Ministry of Agriculture

Zambia Integrated Forestry Landscape Project (ZIFLP)

Climate Smart Agriculture

A Field Manual for Field Staff

September 2018

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ABBREVIATIONS AND ACRONYMS

AER	Agro-Ecological Regions
AESA	Agro Eco-system Analysis
BEO	Block Extension Officer
CA	Conservation Agriculture
CAC	Camp Agriculture Committee
CEO	Camp Extension Officer
CFU	Conservation Farming Unit
CoA	Convectional Agriculture
CSA	Climate Smart Agriculture
CSO	Central Statistics Office
EO	Extension Officer
EP	Eastern Province
FAO	Food and Agriculture Organization
FF	Follower Farmers
FFS	Farmer Field Schools
GART	Golden Valley Research Trust
GHG	Green House Gases
IPCC	Intergovernmental Panel on Climate Change
ISFM	Integrated Soil Fertility Management
JICA	Japanese International Cooperation Agency
LF	Lead Farmers
PTDs	Participatory Technical Development
SMS	Subject Matter Specialist
SSFs	Small Scale Farmers
T & V	Training and Visit
UN	United Nations
ZIFLP	Zambia Integrated Forestry Landscape Project
ZNFU	Zambia National Farmers Union

Module 1: WHAT IS CLIMATE-SMART AGRICULTURE?

Introduction

Climate-smart agriculture (CSA) may be defined as an approach for transforming and reorienting agricultural development under the new realities of climate change (Lipper et al. 2014). The most commonly used definition is provided by the Food and Agricultural Organization of the United Nations (FAO), which defines CSA as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes GHGs (mitigation) where possible, and enhances achievement of national food security and development goals". In this definition, the principal goal of CSA is identified as food security and development ((FAO 2013; Lipper et al. 2014); while productivity, adaptation, and mitigation are identified as the three interlinked pillars necessary for achieving this goal.

Smart Agriculture can mathematically be summarized as below:

- ***CSA = Sustainable Agriculture + Resilience – Emissions.***

The three pillars of CSA

- **Productivity:** CSA aims to sustainably increase agricultural productivity and incomes from crops, livestock and fish, without having a negative impact on the environment. This, in turn, will raise food and nutritional security. A key concept related to raising productivity is sustainable intensification
- **Adaptation:** CSA aims to reduce the exposure of farmers to short-term risks, while also strengthening their resilience by building their capacity to adapt and prosper in the face of shocks and longer-term stresses. Particular attention is given to protecting the ecosystem services which ecosystems provide to farmers and others. These services are essential for maintaining productivity and our ability to adapt to climate changes.
- **Mitigation:** Wherever and whenever possible, CSA should help to reduce and/or remove greenhouse gas (GHG) emissions. This implies that we reduce emissions for each calorie or kilo of food, fibre and fuel that we produce. That we avoid deforestation from agriculture. And that we manage soils and trees in ways that maximizes their potential to acts as carbon sinks and absorb CO_2 from the atmosphere.

Why climate-smart agriculture?

Climate-smart agriculture (CSA) helps address a number of important challenges:

1. CSA addresses food security, misdistribution and malnutrition

Despite the attention paid to agricultural development and food security over the past decades, there are still about 800 million undernourished and 1 billion malnourished people in the world. At the same time, more than 1.4 billion adults are overweight and one third of all food produced is wasted. Before 2050, the global population is expected to swell to more than 9.7 billion people (United Nations 2015). At the same time, global food consumption trends are changing drastically, for example, increasing affluence is driving demand for meat-rich diets. If the current trends in consumption patterns and food waste continue, it is estimated we will require 60% more food production by 2050 (Alexandratos and Brruinsma 2012). CSA helps to improve food security for the poor and marginalised groups while also reducing food waste globally (CCAFS, 2014).

CSA General Context (Zambia)

In the last two decades, many parts of Eastern Province have become drought prone with annual rainfall ranging between 500 – 700mm. However, during the 2017/18 farming season, some parts of Eastern provinces, experienced seasonal droughts and were affected by severe dry spells and flooding. Floods, excessive rainfall, unevenly distributed rains and drought combined with declining soil fertility poses a serious challenge to the agricultural livelihoods of many households and communities in the Eastern Province of Zambia. The negative effect of floods and droughts in these areas poses a risk to the already fragile farming environment upon which rural livelihoods are dependant.

The challenges of agriculture among small scale farmers include low farm productivity and continuing yield decline as a result of soil degradation associated with inappropriate farming practices. HIV/AIDS, together with high costs of external inputs and the vagaries of climate change continue to negatively impact on the agriculture landscape for small scale farmers. Land degradation as a result of inappropriate farming practices, climate variability and rising input costs have all contributed to declining crop production and productivity among small scale farmers (SSFs) in the province.

2. CSA addresses the relationship between agriculture and poverty

Agriculture continues to be the main source of food, employment and income for many people living in developing countries Like Zambia in particular. For Eastern province, Agriculture employs about 67%,the majority of them being women. Indeed, it is estimated that about 75% of the world's poor live in rural areas, with agriculture being their most important income source (Lipper et al. 2014).In Zambia Based on the 2015

Living Conditions Monitoring Survey Report of the Government's Central Statistical Office, an estimated 54.4 percent of Zambians live in extreme poverty (below US$1.90 per day, purchasing power parity terms) and poverty is higher among women. Rural poverty (at 76.6 percent) is more than three times the 23.4 percent rate of urban poverty. As such, agriculture is uniquely placed to propel people out of poverty. Agricultural growth is often the most effective and equitable strategy for both reducing poverty and increasing food security (CCAFS and FAO 2014).

3. CSA addresses the relation between climate change and agriculture

Climate change is already increasing average temperatures around the globe and, in the future, temperatures are projected to be not only hotter but more volatile too. This, in turn, will alter how much precipitation falls, where and when. Combined, these changes will increase the frequency and intensity of extreme weather events such as hurricanes, floods, heat waves, snowstorms and droughts. They may cause sea level rise and salinization, as well as perturbations across entire ecosystems. All of these changes will have profound impacts on agriculture, forestry and fisheries (FAO 2013a). In Zambia since the 1980s, AER I & II have experienced:

- ✓ **A later onset and shortening of the rainy season**
- ✓ **More frequent drought episodes**
- ✓ **More frequent flooding episodes**
- ✓ **Poorly distributed rainfall**

These events have adversely impacted: Agriculture, Wildlife, Infrastructure, and water quality and food security.

The agriculture sector is particularly vulnerable to climate change because different crops and animals thrive in different conditions. This makes agriculture highly dependent on consistent temperature ranges and water availability, which are exactly what climate change threatens to undermine. In addition, plant pests and diseases will likely increase in incidence and spread into new territories as it was observe in the 2017/2018 farming season, when we experienced an outbreak of Fall Army warms which threatened the national food security as well as house hold food security more especially for the small scale farmers of Eastern Province in particular, bringing further challenges for agricultural productivity.

While climate change will have both positive and negative impacts on crop yields – meaning that for some crops in some areas, yields will rise while others elsewhere suffer – negative impacts have outweighed positive impacts to date (IPCC 2014b). Already, it is estimated that climate change has reduced global yields of wheat by 5.5% and of maize by 3.8% (Lobell et al. 2011). By 2090, it is projected that climate change will result in an 8-24% loss of total global caloric production from maize, soya beans, wheat and rice (Elliott et al. 2015). Where these declines in productivity occur will vary. For example, sub-Saharan Africa and Zambia in particular will be hit particular hard; it is estimated that across Africa maize yields will drop by 5% and wheat yields by 17% before 2050 (Knox et al. 2012).

The relationship between agriculture and climate change is a two-way street: agriculture is not only affected by climate change but has a significant effect on it in return. Globally, agriculture, land-use change and forestry are responsible for 19-29% of greenhouse gas (GHG) emissions. Within the least developed countries, this figure rises to 74% (Vermeulen et al. 2012; Funder et al. 2009). If agricultural emissions are not reduced, agriculture will account for 70% of the total GHG emissions that can be released if temperature increases are to be limited to 2°C. The mitigation options available within the agricultural sector are just as cost-competitive as those established within the energy, transportation and forestry sectors. And they are just as capable of achieving long-term climate objectives (Smith et al. 2007). For this reason, mitigation is one of the three pillars of climate-smart agriculture.

CSA SEVEN ENTRY POINTS

This section introduces a range of climate-smart agriculture (CSA) practices and technologies within seven entry points for CSA;

- Soil Management,
- Crop Management,
- Water Management,
- Livestock Management,
- Agroforestry Management,
- Fisheries and Aquaculture, and
- Energy Management.

Practices are understood broadly as ways of doing things, for example, precision farming, tillage, and fertilization; these are all CSA practices. **Technologies** are new materials introduced into new or old practices, and might include new drought-tolerant varieties; a hardy breed of cattle, or a new slow-release fertilizer.

Many of the entry points involve interventions at the farm level. However, in many instances, the management of natural resources will also need to beconsidered at the landscape level, in the majority of cases, there will be an inevitable and desirable nexus among entry points

Module 2: SOIL MANAGEMENT

Maintaining or improving soil health is essential for sustainable and productive agriculture. 'Healthy' soil will help to push sustainable agricultural productivity close to the limits set by soil type and climate. Key aspects of 'healthy' soil include the following:

- A comprehensive soil covers of vegetation.
- Soil carbon levels close to the limits set by soil type and climate.
- Minimal loss of soil nutrients from the soil through leaching.
- Zero or minimal rates of rainfall run-off and soil erosion.
- No accumulation of contaminants in the soil.
- Agriculture, which does not rely excessively on fossil energy through inorganic fertilizers.

In many regions of the world, soil health is severely threatened by human and livestock population increases. This has resulted in the intensification of soil cultivation in existing high potential areas, the expansion of farming into forests and marginal environments with fragile soils, and the over stocking and overgrazing of natural pastures. Combined with the constraints that small-scale farmers face with regard to the availability and cost of organic and inorganic nutrient inputs, these factors have resulted in the wide scale decline of soil health and, hence, productivity in Zambia and Eastern Province in particular.

Contribution to CSA

Improved soil management aims to enhance soil health and contributes to CSA from several important perspectives:

- **Productivity:** All interventions that improve soil fertility, soil water availability and reduce the loss of nutrient-rich topsoil through erosion, will straightforwardly improve productivity.

- **Adaptation:** In many parts of the world, intense rainfall events are already a common occurrence and result in a high risk of rainfall run-off and soil erosion, especially on sloping land. Climate change projections suggest that the frequency and severity of such events are very likely to increase. There is a wide range of soil management interventions, which help reduce the risk of run-off and soil erosion, ranging from field or farm level interventions such as contour ploughing or contour tillage with tied ridges, micro-catchments and surface mulching, to landscape level approaches such as land terracing, contour stone bunds or reforestation.

- **Mitigation:** Soil management can help mitigate climate change as well through a range of interventions (Allen et al. 1998). Soils are an important below ground 'sink' for carbon sequestration, and soil management interventions can help to harness this characteristic. For example, the organic matter additions recommended in **Conservation Agriculture (CA)** (Richards et al. 2014,), the inclusion of trees in crop fields, and the improved grazing management of natural pastures are all practices that help to increase the sequestration of carbon. The emission of the greenhouse gas (GHG) nitrous oxide from inorganic fertilizer use can also be reduced through integrated approaches to the management of nitrogen fertilizer. For example, Integrated Soil Fertility Management **(ISFM)** which the Zambia Integrated Forestry Landscape Project **(ZIFLP)** will be promoting in the Eastern Province of Zambia advocates reduced amounts and more strategically placed inorganic nitrogen fertilizer. Rice lowlands with submergence are known to maintain much higher soil C than lowlands which go through wetting and drying cycles used in rice-wheat cultivation or uplands with maize-wheat rotations (Ladha et al. 2011).

There is common consensus that zero tillage and **conservation agriculture (CA)** systems will considerably reduce nitrate leaching (Macdonald *et al*., 1989). This is because, unlike mechanical tilling practices, zero tillage and conservation agriculture (CA) leave the soil undisturbed, which decreases mineralization and the subsequent production of nitrates. Cover crops take up the nitrogen and reduce its loss from the soil. At the same time, unused mineralized nitrogen remains distributed within smaller pores and are not washed out of the soil (Bergström, 1995; Davies *et al.*, 1996; Gors *et al*., 1993). However, where no-till is used without cover crops and with herbicides to manage weeds, the effects on nitrogen uptake and reduced leaching, as well as on yields, may be less evident. The positive effects of the above principles will be optimized and losses minimized by integrating soil-crop water management practices, identifying the spatial variability within the given land area and fields, and using precision-farming techniques to apply fertilizer and water in ways that are highly efficient and site-specific. **Therefore CA is a major practice to be used under CSA in soil management.**

What is CA and why?

Outline:

- Learning objectives
- Background to agriculture In Zambia
- Challenges of conventional agricultural practices
- What is conservation agriculture
- Why conservation agriculture
- Benefits of conservation agriculture
- Conclusion

Background to Zambian Agriculture

- Modern Zambian Agriculture introduced by white settlers in early 1900
- To supply food to the workforce constructing the railway line and to the mines on the Cooper belt
- Settlers introduced conventional farming using animal draft power and the mouldboard plough for tillage
- Native Zambians adopted modern sedentary agriculture, cultivating using the hand hoe and animal draft tillage methods.
- Command extension services introduced and provided messages e.g. contour ridging
- New Zambian Govt. continued with conventional farming, and largely promoted maize mono-cropping

Main features of Conventional Agriculture

- Tillage of land, Ploughing & or ridging by using hoe or plough to prepare fine tilth seedbed and control weeds
- Yearly burning of crop residues and vegetation to easy land preparation and control of weeds
- Common late land preparation & planting
- Dominance of maize mono-cropping
- Untargeted and excessive application and use of inorganic fertilizers

Challenges of Conventional Agriculture

- Repeated soil inversion destroys soil structure and results in hard a pan which restricts water infiltration and root growth.
- Reduced water retention and availability due to deterioration of soil structure
- With less moisture retention in the soil, plants are vulnerable to droughts and wilt within a few days of no rain
- Increased surface run off washes away valuable top soil and leaves behind poor sub soil and gullies in the fields.
- Environmental degradation - sedimentation and drying of water reservoirs and loss of forest resources
- Aagricultural production may account for some 90% of forest cover loss in Zambia.
- Burning of vegetation and crop residues:-
  - ✓ Denies the soil, source of nutrients
  - ✓ Exposes soil to rain splashes that cause capping , runoff and erosion and loss of nutrients
  - ✓ Sun scorching thereby giving a rise to soil temperature
- Decline in overall soil fertility (chemical, physical and biological) resulting in poor yields, food insecurity and income loss
- As a response to low yields, farmers often apply more and more costly fertilizer.
- Uneven emergence of crops due to none uniform planting furrows
- Ineffectiveness of both fertilizers and manure due to misplacement

Figure 1: Heaped crop residues burnt, exposes soil to erosion (Source: CFU, 2007)

Figure 2: Soil is inverted and pulverised, subjecting it to erosion

Figure 3: Overall digging with a hand hoe subjects the soil to erosion and reduces soil life

Figure 4: Top soil is washed away by the first heavy rains

Figure 5: 10cms or 1,000 tons of top soil per hectare has been lost

Figure 6: Signs of a hard pan

Figure 7: Ridging commonly known as "Galauza" in Eastern Province

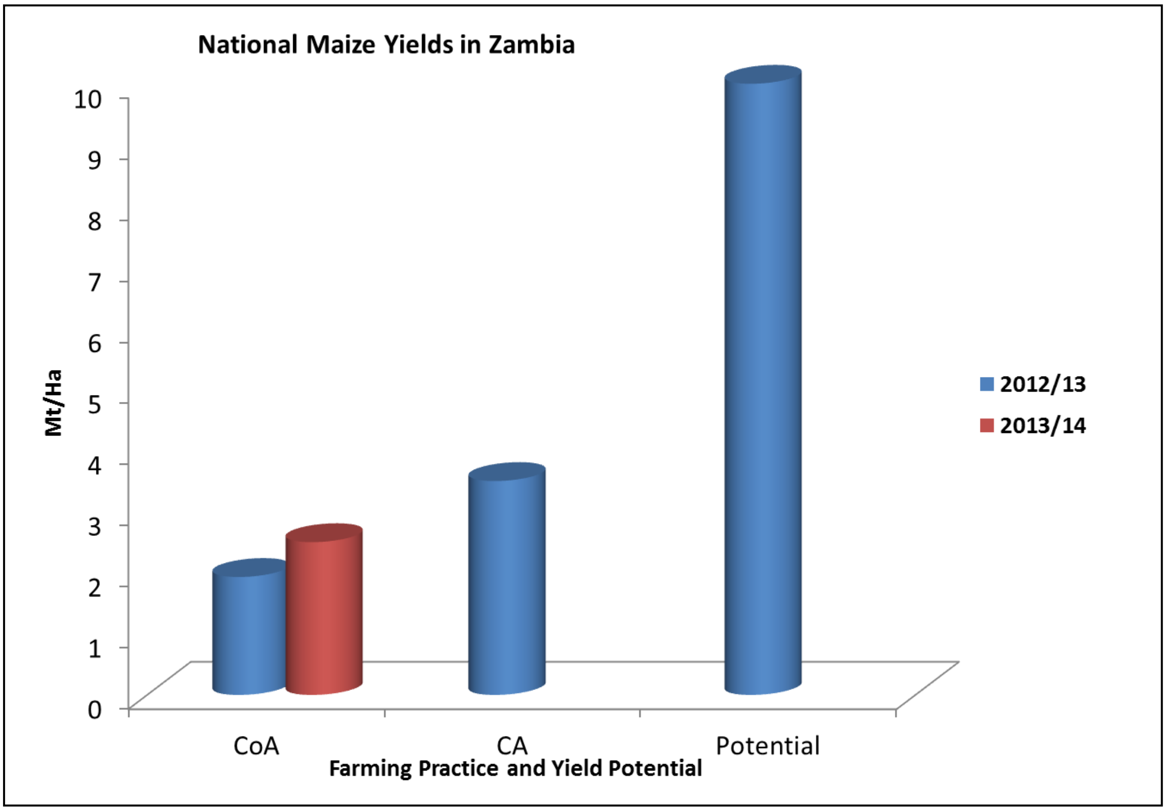


Figure 8: Maize yields under Conventional Agriculture compared to CA

What is Conservation Agriculture?

A Farming practice characterised by:

- Minimal mechanical soil disturbance (i.e., no soil inversion by tillage and direct seeding)
- Maintenance of a mulch of carbon-rich organic matter covering and feeding the soil (e.g. straw and/or other crop residues including cover crops)
- Rotations or sequences and associations of crops including trees which could include nitrogen-fixing legumes. Crop rotation also avoids build-up of pests, diseases and weeds.

Why Conservation Agriculture?

