Soil and water conservation training manual

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Published by International Institute of Tropical Agriculture

June 2023

www.africa-rising.net

The Africa Research In Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-in-development projects supported by the United States Agency for International Development (USAID) as part of the U.S. Government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING is creating opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation, and impact assessment.

Africa RISING appreciates support from the American people delivered through the USAID Feed the Future initiative. We also thank farmers and local partners at all sites for their contributions to the program and the CGIAR system.

Foreword

For West Africa to be self-sufficient in food production, the need to adopt sustainable intensification (SI) approach is urgent. Low productivity across all farming systems is the major challenge for the region's agriculture. The major factors responsible for the low productivity include land degradation, low soil fertility, climate variability and poor adoption of improved technologies.

The farm household scale is the focal domain for Africa RISING's SI investments and activities. This is the scale at which household production decisions, gender, nutrition issues, household welfare as well as soil health and productivity issues operate. Research activities at this scale focus on understanding household needs and incentives that support effective evaluation, adoption, and adaptation of the most relevant interventions.

The program co-develops with partners and shares with end-user soil and water conservation technologies on cowpea in mixed farming systems. Beyond soil and water conservation, field observations in recent years have revealed that farmer planning, including timing of planting and agronomic management practices, is often haphazard. However, if planned well it offers numerous dividends such as early crop vigor, drought avoidance, tolerance to pests and diseases. This reference manual on soil and water conservation also complements training of extension agents and development partners on use of crop planning matrix for improved crop productivity, thus developing both human and institutional capacity. It has been prepared as a practical guide to help farmers produce crops sustainably.

This user-friendly soil and water conservation manual was made possible with support from the American people delivered through the United States Agency for International Development (USAID) as part of the US Government's Feed the Future Initiative. The contents are the responsibility of the producing organization and do not necessarily reflect the opinion of USAID or the U.S. Government. The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation, and impact assessment.

Fred Kizito
Africa RISING West Africa Project Manager

Preface

The Africa RISING Program in West Africa aims at creating opportunities for smallholder farm households to move out of hunger and poverty. Sustainably intensification (SI) farming systems approach is used to conserve the land resource base to improve food, nutrition, and income security, particularly for women and children. It is now known that Soil and water conservation practices ensure that the land resource base is protected from degradation. However, the practices are not easy to implement on the field especially on mixed farming systems. This field manual is designed to assist Africa Rising Farmers practice soil and water conservation in mixed farming systems. These include the use of grassed waterways, erosion control methods, soil fertility improvement, crop-livestock systems, mixed cropping systems for optimum use of soil water at different soil depths.

Climate smart soil and water conservation practices provide scalable SI innovation packages that improve sustainability, resilience, and equity in most farming systems. Training of farmers in Soil and water conservation Farmer Field schools enhances quick adoption of practices. This improves crop productivity (yield), economic profitability (crop sales), environment sustainability (reduced soil erosion, drought stress and improve soil fertility) and social conditions (improved nutrition).

The manual targets extension and farmers. It covers aspects like knowing the soil and terrain that farmers work on. Features of erosion peculiar to farm fields. The soil texture and depth are important for characterizing potential soil moisture retention. Therefore, simple identification of soil texture has been illustrated. Contouring using A-Frame has been illustrated including composting and some methods to regenerate soil fertility. Cowpea living mulch in mixed farming system has been used for most of the illustrations.

Although the materials in the manual do not present a complete program on soil and water conservation, field assistants, students may find it useful for discussions.

Contents

Chapter 1: Know your soils

Observing the soil

Soil and water conservation is important for soil resilience by controlling runoff, erosion and managing soil nutrients. By observing soil surface and mini-pit conditions, we gain insight about specific indicators of the soil. Figure1.1 shows indicators of soil textural conditions.

- Figure 1.2 identifies indicators of soil fertility.
- Figure 1.3 illustrates how to determine the textural class of your soil.

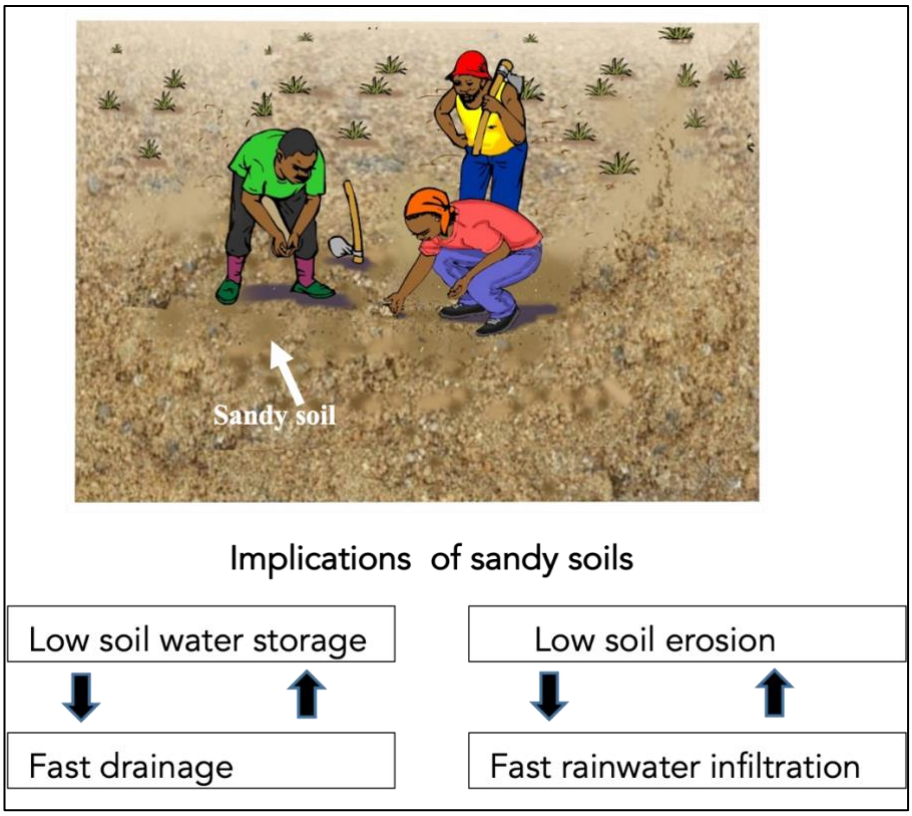

Figure 1.1a: Feeling test for roughness/grittiness and looseness of sandy soil.

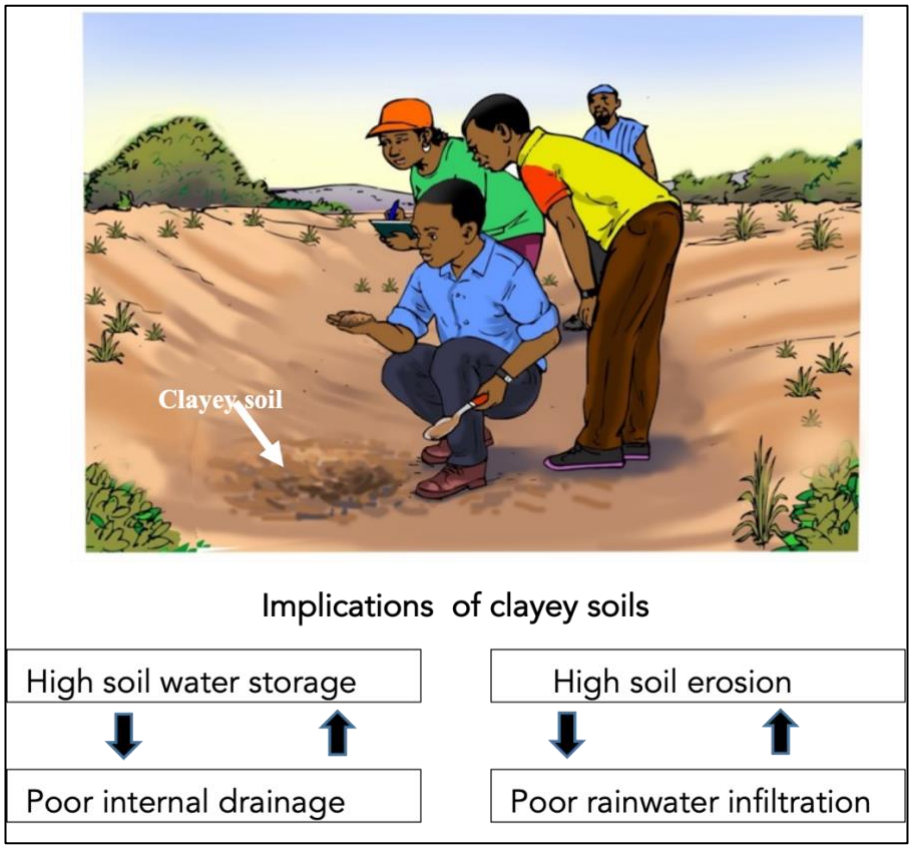

Figure 1.1b: Feeling test for smoothness and stickiness of clayey soil.

