

GLOBAL SOIL SYSTEMS & COMMUNITY-LED SOIL STEWARDSHIP

A Farmers Pride International Research Volume

SOIL SCIENCE.
COMMUNITY KNOWLEDGE.
SHARED PROSPERITY.



WRITTEN BY

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PEOPLE / SOIL / FOOD / PROSPERITY

FRONT MATTER

Global Soil Systems & Community-Led Soil Stewardship

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Written by Elfas Mcloud Zadzagomo Shangwa Hunter

First edition, 2026 | Research synthesis and community implementation

Farmers Pride International

This volume connects soil science with farmer-led learning, equitable community governance and the design of viable agricultural enterprises. It is written for farmers, facilitators, cluster managers, students, researchers, traditional and local leaders, and development partners.

Scope of this edition

This is a research synthesis and implementation volume, not a report of a new controlled field study, a systematic review or a peer-reviewed journal publication. Its research base combines international technical guidance, selected primary institutional resources and published research. Forty numbered references identify the evidence used. Selection was purposive: classification, diagnostic methods, water and nutrient processes, community participation, farmer experimentation and practical delivery were prioritised.

Numerical examples, budgets, trial results and implementation targets are explicitly illustrative unless identified as a documented source. The Ruth's Farm case is based on three supplied pH readings and is not a verified fertility survey or an intervention-success claim. External organizations cited here are not represented as endorsers or confirmed FPI partners.

Use and professional review

Before field implementation, obtain local agronomic, laboratory, engineering and regulatory advice for the particular crop, soil, climate and land-use setting. Rates and thresholds cannot be transferred indiscriminately between methods or regions. This author-review edition contains 100 pages including both covers. No ISBN or independent accreditation is claimed.

Cover artwork is a conceptual soil-and-community illustration, not evidence of a particular FPI project. The FPI logo is an author-supplied brand asset. Research resources were checked on 11 October 2026.

FRONT MATTER

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Page numbers follow the 100-page reader edition, including front and back covers. Chapter and reference links are active in the digital edition.

EXECUTIVE SUMMARY

Start with the soil system, not the product

Soil stewardship begins by asking what a particular soil must do for the people who depend on it. A field may need to support reliable crop establishment, retain scarce water, supply nutrients, protect a downstream water source and remain accessible to several generations of users. No single pH reading, fertilizer recommendation or laboratory score can demonstrate that all these functions are being sustained. International soil-management guidance therefore treats physical, chemical and biological condition as connected rather than interchangeable concerns. [03, 05]

The central argument of this volume is that community-led soil improvement should be organized as a continuing service: diagnose, agree priorities, test an affordable response, monitor outcomes and adapt. A one-off distribution of lime, compost or seedlings is an input-delivery event. It becomes stewardship only when responsibilities, evidence, maintenance and benefit-sharing are in place. This distinction is especially important where soils are shared through grazing, water movement, customary use or family inheritance.

Three decisions before investment

First, establish the dominant constraint. A compacted root zone, saline irrigation supply and phosphorus deficiency can all reduce growth, but they require different responses. Second, determine who can authorize and maintain the intervention. A technically sound drainage proposal can fail when its outlet crosses another household's land. Third, specify how success will be judged. A visible crop response is useful, but it does not alone establish profitability, improved soil carbon or reduced pollution.

This volume separates soil classification from management diagnosis. Arenosols, Vertisols and Phaeozems are World Reference Base Reference Soil Groups, not USDA soil orders. Their names help organize understanding, but the management decision still depends on depth, texture, drainage, chemistry, crop requirements and site history. [01, 02]

A practical sequence

Begin with a community conversation and landscape walk. Record land-use rights, local soil names, erosion pathways, wet areas, previous inputs and the intended crop or enterprise. Divide the site into meaningful management units. Sample those units consistently, interpret results with an appropriate laboratory and select only the interventions that address demonstrated limitations. Use small, well-recorded comparisons before expanding unfamiliar practices.

Core proposition. Healthy soil is not a purchasable input. It is a condition maintained through appropriate management, functioning institutions, reliable measurements and a fair distribution of costs and benefits.

For Farmers Pride International, this creates a foundation for RUAIPP and Agriculture-Based Clusters: a dependable productive resource, a traceable evidence base and a community capable of making informed decisions. The proposed delivery model is developed throughout the volume; it is not presented as an already evaluated FPI programme.

EXECUTIVE SUMMARY

Build community capability and a viable service

Community leadership changes how technical work is commissioned, interpreted and financed. Farmers should help define the questions, identify unusual seasons and judge whether a practice is workable. Women, young people, tenants, pastoralists and less-visible land users need routes to influence decisions, not simply invitations to attend meetings. International guidance on tenure, consent and gender equity provides a foundation; the operational tools in this volume translate those principles into proposed local procedures. [18, 19, 20]

The recommended five-year pathway starts modestly. In year one, establish rights and responsibilities, a baseline, a small set of demonstration or research sites and a minimum monitoring system. During years two and three, expand only the practices that show acceptable technical performance, affordability and participant support. Years four and five should strengthen local service businesses, recurrent financing, transparent governance and evidence that results persist beyond initial project support.

What communities should measure

A useful minimum record combines a soil measure, a crop measure, a financial measure and a participation measure. Examples include repeated pH using the same method, crop yield on a defined area, labour-adjusted gross margin and the proportion of participating households that have meaningful access to services. Add infiltration, ground cover, salinity, soil carbon or erosion observations where they answer a priority question. Avoid collecting expensive indicators merely because an instrument or dashboard makes them available.

What the volume provides

The scientific chapters explain major soil groups, physical condition, nutrient retention, pH, carbon, salinity and water movement. The community chapters show how to document local knowledge without appropriating it, handle cultural restrictions, negotiate responsibilities and support farmer-led research. The implementation chapters provide sampling procedures, amendment calculations, trial designs, decision rules, financing examples and scorecards. All numerical training examples are constructed rather than represented as observed project outcomes.

Three external learning cases address planting pits and stone lines in Niger, farmer-managed natural regeneration, and an East African farmer field school evaluation. The FPI case uses Ruth's Farm to show the limits of interpreting three pH readings. It deliberately does not invent an increase in yield, soil carbon or profitability. [24, 25, 26, 27]

The immediate recommendation is to approve a small, evidence-generating stewardship pilot before purchasing amendments at cluster scale. Such a pilot should have a community-agreed problem statement, named accountable people, a cost ceiling, safeguards, a comparison strategy and a public review date. Finance should reward the quality of the service and the integrity of the evidence, not the number of bags distributed or photographs collected.

First-year success. A credible baseline, a functioning local group, reliable records and a justified decision about what to scale are valuable outcomes even when an initially promoted treatment proves unsuitable.

ABSTRACT

Research purpose, approach and conclusions

Soils connect agricultural production, water regulation, nutrient cycling, biodiversity, cultural identity and rural economic development. Yet many interventions address individual inputs without sufficiently considering the interaction between site-specific constraints, institutions, knowledge systems and the distribution of benefits. This volume examines how soil science can support community-led stewardship within Farmers Pride International's Agriculture Systems Integration approach.

The work is a narrative research synthesis and implementation design. It draws on the World Reference Base, USDA soil classification and field guidance, FAO technical and governance publications, research and extension resources, selected published studies and a limited internal FPI diagnostic record. Sources were selected for methodological relevance and applicability to community decisions. They were not identified through a registered systematic-review protocol, and the volume does not calculate a pooled intervention effect. Evidence quality, geographical transferability and missing information are discussed where consequential.

The analysis is organized around eight themes: soil as a productive and community asset; global soil groups and constraints; chemistry and nutrient dynamics; water and climate resilience; cultural and community approaches; farmer-led innovation; practical intervention packages; and a one-to-five-year implementation pathway. Southern Africa, East Africa and the wider tropics provide contrasting application contexts rather than a single uniform recommendation domain.

The principal conclusion is that sound stewardship requires an explicit chain from question to measurement, interpretation, intervention and review. A soil name cannot substitute for a management diagnosis; pH cannot stand in for total fertility; a higher carbon percentage does not necessarily establish a larger carbon stock; and an attractive demonstration cannot establish a causal treatment effect. Equally, technical performance cannot justify exclusion, unsafe working conditions or the displacement of legitimate land users.

The volume proposes coordinated soil services within RUAIPP and Agriculture-Based Clusters, supported by farmer experimentation, accessible laboratory interpretation, records, accountable local governance and conservative financial planning. It includes newly constructed worked examples and field tools that can be adapted to local conditions. Its contribution is the integration of scientific interpretation with community implementation, not a claim of new empirical discovery.

Keywords: soil health; soil fertility; community stewardship; Indigenous knowledge; farmer field schools; RUAIPP; Agriculture-Based Clusters; salinity; soil carbon; participatory research.

Evidence boundary. Read the cited source and local conditions together. A method may be transferable while its numerical threshold, crop response, cost or governance arrangement is not.

READER GUIDE

How to use this volume

Read Chapters 1 and 5 together when establishing a new community programme: the first sets out the productive and economic purpose, while the second addresses rights, knowledge and participation. Use Chapters 2 to 4 to frame a diagnosis. Move to Chapter 7 only after identifying a plausible constraint and agreeing how the response will be evaluated. Chapter 6 supports the design of those evaluations, and Chapter 8 organizes delivery over several seasons.

Choose a reading route

Farmers and facilitators can start with the diagnostic sequence on page 72, the sampling procedure on page 73 and the community charter on page 61. Students should read the full sequence and reproduce the calculations before using the field tools. Cluster managers should combine pages 13-15 with the roles, budget and monitoring material on pages 86-89. Researchers should pay particular attention to measurement comparability, trial design and the distinction between observations and causal conclusions.

Recognize the evidence labels

A documented case is traceable to a named source. An internal diagnostic case uses an organizational record whose limitations are stated. An illustrative example is a newly constructed teaching situation, not a field result. A proposed protocol is a recommended starting design that still requires local agreement and technical review. These categories must remain separate in training, fundraising and public communications.

Numbers in square brackets identify references on pages 95-98. Field procedures are deliberately written in ordinary language, but specialist terms are retained where precision matters and are explained in the glossary. Units are metric. Monetary examples use USD and do not represent supplier quotations, current commodity prices or financing offers.

Keep a local companion file

For each participating management unit, retain its map or sketch, sampling record, laboratory report, crop and input history, consent record, seasonal observations and decisions. Record the method as well as the number: pH in water is not automatically comparable with pH in calcium chloride; electrical conductivity from a 1:5 extract is not interchangeable with conductivity of a saturated paste extract. [09, 40]

Safety and authority. Do not enter unsupported soil pits, divert water without appropriate design and permission, or apply unfamiliar amendments on the strength of a generic example. Keep contaminated sites and suspect materials out of food-production demonstrations until competent assessment establishes a safe use.

At the end of each planning cycle, return to the question: what evidence would change our decision? This makes the book a working reference rather than a fixed recipe. Page numbers throughout refer to the complete 100-page edition, including covers.

CHAPTER 1

The Edaphic Frontier

1.1 Soil as an operating foundation

Edaphic means related to soil. The edaphic frontier is not a new physical boundary to be conquered; it is the practical challenge of understanding how soil condition shapes the possibilities of a farm, a community and a bio-industrial value chain. A crop enterprise begins below ground, long before its produce reaches a dryer, mill, factory or export warehouse.

Soil supports roots and provides an environment for water, gases, nutrients and living organisms. These functions interact. A nutrient may be present but inaccessible because roots cannot penetrate a dense layer. Irrigation may be available but ineffective where salts accumulate or a water table excludes oxygen. Understanding the interaction is more useful than treating every weak crop as a fertilizer deficiency. [05]

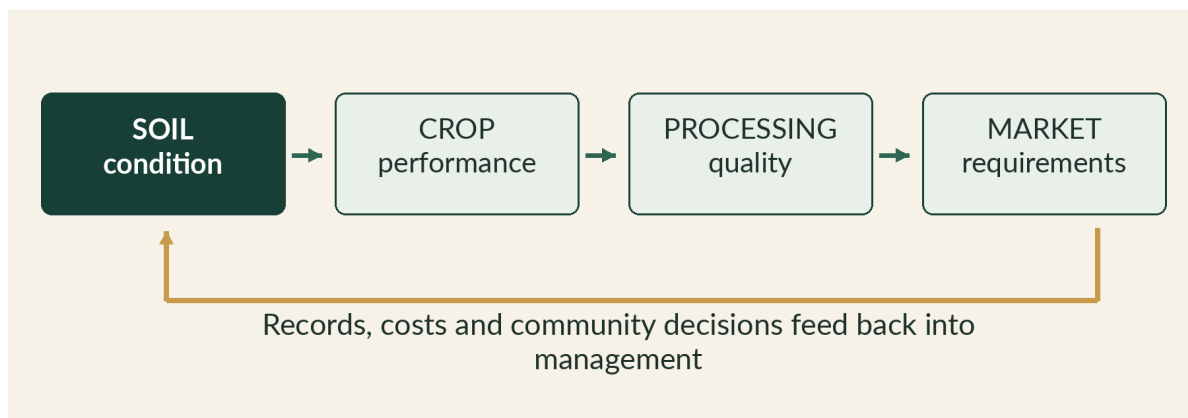


Figure 1.1. Proposed soil-to-enterprise decision chain. Arrows represent information and material relationships, not measured effects.

Learning outcomes

By the end of this chapter, readers should be able to distinguish soil condition from purchased inputs, explain why soil is both an enterprise resource and a shared asset, and outline a cluster soil service with clear evidence requirements. The chapter also introduces a practical boundary: commercial ambition does not establish agronomic suitability.

The farmer's question is usually specific: will this field support the intended crop with acceptable risk? A processor asks whether enough consistent material will arrive. A community asks whether the programme will protect land, water, livelihoods and future choices. A good soil system makes these questions visible together rather than allowing the most powerful buyer or project sponsor to define success alone.

Discussion prompt. Select one local crop enterprise. Trace one soil-related failure through harvest quality, processing costs, buyer confidence and household income. Identify the earliest point where better evidence could prevent the failure.

CHAPTER 1

Soil and the bio-industrial economy

1.1 From field variability to factory reliability

Bio-industry transforms biological materials into food, feed, fibre, energy, extracts or other products. Soil matters because the quantity, quality and timing of those materials depend partly on the root environment. A processing facility can improve handling and consistency after harvest, but it cannot reliably compensate for an unsuitable production base. FPI's organizational approach links production, learning, processing and market access; this volume places soil diagnosis at the beginning of that chain. [38]

Consider a proposed herb-drying operation supplied by several villages. The commercial plan may assume that all contracted hectares produce similar quantities each month. A soil assessment may instead identify shallow uplands, periodically saturated depressions and sandy fields with low nutrient retention. Treating these fields as interchangeable could create an input programme that is too expensive in one zone and ineffective in another. A more defensible plan assigns crops, planting dates and management intensity according to verified conditions.

Four operational connections

The first connection is establishment: a suitable seedbed, accessible water and a functioning root zone determine whether a crop begins uniformly. The second is recovery after harvest or stress: the business should not assume that repeated biomass removal can continue without replacing exported nutrients. The third is quality assurance: suspected contamination must be investigated before raw materials enter food or feed channels. The fourth is scheduling: wet-soil traffic, irrigation interruptions and erosion damage can disrupt supply even when annual production estimates appear adequate.

These connections suggest a change in procurement practice. Instead of asking only for acreage and intended output, a processor or cluster manager should request a management-unit register, a baseline diagnosis, an input and nutrient plan, and an agreed monitoring routine. The depth of the request should be proportionate to enterprise risk; a small local market garden does not need the same data system as a multi-site ingredient operation.

Avoid a false choice

Protecting soil and pursuing commercial production are not inherently opposing goals. The relevant question is whether the production system pays for the maintenance of the resource it uses. High output accompanied by declining soil condition may be drawing down natural capital. Conversely, expensive restoration practices that households cannot maintain are unlikely to persist. A sound plan therefore tracks both productive performance and the condition that supports it.

Enterprise design rule. Before expanding hectares, test whether the soil-management service can expand with them: sampling, interpretation, input quality, trained operators, water management, record keeping and independent review.

CHAPTER 1

Soil evidence and market confidence

1.1 Quality starts before the harvest

Market access depends on product specifications, consistency, traceability and the buyer's confidence in the production system. Soil evidence contributes to those requirements, but it is not a certificate of product safety or a guarantee of an export contract. A field with acceptable pH can still have unsuitable water, a contaminant history or poor hygiene during harvest and processing. Soil pollution can move through environmental and food-production pathways that are not visible during a routine farm visit. [36]

A useful traceability record connects a management unit to its sampling identifiers, interpretation, inputs, crop batch and harvest dates. It should preserve the actual report, not merely a green tick in a dashboard. Where a buyer requests a contaminant test, agree the analytes, sampling design, laboratory method and product matrix. A soil result and a finished-product result answer different questions and should not be substituted without technical justification.

Commercial question	Soil-related evidence	What it does not prove
Can supply be dependable?	Unit-level constraints and management records	A guaranteed harvest volume
Is the raw material safe?	Risk history and relevant soil testing	Finished-product compliance
Is restoration credible?	Comparable baselines and repeat observations	Causation without a comparison
Can claims be audited?	Source reports, methods and batch links	Independent certification

A practical acceptance gate

For a new supplier group, create a staged gate rather than demanding all possible tests at once. The first gate screens land-use history, visible hazards and intended crop requirements. The second commissions the priority analyses and resolves important uncertainties. The third checks whether the agreed management actions have actually been implemented. The fourth reviews crop and product outcomes. A failure at an early gate should trigger support or investigation, not concealment.

For moringa and other botanical ingredients, maintain a clear distinction between agronomic suitability, crop identity, contaminant control and any claims made about the product. A general soil volume cannot validate medicinal or nutritional marketing claims. It can help establish the evidence discipline that prevents an attractive narrative from outrunning what the farm and laboratory records demonstrate.

Communication standard. Say "the sampled unit had these measured results using this method on this date," rather than "the land is certified healthy." Describe uncertainty before presenting the commercial conclusion.

CHAPTER 1

Soil as natural capital

1.2 Assets, condition and service flows

Natural capital describes natural resources and systems that support benefits to people. For community soil planning, the concept is useful only when it distinguishes the resource from the benefits drawn from it. A field's area is an extent measure; its rooting depth, erosion condition or salinity describes aspects of condition; the crop harvest is a flow of production. Ecosystem accounting makes related distinctions between extent, condition and services. [37]

This volume proposes a simplified local account with three linked records. The resource record identifies the management unit and its recognized users. The condition record documents a small number of relevant indicators. The service record captures outcomes such as crop production, erosion protection or access to productive land. Keeping these records separate prevents a high-yield season from being treated automatically as evidence that the soil resource has improved.

Stock and flow can move in opposite directions

Imagine a farmer who achieves a larger harvest by drawing down nutrients accumulated through previous management. Revenue rises in the current season, while the nutrient balance becomes more negative. That result may be commercially acceptable for a limited period, but only if the future replacement requirement is understood. Similarly, removing all residues for sale can create immediate income while increasing the need to protect the soil surface by another means.

The account should not attempt to put a monetary price on every cultural or ecological relationship. Some places have responsibilities and meanings that are not adequately represented by a market valuation. A community may decide that a burial area, sacred grove, wetland or important grazing route is not available for conversion regardless of projected revenue. Respecting that decision is part of stewardship, not a failure of financial analysis.

Use conservative valuation

Where money is useful, start with observable avoided costs or clearly defined production benefits. Examples include reduced replanting expenses, fewer drainage repairs or a lower requirement for purchased nutrients after a verified change. Do not add several overlapping estimates of the same benefit. Do not treat a modelled carbon value as cash unless a valid agreement, eligible methodology and verified sale actually exist.

Asset-account question. If the crop enterprise closed at the end of this year, what condition would remain for the next land user? Record that legacy alongside the current season's income.

A soil account becomes more useful when it is repeated, understandable and linked to decisions. A technically sophisticated valuation that the community cannot inspect may weaken accountability rather than strengthen it.

CHAPTER 1

A community soil-asset ledger

1.2 Turn the concept into a working record

The proposed ledger is a management tool, not a land-title document or formal ecosystem account. Use one record per management unit, showing evidence, uncertainty and responsibility. Update it at seasonal reviews and preserve a community-validated history of changes.

Ledger element	Minimum information	Decision supported
Identity and access	Unit code, area, recognized users, access conditions	Who may authorize work?
Baseline condition	Method, date, depth and relevant observations	What is the starting point?
Main pressures	Traffic, erosion, salts, nutrient export or competing uses	What requires attention first?
Intervention	Material, rate, timing, operator and safeguards	What was actually changed?
Results and costs	Comparable indicators, labour and expenditure	Did the action justify expansion?
Outstanding duties	Maintenance, complaints, follow-up and reviewer	Who must act next?

Keep evidence and opinion distinguishable

A farmer's report that a field dries early is an observation; record its season and comparison. A laboratory result is a measurement with sampling and method limitations. A future yield estimate is a projection. Keep these categories distinct: a projection must not become measured output when copied into a report.

For a shared grazing or water-management area, the ledger should include the users who benefit indirectly or bear downstream costs. A contour structure may protect an upper field while redirecting flow toward another household. A community account should therefore follow the relevant landscape relationship, not stop automatically at a field boundary.

Review and stewardship rights

Provide accessible copies in the languages and formats participants use. Agree who can correct an entry, who holds the original, and which details can be shared outside the group. Do not publicly release exact household coordinates or sensitive cultural information simply because a digital platform allows it. The community should also know whether records will be used in a funding application, research publication or commercial claim.

Worked design choice. For a pilot, use a paper ledger with a photographed backup before purchasing a complex platform. Demonstrate that the group can maintain complete records for a season; then choose technology that solves an observed problem.

The ledger links the natural-capital discussion to the governance and consent procedures in Chapter 5 and to the scorecard in Chapter 8.

CHAPTER 1

FPI's soil vision within RUAIPP

1.3 A proposed cluster soil service

Farmers Pride International describes its work through Agriculture Systems Integration, linking RUAIPP, Agriculture-Based Clusters, capacity building and market-oriented production. [38] Within that framework, this volume proposes a soil service that connects household decisions with cluster coordination. It should be judged by the usefulness and integrity of its advice, not by the volume of amendments it sells.

RUAIPP is used here as the Rural and Urban Agriculture Innovative Production Program. Agriculture-Based Clusters are referred to as ABCs. Agriculture Systems Integration is the linking of production, knowledge, processing, logistics, markets, finance and feedback. Soil stewardship provides an evidence-based foundation for those connections rather than a separate environmental activity at the edge of the enterprise.



Figure 1.2. Proposed FPI soil-service arrangement. Responsibilities are recommendations for programme design, not a statement of existing staffing.

Separate advice from sales pressure

A cluster may aggregate laboratory services and amendment procurement, but the technical recommendation should remain inspectable. Record the diagnosis, alternative responses, expected cost and reason for the selected option. Where the adviser or organization benefits from a product sale, disclose the relationship and provide a route for independent review. This protects both the farmer and the credibility of the service.

The service can begin with basic equipment, a trained facilitator, a laboratory relationship and a modest travel budget. More advanced instruments should be added only when there is a defined demand, an operating budget, maintenance capacity and a plan for quality assurance. Owning an instrument is not the same as delivering reliable analysis.

Service promise. Every participating farmer should receive an understandable explanation of the result, the uncertainty, the available options and the next review date. A laboratory printout without interpretation is an incomplete service.

CHAPTER 1

The economics of maintaining soil

1.3 Make the whole cost visible

A soil intervention should be assessed against the most relevant alternative, usually current practice or a feasible lower-cost option. Include material, transport, storage, application, labour, equipment wear, testing, follow-up and the opportunity cost of land or residues. A donated input may be free to the recipient in year one, but it still has a cost that somebody must fund when the pilot ends.

A partial budget asks what changes because of the intervention. Additional revenue and avoided costs are compared with additional costs and any lost revenue. It does not calculate the entire farm's profit. This distinction is important when a project presents a small positive treatment margin as proof that the whole enterprise is financially secure.

Illustrative one-hectare calculation

Assume, solely for teaching, that a practice costs USD 70/ha more than current management and saves USD 12/ha in other costs. Assume a sale price of USD 260/t and no change in product quality. The break-even additional saleable yield is $(70 - 12) / 260 = 0.223$ t/ha, or about 223 kg/ha. None of these values is a quotation or a forecast. Replace every assumption with local evidence before using the calculation commercially.

