 3-5 L), decanting cup (e.g., beaker with volume approx. 300-500 mL), ideally a spray bottle, one balance that is able to weigh 100 g of soil with precision of one decimal (0.1), and if available another balance that is able to weigh to a precision of 10 (0.01 g) or 1 mg (0.001)), spoon, ruler.

Time estimated: 20 minutes

Location and repetitions: In the composite soil sample taken from all 5 sampling locations. Redo the test to create one replicate.

Step-by-step instruction:

- Place the bottle with the 2 mm holes in the 250-micron mesh bag to form two "layers" of screen material through which the soil must pass. Either secure the mesh bag with a rubber band, or hold it firmly against the bottle during step 4.
- From the composite sample taken from all 5 sampling locations (see Soil Sampling Manual), weigh out 100g of soil. If possible, sieve the soil (5mm) and mix well. If the soil is not sieved, remove large stones and large pieces of organic matter (> 5mm). Use the open tube (cut plastic bottle) as funnel to add 100g (precision of one decimal) of the well-mixed soil sample to the bottle with holes. Make sure all soil enters the bottle but don't worry if a little soil already leaks through the holes and the mesh while filling in. Put on the bottle cap.

1. Holding the bottle inside the mesh, immerse and shake the bottle / mesh / soil vigorously in the bucket of water. Silt and clay particles will start to come out of the mesh bag. Take care that no soil leaves through the mouth of the bottle.
2. After approximately 3 minutes, examine the material inside the bottle. This should contain only large roots and / or stones > 2mm to continue with the next step. If soil aggregates or lumps are still present, it is necessary to break them gently by inserting a stick into the bottle or simply continue shaking the bottle in the bucket.
3. Once there are only stones and larger pieces of organic matter in the bottle, remove it from the bag and rinse the outside of the bottle with some water into the mesh bag, so that any material between 250 microns and 2 mm is kept in the bag and not lost.
4. Some soils may contain very strong aggregates of soil that will hold together in the mesh bag, even after shaking. If you notice this, you should gently massage the bag with your hand to break up these soil crumbs and free any organic matter and clays that will be then rinsed in the next step.
5. Rinse the mesh bag one more time in some clean water to make sure all clay and silt particles are removed.
6. Release the contents of the mesh bag into a beaker used as decanting cup, measuring cup, or other. Use a spray bottle to wash all material in the bag into the container.
7. Mount the pre-weighed cloth on the end of the plastic cylinder (cut-open jar or similar), using rubber bands.
8. Decant the floating POM from the decanting cup into the plastic cylinder with the cloth attached, making sure that mineral soil particles (mostly sand) stay at the bottom of the decanting cup. Refill the decanting cup with water repeatedly, shake lightly to separate less dense POM from the mineral particles and pour into the cylinder with cloth attached. Make sure to separate most of the particles that look organic (darker), but that are left at the top of the layer of mineral particles (their density is

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between the density of the mineral particles and the density of POM). It may not be possible to capture every last piece of POM and at some point you will need to call the evaluation finished.

9. Continue this decanting process until the water above the sand washed in the beaker is free of almost all particles, and nearly 100% of the POM has been captured in the cloth. When finished, rinse the sides of the plastic tube onto the cloth.
10. For a semi-quantitative assessment of the amount of POM, move all material to the center of the cloth and distribute it to form a circle of approximately 1-2mm height. Use the ruler to measure the diameter of the circle.

- If a precise balance is available, dry the cloth with POM and weigh for a quantitative assessment (up to 3 decimals) and send us the weight. If no balance is available, place the dried cloth with the POM into a sealable plastic bag and store with the soil sample collected, and send it to us.

