HOLISTIC RESOURCE MANAGEMENT FOR
CLIMATE RESILIENCE OF FARMING

Farm Survey (Instructions)
ClimateFarming

2022-1-DE02-KA220-VET-000090163

Provided by: Alena Holzknecht, Nils Tolle, Janos Wack
kontakt@triebwerk-landwirtschaft.de; TRIEBWERK - Regenerative Land- und Agroforstwirtschaft UG
Im Rothenbach 49, D-37290 Meißner; https://www.triebwerk-landwirtschaft.de/
Date: May 2023, Version March 2024

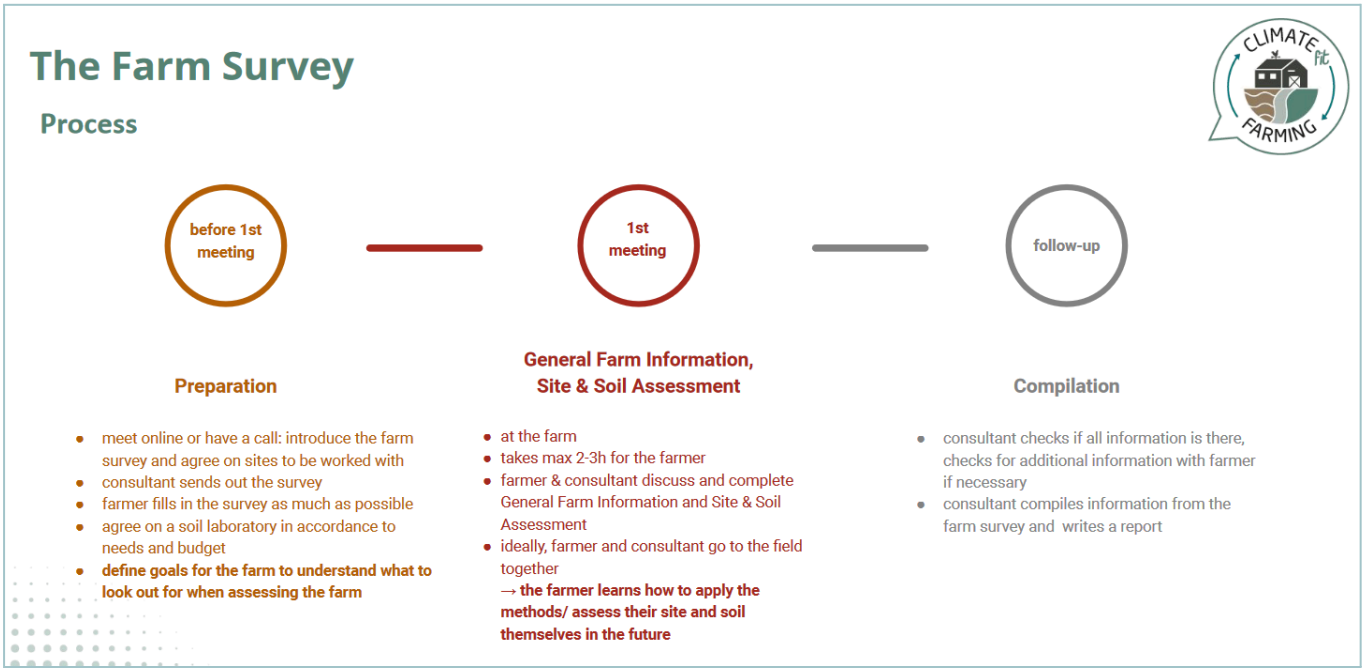
Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Co-funded by
the European Union

Contents

Co-funded by
the European Union



Some of the information may seem excessive to collect at this stage of the assessment but might become relevant in the process. You can skip parts of the survey now, and come back at a later stage when the strategy and goals become more tangible (e.g. ownership of specific fields). Some questions concern sensible farm information one might be reluctant to share with an external consultant. However, it is important to keep in mind that the consultation process will be more effective and overall successful if all involved parties have the same information level. As a guidance, you can follow the 🌱 base case scenario, if you want to collect the most necessary information only, and the ⭐ best-case scenario if you want to do a comprehensive farm analysis.

Icons

🏞️ **On-site assessment**
💻 **Internet research, (online) maps or geodata**
You will find this symbol where (online) maps can support the collection of relevant information. Such can include aerial images, erosion maps, elevation profiles, contour maps, slope and exposition maps, precipitation and temperature maps, various soil maps, geological maps, drainage plans, and protection areas, among others. Here you can find a list of helpful online map services for Germany.
🚜 **This task can be done by the farmer**
💼 **This task should be done by the consultant (or an experienced farmer)**
📷 **Please take pictures** of everything that might be interesting or helpful for interpretation of the results (e.g. color changes within a soil horizon, a lot of soil attached to roots, compacted soil layers, a root is oriented in a different direction than all the others, etc.) and to track your progress! Ideally, photos should be standardized at **1m distance** from the targeted object, e.g. from the soil surface. It could also be helpful to establish fixed photo points to monitor changes. If possible, automatically link the pictures to GPS coordinates, or save them separately. For more information check out this document: CF_Taking Photos_in progress
⏰ **Time this task**
👫 **Should be done with at least 2 persons**
🌱 **Base-case scenario**
⭐ **0 Best-case scenario**
ℹ️ **Why do we look at these indicators?**

