Extension Agents training Guide on soil health

For training in cascade ISFM on **SOIL VALUES** project implementation in northern Nigeria

Developed by ICRISAT in Collaboration with IITA

Date May 2025

Nigeria and Niger

Preamble

"Healthy Soils for a healthy life" is the motto of the International Year of Soils 2015 held in the framework of the Global Soil Partnership, since healthy soils are the foundation of a healthy environment, a productive food system and an improved rural livelihood.

The word 'soil' describes the unconsolidated mineral and organic material on the earth's surface that serves as a natural medium for the growth of plants. It is therefore a fundamental attribute that determines primary productivity and life on earth.

The capacity of land to sustain farming activities provides a primary measure of its economic value and is generally measured based on the ability of soil to perform key functions that sustain crops. In Sub-Saharan Africa, especially in Northern Nigeria, crops such as **maize, millet, rice, wheat, and vegetables** are most affected by soil fertility decline. These crops are central to food security and are the primary targets for soil health interventions under national and regional programs, there is continues grapple with many episodes of hunger and low crop productivity in multiple locations. Coupled with the ever-growing population, farmers continue to grow crops on the same land year after year without replacement leading to soil fertility decline where nutrients removed in crop products are not returned to the soil.

The fact that mineral fertilizers are more expensive in Africa than anywhere else, most farmers use none at all. Improving food security and sustainable soil fertility management in the face of climate change and societal vulnerability has become a critical challenge, more particularly in Northern Nigeria.

To deal with this problem the Dutch government has committed to supporting within an international development framework aligned with its Sustainable Development Goals policy, to facilitate adoption of Integrated soil fertility management technologies, commonly referred to as ISFM in Northern Nigeria across some selected watershed areas.

It is clear that 'one-size-fits-all' or 'silver bullet' solutions that can be applied across large regions do not exist, instead, technologies need to be targeted to farming systems and farms while recognizing their agroecological and socio-economic environments – to different 'socio-ecological niches', the preference to locally adapted ISFM technologies as 'best-fit' options.

Agronomic research over the past decades points to the need to combine both organic resources and mineral fertilizers to increase soil fertility, improve crop yields and improve farmers' livelihoods (Fairhurst, T. (ed.) (2012).

This practical guide to ISFM is meant for training of extension workers in soil fertility management techniques and for lead farmers involved in watershed management in rural communities that would like to learn more about the principles and practices of ISFM.

Soil Values: An Overview

Soil is a dynamic, natural body composed of mineral and organic matter, air, water, and living organisms, forming the top layer of Earth's surface and supporting plant life and ecosystems. It's a Biogeochemical system that are vital to the life cycles of terrestrial vegetation and soil-inhabiting organisms—and by extension to the human race as well.

In academic, Soil is a separate scientific discipline which began about the same time with systematic investigations of substances that enhance plant growth revealing that healthy soil requires a balance of mineral components, organic matter, air, and water, along with factors like pH balance, nutrient content, and soil biology.

- Composition and Structure: soil is a mixture of sand, silt, and clay
- Organic Matter: Decomposed plant and animal matter, crucial for soil structure, nutrient retention, and water infiltration
- Air and Water: Aeration and water availability are vital for root growth and nutrient uptake
- Nutrient Content: Nitrogen, phosphorus, and potassium, along with micronutrients, are vital for plant growth.
- Soil Biology: Ecosystem, with diverse microorganisms, plays a crucial role in nutrient cycling.
- pH Balance: Soil pH affects nutrient availability; most crops thrive in slightly acidic to neutral pH ranges.

Managing these factors that are essential for sustainable soil health and enhanced crop productivity have been but not currently sustainable:

- Fallow system: farming technique in which arable land is left without sowing for one or more vegetative cycles to allow the land recover and store organic matter while retaining moisture and disrupting pest life cycles and soil borne pathogens by temporarily removing their hosts
- Crop Rotation: Rotating crops can help manage pests and diseases, improve soil structure, and prevent nutrient depletion.
- Minimum tillage Practices: Minimize soil disturbance through reduced tillage or no-till methods to preserve soil structure and organic matter
- Pest and Disease control: Strategies to minimize pesticide use and protect beneficial soil organisms

In recent times, Industrial Revolution to produce raw materials demanded by commerce and population pressures associated with human activities like deforestation, intensive agriculture, and urbanization have significantly contributed to degradation of Soil and the decline in quality alongside natural processes like erosion and climate change playing a major role.

To maintain good soil quality, the development of quantitative science offered new opportunities for improved soil management. These involves.

- Soil Testing: Regular soil testing to determine nutrient levels, pH, and other soil properties, enabling informed management decisions.
- Fertilization: Use fertilizers judiciously, considering soil test results and crop needs, to avoid nutrient imbalances and environmental pollution.
- Organic Matter/ Crop Residue: Adding *compost*, manure, crop residue and cover crops can improve soil structure and fertility

The fact that mineral fertilizers are more expensive which most farmers cannot afford, comes the Concept of integrated soil fertility management ISFM).

1.0 Module I: SOIL AND WATER CONSERVATION PRACTICES FOR ENHANCED PRODUCTIVITY ALONG WATERSHEDS

Soil and water are the foundation of all agricultural systems. Yet, these two critical resources are under increasing pressure due to erosion, deforestation, overgrazing, climate change, and unsustainable farming practices. Watersheds, which naturally collect, store, and distribute water, play a key role in this conservation.

1.1. Watershed Zones and Landscape Position

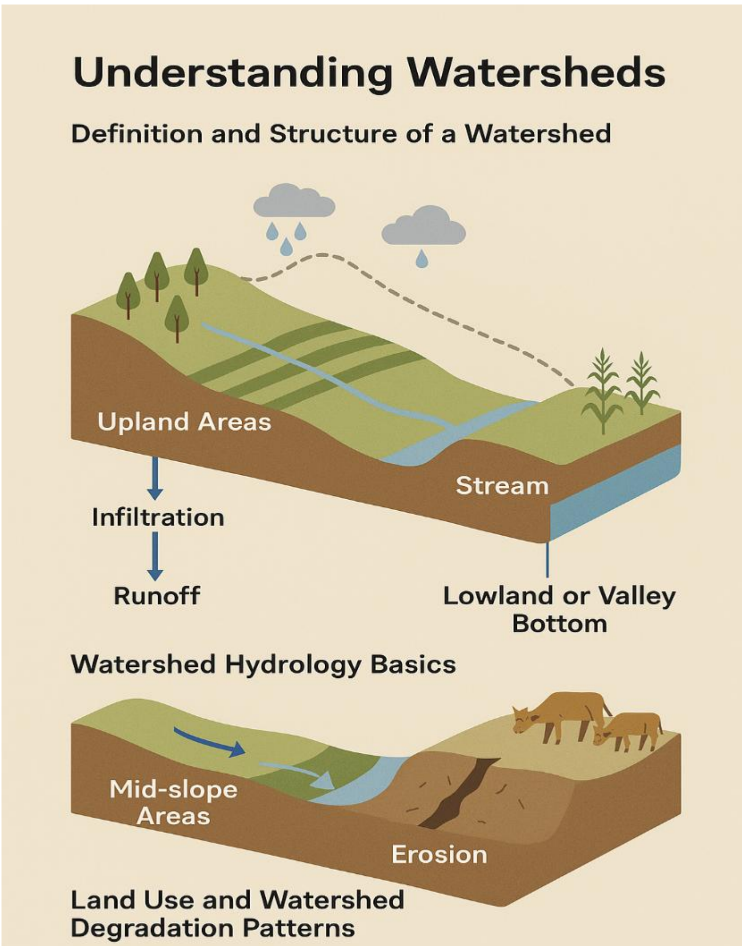


Fig 1: Image depicting different watersheds.

Watersheds can be divided into three main zones based on topography:

- **Upland Areas**: These are the highest parts of the watershed, where water begins to flow. Soil erosion is often severe here due to steep slopes and high runoff potential.