- Increasing crop yields,
- Reducing costs of production,
- Improving and maintaining soil fertility
- Conserving soil moisture and water.
- Achieving intensified sustainable agriculture and improved livelihoods.
- Mitigating negative impacts of climate change

Improvement of Crop yields by CA

- CA enables farmers to reverse negative trends of CoA
- **CA**
  - ✓ prevents hard pans,
  - ✓ protects the soil from erosion and degradation
  - ✓ increases soil organic matter
  - ✓ and moisture holding capacity and availability,
  - ✓ restores soil fertility in all properties; chemical, physical and biological
- CA improves and stabilizes yields over the long term

Reducing production costs

- CA helps farmers cut down on their costs while increasing their yields
- Conservation agriculture allows the farmer to produce more food with less work

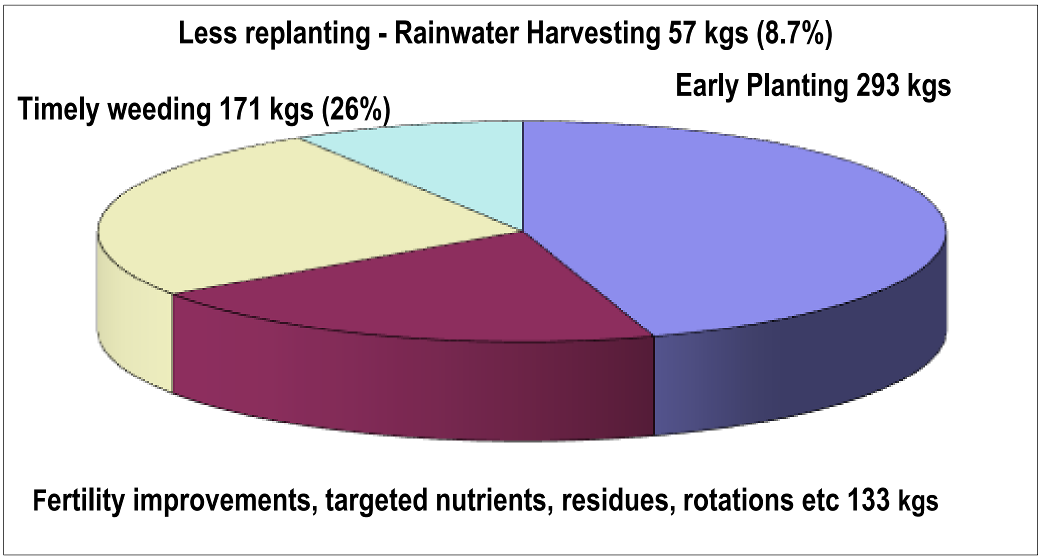
Table 1: Comparison between Conventional Farming and CA operation

Type tillage	**Time to till 1ha**	**Cost per ha (US$)**	**Soil inversion**
Ploughing	12-15 hours	55-65	100%
Ripping	4 hours	30	10%
Dry ridge splitting	30-35 days	100	100%
Wet ridge splitting	20-25 days	21	100%
Wet overall digging	50-60 days	21	100%
Dry basin making	25-30 days	100 (1st Year only)	10-12%
Wet basin holing out	3-4 days	21	7%+

Benefits of CA

Immediate benefits	Medium-long term benefits
• Increased soil water infiltration due to the protection of the soil surface structure by crop residues and the maintenance of continuous pores with the absence of tillage • Reduced water runoff and soil erosion due to increased water infiltration and the ponding effect of residues. Residues hamper water flow and cause small ponds of water on the soil surface • Reduced evaporation of moisture from the soil surface as the residues protect the surface from the sun's radiation • Less frequent and intense moisture stress because of increased water infiltration and reduced evaporation • Reduced traction and labour requirements for land preparation. And thus savings in fuel and labour costs	• Increased soil organic matter resulting in better soil structure, high mineral exchange and nutrient availability, and greater water holding capacity • Increased and more stable crop yields • Reduced production costs, e.g., inclusion of a legume in the rotation and nitrogen fixing trees reduce the requirement for artificial fertilisers • Because seeds are planted in the same place every year, residual fertiliser can subsequently be taken up by the subsequent crop • Increased biological activity in both the soil and the aerial environment leading to improved biological soil fertility and pest control • Because the spaces between the rows are never ploughed, weed populations will decline over time as long as weeds are not allowed to seed

So, where do the CA benefits come from?



Source: (CFU, 2007)

Principles of Conservation Agriculture

Learning Objectives:

- To outline and explain the principles of conservation agriculture
- To list the requirements of conservation agriculture
- To list the challenges of conservation agriculture; and
- To suggest solutions to the challenges of conservation agriculture

Minimum Soil disturbance

Land preparation is restricted to where the crop will be sown. Ripping planting lines or making permanent planting basins, restricts soil movement to 10-12% of the surface area of the total field

Figure 9: Permanent planting basins

Soil surface cover

Two types of soil cover:

- Living plant materials.
- Mulch or dead plant materials

Figure 10: Crop residues covering soil surface

Soil cover protects the soil from erosion, extreme solar radiation ,limit weed growth, protects the soil and micro- organisms that live in it from the heat of the sun and the impact of rain. A good farmer is that who gives the soil an umbrella to keep it health. Only a health soil can produce a good crop.

Benefits of Soil cover

The benefits of soil cover include: (i) protects soil from rain, sun and wind, (ii) Reduces soil erosion, (iii) Suppress weeds, (iv) Increase soil fertility, (v) Improves soil structure, (vi) Earth worms and beneficial micro organisms are protected.

- ✓ Allows for good development of roots

Crop rotation or associations

In CA, mono cropping is broken by planting a variety of crops in a rotation or association from season to season. With the right mix, a legume is incorporated in the rotation to fix nitrogen and improve soil fertility

Figure 11: Cereal and legume association

Figure 12:Maize, Soya beans rotation rotation

Intercropping or crop associations

This is a farming system that involves growing of two or more crops in the same field at the same time (mixed or row intercropping). Choice of crops for inter- cropping very important.

Figure 13: Maize- cowpea intercropping system

Benefits of crop rotations or associations

- Improve soil structure
- Increase soil fertility
- Control weeds
- Minimizes the build-up of pests and diseases
- Reduces risk

Requirements for increasing adoption of conservation agriculture

- CA skills and knowledge
- Quality and consistent CA information
- Supportive extension services
- Adequate access to quality CA inputs; seed, equipment, herbicides, pesticides & insecticides, fertilizer
- Adequate access to markets

Agronomic and Economic perceptions or factors limiting adoption of CA

- Seedbed should be of same quality as in conventional tillage
- Alternatives for free-roaming livestock are needed, as they compact the soil through trampling
- Increases in crop production and soil quality are required
- Increase in organic matter of the soil
- Capacity to control weeds
- Capacity to reduce production costs
- Same production level as conventional tillage
- Accessibility to good quality seed-not too expensive
- Labour and time saving.

Challenges faced by farmers to adopt conservation agriculture

- Lack of understanding of conservation agriculture technology
- Fear of taking economic risks
- Inability to buy new equipment for conservation agriculture
- Poor state of the soils to produce good yields
- Cropping systems need to be adjusted to conservation agriculture and fit into a rotation
- Change of mindset

Change of mindset

Adoption of CA requires change of mind set, Farmers need to understand that there will be a change in:

- Crop management system
- Land management
- Technology (a machine or tool) that can manage the crop residues or cover crops.
- The soil's capacity to sustain production
- The way of thinking about weed management

How does a farmer start conservation agriculture?

Three stages:

- Before starting
- First season
- Second and following season

Before starting

- Plan a good crop rotation.
- Take time to identify and learn to use the herbicide correctly.
- Select only a portion about 10% of the field to start conservation agriculture.
- Get support from friends, neighbours and organisations promoting conservation agriculture in your area
- Compacted soil should have its hard pan broken
- If the soil is acidic, add lime
- Remove rocks, stumps and obstacles that may get in the way of machinery, tools and equipment
- If the land is too bare, cover it with some crop residue to give a fair cover of the soil

First Season

- Ensure there is good soil surface cover
- Plant a cover crop in the first season, such as velvet beans or sunhemp
- Establish permanent planting stations by ripping the soil using animal draft power or by making planting basins using a suitable hand hoe
- Continuously control the weeds by an appropriate conservation agriculture method, such as using the hoe, pulling them out or using a herbicide
- Grow your usual crop but add a legume intercrop, such as cow peas
- At harvest, leave the field covered with crop residues

Second and following season

- There should be enough crop residues in the second year, and there will no need to fetch them from elsewhere.
- Check for weeds and continuously remove them using an appropriate method
- Rotate crops

Table 2: Non-negotiables in initiation of conservation agriculture activities

Year of conservation agriculture activity	**Non-negotiables**	**Detailed Description**
First year	• Correctly spaced permanent planting basins or rip lines before the rains • Early planting of all crops • Early and consistent weeding	Minimum Tillage
Second year	• No burning of crop residues • Correctly spaced permanent planting basins or rip lines before the rains • Early planting of all crops • Early and consistent weeding	By adding a component of No burning of crop residues, MINIMUM TILLAGE graduates to CONSERVATION TILLAGE
Third year	• No burning of crop residues • Correctly spaced permanent planting basins or rip lines before the rains • Early planting of all crops • Early and consistent weeding • Rotation with a legume included	• By adding a component of crop rotation with a legume, CONSERVATION TILLAGE graduates to CONSERVATION FARMING
Thereafter	• No burning of crop residues • Correctly spaced permanent planting basins or rip lines before the rains • Early planting of all crops • Early and consistent weeding • Rotation with a legume included • Planting of Agroforestry trees	• By adding a component of Agroforestry, CONSERVATION FARMING graduates to CONSERVATION AGRICULTURE

<u>Summary Forms of “CA” Technologies</u>

- Minimum tillage **(MT) = reduced soil disturbance (10-20 %)**
- Conservation tillage (**CT) = MT + RETENTION OF RESIDUES**

- Conservation farming **(CF) = CT + CROP ROTATION AND COVER CROPS**

- Conservation Agriculture (**CA) = CF + AGROFORESTRY**

Conservation Agriculture techniques in manual systems

Learning objectives

Participants should be able to:

- Outline conservation agriculture techniques used in land preparation in manual systems
- List the implements used in conservation agriculture techniques of land preparation
- List the guidelines for timing and procedures of planting in manual systems
- Decide the right time to plant
- Outline the recommended plant population and carry out thinning to achieve the recommended plant population

CA techniques used in land preparation in manual systems

- Permanent planting basins
- Rip lines, and
- Advanced direct till-planters

Conservation tillage tools, implements

- **Hoe farmers:**
  - Teren Rope
  - Strong hoe (Chaka Hoe)
  - 2 X 90cm row sticks
  - 2 pegs
  - Fertiliser cups
  - Coca cola tin

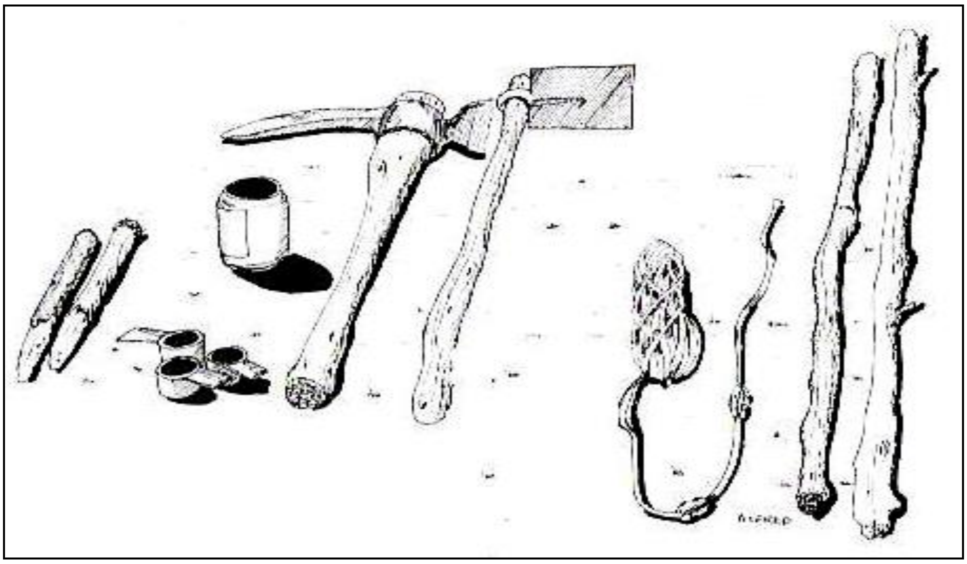


Figure 14: CA Tools used in manual systems

- **Ox farmers:**
  - A ripper
  - A 3.5m trek chain
  - A 180cm yoke
  - A 100ml bottle/jar

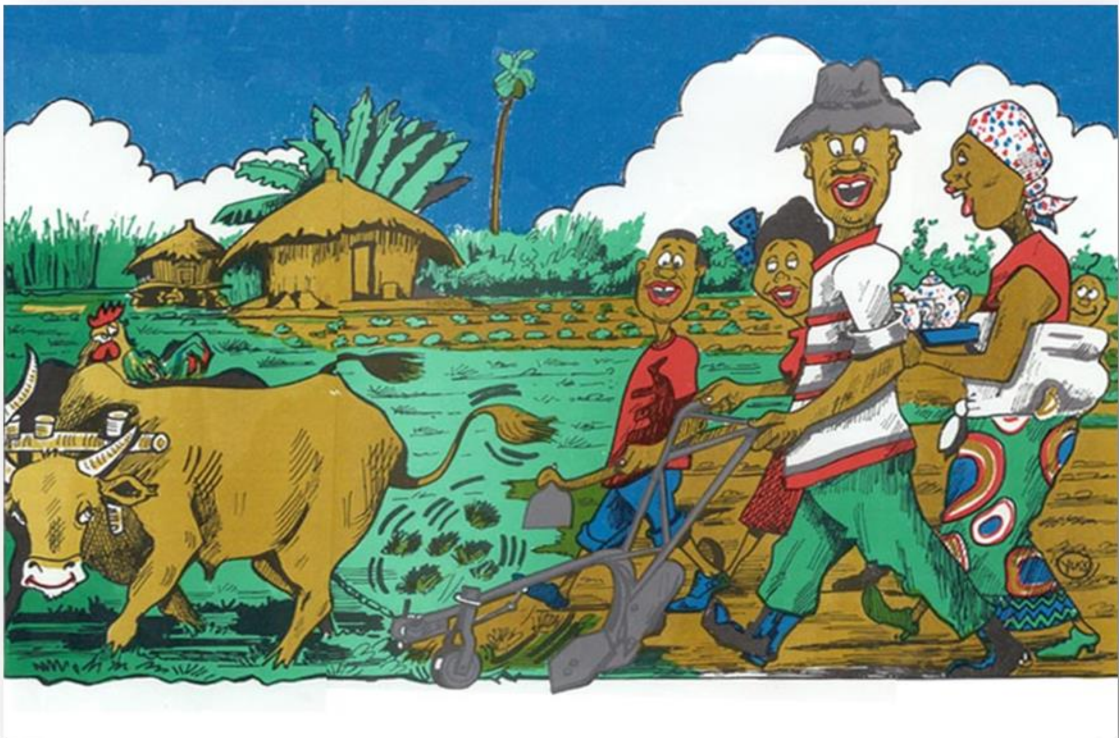


Figure 15: Pictorial presentation of ripping operation

Teren Rope

- Since CA is about precision, the teren rope is a very essential tool for CA because it ensures accurate spacing of the basins.
- It consists of a rope or string with bottle tops squeezed onto it at 70cm.
- It is used to mark out where to dig the planting basins.

Chaka Hoe

- The chaka hoe has an extra strong and long blade of about 15cm.
- Since it is strong, it entails that the hoe is heavy.
- It is used for digging planting basins.
- Despite its heaviness, the chaka hoe is a gender friendly implement.

Row Sticks and Pegs

- The two row sticks which measure 90 cm each are use to measure between rows.
- They are used on both ends of the teren rope so as to have a uniform distance.
- The two pegs are used to hold the teren rope when it is stretched across the field.

Fertiliser cup and coca cola tin

- The fertiliser cup is a special small cup used for applying fertiliser and lime in CA.
- The number 8 fertiliser cup is recommended.
- The coca cola tin is used for applying decomposed manure.

Ripper

- This is a sharp chisel like implement with detachable wings.
- It is attached on a plough beams.
- It is used to make planting rip lines mostly when the soils are dry.

Trek chain and Yoke

- A trek chain is for dragging the ripper and the recommended length is 3.5m
- The yoke links the two oxen and connects to the trek chain.
- The recommended length of the yoke is 180cm between the centre of each neck skei.

100 ml Bottle

- This is used for applying fertilisers and agricultural lime in the rip line.
- 5.3 Permanent planting Basins
- Accurately dig permanent planting basins.
- Basins re-dug each year reduce labor by 35 to 40%.

How to make planting stations (basins)

- Do not burn crop residues of the previous season
- Stretch the teren rope across the slope to mark the first planting row from the centre or edge of the field.
- Keep the rope straightened tight with the two pegs at each end of the field
- Starting at the first clamped bottle top (knot) of the stretched teren rope, dig the first planting basin, measuring 15 wide, 30cm long (the size of a man's foot) and 20cm deep (the length of a man's hand). Digging at 20cm depth will permit breaking through the hard pan.
- Working backwards, move to the next clamped bottle top (knot) on the teren rope and dig another planting basin. Work this way until the end of the field

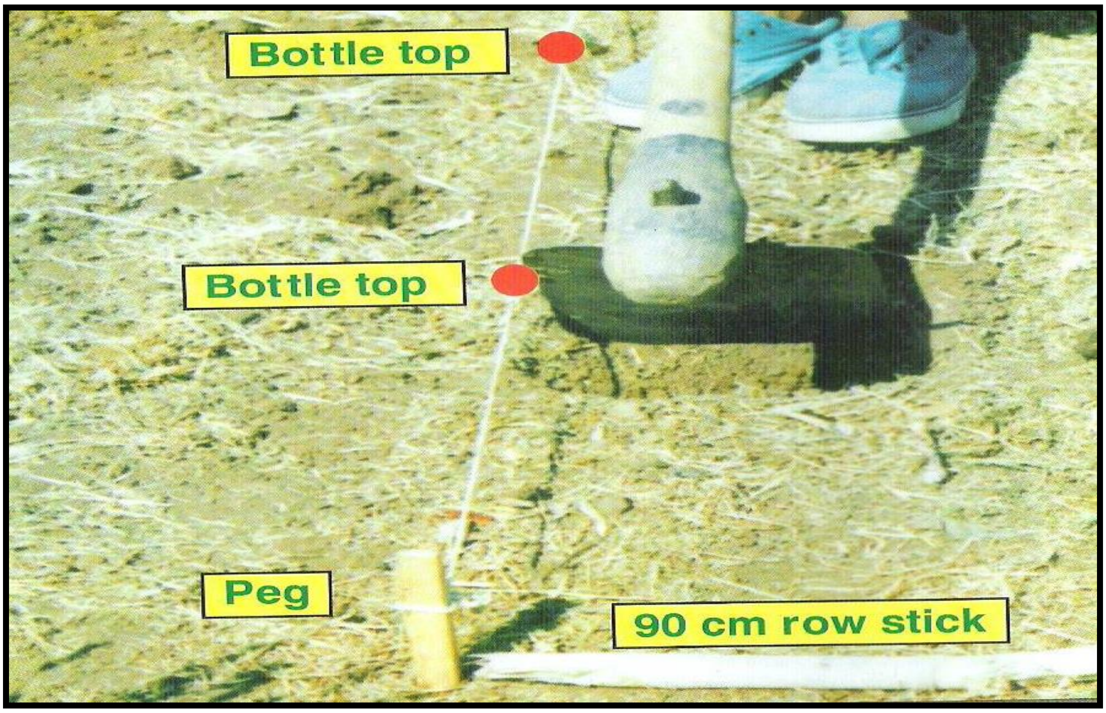


Figure 16: Permanent planting stations making

Using the two 90cm sticks to measure the row distance, move the teren rope to mark the next row and continue digging the planting basins moving backwards. In digging the planting basins of the next row stagger the basins so that they are not directly next to those of the previous row.