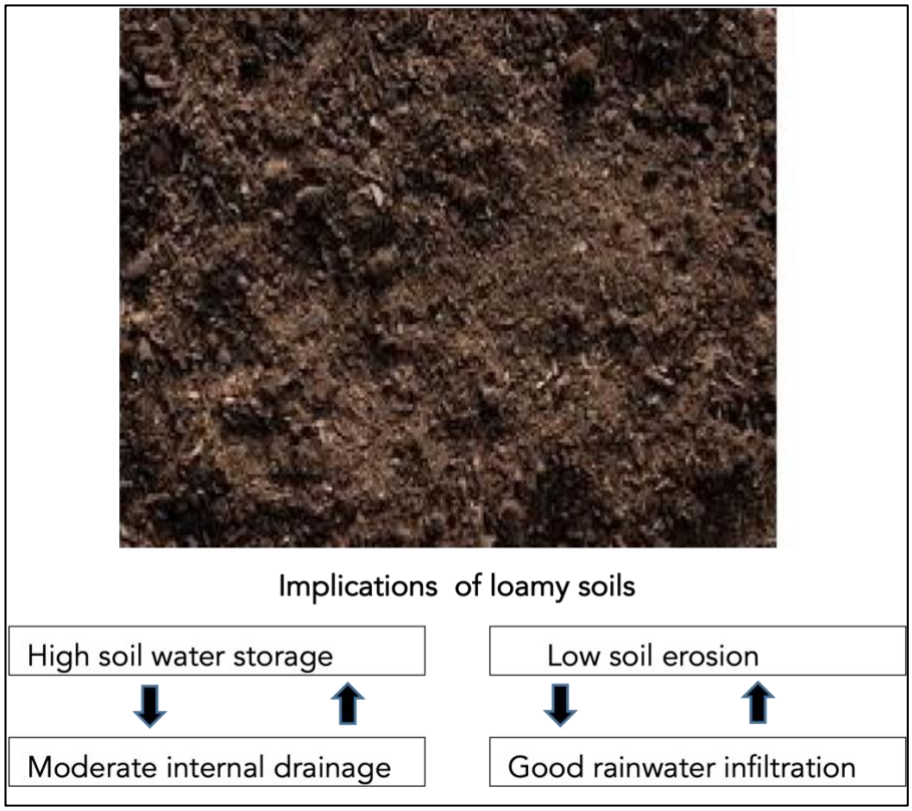

Figure 1.1c: Equal combination of sand and clay to form loamy soil.

Finding out the textural class of your soil

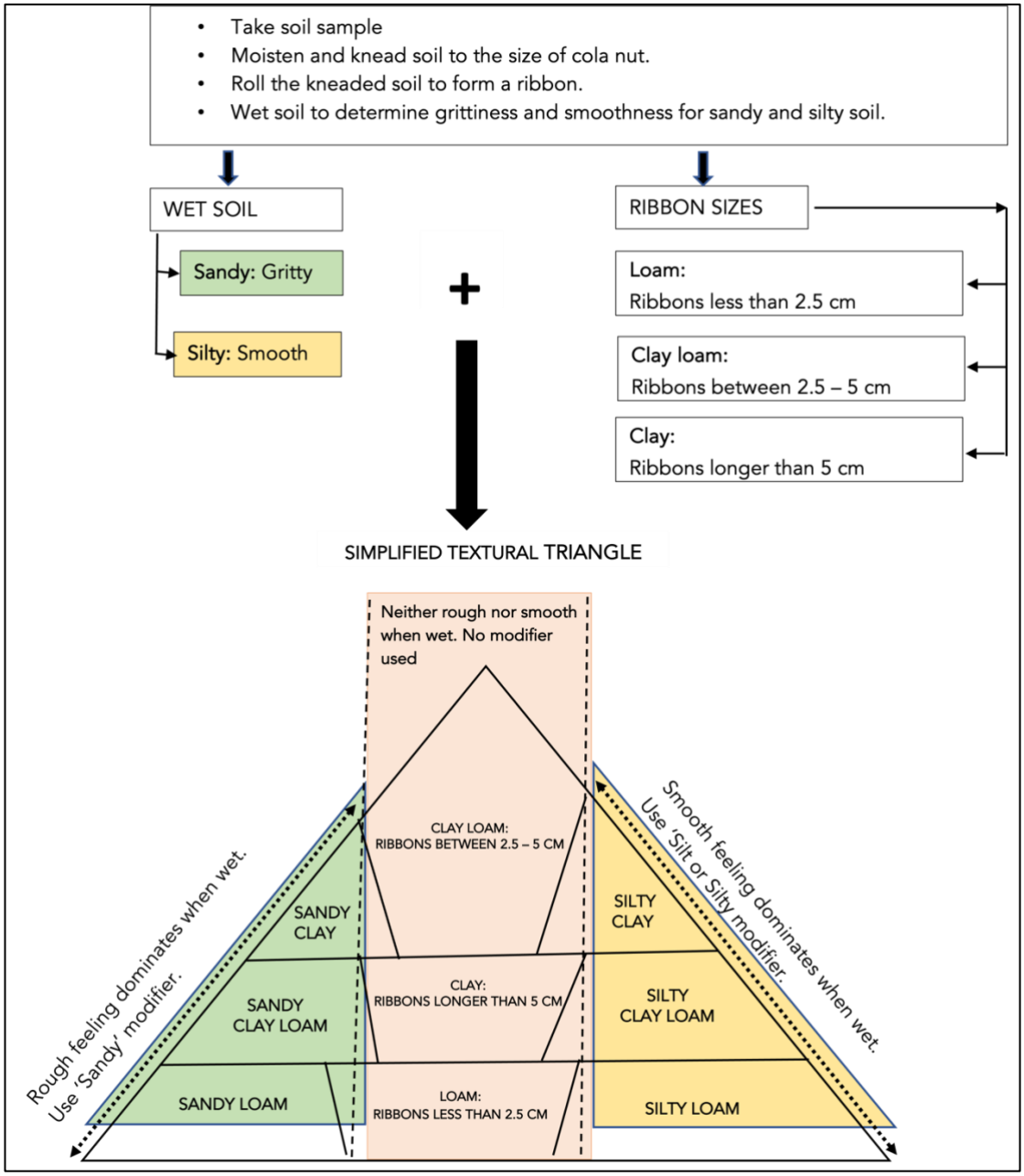

Figure 1.2: Simplified textural triangle by feel method. *Modified from Thien and Graveel (1997).*

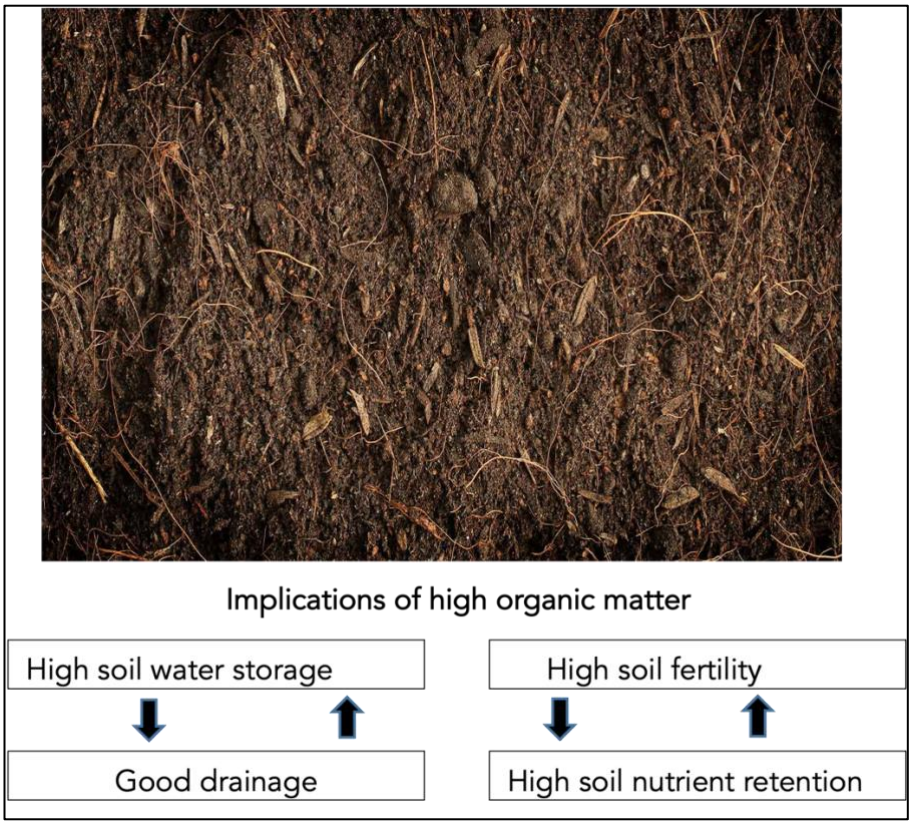

Figure 1.2a: Soil showing decomposing plant debris indicating high soil organic matter.