- **Mid-slope Areas**: These act as the transition zone. Poor management here can cause erosion and sedimentation downstream.

- **Lowland or Valley Bottoms**: Water accumulates here. If mismanaged, these areas can become waterlogged or eroded gullies. Each of these zones requires specific conservation practices tailored to its slope, soil, and water flow characteristics.

1.2 Soil Erosion and Its Impact

1.2.1 Types and Causes of Soil Erosion

Soil erosion is the removal of the topsoil layer by water, wind, or human activity. It is one of the most serious threats to agricultural productivity, especially in hilly or sloped landscapes like watersheds.

The common types of soil erosion in watershed areas include:

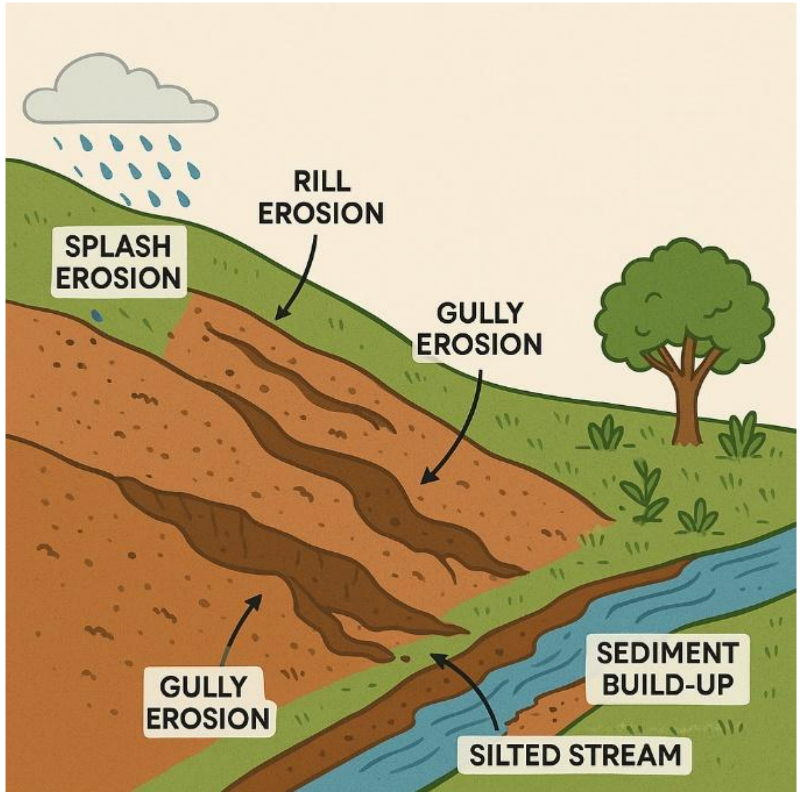


Fig 2: Images depicting different types of erosion.

- Splash Erosion: Caused by raindrops hitting bare soil, dislodging particles and reducing soil structure.
- Sheet Erosion: Occurs when a thin layer of soil is removed evenly across a large area by surface runoff.
- Rill Erosion: Happens when runoff water starts cutting small channels into the soil.
- Gully Erosion: An advanced form of rill erosion where deep channels form, often making the land unfit for farming.
- Streambank Erosion: Erosion along riverbanks, often worsened by farming too close to streams.

Primary Causes of Erosion

- Deforestation: Removing trees reduces root systems that hold soil together.
- Overgrazing: Livestock remove protective vegetation, exposing soil to erosion.
- Improper Tillage: Plowing along slopes rather than across them increases runoff.
- Lack of Ground Cover: Bare soils are more vulnerable to erosion during rainfall or windstorms.
- Construction and Land Use Changes: Roads and settlements disrupt natural water flow.

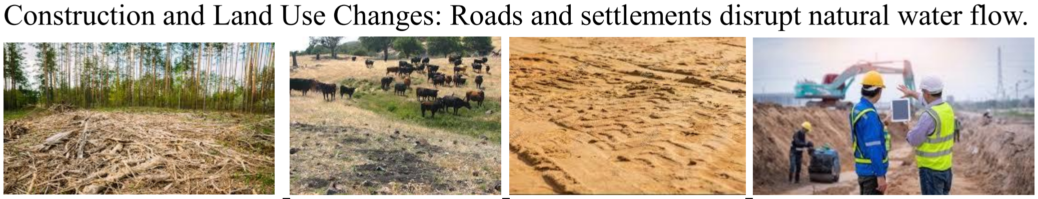


Fig 3-6: Cross-section of images showing the primary causes of erosion

1.2.2 Erosion Patterns in Watershed Areas

Erosion is often more severe in the upper and mid-slopes of a watershed. Water picks up speed and energy as it flows downhill, carrying soil particles and depositing them in the valley bottoms, where it can cause sediment buildup and reduce soil quality.
The result is twofold:

- The upland areas become unproductive.
- The lowland areas face flooding, silting, and waterlogging.

Fig 7-9: Gully Erosion in different parts of Nigeria

Effects on Agricultural Productivity
Soil erosion does more than just reduce soil quantity. It affects soil quality by:

- Removing topsoil that contains organic matter and nutrients.
- Decreasing soil water-holding capacity.
- Breaking down soil structure.
- Reducing root penetration and plant anchorage.
- Increasing reliance on fertilizers to compensate for lost nutrients.

Over time, this leads to lower crop yields, Soil erosion impacts key crops like **maize and millet** in upland zones, and **rice** in lowland and valley bottoms. Conservation practices must therefore be tailored to protect these critical crops across watershed landscapes, higher farming costs, and greater vulnerability to drought and climate shocks.
This module explores key guiding principles that Extension Agents must internalize and pass on to farming communities with both clarity and conviction.

Conservation

This is the proactive and preventive aspect of land management. It includes all actions aimed at preserving existing good soil and water conditions. Conservation strategies are best adopted early, before signs of land degradation appear. They are usually low-cost and can be integrated easily into existing farm systems.

Examples of Conservation Practices:

- Mulching with crop residues to reduce evaporation and prevent erosion
- Minimum or zero tillage to preserve soil structure
- Intercropping with legumes to cover the soil and fix nitrogen
- Agroforestry practices that integrate trees into farming systems

Restoration

Restoration, on the other hand, involves reclaiming or rehabilitating land that has already been degraded, whether by erosion, nutrient depletion, compaction, or deforestation. Restoration efforts often require more investment and take longer before benefits are realized.

Examples of Restoration Practices:

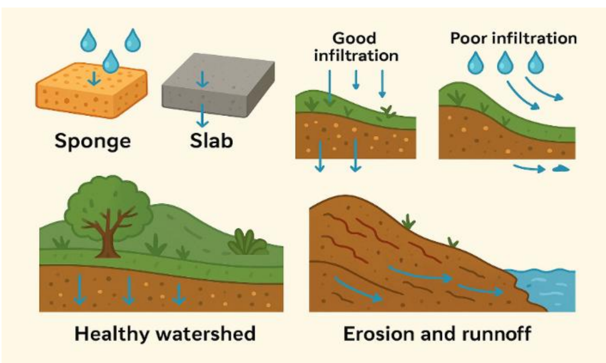
- Reforestation of degraded slopes
- Building check dams and gully plugs
- Application of organic amendments to revive nutrient-poor soils
- Use of vetiver grass to stabilize eroded channels

Proper management of the watershed will reduce the risk of degrading the entire ecosystems that farmers depend on, with the following advantages.

- Reduce runoff and erosion,
- Improve soil structure and fertility,
- Increase water infiltration and availability,
- And ultimately boost farm yields and resilience.

Key Concepts: Infiltration, Runoff, and Retention

These three interrelated water concepts are critical to the performance of agricultural fields and the stability of a watershed.



Infiltration

Infiltration is the process through which water enters the soil from the surface. A good infiltration rate ensures that rainwater is stored in the root zone rather than lost as runoff.

- Healthy infiltration is driven by good soil structure, organic matter, and ground cover.