This is to prevent the water from running through the field for maximum retention

- Planting basin
- *Planting basins rows should go across the slope*
- *Opening furrow may begin at the center of the field and continue as shown below*
- *Opening furrow may begin at the edge of the field and continue from there as shown below*

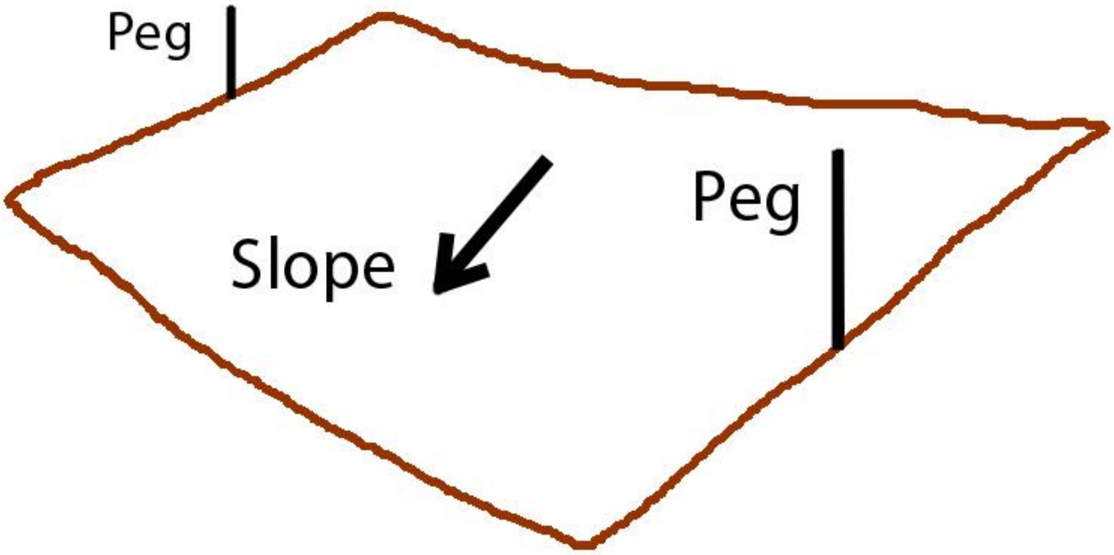


Figure 17: Planting basins rows should go across the slope

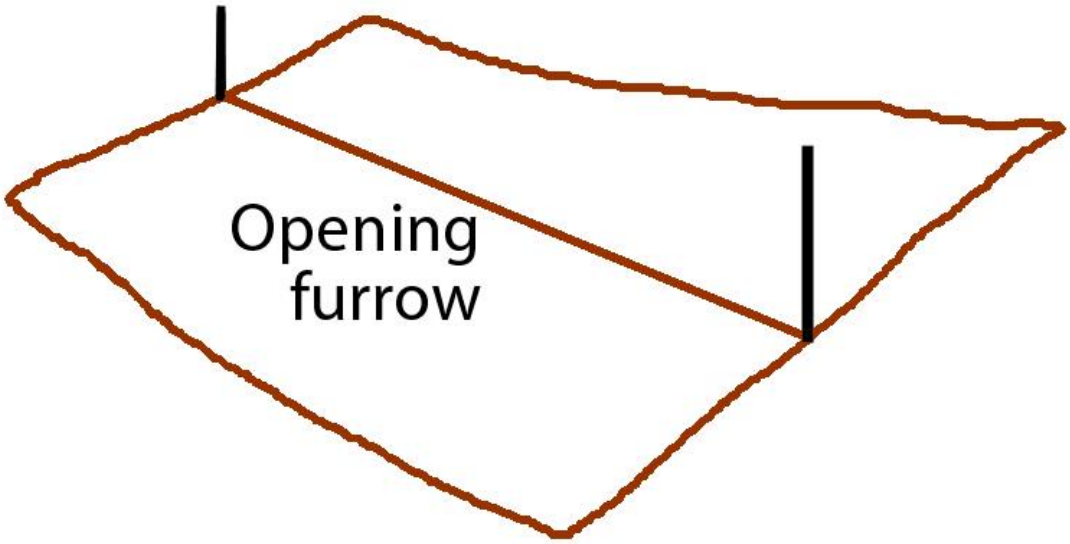


Figure 18: Opening furrow may begin at the center of the field and continue as shown below

Important points in manual systems of land preparation

- Modification and adaptation of the tools to suit conservation methods of land preparation. Use available hand hoe or a mattock for the first year and switch to the appropriate Chaka hoe in the coming year
- Do not burn ay crop residues that may be available during the first year
- Start early and dig the planting basins in the dry season, well before the onset of the rainy season. The hard pan is best broken in the dry season
- Established planting basins are permanent and the farmer will use the same ones from year to year. Do the correct job in the first year with regard to size, spacing, depth, placement of the planting basins (including staggering their positions) and breaking the hard pan
- To work efficiently, prepare planting basins moving backwards so that you do not step on the already prepared basins and the dugout soil
- Labour requirement to prepare the planting basins reduces from year to year, coming to 35-40% by the fourth year
- Train the whole household to make the planting basins to understand and help in land preparation
- At a spacing of 70x90cm, you will establish 15,850 permanent planting basins in a hectare

APPLICATION OF MANURE, LIME AND BASAL DRESSING FERTILISER

Measuring tools for application of fertiliser, lime and manure

- Fertiliser cups to apply basal and top dressing fertilisers and lime
- Empty can of soft drinks (such as Coca-Cola, Fanta and Sprite) to apply manure.

Application of fertiliser, lime and manure in planting basins

- Apply 2 cans full of mature kraal manure or compost at the bottom of the planting basin. This is the equivalent of 4 tons of manure per hectare.
- After manure application, follow with application of D compound fertiliser, placing one No. 8 cupful of fertiliser per planting basin equivalent of 125Kg/Ha.
- In acidic soils apply 2 x No.8 cups full of lime per planting basin, an equivalent of 350kg per hectare.

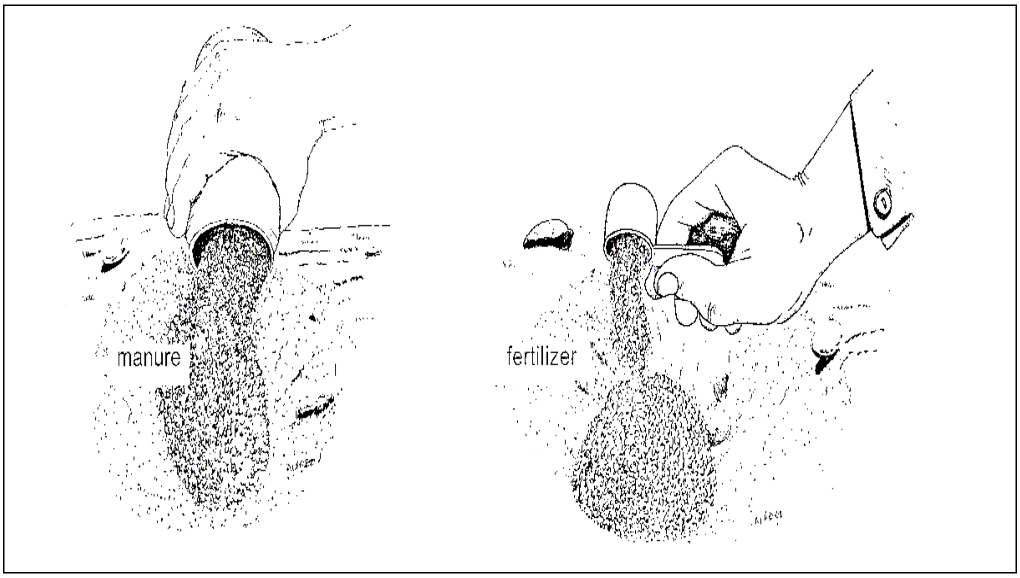


Figure 19: Manure and fertilizer application in basins

Time to Apply fertiliser, lime and manure in planting basins

- Manure, lime and fertiliser, as well as back filling can be done before planting, sometimes as early as August
- A farmer can also apply these soil improvement materials two (2) weeks before planting.
- D compound fertiliser can also be applied at the time of planting, though this tends to slow down the pace of planting for the farmer

When to plant under Conservation Agriculture

- In deciding the timing of planting, the farmer should aim at achieving quick, even and complete emergence of the crop.
- Guidelines on deciding the planting time:
  - Plant the crop with the first heavy rains, up to 48 hours after it has fallen(first effective rains)
  - Plant only when there is enough moisture to allow for uniform germination
  - Attempt to complete planting one field in a day

Table 3: Planting Dates for some crops in regions I & II

Date	Crop and comment
Region II: any time after 8th November or immediately after first heavy rains	In Region II, cotton can be dry planted after 8th November but planting cotton after 15th December can result in low yield
Region 1: planting dates can be relaxed but not later than end of December	In Region I planting date can be relaxed to later than 8th November because of higher temperature during the season
After 15th November	Plant maize and maize after the first heavy rains Early planting will also require planting long-maturing varieties
Between 1st and 15th December	Plant the following crops immediately after heavy rains between these dates: • Sorghum • Millet • Sunflower • Soybeans • Cowpeas • Pigeon peas

Table 4: Planting Procedure of selected crops

Crop	Comment
Maize	4 seeds are sown along the centre line of the planting basin and covered with 5cm of soil
Sorghum	10-12 seeds are sown along the centre line of the planting basin and covered with 2.5cm of soil
Pearl millet	Place a pinch of seeds at each end of the planting basin using the tip of your fingers and cover with 1cm of soil. Millet seeds are very small and should not be planted deep
Soyabeans	Place 10-12 seeds along the centre line of the planting basin and cover with 2cm of soil. Remember that soyabeans needs to be inoculated before planting
Groundnuts	Sow 8-10 seeds per planting basin along the centre line and cover with 3cm of soil For groundnuts, it is recommended to extend the basins so that they measure 40cm in length to avoid overcrowding. It is also recommended that only bunchy type varieties such as MGV 4 and 5, Mount Makulu red and Natal Common should be planted in planting basins, while the spreading type like Chalimbana must be grown on box ridges to allow easy harvesting
Cotton	Recommended for dry planting. Before planting, the soil must be moved back in the basin so that it is level with the ground or leave a small depression in the basin. Place the seeds at each end of the planting basin and push them slightly into the soil but remain visible. For fuzzy seeds plant a pinch of 6-8 seeds at each end of the planting basin and for delinted cotton place 2-3 seeds at each end
Sunflower	Sow 2-3 seeds at each end of the planting basin and cover with 2cm of soil Sunflower will not emerge at a depth deeper than 2cm

Source: (CFU, 2007)

Table 5: Thinning plant population

Maize	At a spacing of 70x90cm, farmers obtain 15,850 planting basins, aiming at 47,000 plants. But placement of 4 seeds per planting basin results in over 63,000 plants. Therefore the farmer has to thin the maize plants to 3 per planting basin to obtain about 47,000 plants per hectare
Cotton	The aim is to have 63,000 plants per hectare. This requires thinning to 4 plants per basin
Soyabeans	The aim is to get 125,000-150,000 plants per hectare. This will require thinning to a vigorous stand of 7-9 plants per planting station
Sorghum	Aiming at 100,000 plants per hectare requires thinning to 6-7 plants per planting basin
Sunflower	Leaving 3-4 plants per planting station should result in about 45,000 plants stand per hectare for sunflower

NB: No thinning is required for millet, cowpeas, and groundnuts, as long as planting was done correctly, adapted from CFU, 2007

Land preparation

Alternative to conventional ploughing

- Ripping for land preparation by farmers with timely access to draft animals and a mouldboard plough beam.
- Ripping is a minimum (reduced) tillage method using a ripper tine attached to a mouldboard plough beam.
- The common attachment to the plough is the Magoye Ripper.
- Ripping opens a narrow furrow in the soil surface, about 5-10 cm deep, reducing soil disturbance to 10%, compared with conventional ploughing which turns the soil 100%.
- The ripper is used to:
    i. Open up furrows for sowing seed either by hand or using a mechanical planter attached to the ripper.
    ii. Break up the hard pan, an impervious sub-surface layer that prevents root penetration and growth.

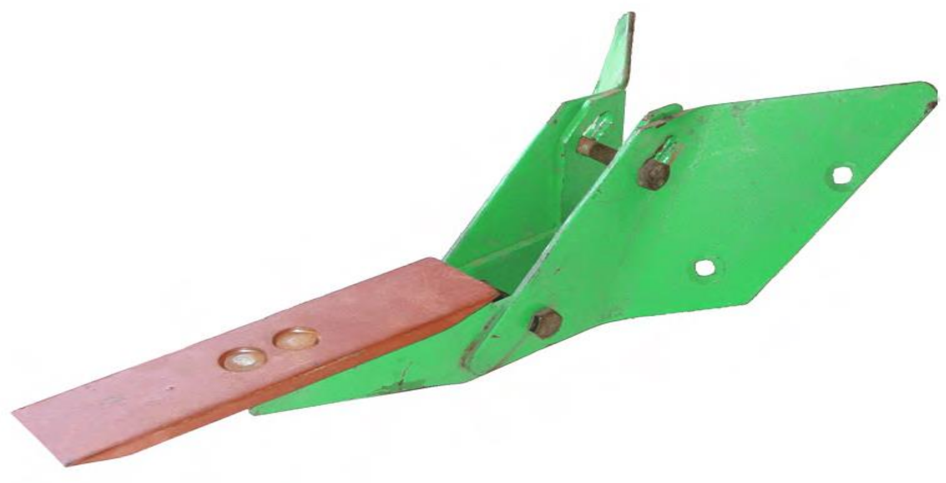


Figure 20: Magoye Ripper (CFU, 2007)

What happens in ripping?

- ***Not the whole surface is worked:*** Ripping is done in narrow bands at a regular distance from each other.
- ***The soil is dry:*** The land is ripped during the dry season, not during the rainy season.
- ***The ripper tine can penetrate deep:*** The ripper tine can penetrate deep about 25cm into the soil, even if the dry soil may be hard.
- ***The surface is not bare***: A lot of crop residues remain on the surface. They must not be burned and also not be ploughed under by the ripper. This is good practice. Crop residues on top of the soil provide a protective cover, suppress weeds and help to build a better soil structure.

Figure 21: Crop residue cover in the field prepared by dry season ripping(CFU, 2007)

Timing of ripping

- To get the best results from conservation techniques of land preparation under animal traction systems, the farmer needs to do ripping in the dry season or just before the rains get heavy

- ***Prevent unnecessary soil destruction***
  i. Soil tillage damages the structure of the soil especially when tilling wet soil, which has high risk of smearing and creating a plough pan.
  ii. So, not only reduce the amount of soil disturbance by replacing ploughing by ripping, but also use the ripper exclusively when the soil is dry.

- ***Finish land preparation before the rains***
  i. Farmers should attempt to finish ripping all the land before the first planting rains, so that they are ready for planting on time.
  ii. Weed growth is another reason why the farmer should not rip long after the rains have arrived

- ***Start ripping as soon as possible after harvest***
  i. Rip soon after harvest, in May or June *i.e. winter ripping when th*e soil is moist.
  ii. Early dry season is also a good time for the oxen as they will still be well fed, and strong.
  iii. Starting early may also enable you to finish ripping all the fields in time.

First time use of ripper

- Farmer must not attempt to rip deep but must adjust the ripper to rip to 10cm deep just when the first showers come before the heavy rains for planting,
- That way the farmer will have an opportunity to rip through the rip line again to 15cm depth
- A second run of ripping must be undertaken after some showers in October or early November concentrate the water in the first rip lines .
- The second ripping must be done 1-2 days after the showers are gone so that the ripping does not end up *"plastering"* or smearing the rip lines (closing the pores) and preventing water and root penetration into the soil.

Ripping requirements

- ***A ripper***
- ***An ordinary mould board plough beam***
- ***Healthy draft animals:***
- ***Yoke and accessories***
- the weeding yoke (long yoke) can be used for the ripping operation.
- For row spacing of 90cm, the farmer needs to make sure the yoke measure 180cm between the centre of each skei.

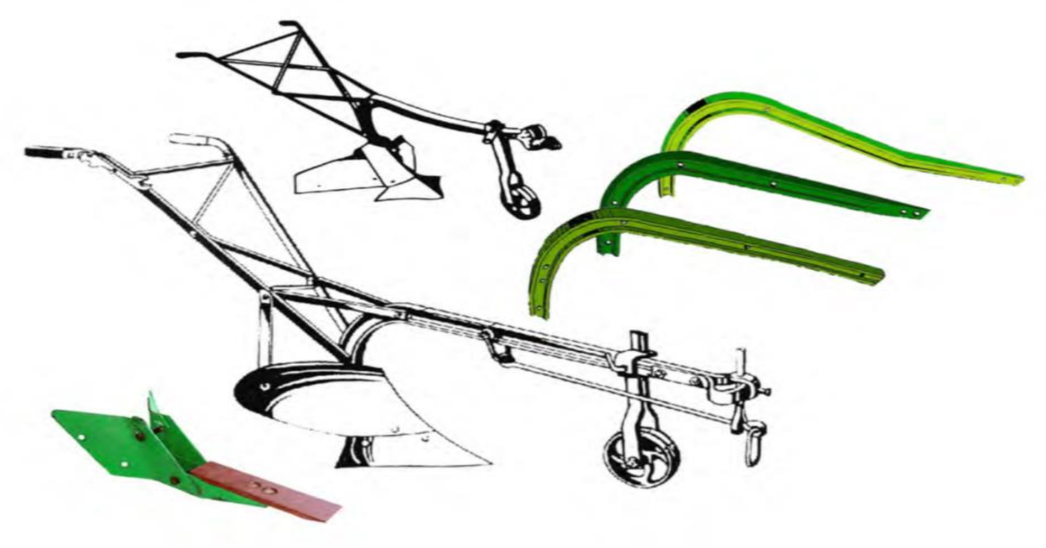


Figure 22: Ordinary implement beam for attachment of Magoye ripper (CFU 2007)

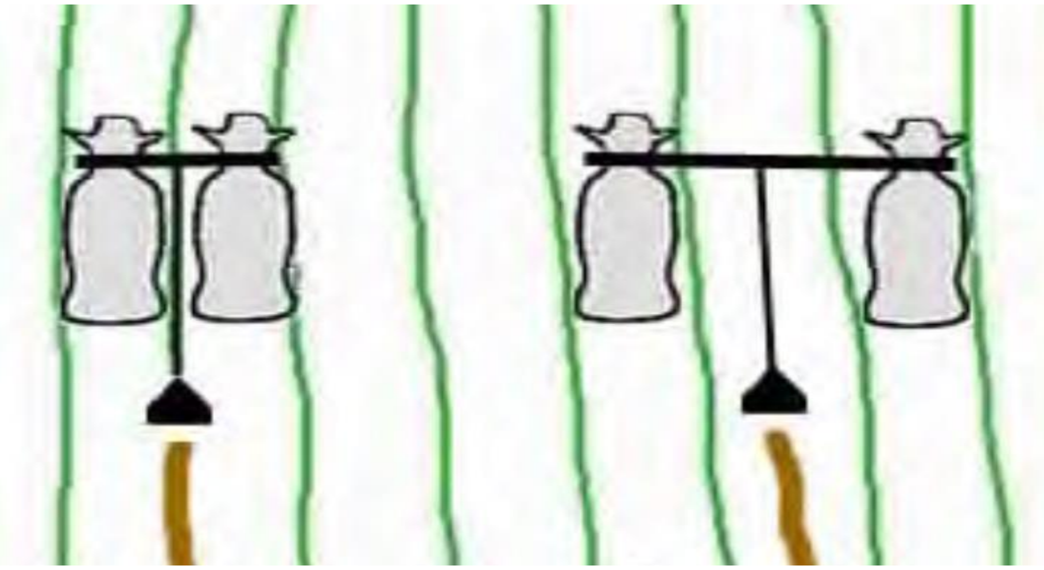


Figure 23: Ripping using a short ploughing yoke (left) and the long weeding yoke (right), (GART, 2004)

- The trek chain which should be as long as 3.5 meter is hooked to the ripper. The long length allows for a large working depth.

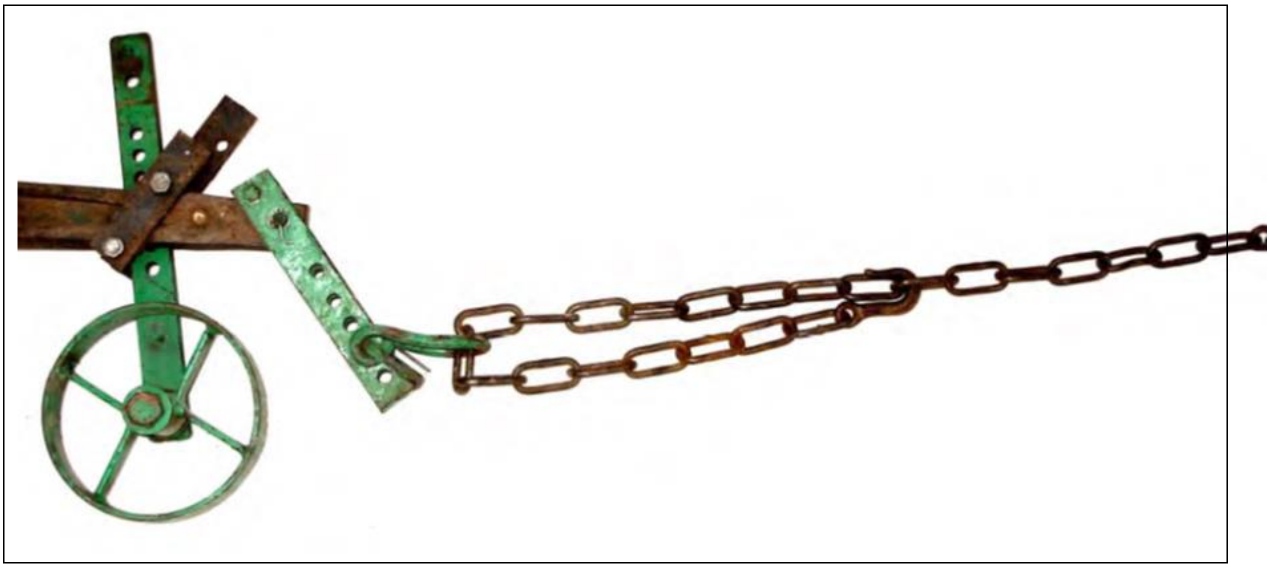


Figure 24: Trek chain with a hook at the end to easily adjust for effective chain length (Courtesy of GART 2004

Fertiliser application in rip furrows

- Use 100ml Vaseline jar as a vessel for application of these emoluments. The jar is usually easily available in the village.
- To achieve recommendation of 200kg/ha of compound fertiliser and lime the following should be applied:

Nutrient	**Application**
D Compound	1 Vaseline jar to 10 paces of furrow
Lime	1 Vaseline jar to 13 paces of furrow
Manure	3 double handful for each pace of furrow (4 ox-carts per ha)

Soil health

Leaning objectives

- Participants should be able to:
- Describe a healthy and an unhealthy soil
- List the factors that make soil to get sick
- Make a field diagnosis of a sick and a healthy soil
- Explain the role of conservation agriculture in soil health
- List and explain conservation agriculture practices that can help build and maintain soil health

What is Soil health?