Extra saleable yield	Added revenue	Net change after costs
0.10 t/ha	USD 26/ha	USD -32/ha
0.25 t/ha	USD 65/ha	USD 7/ha
0.40 t/ha	USD 104/ha	USD 46/ha

The table shows why a visibly better crop can still yield a poor financial result. It also shows why uncertainty matters near the break-even point. A small error in yield measurement, labour valuation or sale price could reverse the conclusion. Repeat the comparison over relevant seasons and consider whether the practice reduces risk as well as changing average output.

Do not ignore distribution

A positive cluster-level margin can conceal a loss for the people who provide unpaid labour or surrender residue access. Calculate household-level consequences where burdens differ. The group should decide whether shared benefits justify compensation, a service subsidy or a different practice. These are governance choices, not numbers that should disappear inside an average.

Financial discipline. Keep speculative carbon revenue and unconfirmed premium prices out of the base case. Present them separately as contingent possibilities with explicit eligibility, cost and verification requirements.

CHAPTER 1

A research agenda that communities can use

1.3 From ambition to answerable questions

A research agenda should begin with a decision that someone needs to make. "Improve soil health" is an aspiration. "Does retaining an agreed amount of crop residue improve establishment sufficiently to cover the extra weed-management and labour costs on these sandy fields?" is a question that can guide measurement and comparison. The latter makes the site, intervention, outcome and economic test visible.

For an FPI cluster, prioritize questions by importance, uncertainty, affordability and the ability to act on the answer. A problem affecting many households may deserve a shared trial. A severe issue limited to one contaminated site may require specialist assessment rather than a public demonstration. Some questions can be resolved by existing local extension evidence; others require a carefully designed experiment. Research is not improved by repeating tests that already answer the same local question adequately.

A proposed minimum research portfolio

The first workstream establishes baseline management units and identifies diagnostic uncertainty. The second compares a few feasible practices, such as application timing, residue management or a locally calibrated amendment strategy. The third evaluates delivery: whether farmers receive and understand advice, whether services reach less-visible users and whether records remain usable. The fourth reviews enterprise outcomes, including costs, reliable supply and any unintended consequences.

Each workstream should identify a responsible person, a data source, an analysis plan and a decision date. Define in advance what would count as failure or a reason to pause. For example, a treatment may be stopped if it increases salinity, creates an unsafe drainage condition, requires unaffordable labour or loses community consent. A credible programme preserves and reports those findings instead of treating every activity as a success story.

Chapter review

Explain why soil classification does not provide a complete crop recommendation. Distinguish a soil-condition measure from a production outcome. Describe how an advisory service can manage a conflict of interest when it also procures amendments. Finally, use the break-even calculation on page 14 to identify which local price, cost or yield assumption needs better evidence before investment.

Suggested answer direction. A strong response names the missing evidence and the decision it affects. "More testing" is not sufficient unless the proposed test could change a management choice. A useful soil service is selective, transparent and accountable.

The next chapter develops the diagnostic language needed for that agenda. It begins with soil groups and then moves deliberately toward the physical, chemical and biological constraints that farmers can observe, measure and manage.

CHAPTER 2

Global Soil Types & Constraints

2.1 Classify carefully; diagnose locally

A soil classification is a structured way to describe and compare soils. A management diagnosis asks what limits the intended use of a particular site and what can realistically be changed. Both are valuable, but they serve different purposes. The World Reference Base uses Reference Soil Groups and qualifiers; USDA Soil Taxonomy uses a different hierarchy that includes orders. A name from one system should not be treated as an exact translation of a name from the other. [01, 02]

For this volume, Arenosols, Vertisols, Phaeozems and the other groups on the following pages are discussed in WRB terms. Their short descriptions are orientation notes, not substitutes for the diagnostic criteria in the classification key. Formal identification may require profile description and laboratory evidence that a surface sample does not provide.

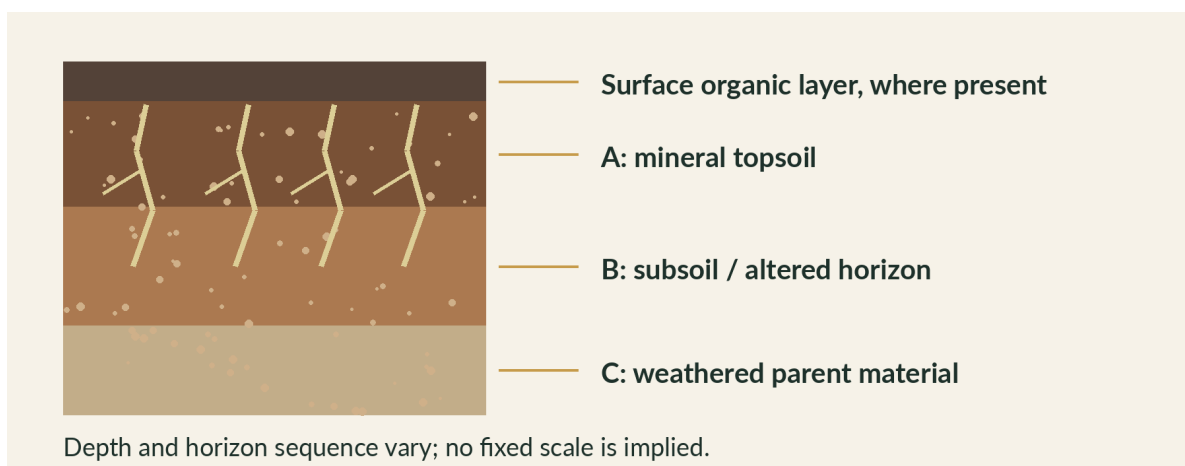


Figure 2.1. Conceptual mineral-soil profile. Horizons, depth and restrictions vary; this is not a profile observed at an FPI farm.

Read the whole root environment

A dark, friable surface can conceal a dense, saline, acidic or waterlogged subsoil. Conversely, a pale sandy surface may overlie a horizon that stores useful water. Record depth, horizon transitions, roots, pores, stones, wetness features and any restriction. Avoid entering unsupported pits; use a safe exposed face, auger or specialist survey method appropriate to the site.

A map is a starting hypothesis. A mapped unit can contain several soil components, and a small farm can cross more than one management environment. The aim is not to assign a prestigious soil label but to identify the features that change a decision: whether roots can explore sufficient depth, whether water can enter and leave, and whether nutrients are available without unacceptable toxicity.

Chapter task. Draw a profile from safe observations and mark what is seen, inferred and unknown. Keep those three categories separate when deciding what to sample next.

CHAPTER 2

Reference Soil Groups: productive contrasts

2.1 A first orientation

The following descriptions summarize prominent features rather than reproduce formal classification criteria. A farm should not be assigned to a group from colour or texture alone. WRB qualifiers and measured profile characteristics add information that the broad group name cannot convey. [01]

WRB group	Broad identifying tendency	Management question to investigate
Arenosols	Sandy profiles with limited horizon development	How much water and nutrient storage is actually available?
Vertisols	Swelling clay, cracking and soil mixing	When is traffic or tillage feasible without damage?
Phaeozems	Dark, base-rich surface horizons	Is erosion or nutrient export depleting a productive resource?
Ferralsols	Strong weathering and oxide-rich, low-activity material	Is phosphorus retention or low nutrient reserve limiting the crop?
Acrisols	Clay-enriched subsoil with low base status	Are acidity and root-zone nutrient constraints important?
Lixisols	Clay-enriched subsoil with higher base status	Does surface condition limit infiltration or establishment?

Translate the label into a field question

For a sandy profile, investigate effective rooting depth rather than assuming that a single frequent-irrigation schedule suits every field. For a swelling clay, examine drainage, cracks, trafficability and the width of the workable moisture range. A dark soil may have a productive surface, but its colour does not remove the need to measure nutrient supply or inspect subsoil conditions. The practical interpretation should always return to the crop, climate and management history.

Imagine two fields both described informally as "red soil." One has stable structure and roots throughout a deep profile; the other has a crusted surface and a compacted layer left by machinery. Their colour is similar, but the immediate management priorities differ. The same lesson applies to broad map classes: useful grouping does not justify identical treatment.

Avoid deterministic language

Do not call a group inherently "good" or "bad" without specifying the intended use and constraints. A soil that is expensive to manage for intensive vegetables may be appropriate for a different crop, grazing system or conservation purpose. Equally, a soil described as fertile may be unsuitable where flood risk, shallow depth or tenure restrictions make the intended investment impractical.

Field record. Write the observed feature first, the provisional interpretation second and the proposed test third. This sequence makes it easier to correct an early classification assumption without losing the evidence.

CHAPTER 2

Reference Soil Groups: special conditions

2.1 Water, minerals and landscape position

Several soil groups draw attention to conditions that demand additional assessment before agricultural intensification. The descriptions below are deliberately brief. They do not imply that every soil within a group has the same agricultural potential, nor that the group can be confirmed without applying the WRB key. [01]

WRB group	Broad feature	Priority investigation
Nitisols	Deep, strongly structured clay-rich profiles	Nutrient supply, acidity and erosion protection
Andosols	Properties associated with volcanic materials	Phosphorus behaviour and appropriate analytical methods
Calcisols	Significant secondary carbonate accumulation	Carbonate depth, micronutrients and irrigation chemistry
Solonchaks	Strong accumulation of soluble salts	Salt distribution, crop sensitivity and drainage
Solonetz	A sodium-affected diagnostic subsoil	Dispersion, infiltration and reclamation feasibility
Gleysols	Wetness-related reducing conditions	Duration, depth and source of saturation
Histosols	Predominantly organic soil materials	Protection from drainage, oxidation, subsidence and fire
Leptosols / Fluvisols	Shallow or stony soils / recent alluvial development	Rootable volume / flood and layered-profile behaviour

Land-use suitability is not an amendment list

A shallow stony field cannot be made deep simply by adding fertilizer. An organic wetland soil may lose important functions if drained for a short-lived cropping project. A river plain may be productive but subject to flooding and uneven sediment layers. These observations can lead to a decision to change the proposed land use, protect part of the area or reduce investment intensity rather than prescribe another input.

The relevant unit may also be smaller than the named soil group. On an irrigated field, salts can vary between the wetted zone and its margins, or with depth. On a floodplain, raised areas and depressions may require different management. A sampling plan should follow these meaningful differences instead of combining them into an average that describes no actual root environment.

Decision safeguard. Where improvement would require altering wetlands, major drainage, land conversion or substantial earthworks, pause for ecological, engineering, rights and regulatory assessment before presenting the land as available for cultivation.

CHAPTER 2

Texture: particle size and management

2.2 What texture describes

Texture describes the relative proportions of sand, silt and clay in the mineral fine-earth fraction. Under the commonly used USDA particle-size convention, sand is 0.05-2 mm, silt is 0.002-0.05 mm and clay is smaller than 0.002 mm. Coarser fragments are recorded separately. Texture is not the same as structure: the first concerns particle sizes, while the second concerns how particles are arranged into aggregates and pores. [02, 05]

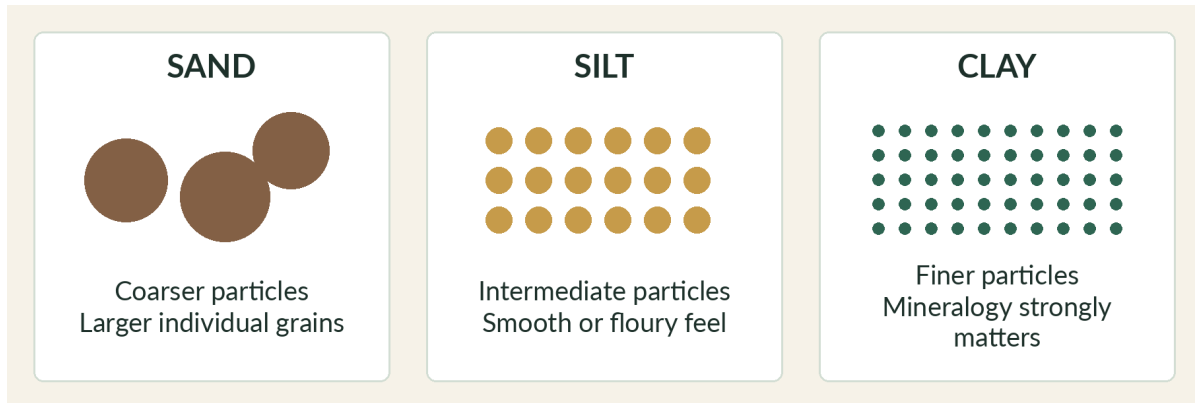


Figure 2.2. Particle-size concepts and practical implications. The schematic is not a laboratory texture triangle or a calibrated water-retention curve.

Use field texture as a screening tool

A trained person can compare moist samples by feel and ribbon formation, but a field estimate should not be presented as an exact laboratory percentage. Record the method and uncertainty. Organic materials, strongly aggregated soils and unusual mineralogy can complicate interpretation. Where a major design or investment depends on texture, confirm the result using an appropriate analytical method.

Texture helps explain why management differs. A coarse root zone may store less plant-available water per unit depth and require closer attention to nutrient timing. A fine-textured soil may hold substantial water but still provide a poor root environment when compacted, saturated or strongly structured into dense units. Neither observation justifies a universal irrigation interval or fertilizer rate.

Observe variation with depth

Take separate notes for the surface and subsoil. A sandy layer over a dense clay horizon behaves differently from a uniformly sandy profile. Layering can change drainage, the wetting pattern and the volume roots can exploit. The observation should guide where soil moisture is measured and whether a deeper sample is needed.

Practical exercise. Compare three safe, clean samples from contrasting local fields. Describe texture by feel, then compare those descriptions with laboratory results when available. Discuss which management decision would change if the field estimate were wrong.

CHAPTER 2

Structure, pores and root access

2.2 The arrangement matters

Soil structure is the arrangement of particles into larger units and the pore spaces between them. For a plant, the important consequences include root penetration, aeration, water entry and access to stored moisture. A soil can have a favourable texture but poor structure because of traffic, surface sealing or other disturbance. Field indicators are therefore most useful when interpreted together rather than reduced to a single appearance score. [05]

Inspect a moist, intact block where access is safe. Look for the shape and size of aggregates, visible pores and the way roots move through or around structural units. Flattened roots or abrupt changes in rooting depth may suggest a restriction, but they do not identify its cause alone. A dry hard layer, a compacted layer, a chemically hostile horizon and seasonal saturation can produce superficially similar symptoms.

Match comparisons for moisture

A clod from a dry field will feel harder than a moist clod from the same soil. A penetration reading is also strongly influenced by moisture and equipment procedure. Compare like with like: similar depth, moisture state, crop position and sampling method. Record recent rain, irrigation and traffic. Without that context, apparent improvement may simply reflect the timing of the visit.

A slaking comparison can help demonstrate aggregate behaviour when soil is wetted. Use similar-sized, similarly conditioned aggregates and the same water and timing. Keep the exercise descriptive unless a validated scoring procedure is followed. Rapid breakdown may reflect several processes; clear or cloudy water alone is not a complete diagnosis of sodicity or biological condition.

Respond to the cause

Where traffic is the main pressure, consider controlled routes, fewer passes and avoiding vulnerable moisture conditions. Where a surface seal develops, investigate cover, rainfall impact, organic inputs and dispersive behaviour. Where a dense subsurface layer is confirmed, assess whether mechanical loosening is justified, at what moisture condition, and how recurrence will be prevented. Deep ripping without a diagnosed restriction can waste money and disturb a functioning profile.

Root-zone worksheet. Record the depth of first restriction, root distribution above and below it, moisture condition and the evidence for the suspected cause. Name one observation or test that could disprove your diagnosis.

A strong structure assessment does not end with "the soil is compacted." It explains what is restricting the intended crop, how confident the diagnosis is and which response has a plausible mechanism.

CHAPTER 2

Bulk density: a measurement with context

2.2 Calculate first; interpret second

Bulk density is the dry mass of soil per unit bulk volume, including pore space. It is commonly expressed as g/cm³ or Mg/m³; these units have the same numerical value. Core sampling provides a defined volume, but errors arise if the core is compressed, incompletely filled, loses material or contains coarse fragments that are handled inconsistently. Texture and soil type influence the interpretation; a single universal "healthy" density is inappropriate. [06]

Illustrative core calculation

Assume a cylindrical core has an internal radius of 2.5 cm and a sampled height of 5.0 cm. Its volume is $\pi \times 2.5^2 \times 5.0 = 98.17 \text{ cm}^3$. If the properly determined dry soil mass is 138 g, bulk density is $138 / 98.17 = 1.41 \text{ g/cm}^3$, rounded to two decimal places. This is a constructed example, not an observed FPI result.

The arithmetic does not say whether roots are restricted. To interpret the result, identify texture, mineralogy, depth, moisture regime, rooting pattern and the relevant reference condition. Compare repeated cores rather than relying on one value. Where stones are substantial, follow a consistent laboratory convention and explain whether the reported density refers to the whole soil or fine-earth component.

Porosity is an estimate, not a second observation

If particle density is assumed to be 2.65 g/cm³, estimated total porosity is $1 - (1.41 / 2.65)$, or approximately 47%. This assumes the particle-density value is suitable. Organic-rich and unusual mineral soils may differ. Moreover, equal total porosity does not imply equal pore connectivity, drainage or root access. The arrangement and size of pores matter as well as their total volume.

Quality check	Why it matters
Confirm internal core dimensions	Volume errors directly alter density
Keep the core intact	Compression or loss changes the result
Use a documented drying method	Residual water inflates dry-mass estimates
Record depth and coarse fragments	Supports meaningful comparisons
Repeat within each management unit	Reveals local variability

Reporting example. "Mean bulk density at the specified depth was X using method Y; replicate range was Z. Root observations and texture indicate whether further compaction assessment is warranted." Do not report the number as a stand-alone soil-health verdict.

CHAPTER 2

Salinity: salts, water and plant stress

2.3 Distinguish measurement methods

Salinity concerns the concentration of soluble salts. Plants can experience difficulty extracting water even when the soil appears moist. Electrical conductivity is a useful indicator of the dissolved-ion environment, but the reported value depends on the extraction method, temperature correction and sample. E_{Ce}, the conductivity of a saturated paste extract, is not interchangeable with EC from a 1:5 soil-water suspension. [04, 29, 40]

A traditional classification threshold of about 4 dS/m E_{Ce} is widely used to identify saline soils, but it is not a universal safe boundary for crops. Sensitive crops can be affected below it, and response changes with growth stage and other stresses. A local interpretation must specify the crop, method, root-zone depth and intended management. [29]

Look for a salt balance

Possible sources include irrigation water, parent material, shallow groundwater, fertilizers and organic amendments. Salts accumulate when inputs and upward movement exceed effective removal. White surface deposits can be a warning, but their absence does not establish safety. Sample relevant depths and compare poor and better-performing areas separately. Record irrigation history and the position of samples relative to drip emitters or furrows.

The practical question is not merely "Can salt be leached?" It is whether suitable water, permeable pathways, drainage capacity and an acceptable destination for saline drainage are available. Moving salts below the root zone does not make them disappear. A community should not solve one field's problem by contaminating another field, wetland or water source.

Respond in stages

First verify the result and map the affected area. Then investigate irrigation-water quality, drainage and crop sensitivity. Consider reducing unnecessary salt inputs, improving irrigation management or changing the crop where appropriate. Reclamation requiring major water or drainage investment should be assessed technically and economically before purchasing amendments.

Stop-and-check rule. A high conductivity result is not an automatic instruction to apply gypsum. Establish whether excess exchangeable sodium is also present, and whether the site can safely drain. Gypsum itself contributes dissolved ions.

FAO's 2024 assessment reports salt-affected soils at global scale, but a global map cannot determine the treatment of a farm. The useful local output is a depth-specific diagnosis linked to a feasible water-and-salt management plan, with a follow-up sampling schedule and clear responsibilities. [04]

CHAPTER 2

Sodicity: a structural and chemical problem

2.3 Why sodium deserves separate attention

Sodicity concerns the influence of sodium on the exchange complex relative to other cations. Under susceptible conditions, clay dispersion can reduce infiltration and damage structure. Salinity and sodicity may occur separately or together. Their management is therefore not identical, and a high pH reading alone is insufficient to establish a sodicity diagnosis. [29]

Exchangeable sodium percentage, or ESP, is the percentage of the measured cation exchange capacity occupied by exchangeable sodium. Sodium adsorption ratio, or SAR, describes sodium relative to calcium and magnesium in an appropriate solution. They are related indicators but are not the same measurement. Interpretation depends on analytical method, clay behaviour and the surrounding electrolyte concentration.

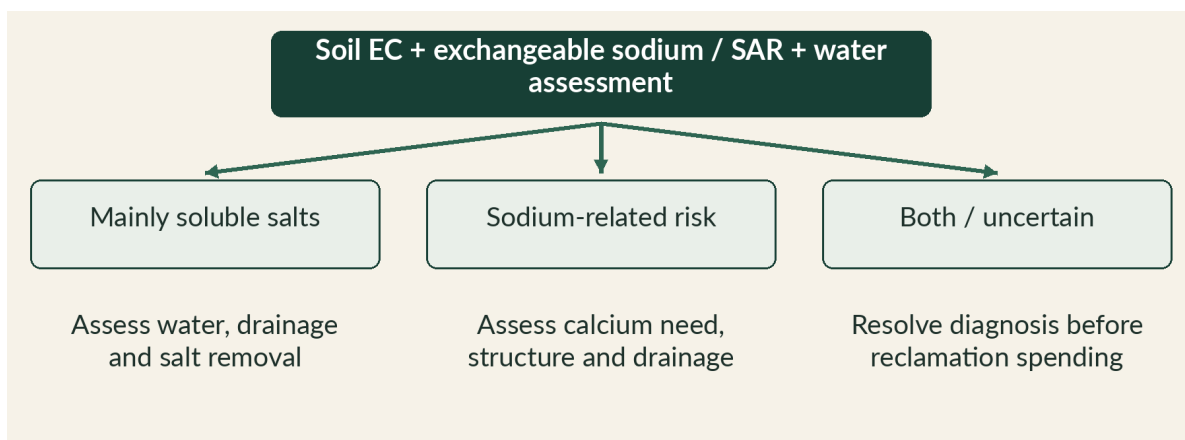


Figure 2.3. Diagnostic logic for salt-affected soils. The pathway requires laboratory and drainage evidence before an amendment decision.

Why sequence matters

In a saline-sodic soil, soluble salts may help maintain a degree of aggregation. Removing those salts without addressing the sodium problem can reveal or worsen dispersion. Conversely, adding a calcium source without adequate drainage may leave both the original salts and the amendment in the root zone. These mechanisms explain why reclamation needs a sequence rather than a single product recommendation. [29]

For community projects, the first useful investment may be a better diagnosis and drainage-feasibility assessment. Confirm the affected depth, obtain water chemistry and determine where displaced sodium and accompanying salts could go. Include maintenance and environmental responsibilities in the plan. A technically possible treatment can still be impractical where water is scarce or the downstream impacts are unacceptable.

Worked interpretation. Two fields with the same pH can need different responses: one may be carbonate-rich but structurally stable; another may show excess exchangeable sodium and poor infiltration. The missing evidence, not the pH number alone, determines the next action.

CHAPTER 2

Toxicity, contamination and unsuitable land

2.3 Separate natural chemistry from pollution history

A toxic concentration is harmful to the particular organism or use being considered. Some constraints arise from natural soil and water chemistry, such as excessive boron or soluble aluminium under certain conditions. Others relate to contamination from mining, industry, waste disposal, spills or previous land management. A routine fertility panel does not necessarily test the substances needed for a food-safety or environmental-risk decision. [36]

Begin with a land-use history and a walkover assessment. Ask about old dumps, workshops, fuel storage, wastewater, treated timber, industrial fill and past chemical use. Record credible concerns without accusing a land user or claiming that visible evidence proves contamination. An unusual colour, odour or bare patch can justify investigation, but it cannot identify a contaminant or concentration.

Follow source, pathway and receptor

A risk assessment asks what substance may be present, how people, crops, livestock or ecosystems could encounter it, and what consequence could follow. Soil ingestion by children, crop uptake, dust movement and leaching are different pathways. The correct sample and analytical method depend on the pathway and the decision. Do not dilute a suspected hotspot into a large composite sample simply to obtain a more reassuring average.

Where credible concern exists, restrict the affected use while competent assessment is arranged. Separate suspect materials from compost feedstocks and food-production areas. Do not recommend growing a food crop as a "clean-up" strategy without a specialist plan for the biomass and its disposal. Moving a contaminant into a harvest can transfer risk rather than solve it.

Do not promise a universal remedy

Compost, biochar, lime and other materials can alter contaminant behaviour in some circumstances, but they do not necessarily remove the contaminant. Immobilization, extraction and destruction are different processes. A reduction in plant uptake under one set of conditions does not automatically establish long-term safety or regulatory compliance. The treatment goal and verification method must be explicit.