Fig 10: An illustration of the concept of run-off and infiltration.

Example: In fields with cover crops or mulch, rainfall is more likely to infiltrate than in a bare field. Demonstrate this with a simple rainfall simulator made from bottles.

Runoff

Runoff is water that flows over the surface of the land rather than soaking into it. It is a major cause of soil erosion, especially on sloping land.

- Runoff increases in areas where the soil is hard, dry, or compacted.
- Runoff not only removes water but also carries topsoil, fertilizers, and seeds — leading to loss of farm inputs and environmental pollution downstream.

Retention

Retention refers to the soil's ability to hold water after infiltration, making it available to plant roots. High soil water retention supports crop resilience during dry periods.

- Organic matter is the biggest contributor to soil water retention.
- Practices such as composting, mulching, and the use of cover crops all increase water-holding capacity.

Extension Tip: Even with good rainfall, crops can wilt if water drains too quickly. Improving retention helps bridge dry spells.

Soil Health Indicators in Watersheds

*Extension Agents should not only teach soil and water conservation — they must also help communities **monitor soil health** over time. This builds ownership and sustainability of practices.*

Soil Health Indicators in Watersheds

- Soil Organic Matter (SOM): Indicates fertility, water retention, and biological activity. Low SOM leads to poor yields and erosion.
- Aggregate Stability: Measures soil structure and resistance to erosion. Unstable soils are prone to compaction and crusting.
- Infiltration Rate: Shows how well water enters the soil, affecting crop water access.
- Soil pH: Reflects nutrient availability and microbial activity. Extreme pH values cause nutrient lockout.
- Soil Color: Indicates organic content and drainage. Darker soils are richer and healthier.
- Vegetation Cover: Protects from erosion and supports biodiversity. Bare soil invites runoff and erosion.

Field Exercise: Take a group of Extension Agents to different parts of the watershed. Let them dig small pits and observe:

- Depth of topsoil
- Soil color
- Root penetration
- Water infiltration (using a small amount of water)

1.3 CONSERVATION PRACTICES IN WATERSHED ZONES

Conservation Practices in Mid-Slope Areas

In mid-slope areas, the goal is to prevent erosion while improving water infiltration and soil fertility.

- Terracing: Creating bench terraces or sloping terraces to slow down water flow and minimize erosion.

Fig 11-13: Contour Farming and Terracing Farming

- Agroforestry and Tree Buffering: Planting trees to protect soil, providing shade, and stabilizing the land.
- Vegetative Barriers: Using grass or shrubs to reduce wind and water erosion.

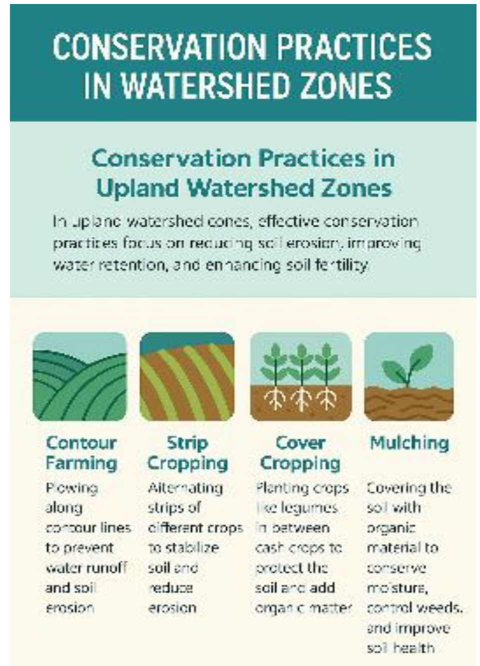


Fig 14: Conservation Practices in watershed zones

Lowland/Valley Bottom Conservation Techniques

Lowland and valley bottom areas are prone to flooding and waterlogging, making it crucial to manage water effectively.

- Check Dams and Gully Plugging: Constructing small dams to trap water and prevent gully erosion.
- Wetland Protection: Protecting and restoring wetlands to improve water retention and biodiversity.
- Drainage Management: Installing proper drainage systems to manage excess water and prevent waterlogging.

1.3.1 WATER HARVESTING AND MANAGEMENT STRATEGIES

Water conservation and harvesting are critical for areas with unpredictable rainfall.

- In-situ Water Conservation Techniques: Using practices like soil mulching and bundling to conserve water in place.
- Rainwater Harvesting Structures: Building structures to capture and store rainwater for agricultural use.
- Small Reservoirs and Ponds: Creating small-scale water storage to irrigate crops during dry periods.

Fig 15-16 : small scale water storage for irrigation along watersheds.

1.3.2 Integration of Soil and Water Conservation Techniques

Integrated Soil Fertility Management (ISFM) is about combining good soil fertility practices, such as using organic matter, fertilizers, and improved crop varieties, with better soil and water management to maximize crop productivity and maintain soil health. Integration of Soil and water conservation techniques play a critical role in ISFM by ensuring that nutrients and organic inputs added to the soil are not washed away by erosion or lost due to poor water management. This integration protects investments made in improving soil fertility and ensures sustainable crop yields over time.

Table 1: Table showing the advantages of integrating the conservation techniques.

Soil and Water Conservation Technique	Integration mechanism	Advantages
Contour Farming	Dibble organic manure using microdosing approach along the contours	Reduces erosion, allowing fertilizers and organic matter to stay in the soil longer, improving nutrient use efficiency.
Terracing	Plant trees horizontal to the slope and form ridges across the slope	Creates level surfaces for applying fertilizers and composts more effectively, improving soil fertility over time.
Cover Cropping	Use of cover crops like lablab, Mucuna, water melon, centrosome, etc	Adds organic matter, fixes nitrogen (if legumes are used), and protects the soil, boosting fertility naturally.
Mulching	Use of dry grass, stalks, straws, synthetics	Reduces moisture loss, encourages microbial activity, and slowly adds organic nutrients to the soil.
Conservation Tillage	Minimum tillage using powered handheld tillers, use of herbicides	Protects soil structure, keeps organic matter intact, and reduces loss of applied fertilizers.
Agroforestry	Planting of fast tress and shrubs spp. E.g. Moringa trees, date palms, etc. in Zai pits	Trees add organic matter through leaf fall and root turnover, improving soil structure and fertility.
Check Dams	Reinforcement with stone and sandbags	Traps sediments rich in organic and mineral nutrients upstream, enriching soils downstream.
Water Harvesting	Construction of halfmoon reservoirs, mini ponds, trench,	Ensure water availability to dissolve and move nutrients in the soil, supporting crop uptake.

Grass Waterways	Planting Gamba and Napier grasses for animal feeds which in turns the droppings will be used as organic manure	Protects fields from erosion, preventing loss of fertilizers and organic inputs.
Gully Plugging	Planting of bamboo plant,	Reclaims degraded land, making it productive again for ISFM practices like composting and fertilization.

1.0 Module II: COMPOST MANURE – PROCESSES AND APPLICATION FOR SOIL HEALTH MAINTENANCE ALONG WATERSHEDS

Maintaining soil health is a cornerstone of sustainable agriculture, especially in regions along watersheds where soil erosion, nutrient leaching, and water contamination are major challenges. Compost manure, a natural organic amendment, presents a sustainable approach to replenish soil fertility, improve structure, and support agroecosystem resilience. This training module equips extension agents with knowledge and practical guidelines for effective composting and its strategic application in watershed areas.

Fig 1 : Compost manure

In watershed regions, compost plays a crucial role in erosion control and water filtration. When applied strategically:
- It increases infiltration, reducing surface runoff.
- Enhances aggregate stability, thus minimizing soil erosion.
- Retains nutrients and reduces leaching into water bodies.
- Improves vegetation growth, which stabilizes slopes and prevents gully formation.

1.1 Understanding Compost Manure

Compost manure is a stable, humus-rich product formed from decomposed organic materials under controlled aerobic conditions. It is an essential tool for maintaining and improving soil health due to its capacity to enhance microbial diversity, supply nutrients, and improve soil structure.