- A healthy soil is a fertile soil which can produce good yields, sustainably
- Soil health, is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.
- *A **Healthy soil*** is teeming with life and activity. It's rich in organic matter, insects, earthworms, air, water and nutrients.
- *A **Healthy soil*** is a must for farmers in particular and society in general

What should a farmer look for in a healthy soil?

- A health soil has a lot of organic matter,
- A healthy soil is a living soil with a lot of worms and other living organisms
- A healthy soil is often described as having a 'sweet' or earthy smell, it appears to have a richer colour and it holds together when squeezed but falls readily apart when firmly tapped by the finger.
- Crops growing in a healthy soil have plenty roots with good structures

Table 6: Rapid field tool for farmers to test the health of their soils

What to look for	**Question**	**Farmer's response**	
		Yes	No
Organic matter	Is the top soil colour lighter than it used to be?		
Soil structure	Does the soil feel hard? If you press a piece of soil in your hand, does it break apart completely?		
Run off	Are there rills or gullies in the field? If the field is flat, does water take a long time to seep into the ground?		
Soil moisture	Does the soil get dry quickly after good rains?		
Soil life	Are earthworms and beetles easily seen in the field?		
Crops	Do the crops look unhealthy, showing signs of yellowing, purplish appearance and poor growth?		
Yields	Are the yields falling year after year?		
Roots	Are crop roots stunted? Are they shallow? Do the taproots grow sideways rather than straight down?		
Weeds	Are there a lot of weeds that like to grow on infertile soil, such as woody weeds and Striga (Witch weed)?		

If the famers answered "Yes" to any or most of these questions, there is strong suspicion that their soil is sick. Something must be done quickly

What signs of soil sickness do you see in the picture above?

Burning is a destructive practice that in the long run leads to the soil getting sick

Table 7: Characteristics of a healthy and an unhealthy soil

Soil health property	Characteristics for a healthy soil	Characteristics for a unhealthy soil
Organic matter	As high level as possible,	Lack of organic matter
Crop appearance	Green, healthy, uniform, lush, Good crop	Yellow, stunted, light green, small
Erosion	Soil stays in place, water and wind is not taking soil	Blows sooner, erodes more, washes easily, topsoil erodes
Earthworms	Fishing and red worms present, seen after rains, see holes and castings	Not there, don't work, no holes, lack of worms
Drainage and infiltration	Water goes away fast, doesn't stand, no ponding, takes a lot of rain	Water logged, dries too fast, ponding, won't drain
Tillage ease	Breaks up easily, smooth, crumbles, easy tillage	Lumps, pulls hard, has to be worked wet
Soil structure	Won't roll out of hand, crumbly, loose, holds together, granular	Hard, doesn't hold together, lumpy, cloddy, compacted, powder
Soil colour	Dark, black, dark brown, dark red	Orange, light, white, blue-grey, sub-soil colour, bleached sandy coloured
Drought sensitivity	Continuous growth despite weeks without rain	Shows signs of water stress after only a short period without rain
Water retention	Holds moisture, get by with less, retains more, gives and takes water freely	Too much water, doesn't hold water, dries out, too wet or dry, runs out of moisture.
Roots	Larger, spread out, grow down deep, numerous, good penetration, lots of feeders	Don't penetrate, undeveloped, balled up, grow crossways, corkscrew shape, shallow, short

Role of conservation agriculture in soil health

- Conservation agriculture recognises the importance of organic matter in the soil
- Encourages optimal combination of both organic matter and inorganic fertiliser,
- Ensures accurate placement of soil improvement emoluments in conservation agriculture.
- Permanent planting stations retain water and nutrients form decomposition of organic matter.
- Crop roots go deeper and more water can sink into the soil.

Therefore, conservation farming keeps the soil healthy so that it can produce better yields.

Fertilisers

Organic fertilisers

- Used to cut down on expenses for farm inputs, such as inorganic fertilisers.
- Organic fertilisers are free and can be grown on the farm if the farmer needs more.
- The farmer can also sell if they have excess of it.
- Organic fertilisers can either be obtained from standing plants/crops on the farm or can be supplied from animal sources or made from plant sources
- Keeping a permanent soil cover is a good way to improve and maintain soil health

Sources of Organic fertilisers:

- *Crop residues*
- *Cover crops*
- *Grasses and weeds*
- *Prunings from agroforestry shrubs and herbs*
- *Compost manure*
- *Animal manure*

Inorganic fertilisers

- Applied as compound or straight fertilisers
- Have a high concentration of nutrients than organic fertilisers.
- Do not contain organic matter but supply soil nutrients more quickly than organic fertilisers.
- Inorganic fertilisers are expensive but organic fertilisers are sometimes of poor quality and contain less nitrogen.
- CA recommends combined use of organic and inorganic fertilisers
- Combination promotes the efficient use of inorganic fertilisers while building the level of organic matter in the soil.

Practices of good soil health

- ***Break the hard pan*** to allow penetration of both water and roots
- ***Stop inverting and pulverising*** the soil but retain and build soil structure by making planting basins, ripping and direct seeding using zero tillage methods.
- ***Retain crop residues*** to protect the soil and add organic matter.
- ***Keeping rain water in the field*** to
  - Prevent carrying away top soil, organic matter and plant nutrients.
  - Encourage microorganism activities in the soil and reduces moisture stress for the crop in the event that there is a dry spell.
- **build water catchment structures along the contours** ; contour ridging, construction of check dams and planting vegetative barriers to retain water in the field
- ***Add organic matter to the soil*** through compost or animal manure or mulching to directly boost soil healthy.
- ***Plant cover crops*** to protect the soil from erosion and to add more organic matter to the soil

Composting

- Composting is an important source of organic matter for improving soil fertility and for sustainable agricultural production
- Plant materials are the primary ingredients for composting:
  - Crop residues, grass, weeds and hay
  - Sweepings
  - kitchen waste
- The second group of materials for composting:
  - ash (adds minerals especially potassium)
  - lime
  - good soil (such as from anthill)
  - animal manure.

Compositing factors

- Catalysts
  - Animal manure
  - portion of mature compost
  - moisture (regular watering during dry season is essential)
  - air circulation
- Compost should be sheltered from wind, rain, sun and runoff.
- Compost pile must not get either very dry or very wet.

Methods of making compost in Zambia

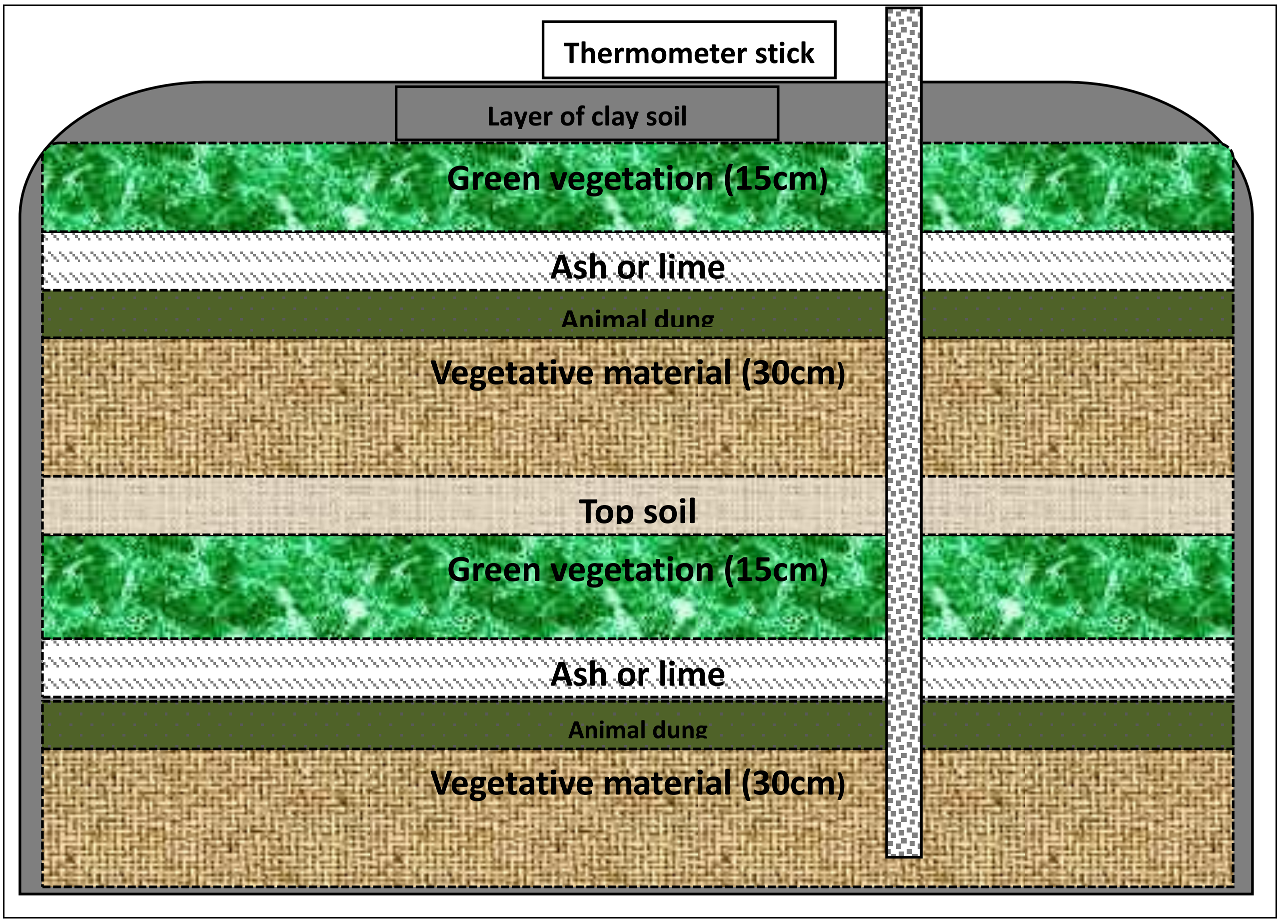
- **Pile method-** recommended for the rainy season
- **Pit method –** recommended for the dry season

Table 8: Building a compost pile

1. Begin with Bottommost layer - 30cm layer of rough materials such as maize stalks and hedge cuttings
2. Second 15 cm layer of dry vegetation, hedge cuttings or grass.
3. Third layer of animal manure or slurry
4. Sprinkle some ash, lime or dust on this layer to add valuable minerals such as potassium, phosphorus, calcium and magnesium.
5. Next layer of green materials about 15-20 cm thick. Use green leaves from high-protein leguminous trees like Acacia, Calliandra, Leucaena, Gliricidia, Cajunas (Pigeon peas) and Sesbania.
6. Sprinkle on a little topsoil or old compost. The topsoil contains bacteria which are useful in the decomposition process.
7. Add more layers in turn, starting with dry vegetative materials, then animal manure or slurry, followed by wood ash, green vegetation and topsoil.
8. Remember to sprinkle water on every layer.
9. Build the pile up to 150cm high. A well-made pile has almost vertical sides and a flat top.
10. To complete the pile, cover it all over with a layer of topsoil about 10 cm thick
11. Lastly, cover the whole pile with dry vegetation such as banana leaves or smear it with a layer of wet clay soil to reduce moisture loss of water through evaporation.
12. Drive a long, sharp, through the pile from top to bottom to save as a “thermometer”,
13. After three days, decomposition will have started in the pile, and the stick will be warm when you pull it out.
14. Pull the "thermometer" out from time to time to check the progress of the pile.
15. Sprinkle water on the pile occasionally (about every 3 days, depending on the weather).
16. After 2 weeks, turn the pile over mix the different layers, making the decomposition faster and more complete.
17. The compost should be ready after 4 weeks.
18. You can store compost by covering it with a layer of banana leaves or polythene.

Layers of a Pile Compost

- Rectangle 120 cm wide and 150 cm or more long
- Rectangle should not be wider than 120 cm, as you must be able to work on the compost without stepping on it.
- Set pile on a shallow pit about 30 cm deep



Pit Method

- Pit method of making compost conserves moisture, so it is useful in areas with low rainfall and a long dry season.
- Should not be used it in wet areas, as the compost may become waterlogged.
- The pit should be 120cm wide and 60cm deep, and as long as you need for the amount of materials you have.
- Start building a pile of materials in the pit, using the same method as in the pile method (see above), and add water to each layer that you add.
- You can produce a regular supply of compost by digging three pits side by side.
- Every 2 weeks, turn the compost from one pit into the next one, and start a new compost pile with fresh vegetation in the empty pit.

Table 9: What to do and not to do when making a compost

What to do	**What not to do**
• Choose a sheltered site for the compost pile • Chop up long stems and big leaves • Sprinkle some water on every layer, and ensure that the compost is moist all the time • Turn the pile every 2 weeks • Protect the finished compost from sun, wind and rain	• use materials that might contaminate the soil • step on the pile • use waxy leaves (such as eucalyptus leaves) • over-water the compost pile • Don't compact the layers • use materials that do not decompose

Application of the compost

- Best applied between two to four weeks prior to planting the crop.
- For perennials the best application time is
  - before the planting or
  - when the tree has reached the flowering stage,
- For fruit trees after fruiting has completed..
- Push a little soil over the compost to protect it from the sun, between application and when the crop is planted, and to protect the seed from direct contact with the compost.

Mulching

- Mulching achieves soil cover which is one of the three principles of CA
- Mulching is the use of dead plant materials to provide soil cover.
- Mulch is most often used to
  - Conserve soil moisture during dry periods
  - Suppress weeds
  - Protect soil from temperature extremes,
  - Provide a quick soil cover to protect the soil from impact of raindrops and erosion
  - Prevent runoff and improve water infiltration and water holding capacity of the soil.
  - Build soil humus and improve soil fertility.

Available sources of mulch on the Zambian farm

Materials used as mulch:

- *Crop residues from previous crop*
- *Dead cover crops e.g. velvet beans, cowpeas*
- *Harvest or resdues of agroforestry species* such as Musangu, Sunnhemp, Tephrosia, Sesbania and Gliricidia
- Grasses cut from the surrounding pastures or fallow lands

Figure 25: Previous season's crop residue used as mulch in the field

Conclusion on soil management

- Converting to conservation agriculture through soil cover, minimum soil disturbance, use of anthill soil and compost and rotation with nitrogen fixing plants builds up soil fertility over a long period and reduces the farmer's excessive reliance on expensive inorganic fertilisers
- In improving soil health, conservation agriculture aims at feeding the soil for long term productivity.

INTERGRATED SOIL FERTILITY MANAGEMENT (ISFM)

ISFM may be defined as: A set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at optimizing agronomic use efficiency of the applied nutrients and improving crop productivity. All inputs need to be managed following sound agronomic and economic principles.

The process is described in terms of interventions, outputs, outcomes and impact in Figure 3.2.

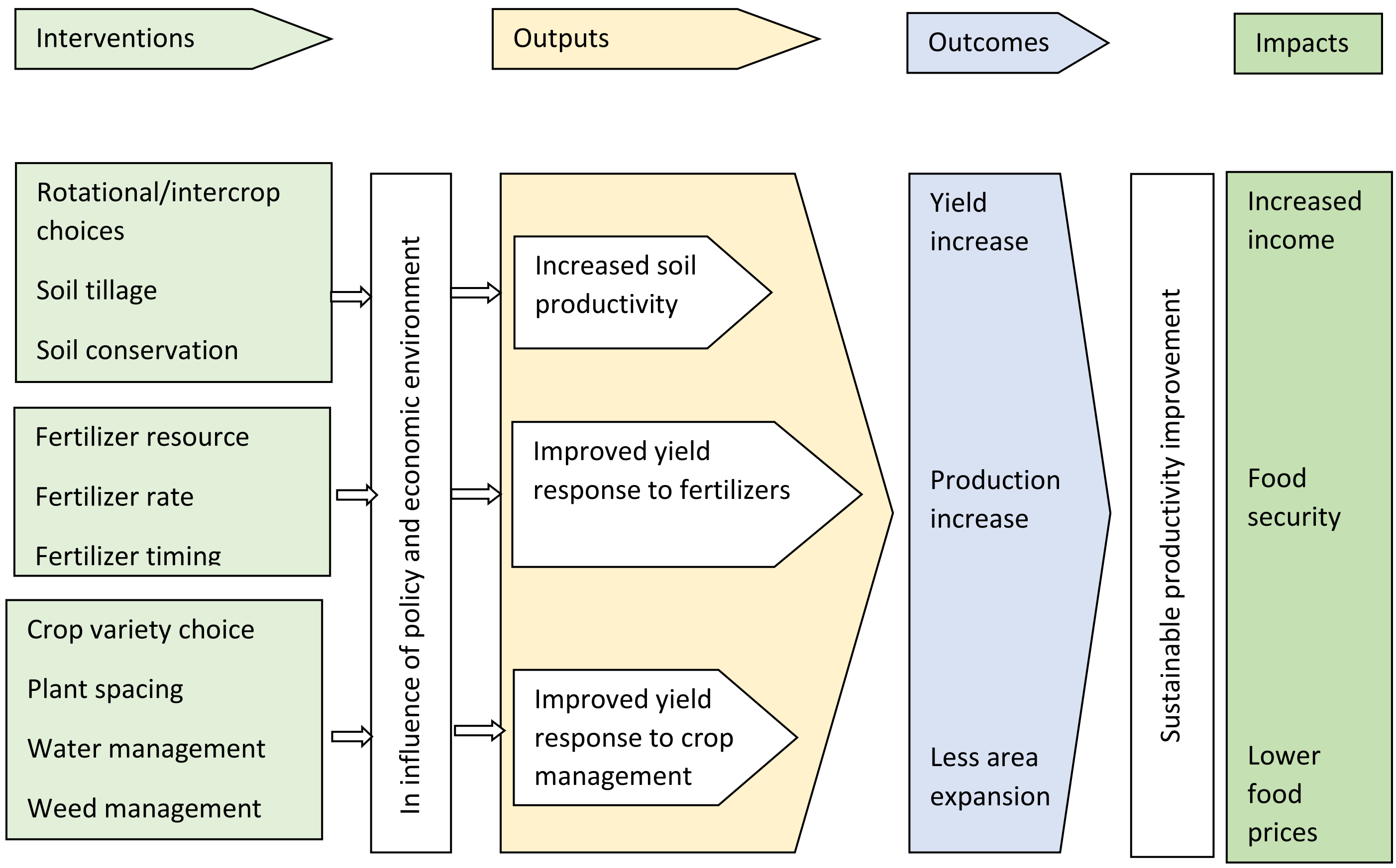


Figure 26: Link between interventions and outcomes in appropriate soil management

As shown Figure 26 ISFM involves the combined use of appropriate interventions on soil management, fertilizer use and crop agronomy to drive the main outputs of increased yield and productivity. The introduction of interventions is affected by market economics and government policy. When introduced successfully, productivity is increased and less land is required to achieve a given level of production. The impact is the sustainable improvement of food security, increased farm incomes and lower food prices, which benefit the urban population.

Integrated Soil Fertility Management (ISFM) is an approach based on the following principles:

- Neither practices neither based solely on mineral fertilizers nor solely on organic matter management are sufficient for sustainable agricultural production.
- Well-adapted, disease- and pest-resistant germplasm is necessary to make efficient use of available nutrients.
- Good agronomic practices - in terms of planting dates, planting densities, and weeding - are essential for ensuring the efficient use of scarce nutrient resources.

  In addition to these principles, ISFM recognizes the need to target nutrient resources within crop rotation cycles, preferably including legumes, thus going beyond recommendations for single crops.