1. General farm information

🚜🌱

Guiding questions:

- What is the total farm area?
- Which different production branches do you have on the farm?
- e.g. Feed production, Sheep herding, Market garden
- How many animals? Which cultures? etc.
- What is your farming practice?
- conventional, organic, conservation agriculture,
- Do you have any certifications?
- e.g. EU-organic, other organic, KAT, QS
- How do you market your products? What are your sales channels?
- e.g. direct marketing, own processing, regional/ interregional/ international partners, bulk purchasers from the agricultural sector, cooperatives, large-scale processers
- Which other establishments belong to the business? (e.g. affiliated restaurant)
- Are there any special geographical features?
- e.g. lee side of mountain range, viticultural climate, special bedrock
- How is the farm located regionally?
- e.g. proximity to villages/ cities, distributors, processors, storage units, etc.
- What is the main soil type and soil texture on your farm?
- Find site-specific questions below

Describe the regional climate around your farm:

- What is the main wind direction? What are peak velocities you experience?
- Precipitation (mean, min, max, per season)
- old and new long-term means, as well as personal estimations
- Do you get most of the precipitation in spring/summer/autumn/winter? Or is it equally distributed over the year?
- Temperature (mean, min, max, per season)
- old and new long-term means, as well as personal estimations
- How many days with temperatures below 0°C do you experience? When do you have temperatures below 0°C during the year? How low do temperatures go in the spring? Are there late frosts in the spring?
- Recall experienced and historic extreme weather events (strong rain, drought, etc.).
- Are there changes in weather patterns/ extreme events/ seasonal shifts in your farming area? Do you observe “new” patterns that have developed over the last year?
- e.g. earlier budding, increased pressure from invasive organisms, less rain events, higher peak temperatures
- Which of your sites are most vulnerable and how?

1.1. Farm overview

🚜 ⭐ Please fill in the area that is available on your farm for the different branches in the table, how much of it is your own property and how much is used under leasing agreements. How many different fields do you have per branch and what are their particularities?

Please state all crop rotations and their approximate output on the farm to get an overview. Specific information on the crop rotations for the concerned site(s) that you want to work with can be stated in the Site Assessment below.

- If you have livestock, please state species, amount, husbandry system, and what the outputs are. How do you source the animal feed?
- e.g. buying feed pellets, grazing your own/ rented land, buying/ making your own silage
- If you graze your animals, can you describe your grazing system?

1.2. Ownership structure and decision making

🚜 🌱 Guiding questions:

- Who are the legal owner(s) of the farmed areas?
- Are there existing lease agreements? What is the duration of such? What is the relation with the owner(s)?
- Are there past or upcoming generation changes/ farm transfers (on both owned and leased land)?
- Do you have partnerships, dependencies or other involved parties that necessitate inclusion in decision making?

1.3. Workforce, facilities and machinery

🚜 🌱 Guiding questions:

- How many people work in each production branch? (Indicate overlaps)
- What is the training and education of farm staff?
- Which special knowledge and skills are available from farm staff?
- Is additional workforce available if needed for workload peaks?
- Which facilities do you have at your disposal?
- differentiate between on-farm and contractors
- Which machinery do you have at your disposal? List your vehicles with their operating widths.
- differentiate between on-farm and contractors
- Do you use agricultural contractors, and if so which?

1.4. Economic background

🚜 🌱 Guiding questions:

- How would you describe the economic situation of your farm (e.g. stable, insecure, potential to grow, need to consolidate, etc.)?
- What is the average farm investment sum in a five-year period?
- Are there any major expenditures planned or necessary (e.g. replacement of machinery)?

- How is the relative contribution of the different production branches to the farm income (e.g. crop production: 70% + pig production: 30%)?

1.5. Climate change measures

🚜 ⭐ Guiding questions:

- Is a farm climate balance (carbon footprint) available? If not, is it planned to do one?
- Are measures implemented or planned which aim at improving the farm climate balance (mitigation; e.g. increasing soil organic carbon)?
- Are measures implemented or planned which aim at adapting the farm to climatic changes (adaptation; e.g. irrigation, undersowing, agroforestry)?

1.6. Formulation of goals and priorities

🚜 What is important to you as a farmer? What is the motivation behind your work? Which topics would you like to develop further on? Formulate your goals and try to order them according to your priorities.

2. Site Assessments

This part of the questionnaire concerns the site(s) on your farm that you would like to assess in more detail. Please copy this section in the documentation form and fill it out separately if you are assessing more than one site.

2.1. General information

🚜 💻
🌱 Guiding questions:

- Note the name, lot number, location, GPS coordinates, and area of this site.
- Who is/ are the current land manager(s) and what is the current land use and vegetation or crops?

- How far away is the concerned site from the main production building?
- Which means of transport do you use to get there?
- How long does it take to get there?
- How relevant is the concerned site within the farm? Is it a formerly merged site, high-yield site, etc.?
- How often is management and/or observation necessary/ reasonable?
- Why did you choose this site for new measures?

💼 🏞️ 🌱 Continue by checking the field for heterogeneity:

- Are there relevant differences within the field?
- e.g. in terms of weeds, harvest, soil quality, soil depth, water logging, compaction
- If so, **divide the field into different zones** according to these differences.
- Visualize zones on a map, note the respective GPS coordinates and possibly measure dimensions. Note what characterizes each zone and give them IDs.