Compost Materials

Composting relies on a combination of two main types of materials:

- Green Materials (Nitrogen-rich): These are fresh, moist materials that provide the nitrogen needed by microorganisms to grow and reproduce. Examples include fresh grass clippings, fruit and vegetable kitchen scraps, and animal manure (preferably from herbivores like goats, sheep, or poultry).

- Brown Materials (Carbon-rich): These are dry, fibrous materials that supply carbon—the primary energy source for decomposing organisms. Common examples include dry leaves, straw, maize stalks, wood shavings, and sawdust.

A good compost pile should have a balanced mixture of green and brown materials. Layering them alternately can help optimize the decomposition process.

Carbon to Nitrogen (C:N) Ratio

The ideal C:N ratio for composting is around 30:1. This means the pile should have about 30 parts carbon to 1 part nitrogen. This ratio creates a favorable environment for microbial activity:

- Excessive nitrogen (from excessive growth) can result in a wet, smelly pile due to anaerobic conditions.
- Too much carbon (excess browns) slows down decomposition, as microbes lack sufficient nitrogen to function effectively.
- Maintaining this balance is critical for producing quality compost within a reasonable time frame.

Moisture Content

Moisture plays a key role in composting, as it facilitates microbial activity. The optimal moisture level is about 50–60%, which can be tested manually:

- Take a handful of composting material and squeeze it.
- If it feels like a wrung-out sponge—damp but not dripping—moisture is adequate.
- If it's too dry, sprinkle water; if too wet, add more brown (dry) materials and turn the pile to aerate.

Aeration

Composting is an aerobic process, meaning it requires oxygen. Lack of aeration can lead to anaerobic conditions, causing bad odor and slowing down decomposition.

- Turn the compost pile every 1–2 weeks to introduce oxygen, redistribute moisture, and mix materials evenly.
- For windrows or heaps, a garden fork or mechanical turner can be used.
- In pit systems, frequent turning is harder but should be done whenever feasible.

Maturity and Readiness Testing

Compost is considered mature and ready for use when:

- It has a dark brown to black color.
- It emits an earthy, soil-like smell, with no offensive odor.
- The texture is crumbly, with no identifiable food or plant material.
- The internal temperature of the pile has dropped to ambient levels and remains stable.

Mature compost should not reheat when piled, which signals the microbial activity has ceased and the compost is stable for soil application.

1.2 COMPOSTING PROCESS AND TECHNIQUES

Key Phases of Composting

-Mesophilic Phase (20–40°C): This initial stage involves mesophilic microbes that begin breaking down soluble, readily degradable compounds. It lasts a few days.
- Thermophilic Phase (40–70°C): Heat-loving organisms dominate, rapidly decomposing complex organic matter like cellulose. This phase sanitizes the compost by killing pathogens and weed seeds and can last several weeks.

- Cooling Phase: As easily degradable material is exhausted, microbial activity declines and temperature drops. More resistant compounds like lignin begin to break down.
- Maturation Phase: Microbial activity continues at a slower pace, forming stable humus. This phase ensures that compost is safe for crops and can last from 1 to 2 months depending on the materials used.

1.3 TRADITIONAL COMPOSTING METHODS

Composting can be carried out using various methods depending on the scale of operation, available resources, climate, and intended use. Below are the major techniques commonly adopted:

1.3.1 WINDROW COMPOSTING

Windrow composting involves piling organic materials into long, narrow rows that are typically 2-3 meters wide and 1.5-2 meters high. These windrows are periodically turned, either manually or with a tractor-mounted turner, to promote microbial activity, maintain aeration, and evenly distribute moisture. The process requires the windrows to reach 131°F for 15 days, with the pile being turned five times to ensure proper decomposition. Local regulations may vary, so it's important to check jurisdiction-specific guidelines. This basic guide provides an overview of the windrow composting system.

Fig 2: illustration of windrow composting processes

Equipment and Materials

- Equipment needed to turn Compost Windrow
  Loaders, skid steers or specially made compost windrow turners are required to turn the Compost Windrow.
- Compost Temperature Guage
- Area for receiving food scrap materials,
- Area for storage of "browns". Straw, Wood Chips, Leaves etc…
- Area for curing and finished Compost piles

Setting up and Operating a Windrow Composting system:

Step i – Preparing area and feed stocks

Prepare area for receiving materials. Keep a separate area for food scraps and a separate area for your "brown" materials.

Food scraps must either be incorporated into a compost pile, or covered with soil, brown material, or finished compost every day in order to prevent animal encounters.

Fig 3: Site selection before composting

Step ii – Active Composting

Mix your food scraps with brown materials.

1. The recipe will vary depending on your feed stocks.
2. Typically, the mix is 2x volume of brown materials to Volume of Food Scraps with an even mixture of bulkier wood chips and more easily digestible brown materials such as leaves or straw.

- Pile mixed materials into a windrow and cover any exposed food scrap material with finished compost, or soil to reduce pest attractants.
- Measure internal temperature of Compost pile with Compost Temperature probe and record every day
- Turn the pile and ensure that the outside of the pile has been moved to the inside of the pile.
    1. Pile to be turned if internal temperatures have reached over 130ºF for 3 days. Pile may also need to be turned if it needs to be dried out, needs moisture added or if internal temperatures have reached over 170ºF.
- Turn the pile each time the internal temperature reaches over 130ºF for 3 days.
- Once the pile stops heating and maintains a consistent temperature even after being turned it can move to the Curing pile.

Fig 4: Compost with the thermometer probe.

Step iii – Recovering Bulking agents (optional)

- If you are using Wood Chips in the mix and wish to reuse them in subsequent compost batches you can screen these out to utilize them again.

Step iv -Curing

- Place com post that is no longer heated in a pile no taller than 5 ft tall and let sit for at least 30 days while continuing to monitor for temperature and moisture.
- If Compost is to be sold or used in home gardens it is advisable to get the Compost tested for Maturity either by germination test or local stick method.

Step v – Screening

1. Depending on its end use the material may need to be screened to provide a consistent compost mixture that gardeners recognize as a soil amendment.
2. However, if Compost is to be utilized as a mulch or under trees it is not necessary to screen the product. Step 6 – Finished Compost
3. Finished Compost will look and smell like soil and may be used in many ways to add to the soil.

- Limitations:
  1. Requires large land area and access to machinery.
  2. Labor and machinery cost may be high.

1.3.2 Pit Composting

This method involves placing compostable materials into shallow or deep pits (about 1–2 meters deep), especially where water availability is low. The pit conserves moisture, making it ideal for arid or semi-arid regions.

- Limitations:
  1. Slower decomposition due to limited oxygen.
  2. Risk of waterlogging in high rainfall areas.
  3. It can be labor-intensive to dig.