Relationship to CSA

Productivity is substantially enhanced when IFSM is successfully adopted. What's more, a positive synergistic effect between organic and inorganic inputs is often observed. As a result, the efficiency of rainfall-use is greatly enhanced. IFSM advocates strategic timing and placement when using inorganic nitrogenous fertilizers, often at rates that are much lower than recommendations based on the sole use of inorganic fertilizers. This contributes to mitigation through reduced nitrous oxide emissions.

Impacts and lessons learned

IFSM is being widely promoted across Africa. For example, in Malawi, about 30,000 farmers, as well as several hundred farmer associations and agricultural extension workers, have been trained in ISFM technologies (Nyasimi et al. 2014). However, for widespread adoption to occur, an enabling environment must be created through:

- Governments that acts as enablers for fertilizer imports.
- An effective extension service, able to deliver the technology to the farmers.
- A vibrant agro-dealer private sector that ensures efficient fertilizer and seed availability and distribution.

In addition, ISFM also emphasizes the need for ‘local adaptation’ when promoting wide-scale adoption. This is necessary due to the variability that exists between farms. Each and every farm is distinguished in terms of farmer goals, farm size, labour availability, ownership of livestock, importance of off-farm income, as well as in the amount of production resources such as cash, crop residues and animal manures that different farming families are able to invest in their farm

Components of ISFM and their integration

Land assessment

- Concerned with the evaluation of land performance when used for specified purposes.
- It involves the execution and interpretation of basic surveys of climate, soils, vegetation and other aspects of land in terms of the requirements of alternative forms of land use.
- Land assessment may be concerned with present land performance. Frequently however, it involves change and its effects: with change in the use of land and in some cases change in the land itself.
- Assessment takes into consideration the economics of the proposed enterprises, the social consequences for the people of the area and the country concerned, and the consequences, beneficial or adverse, for the environment.
- Thus it should answer the following questions:

    - How is the land currently managed, and what will happen if present practices remain unchanged? –
    - What improvements in management practices, within the present use, are possible?
    - - What other land uses are physically possible and economically and socially relevant?
    - - Which of these uses offer possibilities of sustained production or other benefits?
    - - What adverse effects, physical, economic or social, are associated with each use?
    - - What recurrent inputs are necessary to bring about the desired production and minimize the adverse effects?
    - What are the benefits of each form of use that

Agriculture practices

- Agriculture practices are a set of activities combining farming system and soil conservation practices for promoting sustainable agriculture and enhancing land productivity.
- Farming system management and soil conservation techniques are agriculture practices considered effective for soil erosion control and sustaining agricultural productivity. These includes:

    - Land preparation
    - Planting patterns
    - Planting time
    - Intercropping systems
    - Cover crops
    - Mulching
    - Agroforestry and alley cropping systems
    - Improved fallows
    - Crop rotation

Soil Conservation Techniques

- Contour tillage
- Strip farming
- Terracing
- Contour bund

Organic resource management in the context of ISFM

- Organic Matter (OM) or organic material is the material composed of organic compounds that has come from the remains of plants and animals and their waste products. It may be found in the atmosphere, in organisms, or in the water and soil.
- Soil organic matter (SOM) is the organic matter in soil derived from plants and animals. When it decays to the point at which it is no longer recognizable it is called soil organic matter (SOM). The sources of organic matter include:

1. Composit
2. Farm yard manure
3. Green manures
4. Bio fertilizers
5. Crop residues

Inorganic fertilizer use

- Inorganic fertilizers are defined as materials having definite chemical composition with a high analytical value that supply nutrients to plants in available form.
- Thus fertilizer is defined as any materials or substance used as a nutrient carrier for increasing the yield of crops.
- The use of fertilizer is indispensable to alleviate nutrient constraints for improved crop production.
- In inorganic fertilizer, nutrient content can be categorized into macronutrients (primary and secondary nutrients) which are needed for plant growth in larger amounts, and micronutrients or trace elements.

Improved germplasm

- Improved germplasm means seeds, seedlings and other planting materials that have been bred to meet particular requirements of the environment in which they are to be grown .
- It is important that the quality of material offered to farmers meet minimum standards such as: seed purity, diseases and pest free, uniform in size; and high viability.
- It is also important that the farmer uses the crop planting materials (usually seed but sometimes seedlings) best adapted to the particular farm in terms of:
- Responsiveness to nutrients (varieties differ in their responsiveness to added nutrients) .
- Adaptation to the local environment (soils, climate).
- Resistance to pests and diseases (unhealthy plants do not take up nutrients efficiently).
- The seed must meet the standards set by the official seed certifying agency.

Module 3: CROP PRODUCTION MANAGEMENT

These are agricultural practices and approaches that are currently available and contribute to increased production whilst still focusing on environmental sustainability (FAO, 2013) . The crops sector is responsible for 73.8% of agricultural green-house gases emissions (CIAT: World Bank, 2017). There is thus a need to reduce the negative effects of agriculture contributes towards climate change while striving to increase production and productivity

CROP DIVERSIFICATION

Crop diversification is the growing of different crops on a farm. It can be practiced through many farming systems such as intercropping, crop rotation, green manuring and agroforestry. Crop diversification is important because:

- it provides household nutrition security
- it helps to increase incomes of farming households
- when drought tolerant crops are planted, crop diversification offers an alternative source of food particularly if the main crop fails
- provides fodder for livestock

When selecting crops, a farmer should strive to grow: crops that will provide food/nutrition security like maize, sweet potatoes, cassava and groundnuts; a cash crop such as soyabeans, sunflower and beans, and a soil fertility crop like cowpea, soyabean, pigeon pea and sunnhemp.

Under the ZIFLP Project, three crops will be promoted in the farmer field schools. Maize is the food security crop, soyabeans is meant to improve the soil structure and fertility, and sunflower is the cash crop.

INTERCROPPING

This is a farming system that involves growing of two or more crops in the same field at the same time. Some of the common intercropping practices in the Eastern Province are: maize/cowpeas/pumpkin; maize/groundnut; sunflower/groundnut and groundnut/okra. When intercropping, it is important to cons\ider the plant density, plant architecture and the maturity dates of the different crops

Benefits of intercropping

- Improve soil structure
- Increase soil fertility
- Reduce weeds
- Minimizes the build-up of pests and diseases
- Reduces risk of crop losses which occur when a single crop is grown
- May result in the increase in yields

The choice of crops to be grown in an intercrop is very important. The crops in the intercrop must complement each other. For instance:

- Nitrogen fixed by legumes benefit other crops like maize in a maize/ groundnut intercrop
- Cowpeas, beans or pumpkins provides soil cover which suppresses weeds, controls soil erosion and provides a mulch for conserving soil moisture when maize is intercropped with any of these
- Build- up of soil organic matter which improves soil health and benefit all crops
- Maize protects crops below from intense sunlight, rain storms and winds

Types of Intercropping

1. Mixed intercropping
   The growing of two or more crops with no specific arrangement or pattern

2. Row intercropping
   The growing of two or more crops at the same time in rows

3. Relay intercropping
   Involves the planting of a second crop into a field that already has a crop growing.

4. Strip intercropping
   Growing two or more crops in strips wide enough to permit independent cultivation but close enough for the crops to interact.

It is also important to consider the manner in which the crops in the intercrop will be arranged.

Challenges of intercropping

- Intercropping makes it difficult to use herbicides as the different crops require different herbicides
- Non climber types of under sown crops (such as cowpeas) may not compete favourably with vigorous healthy main crops (such as Maize).
- Cowpeas sown later than two weeks after maize will be overshadowed by maize and produce very little.
- Continued intercropping (and no rotation of fields) with the same crops on the same field results on diseases and pests that feed on these to develop.
- If only intercropping is practiced the build-up of soil fertility is slower than when using a good crop rotation
- Intercropping may be unpopular with farmers who consider the main crop (e.g., maize) as the principal crop and may have difficulties marketing the surplus legume.

CROP ROTATION

Crop rotation is the growing of different crops in a sequence on the same piece of land or simply changing crops grown in the field each year or each season. Rotation enables the farmer to mix the 'giving' (nitrogen fixing) type of crops with the 'taking' (non-nitrogen fixing but high consumers of nitrogen) type of crops. Legumes, apart from being sources of food and cash are nitrogen fixing crops and increase the organic matter production

Each crop has different characteristics and fulfilments to the farmer, which may include the following:

- Nutrient demands;
- Ability to fix nitrogen;
- Ability to protect the soil;
- Root depth;
- Hosting of different pests and diseases
- Ability to supply food for the farmer's household
- Ability to generate income for the household

A good rotation must be well planned and based on the knowledge of the soil type, the climate, the characteristics of the area, needs of the crop and market demands. For small scale farmers in Zambia, a good rotation needs the variation of at least three different classes of crops – cereal, legume and cash crop. A three (3) year rotation will be used for the project

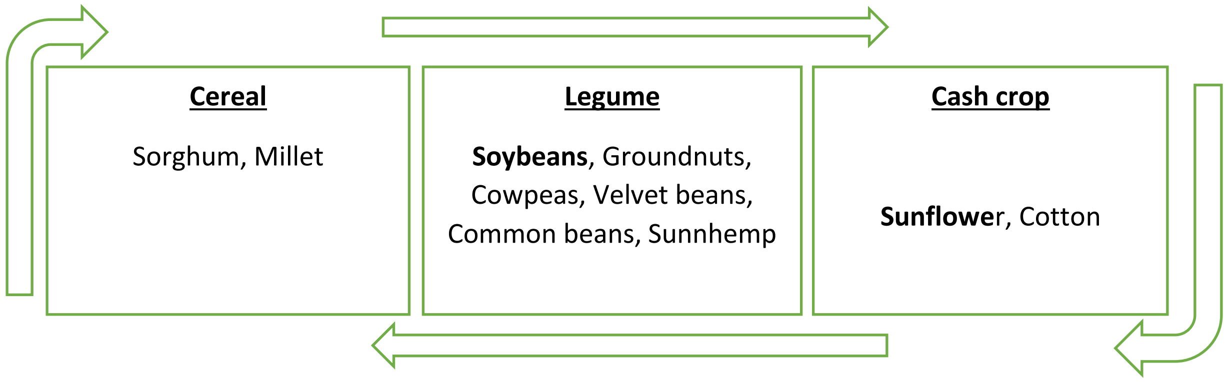


Figure 27: A three crop/ three-year crop rotation illustration

Advantages of crop rotation

- Prevention of
  - disease and pest build up by interrupting pest life cycles and habitat
  - decline of soil fertility
  - Increase of weeds population, particularly the more aggressive species.
- Improvement of soil structure
- Increased soil fertility
- Enhanced control of pests, weeds and diseases
- Reduced risk, in the case of crop failure

GREEN MANURING

The practice of growing crops for the purpose of improving soil fertility and soil structure. The plant can come from a crop that was grown after or within the main crop, or was just grown during a fallow period.

a. Are rich in nitrogen or have the ability to fix nitrogen in the soil,
b. Have the ability to produce large quantity of vegetation, known as biomass.
c. Require very little from the farmer i.e. costs for seed and labour and
d. produces good organic matter just where it is needed.

Green manures are used:

- To improve and sustain soil fertility
- To compliment and reduce use of costly inorganic fertilisers
- To reduce migration of farmers from degraded soils and encroachment of forests
- For pest management by disrupting life cycles of pests and diseases and smothering weeds
- In conservation agriculture, green manuring meets all the CA principles of: minimum soil disturbance, providing a good cover as a fresh standing crop smothering the weeds, as well as after harvest as crop residue and a rotation.

What plants can a farmer use in a green rotation?

- ❖ Annual legume species that are fast growing, fit in a rotation and increase the soil fertility and organic matter,

- Sunhemp is good at drawing up useful minerals from lower soil layers and have strong weed and nematode suppressing properties.
- Velvet bean is a very hardy nitrogen fixing crop; it is both vigorous and sustaining. Like red sunhemp, it can also be used as a livestock feed.

- ❖ Non – leguminous plants like Comfrey (genus *Symphytum*) and Tithonia (*Tithonia diversifolia*) which are usually used through biomass transfers
- ❖ Agroforestry species like Pigeon pea, Tephrosia, Sesbania, *Gliricidia sepium* and *Faidherbia albida* (Musangu)

CROP PRODUCTION UNDER CSA

When to Plant

A farmer should aim at achieving uniform germination of his crop. Guidelines on deciding the planting time include:

- Plant the crop with the first heavy rains, up to 48 hours after it has fallen
- Plant only when there is enough moisture to allow for uniform germination
- Attempt to complete planting one field in a day

Table 10: Recommended Planting Dates

Date	Crop and Comment
Region II – Any time after 8th November or immediately after firs heavy rains	Cotton can be dry planted after 8th November, but not beyond 15th December as it lowers yield
Region I – Planting dates can be relaxed but not later than end of December	Planting can be done later than 8th November because of higher temperatures during the season
After 15th November	Plant maize after the first heavy rain. Early planting requires planting long maturing varieties
Between 1st and 15th December	Plant the following crops immediately after heavy rains between these dates: Sorghum, Millet, Sunflower, Soybeans, Cowpeas, Pigeon peas

How to Plant

Planting can be done in basins or rip lines (Manual or with a planter). Planting in rip lines can be done using a hand operated dibble stick, jab planter, animal drawn conventional planter or fiterelli planter. A dibble stick is a pointed wooden stick for making holes in the ground so that seeds can be planted. Modern jab planters are equipped with two hoppers; one for fertiliser and another for seed. They are hand operated equipment that drop both fertiliser and seed in the rip furrow in one operation. Using a jab planter is easier and quicker than planting by hand. An animal drawn conventional planter (such as Palabana ripper – planter) has a planter attachment that can do both ripping and planting in one run. They may even have a provision for fertiliser application. A conventional animal drawn planter can be used for this purpose, too, following the rip lines.

The animal drawn Fiterelli is an improved zero-tillage implement which can drop seeds directly into the soil in one run without any preliminary land preparation. With the correct seed plates, the Fiterelli can drill maize, sorghum, millet, acid-delinted cotton, cowpeas, common beans, soyabeans, cowpeas, velvet beans, sunnhemp and sunflower. To use the Fiterelli, the farmer has to wait for rains so that they can drill the seed into the moist soil. With the Fiterellli soil disturbance is reduced to below 5%. If the soils are heavily compacted, dry season ripping in the planting lines may be necessary. Remember, that the Fiterelli needs to be used in combination with herbicides; otherwise, weed control would be extremely difficult.

Figure 28: Jab Planter operated by a woman

Figure 29: The Fiterelli direct planter and fertiliser applicator

Table 11: Production guide for the three crops that will be used in the rotation

	Maize	Soya beans	Sunflower
Varieties	4,5 and 6 series	Dina, Safari, Kafue	Milika, Saona, Record
Planting date	November – December, after effective rains	Early to mid of December	November - December
Planting in basins	4 seeds along the basin, but thinned to 3 after germination	10 along the basin but later thin to 7 - 9 plants	2 seeds at each end of the basin
Planting in rip lines	4-5 seeds per meter	20 seeds per meter	1 seed every 25-30 cm
Planting depth	5cm	2.5 – 3 cm	2-3 cm
Row spacing	75 – 90 cm	45 - 50 cm	70 – 90 cm
Basal fertilizer	200 – 300kg/ha of D-compound	Inoculate before planting 150 – 200kg/ha of D-compound	200- 300kg/ha of C-compound
Top dressing fertilizer	200 - 300kg/ha Urea	-	100 – 150kg/ha Urea
Weeding	At least 2 weeding's are sufficient	2 – 3 weeding's are sufficient	2 weeding's are sufficient
Pest	Fall army worm, African army worm, stalk borers	Stink bug	Birds, rodents
Diseases	Maize streak virus, Rust, Grey leaf spot	Bacterial Pastule Bacterial Blight	Downy mildew, rust, fungus
Expected yields	5 – 8Mt/ha	2 – 4 Mt/ha	1.5 – 2 Mt/ha

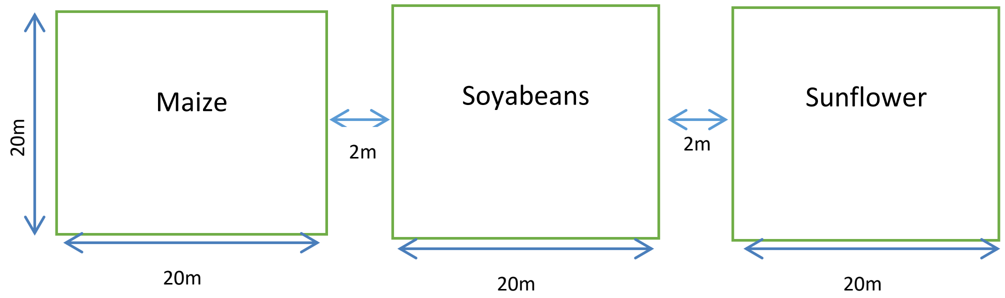
Adapted from CFU, 2007

Soyabeans Inoculation

- Spread 100kg of soyabean seed in a large container
- Mix 100g of inoculant and 1 liter of water in a clean bucket
- Add 50g of sugar into the solution. The sugar acts as an adhesive between the seed and the inoculant
- Stir the solution for 30 seconds
- Sprinkle the inoculant onto the seeds while gentle turning to ensure that all the seeds are coated
- Spread the seeds on a clean plastic under a shade and leave for about 30 minutes to dry and then plant soon after. Inoculated seed should be planted within 24hrs of inoculation
- Sow the seeds in moist soil and cover immediately afterwards to protect the rhizobia from sunlight

For smaller amounts of seed: 10g inoculant (2 heaped teaspoons): 5g sugar (1 heaped teaspoon): 100ml of water for 10kg seed

Field layout for Demonstration plot in the Farmer Field School under ZIFLP



PEST AND DISEASE MANAGEMENT

Integrated pest management

Integrated Pest Management is the use of multiple tactics in a compatible manner to maintain pest populations at levels below those causing economic injury while providing protection against hazards to humans, domestic animals, plants, and the environment (Cornell University 1979).

Pests include all biotic agents (insects, mites, nematodes, weeds, bacteria, fungi, viruses, parasitic seed plants, weeds and vertebrates) that adversely affect plant production

Requirements for successful application of IPM

- Correct identification of the pest, its life history and behavior
- Natural enemies and weather factors affecting pest population
- Pest surveillance
- Establishing the Economic Threshold level (ETL) for each pest in a crop
- Selection of suitable methods of control and analysis of cost/benefit and benefit/risk of each control measure
- Farmer's awareness and participation

Integrated Weed Management and Herbicide Usage

Integrated Weed Management (IWM) uses a combination of different practices to reduce and maintain weed densities at manageable levels. It combines the use of complementary weed control methods such as grazing, herbicide application, land fallowing and biological control. IWM is also integrated in conservation agriculture, through crop rotations, cover crops, mulch covers and use of mechanical tools such as the knife roller

Why Weed?

- Weeds compete with crops for space, nutrients, water and light and can ultimately convert productive land into an unusable state.

- Weeds can be poisonous, distasteful, produce spikes or thorns.
- Weeds can otherwise interfere with the use and management of the crop by contaminating harvests.
- Weeds interfere with irrigation systems, clogging and causing leakages in irrigation canals.
- Weeds can be parasitic, or host pests and diseases that can spread to cultivated crops
    - The witch weed (*Striga*) grows its roots into the roots of the host plant and present symptoms like those of a severe drought.
    - *Nicandra* (Apple of Peru) and *Bidens* (Black Jack) can harbour nematodes

However, some plants are considered weeds by some farmers but beneficial by others. *Nidorella* (poverty weed), *Amaranthus* (Bondwe) and *Bidens pilosa* (Black jack), are all common weeds in Zambia invading crop fields and found in abandoned fields, but provide nutritious vegetables and are valued by beekeepers as they provide pollen to bees for honey production

Factors determining number of times to weed

A farmer should weed as many times as possible to keep the field weed free and reduce weed competition. The aim should be to give the crop an early advantage against the weeds at the time of planting. Secondly the farmer should aim at preventing the weeds from producing seed, so that in the coming years, the weeds are not given chance to produce new ones.

Factors that determine the number of times to weed include:

- The method of weeding used
- Presence of labour
- The state of weed invasion (weed pressure)
- Human nutrition status at the time of weeding
- Condition of the crop and targeted yield
- Soil type

Weeding methods

- Hand Weeding
- Animal Drought Power
- Use of Herbicides

HERBICIDES

Herbicides or weed killers are chemicals used to control weeds. They are mixed with water and sprayed to kill weeds in the field. Weed killers are a good solution for the removal of weeds under minimum tillage and can wholly replace the use of hand-hoe when properly used.