Community safeguard. Maintain a confidential hazard register with a responsible contact, temporary precautions, assessment status and review date. Communicate the practical restriction without releasing unverified allegations or identifying households unnecessarily.

For an agricultural enterprise, deciding not to cultivate a particular area can be the most responsible outcome of soil research. A successful diagnostic service prevents unsuitable investment as well as enabling appropriate production.

CHAPTER 2

Biological constraints and organic matter

2.4 Biology is a system, not a single count

Soil organisms contribute to decomposition, nutrient transformations, aggregation and many other functions. The community includes microorganisms and larger organisms with different roles and environmental requirements. A low earthworm count in a dry sandy setting does not carry the same meaning as a low count in a comparable moist temperate soil. Biological indicators require a local reference and a consistent sampling procedure. [07]

Low organic inputs, repeated disturbance, prolonged bare periods, compaction, adverse chemistry and water stress can all affect the biological environment. However, the diagnosis should not begin by assuming that every field needs a purchased microbial product. Investigate habitat and resource constraints first: whether roots and residues provide carbon, whether water and oxygen are adequate, and whether the soil contains a chemical or physical restriction.

Distinguish organic matter quantity and function

A measured organic-carbon concentration provides useful information but does not describe all aspects of biological activity. A rapid respiration response can indicate available substrate and active organisms, but it can also reflect decomposition of a recent input. High activity is not automatically evidence of long-term carbon storage. Likewise, a dark surface may contain substantial organic material without demonstrating balanced nutrient supply.

For a community baseline, combine manageable observations: ground cover, rooting, residue distribution, aggregate behaviour and a laboratory carbon result when justified. Use more specialized biological tests only when the group can explain how the result will change a decision. The laboratory should state its method and the comparison domain used for interpretation.

Evaluate biological products as treatments

Request a clear product identity, storage requirements, evidence of quality and locally relevant performance. Define the claimed function: improved nutrient availability, disease suppression or another outcome. Then test it against the same management without the product. Do not attribute an effect to the organism when the treatment also introduces extra nutrients, water or organic material that the control did not receive.

Research question. Does the proposed treatment improve the chosen outcome beyond the effect of its carrier or nutrient content? A fair comparison is more informative than a before-and-after photograph.

The practical priority is to make the soil environment capable of supporting useful biological functions. Chapter 3 explains carbon and nutrient processes in more detail, while Chapter 7 evaluates organic inputs without treating them as automatically safe or sufficient.

CHAPTER 2

Regional snapshot: Southern Africa

2.5 Plan for diversity within the region

Southern Africa contains contrasting parent materials, rainfall regimes, landscapes and soil-development histories. Continental soil resources show why a regional label cannot justify one fertility or irrigation prescription. [08] For practical planning in Botswana, Zambia and neighbouring settings, begin with local landscape position, profile characteristics, water availability and management history rather than a presumed "African soil" type.

In a sandy dryland setting, the first questions may concern effective rootable depth, water storage, nutrient timing and wind or surface erosion. In a heavier valley soil, they may concern drainage, trafficability, seasonal saturation or salt accumulation. In more strongly weathered or leached settings, acidity and nutrient constraints can be important. These are diagnostic possibilities, not a map assigning every farm to a fixed category.

A Botswana-oriented screening conversation

Ask whether the enterprise will depend on groundwater, how water quality and supply vary, and whether salts can leave the root zone safely. Examine where storm runoff concentrates and whether sparse cover leaves the surface exposed. For an irrigated moringa or herbal project, check the root environment and water source before converting an ambitious planting density into an expected yield. Density is a design assumption, not evidence of site carrying capacity.

A Zambia-oriented screening conversation

Ask how conditions change between uplands, slopes and lower positions, whether repeated nutrient removal has been recorded, and whether acidity is supported by an appropriate test. Plan field access and erosion protection around the actual seasonal pattern. A cluster operating across several districts should maintain separate diagnostic units and recommendations rather than apply one amendment schedule everywhere.

Community and enterprise implications

Local knowledge can identify fields that pond, dry early or respond differently to management. Use that knowledge to stratify sampling and select representative trial sites. Include different farm sizes and resource levels so that the demonstration does not represent only the best-managed land. A practice that works on a well-resourced demonstration farm may be unavailable to households lacking labour, transport or irrigation.

Regional adaptation checklist. For each proposed site, record climate context, landform, profile depth, water source, chemical constraints, current use, access rights and available services. Leave unknown entries visibly unknown until evidence is obtained.

The purpose of a regional snapshot is to sharpen questions, not to replace a survey. Investment should proceed from site evidence outward, rather than from a regional narrative inward.

CHAPTER 2

East Africa and the wider tropics

2.5 Contrasting environments, shared diagnostic discipline

East African landscapes include highlands, volcanic settings, drylands, lake basins and coastal environments. Across the global tropics, old weathered surfaces coexist with young alluvium, steep slopes, organic wetlands and soils developed from volcanic materials. The practical implication is diversity in both nutrient behaviour and water management, not a single tropical-soil recommendation. [08]

Setting to investigate	Possible priority question	Evidence needed before action
Steep cultivated land	Is erosion removing productive topsoil?	Slope, cover, runoff pathways and safe outlets
Volcanic-material soil	Are analytical methods and phosphorus interpretation suitable?	Profile information and locally appropriate laboratory advice
Seasonally wet lowland	Is oxygen limitation or flooding restricting the intended crop?	Wetness duration, water-table observations and land-use suitability
Intensively harvested field	Is nutrient export exceeding replacement?	Yield, biomass removal and input records
Peri-urban production area	Is there a contamination or wastewater concern?	Land-use history and targeted risk assessment

Transfer principles, not unexamined packages

A conservation practice developed in one environment may require a different species, timing, geometry or labour arrangement elsewhere. A cover crop that protects a humid field may compete for scarce water in a dry season. A water-harvesting structure suitable for gentle crusted land may be unsafe on a steep or already saturated site. A nutrient test calibrated for one crop and soil domain may not support the same critical value in another.

For international partnerships, share the mechanism before the rate: what changes, under which conditions, at what cost and with what risk? Transfer the decision process rather than a standard package.

Chapter synthesis

Soil group, texture, structure, chemistry, biology and landscape position should be read together. A management diagnosis is strongest when it explains both the observed symptom and the reason competing explanations are less likely. The next chapter examines the laboratory and chemical concepts needed to move from a report to a defensible response.

Review exercise. A farmer reports yellow leaves on a wet field with pH 7.1. Explain why adding lime, adding nitrogen and installing drainage are three different hypotheses rather than interchangeable recommendations. Identify the evidence needed to choose among them.

Suggested answer direction: inspect roots and wetness, verify the pH method, examine nutrient and crop evidence, and investigate the actual limiting process before selecting an input or earthwork.

CHAPTER 3

Soil Chemistry, pH & Nutrient Dynamics

3.1 Retention is a process, not a fertilizer prescription

Soil chemistry describes how dissolved substances, mineral surfaces, organic matter and organisms interact. Plant roots obtain most mineral nutrients from soil solution, but that solution exchanges continually with other pools. An apparently small solution concentration may be replenished rapidly; a large total soil reserve may remain inaccessible during the crop's growing period. A laboratory result becomes useful only when the measured pool has a defensible relationship to the decision being made. [10, 11, 13]

Cation exchange capacity, or CEC, expresses the capacity of a soil to retain exchangeable positively charged ions. Calcium, magnesium, potassium, sodium and ammonium can participate in this exchange. Clay mineralogy and organic matter influence both the amount and nature of charge. Some charge is relatively permanent; some changes with pH. Consequently, CEC measured under a buffered laboratory condition may differ from effective CEC at the soil's actual pH. Compare like methods rather than treating all reported CEC values as identical. [10, 28]

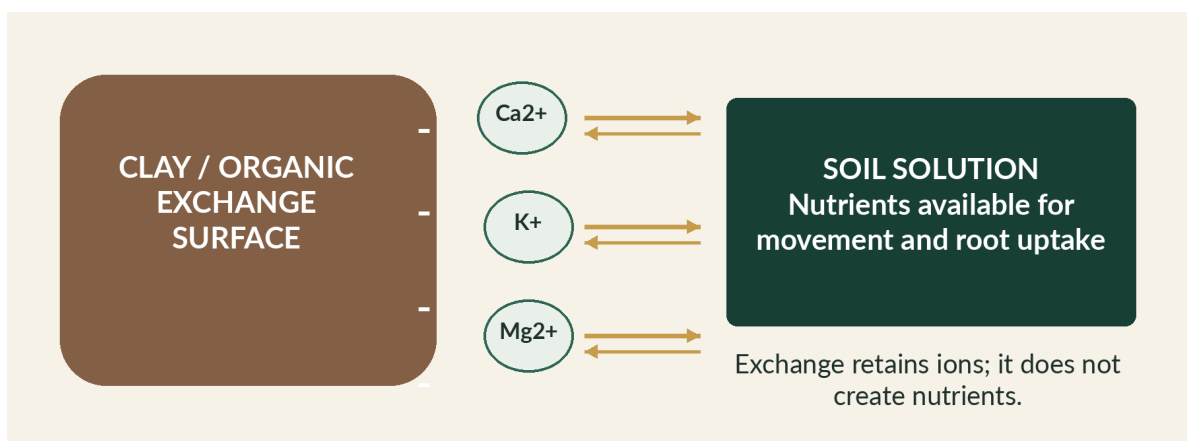


Figure 3.1. A conceptual exchange surface links nutrient reserves and soil solution. Symbols represent processes, not measured proportions or a fertilizer recommendation.

Holding capacity is not availability

A sandy soil with low CEC may require carefully timed nutrient applications to reduce losses, but CEC alone does not determine every nutrient's behaviour. Nitrate is negatively charged and is not retained by the ordinary cation-exchange mechanism. Phosphate can react strongly with mineral surfaces through other processes. Treating CEC as a universal measure of nutrient storage therefore misrepresents important differences. [11, 13]

Exchange sites do not create nutrients. They influence retention and replenishment, while crop supply also depends on roots, water, aeration, mineralization, fertilizer placement and competing reactions. A high-CEC soil can still be nutrient-deficient, poorly drained or sodic. Conversely, a lower-CEC soil can produce well under an appropriate water and nutrient programme.

Reading a laboratory report. Ask whether CEC was directly measured, estimated from texture or organic matter, or calculated from exchangeable ions. Record the method, units and pH basis before comparing fields or seasons.

CHAPTER 3

CEC, base saturation and useful calculations

CEC is commonly expressed as cmolc/kg: centimoles of electrical charge per kilogram of soil. The older unit meq/100 g has the same numerical value. Charge units are not the same as milligrams of a particular nutrient, and a CEC value cannot be turned directly into a fertilizer rate without additional information. [10, 28]

A constructed exchange calculation

Assume a laboratory reports CEC of 12.0 cmolc/kg, with exchangeable calcium 5.0, magnesium 2.0, potassium 0.3 and sodium 0.2 cmolc/kg. The sum of these base cations is 7.5 cmolc/kg. On this stated measurement basis, base saturation is $100 \times 7.5 / 12.0 = 62.5\%$.

Exchangeable ion	Result, cmolc/kg	Share of stated CEC
Calcium	5.0	41.7%
Magnesium	2.0	16.7%
Potassium	0.3	2.5%
Sodium	0.2	1.7%
Sum of listed bases	7.5	62.5%

These illustrative percentages describe the reported exchange complex; they do not show that the crop needs a product to force the soil into an ideal ratio. Interpretation requires attention to crop response calibration, nutrient sufficiency, acidity, salinity and measurement uncertainty. The exchangeable sodium percentage in this example is $100 \times 0.2 / 12.0$, or about 1.7%, but that number alone does not establish infiltration behaviour under every irrigation-water condition. [10, 14, 29]

Why an attractive ratio can be misleading

A cation-balancing sales proposal may recommend amendments merely because one percentage differs from a chosen target. This can add cost without addressing a demonstrated crop limitation. Laboratory methods can also produce estimated CEC and percentage values that shift when soil pH or extraction assumptions change. Use locally validated sufficiency or response information rather than chasing a universal calcium-to-magnesium ratio. [10]

For a cluster manager, the procurement question is practical: what measurable deficiency, acidity problem or sodium hazard is the proposed purchase intended to correct? Request an explanation of expected response, uncertainty, total cost and the evidence for that field. Where the purpose remains unclear, a small comparison is more defensible than a cluster-wide order.

Calculation check. Never add concentrations expressed in mg/kg directly to concentrations in cmolc/kg. Confirm units first; ask the laboratory to explain conversions and the analytical basis of calculated ratios.

CHAPTER 3

Measuring pH without losing the method

3.2 A number requires a measurement context

Soil pH describes the acidity or alkalinity of a specified suspension or extract. It is logarithmic: a one-unit difference represents a tenfold difference in hydrogen-ion activity under the conditions being compared. That does not mean that ten times as much lime is required, because the soil's buffering reactions are not represented by pH alone. [09, 28]

Laboratories may measure pH in water, calcium chloride or another specified solution, using defined soil-to-solution ratios. Results from different methods can differ systematically, but there is no universal conversion suitable for all soils. Field meters, strips and laboratory electrodes also differ in resolution and quality control. A displayed decimal place does not guarantee an equivalent level of accuracy. [09]

A repeatable measurement record

A usable record contains the sample identity, sampling depth, date, preparation procedure, extracting solution, soil-to-solution ratio, instrument and calibration details. It should indicate whether the sample was field-moist or air-dried and identify the laboratory or operator. These details are especially important when a community is tracking small changes over time.

For routine field learning, demonstrate calibration with suitable buffers following the instrument and method instructions. Use clean containers and appropriate water, rinse the electrode between samples, allow readings to stabilize and record unusual suspension or electrode behaviour. Do not improvise a ratio midway through the season. A laboratory procedure should be followed as a complete method, not as a collection of isolated steps. [09, 40]

Interpreting a small difference

A change from 7.1 to 7.2 may reflect spatial variation, method differences or ordinary measurement variability rather than an agronomically important trend. Repeated samples from defined management units, a consistent method and a relevant crop interpretation are more valuable than unsupported precision. Where decisions are costly, investigate repeatability before attributing a small change to a treatment.

Field decision. Write "pH 7.1, method not recorded" rather than silently treating the value as a fully comparable laboratory result. Missing metadata is a limitation to manage, not a reason to invent a method.

The most useful pH question is not whether a soil has reached a fashionable number. It is whether acidity or alkalinity is limiting the intended crop or increasing a specific toxicity risk, and whether the available evidence supports a corrective action.

CHAPTER 3

pH and nutrient availability

A pH diagram is a teaching aid, not a universal calibration chart. Soil minerals, organic matter, redox conditions, crop species and laboratory extraction all influence nutrient availability. A broad tendency can be scientifically useful while still being insufficient to prescribe a field treatment. [09, 13, 28, 39]

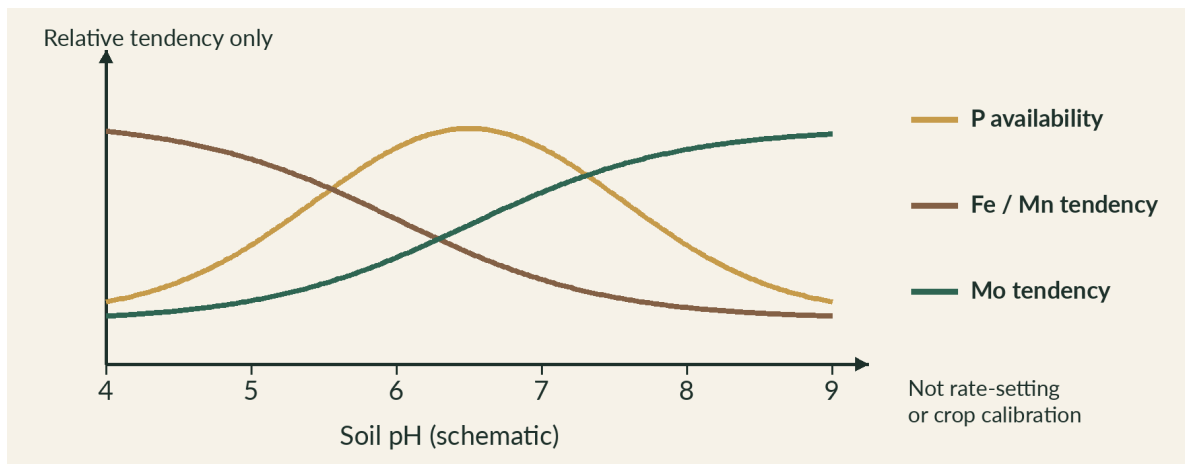


Figure 3.2. Qualitative pH-response tendencies. The schematic curves are not experimental data, do not define universal optimum ranges and must not be used to calculate application rates.

Read the mechanism behind the picture

In strongly acid mineral soils, aluminium or manganese toxicity may constrain roots, depending on the soil and crop. Phosphorus can react with iron and aluminium compounds. In calcareous or alkaline conditions, different phosphorus reactions and lower availability of several micronutrients may become important. These mechanisms explain why the same fertilizer can behave differently across soils; they do not imply that every nutrient becomes adequate after pH correction. [13, 28, 39]

Many crops are managed successfully in moderately acid to near-neutral conditions, but crop-specific requirements matter. A lime recommendation for one crop cannot be transferred uncritically to another. Likewise, an alkaline pH does not establish sodicity: carbonate chemistry, exchangeable sodium and salt concentration must be investigated separately. [14, 29]

Avoid the symptom shortcut

Yellow leaves can arise from nitrogen shortage, iron-related chlorosis, damaged roots, wetness, pests or other causes. A pH reading helps organize hypotheses; it does not identify the cause on its own. Inspect the distribution of symptoms, affected leaf ages, root condition, recent water history and crop nutrient information before choosing a treatment.

Practical interpretation. Use pH to ask better questions about nutrient behaviour. Use suitable soil and, where justified, tissue tests plus field observations to decide whether a nutrient or amendment response is likely.

A poster may simplify these relationships, but an "ideal pH" band must not become a fertility guarantee or conceal drainage, salinity and contamination problems.

CHAPTER 3

Acidity, buffering and the lime question

Two soils can have the same measured pH and require different quantities of lime to achieve the same target under a specified method. The difference arises from their buffering behaviour: exchange sites and other reactive components can replenish acidity as the solution is neutralized. Active acidity and the larger reserve of acidity are related but not interchangeable. [28]

Diagnose the source and the depth

Acidity may be associated with parent material, leaching, crop removal and acidifying processes connected with some nitrogen fertilizers. Management should consider both current correction and the processes likely to continue. Surface pH can also differ from subsoil pH, so a single mixed surface sample may conceal a rooting constraint at depth. Profile diagnosis should be guided by the crop, soil and intended operation rather than by an arbitrary universal sampling depth. [28]

A laboratory lime requirement is normally tied to a target, a measurement method and assumptions about the depth or mass of soil treated. The recommendation should explain the neutralizing-value basis and any adjustment already included for product quality. Farmers need these assumptions because a broadcast surface application, incorporated application and localized treatment are not equivalent operations.

Correction is not instantaneous

Reaction depends on material properties, moisture, placement and time. Fine particles generally react more rapidly than coarse particles, but procurement should rely on a specified effective neutralizing value or locally accepted quality measure rather than appearance alone. Ask for evidence of composition and quality, and arrange a realistic reassessment interval. Repeated applications based only on immediate pH readings risk overcorrection. [28]

Magnesium-containing lime may be appropriate where magnesium supply and acidity both require attention. It is not automatically superior to calcitic material. Similarly, lime is not a substitute for correcting compaction, waterlogging or an unsuitable crop choice.

When not to prescribe. Do not recommend lime simply because a crop is struggling, a field has low organic matter, or another farm used it successfully. Establish an acidity-related need and obtain a method-appropriate rate.

For farmer training, compare two soil samples with similar pH but different laboratory lime requirements. Ask learners to explain why the quantities differ. The exercise separates the intensity of acidity from the capacity of the soil to resist change, a distinction that prevents costly purchasing errors.

CHAPTER 3

Nitrogen: timing, transformations and losses

Nitrogen management requires attention to movement and transformation as well as total input. Organic nitrogen can be mineralized into inorganic forms, while microorganisms can immobilize mineral nitrogen when decomposing some materials. Ammonium can be converted to nitrate through nitrification. Under conditions that support denitrification, nitrate can be lost as gases, including nitrous oxide. Nitrate can also move below the active root zone with drainage water. [11]

Match supply to crop demand and water

A large application before heavy rain or before the crop has an effective root system can increase exposure to loss. Split applications may improve timing in some systems, but the added labour, access and cost must be considered. Surface-applied materials can be subject to ammonia loss under suitable conditions; incorporating or watering in a product should follow appropriate crop, soil and product guidance rather than a universal rule. [11]

Legumes can contribute biologically fixed nitrogen where effective symbiosis, growth and management occur. They do not create an unlimited fertilizer credit. The amount retained for a following crop depends on biomass production, whether material is removed, decomposition, timing and losses. Purchased manure and compost also contain nitrogen in different forms and release patterns. Total nitrogen on a label is not identical to first-season plant-available nitrogen.

Build a field nitrogen account

Record mineral fertilizer, organic inputs, crop residues and known legume contributions separately. Estimate crop removal using actual harvested mass and suitable nutrient-content information, and label assumptions. A simple balance can expose large inconsistencies, but an apparent surplus is not a direct measurement of leaching or emissions. Conversely, a balance near zero does not prove that nitrogen was available when the crop needed it.

Question	Useful evidence
Did the crop receive nitrogen at the right time?	Application dates, crop stage and rain or irrigation records
Could roots access the nutrient?	Root depth, wetness, compaction and placement observations
Was organic nitrogen credited appropriately?	Dry matter, total N, material history and locally justified release assumptions
Is a loss pathway plausible?	Water movement, exposure conditions and timing; further measurements where needed

A cluster should maintain a common record format while allowing field-specific decisions. This creates comparable evidence without forcing identical rates onto soils, crops and seasons with different requirements.

CHAPTER 3

Phosphorus and potassium: different pools

Phosphorus and potassium are both essential nutrients, but their reactions differ. Much soil phosphorus is associated with mineral or organic pools rather than freely dissolved in solution. Crop availability depends on replenishment, placement, roots and chemical conditions. Potassium occurs in solution, exchangeable and more strongly held mineral pools, with release and fixation influenced by mineralogy. A single concept of "nutrient holding" is therefore too crude for practical diagnosis. [10, 13, 39]

Phosphorus interpretation is method-sensitive

Different extractants are designed for particular soil conditions and interpretive systems. A phosphorus concentration measured by one method cannot automatically be judged against a critical value developed for another. Ask the laboratory which method was used, whether local response calibration exists for the crop, and how pH or carbonate conditions affect interpretation. A high total phosphorus content does not establish adequate crop supply. [13, 39]

Placement can matter because phosphorus movement to roots is often limited. However, a placement strategy should fit the crop, equipment, fertilizer properties and root-zone conditions. Excessive application can create environmental concerns where phosphorus is transported with eroded particles or dissolved runoff. Adding more does not necessarily overcome a physical rooting limitation.

Potassium and harvested biomass

Crops that remove substantial vegetative biomass may export appreciable potassium, but the actual amount depends on biomass and nutrient content. Repeated leaf or fodder harvesting should therefore be accompanied by a defensible nutrient budget. A high-yield projection is not evidence that the soil can sustain the associated nutrient removal indefinitely. Soil testing, crop performance and local response guidance should inform replacement. [10, 39]

Fertilizer labels commonly express phosphorus as P_2O_5 and potassium as K_2O rather than elemental P and K. For mass calculations, $P = P_2O_5 \times 0.4364$ and $K = K_2O \times 0.8301$. Thus, 100 kg of a 15-15-15 grade contains 15 kg N, about 6.55 kg elemental P and 12.45 kg elemental K. It does not contain 15 kg of each elemental nutrient.

Procurement control. Every nutrient budget should state whether values are elemental P and K or oxide equivalents. Mixing the two conventions creates an accounting error that can propagate into purchase quantities and cost comparisons.

CHAPTER 3

Organic matter, humus and carbon pools

3.3 Organic matter is a changing mixture

Soil organic matter includes materials at different stages of transformation, from recognizable residues and living organisms to small compounds associated with minerals. The word humus is used in several traditions, but it should not be treated as a single uniform substance with an inherent permanence. Modern interpretation emphasizes continuing transformations, environmental conditions and physical or mineral protection. [07, 12]

Particulate organic matter is often associated with relatively recognizable plant-derived material, while mineral-associated organic matter is linked to interactions with mineral surfaces. These operational categories help describe behaviour, but analytical definitions vary. Neither category can be assessed reliably by soil colour alone, and neither provides a universal prediction of future carbon persistence. [12]

Inputs, protection and losses interact

Roots, residues, compost and manure can add carbon, while decomposition and erosion can remove it. Temperature, moisture, aeration, aggregation and mineral surfaces influence what happens next. A management practice may improve cover or infiltration before a statistically detectable increase in soil carbon appears. Conversely, adding a carbon-rich material can increase measured carbon without resolving salinity, nutrient imbalance or land-use conflicts.