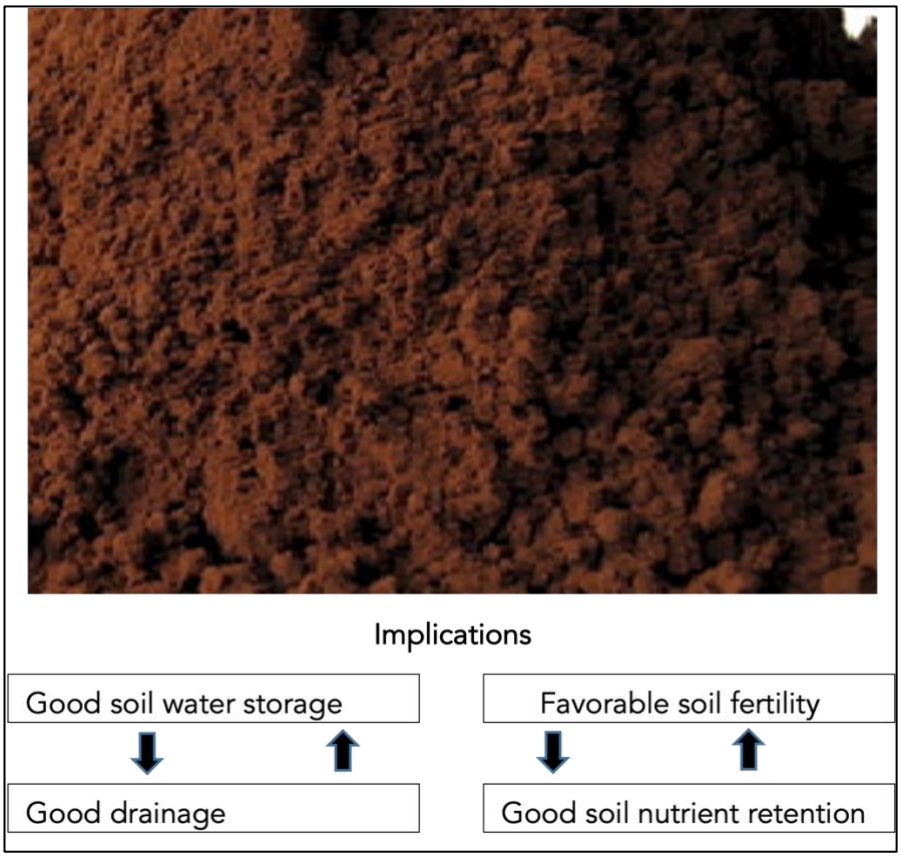

Figure 1.2b: Soil indicating medium soil organic matter.

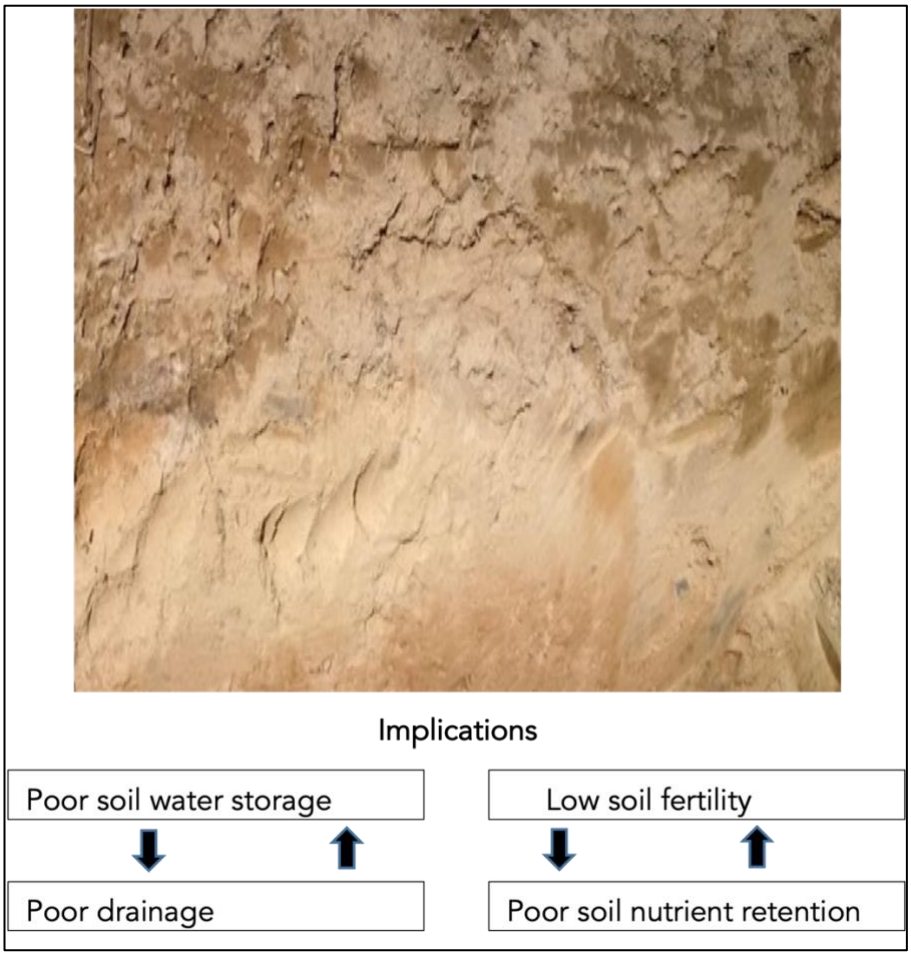

Figure 1.2c: Soil indicating poor soil organic matter.

Chapter 2: Know your terrain

Identifying erosion features

It is appropriate to know your terrain. Best farmlands are generally flat or gently sloping. Note that most fields in Northern Ghana slope in multiple directions. To understand your terrain:

- Move round the field and observe erosion features on the soil surface (Figure 2.1a).
- Identify the direction and level of slope as flat, steep, and gentle (Figure 2.3).
- Use A-frame to determine master contour (Figure 2.4).

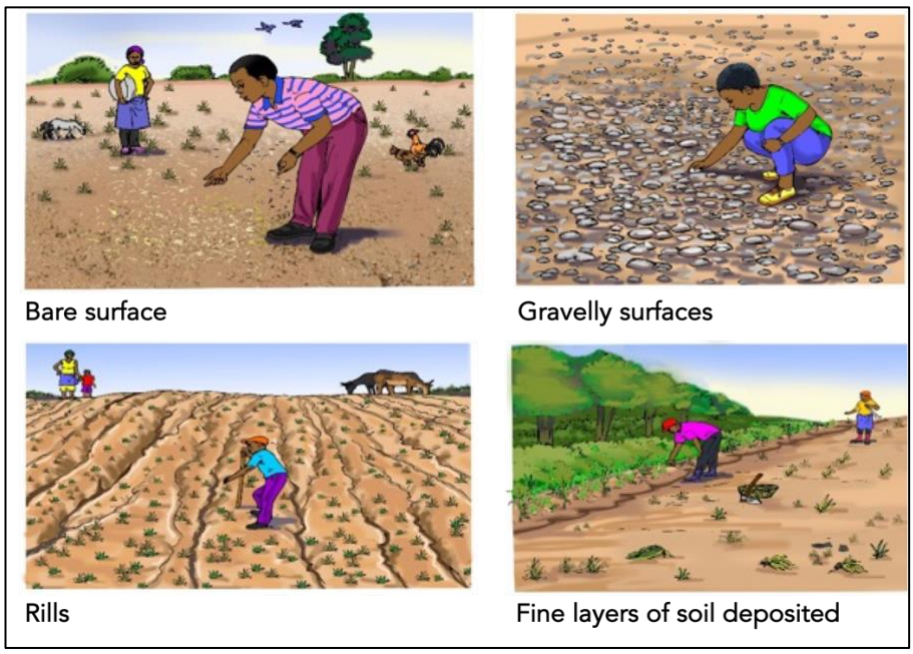

Figure 2.1a: Some common features of soil erosion.