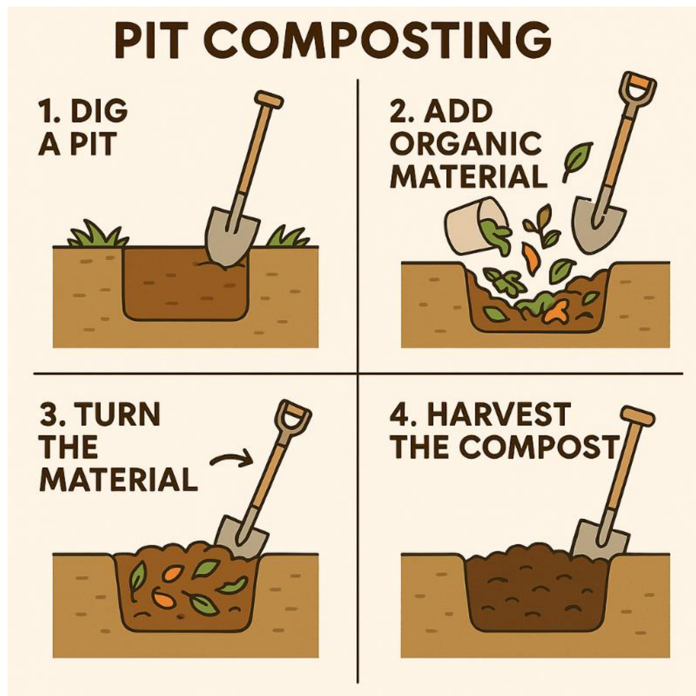


Fig 5: illustration of Pit Composting Processes

Step-by-Step Guide to Pit Composting

- Prepare the Pit:
  1. Location: Choose a well-ventilated area away from direct sunlight and water sources.
  2. Digging: Dig a pit or trench about 12-15 inches (30-38 cm) deep and 8-10 inches (20-25 cm) wide
- Collect Organic Waste:
  1. Materials: Gather kitchen scraps, garden waste, and farm residues.
  2. Examples: kitchen waste, Fruit peels, vegetable scraps, leaves, grass clippings, and manure
- Add Organic Waste to the Pit:
  1. Layering: Place the organic waste into the pit, filling the bottom 4 inches (10 cm) with compost material
- Add Water:
  1. Moisture: Ensure the compost material is moist but not soggy. Water the pit if necessary.
- Mix the Materials:
  1. Action: Mix the compost materials to promote decomposition.
- Cover the Pit (Optional):
  1. Covering: Cover the pit with soil and mulch to retain moisture and prevent pests.
- Monitor and Maintain:

1. Check: Regularly check the moisture levels and add water if needed

- Harvest the Compost:

1. Time: Compost is ready in 6-12 months.
2. Indicators: Finished compost is dark, crumbly, and has an earthy smell

- **Best suited for**: Areas with dry climates or limited space; smallholder farms.
- **Advantages**:

1. Conserves moisture and nutrients due to containment.
2. Minimizes odor and pest problems.
3. Requires minimal turning.

1.3.3 Heap or Pile Composting

This is the most common and simplest method used by small-scale farmers. Organic materials are simply stacked into a heap or mound above ground, typically in a shaded area. Materials should be layered (e.g., dry-wet-dry) to balance carbon and nitrogen.

Fig 5: illustration of Heap or Pile Composting Processes

Step-by-Step Guide to Heap or Pile Composting

- Select a Location:

Choose a well-drained area with good air circulation, away from direct sunlight and water sources.

- Collect Organic Waste:

Gather kitchen scraps, garden waste, and farm residues. Examples include fruit peels, vegetable scraps, leaves, grass clippings, and manure.

- Create the Pile:

Start with a layer of coarse materials like twigs or straw to ensure good drainage.

Alternate layers of green (nitrogen-rich) and brown (carbon-rich) materials. Green materials include vegetable scraps and grass clippings, while brown materials include dried leaves and straw.

- Moisture Control:

Ensure the compost pile is moist but not soggy. Water the pile if it’s dry and cover it if it’s too wet.

- Turning the Pile:

Turn the compost pile every 2-3 weeks to aerate it, speed up decomposition, and prevent odor.

- Monitoring:

Regularly check the temperature and moisture levels. A well-maintained pile will heat up and break down materials efficiently.

- Harvesting Compost:

Compost is ready in 3-6 months. Finished compost is dark, crumbly, and has an earthy smell.

- Best suited for: Household gardens, smallholder and subsistence farmers.
- Advantages:

1. Low-cost and easy to set up.

2. Suitable for diverse farm wastes.
3. Allows flexibility in scale.

- Limitations:
    1. It is difficult to control moisture and aeration.
    2. Slower breakdown if not turned regularly.
    3. May attract rodents or insects if poorly managed.

1.3.4 VERMICOMPOSTING

Vermicomposting uses special earthworms, most commonly *Eisenia fetida* (red wigglers), to decompose organic matter into high-quality compost called "vermicast." It is done in bins, crates, or beds under shaded and controlled conditions.

Steps in Vermicomposting – Training Guide for Extension Agents
Step 1: Select or Build a Worm Bin
Use a plastic or wooden bin with a lid (size depends on waste output).
Ensure drainage holes at the bottom and ventilation holes on sides.
Elevate slightly to allow air circulation and collect excess moisture (leachate).

Step 2: Prepare Bedding
Use shredded newspaper, cardboard, coconut husk fiber, or dry leaves.
Moisten the bedding until it feels like a wrung-out sponge.
Fill 1/3 to 1/2 of the bin with bedding.

Step 3: Add Composting Worms
Recommended species: Red Wigglers (Eisenia fetida).
Quantity: ~1 pound (450 g) of worms per ½ pound (225 g) of daily food waste.

Step 4: Feed the Worms
Feed kitchen scraps 2–3 times a week.
Good: Fruit peels, veggie scraps, tea bags (no staples), coffee grounds, eggshells.
Avoid: Meat, dairy, citrus, spicy food, oily items, and processed foods.
Chop waste into smaller pieces for faster breakdown.

Step 5: Cover with Bedding
Always cover fresh food with a layer of bedding to:
Prevent flies and odor
Help maintain the moisture balance

Step 6: Maintain the Bin
Keep bedding moist and fluffy.
Keep in a cool, shaded place (ideal temp: 15–25°C / 59–77°F).
Add fresh bedding every few weeks as it breaks down.

Step 7: Monitor Decomposition
Worms will begin converting food and bedding into compost (castings).
This takes 2–3 months for the first harvest.
A healthy bin should smell earthy, not foul.

Step 8: Harvest the Vermicompost
Method A: Move contents to one side, add new food to the empty side. Harvest after worms migrate.
Method B: Dump and separate worms from compost manually using light/sorting method.
Step 9: Use the Vermicompost
Apply to:
Garden beds
Flower pots
Seedling trays
Make compost tea (steep in water 24 hrs)

- Benefits:

1. Enriches soil with nutrients and microbes
2. Improves plant growth and resistance

- **Best suited for**: Small-scale production, household use, urban gardens, or educational farms.
- **Advantages**:

1. Produces nutrient-rich compost with high microbial diversity.
2. Faster than traditional composting methods.
3. Low odor, environmentally friendly, and educational.

- **Limitations**:

1. Sensitive to extreme temperatures and moisture imbalance.
2. Requires careful management to avoid worm death.
3. Not suitable for large-scale composting without significant investment.

1.4 APPLICATION OF COMPOST FOR SOIL HEALTH MAINTENANCE

Effective soil management also involves understanding soil properties, addressing issues like compaction, and managing water and nutrients appropriately. Management practices should focus on minimizing soil disturbance, maximizing soil cover, increasing organic matter, and promoting biodiversity, including plant diversity and beneficial organisms.
In degraded areas or sandy soils, higher compost rates can be used to restore fertility. In sandy soils often used for millet farming, higher rates of compost (8–10 tons/ha) are recommended. For vegetable gardens, well-matured compost applied at 5 tons/ha enhances soil structure and nutrient availability for leafy vegetables. Integration with mulching and cover cropping further boosts soil health outcomes using well adopted techniques
Applying compost improves soil structure, promotes beneficial microbial life, and enhances nutrient availability. Recommended rates range between 5–10 tons/ha. Application can be done:
- During land preparation.

- As top dressing between planting rows.
- Incorporated into planting basins or pits known as Zai, Half Moon.

1.4.1 ZAI AND HALFMOON TECHNIQUE

Traditional Zai hole acts as a catchment for rain, where water flows into the hole instead of continuing to flow down the slope and being lost. A rim or bund of soil around the lower half of the hole contains the water so that it has time to sink in. When the hole is dug, manure or compost is mixed into the soil and placed back into the Zai pit.

Fig 6: Zai/Halfmoon technique in Land rehabilitation

Fig 7: Farmers filling up the Zai pits

2.0 ADVANCED ORGANIC SOIL AMENDMENTS FOR SOIL HEALTH ENHANCEMENT

While traditional composting plays a vital role in improving soil fertility and watershed health, farmers can benefit even further by adopting additional organic technologies. This section introduces three practical, farmer-friendly methods — Bokashi composting, Biochar production, and Liquid Organic Fertilizer preparation — that offer faster nutrient cycling, improved soil structure, and greater resilience for crops across different landscapes. These advanced techniques complement existing composting efforts and strengthen the foundation for sustainable soil management.