Organic matter contributes to multiple functions, but a single target percentage cannot be assigned fairly to every soil and climate. Sandy soils, clay-rich soils and organic soils have different starting points and capacities. A useful target is a locally justified trajectory linked to function, affordability and measurement quality rather than an unqualified global percentage. [03, 07, 12]

Measure the right quantity

Laboratories may report organic carbon directly or estimate organic matter using a conversion. A fixed carbon-to-organic-matter factor is only an approximation and should be declared, not assumed to be exact. Loss-on-ignition and carbon-analysis procedures can also respond differently to mineral composition and carbonates. The report must identify the method and, where relevant, distinguish organic from inorganic carbon. [33, 40]

Management question. Ask whether an input improves the limiting function at an acceptable cost and risk. A larger laboratory organic-matter number is useful only when its measurement and practical significance are understood.

For community learning, examine residues, roots, aggregate structure and the laboratory record together. This links the visible processes of management to the less-visible pools reported by laboratories without suggesting that any one observation measures the entire system.

CHAPTER 3

From carbon concentration to carbon stock

A carbon concentration answers how much carbon is present per unit mass of soil. A carbon stock adds the mass of soil within a defined area and depth. Changes in bulk density, sampling depth or coarse fragments can therefore change the stock estimate even when concentration appears similar. Monitoring protocols need to specify these elements before claiming sequestration. [33]

Constructed calculation: one hectare, 0-20 cm

Assume organic carbon is 1.2% by dry mass, fine-earth bulk density is 1.35 Mg/m³, depth is 0.20 m, and coarse fragments occupy 10% of the sampled volume. For this simplified example, the bulk-density definition and coarse-fragment correction are explicitly compatible.

Stock = 0.012 x 1.35 x 0.20 x 10,000 x (1 - 0.10)

Stock = 29.16 Mg organic C/ha, equivalent to 29.16 tonnes of organic carbon per hectare in the stated layer.

Input	Value used	Important limitation
Carbon fraction	0.012	Must be organic carbon, not an undeclared organic-matter conversion
Fine-earth bulk density	1.35 Mg/m ³	Must be measured and defined consistently
Depth	0.20 m	Surface-only measurements do not describe the whole profile
Coarse-fragment volume	0.10	Correction must not be applied twice

If concentration later reads 1.4% and every other assumption is held constant, the arithmetic stock is 34.02 Mg C/ha, a nominal difference of 4.86 Mg C/ha. This is a teaching calculation, not evidence of a measured project gain. Real comparisons require sampling design, uncertainty assessment and attention to changes in soil mass. [33]

Avoid a false carbon claim

A fixed-depth comparison can be misleading where management changes bulk density or erosion redistributes soil. Equivalent-soil-mass approaches can help make comparisons more meaningful. Baseline selection, spatial variability, laboratory consistency and repeated measurements all affect confidence. A concentration increase in a few convenient samples is not sufficient evidence for saleable carbon credits.

Finance boundary. Do not place carbon-credit revenue in the base budget simply because a practice is expected to add organic matter. Eligibility, additionality, permanence, leakage, monitoring costs and verification belong to a separate project assessment.

CHAPTER 3

Micronutrients and trace elements

3.4 Small quantities do not mean small consequences

Plants need several nutrients in relatively small amounts, while other trace elements may be unnecessary or harmful at sufficient exposure. Deficiency, sufficiency and toxicity depend on the element, crop, soil conditions and exposure pathway. A micronutrient product should therefore be selected to address a supported need, not as an automatic addition to every fertilizer programme. [36, 39]

Element or group	Diagnostic issue	Caution before treatment
Iron and manganese	Availability can be affected by pH and aeration	Yellowing alone does not identify the cause
Zinc and copper	Deficiency may occur in specific soil-crop settings	Repeated additions can accumulate; use suitable tests
Boron	Both deficiency and excess can matter	The useful range can be narrow; avoid unmeasured dosing
Molybdenum	Requirement and pH response differ from some other micronutrients	Do not assume all micronutrients respond to pH in the same direction
Potentially toxic elements	Land-use history and exposure are central	Food safety requires targeted risk assessment, not a generic fertility test

Soil tests and tissue tests answer related but different questions. A tissue concentration reflects the sampled plant part and its growth stage as well as supply, dilution and stress. A soil extract measures an operationally defined pool. Interpret each against appropriate crop and method guidance, and investigate disagreements instead of choosing whichever result supports a preferred product. [39]

Application quality matters

Small application quantities make weighing, mixing and distribution especially important. Concentrated products can create local damage when poorly mixed. Foliar applications require product- and crop-specific guidance; they do not necessarily correct the underlying root-zone problem. Label instructions, compatibility, worker protection and local regulatory requirements should be checked before use.

For community procurement, retain the product label, lot number, analytical specification and application record. Avoid formulations with undisclosed composition or unsubstantiated claims of solving every soil problem. An amendment introduced to correct one deficiency should not create a contamination problem elsewhere in the value chain. [36]

Escalation rule. Where prior industrial activity, mining waste, contaminated water or unknown imported fill creates a plausible hazard, obtain a targeted assessment. Ordinary pH and NPK tests cannot establish that soil or produce is safe.

CHAPTER 3

Laboratory indicators and quality assurance

3.5 Choose a panel that answers the question

A useful laboratory panel is selected from the land-use history, crop, visible constraints and intended investment. Routine fertility analysis may be an appropriate first step, but suspected salinity, sodicity, contamination or unusual mineralogy can require additional methods. Paying for a long list of tests is not a substitute for defining the decision. [35, 39, 40]

Indicator	Interpretation requires	Common reporting failure
pH	Solution, ratio and preparation method	Comparing water and salt-solution pH as identical
Electrical conductivity	Extract or paste method and temperature basis	Treating 1:5 EC as saturated-paste E _{Ce}
Available nutrients	Extractant, crop calibration and units	Using an unrelated regional critical value
CEC and exchangeable ions	Analytical or estimation method	Prescribing an ideal cation ratio without response evidence
Organic carbon	Method, carbonate handling and sampling depth	Calling concentration a carbon stock
Texture and bulk density	Defined fractions and field sampling method	Inferring compaction from texture alone

Quality control belongs to the whole chain

Laboratory proficiency and internal controls matter, but so do field sampling, labels, packaging, storage and transport. A highly capable laboratory cannot reconstruct the correct field identity of a mislabelled bag. Establish a chain of custody and a process for checking unexpected results before a large purchase is authorized. GLOSOLAN resources provide a framework for harmonized procedures and laboratory quality assurance. [35, 40]

For important decisions, discuss duplicate samples, reference materials and suitable checks with the laboratory. A field duplicate, split sample and laboratory analytical repeat examine different sources of variation; they should not be described as interchangeable. Do not average away a surprising result until its origin is understood.

Request an interpretable report

The report should separate measured values from calculated indices and recommendations. It should state units, methods and any limits affecting interpretation. Ask whether the recommendation assumes a crop yield, rooting depth, water supply or product composition that differs from the proposed farm plan.

Release gate. A cluster manager should sign off the sample list, field map and laboratory interpretation before issuing an amendment order. The authority to purchase should be separated from the commercial interest of the input supplier.

CHAPTER 3

A worked diagnosis: do not treat the number alone

The following example is constructed for teaching. It is not an FPI farm result and contains no locally calibrated fertilizer recommendation. A vegetable grower reports poor growth after irrigation on a field that remains wet for several days. Three management zones have been sampled separately.

Evidence	Zone A	Zone B	Zone C
pH in water, same method	6.4	6.5	6.4
Laboratory nutrient interpretation	No major tested deficiency indicated	No major tested deficiency indicated	No major tested deficiency indicated
Field wetness and roots	Drains promptly; roots extend	Persistent ponding; shallow damaged roots	Slow drainage; restricted rooting
Recent traffic	Light	Repeated heavy traffic when wet	Moderate

Step one: state what the evidence supports

The pH values are similar, while physical observations differ. A claim that pH is the dominant cause is not supported by this comparison. The laboratory panel also does not demonstrate a major deficiency among the nutrients tested. Neither finding proves that the crop has unrestricted access to nutrients, because oxygen limitation and damaged roots can reduce uptake. [05, 39]

Step two: keep alternatives open

Investigate levels, compaction, profile restrictions, irrigation, outlets and plausible crop disease. Check sampling quality where findings conflict. Any drainage response needs suitable design and an agreed safe outlet; it must not transfer risk to neighbours.

Step three: propose a safe comparison

Test a suitable water- or traffic-management adjustment against unchanged practice. Record moisture, roots, crop response, labour and cost. Keep fertilizer consistent unless the design explicitly tests another factor; otherwise the cause of a response remains unclear.

Review question. What evidence would justify revising the initial diagnosis? Possible answers include a verified nutrient deficiency, a confirmed disease, or a profile showing a different water restriction. Good diagnosis remains open to disconfirming evidence.

The chapter's central lesson is that chemistry belongs inside a soil-system assessment. CEC, pH, carbon and nutrient tests become decision tools when their methods, mechanisms and field context are understood.

CHAPTER 4

Water, Climate & Soil Resilience

4.1 Follow the water through the landscape

Rainfall or irrigation can infiltrate, run off, evaporate, be used by plants, move laterally or drain below the root zone. The distribution depends on rainfall intensity, surface condition, soil structure, rooting, slope and prior wetness. A soil-resilience plan should therefore examine pathways rather than assume that every additional unit of water reaches the crop. [03, 14, 16]

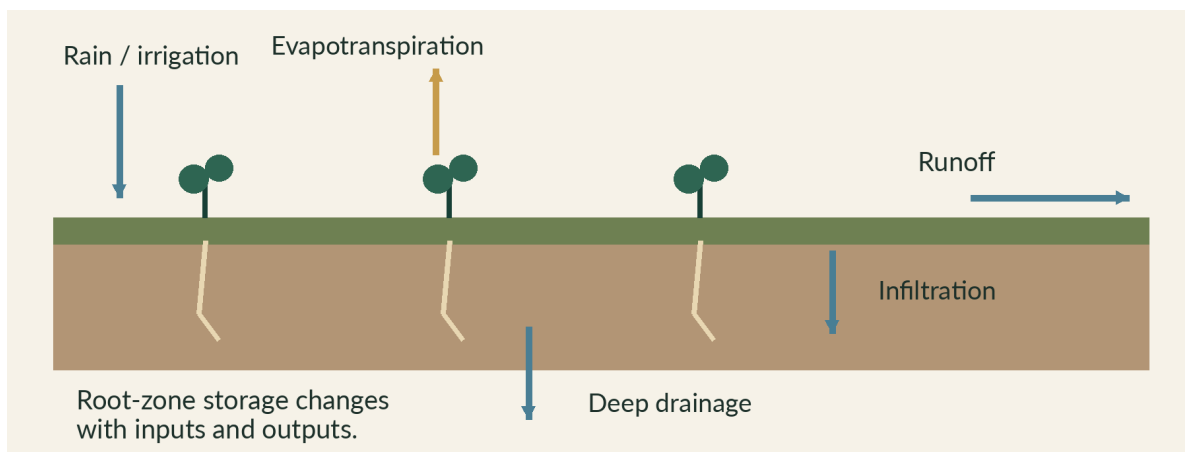


Figure 4.1. Conceptual field water balance. Arrows show possible pathways; their widths are not measured volumes and the diagram is not an engineering design.

For a defined period, a simplified balance is $\text{change in soil-water storage} = \text{rainfall} + \text{irrigation} - \text{runoff} - \text{evapotranspiration} - \text{deep drainage}$, with additional terms where lateral inflow, outflow or capillary rise are important. Leaving out a major pathway can make an apparent efficiency improvement misleading. A field may infiltrate more water but also drain more below the crop's effective roots.

Resilience includes both shortage and excess

Drought management seeks to improve access to limited water, reduce avoidable loss and match demand to supply. Flood management seeks to protect people, structures, roots and downstream users from excess or poorly timed water. The same practice can help one objective while creating a problem for the other. Retaining runoff on a crusted dry field differs from concentrating water on an already saturated site. [14, 15]

Community planning should identify shared catchments, drainage lines, water points and sensitive downstream areas. Small field changes can accumulate across a slope. A contour structure, road crossing or outlet must be evaluated as part of the connected landscape rather than as an isolated farm asset.

Design boundary. Use the following field methods for diagnosis and learning. Sizing dams, major drains, culverts, terraces or flood-control works requires competent local engineering, permissions and an assessment of failure consequences.

CHAPTER 4

A field infiltration test and its limits

A ring infiltration test can support farmer learning about surface condition and water entry. It is not automatically a measurement of saturated hydraulic conductivity, and one test does not characterize an entire farm. Initial moisture, ring insertion, cracks, vegetation and soil disturbance can influence the result. Use a consistent protocol and replicate within meaningful management units. [16]

A practical comparison procedure

Choose comparable locations that represent the question: for example, a protected crop row and a trafficked strip. Record the soil condition, recent weather, cover and visible cracks. Insert an appropriate ring carefully to the specified depth without excessively disturbing the enclosed surface. Add a known water depth using a method that avoids scouring, and time infiltration according to the chosen protocol. Repeat as specified and record every result rather than only the fastest or slowest.

A later application can behave differently because the soil is wetter. This is information, not a reason to discard it. Note preferential flow down cracks or along a poorly sealed ring. Repeat tests across the unit and report the range as well as a summary. Measurements from different initial moisture conditions should not be presented as an unqualified treatment effect. [16]

Constructed volume and rate calculation

For a ring with 20 cm internal diameter, area = $\pi \times 0.10^2 = 0.0314 \text{ m}^2$. A water depth of 25 mm requires approximately 0.785 litres. If that depth enters in 20 minutes, the simple average rate is $25 / (20/60) = 75 \text{ mm/hour}$. If a subsequent equal depth takes 40 minutes, its average is 37.5 mm/hour.

These illustrative rates are interval averages, not proof of a stable long-term rate. They should not be used alone to size irrigation systems or drainage works. The comparison becomes useful when combined with surface sealing, root, profile and runoff observations.

Field record. Record ring diameter, insertion depth, added volume, time, initial moisture, repeat number, surface cover, location and unusual flow. A rate without this context is difficult to compare or audit.

Ask learners what management process could explain a difference and what other evidence would test that explanation. This keeps the exercise focused on diagnosis rather than on producing an impressive number.

CHAPTER 4

Runoff, erosion and sediment control

Erosion is a detachment-and-transport process, not simply the presence of a steep slope. Rain impact, concentrated flow, ground cover, soil structure, slope length and water pathways interact. Productive fine material and associated nutrients can leave a field even when the loss is not visually dramatic after every storm. Deposited sediment elsewhere is not proof that the source field can tolerate continuing loss. [03, 08]

Start with a landscape walk after rain

Look for splash marks, surface crusts, small channels, exposed roots, sediment fans and blocked outlets. Mark where water enters the property and where it leaves. Observe roads, tracks and roof drainage as well as cropped land, because concentrated flow may originate outside the cultivated area. Photographs should be taken from fixed points and paired with dates and rainfall context.

Protecting cover and avoiding unnecessary disturbance can reduce exposure. Vegetated strips, contour-aligned operations and suitable water-spreading measures can help in appropriate settings, but their design must match slope, soil, flow and maintenance capacity. A barrier that fails or diverts water onto an unprotected neighbour can make conditions worse. Do not prescribe spacing or embankment dimensions without site-specific design. [03, 25]

Separate prevention, repair and engineering

Preventive management includes maintaining protective cover, controlling traffic and managing runoff sources. Repair may include stabilizing disturbed areas and restoring vegetation. Active gullies, unstable banks and large concentrated flows require specialist assessment; filling a gully with loose material or blocking a drainage line can create a new failure.

Observation	Immediate management question
Sediment at a field edge	Where did it originate, and is the flow source still active?
Water crossing a farm road	Does the crossing safely accommodate expected flow?
Exposed roots on a slope	Is ongoing soil removal affecting anchorage or productivity?
A new channel below a barrier	Has the intervention concentrated or redirected runoff?

Community responsibility. Agree who inspects shared structures after major rain, who can authorize repairs and how downstream complaints are handled. Installation without a maintenance arrangement is an incomplete intervention.

Monitoring should connect physical observations to management decisions. A declining number of visible rills is encouraging, but comparisons need similar observation conditions and should not be converted into tonnes of soil saved without a defensible measurement method.

CHAPTER 4

Drought and root-zone water accounting

4.2 Water storage must be accessible to roots

A soil may contain water that the crop cannot extract effectively, or a wet layer may lie below the active root zone. Plant-available water is often approximated from the difference between field capacity and permanent wilting point, multiplied by effective rooting depth. These terms are operational and crop access changes with rooting, salinity and soil structure. A calculation is a planning aid, not a substitute for field monitoring. [14, 15]

Constructed root-zone example

Assume volumetric water content at field capacity is 0.30 m³/m³, at wilting point 0.15 m³/m³, and effective rooting depth 0.60 m. Total available water is $(0.30 - 0.15) \times 0.60 \times 1,000 = 90$ mm.

For an illustrative allowable depletion fraction of 0.40, the planning trigger is 36 mm depletion. At an assumed net demand of 4.5 mm/day and with no rainfall, the arithmetic interval is eight days. The fraction and demand are assumptions, not recommendations for a specific crop. Weather, rooting and growth stage can alter the appropriate trigger.

If the net replacement requirement is 36 mm and an assumed application efficiency is 85%, gross applied depth is $36 / 0.85 = 42.35$ mm, equivalent to about 424 m³/ha. This excludes any separately justified leaching requirement and does not prove that the irrigation system distributes water uniformly. [14]

Manage before stress becomes severe

Use field observations or suitably calibrated sensors at relevant depths, and check whether the crop is rooting where water is being measured. Repair avoidable distribution problems, prioritize critical growth stages and match planted area to dependable supply. Mulch or improved infiltration may help, but neither creates water where seasonal supply is insufficient.

Drought decision. A smaller, reliably watered and well-managed area may be more defensible than expanding acreage on optimistic water assumptions. Agree allocation rules before shortage creates conflict.

Community planning should include crop choice, planting windows, water access, feed reserves where relevant and financial exposure. The soil component is essential, but resilience also depends on the ability to change plans without losing land rights, access to services or household security.

CHAPTER 4

Flooding, waterlogging and drainage safeguards

Waterlogging restricts oxygen supply to roots and changes soil chemical and biological processes. Flooding can also move sediment, contaminants and plant material across boundaries. The consequences depend on duration, temperature, crop tolerance, water quality and the soil profile. A wet field therefore requires diagnosis of both the water source and the crop's sensitivity. [03, 14, 15]

Distinguish the problem before moving soil

Surface ponding caused by poor levelling differs from a perched water table above a restrictive layer, high groundwater or river flooding. Each requires different information. Record when water appears, how long it persists, whether neighbouring fields are affected and whether the profile shows a restrictive horizon. Identify any existing drainage infrastructure and its condition.

A drain is not complete until a safe, lawful and physically suitable outlet exists. Discharging saline or contaminated water can create harm beyond the treated field. Wetland conversion and major water diversion may carry ecological, tenure and regulatory implications. Obtain local specialist and regulatory advice rather than assuming that making land drier is always an improvement. [14, 18, 36]

Low-regret operational measures

Avoid heavy traffic when the soil is vulnerable to deformation. Keep known safe access routes and existing permitted drainage paths maintained. Separate clean and potentially contaminated water where appropriate. Protect stored amendments, seed and harvested produce from flood exposure. Where a crop is repeatedly unsuitable for the wetness regime, changing land use may be preferable to an expensive and damaging drainage attempt.

Trigger	Proposed response to localize
Persistent ponding after ordinary irrigation	Review application, levels, roots and profile restrictions
Forecast or observed hazardous flooding	Protect people first; follow local emergency guidance
Suspected contaminated floodwater	Restrict exposure and seek crop/soil safety assessment
Recurrent crop loss in a wet depression	Reassess land use and full drainage feasibility

Safety boundary. Do not enter unstable channels, excavations, confined drains or fast-moving floodwater to obtain observations. Field data never justify putting workers or community members at avoidable risk.

Following a flood, document impacts before repair where safe, review the cause and update the contingency plan. A repair that simply restores the previous failure-prone arrangement is not necessarily a resilience improvement.

CHAPTER 4

Climate risk without false precision

4.3 Plan for changing conditions and uncertainty

Climate assessments identify important risks to African agriculture, including heat, drought, heavy rainfall and interacting pressures on livelihoods and ecosystems. These risks vary by region and are shaped by exposure and vulnerability as well as the physical hazard. A continental assessment cannot supply a precise forecast for an individual field or guarantee the effectiveness of a particular adaptation. [15]

Soil management influences how a farm experiences weather: cover affects surface exposure, roots and structure affect access to water, and erosion can reduce future productive capacity. Yet good soil management cannot eliminate all climate losses. Financial reserves, crop choice, reliable information, water governance and social support remain part of the adaptation system.

Use a scenario rather than a single optimistic season

Develop at least a normal-operating scenario, a dry or interrupted-rainfall scenario and an excessive-water scenario relevant to the site. For each, identify what fails first, what can be observed early and what action is feasible. A response should have a named decision-maker, a cost and a trigger. "Be climate smart" is not an operational instruction.

For a community cluster, examine correlated risk. If many members depend on the same water source or planting window, losses may occur together. A pooled service or revolving fund should not assume that member risks are independent. Diversification can help only where enterprises genuinely differ in exposure and market demand; adding another crop name is not automatically diversification.

Review the adaptation itself

A cover crop may improve protection but consume water before the main crop. A water-harvesting structure may benefit a field while reducing access downstream. A heat-tolerant variety may have a market disadvantage. Review these trade-offs with affected users, not only with the technical team. [15, 17, 18]

Evidence statement. Describe an intervention as intended to reduce a specified risk under stated conditions. Avoid claims that it will climate-proof the farm, guarantee yields or permanently restore resilience.

The practical goal is adaptive capacity: the ability to recognize change, evaluate evidence, act early and revise management. Soil indicators should support those decisions rather than become a reporting exercise disconnected from the next season's choices.

CHAPTER 4

Mulch: protection with a resource budget

4.4 Match the material to the function

Mulch can protect the soil surface, reduce direct evaporation and influence temperature, weed emergence and biological activity. The outcome depends on material, coverage, timing, climate and crop management. A mulch layer is not automatically beneficial in every wetness, pest or fire-risk setting, and it does not replace a nutrient or irrigation plan. [03, 17]

Crop residues have competing uses: livestock feed, bedding, fuel, building material and sale. A technical recommendation that assumes all residues are freely available can transfer costs to households or livestock keepers. Community planning should establish ownership, seasonal demand and the consequences of retaining or moving material. Imported mulch also brings transport cost and possible weed, pest or contamination risks.

A practical allocation process

Estimate the material available after legitimate competing uses. Identify the fields or periods where surface protection has the greatest value, such as vulnerable establishment stages or exposed strips. Trial a manageable treatment alongside current practice and record cover, labour, moisture observations, crop response and any pest problems. Specify the material and application method so another farmer can understand what was actually tested.

Avoid placing inappropriate wet organic material against sensitive plant stems. Investigate material quality and crop-specific disease or pest concerns. Where plastic mulch is used, account for retrieval, disposal and fragment pollution rather than treating it as equivalent to a biodegradable residue. [03, 36]

Cost or benefit	What to record
Material supply	Source, ownership, quantity and competing use
Labour	Collection, transport, spreading and later handling
Soil protection	Consistent ground-cover observations and erosion signs
Crop outcome	Establishment, yield, quality and water-management changes
Side effects	Weeds, pests, fire exposure or disposal problems

Community agreement. A residue-retention trial on an individually cultivated field may still affect communal grazing. Negotiate access and compensation arrangements before installation, not after conflict emerges.

A successful mulch strategy is one that improves the relevant soil function and remains workable through the agricultural calendar. It may involve selective placement, timing or integration with livestock management rather than blanket retention of every available residue.

CHAPTER 4

Cover crops: functions, timing and water trade-offs

Cover crops can protect soil, support biological activity, capture nutrients or provide other services between or alongside cash crops. Species choice, establishment and termination determine whether those functions are achieved. A species list from another region is a starting point for investigation, not a local recommendation. [17]

Specify the job before choosing the species

Decide whether the priority is erosion protection, weed suppression, nitrogen contribution, nutrient capture, forage or another function. One species or mixture may not deliver all objectives simultaneously. Consider seed availability, crop rotation, pest hosts, equipment, labour and whether the species could become invasive or problematic locally.