Table 12: Comparison between Manual weeding and Herbicides

	Weeding method	
Output	***Conventional***	***Herbicide***
No. bags/ ha (50kg)	**40**	**200**
Income @ K70.00/50kg	**K2,800**	**K14,000.00**
Input/weeding cost		
First weeding	K330	K100 Maize weed killer + K100 1litre Acetocholr
Second weeding	K330	
Total cost of weeding	**K660**	**K200**

Table 13: Advantages and disadvantages of using Herbicides

Advantages	Disadvantages
• Selective control without injury to crop • Requires less field labour • Fits well in CA; little or no soil disturbance, supports soil cover • More effective against perennial weeds than other methods • Cost effective • Protects crops from adverse effect of early competition • Effective under very wet soil conditions, which makes mechanical weeding extremely difficult	• Requires some skill • Risk of poisoning the operator and environment • Risk of injury to the crop • Mostly used in mono cropping systems

Safe use and waste management of herbicides

Farmers need to be trained in use and management of herbicides in order to avoid damage to the crop and environment. Critical training areas for herbicide management are:

- Choice and use of herbicides
- Choice and maintenance of sprayer
- Timing of application
- Calibration of sprayer
- Correct walking speed and pressure,
- dilution of herbicides and
- safe use/storage/disposal of herbicides

Herbicides have potential dangers and as such, the farmer must be properly trained and should fully understand the manufacturer's instruction on the label before they start using the herbicides. Herbicides should be purchased from authorised agro-dealer. The person spraying should observe the following measures:

- The sprayer should be calibrated the so that the correct amount is discharged and the nozzle, tank and rubbers should be checked for pressure, blockages and leakages
- The herbicide should be mixed with clean drinking water so that the active ingredient in the herbicide does not bind with mud, debris and other impurities in water, which may render it ineffective
- During spraying the farmer should maintain an appropriate height of the spraying nozzle. This will depend on the height of the weeds and the cone of spray so that the spray herbicide thoroughly covers the weeds. It is important that a constant pressure of the sprayer is maintained so that a there is and uniform discharge from the nozzle
- The person spraying should maintain an overlap of spraying for effective weed control so that no gap is left

The farmer should be able to identify the weeds and know what weeds herbicide control these weeds. Herbicides should be rotated between years to avoid development of resistance by the weed

Safety when using herbicides and other chemicals for pest control

It is the duty of the extension officers to train the farmers in use and safety of chemicals during pest and disease control. Herbicides and other chemicals will not only kill the weeds, but can also harm the farmer, their household, other people and the environment. Safety must be the top most priority when using these potentially dangerous chemicals.

What safety measures should the farmer take when using herbicides?

NOTE: This information applies to the use of all chemicals (herbicides, pesticides, fungicides, and bactericides).

- The first step in safety is to understand the use, effectiveness, and dangers of the selected herbicide. Read the label carefully and understand the instructions
- Use protective clothing including a mouth/nose aspirator and gloves when handling herbicides
- Do not eat, drink and/or smoke when handling herbicides
- Do not spray the herbicide mixture against the wind
- Wash the face, hands and body, as well as the equipment, with soap and thoroughly rinse with plenty of water immediately after handling herbicides
- Do not use or dispose of herbicide or wash clothing used and equipment at or near water sources
- Store the herbicides in their original containers, maintaining their labels and lids, and lock away from children and other people
- Dispose of the containers and the remaining herbicide mixture according to the manufacturer's instructions
- Inappropriate disposal of empty herbicide containers can lead to health risks for humans and livestock as well as causing environmental pollution.

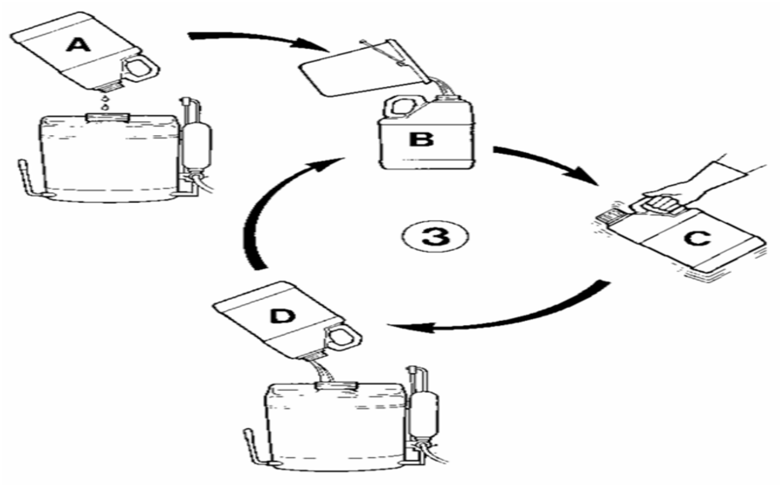
In Zambia the disposal of these containers is governed by laws. Not following these laws can be a criminal offence. The disposal of empty pesticide containers is a two - step process:

Step 1: Ensure the container is clean, by triple rinsing.

Step 2: Dispose of the clean container in a way that follows local laws and/or best practice guidelines.

If there is a time gap between steps 1 and 2 then the container should be kept securely to avoid potential misuse. To reduce the hazard of empty herbicide containers before disposal, do *triple rinsing* as follows:

- Drain the remaining pesticide from the container for at least 30 seconds into the sprayer tank (Step A).
- Add clean water to the empty container until it is approximately one quarter full
- Replace the container cap securely, then shake the container for about 30 seconds, making sure that all the inner surfaces of the container are well rinsed (it is recommended to vary the shaking movement i.e. side to side, up and down, circular motion etc). Large containers may need to be rotated or rolled
- Remove the cap and empty into the sprayer tank, so that it forms part of the spray mix. Allow the herbicide container to drain for at least 30 seconds.
- Repeat steps A-D twice more until rinse water is clear. If the rinse water is still coloured or milky after three rinses, then repeat the rinsing process until the rinse water is clear.
- Wear suitable protective clothing when rinsing containers



On farm disposal is no longer a recommended method of disposal by FAO code of conduct guidelines but where no waste collection schemes are operating, **empty washed** containers can be burnt or buried following local guidelines if local laws permit.

- Burn away from people, livestock and buildings, avoid any smoke
- Bury the ash in a deep pit
- Bury containers in a deep pit away from wells and surface water.

- Farmers must be advised to seek advice and clarification from local authorities such as the DACO's office, the Council and Public Health technicians
- Select a burial site for the pit that is away from water courses and the site
  - must also be fenced off
  - clearly signed that it is a site of hazardous materials
  - must be deep enough to ensure animal and human activities will not uncover the buried waste.
  - Bottom of the burial pit must be at least 2m above the ground water level.
  - must not be in areas prone to flooding.
- Compress containers as much as possible before throwing them into the burial pit.
- Cover layers of contaminated waste with bio-degradable household waste to assist biological degradation.
- Once the pit is full, cover with soil; and plant bushes to avoid the rapid drainage of rain water

Never:

- Discard empty containers in the field, ditches or water courses
- Reuse empty containers for any other purpose
- Bury, burn or recycle unwashed containers
- Allow children near pesticide waste
- Allow containers to accumulate above your safe storage capacity
- Allow container washings to enter any water course.

Selection of Herbicides

Herbicides are classified on the basis of:

- Weeds they can control
  - Non-Selective, kills all weeds
  - Selective, kills only selected type of weeds
- Time they can be applied
  - Pre-planting which are applied before planting
  - Post-emergence which are applied after emergence of growing crop

Herbicides that are not recommended

Crop rotation is an important part of climate smart agriculture and because some chemical are poisonous and too dangerous to handle, they are not recommended

The following chemicals are not recommended

- All herbicides containing the chemical *paraquat* (very poisonous for both humans and animals). They may come under the following trade names: Gramoxone, Uniquat, Afriquat, Paraquat20%, Mupaxarone, Leaderb24, Herbikill, Paraforce, Harpoon and Parabat.
- All herbicides containing the chemical *Atrazine only and Atrazine with terbulthylazine* to control weeds in maize. These may affect a rotation or intercrop with a legume the following season. Trade names include: Atacell, Agrazine, Atraforce, Fermizine 600C, Atrazine 500SG, Afrizine, Atraprime, Bullet, Cheetah, Scorpion, Emerald, Ballistic Gold and Rhino
- All herbicides containing the chemical *Formesafan and Imazethapyr* to control weeds in g/nuts and soya beans may affect a rotation with a maize the following season, and the crop may be damaged. Trade names include: Flex, Candy, Formesafan, Quizafom, Imax, Image, Zephyr, Imaze, Legume weed killer.

Table 14: Common herbicides in Zambia

Herbicide	**Classification**	**Use**
Round-up (Glyphosate)	Non-selective Post emergence to weeds Pre-emergence to crops	• Kills all weeds (annual, biannual and perennial) • Can be used on all crops • Taken up by actively growing leaves and moves to roots/bulbs/rhizomes/stolons • Completely inactivated on contact with soils
Gramoxone	Non-selective	• Kills all weeds (annual, biannual and perennial)
Imax (by Crop Serve)	Selective Pre-emergence to broadleaf crops	• Kills broadleaf weeds • ay be used on annual broadleaf weeds in dry beans, soya beans and groundnuts. • Apply after third trifoliate leaf but before flowering, • Allow 3 months between application and crop harvest
Pentara (by Crop Serve)	Selective Post-emergence to broadleaf crops	• Kills grasses in dry beans, groundnuts, soybeans, sunflower and cotton • To be applied on actively growing grasses
Cotoguard (Diuron)	Selective Pre-emergence	• Kills annual broadleaf weeds • Commonly used in cotton
Cottonex	Selective	• Kills annual broadleaf weeds • Commonly used in cotton
Acetochlor	Selective Pre-emergence	• Kills annual grasses and certain broad leaf weeds in maize • Must be applied pre-emergence of crop and weeds. • Also controls yellow nutsedge if applied before it germinates. • Best results are obtained when applied to moist soil and free from established weeds

POST-HARVEST STORAGE

Moisture content at harvest

Moisture content is a critical parameter to consider for safe storage of a crop after harvest. High moisture content leads to storage problems because it encourages fungal and insect problems. It can also cause germination of the crop

Moisture content of maize can be measured at household level using the salt – jar method. Place a teaspoon full of salt in a dry bottle to which kennels of the harvested maize is added and sealed. The bottle should then be shaken and rolled gently for 3 minutes. If the salt does not lump or adhere to the sides of the jar, the moisture content is usually below 15%.

Grain Storage

The type of storage method used will be determined by:

- The type and amount of crop harvested
- The price of the storage system selected
- The storage requirements and form in which the crop is stored

Grain can be stored in traditional granaries, traditional bins, grain bags, pics bags and metal silos.

Metal silos

Metal silos are a type of storage that uses the principle of hematic storage. By construction capable of ensuring storage of cereal produce beyond a season in line with the desire for climate change mitigation in case of crop failure due to either floods or drought. Storage of legumes (beans and cowpeas) and maize in silos would enhance food security in the face of climate and weather unpredictability. The silos are potable, easy to use by farmers and do not require any chemical treatment of the grain. They also protect grain from rodents and birds.

Module 4: WATER MANAGEMENT

Water resources especially in the agriculture sector continues to suffer severe impacts from climate change. Most noted impacts include increased variation in rainfall distribution and intensity, higher temperatures, as well as extreme weather events, such as floods and droughts. Climate change is expected to bring more challenges on already stressed water systems due to agricultural development.

Agricultural water management: status and trends

With increased demand for food and other agricultural products, agricultural production has been increasing to meet the demand. With the doubling of irrigated area, water withdrawal for agriculture has been rising sharply. Globally, agricultural water withdrawal represents 70 percent of all withdrawals (FAO, 2016). An increasing number of the world's river basins have reached conditions of water scarcity through the combined pressure of agriculture and other sectors. FAO estimates that more than 40 percent of the world's rural population lives in river basins that are classified as water scarce (FAO, 2013).

Pressure on water resources has had serious impacts on farmers and environment resulting into over water utilisation especially in water systems without water use structures. Public surface irrigation systems and dams built by the government have dominated the Zambian landscape and have a profound impact on the flow of many rivers and streams. Private investments, stimulated by the availability of cheap pumps and well drilling capacity, have been directed to tapping groundwater.

Pollution from agriculture, cities and industries has affected rivers and aquifers and further reducedthe amount of water available for use. With the projected 9 billion world population by 2050 demand for water shall continue to rise as result of increased food consumption of food. The role climate change will play with regards to water in agriculture must be considered in this context ofrapid increases in water withdrawals, the degradation of water quality and the competition for water at all levels. The following sections look at the current state of knowledge about climate change impacts on water resources and the demand for these resources.

Potential impacts of climate change on water in agriculture

Water is the prime channel through which the impacts of climate change on the world's ecosystems and livelihoods are felt. Climate change will have an impact on every element in the water cycle (FAO, 2013; UN, 2010). Agriculture will be affected by increased evaporative demand, changes in the amount of rainfall and variations in river runoff and groundwater recharge, the two sources of water for irrigation (Figure 29). These impacts are described in more details below.

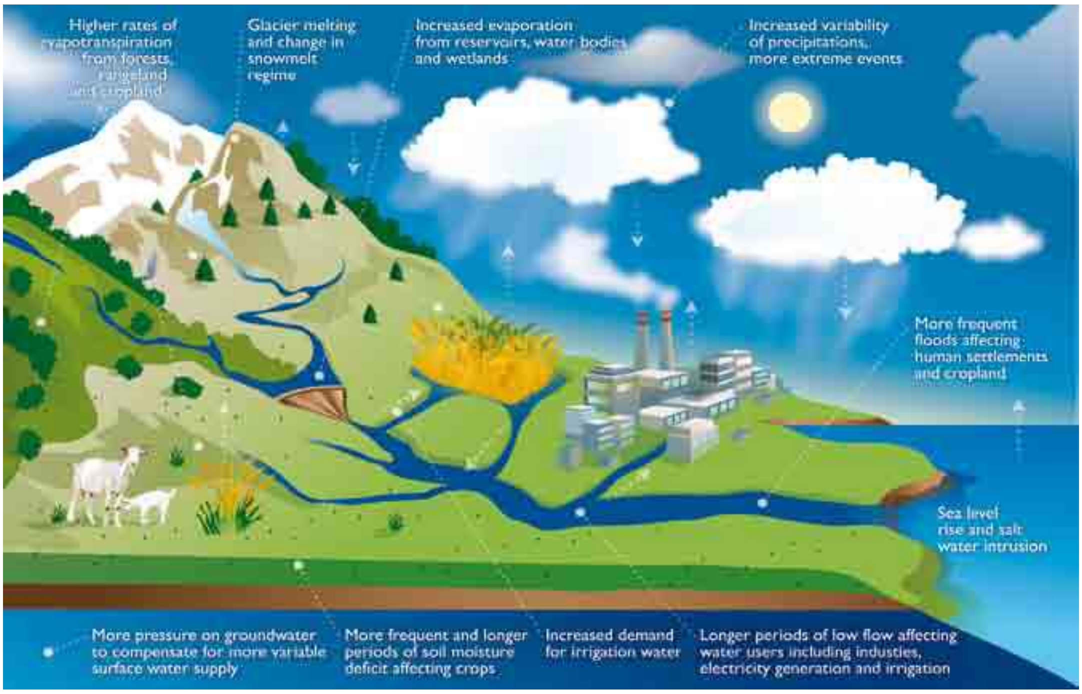


Figure 29: Impacts of climate change on water cycle and agriculture (FAO, 2013)

Impact on water supply and demand

A global increase in atmospheric temperatures is predicted to affect agricultural productivity through heat waves that will affect both crops and animals. An increase in temperatures will trigger increased demand for evapotranspiration water by crops and other vegetation. This will lead to more rapid depletion of soil moisture, and if combined with combined with rainfall patterns variations, may lead to frequent crop failures occurrences. Changes in the distribution of precipitation, with longer periods between rainfall events and more intense precipitation, are expected everywhere. This may lead to increased occurrence of extreme weather events, including floods and droughts. The combined effects of water withdrawal and pollution are affecting ecosystems and agriculture. The extent to which climate change will affect the water cycle and agriculture needs to be considered in light of these developments.

Vulnerability to climate change and resilience: a variety of situations

The potential effects of climate change on agricultural systems depends on a combination of exposure and sensitivity, as well as level of resilience of the systems to changes in water supply and demand. With or without climate change, agricultural societies most at risk are those that rely exclusively on farming for their livelihood, have little scope for diversification and are highly exposed to climate variability. Actions that build resilience include: better conservation of soil moisture (in particular through improved soil water holding capacity or access supplementary irrigation); better storage of grain; and better access to markets and to drought protection schemes.

The distinction between rainfed and irrigated production systems will dictate the impacts and associated risks related to climate change. Rainfed systems will be mostly affected by changes in rainfall patterns and temperatures. These changes will lead to greater frequency of crop failures as a result of increased variations in soil moisture. Pastoral areas will suffer from more frequent drying of water points and greater variability in available animal feed. Irrigated systems are better protected against rainfall variability, but these systems will increasingly require greater storage capacity to respond to more frequent droughts and floods and changes in rainfall distribution. For surface or groundwater systems already being over-exploited, climate change will add an extra burden to water management and generally lead to a reduction in the availability of water and greater competition for water resources. Fish production will be affected by changes in the quality and quantity of freshwater, thereby affecting the production.

Assessing risk, preparing responses

To design water management responses in relation to climate change, it important to undertake a risk assessment of the target community. An impact-based approach is needed to ensure that long-term investments such as irrigation development take into account expected changes in water supply and demand. It is also important to consider better protection for land and socio-economic assets. Improving the resilience of water infrastructure to climate change-related shocks and extreme events is a vital part of any effective water investment planning. Resilient coping strategies are those that have the potential to be reasonably effective under the largest possible range of scenarios.

Options for adaptation to climate change

Options for adaptations will be implemented at different scales: on fields and farms, in irrigation schemes, in watersheds and in river basins. Each option chosen shall require specific designs according to situation on the ground.

Table 15: Options for climate change adaptation in water at different scales

Options	Field/farm	Irrigation scheme	Watershed/ aquifer	River basin
On farm water storage: water harvesting	x			
Groundwater development	x			
Modernisation of irrigation infrastructure		x		
Breeding for resistance to droughts and floods	x			
Dam construction/enhancement		x	x	X
Drainage	x		x	X
Introduction of appropriate fish species	x		x	x
Enhancing soil moisture retention capacity	x			
Changing cropping pattern and diversification	x			
Adapting cropping (and fish harvesting) calendar	x			
Supplementary irrigation	x	x		
Deficit irrigation		x		
Alternative wet and dry rice production system	x	x		
Drainage and flood management		x		
Irrigation scheme operation improvement		x		
Integrated water resources management				x
Adaptation of dam operation rules				x
Riparian habitat restoration or creation				x
Climate proofing of irrigation & dam infrastructure		x	x	x
Crop insurance	x			
Improved hydrological monitoring			x	x

Source: adapted from (FAO, 2013)

Water management good practices in Agriculture

Good agricultural water practices includes maximum water infiltration and minimising unproductive runoff surface waters. It also involves promotion of technologies and practices that improves soil structure and enhancement of organic matter content in the soil. The practice of ensuring that accurate scheduling of irrigation as well as adopting water saving measures and recycling where possible. Another good agricultural practice is the establishment of permanent vegetative cover to enhance water retention and recycling. Such practices should be promoted in light of water scarcity due to climate change.

Rainwater harvesting technologies common in Zambia

Roof Catchment

The roof forms the catchment from which rainwater is harvested and channelled using gutters to a tank. A ferro-cement, plastic or brick tank can be used to collect the water from the gutters. Rainwater can be collected from any kind of impervious roof. The only common type of roof which is not suitable to collect rainwater with lead flashings or roofs with lead based paints and asbestos roofs with loosed fibres. Figure *30* show an example a collection structure in rainwater harvesting operation.

Figure 30: PVC Tank used to collect water during water harvesting operation (Earth Eclispe, 2018)

Sinking well

The Sinking well has the highest potential of replacing the traditional method of harnessing shallow ground water. The method is relatively cheap and readily acceptable because it offers an improvement to traditional method of digging shallow wells.

Hemispherical Tanks

These tanks are promoted for water harvesting, of which water can be used for irrigation, fish farming or small livestock drinking water. The water recharge into the tank is usually done by a spring or water diverted from a stream or runoff from a road.