💼 🏞️ 🌱 Continue with the assessment of the total area; or if zonation, then every zone respectively. Depending on the geometry of the field, chose according locations for soil sampling

- Walk through the field in an N or X-shape and sample in 4-5 locations
- Borders and irregular areas within the zone should be avoided

The goal for all methods is to get a **representative impression** of the respective zone/ area, but keep it pragmatic and don't divide it into too many subareas.

2.2. Management history

💼 💻 🌱

Tip: Use for example Google Earth (web application), or Google Earth Pro (desktop application with more functions) to determine e.g. cultivation borders, which can be seen especially well on winter imagery after seeding. Look at different seasons over several years to get a good impression of the conditions.

Guiding questions:

- How long have you been the farm manager? Do you know the previous farm manager/ have information on their management practices?

- What has been grown in the last 5-10 years?
- Have there been additions of fertilizers/ pesticides/ herbicides/ manure/ compost/ etc.? Which approximate amounts?
- e.g. fertilizers: pig slurry, farmyard manure, NPK fertilizer
- e.g. other amendments: soil improvers, biotite, liming
- Did you leave crop residues on the field?
- What was the tillage regime (frequency, depth)?
- Which machinery has been used on the site? Has work been done with heavy machinery?
- Have there been any other noteworthy management practices?
- e.g. soil cultivation/ harvesting under unfavorable conditions

2.3. Protection status

💼💻🌱

- Are any of the fields or nearby areas under special protection?
- E.g. Water protection area, Birds Directive, Habitats Directive
- How does the protection status influence your farming decisions?

2.4. Climate/weather

💼💻

Describe the climate **specifically on the concerned site**. If it does not differ from what was noted in 1. General farm information, you can omit this step.

🌱 Guiding questions:

- What is the main wind direction? What are peak velocities you experience?
- Precipitation (average, min, max, per season)
- old and new long-term averages, as well as personal estimations
- Temperature (average, min, max, per season)
- old and new long-term averages, as well as personal estimations
- Recall experienced and historic extreme weather events (strong rain, drought, etc.).
- Which of your sites are most vulnerable and how?

2.5. Topography & Terrain

💼🏞️/💻

🌱 Guiding questions:

- What is the altitude of the site (min-max)? Is there a lot of elevation change/ are there steep slopes?
- Where do you get the most sunlight/ shade/ rain?
- Which areas are prone to surface runoff or water erosion? Are there wide open areas that are exposed to high wind velocities?

⭐ Outline the terrain/ topography in min. 2 directions (e.g. N-S and E-W) on Google Earth Pro (free Desktop app) or GIS services.

2.6. Landscape elements, compaction, drainage & surrounding vegetation

💼🏞️/💻

🌱 Guiding questions:
- Do you have areas/ zones in your field where puddles form easily after rain? How long does the water take to infiltrate?
- Are there any especially compacted areas in your fields? What causes the compaction?
- Do you have drainage systems in place? Which? Where?
- What is the regular water table on the site?

🌱 Describe shortly if / where you can find such elements on your fields:
- Trees, shrubs and other perennials
- Wetland areas or ponds
- Depressions, hills
- Power lines
- Underground cables, pipes, power lines

⭐ Guiding questions:
- What is the usual time of budding of surrounding vegetation?
- compare with phenological calendar (e.g. flowering of forsythia), especially interesting over the course of several years
- What is the species composition on the site?
- Which plant communities do you find in the area?
- What is the growth rate of local plants (especially shrubs/ bushes/ trees)?
- What is the yield of local plants? How regular is it?
- (e.g. irregular yield of walnuts might indicate critically late frosts)

2.7. Existing cultures

💼🏞️/💻
🌱 Guiding questions:
- Do you have an existing field journal of cultures and activities on the field?

🌱 Guiding questions:
- Describe the following elements on the concerned area:
  -
  - Are you struggling with diseases or pests?
  - Are there root or harvest residues left on the field?
  - What is the height of your culture? Is it uniform?
  - How high is/ was your yield?
  - Do/ did you observe any deficiency or excess symptoms on the culture?

⭐ Guiding questions:
- Identify the phenological development stages of your culture using the BBCH scale.
- For grasses: What are the tillering rates?
- Use a refractometer to measure the Brix level (=sugar content; indicator for crop quality) of the leafsap.
- Get micro- and macronutrients of leafsap checked.
- or check in the field with e.g. Yara-N-Sensor, HORIBA plant sap device

- Do you observe indicator plants indicating:
  - Nitrogen
  - Water
  - Compaction
  - Salt

  → You can e.g. use the Ellenberg indicator values, that can be found for various regions in Europe, for orientation
  (e.g. http://botanik.mettre.de/alpha_liste.shtml (German))

2.8. Issues & Optimisation

💼🏞️💻
🌱 Are there problems or optimisation needs currently, or have been in the past concerning e.g.:

- Microclimate: e.g. solar radiation/ shade, wind
- Weeds, pests
- Yields
- Erosion: water or wind
- Water balance/ management: Is there too much or too little water? Is it raining at the "wrong" time? Can all the water infiltrate or does it run off? Do you employ measures to keep water in the landscape?
- Biodiversity: Is your farming area genetically diverse? How many species grow on your fields? Are annual or perennial plants dominant? Are animals part of your rotation? Is the surrounding landscape heterogeneous and diverse (e.g. different trees/ forests, bushes, water areas, buffer stripes, wildlife habitat zones)?
- Wildlife: Do you experience game pressure? Are your fields located in proximity to a forest? Do you observe many (beneficial) insects?
- Others: Are there any other issues or optimisation potentials that have not been listed above? Please describe.