Water is a central trade-off. Growing cover uses water as well as protecting the surface. In a water-limited season, late termination can reduce moisture available to the following crop. In other conditions, improved cover and structure may support better water management. The balance must be tested with the actual climate, soil and calendar rather than described as universally positive. [17]

Design a fair local comparison

Compare a clearly defined cover-crop treatment with current practice on similar land. Record establishment date, rainfall or irrigation, biomass management, termination date, labour, seed cost and following-crop performance. Where grazing is part of the system, include its effects and value explicitly. A harvested forage cover and an unharvested green manure are different treatments.

Legume nitrogen contributions require careful accounting. Biomass removal reduces what remains for the following crop; decomposition and release may not coincide with demand. Do not claim a fixed fertilizer replacement merely because the seed mixture contains a legume. [11, 17]

Go/no-go rule. Do not expand a cover-crop package until the community understands its water requirement, termination method, labour peak and effect on the following crop. Good biomass production alone is not enough.

An appropriate programme may begin with a few locally adapted species and a single clear question. Adding many untested species can make seed procurement difficult and results uninterpretable. Farmers should retain the ability to stop or modify a treatment when agreed moisture, labour or crop-establishment thresholds are breached.

CHAPTER 4

Agroforestry and living landscape infrastructure

Trees and shrubs can contribute litter, roots, shade, habitat and products, while influencing wind, water and nutrient pathways. They can also compete with crops for light, water and nutrients. The outcome depends on species, density, arrangement, management, site and rights over the trees and land. Agroforestry is therefore a design problem rather than a universal instruction to plant more trees. [03, 26]

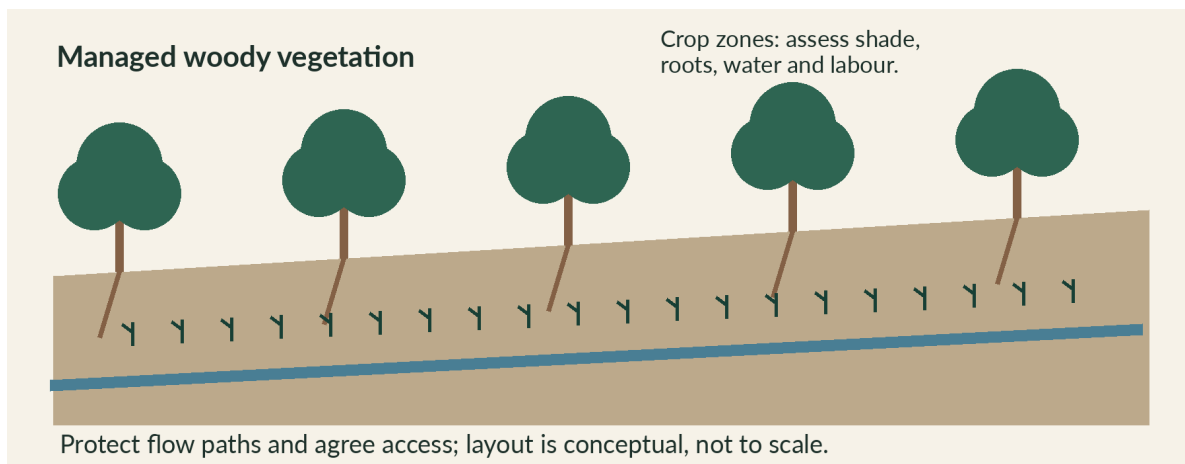


Figure 4.2. Conceptual integration of trees, cropped areas and protected flow paths. Spacing and species are intentionally unspecified because they require local assessment.

Start with existing vegetation and rights

Assess natural regeneration, useful established trees and sensitive habitats before purchasing seedlings. Farmer-managed natural regeneration may be appropriate where living root systems or suitable seedlings are present and users have the authority and incentive to protect them. It is not the same as a plantation, and it cannot be assumed feasible on every treeless site. [26]

Discuss who may prune, harvest, graze beneath or sell products from trees. A long-lived planting can create expectations about land ownership or future access. Agreements should address tenants, women, neighbouring users and succession rather than relying on the person who attends the launch ceremony. [18]

Monitor both benefits and competition

Record survival or retained stems, management labour, crop performance near and away from trees, product use and disputes. Observe effects across seasons, because a short-term establishment visit may miss later competition or benefits. Avoid extrapolating carbon or income gains from tree counts alone.

Design question. What problem does each tree component solve, who maintains it, and what happens if it reduces crop performance or access? A clear answer is more useful than a target number of seedlings.

Do not use agroforestry to justify ecosystem conversion or displacement. Specify where trees belong, where they do not, and how management will adapt as they mature.

CHAPTER 4

A resilience plan with observable triggers

A resilience plan should be short enough to use during a difficult season and specific enough to guide action. It connects a hazard, an observation, an accountable person and a pre-agreed response. The example below is a proposed framework, not a forecast or a substitute for local emergency procedures. [15]

Risk	Evidence or trigger to define locally	Prepared response
Water shortage	Root-zone depletion and dependable supply fall beyond an agreed limit	Prioritize critical areas, revise scheduling and avoid unsupported expansion
Erosive runoff	New rills, sediment or failure at a known flow concentration	Inspect safely, protect affected areas and obtain design advice where needed
Waterlogging	Persistent saturation or repeated root damage	Review irrigation and drainage feasibility; reassess crop suitability
Salt accumulation	Repeated method-consistent EC evidence and crop symptoms	Test water and soil profile; review salt balance before reclamation
Material shortage	Residues or cover seed unavailable at the planned time	Use an agreed alternative rather than untested emergency procurement

Assign responsibility before the event

The farmer records field conditions, the cluster facilitator checks the consistency of observations, and a competent specialist addresses high-risk technical questions. Community representatives help resolve shared-water or grazing implications. The project manager records costs and authorizes changes within a stated budget. These are proposed roles to adapt, not a claim that every FPI cluster already operates this system.

Learn from both failure and recovery

After an extreme event, ask which assumptions failed. Was the hazard larger than expected, the structure poorly maintained, the soil diagnosis incomplete or the response delayed? Distinguish unavoidable exposure from preventable management weakness. Include households whose losses were not visible at the demonstration plot.

A useful review compares the crop result, soil condition, cost and recovery time. A treatment that protects yield but creates unacceptable downstream damage or labour demand is not an unqualified success. Similarly, a modest crop outcome with lower financial exposure may be valuable in a severe season.

Chapter exercise. Develop one dry-season and one excessive-water scenario for a selected field. State the early observation, the action threshold, the person responsible and the cost ceiling. Identify one way the proposed action could harm another user.

Water resilience is strongest when physical measures, reliable observations and community agreements reinforce each other. The next chapter examines the social arrangements that allow those decisions to remain legitimate over time.

CHAPTER 5

Cultural & Community Approaches to Soil

5.1 Knowledge, authority and daily practice

Soil interventions change how land, water, residues, labour and information are used. These resources rarely belong to a project in isolation. A field may be cultivated by one household, grazed seasonally by others, crossed by a drainage line and understood through several knowledge traditions. Community-led stewardship begins by recognizing these relationships rather than treating the site as an empty technical space. [18, 19, 21]

Local and Indigenous knowledge can include distinctions in soil behaviour, landscape position, crop performance, seasonal signals and management history. Scientific methods add other forms of observation and testing. The purpose of collaboration is not to force one system to validate the other in every respect, but to make practical decisions more informed while respecting the authority of knowledge holders over what they share. [21]

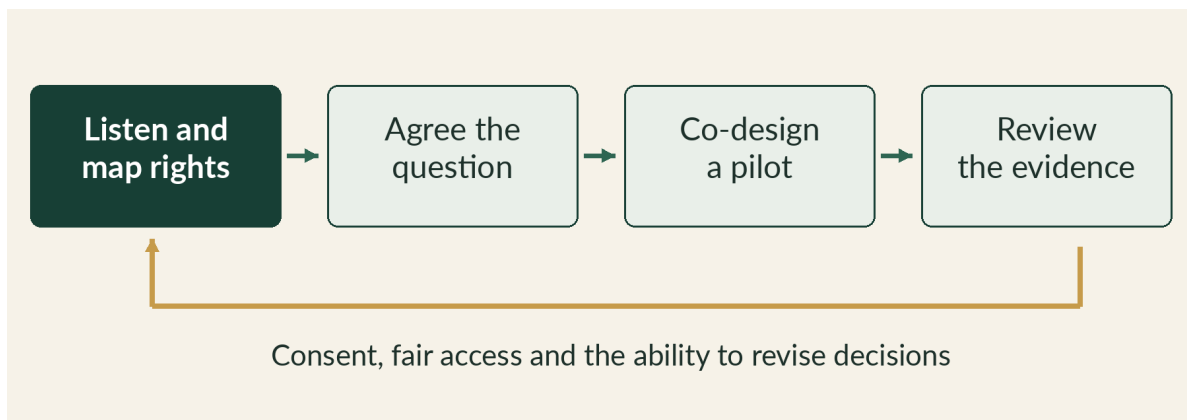


Figure 5.1. A proposed community decision cycle. Consent, access and the right to revise decisions apply throughout, not only at the first meeting.

Participation must change the decision

A meeting is not community leadership merely because local people attend. Meaningful participation affects the problem definition, options, resources, implementation and review. People should be able to question a proposed input, refuse a trial, request an alternative or challenge how benefits are distributed without losing access to unrelated services. [19, 20]

Facilitators should identify whose knowledge is absent: women managing particular crops, tenants, seasonal workers, livestock keepers, young people, people with disabilities or households far from the meeting place. No single spokesperson can automatically represent all interests. Recognize legitimate institutions while creating safe routes for less-powerful participants to contribute.

Working principle. Do not ask only, "Will the community adopt this practice?" Ask, "Who helped choose it, who carries its costs, who benefits, and who can change the decision?"

The tools in this chapter are proposed operating practices for FPI and its partners to adapt. They are not claims about the customs of a named community, and they do not replace local legal obligations or the specific rights of Indigenous peoples.

CHAPTER 5

Local soil names as structured evidence

A local soil classification may distinguish soils through colour, feel, wetness, landscape position, vegetation or crop behaviour. Names may also encode history and use. These distinctions can reveal management boundaries that a coarse map misses. However, a local name should not be translated automatically into a WRB Reference Soil Group: the systems may classify different attributes for different purposes. [01, 21]

A respectful documentation method

Begin by asking whether the knowledge can be recorded, by whom and for what use. Work in the preferred language and retain the original term where the speaker agrees. Ask knowledge holders to describe the attributes and decisions associated with the term. Record disagreement or variation rather than forcing a single official definition.

Walk to several examples with willing participants. Describe landscape position, texture by field assessment, wetness, vegetation, management history and observed crop behaviour. Where laboratory or profile work is appropriate and consented, link those results to the same locations. The aim is a cross-reference that supports learning, not a declaration that the local term was wrong because it does not match an external category.

Documentation field	What to record
Original term	Language, spelling and agreed pronunciation guidance
Knowledge source	Attribution or anonymity as requested; consent conditions
Defining characteristics	Observable features and seasonal behaviour
Management meaning	Crops, timing, risks or practices associated with the term
Scientific cross-reference	Measured attributes, with uncertainty and no forced equivalence
Sharing restriction	What may be published, stored, taught or withheld

Keep the classification open

A term can vary between neighbouring settlements or generations. Record whose usage is represented and invite correction before publication. Avoid extracting knowledge into a database that the community cannot access, read or amend. Return the documented material in a useful format, including oral or visual formats where needed. [19, 21]

Research question. When local classifications identify two areas that a map treats as one, investigate the difference. When a laboratory identifies a difference that farmers do not regard as important, discuss whether it changes an actual management decision.

This approach preserves the practical value of local observation while making methods and uncertainty visible. It also creates a shared vocabulary for later sampling, trials and community scorecards.

CHAPTER 5

Cultural beliefs, restrictions and land practices

5.2 Respect without stereotyping

Soil and land may carry spiritual, ancestral, historical or collective meanings. Some places, activities or knowledge may be restricted. These relationships should be learned from the people concerned, not inferred from ethnicity, country or a generic description of tradition. This volume does not attribute a specific ritual or taboo to any named community without evidence and permission. [19, 21]

A cultural restriction can affect where sampling is allowed, who may enter a site, when work can occur or whether a photograph may be taken. The appropriate response is dialogue and an agreed alternative, not a claim that scientific work automatically overrides local authority. At the same time, engagement should respect individual rights and avoid using custom as a reason to exclude or silence affected people. [18, 19, 20]

Questions a facilitator can ask

Ask whether there are places that should not be entered, materials that should not be removed, times when work should pause or procedures that require discussion. Ask who should be consulted and whether some conversations should happen separately. Explain the proposed activity in practical terms: the size of the sample, the destination, whether it will be destroyed during analysis and how results will be used.

Do not photograph, collect, publish or commercialize culturally sensitive material merely because a person allowed a site visit. Consent should fit the specific use. A community may permit a soil test while declining publication of the location or associated knowledge. These choices can be recorded without disclosing the restricted content itself. [19, 21]

When views differ within the community

Expect variation. Elders, farmers, women, youth and formal institutions may hold different views about a place or intervention. Create a process for resolving disagreement without assuming that the most powerful participant has settled every question. Where a conflict concerns rights or safety, pause the affected activity and seek appropriate local advice.

Practical alternative. A protected site can sometimes be excluded from sampling while nearby permitted land is studied. State the resulting limitation honestly rather than entering without consent or implying that the unsampled area was assessed.

Cultural respect strengthens research quality by clarifying where evidence was obtained, what cannot be inferred and how collaboration can continue. It is part of the method, not a ceremonial addition to the launch event.

CHAPTER 5

Participatory mapping and consent

A community soil map can combine land-use history, local soil distinctions, wet areas, erosion pathways and proposed management units. It should not be presented as a cadastral survey, a legal determination of ownership or a precise soil-classification map unless those separate processes have actually been completed. [18, 19]

Build the map in layers

Start with a sketch that participants can recognize: roads, water points, fields and landmarks. Add soil and water observations in a different layer from tenure or access information. Mark uncertain boundaries and disputed areas explicitly. Separate public information from sensitive locations and personal records, and decide who can view each layer.

Walk selected areas with willing users to check the sketch. Record dates and the basis of each feature: observed, reported, measured or inferred. A GPS point can improve location accuracy but does not make an uncertain boundary legally authoritative. Confirm the map with affected users before using it to allocate resources or publish project claims.

Consent is specific and revisable

Explain the purpose of mapping, expected outputs, who will hold the data, possible risks and the options for declining. Use language and formats participants understand. Allow time for discussion without pressure from a grant deadline or input-distribution event. Where Indigenous peoples' rights are engaged, apply the relevant free, prior and informed consent framework and obtain appropriate local guidance. [19]

Proposed use	Permission to resolve
Internal sampling plan	Who may see field identities and access routes?
Training poster	Which locations and names may be displayed?
Public website map	Could disclosure create tenure, security or commercial risk?
Research publication	What attribution, review and sharing conditions apply?
Future commercial use	Is new consent or a benefit-sharing agreement required?

Map legend rule. Use different symbols for measured points, community-reported features and uncertain boundaries. A clean-looking map must not erase uncertainty or disagreement.

Give participants a copy or accessible record of the agreed map and a way to request corrections. Review it when land use, access or the project purpose changes. The map should serve the community's decisions rather than become a one-way extraction of information.

CHAPTER 5

Gender, labour and decision-making power

5.3 Inclusion is more than attendance

Women and men can face different access to land, finance, training, labour, information and decision-making power. These patterns vary within and between communities. A soil programme should investigate the actual distribution of work and authority rather than assume that inviting equal numbers to a meeting creates equal benefit. [20]

A practice may look inexpensive because unpaid labour is omitted. Compost preparation, residue transport, water collection and repeated monitoring can shift work onto people whose time is already constrained. Record who performs each task, when it occurs and what activity is displaced. Report both cash expenditure and labour requirements so the community can judge the full cost.

Design access around real constraints

Discuss meeting time, location, transport, childcare needs, language and safety. Offer more than one route to contribute, including smaller conversations where appropriate. Ensure that the person who performs field work can access the results and training, even when another household member holds a formal title or signs the purchase order.

Separate participation indicators from agency indicators. Attendance measures presence. Agency concerns whether people can influence the choice of practice, control benefits, access services and raise concerns without retaliation. A programme can meet a numerical attendance target while leaving these conditions unchanged. [20]

Question	Evidence to collect ethically
Who performs the new work?	Task and seasonal labour records, not assumptions
Who controls the input or equipment?	Access arrangements and actual use
Who receives or decides over income?	Voluntary, appropriately confidential feedback
Who can challenge a decision?	Functioning complaint routes and documented responses
Who drops out, and why?	Safe follow-up that does not punish refusal

Safeguard. Do not publish sensitive household financial or conflict information merely to demonstrate inclusion. Aggregate or anonymize results as agreed, and avoid exposing participants to harm.

An equitable soil intervention should improve both the technical service and access to its benefits. Where a proposed practice increases unpaid work or reduces control over resources, redesign the delivery or financing arrangement rather than treating resistance as a lack of awareness.

CHAPTER 5

Youth as skilled stewards, not unpaid labour

Young people can contribute to soil sampling, records, nursery work, digital mapping, equipment services and farmer-to-farmer learning. A credible programme should define these as skilled roles with supervision, learning outcomes and fair terms, rather than assuming that enthusiasm substitutes for remuneration or land access. The proposed approach is consistent with FPI's stated emphasis on inclusive agricultural enterprise development. [38]

Build a service pathway

A trainee might begin with field identification, sample labelling and basic safety, then progress to supervised measurements, record checking and interpretation meetings. Competence should be demonstrated through accurate work, not attendance alone. Tasks such as chemical handling, machinery use or work near unstable excavations require appropriate age, training, supervision and local legal compliance.

Provide access to the tools needed for the role. A digital record system that requires a personal smartphone and paid data can exclude capable participants. Shared devices, paper backups and offline entry may be more equitable. Establish who owns the data and equipment, who pays for maintenance and what happens when the trainee leaves.

Link training to a viable opportunity

Before promising enterprise income, assess actual demand for the service, the price customers can pay, seasonal workload, transport and quality-control costs. A soil-sampling enterprise needs reliable sample handling and laboratory relationships; an attractive certificate alone does not create a market. Avoid guaranteeing employment or business success without a real arrangement.

Proposed role	Competence to demonstrate	Support required
Sampling assistant	Correct unit, depth, labels and chain of custody	Supervision, tools and transport
Data steward	Accurate entry, backups and privacy	Device access and clear permissions
Demonstration facilitator	Explain methods and distinguish evidence from claims	Mentoring and locally appropriate materials
Service entrepreneur	Costing, quality control and customer communication	Market testing and realistic finance

Programme quality. Record paid work, practical competence, continued participation and access to opportunities. Do not describe every trained participant as an established agribusiness owner.

Youth involvement becomes durable when it offers a credible progression from learning to responsibility and, where feasible, income. That progression should be negotiated alongside the land and resource decisions discussed in the following sections.

CHAPTER 5

Land governance and the investment horizon

5.4 Secure decisions before long-lived investments

People are more able to maintain soil improvements when their rights and responsibilities are sufficiently clear. Tenure can involve statutory, customary, collective and informal arrangements, often with overlapping users. The relevant question is not only who holds a document, but who has legitimate access, use and decision rights under the applicable framework. International voluntary tenure guidance provides principles; local legal advice remains necessary. [18]

A short-term tenant may not recover the benefit of a multi-year amendment or tree investment. A communal grazing area may be affected by fencing a demonstration plot. A drainage outlet may depend on permission across another property. These are design conditions, not administrative details to resolve after procurement.

A practical rights-and-responsibilities review

Identify owners, cultivators, tenants, seasonal users, grazers and affected downstream users. Record the duration and limits of permissions, the authority to install or remove structures and the treatment of improvements when an agreement ends. Discuss inheritance, leadership changes and what happens if a participant withdraws. Keep disputed claims visible and avoid implying that the project has adjudicated them.

Investment	Governance question before approval
Lime or other multi-season amendment	Can the current user benefit over the intended period?
Trees or perennial crops	Who owns the trees and may harvest or remove them?
Shared compost site	Who provides land, controls access and bears nuisance risks?
Drainage or water-harvesting work	Whose land and water rights are affected?
Monitoring installation	Who can access, maintain and remove equipment?

Avoid coercive conditionality

Access to unrelated training or services should not be withheld to force acceptance of a land-use change. Contracts and consent documents should be understandable, and people should have a realistic opportunity to seek advice. Where a dispute is unresolved, select another site or postpone the affected investment rather than allowing the project schedule to determine rights. [18, 19]

Governance gate. No long-lived installation should proceed until access, maintenance, benefit-sharing and exit arrangements are documented at a level appropriate to its risk and the applicable law.

Clear governance protects both communities and project resources. It also improves the interpretation of results, because an intervention that cannot be maintained under real tenure conditions is not ready for wide promotion.

CHAPTER 5

Commons, residues, grazing and shared water

A soil practice can create benefits on one field and costs elsewhere. Retaining crop residues may reduce livestock feed; fencing a restoration area may change movement routes; harvesting runoff may alter downstream supply. Community stewardship requires discussion of these external effects, not only the yield response on the treated plot. [03, 18]

Make the seasonal resource calendar visible

Map when residues, grazing, water, labour and access routes are most important. Include dry-season and emergency uses that may be absent during a rainy-season consultation. Ask different user groups to describe the calendar separately before negotiating a shared picture. This reduces the chance that the dominant agricultural enterprise defines every other use as waste or inefficiency.

A negotiated arrangement might reserve part of the residue for cover, identify alternative forage, allow managed grazing after a defined period or protect a small trial rather than a large area. These are options to assess, not universal prescriptions. The agreement should explain enforcement, exceptions during hardship and who reviews unintended consequences.

Use a transparent dispute process

Record the issue, affected users, evidence and proposed options. Separate technical questions from rights questions: a measurement of water flow does not decide who is entitled to the water. Provide a neutral or agreed route for mediation and appeal. A traditional or elected leader may play an important role, but participants should also have a safe way to raise concerns about the process itself. [18, 19]

Conflict risk	Preventive agreement
Livestock enter a trial	Mark boundaries, discuss access and define proportionate responses
Residue removal undermines cover	Agree quantities, timing and legitimate alternative uses
Drainage affects a neighbour	Assess the outlet and obtain appropriate permissions before work
Shared tools are captured by a few members	Publish booking, fee and maintenance rules
A benefit-sharing promise is disputed	Record the terms and review evidence openly

Do not confuse compliance with consent. A person may follow a rule because they fear losing access to land or services. The programme should investigate whether the arrangement is understood and regarded as legitimate, not simply whether violations are rare.

A functioning commons arrangement is a soil-management asset. It makes maintenance, monitoring and adaptation possible across boundaries that individual field recommendations often ignore.

CHAPTER 5

Building commitment through credible choices

5.5 Replace persuasion with informed co-design

Community "buy-in" is strongest when people can evaluate a real choice. Present the problem, the evidence, the alternatives, the likely effort and the uncertainty. Do not frame a meeting as consultation when procurement or land-use decisions have already been finalized. People should be able to propose a smaller pilot, a different practice or no intervention. [19, 22]

Show the full proposition

Explain what the practice is intended to change and what it will not solve. State who pays, who supplies labour, who receives benefits and who bears failure risk. Demonstrate the measurement method and allow participants to inspect records. Where an input supplier is involved, disclose the commercial interest and separate sales claims from independent interpretation.

A useful communication sequence begins with the farmer's observed problem, moves to competing explanations and ends with a testable decision. For example: poor crop growth might reflect acidity, waterlogging or nutrient shortage; the proposed diagnosis distinguishes these; the pilot will test the selected explanation within an agreed cost ceiling. This is more credible than promising a universal yield increase.

Treat hesitation as information

A farmer may decline because of labour timing, tenure insecurity, feed needs, previous project experience or uncertainty about the market. These are not necessarily failures of awareness. Record concerns without naming or shaming individuals, and modify the design where possible. A programme that learns why people decline can improve more than one that reports only acceptance rates.

Communication claim	More defensible wording
"This restores all soils"	"This addresses a specified constraint under these conditions"
"Every farmer will benefit"	"The pilot will test benefits, costs and who can use the practice"
"The laboratory proves success"	"The laboratory measures selected indicators; field outcomes also matter"
"The community agreed"	"These users agreed to these activities, with these recorded limits"

Trust practice. Publish disappointing or neutral findings alongside favourable ones. Explaining why an attractive treatment was not scaled can strengthen confidence in the service.