Small on-farm water retention structures

The small on farm water retention structures are designed on farms to improve soil water or moisture retention in crop production. The structures include terraces, level and graded bunds, tied ridges, potholing; infiltration ditches etc.

Farm Ponds

The farm ponds can be constructed in various sizes depending on the water demand. Runoff collects and get to be used when needed. The harvested water can be used for irrigation or fish farming. An individual farm pond can be about 20m by 20m by 3m. A dam liner can be used in sealing the bottom surface to reduce on permeability.

Rock Catchment

A vertical wall is constructed around the edge of a depression or hollow in rock surface to capture and retain water running off the rocky surface. The rock catchment when combined with a series of standing tanks can provide a reliable and clean source of water throughout the rain season with carry over into the dry season.

Coping with water scarcity

Water scarcity is major challenge facing the agriculture sector especially in agro ecological region 1 and 2 of Zambia. Climate change is expected to exacerbate tensions and raise competition for water in areas of water scarcity. Options to cope with water scarcity in agriculture can be seen as running a spectrum from the source of water to the end user (the farmer and fisher), and beyond, to the consumer of agricultural goods. A combination of interventions are needed to help the farmer produce more with less water (FAO, 2013).

Building resilience

This involves reducing farmer's exposure or sensitivity to shocks, or increasing their capacity to respond. It is important to increase farming systems' buffering capacity during variable supplies of rainwater. It calls for in increased capacity to store water in the soil, in surface reservoirs. Actions to improve capacity to access water when needed should be promoted. Such actions include: on-farm water harvesting; enhancing soil's capacity to hold moisture; on-farm water retention and enhanced infiltration; more systematic access to groundwater. Supplementary irrigation at critical periods of the cropping season can reduce losses and boost productivity.

Adaptation at field and farm level

Much more efficient irrigation technologies such as drip enhance evaporation losses reductions shall be recommended. The selection of crops and changes in crop calendars will help farmers adapt to new temperatures and rainfall patterns. It will be important to use crops or varieties with better resilience to dry spells. Increased agricultural diversification, including better integration of trees, crops, fish and livestock will reduce risk and increase the resilience of farming systems. Farmers will also need to adopt more systematically measures to respond to increased frequency of floods and more intensive rainfalls. A combination of erosion control actions and better drainage capacities will be needed.

Adaptation at irrigation scheme level

The adaptation of irrigation schemes infrastructure and management for more flexible and reliable delivery of agricultural water needs shall be encouraged in light of water scarcity arising from climate change (FAO, 2007). It will also be help in building resilience through farmers' enhanced access to ground water in their irrigation scheme. This shall be actuated through designs and constructions of micro irrigation schemes that promote utilisation of solar energy for pumping water from the ground. With more than 3000hrs of sunlight (Kachapulula-Mudenda et al., 2018), Zambia offers a greater opportunity for development of solar pump based irrigation interventions for climate change adaptation. Other options for adaptation in irrigation schemes include better water use and reducing water wastage. Strengthening Water Users Associations (WUAs) in irrigation schemes will also to some level aid in controlling water use and lessening of water wastage.

Solar powered irrigation

Solar powered irrigation system offers affordable technologies for smallscale farmers. For farmers with no water source, it can provide a cheaper access to underground water for irrigation. Solar powered irrigation system poses relative advantages. It provides a cleaner option to fossil fuels and causes establishment of low carbon emissions irrigation farming. For farms without reliable energy source, solar power may contribute to rural electrification and reduction in energy costs for irrigated agriculture.

Adaptation at watershed level

Increased frequency and intensity of extreme weather events will require adjustments in the storage capacity and management of dams and stream protection works. There will be a need to shift from drought emergency response to drought management plans that include prevention, preparedness, relief and rehabilitation and long-term measures to mitigate the impacts of droughts (FAO and NDMC, 2008). Integrated watershed management planning shall require all efforts of players in a particular watershed. Improved governance of land and water use will be required to accommodate the multiple uses of water, including for livestock and fish. At a local level, involvement of CACs, traditional leadership and other structures will be necessary.

Conclusions on Water management

Increased frequency in rainfall variability and resultant occurrence of extreme weather events such as floods and droughts shall have severe impacts on all aspects of agricultural development. Adaptation and mitigation efforts will be executed with special considerations for water sensitivity to climate change.

Module 5: AGROFORESTRY MANAGEMENT

Introduction

Afro – forestry is the integration of trees and/or shrubs with other crops and/or animals in farming systems in order to sustain production for increased social, economic and environmental benefits for farmers at all levels. It involves the usage of plants that are rich in nitrogen or have the ability to fix nitrogen in the soil and have the ability to produce large quantity of vegetation, known as biomass. Growing of trees require very little from the farmer i.e. costs for seed and labour and produces good organic matter just where it is needed. Planting of trees and shrubs on farm landscapes is gaining momentum especially with high deforestation rates. Trees and shrubs provide us with many products and services on earth. Agroforestry trees and shrubs can be classified into the following broad themes:

- Trees for soil improvement (often termed as “fertilizer trees”)
- Trees for fodder
- Trees for fuel wood and building poles
- Trees for food (fruit trees) and medicine

Objectives:

- To help participants know how to set up and manage an agroforestry field/nursery
- To introduce the concept of agroforestry
- To help the participants understand know the different agroforestry practices
- To help participants understand the role of agroforestry in CSA

Agroforestry Nursery

Some general guidelines on the best site for nursery establishment (Kasisi Agricultural Training Centre, n.d.):

- It should be in a shade, preferably under a tree or a simple constructed shade from grass or palm leaves.
- Should be near a water source
- Should be protected from animals e.g. chickens, goats and cattle. This can be done by establishing a living fence around the nursery (e.g. live fence or Jatropha).

General Soil Preparation and Planting

- Thoroughly mix black soil, compost or animal manure and coarse sand in the ratio 3:1:1.
- Wet the mixture lightly the day before putting it into containers. Any kind of containers may be used, e.g. milk cartons, polythene sleeves or shake shake packs among others.
- The seeds should be planted by October. This is the best time for fast growing trees such as pawpaw, sesbania sesban or Leucaena. Slow growers such as pines, Mukwa and indigenous trees should be planted from July through September.
- Trees can either be planted from seed or cuttings.
- Seed or cuttings can either be planted directly into the desired stations during the rainy season or raised in a nursery 2-3 months before the onset of the rainy season.
- Raising seedlings in polythene sleeves or pots in a nursery increases the chances of survival when transplanted in the field for some specific seeds.
- Seeds should be planted to a depth of about 1 to 2 times the width of the seed. Plant about 1 to 2 seeds per pot and lightly water with a fine sprinkle.

Pretreatment

- Some seeds need pretreatment to increase chances of germination and speed up the germination process.
- Sesbania and Leucaena can be pretreated with hot water a day before planting. Basiacally bring water to boil, take the water off the fire and allow it to cool for one minute. You can then drop the seeds in the water. After about 2 minutes, pour out the hot water and pour on cool water and leave seed overnight; plant them the next morning.
- Another pretreatment method that works well with large seeds, for example Musangu or Mukwa, is to scratch each seed lightly on a rough surface (cement surface); then soak the seed overnight in water and plant them the next morning. If you have a nail cutter, it can be used instead of scratching the seed.
- Some seeds such as the Moringa, can simply be soaked in water overnight and planted the next morning.
- However, some seeds do not need pretreatment, e.g. Pawpaw, Pigeon pea, Tephrosia.

Transplanting

- The best time to transplant is when the rains are well established. This is usually around the middle of December.
- The planting site should well be prepared so that the trees will become well established during the rainy season.
- Put a little compost at the bottom of the planting hole.
- Weeds should be removed in the areas around the planting site of each tree, at least 50cm away from the site.
- Water before transplanting and make a small basin around the seedling to help retain rainwater.

Caring for the Seedlings

There are a number of agents that can destroy your seedlings and therefore seedlings should be protected against agents such as:

- **Livestock: -** Trees need to be protected from livestock for 2-3 years. Livestock e.g. cattle, goats and pigs, are normally left on free range during the dry season after the crops have been harvested. It is during this time when animals tend to eat leaves and even branches of the seedlings. The best way to protect seedlings is by making fences using thorny branches, sticks and poles.
- **Fire: -** Ensure that there is no dry grass near plants to fuel a fire. Making a fire break helps to protect trees against fire.
- **Termites: -** The best way to control termites is to use resistant species. The other method is the use of natural insecticides such as Tep hrosia vogelii (ububa) and ash. You can sprinkle any of these natural remedies around the tree.
- **Wind: -** Young trees should be protected against strong winds. A wind break or hedge is effective against wind. Sticks can also be used to support weak seedlings.

Classification of Agroforestry Practices

1. Trees for Soil Fertility (Fertilizer trees)

Fertilizer trees are based on three basic principles in which they improve soil fertility and these include:

- Biological nitrogen fixation
- Biomass production and
- Nutrient recycling

The following are some of the benefits of planting fertilizer trees:

- Soil fertility improvement (nitrogen and other plant nutrients are increased).
- Increase in organic matter
- Soil structure, aeration and water holding capacity improvement
- Prevention of soil erosion
- Weeds suppression

Below are excellent fertilizer tree practices that would work well in Zambia:

a. Inter-cropping with Faidherbia albida (Musangu)

Remember that you should raise Faidherbia albida seedlings on a raised rack. The raised rack ensures that the roots are air pruned naturally. Faidherdia seedlings are raised this way because its roots are very sensitive to physical disturbances. When disturbed, the tree does not grow as expected.

Spacing

When establishing the Faidherbia albida field, space the seedlings at 10 by 10 meters. When mature, a lima will require about 25 – 30 trees to supply an equivalent of 300kg (6 bags) of complete fertilizer and 250kg (5 bags) of lime annually.

b. Inter-cropping with Gliricidia sepium

Spacing

When establishing the Gliricidia sepium seedlings in the field, space the seedlings at 1.8 meters (between rows) by 1 meter (within rows). This system works well with planting basins. Normally the trees should supply the leaves for fertilizing crops in the planting basins. You can harvest the tree leaves 3-4 times during the rainy season. The harvested leaves are normally put into the planting basin. The leaves should only be harvested after one season from establishment. The trees should be cut back to 30cm.

c. **Improved Fallows**

Fallowing is the practice of leaving cropped fields to lie idle in order to allow the soil to rest and recover some of its fertility. There are generally two types of fallow:

i. The classic bush fallow (traditional fallow) with a fallow period ranging from 10-20 years.
ii. The improved fallow in which nitrogen fixing trees are deliberately planted on the fallow field to shorten the fallow period to about 1-3 years.

Some recommended nitrogen fixing tree species for improved fallow system include: Sesbania sesban, Tephrosia vogelii, Gliricidia sepium.

Trees for Fodder

- Fodder banks are reserves (or banks) of trees, shrubs, pasture legumes or grasses intensively grown for fodder.
- The fodder bank field should be fenced to allow controlled grazing or exclude animals so that the fodder can be cut and carried to animals.
- For fodder trees and shrubs, the leaves can be conserved by drying them in the shade and packing them in bags.
- Trees in the fodder banks can be cut back 3-4 times during the rainy season. This may then be fed to animals during the long dry season or in drought periods.
- During the dry season, grass, the main fodder is scarce and of poor quality. Its protein, vitamin and mineral content are very low.
- As grass matures, it becomes more fibrous, loses much of its protein and becomes less digestible. This makes it difficult to keep the animals healthy during the dry season.
- Quite reverse, tree fodder maintains its protein content when dry and it is digestible throughout the year.
- The recommended spacing for the fodder bank field is 50cm by 50cm.
- Besides fodder from the leaves, pods from trees such as Musangu are very important sources of protein for livestock feed in Zambia.
- Protection, conservation and planting of these indigenous tree species is vital.

1. **Trees for fuel wood and building poles**

Permanent or traditional woodlots help solve firewood and building pole problems. Excellent species for woodlots are Senna siamea, Leacaena, Mululu and many more indigenous trees which could be protected to support the above products and services.

Spacing

- Establish woodlots at a spacing of 3m by 3m. Sienna is one of the best fuel wood tree species. It is fast growing and re-sprouts when cut back. **However**, for the sake of this manual, much interest for now and for the purposes of this project the following tress will be emphasized: **Gliricidia sepium, Pigeon pea,Tephrosia, Sesbania and *Faidherbia* *albida* (Musangu)**

Agroforestry species as green manure plants

Species used in Zambia includes: Pigeon pea, Tephrosia, Sesbania, Gliricidia and *Faidherbia albida* (Musangu)

Musangu is widely promoted due to its phenomenal characteristics of shedding its nitrogen-rich leaves in the rainy season. Musangu keeps its leaves in the dry season, when most other deciduous trees have shed off theirs and slowly starts to shed them off as the rainy season progresses such that by the time the crop grows there is no shading of light for the crop. Through leaf and pod fall, Nitrogen fixation and association with soil micro-organisms, fertility accumulation under mature Musangu tree canopy per hectare can be as follows: 75kg N; 27kg P_20_5; 183kg Ca0; 39kg MgO; 19kg K_20 and 20kg S. This is equivalent to 300kg of complete fertiliser and 250kg of Lime.

Figure 31: Musangu tree species (CFU 2007)

Field Establishment and Management of Gliricidia Sepium

Field Establishment

At the onset of rains, a week after planting the crops, you can mark stations for transplanting. Start at the beginning of the furrow (the valley between ridges) after the first ridge. Mark a space every 90 cm along every other furrow until the end. 90 cm can be measured by taking two normal walking steps.

Planting Pattern

Gliricidia sepium is planted at a spacing of 90*150 cm within the crop field (maize)

Figure 32: Field planted with Gliricidia sepium

Biomass incorporation systems

- Gliricidia sepium trees grow very fast in low land areas hence pruning in February might be necessary to minimize competition with maize plants for the above ground resources.
- Pruning will also encourage more branching. When pruning the trees, cut all vegetation and branches above 30cm
- In Conservation Agriculture (CA), it is advisable to incorporate on the planting stations

Biomass incorporation rules and schedules

- Prune all biomass above 30cm with a panga knife.
- Remove any woody biomass (though there should be minimal this time as the last pruning was recent).
- Place the leaves and tender branches on the sides of the ridges.
- First incorporation is done in October
- Second incorporation is done soon after germination
- Third incorporation is done in January or February

Field Establishment and Management of Sesbania Sesban

Field Establishment

At the onset of rains, a week after planting the crops, you can mark stations for transplanting. Start at the beginning of the furrow (the valley between ridges) after the first ridge. Mark a space every 90 cm along the furrow until the end. 90 cm can be measured by taking two normal walking steps.

Figure 333: Field for sesbania sesban

Planting Pattern

- Sesbania sesban produces little biomass when compared with Gliricidia
- Planting spacing is at 90*90cm in every furrow within the crop field

- Sesbania can be either established under Relay Intercrop or under 2 or 3 year Improved Furrows

Biomass incorporation systems

- Cut the *Sesbania* trees and prepare fields in October to November close to the rains.
- Cut at ground level leaving the trees and incorporate while the leaves are green
- Stems are collected for fuel wood and stakes.

Maize yield potential for Sesbania sesban.

- Maize yield improves from 1.1MT to 3.43MT or up to 5.36 MT under the control, 1year fallow (Relay Intercrop) and 2 year improved fallow per ha respectively.
  If the same field is under inorganic fertilizer average yield is 3.96 ton. In addition,
- *Sesbania* will provide 5ton, 10ton or 15 tons fuel wood from a 1 year, 2 year or 3 year *Sesbania* established at 1m X 1m.

Field Establishment and Management of Tephrosia

Field Establishment

- At the onset of rains, a week after planting the crops, plant your Tephrosia at a spacing of 75cm (25cm type of maize planting)
- Plant at 90cm in between maize plants
- Planting is done in every ridge.

Planting Tephrosia

- Tephrosia is planted at 75cm every ridge but can also be planted at 90cm.

Figure 35: Field planted with Tephrosia

Biomass incorporation systems

- Tephrosia incorporation is done once in a season (3 weeks before the first rains- November)

Figure 34: Biomass incorporation

Figure 37: Biomass incorporation

Maize yield potential in Tephrosia field

- Yield potential of about 2.8 metric tons of maize per Ha
- Produces wood of about 5-10 metric tons per Ha.
- Has potential of 100+ of nitrogen per ha

Field Establishment And Management Of *Faidherbia Albida*

Field Establishment

- At the onset of rains, a week after planting the crops, you can mark stations for transplanting. Start at the beginning of the furrow (the valley between ridges) after the first ridge. Mark a space at every 5m * 5 m when starting.

Musangu trees

Planting pattern

- FA can be planted at a spacing of 5m*5m at the early stage within the crop field (maize)
- After 5-10 years FA can be reduced to 10*10 m. Otherwise one may choose to plant at 10m x 10m from the word go.

Biomass incorporation systems

- Faidherbia is different from other species that we have just learnt. Naturally it loses its leaves during the crop season and regain after the season.

Maize yield potential in Faidherbia field

- Its yield potential is similar to Tephrosia.
- Fuel wood yield potential is higher than any other species mentioned

Table 16: Summary of planting and spacing

Species	Spacing	Number of trees/plants per Ha
Gliricidia sepium	90m x 150 cm	16, 666
Faidherbia albida	5m x 5m/10m x 10m	400
Tephrosia	75 x 75cm	33, 000 plants
Pigeon peas	75 x 75cm	33,000 plants

Exercise on Agroforestry

- What is agroforestry?
- What is the importance of practicing agroforestry?
- What is the importance of raising seedlings in an agroforestry nursery?
- When do you start nursery activities?
- List agro-forestry practices, recommended spacing for each practice and species to be used in each practice?

Module 6: LANDSCAPE APPROACHES

Introduction

A landscape approach deals with large-scale processes in an integrated and multidisciplinary manner, combining natural resource management with environmental and livelihood considerations. The landscape approach also factors in human activities and their institutions, viewing them as an integral part of the system rather than as external agents. This approach recognizes that the root causes of problems may not be site-specific and that a development agenda requires multi-stakeholder interventions to negotiate and implement actions (FAO, 2018). The Landscape approaches involve a multistakeholder process in achieving multiple economic, social and environmental objectives. It incorporates activities and processes that that recognises, reconciles and synergises the interests, attitudes and actions of multiple actors in a given environment.

Landscape approaches for climate smart agriculture

The main objective of landscape approaches is to find and promote synergies among activities that improve production systems. Enhance livelihoods, support the conservation of biodiversity and sustain ecosystem services. This ensures sustainability.

Some elements guiding landscape approaches for climate-smart agriculture interventions include:

- The integration of mechanisms for the governance of natural, semi-natural and agricultural ecosystems. It is based on optimizing synergies between multiple stakeholders and sectors in the landscape in terms of production, climate adaptation and mitigation.
- To enhance resilience to climate change, interventions applying a landscape approach should bring together agro-environmental and socio-economic governance issues that are of interest to multiple stakeholders.
- The dynamics and functions of agricultural ecosystems are at the heart of landscape approaches for climate-smart agriculture interventions. Consequently, activities need to be undertaken at multiple scales to encompass the entire agricultural ecosystem and follow a life cycle approach.
- Support governance and an enabling environment. In the field, and especially on small farms, this involves the design of packages of incentives for maintaining ecosystem services that can support small-scale producers' adoption of best practices and sustain climate-smart interventions.

Landscape approaches considers the fact that synergies should emphasize functionally sustainable landscape systems in which adaptation and mitigation are optimized.

Climates smart landscapes are multifunctional

- Landscape approaches provide an effective and efficient scale for the analysis and management practices to establish climate smart multifunctionality.
- Multifunctionality in landscapes is achieved by promoting synergies and reducing trade-offs across different land uses and objectives.
- Both additive synergies, in which the sum of parts constitutes the whole and super additie synergies, should be sought within landscapes to promote multifunctionality.
- Objectives guiding the identification of opportunities to achieve synergies should be clearly defined and understood, and ideally identified through collaborative multistakeholder processes.
- If synergies and landscape multifunctionality are not sought there is a risk that detrimental feedback cycles will be perpetuated and exacerbate the negative impacts of climate change.