3. Soil Assessment

In the soil assessment we will collect information about the state of the soil before interventions, and regularly afterwards.

Timing: The ideal time to do the in-field assessment is in autumn or spring, at least two days after the last rain (depending on the quantity). More importantly, the sampling should be consistent, and always be repeated under similar conditions, ideally by the same person. If one year, you sample after harvest and before sowing, keep doing so in the next years (or at least document what activities have been carried out previously).
Don't assess during frost, in very wet or very dry conditions, as this will influence the results of soil health indicators. Wait for 6-8 weeks after tillage or slurry application to get unadulterated data. Record any information that may help to remember the sampling or interpret the results later on.

Frequency: Some soil tests like earthworm counts, spade analyses or infiltration tests can be carried out several times a year, to see the development e.g. at the beginning and end of the vegetation period or to get a feeling of the impact of certain interventions.

Depth: For some assessments below (like the Extended Spade Analysis), specific sampling depths are given. If you are specifically sampling for soil organic matter/ carbon analysis, sampling at greater depths e.g. 0-15 cm, 15-30 cm, >30 cm is advisable. Check which specifications for sampling (depth, sampling frequency and distribution, separate or aggregated samples) are required, for example by your chosen soil laboratory and/ or carbon credit scheme.

You can choose between two scenarios: If you have little time and want to make a basic soil assessment, please follow the 🌱 base case scenario, which includes a analyses of surface, aggregate structure, water stability, and roots. If you want an in-depth field assessment with added indicators for a more thorough understanding of the state of the soil, please first follow the base case scenario and then proceed to the ⭐ best-case scenario. It includes counting earthworms, a lime test, infiltration measurements, and noting some more soil characteristics.

For comparison you could also perform one test in an undisturbed area, e.g. a grass strip next to the field. This can be comparable to "natural conditions" and may help to understand the site-specific soil development under undisturbed, permanently vegetated conditions.

⏰ Please time how long it takes you to assess every method and one zone/ field. It is interesting for both the farmer and the advisor to know the amount of time needed.

👫 You should be **two persons** to carry out the soil assessment.

3.1. Visual Soil Assessment and Extended Spade Test (according to Beste 2003 and Junge)

💼 🏞️ 🌱 This is a standardized in-field soil assessment that allows us to calculate an overall soil score at the end.

ℹ️ Aggregate stability is a major indicator for soil health. Soil minerals stick together with organic materials like fungi, bacterial cells, roots and their exudates, to form small and large aggregates. A well-aggregated soil will enable healthy root growth, water infiltration, and soil aeration, and decrease the chances of soil erosion, among others. Aggregation is also the most important process

in soil organic carbon stabilization, as it protects organic matter from biodegradation. Disturbances like tillage and heavy machinery, and bare soil (and thus erosion) decrease aggregation.

ℹ️ Roots supply plants with water, nutrients and oxygen. They stabilize the soil against erosion and compaction, are a primary material for the formation of humus and habitat for many soil organisms. Root exudates stimulate microbial growth and are important carbon inputs to the soil. Root-fungi symbioses are important for nutrient acquisition. The space close to the roots is called the rhizosphere.

Required material: spade, soil probe, hydrochloric acid, tweezers, 3 ice cube trays, distilled water, stopwatch, camera, cardboard, sieves 3 mm and 5 mm

3.1.1. Surface analysis, organic matter, root and harvest residues

🏞️ Describe what the surface looks like:
Do you see pores, crumbs, aggregates, algae, organic residues, crusting, cracks, etc.? Is the surface dry/ wet/ do you see surface ponding? Do you see signs of erosion (rills/ gullies/ sheet erosion)?

Horizon	Description	Score
Surface (0-1 cm)	rough surface, single aggregates are visible, not platy, worm castings, no slaking, no crusting	100
	transition	75
	aggregates are slaked, platy, no/ little worm castings, initiating crusting (cracks)	50
	transition	25
	platy aggregates, crusts, cracks, slaking, sealing	0

ℹ️ Soil organic matter is material like microbial, plant and animal residues that is alive and in various stages of decomposition. It is an important indicator for soil health as it feeds microbial activity, influences soil physical and chemical properties and all soil ecosystem services like carbon and nutrient cycling, infiltration, and water holding capacity.

🏞️ Do you find any organic materials or residues on the soil surface? Describe which & how much.

3.1.2. Soil sampling

🏞️ Sample a soil block of about 30 cm depth with a spade. Mark at 15 cm depth, as we will analyze the block from 0-15 cm and 15-30 cm separately.
📷 Take a picture of the sample.