Commitment grows when the programme keeps promises that are within its control: respectful engagement, accurate records, timely feedback and fair review. Those commitments are more reliable than promises about weather, markets or guaranteed biological responses.

CHAPTER 5

A community co-design workshop

The following workshop format is proposed for local adaptation. Its purpose is to agree a manageable soil-learning pilot, not to secure unconditional approval for a preselected package. Preparation should include accessible invitations, a clear explanation of the decision, language support and a plan for participation by people whose schedules or responsibilities differ. [19, 20, 22]

Before the meeting

Prepare a simple site sketch, the available soil evidence and a list of uncertainties. Identify who may be affected beyond the proposed demonstration site. Disclose any input-sales interest and explain which resources are actually available. Do not present speculative funding or future market access as a confirmed benefit.

Workshop stage	Activity	Agreed output
Understand the problem	Farmers describe symptoms, history and seasonal constraints	A jointly worded problem statement
Compare explanations	Review field observations and laboratory evidence	Questions requiring more evidence
Examine options	Discuss at least one alternative and the option to pause	A short list with costs and risks
Design the pilot	Select site, comparison, measurements and responsibilities	A practical trial or demonstration plan
Establish safeguards	Discuss consent, labour, access, data and complaints	Recorded conditions and unresolved issues
Set review	Agree when and how results will be discussed	Review date and decision criteria

During discussion

Use small groups where they help people speak freely, but do not assume that every group member shares the same opinion. Ask participants to distinguish direct observations from expectations. A facilitator should summarize disagreement accurately rather than forcing a unanimous-looking record. Where a rights or safety issue remains unresolved, record the pause and the next step.

After the meeting

Return the agreed plan in an accessible form. Confirm that the people assigned tasks accept them and have the tools and resources to perform them. Provide a correction period before work begins. Follow up with absent affected users where necessary, because attendance at one meeting does not settle every permission.

Workshop deliverable. A one-page pilot agreement should state the question, site, treatment, comparison, cost ceiling, responsibilities, safeguards, measurements and review date. A photograph of participants is not a substitute.

The quality of the workshop is judged by the clarity and legitimacy of the resulting decision, not by the number of speeches, banners or signatures collected.

CHAPTER 5

Research ethics and community data stewardship

Soil records can reveal more than chemistry. Field locations, yields, land-use histories, input purchases and household information may affect privacy, bargaining power or tenure disputes. A community programme should decide how these data are collected, stored, shared and reused before building a dashboard or publishing a case study. [18, 19, 21]

Distinguish necessary from interesting data

Collect the information needed for the agreed decision. A sampling programme may require a field identifier and location but not a household's unrelated financial or personal history. Explain what will be public, restricted or anonymized. Keep consent records separate from technical data where that improves privacy and access control.

Use clear permissions for staff, trainees, laboratories and external analysts. Back up records securely and maintain an audit trail of corrections. Where internet access is unreliable, establish paper or offline procedures and a controlled process for later entry. The ability to use a digital tool does not establish permission to upload sensitive information to it.

Publication and attribution

Before naming a farmer, community or location in a publication, confirm that the proposed use is understood and authorized. Offer the opportunity to check factual descriptions without promising control over independent scientific conclusions. Credit knowledge and contributions as agreed; do not present community knowledge as the exclusive invention of an outside institution. [19, 21]

Data category	Proposed handling
Public technical summary	Aggregate results with method and uncertainty
Identifiable farm record	Restricted access for the agreed service
Sensitive cultural knowledge	Do not record or publish beyond explicit permission
Trial data for research	Agreed anonymization, attribution and reuse conditions
Complaint record	Confidential route with defined access and response

Consent boundary. Permission for one project or publication is not automatically permission for future commercial reuse, public mapping or unrelated research. Revisit consent when the purpose changes.

Communities should receive usable results, not merely supply data. Return findings in local language and suitable formats, explain uncertainty and preserve a route for corrections. Data stewardship is successful when information improves decisions without exposing participants to unnecessary harm or removing their ability to shape its use.

CHAPTER 5

A proposed community soil charter

This proposed charter is a discussion template, not a legal instrument or existing FPI policy. Adapt it with affected users and appropriate local advice. [18, 19]

Purpose and scope

We agree to improve the soil functions that support our livelihoods while respecting legitimate land and resource rights. The programme covers the management units and activities recorded in the attached community plan. Areas or activities not consented to remain outside the programme.

Decision and participation commitments

Participants will define priorities, compare options and review results. Women, youth, tenants and other affected users will have meaningful influence. No person will be penalized for declining a voluntary trial or raising a concern. Wider effects require wider consultation.

Technical and financial commitments

Inputs will address demonstrated needs with disclosed conflicts of interest. Record methods, costs, labour and uncertainty. Obtain specialist review for high-risk work and unfamiliar materials. Use transparent procurement, tool access and fees.

Knowledge and data commitments

Local knowledge will be recorded and shared only under agreed conditions. Personal and sensitive records will be protected. Public claims will distinguish measured findings, reported observations and illustrative examples. Community members will receive accessible results and an opportunity to correct factual errors.

Review and accountability

Assign responsible people, maintain a complaint route and review regularly. Use positive, neutral and negative findings. Modify or stop practices when evidence, affordability, safety or consent no longer supports them.

Charter record	Complete locally
Community and management units	_____
Representatives and affected-user routes	_____
Review date and record custodian	_____
Complaint and appeal contact	_____
Unresolved conditions or exclusions	_____

Chapter review. Identify one technical decision that could fail without a social agreement. Explain whose rights or workload are involved and how the charter would make the decision more legitimate and practical.

Community-led stewardship is not a softer alternative to technical rigour. It creates the conditions under which good methods can be used, maintained, questioned and improved.

CHAPTER 6

Farmer-Led Innovation & Case Studies

6.1 Turn an observation into a testable question

Farmers routinely compare seasons, crops and management practices. A formal on-farm trial strengthens that learning by defining the question, comparison, measurements and decision rule in advance. It does not remove local judgement; it makes the basis of that judgement more visible and less vulnerable to misleading differences between fields or seasons. [22, 34]

A useful question is specific: does a defined mulch treatment improve establishment and labour-adjusted return on this soil under the available water regime? A vague question such as "does regenerative farming work?" contains too many changing components to support a clear answer from one small trial.

Distinguish trial types

A demonstration shows how a practice is implemented. It may be valuable for teaching even without a rigorous comparison. A comparative trial tests a defined difference against a suitable control or current practice. An adaptive trial explores how to fit a practice to local conditions. The label should match the design; a demonstration photograph is not proof of causal effect. [22, 34]

Design element	Question to resolve before planting
Objective	What decision will this trial inform?
Treatment	What exactly changes, including rate, timing and method?
Comparison	What would the farmer otherwise do?
Replication	How will field variability be represented?
Measurement	What will be measured, by whom and at what time?
Decision rule	What result, cost and risk would justify the next step?

Keep the first experiment interpretable

Where practical, change one main factor while keeping other management comparable. A whole package can be tested, but its result cannot reveal which component caused the outcome. Record deviations, pest events, weather and management interruptions. Do not remove an inconvenient plot from the analysis without a documented reason and a transparent account of the effect.

Learning outcome. A trial that shows no worthwhile response can prevent an expensive scale-up. Its value is the quality of the decision, not whether it confirms the original proposal.

For FPI clusters, a shared protocol can make trials comparable while preserving local adaptation. A coordinator should protect measurement quality and honest reporting rather than require every farmer to produce the same positive story.

CHAPTER 6

Replication, randomization and blocking

Field conditions vary over short distances. A treatment placed only on the better part of a field can appear successful even when the treatment itself has little effect. Replication, randomization and blocking help separate treatment response from spatial variation, although they do not remove every source of uncertainty. [34]

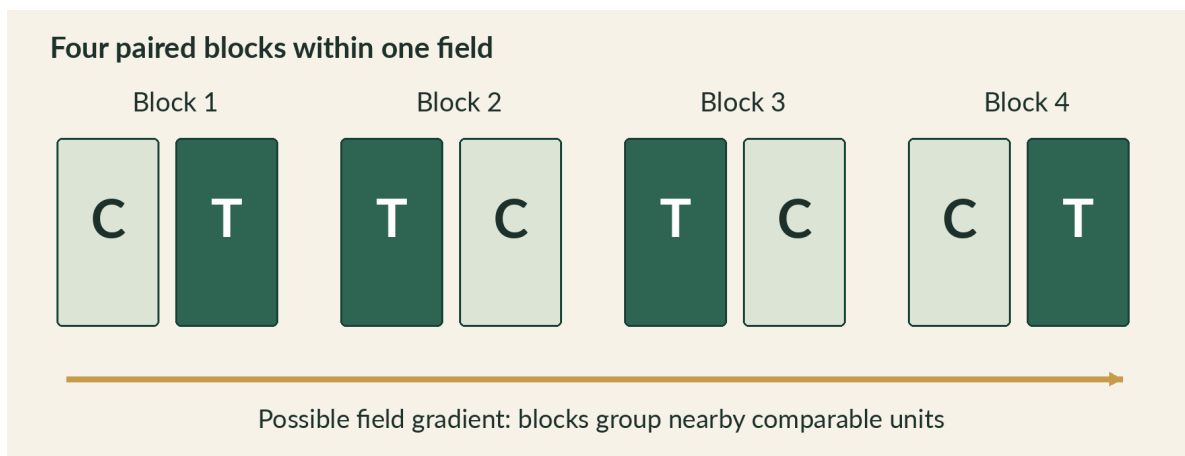


Figure 6.1. Illustrative randomized paired-block layout: C is current practice and T is the test treatment. Four blocks are independent plot pairs within one field, not four independent farms.

Use blocks to manage a known gradient

Where a field has a likely fertility or moisture gradient, place comparable treatment units within blocks and randomize treatment positions within each block. Each treatment should have a fair opportunity to occur in different positions. The diagram is conceptual; plot dimensions, buffers and orientation must suit the crop, equipment and field.

Define the experimental unit: the area that receives the treatment independently. Several plants measured within one treated plot are subsamples, not separate treatment replicates. Treating them as independent plots produces false precision. Likewise, several blocks on one farm do not establish performance across a region or across many farmers. [34]

Prevent avoidable interference

Allow suitable buffers where fertilizer movement, roots, shading, water flow or spray drift could affect neighbouring plots. Record any unavoidable interaction. Use comparable seed, planting dates and management except for the intended treatment difference. A practical field trial must fit farming operations, but convenience should not silently destroy the comparison.

Before starting. Draw the layout, record the randomization, identify every plot and agree how damaged or missing plots will be handled. Keep the original plan even if later changes are necessary.

The minimum appropriate replication depends on expected variability, effect size and resources. Four pairs are used here for teaching, not as a universal sample-size rule. For consequential research or regional recommendations, obtain statistical design advice before collecting data; analysis cannot fully repair a design that confounds treatment with location.

CHAPTER 6

Measurement quality and honest harvest records

A good trial can be undermined by inconsistent measurement. Define the harvest area, border exclusions, crop stage, moisture basis and handling procedure before results are visible. Use the same method for treatment and comparison plots. Keep raw measurements as well as calculated yields so errors can be checked. [34]

Harvest a known area

For a 50 m² net harvest area, 10.5 kg of harvested product corresponds to $10.5 \times 10,000 / 50 = 2,100$ kg/ha, or 2.10 t/ha. The conversion is arithmetic; it does not correct for different moisture contents, quality grades or losses. State whether the mass is fresh, air-dry or adjusted to an agreed standard moisture basis.

For crops harvested repeatedly, record every harvest date and quantity from the same defined area. A single peak harvest must not be reported as annual yield. For leaf crops or mixed products, distinguish fresh biomass, dried product, saleable grade and rejected material. These categories can differ greatly in commercial value.

Record more than yield

Measure labour, purchased inputs, machinery use, water-management changes and quality. Include treatment-specific collection or transport work. A practice may increase yield but reduce net return or shift costs to unpaid labour. Record adverse effects and operational difficulties rather than excluding them from the success narrative.

Record	Minimum detail
Plot identity	Farm, block, treatment and net area
Harvest	Date, mass, product form, moisture basis and grade
Management	Inputs, timing, labour and deviations from protocol
Context	Rainfall or irrigation, unusual stress and pest events
Data check	Scale check, recorder, calculation and correction history

No pseudoreplication. Ten plants sampled inside one treatment plot do not become ten independent treatment replicates. Summarize subsamples appropriately and analyse the actual experimental units.

Discuss results with participating farmers before interpreting unexpected differences. Their management history can reveal an unrecorded event, but explanations should be documented rather than used selectively to protect a preferred conclusion. The strongest report preserves both the numerical record and the practical account of what happened.

CHAPTER 6

Worked trial: higher yield is not always profit

The following four-pair dataset is entirely constructed for teaching. It is not an observed FPI result. Each row represents one block containing current practice and a test treatment, with yields measured on the same product and moisture basis.

Block	Current practice, t/ha	Test, t/ha	Paired difference, t/ha
1	2.10	2.38	0.28
2	2.25	2.45	0.20
3	1.95	2.21	0.26
4	2.20	2.34	0.14
Mean	2.125	2.345	0.220

The mean difference is 0.220 t/ha, approximately 10.4% of the control mean. The paired differences have a sample standard deviation of about 0.063 t/ha and a standard error of about 0.032 t/ha. Under the assumptions of a paired t analysis, the illustrative 95% confidence interval is approximately 0.119 to 0.321 t/ha. With only four pairs, assumptions and unusual observations deserve particular attention. [34]

Add the economic test

Use the illustrative price and costs from Chapter 1: product price USD 260/t, added treatment cost USD 70/ha and other savings USD 12/ha. At the mean yield difference, incremental net benefit is $0.220 \times 260 + 12 - 70 = \text{minus USD } 0.80/\text{ha}$. A positive yield response has not produced a positive mean financial result under these assumptions.

At the lower and upper ends of the illustrative yield interval, the same arithmetic gives approximately minus USD 27 and plus USD 25/ha. These are sensitivity illustrations, not a complete confidence interval for profit: prices, costs and other uncertainties have been held fixed.

Decide what follows

The result could justify another season, a cheaper delivery method or no expansion. It does not establish regional profitability, because the trial represents one field and its conditions. Consider product quality, labour timing and unmeasured longer-term effects, but do not invent future benefits to rescue an unfavourable result.

Decision lesson. Technical response, statistical uncertainty and economic value are different questions. Report all three, including the assumptions that could change the decision.

CHAPTER 6

Demonstration plots and farmer field schools

6.2 Learning through repeated observation

Farmer field schools emphasize experiential learning over a production cycle: participants observe, compare, discuss and make decisions together. A one-day lecture or an input-distribution event can support training, but it should not be described as a full field-school process merely because it occurs on a farm. FAO guidance stresses programme quality, facilitation and learning design. [22]

Build the learning sequence around decisions

A soil-focused school can begin with landscape observation and local soil names, then progress through sampling, laboratory interpretation, treatment comparison, crop monitoring and economic review. The calendar should follow actual field operations. Participants need time to revisit an earlier assumption after seeing new evidence, not simply receive a fixed set of answers.

Demonstration plots can show correct procedures and compare visible conditions. Where causal claims are intended, add an appropriate experimental design rather than assuming the demonstration is sufficient. Keep signage clear about the purpose: teaching, adaptive comparison or replicated trial. Record who selected the site and whether it represents the wider participant group.

Learning stage	Farmer task	Evidence of learning
Observe	Describe soil and water behaviour	A reasoned field diagnosis with alternatives
Test	Collect a traceable sample or measurement	Correct method and usable record
Compare	Examine treatment and current practice	Interpretation that recognizes variability
Decide	Evaluate cost, labour and risk	A justified management choice
Share	Explain findings to others	Clear distinction between evidence and expectation

Support the facilitator

Facilitators need technical competence, respectful communication and the ability to say when specialist advice is required. They should not be rewarded only for adoption or product sales. A farmer's decision not to adopt can demonstrate good learning when the practice is unsuitable or unaffordable.

Quality measure. Assess whether participants can explain and apply the decision process. Attendance, certificates and photographs are incomplete measures of learning.

The proposed FPI approach can draw lessons from established field-school guidance without implying formal FAO affiliation, certification or endorsement. Partnerships should be described only when an actual agreement exists, and the quality of local delivery should be evaluated on its own evidence.

CHAPTER 6

Cooperatives and soil health clubs

6.3 Organize a service, not only a membership list

A cooperative or soil health club can reduce the cost of shared equipment, sampling logistics, learning and procurement. It can also create exclusion or conflicts if access and fees are unclear. The proposed model should therefore define the service, quality standard, governance and recurrent cost before recruiting members with broad promises. [18, 22, 23]

FAO's Global Soil Doctors Programme offers an established farmer-to-farmer training example. It is distinct from any proposed FPI club; citing it does not establish that FPI participants have been trained or certified within that programme. The useful lesson is the value of locally accessible skills linked to reliable methods and institutional support. [23]

Proposed club service	Quality requirement	Recurrent cost to recognize
Shared sampling kit	Clean tools, correct depth and traceable labels	Replacement, cleaning and transport
Laboratory coordination	Suitable methods and verified sample identities	Analysis, packaging and administration
Farmer learning sessions	Competent facilitation and inclusive access	Time, materials and travel
Input procurement	Evidence of need and product quality	Handling, storage and independent checking
Monitoring and records	Consistent methods and privacy protection	Data management and follow-up

Governance for trust

Publish membership and access rules, including whether non-members can purchase a service. Separate the roles of recommending an input, selecting a supplier and approving payment where feasible. Maintain a tool register, booking system and repair reserve. Disclose conflicts of interest, and give members a route to challenge fees or service quality.

A cooperative is not automatically cheaper or more equitable. Compare total service cost, timeliness and reliability with realistic alternatives. A subsidized first year can conceal costs that members will later struggle to pay. Plan for maintenance and staff turnover from the beginning.

Service test. Can a farmer receive a correctly labelled sample, understandable result and practical interpretation at the promised time and cost? This is more informative than the number of people registered in the club.

A strong club builds local capability while retaining access to specialists for high-risk or unfamiliar problems. It should not encourage unqualified members to make engineering, contamination or chemical recommendations beyond their competence.

CHAPTER 6

Documented case: planting pits and stone lines

6.4 Case A - Niger, WOCAT technology record

WOCAT documents a Niger technology combining planting pits and stone lines to rehabilitate degraded land and support crop production. The record concerns a specific land-management experience; it is not an FPI project and is not presented here as a randomized trial. The useful evidence is the described practice, its setting and implementation considerations. [25]

Planting pits can concentrate water and organic resources near plants, while stone lines can slow or redistribute surface flow in suitable terrain. The mechanisms are plausible only within appropriate soil, slope and runoff conditions. They do not justify excavating pits or constructing barriers indiscriminately on saturated, steep or unstable land. [25]

What a community can learn

The case links soil-surface condition, water movement, fertility placement and labour. Its value is the integrated diagnosis: water may run off a crusted surface while crops also lack nutrients, so addressing only one constraint can be insufficient. A locally adapted trial should examine whether these same constraints exist before copying the physical form.

Labour and materials are central. The availability of stone, transport, seasonal work capacity and maintenance arrangements can determine feasibility. A practice described as low in purchased inputs can still be costly in time or compete with other essential work. Rights over treated land and the distribution of benefits also affect willingness to maintain it.

Transfer question	Evidence needed locally
Is runoff being lost from a crusted surface?	Field observations during relevant rain and profile assessment
Can water be retained safely?	Slope, wetness, flow concentration and suitable design advice
Are organic resources available?	Quantity, quality, competing uses and labour
Who benefits over time?	Land access, tenure duration and maintenance agreement
Is the approach worthwhile?	A small comparison including yield, labour, cost and adverse effects

Evidence limit. A documented technology is not proof of the same yield effect in another country. This volume does not assign an unverified percentage gain or claim an FPI implementation result.

Discussion exercise: identify two conditions under which a water-harvesting practice could fail or cause harm. Then propose a local pilot that would test the intended mechanism without committing the entire community's land or labour.

CHAPTER 6

Documented case: farmer-managed regeneration

Case B - African dryland experience in published synthesis

A published synthesis of farmer-managed natural regeneration describes management of naturally occurring woody regrowth in African drylands and its relevance to adaptation and mitigation. This is a sourced external learning case, not a report of a new experiment or a verified FPI project. Outcomes vary with ecological conditions, species, rights and management. [26]

FMNR generally works with existing living stumps, roots or naturally established seedlings, selecting and managing stems rather than relying only on planted nursery stock. This distinction matters operationally. Where suitable regeneration is absent, the same approach cannot simply be declared available. Where it is present, protection and management may be as important as seedling purchase.

The soil connection

Trees and shrubs can influence litter inputs, rooting, shade, wind and water pathways. These processes may support soil functions, but the net crop effect also depends on competition and management. A credible local assessment should examine crop performance, labour, products, access and soil indicators rather than assuming that a greater number of stems is always better. [26]

The institutional connection

Farmers need incentives and authority to manage the regrowth. Rules about tree ownership, pruning, grazing and harvest can support or undermine the practice. A project that encourages protection without resolving who may later use the tree products can create conflict. Women, livestock users and tenants may have interests that differ from the nominal field holder. [18, 26]

Element to assess	Local pilot question
Regeneration potential	Are suitable living roots, stumps or seedlings present?
Species and arrangement	Which individuals should be retained, managed or excluded?
Crop interaction	Where do shade or water competition become important?
Rights and benefits	Who may protect, prune, harvest and sell products?
Persistence	Does management continue after initial project support?

Do not convert counts into credits. Retained stems are a management indicator, not a measured soil-carbon gain or an automatically saleable carbon asset. Those claims require their own methods and verification.

The transferable lesson is to work with ecological opportunity and local institutions together. The practice should be evaluated as a managed system, not marketed as a universal low-cost replacement for every form of restoration or agroforestry.

CHAPTER 6

Documented case: East African field schools

Case C - IFPRI evaluation in Kenya, Tanzania and Uganda

An IFPRI discussion paper evaluated farmer field schools and agricultural outcomes in Kenya, Tanzania and Uganda. It provides evidence that programme outcomes can differ across countries and participant groups, and that a learning approach must be assessed in its implementation context. The study is historical evidence, not a prediction of the effect of a new FPI programme. [24]

This volume does not transfer a headline average impact into a local business plan. Evaluation findings depend on the participating population, comparison strategy, implementation quality and wider conditions. Even a favourable result elsewhere does not establish that a new programme will produce the same effect or that every participant will benefit equally.

What the case adds to soil stewardship

Field schools can support repeated observation and collective analysis, which are useful for diagnosing soil constraints and evaluating management. However, the quality of facilitation, relevance of the curriculum and farmers' ability to act on what they learn affect the pathway from training to outcomes. A farmer may understand an intervention but lack secure land access, labour or finance to implement it. [22, 24]

A proposed FPI soil school should therefore measure more than attendance. It should assess practical competence, changes in decision quality, access to services and field outcomes where the design permits. Adoption alone is ambiguous: it may reflect good evidence, subsidy pressure or the absence of alternatives.

Evaluation question	Proposed local evidence
Did participants learn the method?	Observed sampling, interpretation and calculation tasks
Did learning change decisions?	Documented choices and reasons, including decisions not to adopt
Were outcomes equitable?	Access, workload and benefit patterns, collected ethically
Did the practice perform?	Suitable field comparisons and cost records
Did capability persist?	Follow-up after the initial training and subsidy period

Attribution caution. When yields improve after training, weather, prices, input access and other programmes may also have changed. A before-and-after comparison alone does not isolate the school's causal effect.

The practical lesson is to invest in programme quality and evaluation design together. A field-school label is not a guarantee; its value emerges through credible facilitation, relevant questions, repeated learning and the ability to make better decisions under local conditions.

CHAPTER 6

Internal FPI case: Ruth's Farm pH assessment

Case D - A preliminary diagnostic record, not a success claim

The internal FPI report for Ruth's Farm concerns moringa and contains three supplied soil pH readings. The sampling date, depth, measurement method and laboratory details were not provided. The report therefore supports a limited interpretation of soil reaction, not a complete fertility assessment, suitability survey or prediction of yield. No intervention response was measured. [27]

Sampling point	Supplied pH
Corner 1	7.1
Corner 2	7.1
Corner 3	7.2
Arithmetic mean	7.13, reported as 7.1 to one decimal place

The arithmetic is $(7.1 + 7.1 + 7.2) / 3 = 7.133...$, but the original precision and missing method do not justify an elaborate statistical interpretation. An average of three corner readings is not necessarily a representative field estimate. The small difference among values should not be treated as a meaningful spatial pattern without better sampling information. [09, 27]

What can reasonably be concluded

The supplied readings are near neutral to very slightly alkaline in ordinary descriptive terms. They do not, by themselves, establish a need to raise pH. They also do not prove adequate nutrient supply, safe salinity, good drainage or absence of contamination. The report appropriately limits its conclusions to pH and recommends broader observation and monitoring. [27]

A proposed next assessment

Define the field's management units and sampling purpose; record crop history, irrigation and input use; inspect rooting and wetness; then obtain a method-consistent laboratory panel suited to the actual questions. Where salinity or sodium is suspected, include the relevant soil and water assessment rather than infer it from pH. Retain the initial readings as a historical record with their limitations clearly attached.