Video tutorial: https://youtu.be/cL_nWS_xWAw

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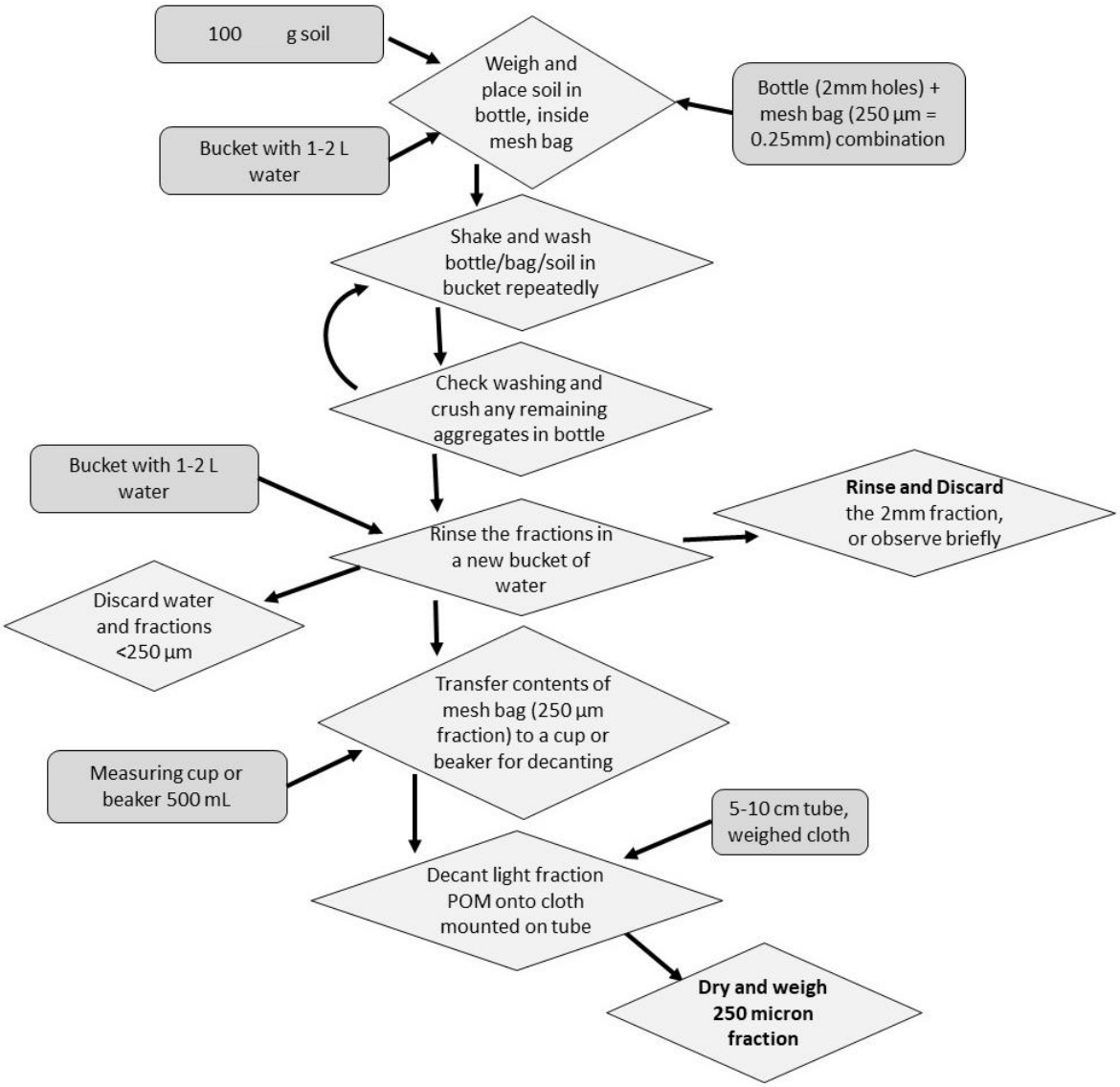

Figure 3 Flowchart for the streamlined POM method instructions.

Form

- Diameter of the POM circle: _____
- Initial (cloth weight) and final weight after drying: _____

Soil Test 6: Penetration Resistance

Purpose: to identify compacted soil layers that may restrict root growth and water infiltration.
Material needs:
Provided by us: metal rod
*Provided by land manager or **AELL coordinator**:* ruler

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Time estimated: 5 minutes
Location and repetitions: 1m away from each of the 5 VESS spade tests per parcel, otherwise: in a five-point sampling per parcel (center + corners, minimum 1m from the edge of parcel)

Step-by-step instruction:

1. Use the metal rod to probe vertically into the soil.
2. While pushing the rod down, determine changes or differences in penetration resistance. Use a ruler to measure the depth at which resistance is observed.
3. Record the depth of resistance.

Form

Note penetration resistance score:

0 – No resistance: Rod enters easily and can penetrate fully (no compaction perceived).

1 – Slight resistance: Rod enters with minor effort; continuous penetration.
2 – Moderate resistance: Noticeable effort; may hit a thin compacted layer; penetration often slows/stops around 10–20 cm.
3 – High resistance: Rod enters only with strong effort; penetration limited to ~5–10 cm.
4 – Very high resistance / refusal: Rod will not enter or bends readily at the surface.

- Depth of resistances (record several if multiple exist): _____

Soil Test 7: Infiltration Rate

Purpose: to measure how quickly water enters the soil, reflecting soil structure, compaction, and the risk of runoff or erosion.
Material needs:
Provided by us: ring (16 cm diameter) with marked lines
Provided by land manager or AELL coordinator: piece of wood, hammer, water (min. 2L), stopwatch (on phone)
Time estimated: 80 minutes, time needed can vary, depending on the soil properties.
Location and repetitions: In two distant locations per parcel (approx. 1m from VESS spade test).

Step-by-step instruction:

1. Clear a new sampling area of surface residue, etc. If the site is covered with vegetation, trim it as close to the soil surface as possible without disturbing the surface. Avoid areas with visible disturbances such as ant nests, worm casts, rodent holes, or obvious cracks, as these can bias the infiltration rate.
2. Using the hammer and block of wood, drive the ring, beveled edge down, to a depth of 7.5 cm (line marked on outside of ring) into the soil. If the soil contains rock fragments, and the ring cannot be inserted to depth, gently push the ring into the soil until it hits a rock fragment. Measure the height from the soil surface to the top of the ring in cm.
3. With the ring in place, use your finger to gently firm the soil surface only around the inside edges of the ring to prevent extra seepage. Minimize disturbance to the rest of the soil surface inside the ring.