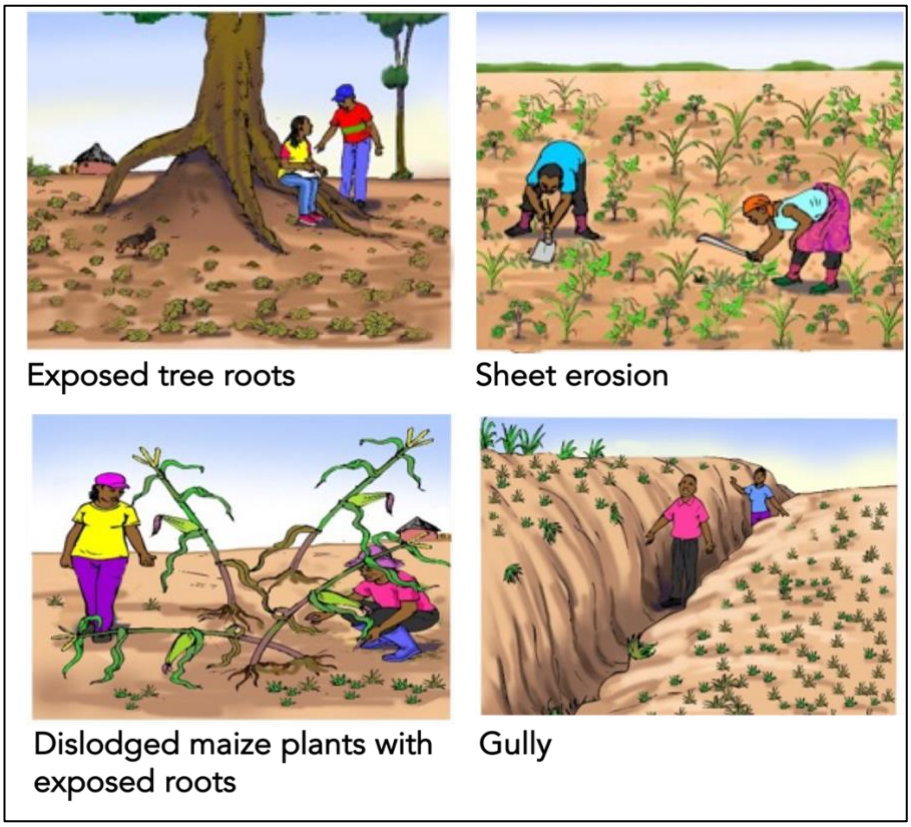

Figure 2.1b: Some common features of soil erosion.

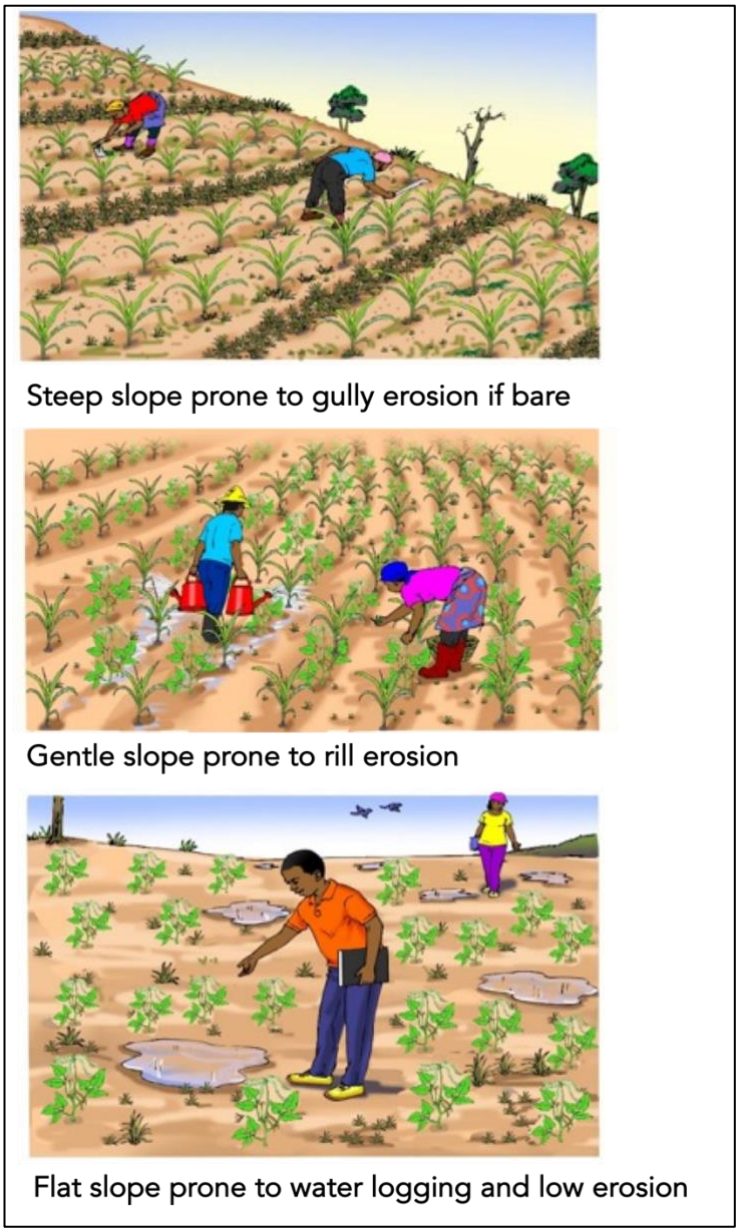

Figure 2.2: Slope type.

What is the slope of my land?

Use the line level to determine your slope as following:

- Hold the two sticks vertically upright with the first stick placed at the starting point.
- Stretch the string tightly between the two sticks.
- Move the second stick along the direction of slope.
- Move the string of the second graduated stick up until the bubble in the spirit-level indicates level. This gives the difference in height of the two (2) positions.
- The height difference divided by the distance between the two sticks indicate the slope.

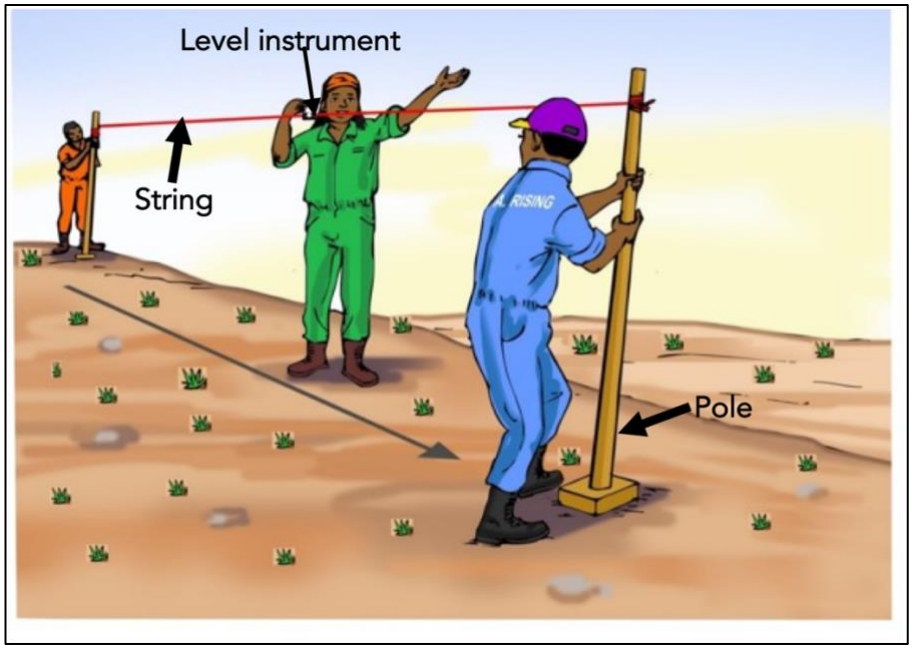

Figure 2.3: Finding out the difference in land level.

How do I fix my master contour?

To control soil erosion typical of Africa RISING farmers' fields in Ghana, the difference in land level between contour lines should be 0.3 - 0.5 m. The following procedure should be adopted to establish the master contour and other subsequent contours.

- Position your master contour in the middle of the field.
- Use Line-Level to establish the master contour by stretching the string tightly between the two sticks across the slope.
- Move the string of the second graduated stick up until the bubble in the spirit-level is at the centre.
- Put a peg and continue.
- Re-align zigzag pegs to smooth out the master contour.
- Other contour lines should be established at the same distance upslope and downslope.