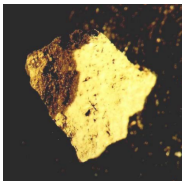
3.1.3. Soil structure assessment

🏞️

Term	Diameter	Surface	Shape	Emergence
fine crumb	few millimetres	rough surface	round	mainly biologically built structure
polyhedron	few millimetres	smooth surface	angular	swelling-shrinking cycles, mechanical cultivation
fragments	**general term for aggregates in centimeter and decimetre range**			
large crumbs	=< 5 cm	rough, round edges, fracture surface rough	round	built up structure
clumps	> 5 cm	rough or	rather round,	swelling-shrinking

(also called clods)		smooth	very compact	cycles, mechanical cultivation

Polyhedron:
smooth surface, no pores



Sub-polyhedron:
smooth surface, few pores

Fine crumb:
rough surface, lots of pores

Horizon	Description	Score
Topsoil (0-15 cm)	more than 80% fine crumbly structure, at high clay content also small polyhedra, loose, few crumbs	100
	transition	75
	(after slight pressure disintegration in) mixed structure of differently sized aggregates, small polyhedra and single particles, disintegrates easily with low pressure	50
	transition	25
	dominated by large crumbs and sharp-edged fragments or clumps with smooth surface or unaggregated structure, only a few crumbs	0

Horizon	Description	Score
Subsoil (>15-30 cm)	(after slight pressure disintegration in) mixed structure of differently sized aggregates, small polyhedra and single particles	100
	transition	75
	Large crumbs and dense, large fragments/ clumps, with partially smooth surfaces, disintegrate with low pressure	50
	transition	25
	more than 80% sharp-edged fragments/ clumps, larger and distinctively smooth surfaces, coherent structure	0

3.1.4. Root assessment

📷 Detailed pictures are especially interesting for documentation/ evaluation over several years and consultation.

Horizon	Description	Score
Topsoil (0-15 cm)	high root penetration, many roots and fine roots, strongly branched, evenly distributed and glued together with small soil aggregates (large contact area between roots and soil)	100
	transition	75
	moderate root penetration, few fine roots, slightly branched, partially in irregular tufts, growing in coarse pores of larger fragments and large crumbs	50
	transition	25
	very irregular root growth, tufts and partly horizontal root felts, growth mainly in large pores through (or on the surface of) larger, angular fragments and large crumbs	0

Horizon	Description	Score
Subsoil (>15 - 30 cm)	high root penetration, many roots and fine roots, strongly branched, evenly distributed and glued together with small and large soil aggregates (large contact area between roots and soil)	100
	transition	75
	moderate root penetration, few roots and fine roots, poorly branched, partially: several roots grow in parallel in coarse pores through (or on the surface of) larger angular fragments and large crumbs	50
	transition	25
	very irregular root growth in tufts, partially: several roots grow in parallel in large pores through (or on the surface of) larger angular fragments and crumbs, partially horizontally kinked and flattened	0

3.1.5. Aggregate sampling

Sample aggregates from different locations in the soil block 0-15 cm and >15-30 cm. Aim at getting a representative sample. Sieve the aggregates, first through a 5 mm- sieve and then through a 2 mm- sieve to obtain aggregates of size 2-5mm. Count 45 aggregates from both soil blocks respectively. If you are short on time in the field, you can store the sieved aggregates in a small jar or closable test tube and continue with the aggregate stability test later (but the aggregates should still be field fresh).

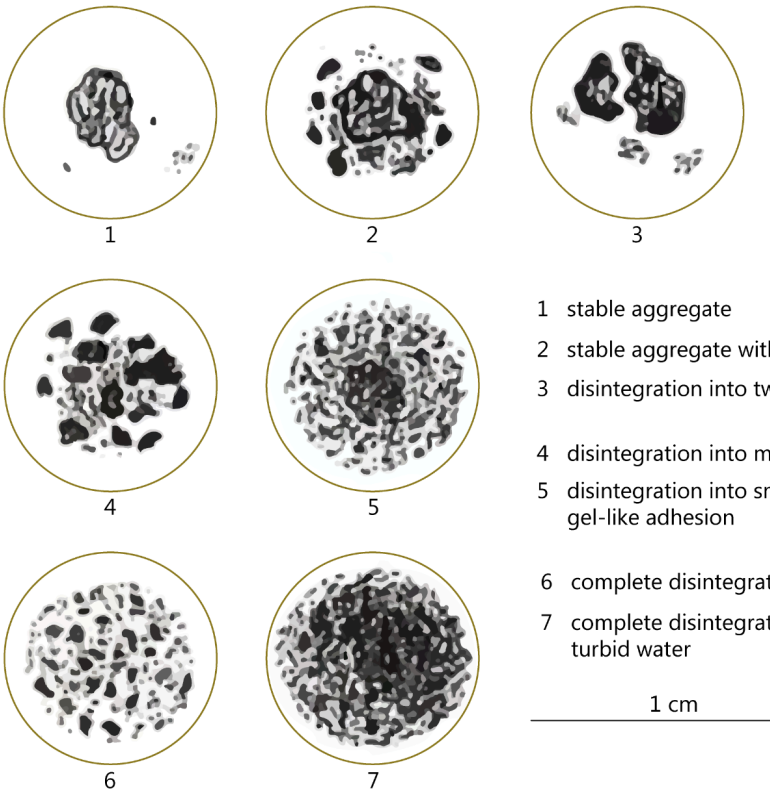
3.1.6. Aggregate stability test / Slaking test

Distribute the aggregates in the ice cube trays: two aggregates per small compartment. Carefully pour deionized water in the trays, wait for *one minute* and then tap the individual compartments repeatedly. Did the aggregates disperse? Check the figure below to score the slaking of the aggregates.