Evidence integrity. This case is useful because it shows where advice should stop. The volume does not invent a yield increase, carbon gain, financial return or successful FPI treatment to turn a preliminary report into a success story.

Chapter exercise: draft a three-sentence farmer explanation that states the limited finding, warns against unnecessary pH amendment and identifies the next evidence needed. A strong answer is understandable, specific and honest about what the three readings cannot establish.

CHAPTER 7

Practical Solutions & Intervention Packages

7.1 Choose the response that fits the constraint

An intervention package should be assembled from a diagnosis, not selected because all its components are available from one supplier. The starting question is which process limits the intended use of the land. The next questions concern feasibility, safety, cost, rights and the evidence needed to judge the response. [03, 05]

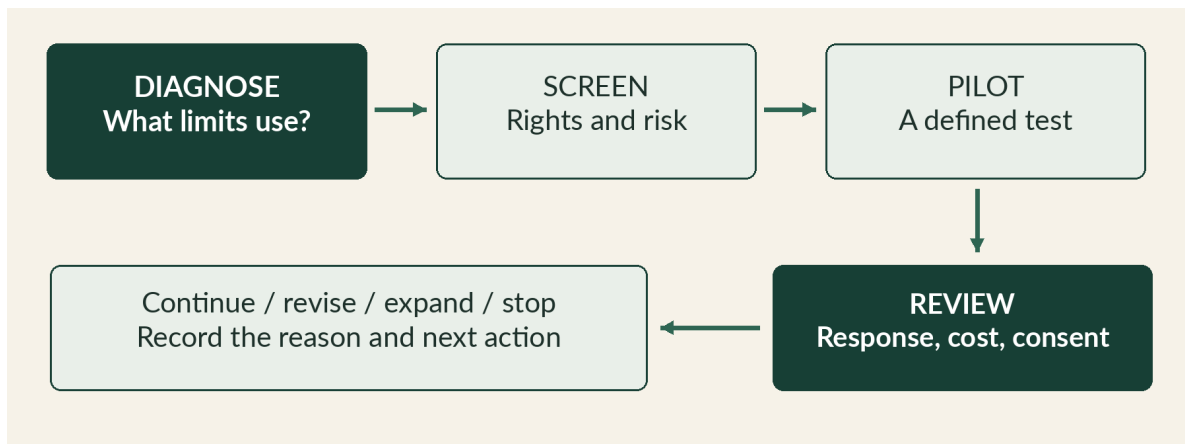


Figure 7.1. Proposed decision pathway: diagnose, screen safeguards, compare options, pilot, evaluate and adapt. A decision to pause is a legitimate output.

Sequence matters

Where waterlogging prevents root function, additional fertilizer may not solve the problem. Where sodicity restricts infiltration, a reclamation plan must consider calcium, water quality and drainage together. Where land rights are unresolved, a long-lived investment should wait. A package is integrated when its parts address connected constraints in a defensible order, not merely when it contains many inputs. [14, 18, 29]

Build the smallest package capable of testing the main diagnosis. Define each component, its purpose and its cost. Distinguish essential components from optional additions and identify what evidence would justify adding them later. This makes the pilot easier to interpret and reduces the risk of purchasing a large bundle whose value cannot be assessed.

Three screening questions

First, could the intervention harm people, crops, water, soil or neighbouring users? Second, is the material or service specified well enough to purchase and apply consistently? Third, can the community maintain and evaluate it after the initial support ends? A negative answer does not always rule out the practice, but it identifies work required before implementation.

Procurement principle. Purchase a defined service or material for a demonstrated purpose. Avoid buying an outcome claim such as "complete soil restoration" when the supplier cannot specify composition, method, conditions and evidence.

CHAPTER 7

A sampling procedure farmers can audit

Start with a clear question and a map of management units. Separate areas with different soil, crop history, irrigation, visible problems or recent management. A composite sample is useful only when its component locations represent the same intended unit. Mixing a wet depression, a manure pile area and an ordinary field can hide the very differences the assessment needs to understand. [29, 39]

Before entering the field

Agree sampling depth and laboratory requirements with an appropriate adviser or laboratory. Use clean, suitable tools and containers, labels that remain readable, a field record and a sample list. Confirm whether the intended analysis requires special handling, cooling or rapid delivery. Routine fertility samples and tests for some biological or contamination questions may have different requirements. [35, 40]

Collect, mix and label consistently

Take multiple cores or subsamples across the defined unit using a documented pattern and consistent depth. The number should reflect area, variability and the laboratory or local protocol; do not treat a universal core count as adequate for every field. Avoid unrepresentative spots unless they are the subject of a separate diagnostic sample. Remove surface litter as required by the chosen method without discarding the soil layer of interest.

Combine and mix the routine subsamples thoroughly using clean equipment, then submit the required representative portion. Keep separate depths separate. Label the sample immediately with a unique identifier linked to the map, depth, date, crop and question. Record unusual conditions and any departures from the protocol. Follow laboratory instructions for drying, packaging, storage and transport.

Close the chain of custody

Check the physical bags against the submission form before dispatch. Record who collected, transferred and received them. When results arrive, verify identities, methods and units before interpretation. Investigate values that conflict with the site history rather than silently correcting them or ordering inputs immediately.

Sampling frequency. Set a schedule according to crop system, management changes, risk and local guidance. Repeated measurements are most useful when timing, depth, method and management unit remain comparable.

For high-value decisions, discuss quality-control samples with the laboratory. A duplicate can reveal part of the variation, but it does not repair a sampling design that consistently misses an important area. Good sampling is the foundation of every later calculation in this chapter.

CHAPTER 7

Lime: converting a recommendation into a purchase

7.2 Use a laboratory requirement, not pH alone

Lime requires a supported acidity diagnosis and target. Rate depends on buffering, depth, crop and material quality, not pH alone. Confirm the laboratory recommendation's basis before adjusting for a commercial product. [28]

Constructed effective-value calculation

Assume the laboratory recommends 2.0 t/ha of calcium carbonate equivalent for the stated incorporation depth and crop target. A supplied product has an effective neutralizing value of 80% on the same accepted basis, with no product correction already included in the laboratory recommendation.

Product required = 2.0 / 0.80 = 2.50 t/ha.

For a five-hectare treatment area, the arithmetic quantity is 12.5 tonnes. This is an illustrative conversion, not a recommendation for any farm. Confirm whether moisture, fineness, chemical neutralizing value and other quality factors are already included in the reported effective value. Applying the same correction twice would overstate the purchase.

Before ordering	Evidence to retain
Need and target	Crop-specific interpretation and laboratory requirement
Treated soil mass	Depth and incorporation assumptions
Product quality	Current specification and neutralizing-value basis
Application	Equipment, distribution, timing and worker protection
Follow-up	Agreed interval and method for reassessment

Manage the whole operation

Plan even distribution, transport, access, dust protection, moisture and equipment calibration. Compare delivered-and-applied cost per unit of effective neutralizing capacity, not merely price per tonne.

Lime does not solve all fertility problems and should not be applied to an already suitable pH merely to follow a standard package. Magnesium-containing material is not automatically required; use it where the diagnosis supports its role. [28]

Reassessment. Allow for the material's reaction and the management conditions before judging the result. Do not repeatedly add lime because an immediate post-application reading has not reached the target.

A cluster purchase should be supported by field-specific requirements and a verified total, not one uniform rate multiplied across every member's acreage.

CHAPTER 7

Gypsum: sodium correction is a system task

Gypsum supplies calcium and sulfur and can be useful in a properly diagnosed sodic-soil reclamation plan. It is not a universal remedy for clay, high pH or salinity. Calcium replacement of exchangeable sodium must be accompanied by suitable water movement and a safe outlet for displaced salts. Water quality, soil profile and drainage feasibility are essential parts of the assessment. [14, 29]

A theoretical charge-balance example

Assume CEC is 12 cmolc/kg, initial exchangeable sodium percentage is 18%, and a hypothetical design target is 8%. The target is chosen only to demonstrate arithmetic, not to prescribe a safe ESP for a particular soil. Sodium charge to replace is $12 \times (18 - 8) / 100 = 1.2$ cmolc/kg.

With bulk density 1.40 Mg/m³, depth 0.20 m and no coarse-fragment correction in this simplified example, soil mass is 2,800 tonnes/ha. One cmolc/kg of calcium corresponds stoichiometrically to about 0.861 g of pure gypsum, CaSO₄·2H₂O, per kg of soil. The theoretical gypsum equivalent is approximately $1.2 \times 0.861 \times 2,800 / 1,000 = 2.89$ t/ha.

At 85% product purity, the arithmetic quantity becomes about 3.40 t/ha. This remains a theoretical teaching result: it excludes field reaction efficiency and other site-specific chemistry and must not be used as an application rate without competent assessment. A laboratory gypsum-requirement method and a designed reclamation plan may be more appropriate. [29]

Why calculation alone is insufficient

The calcium must reach the relevant exchange sites, and displaced sodium must leave the target zone. Poor permeability, unsuitable irrigation water or no safe drainage outlet can prevent reclamation. In saline-sodic soils, simply removing soluble salts without considering sodium can destabilize structure. Conversely, adding gypsum to a merely saline soil can add salt without addressing the actual problem. [14, 29]

Approval gate. Do not authorize gypsum from pH alone. Require a sodium diagnosis, product specification, water assessment, drainage plan, cost review and monitoring arrangement.

Worker safety, storage, dust control and protection of neighbouring water users belong in the operation. Where reclamation is technically or economically unsuitable, a different crop, management strategy or land use may be the more responsible choice.

CHAPTER 7

Compost: quality and nutrient accounting

7.3 Calculate on a declared moisture basis

Compost can add organic resources and nutrients, but composition varies with feedstock and processing. Quality assessment should consider maturity, salts, contaminants, nutrient content and the intended crop use. A pleasant appearance or an organic label does not establish every relevant property. [30, 36]

Constructed nutrient budget

Assume an application of 5.0 tonnes of wet compost per hectare, 60% dry matter, total nitrogen of 1.5% on a dry-matter basis, phosphorus of 0.3% and potassium of 1.0%, also on a dry-matter basis.

Calculation	Illustrative result
Dry material: 5.0×0.60	3.0 t dry matter/ha
Total N: $3,000 \times 0.015$	45 kg N/ha
Assumed first-season N release: 45×0.20	9 kg plant-available N/ha
Total elemental P: $3,000 \times 0.003$	9 kg P/ha
Total elemental K: $3,000 \times 0.010$	30 kg K/ha

The 20% nitrogen-release fraction is a teaching assumption, not a universal value. Actual availability depends on material, soil, climate and management. The P and K quantities are total inputs, not a claim of complete immediate crop availability. Use locally justified interpretation when integrating compost with fertilizer. [11, 30]

Check what repeated applications accumulate

An application selected to meet nitrogen demand may add more phosphorus, salts or other constituents than intended. Track repeated inputs rather than assessing each load in isolation. If the material comes from mixed waste, obtain appropriate evidence of contaminant control and suitability for food-crop production. Keep delivery and batch records. [30, 36]

Compare total delivered-and-applied cost with the functions needed. Compost may contribute more than nutrients, but those additional benefits should be observed or tested rather than assigned an invented monetary value. Transporting bulky, wet material can dominate cost.

Label check. A percentage on a wet basis and the same percentage on a dry basis describe different quantities. Confirm moisture basis, units and whether P and K are elemental or oxide equivalents before calculating.

A useful pilot records material quality, application, crop response, soil function, labour and any adverse effects. It should not assume that a higher application automatically produces a better outcome.

CHAPTER 7

Manure, organic inputs and biosecurity

Organic inputs can connect livestock, crop production and processing within an integrated enterprise. They can also carry pathogens, weed seeds, salts, residues or contaminants, depending on source and handling. The soil benefit must therefore be assessed alongside crop safety, worker protection, water quality and the intended market. [30, 36]

Know the source and process

Record the livestock or feedstock source, bedding, storage, treatment and any relevant contamination history. Separate treated and untreated materials to avoid recontamination. Keep handling equipment and routes from compromising clean harvest or processing areas. Where a material is composted, use an appropriate validated process and records rather than assuming that age alone proves adequate treatment.

Food-safety requirements differ by jurisdiction, crop, certification scheme and buyer. Do not transfer a waiting period or processing rule from an unrelated standard without checking applicability. For crops consumed raw or dried for food markets, consult the relevant competent authority, adviser and buyer requirements before application. This volume does not certify a material or prescribe a universal pre-harvest interval.

Include environmental controls

Locate storage to reduce contaminated runoff and uncontrolled leaching. Protect water sources and manage odour, flies and access where relevant. Test salts and nutrients when repeated applications or sensitive crops make them important. Avoid overloading land simply because a waste stream needs disposal; agronomic use should be based on land capacity and crop needs. [30, 36]

Input record	Why it matters
Source and batch	Traceability when a problem is detected
Treatment and storage	Evidence of the actual process, not a marketing label
Nutrients and moisture	Accurate loading and fertilizer credits
Salts and targeted contaminants	Suitability for the field and crop
Application date and location	Follow-up, compliance and investigation

Stop-use condition. An unknown or suspect waste stream should not enter a food-crop field while its safety is unresolved. Low purchase cost is not a justification for transferring contamination risk to farmers or consumers.

A cluster can reduce risk through shared specifications, approved-source records and independent checks. The same traceability system that supports market confidence should include soil inputs, not only the harvested product.

CHAPTER 7

Biochar: evaluate the material, not the label

Biochar refers to carbon-rich material produced through thermal conversion of biomass under limited oxygen, with properties that depend on feedstock and production conditions. Potential soil effects vary accordingly. A product called biochar is not automatically suitable for every soil, crop or application rate, and it should not be marketed as a guaranteed yield or carbon-credit solution. [31]

Define the proposed function

Is the aim to alter nutrient retention, water behaviour, pH, waste handling or carbon storage? The material's characteristics must match the function and the field. A high-ash or alkaline material may be inappropriate where salts or pH are already problematic. Contaminants and feedstock history require attention, particularly when materials originate from treated wood or mixed waste. [31, 36]

Ask for the feedstock, production information, analytical specification and evidence relevant to the intended agricultural use. Review moisture, particle size, salts, pH and targeted contaminants as appropriate. Carbon content alone does not describe agronomic performance. The evidence should concern the actual product or a sufficiently comparable material, not a generic claim about all biochar.

Start with a controlled local pilot

Use a defined rate and application method, a suitable comparison and a plan to observe establishment, crop performance, water management and any adverse effects. Include transport, handling, incorporation and dust-control costs. Avoid creating an operational burden that cannot be maintained at the intended scale.

Production equipment introduces fire, heat, emissions and occupational hazards. A soil manual should not substitute for competent process design, permitting and operator training. Likewise, carbon accounting requires its own assessment of feedstock sourcing, production emissions, durability, additionality and verification; a bag of biochar does not by itself establish a credit.

Decision	Evidence required
Material acceptance	Traceable feedstock and relevant quality results
Agronomic use	A diagnosed purpose and suitable soil-crop context
Scale-up	Local response, affordability and safe handling
Carbon claim	Applicable methodology and independent project assessment

Commercial discipline. Compare biochar with realistic alternatives for the same problem. A technically interesting material may still be the wrong purchase when cost, supply, risk or field response is unfavourable.

CHAPTER 7

Rotations, cover and reduced tillage as a system

7.4 Integrate practices rather than collecting labels

Rotations change crop sequence and can influence rooting, residues, pests, nutrient demand and labour. Cover crops add living cover for selected functions. Reduced tillage changes soil disturbance, but its effects depend on equipment, traffic, residues, weeds, climate and soil condition. These practices should be designed together where appropriate, not treated as interchangeable badges of good management. [03, 17]

Begin with the operational calendar

Map planting, harvest, grazing, irrigation, labour peaks and market commitments. Identify periods of bare soil and opportunities for a different crop or cover. A rotation that protects soil but produces a crop without a viable use or market may not persist. Conversely, a commercially attractive sequence can exhaust a field if nutrient removal and water demand are ignored.

Reduced disturbance does not mean that every existing physical restriction disappears. Diagnose compaction and traffic before changing operations. Repeated heavy traffic on wet soil can undermine benefits from other practices. Where a corrective mechanical operation is considered, assess its necessity, timing and the management that will prevent recurrence rather than repeating it by habit. [03, 06]

Anticipate trade-offs

Weed management, seed placement, residue handling and pest habitat can change during transition. Equipment that performs well in one residue or soil condition may not suit another. Cover crops can compete for water, and residues may be needed for livestock. Plan these changes with users rather than assuming that a single practice has no opportunity cost. [17]

Design question	Practical evidence
What follows each crop?	Market or household use, seed supply and calendar fit
Where are roots and cover missing?	Seasonal field observations
What causes compaction?	Traffic, moisture and profile evidence
How will weeds be managed?	Crop-specific, lawful and locally feasible plan
Can the system continue?	Labour, equipment, finance and farmer preference

Transition rule. Expand after observing the whole sequence, not only the first attractive crop. A practice that shifts a problem into the next season has not yet demonstrated system improvement.

The strongest package is often a modest combination that addresses an identified constraint and fits the farm's resources. Complexity should be added only when its purpose and maintenance requirements are clear.

CHAPTER 7

Digital soil tools and their decision limits

7.5 Models complement field evidence

Digital soil maps can help identify broad patterns, plan sampling and organize questions. They do not replace field observations or laboratory analysis. ISRIC's SoilGrids provides global predictions at 250 m resolution for multiple properties and depths, with uncertainty information. A grid cell is a model estimate over an area, not a measurement taken at the farmer's GPS point. [32]

A 250 m cell represents roughly 6.25 hectares in simple plan area. Small farms, boundaries and contrasting management units may therefore fall within the same cell. Interpolating or enlarging the display does not create additional observed detail. Use the map to guide reconnaissance and compare its prediction with local evidence.

Preserve uncertainty and service continuity

Record the dataset, version, depth, units, uncertainty layer and access date. Do not mix soil-carbon, pH or texture layers without checking their definitions. The SoilGrids documentation available during preparation notes that its REST API is paused; access methods and availability should be checked before building a live service. Design an offline or cached-data fallback and label stale or unavailable information honestly. [32]

A farm dashboard should distinguish measured, reported, modelled and calculated values. Include sample dates and laboratory methods beside the result. An attractive colour scale can conceal uncertainty if the data basis is absent. Avoid presenting model outputs as exact amendment rates or parcel-level certification.

Data type	Appropriate role	Main limitation
Global soil prediction	Reconnaissance and sampling priorities	Scale and model uncertainty
Field observation	Local diagnosis and context	Observer and seasonal variability
Laboratory analysis	Method-defined property measurement	Sampling and calibration limits
Sensor record	Repeated local monitoring	Placement, calibration and maintenance
Decision model	Compare stated scenarios	Output depends on assumptions and validation

Privacy rule. Do not upload identifiable farm, tenure or cultural information to an external platform without appropriate permission and a clear data-handling arrangement.

For FPI Agricultural Intelligence, the strongest architecture connects verified records with interpretation and action. It should show "data unavailable" where coverage is absent rather than filling gaps with unsupported precision or invented observations.

CHAPTER 7

Three contrasting intervention packages

The following packages are constructed examples of decision logic, not prescriptions or claims about specific FPI farms. Each begins with a different dominant constraint. Local diagnosis, crop requirements, consent and feasibility must determine the actual treatment. [03, 14, 28, 29]

Illustrative setting	Initial package to investigate	Evidence required before expansion
Acid mineral soil with a crop-related acidity limitation	Laboratory lime requirement, verified product quality, suitable nutrient programme and protected cover	Method-consistent pH follow-up, crop response, full cost and no overcorrection
Sandy, low-retention field with limited water	Root-zone water monitoring, appropriately timed nutrients, targeted cover or organic-input trial	Water balance, crop response, input losses or proxies, labour and affordability
Sodium-affected irrigated soil	Soil and water diagnosis, drainage feasibility, specialist-designed calcium and leaching strategy where appropriate	Repeated sodium and EC assessment, infiltration, safe discharge and economic viability

What all three packages share

Each needs a baseline, an understandable objective, a defined treatment, a comparison or other suitable evaluation, a cost record and a review date. Each also needs an explicit stop condition: unresolved safety, no suitable outlet, unacceptable cost, loss of consent or evidence that the diagnosis was wrong.

The common management system matters as much as the different input choices. A well-recorded small treatment can generate useful evidence; an undocumented large treatment may leave the community unable to explain either success or failure. Procurement should follow the diagnosis and review process, not set it.

What should not be bundled automatically

Lime, gypsum, compost, biochar, microbial products and micronutrients should not all be added simply to make a package appear comprehensive. Every component requires a purpose, quality specification and realistic expectation. Products with weak or non-transferable evidence should be tested independently before being presented as established solutions.

Chapter exercise. For a selected field, write a package with no more than three initial actions. Explain the constraint addressed by each, the evidence supporting it, the cost or risk, and the observation that would make you stop or revise it.

A strong answer may recommend further diagnosis rather than immediate treatment. The implementation roadmap that follows explains how communities and partners can organize this discipline over several years without turning a flexible learning process into a rigid input-distribution schedule.

CHAPTER 8

Implementation Roadmap for Communities & Partners

8.1 Build capability before scale

The proposed roadmap treats soil stewardship as a continuing service. It begins with rights, diagnosis and a small evidence-generating pilot, then expands only when technical performance, affordability and community support justify doing so. Years are planning stages, not promises that every soil will improve on the same timetable. [03, 18, 22]

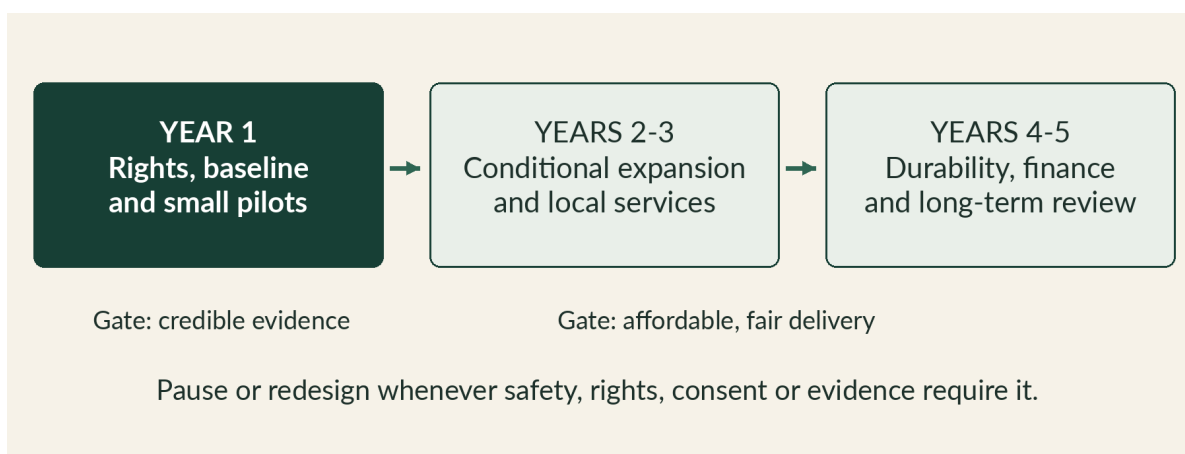


Figure 8.1. Proposed five-year sequence. Movement between stages depends on evidence and consent; a calendar date alone does not authorize expansion.

Gate one: permission and baseline

Before field intervention, confirm access, affected users, the management units, the question, methods and minimum records. Resolve high-risk issues such as contamination or drainage feasibility. Establish who can authorize expenditure and who can challenge a decision. The baseline must describe the actual starting condition rather than a generic regional average.

Gate two: a worthwhile pilot

A pilot should demonstrate correct implementation, interpretable records and a practical decision about the treatment. Positive crop response is not enough where labour, cost, safety or rights make the practice unsuitable. Neutral or negative findings can justify stopping, redesigning or testing another option.

Gate three: a sustainable service

Expansion should preserve quality while strengthening local skills, maintenance, financing and accountability. A programme that serves many farms but loses sample identity, timely results or fair access is not a successful scale-up. Recurrent costs must be visible before the initial grant ends.