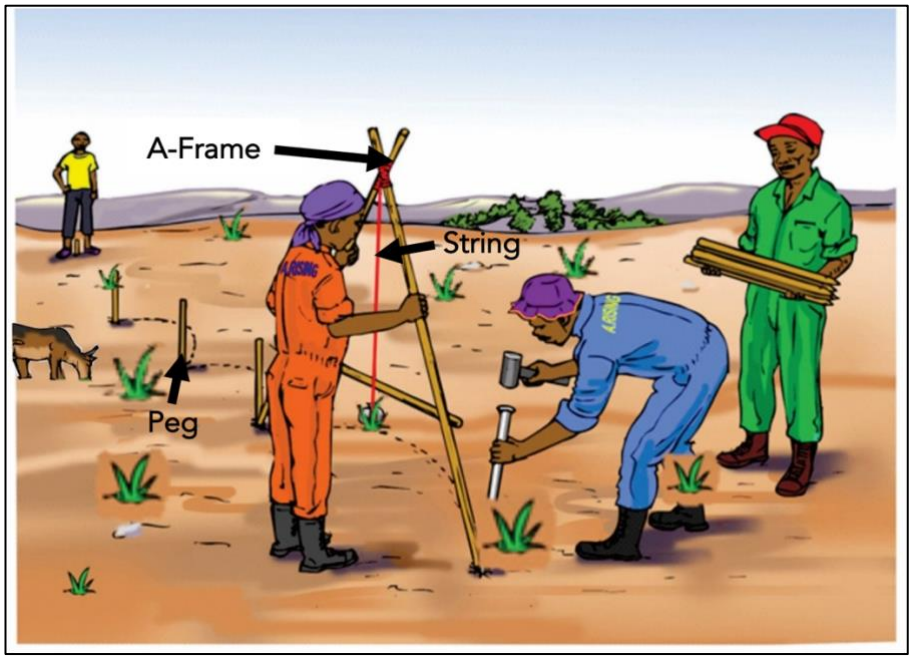

Figure 2.4: Using A-frame to determine master contour.

Alternatively, A-Frame can establish the master contour (Figure 2.4).

- At the middle of the field, position the A-Frame and put a peg for the first point.
- Swing the second leg slowly across the slope until the plumb line is at the center of marked line.
- The two (2) points are at the same level so put a second peg.
- Place the first leg at the second peg and swing the second leg to determine the next level.
- Continue the process to the edge of the field.
- Re-align zigzag pegs to smooth out the master contour.
- Other contour lines should be established at the same distance upslope and downslope.

Chapter 3: Agronomic soil and water conservation

Effective soil and water conservation is a combination of a number of technologies. These may be classified as agronomic (Figures 3.1 and 3.2), crop management (Figure 3.3).

Compost

The natural process of decay tends to change organic wastes into humus-like material usually called compost. Figure 3.1 shows preparation of compost. From soil and water resilience perspective, it can be used to improve soil fertility by:

- Providing organic matter to the soil and improving capacity for nutrient retention.
- Increasing soil water holding capacity and reducing soil erosion.

Approach

i. Choose a site under shade close to the house and dig a pit about one (1) cubic meter.
ii. Collect biodegradable materials and separate them into their components.

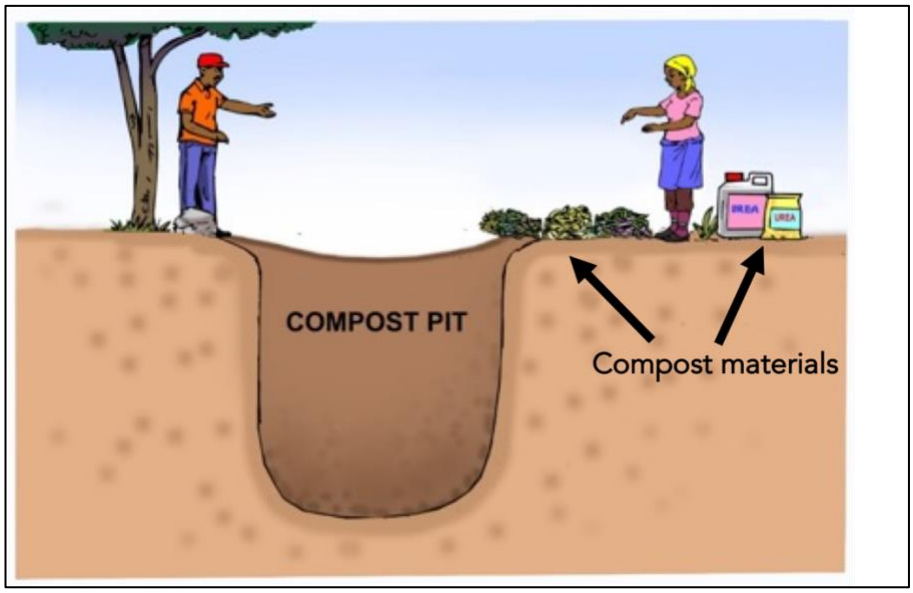

Figure 3.1a: Preparing compost pit.

Approach

i. Start the foundation with chopped maize/cowpea straw, animal beddings or leaves.
ii. Sprinkle water and wood ash.
iii. Add manure and repeat the process until pit is almost full.
iv. Sprinkle urea or sulfate of ammonia if available.
v. Cover with soil and sprinkle some water.
vi. After 14 to 20 days open the pit and remove wastes layer by layer.
vii. Re-pile the layers with the first layer at the bottom followed by the second layer in that order and cover with soil.
viii. After 40 to 45 days, the compost is ready to use.

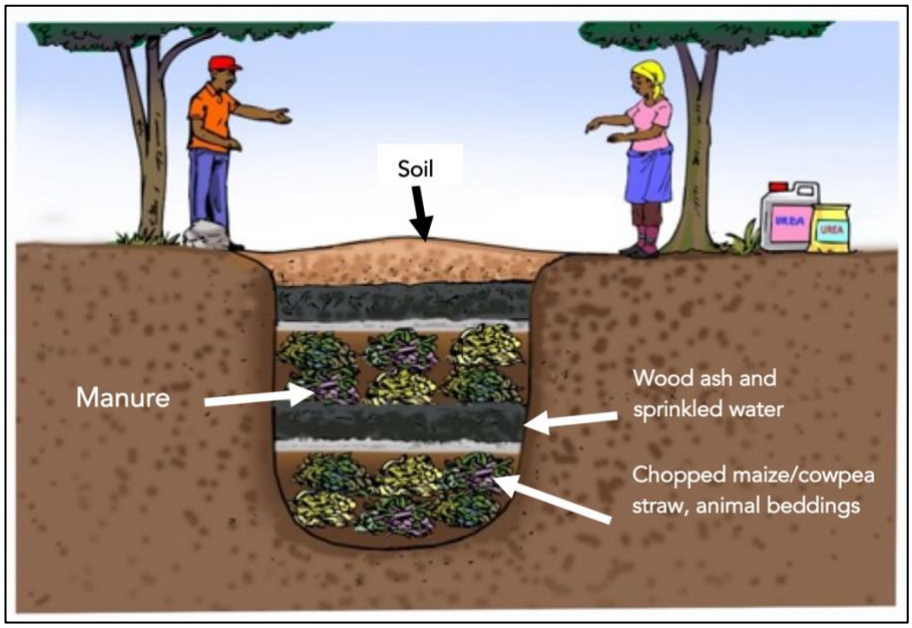

Figure 3.1b: Building the compost.

Soil and water tillage technologies

Soil and water tillage technologies reduces runoff and soil erosion, increases infiltration, and improves soil water retention. The technologies are more suitable for cereal-legume mixed farming systems. These include No-till, Ridge-furrow, Tied-ridging, Mulching and Broad bed and Furrow tillage (Figure 3.2).

No-till mixed farming using maize and cowpea-living mulch

Figure 3.2a: No-till maize intercropped with cowpea.

Description:

- No-till is planting on unprepared land by opening narrow slits for seed coverage. Weeds may be controlled by using herbicides.

Method:

- Plant maize at 100 -120 cm intervals row distances.
- Plant cowpea at mid row intervals of maize (50 – 60 cm).
- Set cowpea within row spacing at 20 – 25 cm.

Suitability: All soil types

Benefits:

- Increases soil organic matter and preserves soil structure.
- Decomposed mulch adds organic matter to the soil.
- No soil erosion occurs.