3.1.7. Calculation of the Assessment score

$$Soil\ structure\ index\ = \left(\frac{soil\ score_{topsoil} \times aggregate\ stability_{topsoil}}{2}\right) + \left(\frac{soil\ score_{subsoil} \times aggregate\ stability_{subsoil}}{2}\right)$$

→ Score: 0 – 100 points for topsoil and subsoil together. However, it is important to also look at the results from topsoil and subsoil separately. They might develop differently, or there may be a specific problem in one horizon, which is not represented in the total score.



3.2. Root indicators:

💼🏞️🌱

Root tips: Are no/ few/ many/ all root tips white?
ℹ️ Root tips are especially important for water, oxygen and nutrient uptake and thus are essential for sound plant growth. Active and healthy root tips are white.

Soil attached to roots: Is there no/ little/ moderately/ a lot of soil attached to the roots?
ℹ️ Root exudates are substances that are secreted from living and active plant roots and are one of the major driving force for interactions between plants and microorganisms in the soil. The more exudates, the more soil is attached to the roots, even when shaking strongly.

Smell: Smell the roots. Do you smell anything distinct? Is it a foul or putrid, fungal or pleasant smell?

Root nodules on legumes: Do you see nodules (little bulbs) on the roots? How many? What is their colour? Actively N-fixing nodules are reddish/pink inside, indicating that the bacteria are alive and active. Dead or inactive nodules are greyish green or brown inside.
ℹ️ Roots of legumes (and a few other plants like alder) form small bulbs, called nodules, that are in a symbiotic relationship with nitrogen-fixing bacteria, called rhizobia (or frankia in the case of alder). Rhizobia (or frankia) bacteria convert atmospheric nitrogen to plant-available forms of nitrogen. In exchange, the plant root supplies sugars to the rhizobia (or frankia).

Root orientation: Are all roots oriented in the same direction? Do you see one or a few roots that are growing in a different direction? Is there a visible obstacle (mechanical/ chemical) they avoid?
ℹ️ Roots grow in response to resource availability and constraints like compaction. Thus, limitations in the soil can often be recognized looking at root orientation and depth.

Root depth: How deep are most of the roots reaching? How deep are the very deepest roots reaching? Do you see a layer/ area that is prohibiting root growth? E.g. compaction, water logging, rocks.

Mycorrhizae: Do you see mycorrhizae? How much?
ℹ️ Mycorrhizae are symbiotic associations between plant roots and fungi that play an important role in plant nutrition. The plant root supplies sugars to the fungus which in return acquires nutrients and water for plant uptake by exploiting a larger soil volume than the plant roots alone.

🌱 **If you are doing the base case scenario, you have finished the Soil Assessment and can proceed to 3.7. Soil sampling.**

⭐ **For best-case scenario, continue:**

3.3. Soil texture

💼🏞️⭐ Use the flow diagram “Determine Soil Texture by the Feel Method” (= Soil Ribbon Test) at the end of this document.

3.4. Other soil indicators

💼🏞️⭐

Carbonate testing with Hydrochloric acid: Add hydrochloric acid dropwise to different depths on the spade sample.
ℹ️ If you see foaming or bubbling, there is are carbonates in your soil, which usually means that the soil is well buffered against acidification and thus the pH is naturally higher than in soils without carbonates.

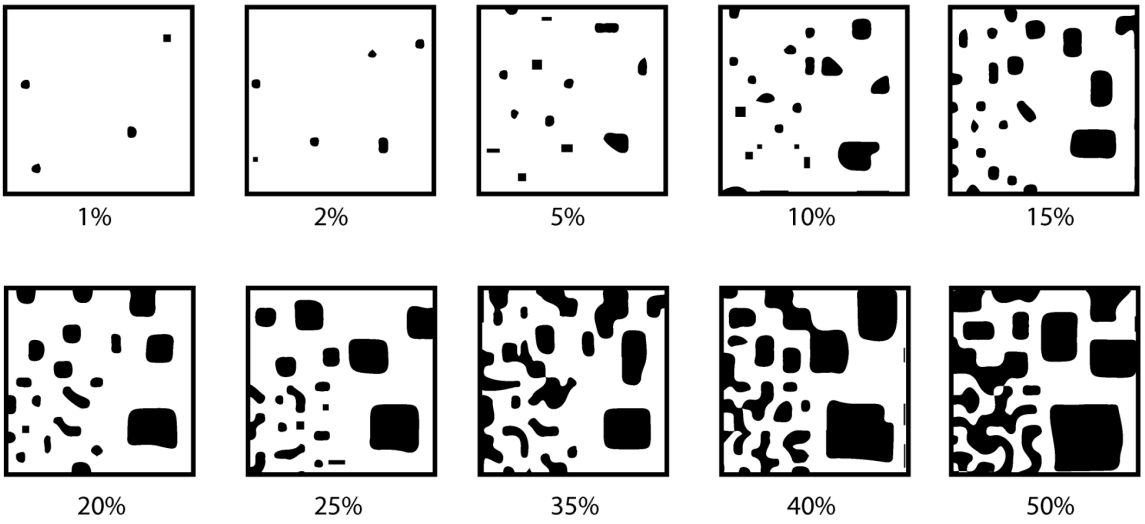
Moisture: Assess the soil moisture by looking at and possibly squeezing some soil in your hand.