2.1 Bokashi Composting

Bokashi is a method of composting **ferments organic waste** using specific beneficial microorganisms, under **anaerobic (no air)** conditions.
Unlike traditional composting, which breaks down organic matter by aerobic decomposition, Bokashi preserves most of the nutrients and completes fermentation within **2 to 4 weeks**. The word "Bokashi" is a Japanese term meaning "fermented organic matter."

Fig 8: Bokashi composting

Importance and Uses

- Fast nutrient recycling: Bokashi compost is ready much faster than traditional compost.
- Preserves nutrients: Minimal nutrient loss, especially nitrogen.
- Low odor: Suitable for semi-urban and rural households.
- Improves soil structure: Enhances microbial life and organic matter when buried in soil.
- Reduces waste: All kitchen waste (including cooked food and meat scraps) can be recycled safely.

Is best applied for: Maize, Vegetables (tomato, pepper, cabbage, lettuce), Rice paddies (after soil incorporation)

Materials Needed

- Bokashi bran (a mix of beneficial microbes, wheat/rice bran, molasses)
- Airtight containers or buckets (with a tight lid)
- Kitchen scraps (vegetable peels, food leftovers, meat, fish, fruits)
- Optional: Gloved hands or small spade for mixing

Steps Involved in Making Bokashi Compost

1. Prepare Bokashi Bran:
   If unavailable commercially, it can be made by mixing molasses, effective microorganisms (EM), and wheat/rice bran.
2. Collect Organic Waste:
   Gather daily kitchen waste or farm residues. Avoid large bones or overly woody material.
3. Layering:
   - Place a layer of food waste at the bottom of the airtight container.

   - Sprinkle a handful of Bokashi bran over the waste.
   - Press down firmly to remove air pockets.
4. Repeat:
   Add layers of waste and bran until the container is full.
5. Seal and Ferment:
   - Close the lid tightly.
   - Store the container in a cool, shaded area for about 2–4 weeks.
   - Liquid ("Bokashi tea") may accumulate — drain weekly and dilute for use as liquid fertilizer.
6. Application:
   After fermentation, bury the material in trenches or compost pits for another 2–3 weeks to fully decompose before planting.

Notes for Trainers

- *Bokashi can be made year-round, even during the rainy season.*
- *Use Bokashi compost especially **before maize planting** or in **vegetable beds** to boost early root growth.*

2.2 Biochar Production and Application for Soil Health

Biochar is a carbon-rich, stable form of charcoal produced by heating organic materials (such as maize stalks, rice husks, groundnut shells, or wood chips) in a low-oxygen environment. The process, known as pyrolysis, prevents the material from burning into ash and instead locks carbon into a stable form that can last in the soil for hundreds of years.
Unlike ordinary ash, biochar improves soil quality, water retention, and nutrient holding capacity, making it one of the most powerful tools for restoring degraded soils.

Fig 9: Biochar/ Biochar production processes

Importance and Uses

- Improves Soil Structure: Increases porosity and aeration, allowing better root penetration.
- Enhances Water Retention: Particularly valuable in dry regions by keeping moisture around plant roots.
- Boosts Nutrient Efficiency: Retains fertilizers and organic nutrients, reducing leaching losses.
- Stimulates Soil Biology: Provides habitat for beneficial soil microorganisms.
- Climate Benefits: Captures and stores carbon in the soil, helping to fight climate change.

Biochar is especially beneficial for:

- Millet and sorghum in drylands
- Maize in sandy, nutrient-poor soils

- Rice (after incorporating into lowland soils)
- Vegetables such as tomatoes, onions, peppers, and leafy greens

Materials Needed

- Dry biomass: maize stalks, rice husks, groundnut shells, coconut husks, dry wood chips
- Pit or simple kiln: dug pit, half-drum, or metal kiln
- Matches or lighter
- Shovel or spade
- Water (for quenching the fire)
- Protective gear: simple mask or cloth over mouth/nose if lots of smoke

Steps Involved in Making Biochar

1. Collect Dry Biomass:
   Use only dry materials for easier ignition and better-quality biochar.
2. Prepare a Pit or Kiln:
   - Dig a shallow pit (about 50 cm deep) or use a metal drum with side holes for limited air entry.
   - The goal is low oxygen, so that materials char rather than burn fully.
3. Start a Small Fire:
   - Place a little dry material at the bottom and light it.
   - Gradually add more biomass while controlling the flame — keep it smoldering, not flaming.
4. Control Oxygen Flow:
   Cover partially with soil, sand, or metal sheets to minimize oxygen. Avoid full exposure to air.
5. Quench the Fire:
   - Once the material turns deep black and brittle (not gray ash), immediately quench with water.
   - Stir with a shovel while sprinkling water to fully extinguish hidden flames.
6. Crush and Store Biochar:
   After cooling, crush into smaller pieces for easier soil incorporation.
   Store in a dry sack until ready for use.

⚠ Important Tips for Trainers

- Activate ("Charge") Biochar Before Use: Fresh biochar can absorb nutrients and water initially, so it's best to "charge" it by mixing with compost, manure, or liquid organic fertilizer before applying to fields.
  Example: Soak biochar in compost tea for 1–2 weeks before mixing into soil.
- Safety Precaution: Always stand upwind while burning biomass to avoid inhaling smoke. Wearing a simple cloth mask is recommended.

Field Application Methods

- *Mix with compost or manure: About 10–20% biochar by volume in compost piles.*

- *Direct Soil Incorporation: Apply biochar at 2–5 tons per hectare, depending on soil condition.*
- *Targeted Micro-Dosing: Place small amounts of biochar directly into planting holes for crops like maize or sorghum.*

Table 2: Examples of Crops for Biochar Application

Crop	**Biochar Application Benefits**
Millet and Sorghum	Enhances drought resistance by improving water retention
Maize	Boosts nutrient uptake and stabilizes soil in sandy areas
Vegetables (Tomato, Pepper, Onion)	Improves root development and yields in gardens
Rice (Paddy Fields)	Enhances soil drainage and microbial health after mixing

Extension Tip: "Biochar turns poor soils into healthy soils — it's like giving the land a new life."

2.3 Liquid Organic Fertilizer Production and Application

Liquid organic fertilizer (LOF) is a nutrient-rich solution made by fermenting organic materials such as fresh plant leaves, animal manure, and crop residues in water. Unlike solid compost, liquid fertilizers are fast-acting and allow quick nutrient absorption by plants through the roots or leaves (as a foliar spray).

It is a low-cost and easy-to-make alternative to expensive chemical fertilizers, especially for smallholder farmers.

Fig 10-12: Liquid Fertilizer production and processes.

Importance and Uses

- Fast Plant Nutrition: Nutrients are immediately available for plant uptake.
- Low Cost: Can be made with locally available farm and household materials.
- Enhances Plant Growth: Boosts photosynthesis, flowering, and fruiting.
- Improves Soil Microbiology: Feeds beneficial microbes in the soil and on plant surfaces.
- Reduces Environmental Impact: Organic and eco-friendly compared to synthetic fertilizers.