Contour ridge-furrow tillage with cowpea intercropped within maize rows

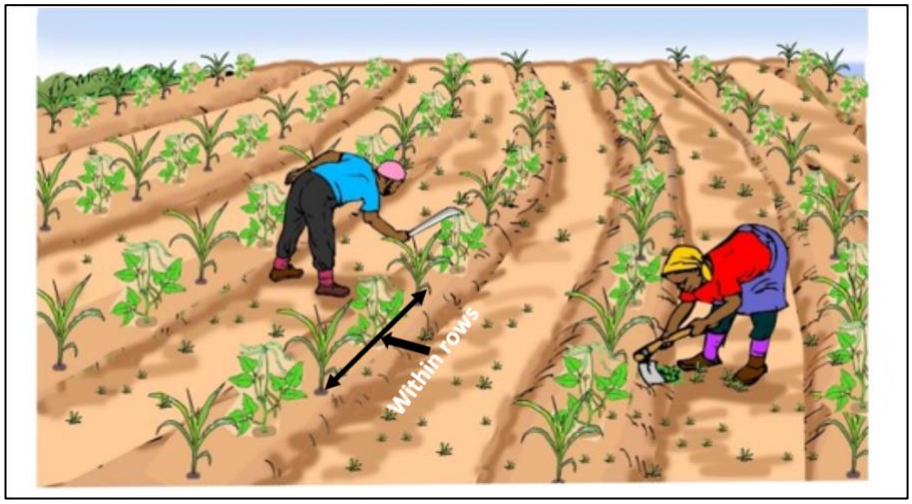

Figure 3.2b: Contour Ridge-furrow tillage with cowpea intercropped within maize rows.

Description:

- Contour ridges or beds are ridges/beds constructed across the slope of the farmland.

Method:

- Use A-Frame to peg out the master contour of the farmland.
- Construct the ridges/beds along pegged master contour.
- Plant maize at 60 -80 cm within row intervals on the ridges (Figure 3.2b).
- Plant one (1) cowpea stand within maize rows at 30 – 40 cm.

Suitability: Sloping farmlands.

Benefits:

- Furrows within the ridges or between beds slow rainwater movement to improve moisture storage.
- Cowpea provides nitrogen and organic matter.

Tied-ridge tillage with cowpea intercropped within maize rows

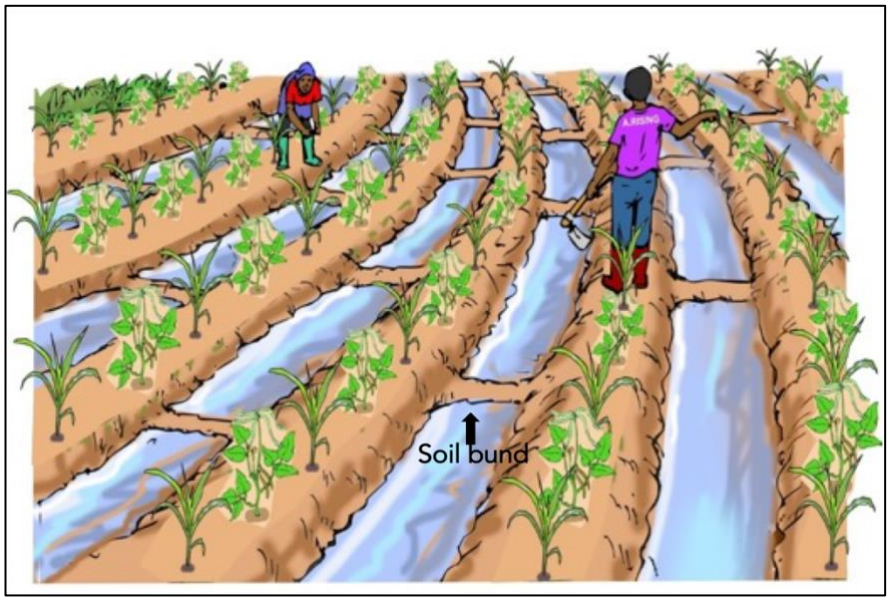

Figure 3.2c: Tied-ridge tillage with cowpea intercropped within maize rows.

Description:
Tied ridges are adjacent ridges bonded with soil at some intervals to impound water.

Method:

- Use A-Frame to construct contour ridges on slope lands else not necessary on flat lands.
- Bond ridges with soil to 2/3 of ridge height at predetermined intervals and staggered.
- Plant maize at 60 -80 cm within row intervals on ridges (Figure 3.2c).
- Plant one (1) cowpea stand within maize rows at 30 – 40 cm.

Suitability: All landforms in areas of low rainfall regime.

Benefits:

- Rainwater forms ponds within the ridges to store more water in the soil.
- Cowpea provides nitrogen and organic matter.

Crop management

Crop management involves cropping systems that reduce erosion and maintain soil fertility. Figure 3.3 shows crop management methods used in soil and water conservation.

Cowpea-living mulch as cover crop under maize

Figure 3.3a: Cowpea-living mulch as cover crop under maize.

Description:
Cover crop is planting a life plant to cover the soil especially a legume.

Method:

- Cultivate the soil and sow a legume such as cowpea as the main cover crop.
- Intersperse the main cover crop with maize.
- Harvest the maize.
- Plough the cowpea into the before it seeds to increase soil organic matter.

Suitability: All landforms, especially bare soil with low inherent soil fertility.

Benefits:

- Protects soil surface from soil erosion.
- Adds nitrogen to the soil.
- Improves soil moisture retention.

Afforestation and woodlots

Figure 3.3b: Afforestation and woodlots.

Description:
Afforestation and woodlots are trees specially planted for specific purpose.

Method:

- Establish seedling nurseries for specific tree/woodlot species.
- Drill holes at required spacing and put in starter fertilizer.
- Plant seedlings usually during the main rainfall season.
- Protect plantations from destruction by cattle.

Suitability: Degraded lands.

Benefits:

- Protects degraded fields from wind and runoff erosion.
- The roots bring deeply buried nutrients into the topsoil through litter fall.
- Roots improve soil water storage.

Parklands

Figure 3.3c: Parklands.

Description:
Parklands describes planting food crops within open spaces of established trees.

Method:

- Carry out land clearing without destroying already established trees.
- Plant desired crops under open spaces within the trees.
- Protect plantations from destruction by cattle.

Suitability: Degraded lands.

Benefits:

- The roots bring deeply buried nutrients into the topsoil through litter fall.
- Wind erosion reduced.
- Roots improve soil water storage.
- Natural soil fertility is regenerated.

Mixed cropping of maize, cowpea, and pepper

Figure 3.3d: Mixed cropping of maize, cowpea, and pepper.

Description:
Mixed cropping is planting different crops on the same piece of land.

Method:

- Cultivate the soil and sow one main crop of longer duration.
- Intersperse the main cover crop with crops of intermediate maturity periods.

Suitability: Fields prone to sheet and rill erosion.

Benefits:

- Provides maximum soil cover but exploits nutrients and soil water at different layers of the soil.
- Provides food for household at different periods in the growing season.

Vegetative barriers

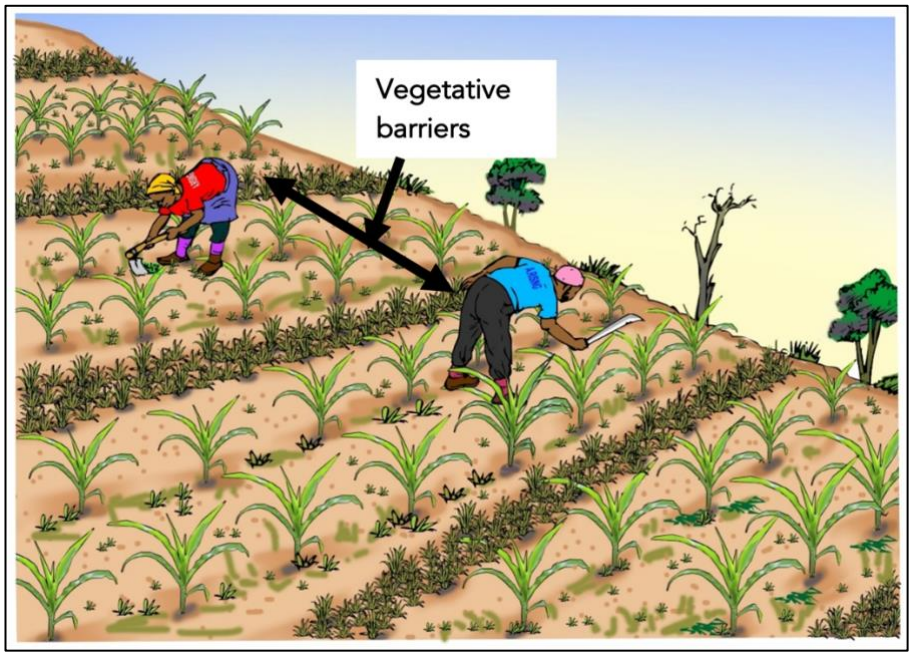

Figure 3.3e: Maize planted within vegetative barriers.