Smell: Take a handful of soil and smell it. Do you smell anything distinct? Is it a foul or putrid/ fresh forest soil smell?

Color, color gradient: Note: dark/ light brown, gray, greenish, white, other (describe). You can also compare your sample with a handful of soil from an undisturbed area (e.g. grass strip next to the field). Do you see any difference in color, is it paler/ darker than the undisturbed soil?
ℹ️ Typically, a darker soil contains a higher amount of organic matter. Gray or greenish colors indicate disturbed soil respiration, poor drainage or water logging.

Mottles: Describe the color and percentage (compare with percentage chart below) of mottles (=spots with distinctly different color than the surrounding soil).
ℹ️ They are a good indication about whether a soil is well- drained and aerated. Mottles can also indicate poor soil structure and compaction with a lack of soil pores.

Percentage chart (own representation after FAO)



Soil pit: Horizon formation, Soil depth, Bedrock depth, Groundwater depth: Do you see distinct layers in your soil profile? These can be characterized by differences in color, texture or other soil attributes. Describe and make a sketch. Note how deep the A-horizon reaches in several locations. Do you know how deep you can dig until you reach bedrock? Is groundwater coming up when digging deeper?
ℹ️ Usually, we find a distinct “A-horizon” at the top with a darker color because of its higher organic matter content.

Compaction: Penetrate the soil with a soil probe in several locations and note if you feel higher resistance at a specific depth.

ℹ️ Compaction is promoted by the use of heavy machinery, overgrazing and intensive tillage. It impairs root growth and thus plant development, reduces water infiltration, and soil aeration. Often a plough pan (= compacted layer) can be detected at around 25-40 cm depth. Does the soil on the spade break open "like a book" at specific depths?

Volumetric stone content: Determine the percentage occupied by stones in the A-horizon of the soil. You can compare with the percentage chart below.

3.5. Earthworms

💼🏞️⭐ To get a feeling of the population in your soil, dig out a pit of 20cm x 20cm x 20cm and count the number of earthworms, in this volume of soil , ideally in several locations on your field. This is especially interesting to do repeatedly over the season/ years. You can also work with this more detailed method:
https://ahdb.org.uk/knowledge-library/how-to-count-earthworms (attached in the end of this document).
ℹ️ Earthworms provide essential services like improving soil structure by burrowing, mixing, aerating and recycling nutrients. They are excellent indicators of soil health and the presence of accessible organic materials, acting as feed for the worms.

3.6. Infiltration test

💼🏞️⭐ *Required material: piece of wastewater pipe, ~10L water, stopwatch, possibly mallet and piece of wood*

- Note some information about the place where the infiltration test is done. Is there a slope? On bare ground or vegetation? Is the surface crusted?
- The wastewater pipe is smacked into the soil (~5 cm), so no water runs out on the side of the ring.
- Mark a distance of 10 cm from the ground on the pipe.
- Pour water into the ring up to the 10 cm- mark and time how long it takes for all the water to infiltrate (no more visible water puddles on the surface).
- Repeat 3 times around the sampling plot, note all 3 results and calculate the mean value.

ℹ️ In the infiltration test we estimate the infiltration rate, i.e. how well the soil can take up precipitation. This depends highly on soil texture, but can also be influenced by organic matter content, nutrient content, soil fauna, rooting systems, surface crusting etc..

The infiltration rate is often given in mm (e.g. weather reports), but can also be expressed in liters / m^2. Thus, **mm / hour = L / m^2 / hour**. We measure how long it takes for a 10cm (=100mm) water column to infiltrate, thus we can calculate the infiltration rate:

$$infiltration\ rate\ (mm/hour) = \left(\frac{water\ column\ (mm)}{infiltration\ time\ (sec)}\right) \times 3600$$

3.7. Soil sampling for laboratory analysis

💼🏞️🌱 We are sampling soil for analysis in soil laboratories. You can also easily estimate bulk density and soil moisture of the sampling day yourself.

Please attach any available soil results from earlier analyses.

<u>Required material</u>: shovel/ soil auger, sampling rings of known volume, sealable plastic bags (~2L), sharpee

Note on each bag: farm, field, sample ID, date, which horizon/ depth, purpose of sample (e.g. for SoilBalancing, for freezing, for BD). Note the sample IDs under 2.1. General information.

<u>Per homogenous area/ zone:</u>

🌱 **One or several (composite) sample(s), depending on soil laboratory requirements**

⭐**Three samples with sampling ring**: for bulk density in the A-horizon (top horizon, below vegetation). The bag with the three samples should be weighed field moist, then dried until constant weight (at 105°C, e.g. in an oven for 2 hours) for a few days and weighed again. Like this, we can calculate bulk density and volumetric soil moisture on the sampling day.

$$Bulk\ Density\ [g/cm^3] = \frac{mean\ weight\ of\ air{-}dried\ soil\ [g]}{sampling\ ring\ volume\ [cm^3]}$$