Best applied for: Vegetables like tomatoes, peppers, onions, cabbage, Maize (especially during early growth stage), Rice seedlings (before transplanting) and Fruit trees (as a foliar spray for vigor)

Materials Needed

- Fresh animal manure (preferably cow, goat, sheep, or poultry droppings)
- Green plant material (leguminous plants like cowpea leaves, banana stems, or grasses)

- Water
- Molasses or sugar (optional, to speed up fermentation)
- Large plastic drum or container (with cover)
- Stick or paddle for stirring
- Sieve or cloth for filtering (optional)
- Sprayer or watering can for application

🛠 Steps Involved in Making Liquid Organic Fertilizer

1. Prepare Organic Materials:
   - Chop fresh green leaves into small pieces.
   - Collect fresh animal manure.
2. Mix in Container:
   - Fill the drum about one-third with chopped greens and manure.
   - Add clean water to fill about two-thirds of the container.
   - Add one cup of molasses or a few tablespoons of sugar (optional) to feed microorganisms.
3. Fermentation:
   - Stir the mixture well and cover loosely (not airtight) to allow gases to escape.
   - Stir the mixture every 2–3 days to ensure even fermentation.
4. Maturation Time:
   - Allow the mixture to ferment for about 10–14 days.
   - When ready, the solution should smell slightly sweet or earthy — not rotten.
5. Filtering and Storage:
   - Strain the liquid through a sieve or cloth into clean containers.
   - Keep the liquid fertilizer in a shaded place until use. Use within 2–4 weeks for best results.

🏡 How to Use Liquid Organic Fertilizer

Dilution:

- Always dilute before applying to crops: 1 part fertilizer to 10 parts water (e.g., 1 liter fertilizer + 10 liters water).

Application Methods:

- Foliar Spray: Spray directly on the leaves early in the morning or late in the afternoon.
- Soil Drench: Pour diluted fertilizer at the base of plants.
- Apply every 7–10 days during active crop growth stages for best results.

⚠ Important Tips for Trainers

- Avoid using diseased plants or too much animal manure, to prevent spreading diseases.
- Do not spray under strong sunlight — this can burn the leaves.
- Always stir well before each use to re-mix nutrients that settle at the bottom.

Table 3: Examples of Crops and Application Stages

Crop	Stage for Application	Expected Benefit
Tomato, Pepper, Onion	Early vegetative and flowering stage	Boosts flowering, fruit set, and plant vigor

Crop	Stage for Application	Expected Benefit
Maize	2–4 weeks after planting (when 4–6 leaves appear)	Improves early root development and nutrient uptake
Rice Seedlings	Before transplanting and 2 weeks after	Enhances establishment and tillering
Fruit Trees (Mango, Guava)	At flowering and fruit formation	Increases yield and fruit size

***Extension Tip:** "Liquid organic fertilizer is like giving your crops a healthy energy drink*

1.0 Module III: CLIMATE SMART TECHNOLOGIES FOR MITIGATING SOIL DETERIORATIONS IN THE FACE OF CLIMATE CHANGE

Climate-smart soil practices like microdosing fertilizers, adopting stress-tolerant crop varieties, and using organic amendments offer practical, low-cost solutions that help farmers adapt to changing conditions, boost productivity, and maintain soil health. By improving water and nutrient efficiency, these practices not only protect the soil but also increase farm resilience and household income.

Extension agents are the bridge between research and reality. Their role in promoting these technologies is vital to helping farmers in Northern Nigeria overcome climate challenges and build a more sustainable agricultural future.

Fig 1-4: Microdosing Technologies Climate Smart Variety Mulching

1.1 Principles of Climate Smart Agriculture (CSA)

Climate Smart Agriculture (CSA) is a comprehensive, integrated approach designed to meet the dual challenge of ensuring food security and supporting climate adaptation and mitigation. CSA aims to:

- **Sustainably increase productivity and incomes**: By improving farm productivity, CSA helps farmers increase their yields and, ultimately, their income. This is done through better resource management, more efficient input use, and adoption of resilient agricultural practices.
- **Adapt and build resilience to climate change**: CSA equips farmers with the tools and techniques to withstand the impacts of climate change, such as unpredictable rainfall, temperature fluctuations, and extreme weather events. It emphasizes the need for adaptive strategies to secure crop production even under changing conditions.

- **Reduce and/or remove greenhouse gas emissions**: CSA focuses on reducing the carbon footprint of agriculture through practices that sequester carbon in soils and reduce emissions from fertilizers, livestock, and land-use changes. Techniques such as agroforestry, conservation tillage, and organic amendments are key contributors.

1.2 Climate Smart Technologies for Soil Health

For **soil health**, CSA is especially crucial. Soil is not only the foundation of agricultural production, but it also acts as a natural carbon sink, storing more carbon than the atmosphere and plants combined. CSA practices for soil health focus on:

- Enhancing soil fertility and structure, making it more productive and resilient.
- Reducing erosion and organic matter loss, thus protecting the soil's ability to store nutrients and retain moisture.
- Promoting carbon sequestration, whereby the soil absorbs carbon dioxide, helping mitigate the effects of climate change.

1.2.1 Cropping System Approaches

Practices:

- Crop rotation: Alternating crops (e.g., legumes with cereals) to break pest/disease cycles and improve soil fertility.
- Intercropping: Growing two or more crops together (e.g., maize + cowpea) for improved land use and biodiversity.
- Agroforestry: Integrating trees with crops/livestock to enhance organic matter and protect soil.
- Cover cropping: Using plants like legumes or grasses during off-season to prevent erosion and enhance soil health.

Benefits:

- Prevents soil nutrient depletion.
- Reduces erosion and run-off.
- Increases organic matter and microbial activity.

Cover Cropping and Green Manuring Planting non-cash crops to protect the soil during off-seasons.

- **Benefits**: Prevents erosion, fixes nitrogen, suppresses weeds.
- **CSA Link**: Builds carbon soil and improves resilience.

1.2.2 Fertilizer Microdosing

What It Is:

- The application of **small, precise amounts of fertilizer** near the seed at planting or early growth stages.

Microdosing Fertilizer Technology Microdosing involves applying small, targeted quantities of fertilizer directly at the root zone during planting or early crop stages. This method increases efficiency and minimizes environmental losses.

- **Process**:

1. Fertilizer is applied in doses as small as 2–6 grams per planting hole or alongside the seed row.
2. Application is done manually using bottle caps, small cups, or simple tools for uniformity.
3. Timing is critical: apply during planting and/or within the first few weeks of crop emergence.

- **CSA Link**: Improves fertilizer use efficiency and supports soil nutrient balance, especially for resource-poor farmers facing erratic rainfall.

Benefits:

- Improves nutrient use efficiency.
- Reduces nutrient leaching and environmental impact.
- Cost-effective, especially for smallholder farmers.
- Enhances crop yields even in low-input systems.

Field Tip:

Use bottle caps or small scoops to standardize doses. Combine organic matter with sustained fertility.

1.2.3 Climate-Resilient Varieties

Focus:

- Drought-tolerant, early-maturing, and disease-resistant crop varieties.

Use of Climate-Smart Crop Varieties Climate-smart varieties are bred or selected to withstand adverse climatic conditions such as drought, salinity, flooding, and heat.

- CSA Link: Helps maintain productivity under shifting climate regimes while optimizing soil moisture and nutrient use.

Benefits:

- Maintains yields under climate stress and Enhances crop survival.
- Reduces the need for chemical inputs.
- Ensures food security and resilience.
- resilience in stress-prone environments.

Extension Tip:

Include demo plots to showcase variety performance under local conditions.

1.2.4 Conservation Agriculture

Conservation Agriculture (CA) is an approach that focuses on three main practices that help protect the soil while increasing crop yields:

Minimal Soil Disturbance (No-Till): This means avoiding plowing or tilling the soil, leaving it undisturbed. Instead of turning the soil over, farmers plant crops directly into the soil surface.

Permanent Soil Cover (Mulching): Keeping the soil covered with mulch, which can be crop residues, cover crops, or any other organic material, ensures that the soil is not exposed to the sun or wind.

1.2.5 Crop Rotation: This involves changing the crops grown in a field each season, rather than planting the same crop year after year.

Benefits for Farmers:

- Improves Organic Matter: When soil is kept covered and disturbed minimally, it naturally becomes richer in organic matter, which is great for plant growth.
- Reduces Erosion: By avoiding plowing and keeping the soil covered, wind and rain cannot easily wash or blow the soil away. This is especially helpful during heavy rains or droughts.
- Improves Water Retention: Mulch keeps the soil moist, helping crops survive in dry conditions.