Description:
Vegetative barrier is a closely planted hardy shrubs or grass species across the slope. Food crops are planted within the space between two (2) vegetative barriers. Trash lines can be used but must be firmly gripped to the soil.

Method

- Use A-Frame or line level to establish the master contour.
- Determine the number of rows of the intended crops to be planted.
- Plant the vegetative barriers before and after the crop.
- Maintain both the food crops and vegetative barriers.

Suitability: Slope lands prone to gully erosion.

Benefits:

- It slows down the speed of runoff on the slope.
- The barriers act as sediment filters to prevent soil erosion downslope.

Crop and livestock mixed farming

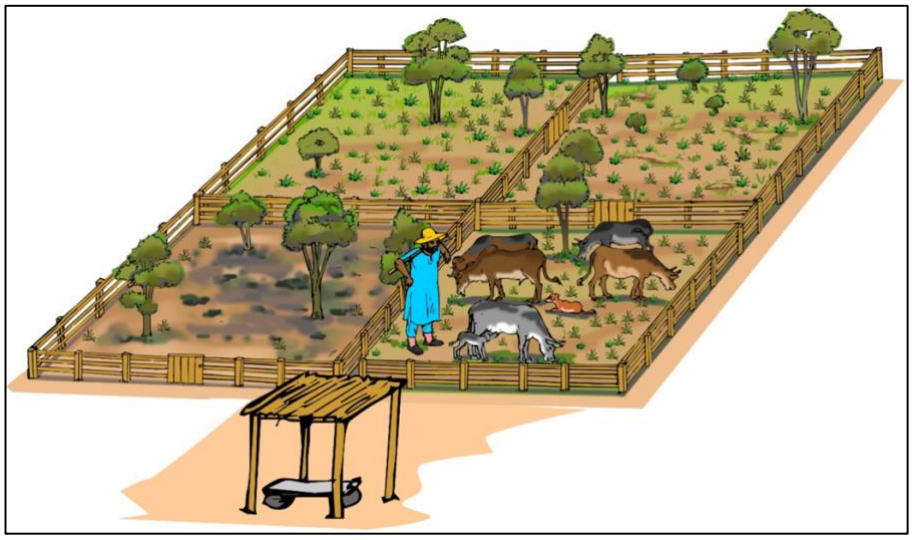

Figure 3.3f: Crops and livestock in rotation.

Description:
Crops and animals are rotated within demarcated fields.

Method:

- Divide the field into blocks and fence.
- Plant food crop, grass, or fodder in rotation with livestock.

Suitability: Rangelands.

Benefits:

- This reduces overgrazing.
- It allows the land to recover after browsing.
- It improves soil fertility.
- It reduces soil erosion.

Cowpea-living mulch in mixed cropping

Figure 3.3g: Cowpea-living mulch planted within maize rows.

Description:
Cowpea is planted within a main crop.

Method:

- Plant cowpea within a main crop.

Suitability: All farmlands.

Benefits:

- Prevents soil erosion downslope.
- Adds nitrogen to soil.
- Provides food for households at periods in the growing season when main crop is not harvested.

Crop rotation in mixed farming system

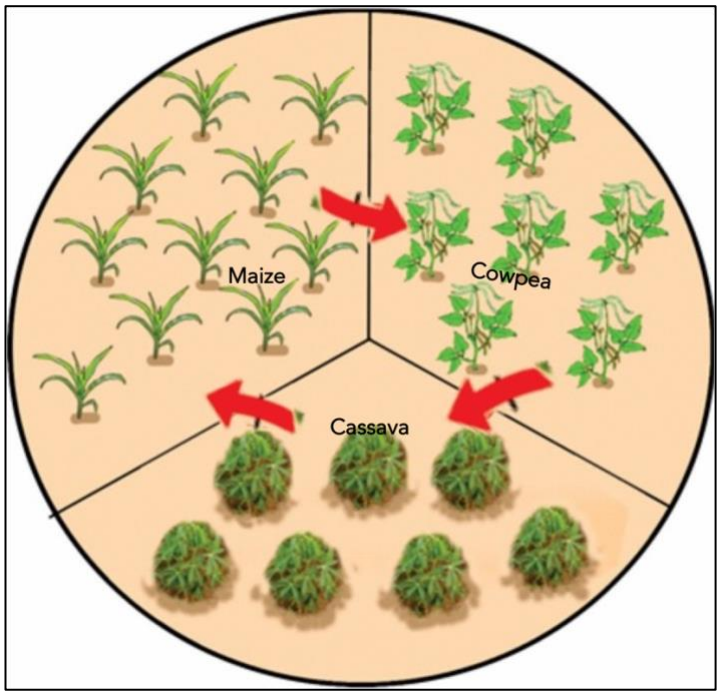

Figure 3.3h: Maize, cassava, and cowpea crop rotation.

Description:
Land is divided into blocks and cropping rotated among the blocks with one block planted to a legume.

Method:

- Divide the field into blocks.
- Plant each block to a main food crop.
- Rotate the crops after each cropping season.

Suitability: All farmlands.

Benefits:

- Soil fertility is generated.
- Soil water storage is improved.

Shifting cultivation in mixed farming

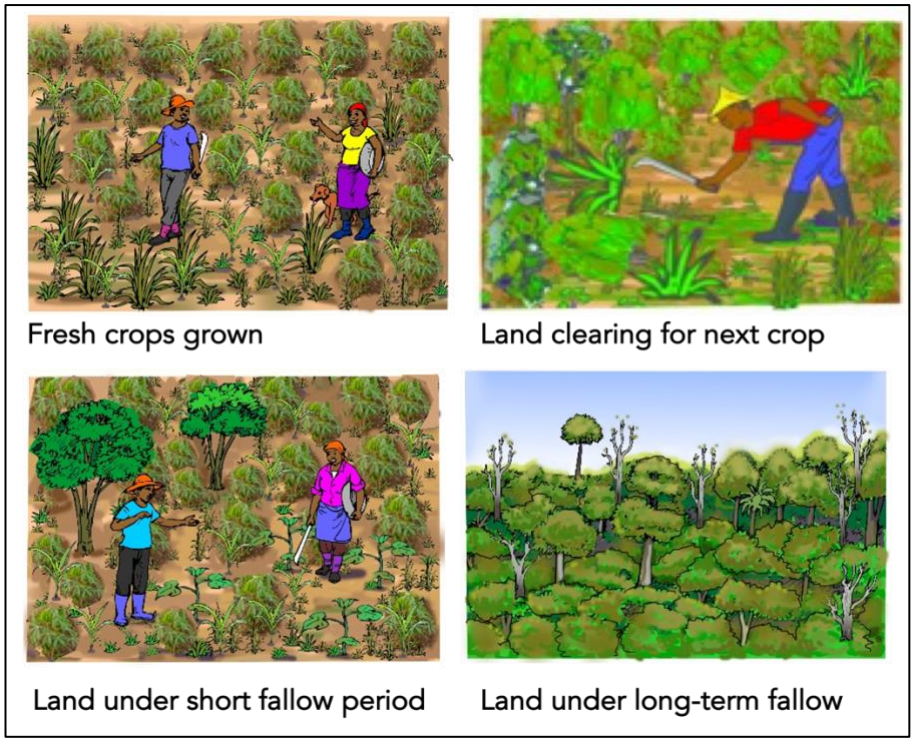

Figure 3.3i. Shifting cultivation.

Description:
Land is cultivated for a couple of years figures 3.3i (1 and 2) and left to fallow for some years figures 3.3i (3 and 4) before cultivating the land again figures 3.3i (1 and 2).

Suitability: Where land is abundant.

Method:

- Prepare the field and plant fresh crops for year 1.
- Clear the land again the following year for next crop.
- Fallow the land in the year three (3) but harvest food from it without cultivating.
- Leave the farm under long-term fallow for trees and shrubs to regenerate the soil.

Benefits:

- Provides maximum soil cover.
- Exploits nutrients and soil water at different layers of the soil.
- Natural soil fertility is regenerated.