Roadmap principle. Scale the decision process as well as the practice. A community should gain the ability to diagnose and adapt, not become permanently dependent on one externally supplied package.

CHAPTER 8

Year one: baseline, safeguards and a pilot

Year one should establish a trustworthy foundation. The proposed sequence below can be adapted to the crop calendar and local conditions. Where consent, rights, safety or technical feasibility remain unresolved, the affected activity should pause rather than be forced into an administrative deadline.

Period	Main work	Evidence required to proceed
Months 1-2	Community engagement, rights review, site history and management-unit map	Agreed scope, permissions and unresolved-risk register
Months 2-3	Sampling, field observations, laboratory interpretation and cost review	Traceable baseline and a supported priority constraint
Months 3-5	Co-design and establish a limited pilot	Defined treatment, comparison, roles and safeguards
Months 5-10	Monitor crop cycle, labour, inputs and soil observations	Complete records and documented deviations
Months 10-12	Review outcomes and next-season options	Community decision with technical and economic reasoning

Select sites for learning, not publicity

Include relevant variability and realistic management conditions. A conveniently located, unusually fertile demonstration field may be useful for training but unrepresentative of the wider group. Record why each site was chosen and what it can and cannot represent. Consider access for learners without placing undue burden on the host farmer.

Establish minimum service standards

Agree sample turnaround expectations, report interpretation, tool access, record custody and complaint response. Do not promise laboratory timing until it has been confirmed. Create a backup plan for equipment failure, delayed analysis or crop loss. A pilot should remain understandable even when the season does not follow the plan.

Training should cover both technical procedures and evidence literacy: measured versus modelled data, illustrative versus observed results, and the difference between yield response and profit. These concepts protect the community from misleading claims during later procurement.

Year-one deliverable. Produce a baseline register, a small number of well-documented pilots, a service-cost record and a jointly agreed scale, revise or stop decision. None requires inventing a success story.

At the annual review, include people who withdrew or could not participate. Their experience can reveal barriers that are invisible in the results of the most active members. The second year should address those barriers before simply increasing the participant target.

CHAPTER 8

Years two and three: expand with safeguards

Expansion should follow evidence about where a practice works and for whom. A pilot on one soil, crop and water regime does not justify a blanket recommendation across the cluster. Group potential expansion sites by relevant conditions and identify where another local test or specialist assessment is needed. [03, 34]

Retain comparison and learning capacity

As adoption increases, maintain some suitable comparison sites or another credible evaluation strategy. Otherwise, the programme may lose the ability to distinguish treatment performance from a favourable season or changing market conditions. Do not force farmers to retain an unsuitable practice merely for research; design evaluation ethically and with consent.

Develop experienced farmers and trainees as local facilitators while preserving technical supervision. Use competency checks for sampling, calculations, records and communication. An expanding team needs a shared method manual and a correction process, not just a shared logo.

Expansion gate	Question for the review team
Technical relevance	Do the new sites share the constraint and conditions tested?
Operational quality	Can the material, method and timing be delivered consistently?
Economic value	Are full costs and realistic market assumptions acceptable?
Social legitimacy	Are access, labour and benefit arrangements still supported?
Monitoring capacity	Can the programme detect failure or unintended harm promptly?

Avoid procurement-driven scale

Larger orders can reduce some unit costs, but they can also lock the programme into an unsuitable material or exceed storage and application capacity. Base purchasing on verified requirements and delivery timing. Inspect quality and retain batch records. A discount does not justify treating land that has no demonstrated need.

Review whether subsidies are masking a service that users cannot sustain. Where support is necessary for public benefits or inclusion, state the rationale and financing source explicitly. Do not call a permanently subsidized service commercially self-sustaining without evidence.

Year-three checkpoint. Compare the original theory of change with actual experience. Which households benefit, which costs persist, which indicators improve, and which claims remain unproven?

The output should be a refined recommendation domain: the conditions under which the practice is worth considering, the evidence required before use and the situations where it should not be promoted. This is more valuable than a universal success rate.

CHAPTER 8

Years four and five: institutional durability

Long-term stewardship depends on whether skills, financing, records and accountability survive changes in staff, leadership and project support. Years four and five should therefore test the service's durability rather than focus only on adding new sites. A functioning local institution can adapt practices as soils, markets and climate conditions change. [03, 18]

Secure the recurrent system

Review who pays for laboratory analysis, transport, equipment replacement, facilitation and data management. Establish realistic maintenance and renewal reserves. Confirm that service fees, grants or other support cover the actual operating model. Where a public subsidy supports erosion prevention or inclusive access, make its purpose and duration transparent.

Document procedures and train more than one person for critical tasks. Sample identity, financial approval and record access should not depend on a single individual's memory. Create a handover process for leadership changes and preserve community ownership or agreed control of essential records.

Evaluate persistence and unintended effects

Repeat appropriate soil and crop measurements on a method-consistent basis. Review whether improvements continue, plateau or reverse. Examine labour, access, disputes and downstream impacts as well as the headline production result. Avoid attributing every change to the programme without considering other influences.

Durability question	Evidence to review
Can the service continue without launch funding?	Recurrent revenue, costs and renewal provision
Are skills retained locally?	Demonstrated competence and succession arrangements
Are benefits maintained?	Repeated field and household-level evidence, collected appropriately
Are rights and access protected?	Updated agreements, complaints and participation patterns
Can the system adapt?	Documented revisions after new evidence or changing conditions

Exit is a design question. Agree from the beginning what external support will leave behind, what it will stop funding and how responsibilities will transfer. A sudden funding gap is not a community failure.

At the five-year review, publish a balanced account of what is known, what remains uncertain and what should change. A mature programme may retire a practice, modify a service or reduce activity in an unsuitable area. Adaptation is evidence of responsible management, not a reason to conceal the record.

CHAPTER 8

Roles, accountability and escalation

8.2 Assign responsibility without erasing local authority

The proposed role structure below separates field work, technical interpretation, community representation and financial approval. Adapt it to local institutions and legal requirements. A written role should include the authority, resources and competence needed to perform it; naming someone without providing these conditions does not create accountability. [18, 19, 22]

Role	Proposed responsibility	Accountability or escalation
Farmers and field users	Describe conditions, consent to activities, implement agreed practices and keep records	Review decisions and report problems through an accessible route
Traditional and community leaders	Convene affected users and support legitimate local processes	Do not substitute their agreement for every individual's rights
Cooperative or cluster committee	Coordinate tools, schedules, fees and transparent procurement	Report to members and disclose conflicts of interest
Soil facilitator or trained youth team	Apply agreed methods, maintain records and explain results within competence	Refer unfamiliar or high-risk questions to specialists
Agronomist and laboratory	Select appropriate methods and interpret soil-crop evidence	State limitations, methods and recommendation assumptions
Local government and relevant authorities	Address applicable land, environmental, water and public-service requirements	Follow formal procedures and jurisdiction-specific duties
FPI or implementation partner	Coordinate quality, learning, safeguards and reporting under actual agreements	Distinguish commitments from proposals and retain an audit trail

Keep critical decisions reviewable

High-cost amendment orders, major earthworks, contamination responses and public performance claims deserve documented review. The person recommending a product should disclose any financial interest. A committee should not approve technical work it cannot evaluate without obtaining appropriate advice.

Use a simple escalation register: issue, date, person responsible, interim safeguard, advice requested and closure evidence. A matter is not closed because it has been forwarded to someone else. Participants should know how to check progress and how to appeal an unresolved decision.

Responsibility test. For every important task, ask who does it, who authorizes it, who checks it and who is informed. Avoid assigning the same person every role where that prevents independent scrutiny.

Clear roles reduce delay and protect trust. They also make the programme easier to evaluate, because a failure of material quality, sampling, communication or governance can be investigated rather than described vaguely as poor adoption.

CHAPTER 8

Financing a soil-learning service

8.3 An illustrative first-year budget in USD

This constructed budget describes a small learning service for 40 participating farmers and an assumed 80 hectares of associated land. It is not a supplier quotation, funding commitment or complete farm-development budget. Costs must be replaced with current local quotations and a defined service scope before approval.

Item	Illustrative USD	Scope assumption
Shared field equipment	1,200	Basic sampling and learning tools; not a full laboratory
Baseline analysis and logistics	2,400	A defined sample programme to be specified locally
Training and facilitation	4,800	Planned sessions, preparation and field support
Demonstration inputs	1,600	Limited pilot materials, not all farm inputs
Data and monitoring	1,200	Record management and scheduled follow-up
Subtotal	11,200	Before contingency
Contingency, 10%	1,120	Controlled reserve, not automatic expenditure
Total	12,320	Illustrative first-year service budget

The arithmetic average is USD 308 per participating farmer or USD 154 per associated hectare, but these are allocation ratios, not actual uniform service costs. Land purchase, major drainage, irrigation systems, buildings, commercial amendment quantities, taxes and financing costs are excluded unless later added explicitly.

Match the financing source to the benefit

Member fees may support private services such as sampling logistics. Grants or public support may be justified for shared learning, inclusion or downstream environmental benefits. Equipment finance requires a credible utilization and repayment plan. Keep these rationales separate instead of treating every activity as a commercial investment with guaranteed returns.

Do not include carbon-credit revenue in the base case without a separately assessed and verified project pathway. Likewise, higher yield, premium prices or assured offtake should not be entered as facts merely because the programme intends to improve soil management.

Financial control. Record commitments, invoices, payments, in-kind contributions and unpaid labour separately. A cash surplus can coexist with an unsustainable burden of unpaid work.

At review, compare planned and actual cost per service delivered, not only money spent. A cheaper programme that produces unusable samples or excludes difficult-to-reach farmers may provide less value than a more carefully resourced service.

CHAPTER 8

Monitoring that supports decisions

8.4 A minimum indicator set

Choose indicators from the programme's actual theory of change. Each should have a definition, method, timing, responsible person and action linked to the result. A long dashboard is not inherently better than a small reliable set. Baselines and targets should be locally justified, with uncertainty retained. [03, 05, 33]

Indicator	Suggested observation timing	Decision use and caution
pH, same method and depth	Baseline and an appropriate follow-up interval	Check acidity management; small changes may be noise
Ground cover and erosion signs	At defined crop stages and after relevant storms	Review exposure and runoff; do not infer tonnes lost without measurement
Infiltration comparison	Under documented comparable conditions	Investigate water entry; not a stand-alone engineering parameter
Yield and saleable quality	Each relevant harvest	Assess crop response using known area and product basis
Costs and labour	At each operation, reviewed seasonally	Test affordability and opportunity cost
EC and sodium indicators	Where the diagnosis requires; timing set by risk	Assess salts using consistent methods and water context
Carbon stock	Only with a suitable repeated-sampling design	Concentration alone does not establish sequestration
Access, agency and complaints	At agreed reviews with privacy safeguards	Identify exclusion, workload and unresolved harm

Separate outputs from outcomes

Samples collected, people trained and materials distributed are outputs. Better decisions, improved soil function, viable returns and fair access are outcomes. Both can be tracked, but one should not be substituted for the other. A programme may deliver all planned training while failing to create a service farmers can use.

Maintain a usable audit trail

Keep the original measurement, any correction, the reason and the person making it. Use common units and clear sample identifiers. Review missing data openly rather than filling gaps with invented values. Where a sensor or platform fails, label the gap and use the agreed fallback method.

Indicator discipline. Do not set a universal soil-health score or carbon target simply to make farms rankable. Compare against relevant conditions, methods and the agreed management objective.

Monitoring should end in a decision: continue, investigate, modify, expand or stop. If no plausible action depends on an expensive indicator, reconsider whether collecting it is justified.

CHAPTER 8

A community scorecard and annual review

A scorecard can make technical and social performance easier to discuss, but it should not compress every issue into a misleading single number. The proposed system uses evidence-linked ratings and treats safety, rights and consent as conditions that cannot be cancelled out by a high yield score.

Dimension	Evidence to bring	Locally assigned status
Soil function	Relevant method-consistent measurements and field observations	Improving / unclear / deteriorating
Crop and economic performance	Yield, quality, full costs and labour	Worthwhile / uncertain / not worthwhile
Service quality	Timeliness, sample integrity and usable interpretation	Reliable / needs correction / unacceptable
Fair access and agency	Participation, control over benefits and safe feedback	Supported / contested / exclusion evident
Safeguards	Water, contamination, safety, consent and rights review	Cleared / unresolved / stop required
Institutional durability	Finance, maintenance, skills and succession	Sustainable pathway / gap / no viable plan

Use the review to decide

Present the evidence before the rating. Allow participants to challenge methods, missing information and interpretations. Record minority views and explain how disagreement affects the next step. Avoid assigning a favourable rating merely because the programme met its spending or recruitment target.

A scale decision requires a justified recommendation domain, affordable delivery and adequate safeguards. A revise decision should specify the change and the evidence needed next. A stop decision should protect participants and explain what will happen to equipment, land improvements, outstanding costs and records.

Close the feedback loop

Publish an accessible summary of decisions, responsibilities and dates. Return individual results privately where required. Update the implementation plan and budget, and review whether the original problem remains the highest priority. New evidence can change the programme's direction without invalidating the effort invested in learning.

Final implementation test. Can a farmer explain why the next action was chosen, what it will cost, what could go wrong and how the result will be judged? When the answer is yes, soil knowledge is becoming community decision-making capacity.

The volume's conclusion is practical: productive soils and strong communities are built through repeated, legitimate, evidence-informed choices. RUAIPP and Agriculture-Based Clusters can provide an organizational setting for those choices, but outcomes must be earned and documented field by field, season by season.

GLOSSARY

Soil and stewardship terms: A-L

Terms for reading, fieldwork and discussion

Aggregate. A group of soil particles bound together. Aggregate stability concerns resistance to disruption under a specified test; it is not identical to texture. [05]

Agroforestry. Deliberate integration or management of woody vegetation with agricultural land uses. Benefits and competition depend on design, species, site and rights. [26]

Available water. An operational estimate of water potentially available to plants between defined soil-water conditions. Effective access also depends on roots, salinity and crop behaviour. [14]

Base saturation. The percentage of a stated CEC occupied by specified exchangeable base cations. It depends on the analytical basis and is not a universal fertilizer target. [10]

Biochar. A carbon-rich material from limited-oxygen thermal conversion of biomass. Feedstock and process determine properties; the name alone does not establish suitability. [31]

Bulk density. Dry soil mass per bulk volume, with the treatment of coarse fragments and soil fraction specified. It is not particle density. [06]

Cation exchange capacity. Capacity to retain exchangeable positively charged ions, usually reported as cmolc/kg. Method and pH basis matter. [10]

Community consent. Agreement to defined activities under understandable, non-coercive conditions. It should not be inferred from one person's attendance or a photograph. [19]

Compaction. A change that reduces pore space or alters its continuity under pressure. Interpretation requires soil, moisture, rooting and traffic context. [06]

Electrical conductivity. A measure related to dissolved-ion concentration in a specified extract or solution. The extraction method must accompany the value. [14, 29]

Equivalent soil mass. A basis for comparing stocks using comparable soil mass rather than assuming that a fixed depth always contains the same mass. [33]

Exchangeable sodium percentage. Exchangeable sodium expressed as a percentage of a stated CEC. Its physical implications depend on other soil and water conditions. [29]

Free, prior and informed consent. A rights-based process particularly important for Indigenous peoples, with application guided by the relevant framework and context. [19]

Humus. A historically variable term for transformed soil organic material; not a single uniformly permanent substance. [12]

Indigenous knowledge. Knowledge systems associated with Indigenous peoples, with their own holders, institutions and conditions for sharing. It is not interchangeable with every form of local knowledge. [21]

Infiltration. Entry of water through the soil surface. A ring-test average is not automatically saturated hydraulic conductivity. [16]

Leaching. Movement of dissolved substances with water through soil. Its value or harm depends on what moves, where it goes and the management objective. [14]

GLOSSARY

Soil and stewardship terms: M-Z

Management unit. An area treated as sufficiently similar for a stated sampling or management decision. Its boundary should follow relevant variation rather than convenience alone. [29]

Mineral-associated organic matter. Organic material associated with mineral surfaces, defined through particular conceptual or analytical approaches. It is not synonymous with all persistent carbon. [12]

Natural capital. Environmental assets considered in relation to the services and benefits they support. Monetary valuation is only one possible way to inform decisions. [37]

Organic carbon stock. Organic carbon mass in a specified area and soil layer, calculated using concentration and a compatible soil-mass estimate. [33]

Particulate organic matter. A fraction often containing relatively recognizable organic residues; its measured definition depends on the method. [12]

pH. A logarithmic measure related to hydrogen-ion activity in a specified system. Soil pH should be reported with solution and method. [09]

Pseudoreplication. Treating non-independent observations, such as plants within one treatment plot, as independent experimental replicates. [34]

Reference Soil Group. A major category in the World Reference Base. It is not the same classification level or system as a USDA soil order. [01, 02]

Resilience. In this volume, the capacity to maintain, recover or adapt important functions under disturbance. It is a management objective, not a guaranteed product attribute.

Salinity. The condition associated with soluble salts. Crop effects depend on concentration, composition, stage and environment, not only a classification threshold. [14, 29]

Sodicity. Excessive exchangeable sodium relative to the relevant soil system, potentially affecting structure and water movement. High pH alone does not diagnose it. [29]

Soil stewardship. Ongoing, accountable management of soil functions and the rights, knowledge and resources connected to them. The volume uses the term as a practical governance commitment.

Tenure. The rules and relationships governing access to and use of land and associated resources. Legitimate rights may involve different legal and customary arrangements. [18]

Texture. Relative proportions of sand, silt and clay under a specified particle-size system. Texture differs from structure and is not rapidly changed by ordinary amendments. [01, 05]

Traceability. Ability to connect an observation, material or product to its identity, origin and handling record. It requires reliable records, not only a label.

Waterlogging. Excess water that restricts soil aeration for the intended crop or use. Diagnosis should identify source, duration and profile conditions. [14]

Cultural terms require local definition

Words translated as taboo, sacred place, communal land or traditional authority may carry meanings that differ between communities and languages. Record the agreed local meaning and permissions rather than assigning a universal definition. Respect a decision not to translate, record or publish a term. [19, 21]

REFERENCE CHARTS

Units, conversions and interpretation safeguards

These relationships support calculations; they do not supply crop-specific thresholds or application rates. Always retain the measurement method, soil fraction, depth and moisture basis alongside a value. [06, 09, 14, 33, 40]

Quantity or conversion	Relationship	Important qualification
Land area	1 ha = 10,000 m ²	Use the actual net treated or harvested area
Water over one hectare	1 mm = 10 m ³ /ha	Applied water is not automatically crop uptake
Density	1 g/cm ³ = 1 Mg/m ³	Specify dry mass and soil-volume basis
Charge capacity	1 cmolc/kg = 1 meq/100 g	Do not confuse charge with mass concentration
Mass concentration	1 mg/kg = 1 ppm by mass	Not interchangeable with mg/L without context
Electrical conductivity	1 dS/m = 1 mS/cm	Extract method and temperature basis still matter
Phosphorus	P = P ₂ O ₅ × 0.4364	Confirm fertilizer-label convention
Potassium	K = K ₂ O × 0.8301	Confirm fertilizer-label convention
Yield	kg/ha = harvested kg × 10,000 / net m ²	State product form, grade and moisture basis
Carbon stock	C fraction × density × depth × area	Use compatible coarse-fragment and soil-mass treatment

Classical salt screening is not a crop-safety certificate

Historically used category boundaries include saturated-paste EC_e near 4 dS/m, ESP near 15% and SAR near 13. These are screening conventions, not universal safe limits. Some crops are affected below the salinity boundary, and structural response depends on electrolyte concentration, clay and other conditions. Do not apply the EC_e boundary directly to a 1:5 extract. [14, 29]

Three comparisons that require extra care

A pH measured in water is not automatically equivalent to pH in calcium chloride. Organic matter estimated by one method is not automatically equivalent to directly measured organic carbon. A mapped prediction is not equivalent to a sample measured at that location. These distinctions should appear in training materials and procurement reviews, not only in technical appendices.

Calculation safeguard. Write the units on every step. A correct formula with mismatched units, depth or moisture basis can produce a precise but wrong answer.

For regulatory, certification or buyer thresholds, consult the applicable current document. This chart intentionally does not invent global compliance limits for contaminants, manure treatment or agricultural exports.

FIELD TOOL 1

Soil observation and sample record

Use one sheet for each defined management unit and sampling event. Duplicate the sheet as needed. This is a proposed field tool; the selected laboratory method may require additional information. [35, 40]

Identification	Complete in the field
Farm / community / unit ID	_____
Date / recorder / contact route	_____
Location reference and permission	_____
Crop, stage and intended use	_____
Management-unit area and boundaries	_____
Sampling question	_____

Field context

Recent rainfall or irrigation: _____

Wetness, runoff and erosion observations: _____

Roots, structure, cover and unusual areas: _____

Previous crop, inputs and traffic: _____

Land-use or contamination concerns requiring referral: _____

Sampling details	Complete before dispatch
Depth and soil fraction	_____
Pattern and number of subsamples	_____
Tools, preparation and packaging	_____
Sample IDs and duplicate/check IDs	_____
Laboratory and requested methods	_____
Collector / dispatch / receipt record	_____

Interpretation and next action

Result received and identities checked by: _____

Measured finding and important limitation: _____

Agreed next step, responsible person and date: _____

Keep the link. Attach the map, laboratory report and any photographs using the same unit and sample identifiers. Do not separate a result from the method and field context that make it interpretable.

FIELD TOOL 2

Trial decision and annual review record

Complete before the trial, then return to the same sheet at review. Preserve the original plan and date any changes. Use additional sheets for plot-level measurements and financial records. [34]

Before implementation

Decision question: _____

Why this question matters to participating farmers: _____

Treatment, rate, timing and method: _____

Current-practice comparison and replication: _____

Map / randomization / plot IDs / harvest area: _____

Planning control	Agreed record
Consent, access and affected users	_____
Material specification and quality checks	_____
Budget ceiling and labour allocation	_____
Measurements, dates and recorder	_____
Safety, environmental and stop conditions	_____
Review date and decision authority	_____

At review

What was implemented, including deviations: _____

Measured outcome, method and uncertainty: _____

Incremental revenue, cost, labour and net benefit: _____

Adverse effects, complaints and missing evidence: _____

Decision and accountability

Decision: continue / revise / expand within stated conditions / stop / obtain more evidence.

Reason and conditions: _____

Next action, responsible person, resources and deadline: _____

Participants' unresolved concerns or differing views: _____

Report honestly. Label constructed examples, missing data and uncertain results. A review record should explain a decision, not manufacture evidence that the original proposal was correct.

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REFERENCES & FURTHER READING

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Numbered citations in the text link to these entries. Online resources were checked on 11 October 2026; access and services may change.

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Interpreting fertilizer grades and nutrient contributions; examples in this volume are newly constructed.

[40] FAO GLOSOLAN (living resource). Standard Operating Procedures (SOPs). Accessed 11 October 2026.

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Harmonized analytical procedures covering sample handling, chemistry, carbon and physical measurements.

ABOUT THE VOLUME

Farmers Pride International and the author

Farmers Pride International

Farmers Pride International describes its work through integrated agricultural development, linking production, value addition, enterprise and markets. Its public materials identify it as a subsidiary of Hunter's Global Network and present Agriculture Systems Integration through RUAIPP and Agriculture-Based Clusters. This volume applies that organizational context to a proposed soil-stewardship service. [38]

RUAIPP means Rural and Urban Agriculture Innovative Production Program. Agriculture-Based Clusters are used here as an organizational approach for coordinating farmers, services, learning, processing and market relationships. Agriculture Systems Integration connects these activities so that decisions about land and soil remain linked to water, inputs, product quality, logistics, finance and community governance.

The soil model in this volume is proposed for local adaptation. Its publication does not establish that every described service, trial or governance arrangement is already operating, funded or evaluated. FPI programme claims should be supported by the relevant project records and agreements.

About the writer

Elfas Mcloud Zadzagomo Shangwa Hunter is credited as the writer of this volume. His stated organizational role is Executive President and Founder. The volume reflects his emphasis on connecting agricultural knowledge, community capability and enterprise development within Farmers Pride International's integrated approach.

Partners, acknowledgements and evidence

Farmers, community institutions, laboratories, researchers, extension services and public authorities can contribute distinct expertise to a soil programme. Their roles must be established through actual agreements. FAO, IUSS, USDA, ISRIC, UNESCO, IFPRI and other organizations cited in this volume are research sources, not claimed endorsers or confirmed FPI partners by virtue of citation.

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Official organizational website: www.farmersprideinternational.org

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Research synthesis and community implementation