2.0 How Conservation Agriculture Links to Climate Smart Agriculture (CSA):

- Mitigates Greenhouse Gas (GHG) Emissions: By not tilling the soil, farmers can reduce carbon emissions.
- Improves Drought Resilience: Mulching and no-till practices make soil more resilient during droughts by retaining moisture for longer periods.

Agroforestry Systems The integration of trees with crops and/or livestock.

- Benefits: Reduces erosion, stabilizes microclimates, and increases carbon sequestration.
- CSA Link: Enhances biodiversity and soil organic carbon.

Organic Amendments and Soil Conditioners Use of compost, manure, and biochar to replenish soil organic matter.

- Benefits: Enhances soil fertility, structure, and microbial activity.
- CSA Link: Promotes carbon storage and reduces dependency on synthetic inputs.

Integrated Nutrient Management (INM) Combining organic and inorganic nutrient sources with precision application.

- Benefits: Optimizes nutrient use efficiency and maintains long-term fertility.
- CSA Link: Reduces nutrient losses and enhances adaptive capacity.

Climate-Smart Irrigation and Water Management Technologies like drip irrigation, rainwater harvesting, and soil moisture sensors.

- Benefits: Prevents waterlogging, salinization, and conserves water.
- CSA Link: Improves water use efficiency under erratic rainfall.

Recommendations for Extension Agents

- Promote participatory learning models such as Farmer Field Schools.
- Encourage use of locally available materials for compost and mulch.
- Integrate gender-sensitive approaches to CSA adoption.
- Collaborate with local institutions and research centers.
- Facilitate access to credit and inputs for smallholder adoption of CSA.
- Demonstrate the economic and agronomic benefits of microdosing and climate-smart varieties.

Conclusion

Soil is both a victim and a solution in the climate crisis. Promoting climate smart technologies is essential for sustaining soil functions, protecting rural livelihoods, and ensuring long-term agricultural productivity. Extension agents are the bridge between innovation and on-farm application—making their role in disseminating CSA knowledge indispensable.

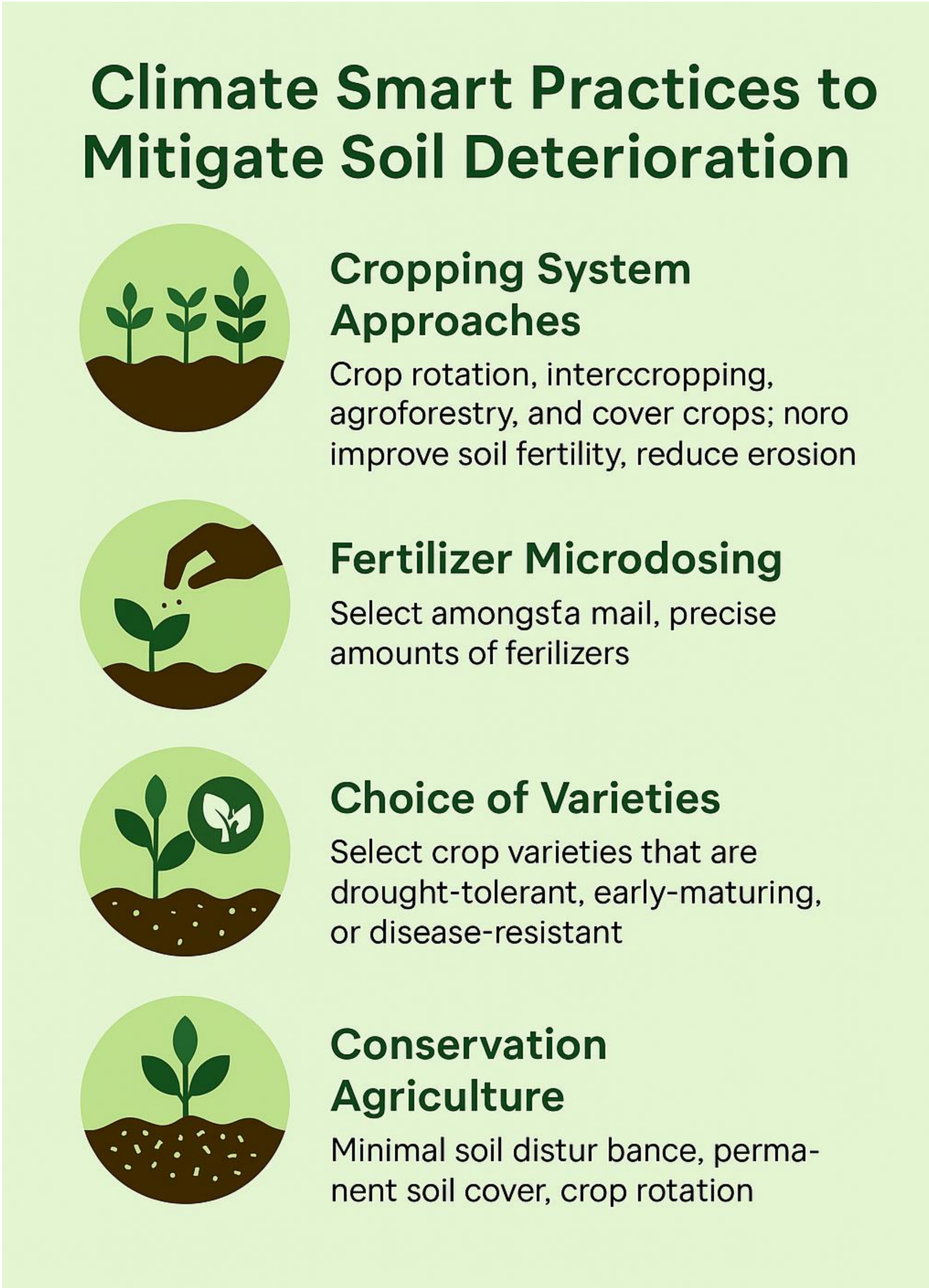
Illustration


ISFM
Integrated Soil Fertility Management
N
K
Balanced fertilization
Organic inputs
Improved varieties
Soil conservation


PIT COMPOSTING
MATERIALS NEEDED
Straw
Dry leaves
Wood shavings
Fresh leaves
Fresh leaves
Manure
Shovel
Tarp
Water
Harvest
STEPS
1 Excavate pit
2 Layer browns
3 Layer greens
4 Moisten & compact
5 Cover & wait


Heap or Pile Composting
1. Choose a Composting Site
Flat area on dare earth, Good drainage, sure o to maintain eʌy to maintain moisture.
2. Prepare Base Layer
Greens
Browns
• Dry
• Straw
• Hay
(intruisted)
• Start with a 4-6 inch layer of coarse, dry materials
• Aim for about 4-6 inches thick
Avoid
Meat, pet s4-. diseasee plants
3. Collect and Sort Compostable Materials
Greens
Browns
• Dry
• Leases
• Straw/ Itray
Avoid
Meat, pet waste, diseased plants
• Aim for approximately 2-3 parts brown
5. Add Moisture
Ad pl: should be as moist as a wrung-out sponge.
4. Add Moisture
Turn the pile every 1-2 weeks using a garden fork or shovel
8. Let It Compost Over Time
Actively managed pile 2- 3-3 months.
Passive heap 2-3 months or more
7. Monitor and Maintain the File
Check for heat, moisture level and smell
9. Use the Finished Compost
Use the finished compost in or rdons, pots


Steps in Heap or Pile Composting
1. Choose a spot
2. Gather your materials
3. Create the first layer
4. Let it breathe


Climate Smart Practices to Mitigate Soil Deterioration
Cropping System Approaches
Crop rotation, interccropping, agroforestry, and cover crops; noro improve soil fertility, reduce erosion
Fertilizer Microdosing
Select amongsta mail, precise amounts of ferilizers
Choice of Varieties
Select crop varieties that are drought-tolerant, early-maturing, or disease-resistant
Conservation Agriculture
Minimal soil distur bance, perma-nent soil cover, crop rotation