Chapter 4: Engineering approaches of soil conservation

This approach prevents water from causing damage by reducing runoff speed. This tends to conserve water and control runoff. The major limitation is the high cost of construction and the need for technical support. These include:

- Earth and stone bunds (Figure 4.1).
- Alternating beds/bunds and drainage channels (Figure 4.2).
- Terracing (Figure 4.3).
- Vegetated waterways (Figure 4.4).

Mixed farming within inter-stone bunds

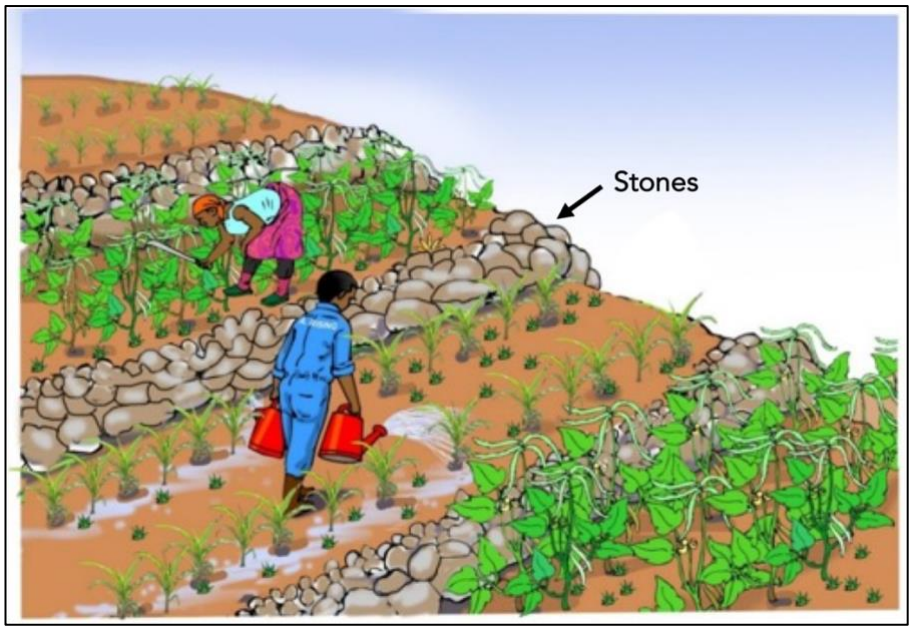

Figure 4.1: Maize and cowpea planted between spaces of stone bunds.

Description:
Stone bunds are piled stones parallel to the master contour at specific distances. Cropping is carried out within the inter-contour bunds. Earth bunds can be used.

Method:

- Use A-Frame or line level to establish the master contour.
- Determine the number of rows of the intended crops.
- Arrange the stone barriers before and after the number of rows crop.

Suitability: Stony areas.

Benefits:

- Soil water storage is improved.
- The stones trap soil particles and decomposed organic matter.

Mixed farming on alternating beds

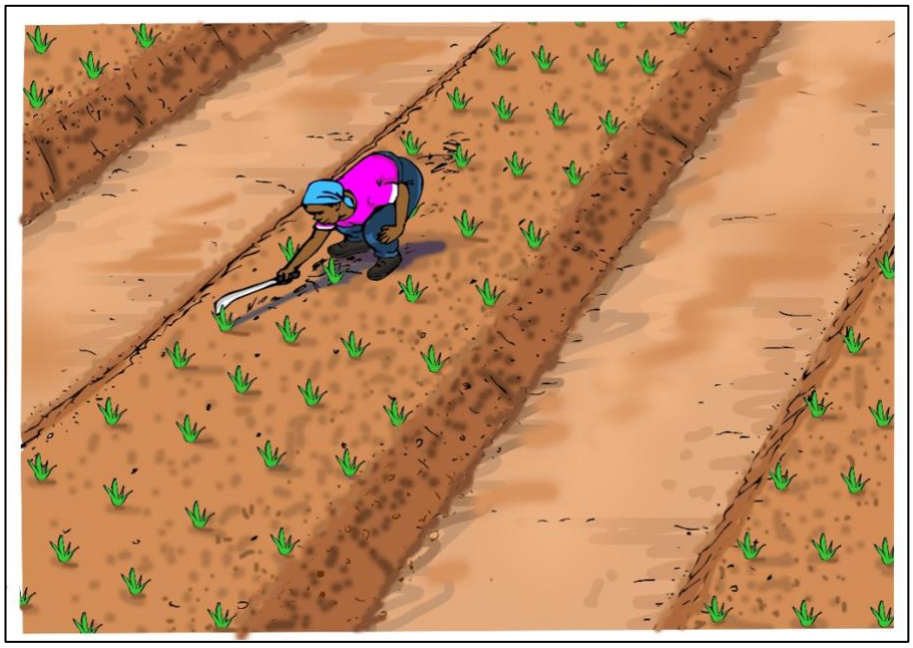

Figure 4.2: Alternating beds and drainage channels.

Description:
These are raised earth beds alternating with channels at specific distances. Cropping is carried out on the beds.

Method:

- Use A-Frame to peg out the master contour of the farmland.
- Construct the beds along pegged master contour.
- Plant crops on the beds only.

Suitability: Areas subject to flooding.

Benefits:

- Used to drain water-lodged fields in river valleys for vegetable production during the rainy season.

Mixed farming on terraced fields

Figure 4.3: Maize on terraced field.

Description:
Terracing is earth construction in steps to reduce the slope length. Different crops are cultivated within the reduced slopes.

Method:

- Use the line level to determine your master contour.
- Nail one end of the line level to the base of the master contour (Peg 1).
- Stretch the string tightly raising the other end to a predetermined height of 0.3 -0.5 m and peg (Peg 2).
- Put a peg (2).
- Move Peg 1 to Peg 2 and stretch the line level to height of 0.3 -0.5 m and peg (Peg 3).
- Continue to end of the field.
- Dig up soil from Peg 1 and use it to level field to same level as Peg 2.
- Do same from Peg 2 to Peg 3.

Suitability: Sloping fields.

Benefits:

- Soil water storage is improved.
- Prevents soil erosion downslope.

Grass waterway

Figure 4.4: Grass waterway.

Description:
These are grassed channels to transport excess runoff out of the field. They are not used for streams.

Method:

- Identify the channels for discharging excess runoff.
- Train the channel into V-shaped channel to discharge runoff safely off the field.
- Plant grasses within and around the entire channel.
- Maintain it until established.

Suitability: Areas subject to gully erosion, flooding, and sheet erosion.

Benefits:

- Diverts storm drains safely through natural drainage system.

Chapter 5: Cropping calendar for cereal-legume mixed cropping systems

Onset and cessation of rains is very important for cropping calendar of Africa RISING farmers. The cropping calendar begins with land preparation, planting, fertilizer application, weeding, harvesting and fallow period. The cropping is interspersed/separated with drought depending on soil water requirements of the intended crop. Figure 5.1 presents the general cropping calendar for maize, groundnut, soybean, and cowpea in Northern Ghana for planning cereal-maize mixed farming systems.

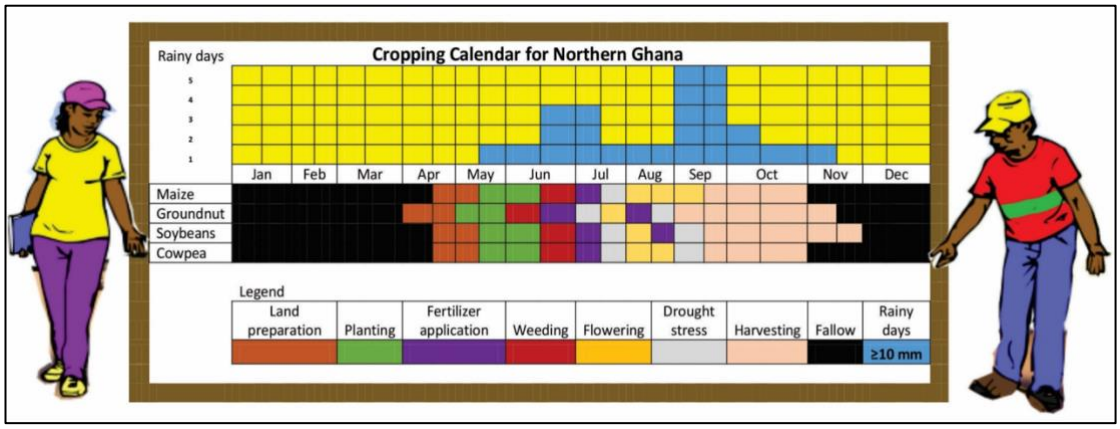

Figure 5.1: Cropping calendar for Northern Ghana.

References

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