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4. Fill the ring gently (!) to the top mark with water. Record the amount of time (in minutes) it takes for the water to reach the different lines while infiltrating the soil. Stop timing when the surface is just glistening. If the soil surface is uneven inside the ring, count the time until half of the surface is exposed and just glistening.

Video tutorial: https://www.youtube.com/watch?v=YsEYs3YfkKE / https://www.youtube.com/watch?v=3PSroyhfXDM

Form

- Time until water reached line 1: _____
- Time until water reached line 2: _____
- Time until water reached line 3: _____
- Time until water reached line 4: _____

Soil Test 8: Soil Your Undies

Purpose: to give a visual and engaging measure of soil biological activity and organic matter decomposition.
Material needs:
Provided by us: underpants
Provided by land manager ***or AELL coordinator****:* spade, something to mark location, phone to photograph
Time estimated: 10 minutes
Location and repetitions: In three distant locations per parcel (approx. 1m from VESS spade test).

Step-by-step instruction:

1. Remove the top soil layer with vegetation and put aside. Dig a hole of approximately 30cm depth and 50cm width, so that the underpants can be inserted vertically into the soil without folding the textile.
2. Attach the underwear horizontally to the edge of a hole, with the waistband protruding just above the soil surface.
3. If necessary, secure the waistband with a stone or your foot.
4. Refill the hole with soil in the same order as it was dug, start with the lower soil layer first, then place the upper soil layer on top.
5. Replace the vegetated layer (if present) on top.
6. Press everything down firmly so that the white waistband is still visible.
7. Place the marker next to the underwear.
8. After 8 weeks, carefully dig up the underwear again.
9. Compare the degree of decomposition with the reference scale.

Video tutorial: https://www.youtube.com/watch?v=Wk_L34ufHg4; https://www.youtube.com/watch?v=5W1wE7obF10

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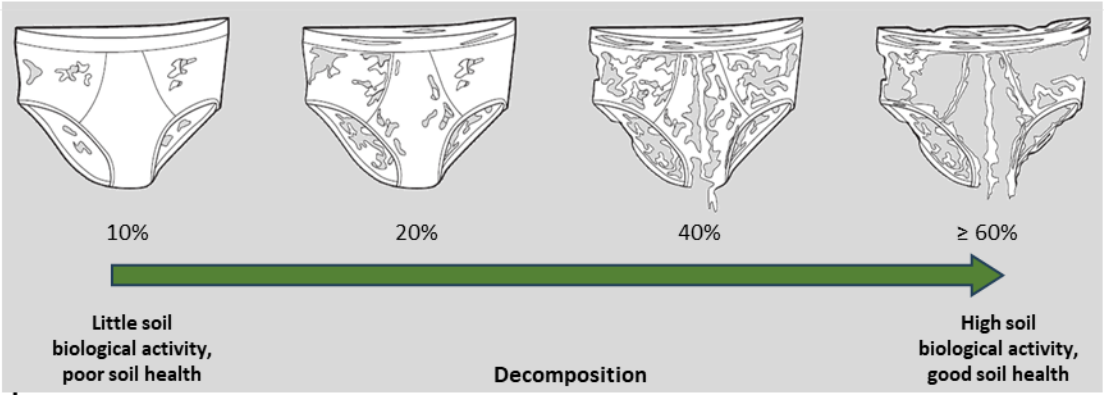

Figure 3 Degradation degree of soil underpants.

Form

- Time buried before excavation: _____
- Was the area watered?: Yes / No
- Degradation degree: 10% / 20% / 40% / 60%+ / don't know / gone

3. Control plot

Control plot sampling is an essential component of the participatory soil health assessment, as it provides a reference against which the effects of new management practices or innovations can be evaluated. For each farm, a control parcel should be selected that, ideally, follows the same management practices as the innovation parcel but without the innovation applied. If no such parcel is available, a nearby grassland may serve as a control alternative, or we can be contacted for further guidance. Each Living Lab is expected to conduct the full participatory soil health assessment on at least two parcels per farm (1 parcel with innovation, 1 control). For living labs with more than 5 participating farms, a minimum of five farms (2 parcels, each) should conduct the full soil health assessment, including the repetitions specified. On the remaining farms/parcels, a reduced version of the assessment (Chapter 4) can be applied.

4. Reduced Participatory Soil Health Assessment

In cases where more than five farms or parcels within a Living Lab have identified Soil Health as one of their priority sub-themes, a reduced version of the participatory soil health assessment can be conducted on the additional sites (parcels/farms). The reduced assessment is designed to focus more on the feasibility and the participatory nature/ the learning effect of the farmer, rather than comparability and scientific rigor, ensuring broader coverage without overburdening participants. In this version, each test is carried out once together with the farmer, providing both data collection and an opportunity for discussion and learning. If desired, and if the farmer is motivated, individual tests may be repeated up to three times to improve reliability or to capture variability within the parcel.

5. References

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