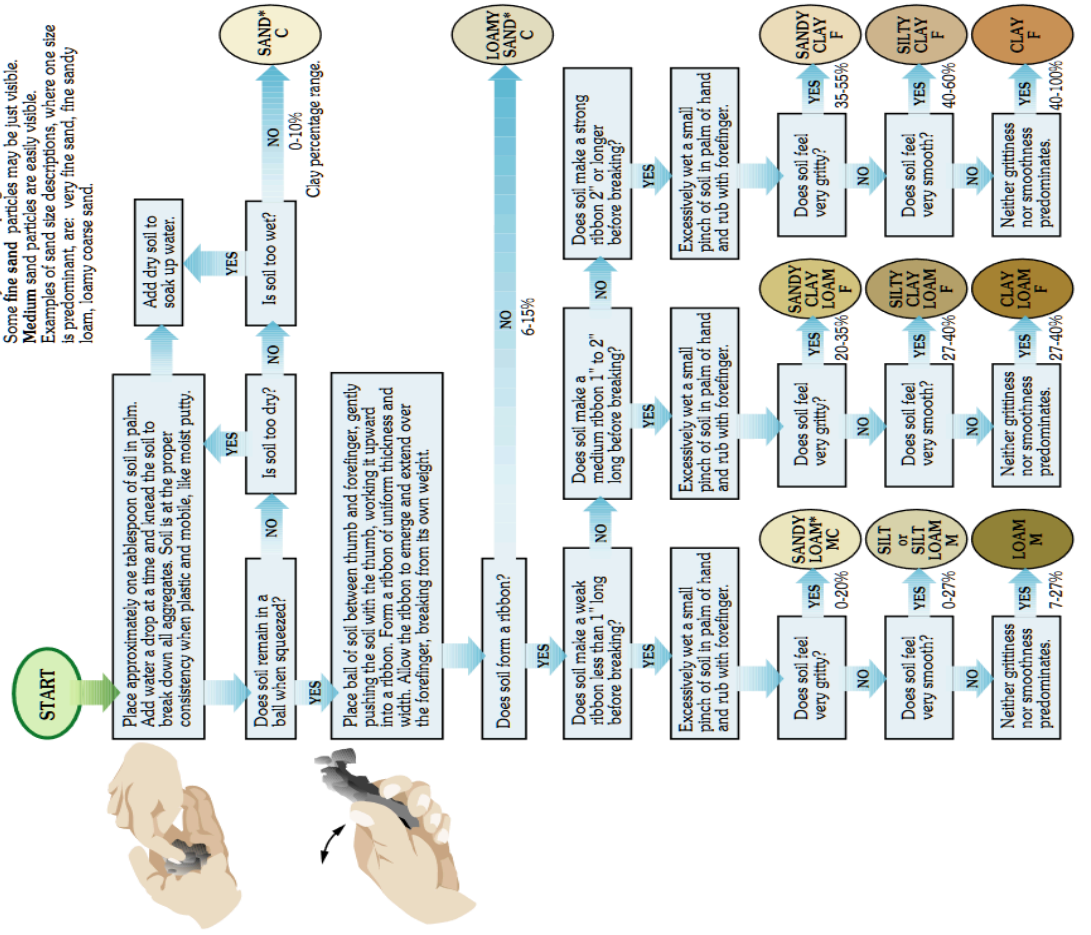
$$Volumetric\ Water\ Content\ [\%] = \frac{mean\ weight\ of\ moist\ soil\ [g] - mean\ weight\ of\ air{-}dried\ soil\ [g]}{sampling\ ring\ volume\ [cm^3]} * 100$$

Co-funded by the European Union

Determining Soil Texture By the Feel Method

TEXTURE CLASSIFICATION
C = Coarse
MC = Moderately Coarse
M = Medium
F = Fine

Sand particle size should be estimated (very fine, fine, medium, coarse) for these textures. Individual grains of **very fine sand** are not visible without magnification and there is a gritty feeling to a very small sample ground between teeth. Some **fine sand** particles may be just visible. **Medium** sand particles are easily visible. Examples of sand size descriptions, where one size is predominant, are: very fine sand, fine sandy loam, loamy coarse sand.



Modified from: Thien, Steve J.; Kansas State University, 1979 Jour. Agronomy Education.

Identifying adults and juveniles

Adult earthworms have a clearly developed **saddle** (reproductive ring) and juveniles do not.

You may need to rinse worms with water to determine if a saddle is present.

Size is not a good indicator of maturity as adult earthworms typically range in size from 2cm to 15cm, depending on species.

Assessing earthworm populations in just 60 minutes

When is it best to count earthworms?

Spring and autumn are the best times to carry out earthworm assessments.

Timing the sampling after warm, wet conditions often provides the best earthworm population estimates.

How to assess the earthworm populations

Tools: Spade, pot, bottle of water, mat and a record sheet available to download at **ahdb.org.uk/greatsoils**

Procedure: Dig 10 soil pits per field following a standard W-shape field-sampling pattern. Aim to spend five minutes hand-sorting the soil from each pit.

1	2	3	4
Dig out a soil pit (20cm x 20cm x 20cm) and place soil on mat	Hand-sort the soil, placing each whole earthworm into the pot	Count and record the total number of earthworms	Separate earthworms into adults and juveniles (see above)
5	**6**	**7**	**8**
Return juveniles to the soil pit	Count and record the number of each type of adult earthworm (see overleaf)	Return earthworms to the soil pit and backfill with soil	Repeat steps 1–7, until 10 soil pits per field have been assessed