Adapted from FAO, 2013

Landscape approaches in ZIFLP

- The goal of the proposed planning efforts is to use participatory integrated landscape approaches to determine the optimal mix and spatial configuration of land use options at the local level.
- Well-designed land use plans at the local level together with established land tenure rights could incentivize land management that has positive impacts on agriculture, energy, forests and woodlands, wildlife conservation, and on livelihoods in selected deforestation and forest degradation hot spots in the EP of Zambia.
- For the integrated landscape approach, it is important to include all wards in the land use planning from the Natural Resource Management (NRM) perspective.
- The project will promote the adoption of improved land and forest management practices, developed under a landscape approach. Such practices will serve two goals:
  - (a) Livelihood improvements for some of the poorest rural communities in Zambia; and
  - (b) A transition to lower-carbon practices, particularly in agriculture and forestry. This transition over the next 10 to 15 years is critical for the Eastern Province (EP) as a whole to be able to access the future emission reduction payments from the BioCF ISFL and also for Zambia to reach their NDC goals.
- Adopting a landscape approach means implementing a development strategy that is climate-smart, equitable, productive, and profitable at scale and strives for environmental, social, and economic impact.
- The ZIFLP's engagement of the private sector in landscape conservation is another key design feature that sets the ISFL apart from other climate and forest initiatives.
- For sustainability of the livelihood investments in the EP, the following will be important to consider:
  - (a) Improvements that will be support institutional, technical, regulatory, and implementation capacity of both national and provincial organizations, and the project's emphasis on a cross-sectoral landscape approach.
  - (b) At the local level, it is considered that the ZIFLP investments will only be successful to the degree that capacity is built locally in planning and resolution of land tenure.
  - (c) The project investments in these areas will have long-term value for targeted communities.

Module 7: FARMER FIELD SCHOOL FACILITATION

Introduction to the Farmer Field Schools

The agriculture sector identifies different challenges that need to be tackled such as enhancing the farmer's access to development of sustainable crop management practices and strengthening technology dissemination. Due to rising concerns on climate change, there is need to promote CSA in the country through enhanced extension service delivery. The recommended approach to enhance extension service delivery of CSA is through the Lead Farmer and the Farmer Field Schools. A farmer field school is a learning approach that is field oriented and participatory emphasizing on learning by doing. The training takes place over an extended period such as a growing season and involves classroom and field work. The training is holistic; it follows the farming systems adopted by participants. Farmer field schools (FFS) can also be defined as a Platform or "School without walls" for improving decision making capacity of farmers and stimulating local innovation for sustainable agriculture. Basis or purpose of FFS is to enable small-scale farmers investigate, and learn, for themselves the practices and skills required for, and benefits to be obtained from, adopting CSA practices in their fields.

The goal is to implement CSA activities in all the districts where the ZILFP project is operating using the FFS approach.

Learning Objectives:
Participants must be able to:

- Appreciate the importance of Lead farmer Approach
- Explain the basis of use and application of farmer field schools in conservation agriculture
- Identify and explain the fundamental elements of farmer field school
- Describe the principles of farmer field school
- Explain and follow the steps of introducing farmer field schools in the community
- Facilitate the learning process in a farmer field school
- Identify and use methods of disseminating results of conservation agriculture

The Lead Farmer (LF) Approach

The Lead Farmer Approach is a farmer-to-farmer-extension system where activities are carried out by a model Farmer. In the context of CSA, Lead Farmer is a farmer who is selected and trained on the basic knowledge and skills of CSA. He or she uses locally available resources (seeds, labour and hand-tools) within a walking distance from his or her place of dwelling to demonstrate to others following the seasonal cycle with support from the local extension officer. A Lead Farmer is expected to extend practical knowledge and skills of CSA to other farmers voluntarily using their own demonstration plot. The cycle consists of all processes involved in sustainable agriculture which includes: site selection, land preparation, planting, weeding, harvesting and storage. The lead farmer approach works with groups of 15 to 25 smallholder farmers. The Lead farmer approach is an effective way of Agricultural Technology Dissemination (JICA, 2018).

Roles and Activities of a Lead Farmer

A Lead farmer is trained in a particular community and will have specific roles and responsibilities. These roles and responsibilities are linked to the knowledge and skills on basic knowledge on CSA and the experiences gained from conducting the farmer-to-farmer-extension activities. Since a Lead farmer is expected to become an agent-for-change, demonstrating technical and technology innovation his or her roles must be clearly defined. The following are some of the roles and activities of a lead farmer:

- Management of the Demonstration Plot; The first requirement for a lead farmer is to establish a demonstration plot for demonstration to other farmers, progressively validating and improving his skills and knowledge acquired at the first training while working with guidance from the extension officer.

- A lead farmer must practice new technologies on own field which becomes the learning center for other farmers.
- Train follower farmers in new technologies and agricultural development
- Take up new innovations as quickly as possible
- Awareness Campaign; By using demonstration plot, the LF can raise awareness on all aspects of sustainable production.
- Hosting and organization of Field Days. Field-day is an event when and where the LF can call members of the community to witness an event or series of events the LF believes can help promote CSA.
- Record keeping and Reporting
- Organization of Farmer Meetings

Selection criteria of a Lead farmer

Before selecting a model LF, it is important to assess the interest and availability of arable land. The following are the selection criteria of a lead farmer:

- Lead farmers should be chosen by CAC/CEO in a particular zone/camp
- At least 45 lead farmers are chosen /camp and 10 Participating farmers per LF
- Farmer who has dignity and stewardship qualities
- Farmer who has enough cultivable land and is able to spare at least a 20m x70m of land to establish a farmer field school and/or carry out demos.
- Farmer who is not involved in any CA activities with other partners
- Currently involved in either food or cash crop production
- Permanently domiciled in that area
- Farmer who is acceptable and can mentor other for effective adoption of new agricultural technologies
- Farmer with basic literacy and numeracy skills, including skills to communicate and listen.
- Farmer who is a member of the community, both culturally and physically, with long-term residence in the community and has been recommended by the community from the area.
- Farmer who has demonstrated keen interest and has the desire and determination to practice CSA practices and share his knowledge and skills with others.
- Farmer must be self-motivated to demonstrate and share his knowledge and skills.
- Farmer must demonstrate some competence in basic technical knowledge and skills on the commodity of interest or have willingness to learn.
- Farmer must command some level of influence and leadership role in the community.
- Farmer must be able to lead by example in applying the Knowledge, skills and improved technologies on CSA.
- During lead farmer selection, gender issues should strongly be considered, and under this project, a recommendation of at least 30% of lead farmers should be women.

Pitfalls of the Lead Farmer (LF) Approach

It is important that the right Lead farmer is properly chosen right from the start in order to ensure that technology is transferred smoothly to the community. Therefore, it is important to look out for the following pitfalls and avoid them in order to ensure an effective lead farmer approach.

- Farmer acceptability by fellow farmer and the community in general. Selecting individuals not recommended by the community.
- Fall-out of follower farmers as a result of perceived benefits only being received by lead farmers.
- High expectations from lead farmers.

- Difficulties in keeping lead farmers for their role
- Low commitment by lead farmers to perform their function
- No control on lead farmers after the project (sustainability)
- Relocation of the lead farmer. Selecting a candidate who is not a permanent member of the community.
- Selecting individuals that have hidden motives such as self-recognition within the community or for political reasons
- Selecting a candidate as a special treat or return of a favor without seriously considering his or her ability and role as a rice grower or farmer
- Selecting a socially and mentally unstable person who may be a liability than an asset for the community.

Advantages of the Lead Farmer (LF) Approach

The Lead Farmer approach if managed properly offers several advantages in disseminating CSA extension messages and technologies. The following are the advantages offered by the lead farmer approach:

- Increased extension coverage
- Increased adoption of technologies
- Sustainability- increased ownership
- Less costly – lead farmer provides the opportunity to reach more farmers at lower cost
- Farmer Capacity building
- Feedback from farmers facilitated

Guidelines for management of Lead Farmer Demonstrations

- The objective of the demonstration
- Selection of the technology
- Selection of site and beneficiary
- Size of demonstration plot
- Planning of demonstration
- Implementation
- Monitoring
- Reporting and documentation

Farmer field school Approach

- A farmer field school is a learning approach that is field oriented and participatory emphasizing on learning by doing. The training takes place over an extended period such as a growing season and involves classroom and field work. The training is holistic; it follows the farming systems adopted by participants. Farmer field schools (FFS) can also be defined as a Platform or "School without walls" for improving decision making capacity of farmers and stimulating local innovation for sustainable agriculture.
- FFS is a forum where farmers and trainers meet and debate field observations; apply their previous experiences and present new information from outside the community.
- Basis or purpose of FFS is to enable small-scale farmers investigate, and learn, for themselves the practices and skills required for, and benefits to be obtained from, adopting CSA practices in their fields.

Objectives of Farmer Field Schools

General Objective:

- To bring farmers together to carry out collective and collaborative inquiry with the purpose of initiating actions in solving common problems

Specific Objectives:

- To empower farmers with knowledge and skills necessary for making their farming productive, profitable and sustainable.
- To increase the expertise of farmers to make informed decisions on what works best for them, based on their own experiences and observations in their Field schools.
- Help farmers learn how to organize themselves and their communities

Principles of Farmer Field Schools

FFS put emphasis on growing crops or raising livestock with the least disruption on the agro-ecosystem. The training methodology is based on learning by doing, through discovery, comparison and a non-hierarchical relationship among the learners and trainers and is carried out in the field**.** The major principles within the FFS process are:

- Grow a healthy crop
- Observe fields regularly
- Conserve natural enemies of crop pests
- Farmers understand ecology and become experts in their own field

Elements of a Farmer Field School

Group: A group of 15-25 people with a common interest form the core of the farmer field school

Field: The field is the learning place. Farmer field schools consist of learning plots, in which the field is the teacher and the plants are the books. All learning is conducted in the field. The FFS group learn by recording, reading and discussing the condition of the plants in the field.Working in small subgroups farmers collect data in the field, analyse the data, and make action decisions based on the analysis and make presentation to the whole farmer's group. The field conditions provide lessons to the participants

Extension Officers (EO): Each farmer field school needs a technically competent facilitator to lead and guide members through the hands-on exercises and to support their learning process. The extension worker takes the role of a facilitator rather than a conventional teacher. Once farmers have become more knowledgeable about the things they wanted to learn, the EO takes a back seat role, only offering help and guidance when asked to do so.

Farmers as experts: Recognise and appreciate farmers' wealth of experiences and knowledge. Farmers carry out themselves various activities related to issues or practices they have identified and want to study and learn e.g. establishment and management of "Musangu" nursery or ripping and direct seeding. Farmer training is based on field studies, conducted by farmers themselves and not extension staff or researchers. Consequently farmers become experts on the particular practice or technology they are studying.

Curriculum: The farmer field school curriculum follows the natural cycle of its subject, be it crop or animal. This approach allows all aspects of the subject to be covered, in parallel with what is happening in the farmer field school plots: crop husbandry, animal husbandry, horticulture, agroforestry, land husbandry's are considered together with environment, economics, health, sociology and education to form a holistic approach.

Leadership: Running a successful FFS programme requires presence of a good programme leader who can support the training of facilitators, get materials organised for the field, and solve problems in participatory manner and provide field-staff with support and feedback.

Regular group meetings: Farmers meet at agreed regular intervals. For annual crops such meetings may be every 1 or 2 weeks during the cropping season. For other farm/forestry management practices the time between each meeting would depend on: what specific activities need to be done, or be related to critical periods of the year when there are key issues to observe and discuss in the field.

STEPS IN ESTABLISHING FARMER FIELD SCHOOLS

1. **Ground working**
    - First activity is sensitization of traditional leaders and other local stakeholders. This is done in order to create ownership of the FFS programme. Without the involvement of traditional leaders the chances of sustainability could be compromised.
    - Identify focus enterprises
    - Identify priority problems
    - Identify solutions to identified problems
    - Establish farmers' practices
    - Identify field school participants
    - Identify field school sites
2. **Training of Facilitators**
    - Commodities to be studied should be those with a comparative advantage and have high potential for improving farmers' livelihoods if correctly managed.
    - Would-be facilitators are also trained to understand the Agro Eco-System. This enables them to understand the environment in which farmers operate.
3. **Identifying Field School Participants**
    - Only willing farmers should be allowed to be participants of the FFS.
    - Facilitator should make it clear from the outset that joining a FFS is voluntary
    - Only those who believe that they could improve their livelihoods by embarking on particular commodities through proper implementation of knowledge gained from the FFS should be members.
4. **Identification of Field School Sites**
    - FFS sites could be availed by the traditional leader, village headman, a farmer field school member or a lead farmer.
    - Before the field school plot is demarcated and utilised, the facilitator should ensure that the location and soil type are suitable.
    - It is useful at times to get a brief back ground of the plot.

5. **Running a farmer field school**
    - The running of a FFS starts immediately after the site has been identified.
    - The facilitator will have to explain WHY the site was selected and HOW suitable it is for the commodity of study.
    - The group meets regularly throughout the season.
    - How regular the sessions will be held depends on the enterprise being studied.
    - If the field school is a lead farmer's production field, members should agree with the lead farmer on meeting dates.
    - Implement Participatory Technology Development (PTDs - Test and Validate)
    - Conduct AESA and Morphology and collect data
    - Process and present the data
    - Group dynamics
    - Special topics
6. **Field Observation and Agro Eco-System Analysis (AESA)**

Apart for the general management practices such as weeding or fertilizer application which can be done by all field school members at the same time, field observations of the commodity also known as Agro Eco-system Analysis is the cornerstone of the FFS methodology. This is the establishment by observation of the interaction between crops/livestock and other biotic factors coexisting in the crop/livestock field. The farmers work in sub-groups of 4 to 6 under the guidance of a trained facilitator to enhance the participatory learning process by going through the following stages:

Stage One-Field observation

During this stage, the small groups learn to sample the crop, livestock or fish and carry out their structured observations of their crop/livestock/fish. Growth stage, beneficial or pest insect abundance, diseases, nutrient deficiencies and any other factors that have a bearing on crop/livestock/fish performance are all recorded or noted in the field observation. The facilitator's role is to move from one small group to the other assisting in recognition and identification of what the farmers observe, asking questions and making observations. The facilitator should encourage the small group members to as WHAT (they are observing), HOW (it affects the commodity of study) by answering question by question. For a example, a farmer comes across an insect in the field and facilitator's asking would be like: what do you think it is? Where did you find it? What was it doing? How many where they? Have you seen it before? What is it called in the local language?

Step Two: Detailing Field Observation

During this stage, field observations are detailed on a presentation sized sheet of paper to reinforce field observations and create a record of field activities. Each group prepares their presentations with a summary of data, pictures of the field situation, and decisions from the group as to the interventions required in the field. The following table shows an example of a FFS observation checklist. A simple notebook could be ideal for in a village setup.

Example of FFS observation checklist

Field School Observation Checklist			
Problems Observed	How It Affects Commodity	Action Taken/To be Taken	Lessons Learnt
1.			
2.			
3.			
Other Field Observations			
1.			
2.			
3.			
Picture for Remembrance			

Stage Three: Presentation of results

The small groups of 4-6 now come together to constitute a complete FFS class and could sit in a suitable place such as a nearby shady tree or meeting place. During this stage, each group presents their results and conclusions back to the full FFS. This presentation by participants strengthens presentation skills and requires group to defend their decisions with ecological arguments. It is important at this stage to emphasize that no superstition is entertained during the discussions.

Stage Four: Synthesizing presentations

During this stage, results from the discussion are summarized and put together for collective implementation of the decisions arrived at. The facilitator's role is to guide the farmers harmonize the different decisions from different sub-groups. Farmer's own experience is incorporated in all stages of the analysis. This is done throughout the season as the problems and decisions being studied overlap with similar issues in participant's fields. The AESA can take up to 2 hours, but should not go beyond 3 hours. Experience has shown that going beyond 3 hours discourages FFS members from regular participation due to the time demand for their other livelihood activities, and this can lead to a gradual fall in the number of FFS participants.

7. Special topics to be addressed at every stage of training

Facilitators are encouraged to conduct special topics during the implementation of the FFS. These topics arise from the field, for example the observation could lead to a discussion topic such as the importance of cereal/legume rotations, or the use of natural enemies to manage aphids or the application of inoculants to improve soybean yield. Another example would be scattering of planting sunflower to establish whether planting times have any effect on oil content and weight. Identified technologies to be implemented also largely depend on identified problems.

8. Role of Subject Matter Specialist (SMS)

There are times when the farmer study group encounters a difficult or new situation and when answers are not easy to get. Sometimes the topic may be too technical to understand or explain. The farmers and the facilitator must not hesitate to seek the services of an external technical person who is a specialist in the subject. The facilitator takes the responsibility to invite and coordinate with the SMS to the next meeting. The role of the SMS in a FFS is that of providing backstopping support to the FFS. The SMS should be guided by the facilitator to work in a consultative manner with farmers. Instead of lecturing farmers and giving instructions and detailed scientific jargon, the SMS must project their role as being one of a colleague or advisor who can be consulted for advice on solving specific problems, and who can serve as a source of new ideas and information on locally unknown technologies.

A typical Farmer Field School Day is divided into:

I. **Opening prayer** (2 minutes)
II. **Roll call** – To check who is present and who is absent (3 minutes)
III. **Review of previous activities** – to remind participants of what was done in the last session (5 minutes)
IV. **Briefing on day's activities** – to brief all participants of the day's activities (5 minutes)
V. **Field observations** (30 minutes)
VI. **Presentation** to larger groups by sub groups for decision making (30 minutes)
VII. **Group dynamic activity** in small or large groups – for group building purpose so they see the value of working together (10 minutes)
VIII. **Special topic activities** – An important topic presented by facilitator or subject matter specialist on a subject arising from the field. For example, safe use of pesticides (30 minutes)
IX. **Review of day's activities** – to make sure that the day's activity has well been understood by the participants (5 minutes)
X. **Planning for next session** – this is to ensure that little time is wasted in the next session and required resources for the next session are sourced well in advance (5 minutes)
XI. **Announcements** (2 minutes)
XII. **Roll call** – this is to compare the attendance before and after the session. It serves to understand the seriousness of the participants (3 minutes0
XIII. **Closing prayer** (2 minutes)

Total Time = 2hrs 12 minutes

Demonstrations, Experiments and field trials related to the selected

A farmer field school is a forum where farmers make regular field observations, relate their observations to the ecosystem, and apply their experience and any new information to make a crop or livestock management decision with the guidance of the facilitator. An FFS is not about technology, it is about people development; farmers "learn by doing". In the course of implementing farmer field school, there may arise need to study and compare different treatments using demonstration plots (for example use of soybean inoculants scattering planting dates for sunflower). In so doing, FFS members become experts on particular practice they are investigating. Facilitators of a farmer field school should clearly distinguish between a farmer field school and ordinary field demonstration plots.

Table 17: Comparison between FFS and conventional T&V (Train & Visit)

PARAMETER	**FARMER FIELD SCHOOL**	**CONVENTIONAL T & V**
Learning method	By doing, experimenting, participating, discovering	By listening (Element of experimenting and discovering still absent)
Training venue	Subject of learning (field, crop, animal etc.)	Training shade or tree
Duration	Complete study (Season long cycle)	One or two sessions
Extension Agent and their role	Trained expert. Spends most of their time assisting farmers convince themselves about a given technology	Jack of all trades. Spends most of their time trying to convince farmers
Farmer and his/her role	Participator, Contributor, Decision-maker. ***Assumption- farmer is a cup of tea full of knowledge but needs steering***.	Listener. Management decisions usually prescribed. ***Assumption- farmer is an empty cup of tea that needs to be filled***.
Qualification to participate	None discriminatory	Need to be able to write with some intensive programmes (Master farmer training)
Programme Planning	Done and agreed upon by/with farmers. Extension agent commits themselves	Office work. Extension commitment not guaranteed
Evaluation and adoption	Together with farmers. Adoption is the choice of the farmer	Office. Usually persuasion/force

9. Field Days

During the period of running the FFS, field days are organized where the rest of the farming community is invited to share what the group has learned in the FFS. Farmers themselves facilitate during this day.

10. Graduation

This marks the end of the season long FFS. The farmers, facilitators and the district coordinating office usually organize it. Farmers are awarded certificates at a usually colorful ceremony. It should be emphasized at this stage that the certificates they get are for successfully completing the course and not to go looking for employment.

11. Farmer – run Farmer Field Schools

FFS graduates are experts in the management of their studied commodities. They now have the knowledge and confidence to facilitate and help their fellow community members learn about the same commodities they mastered. The advantage of these graduates to the field extension worker is that they will help create and manage more field schools and thus allow the extension worker to concentrate on creating more field schools in other agricultural zones.

12. Follow up by Core facilitators

Occasionally the core facilitators (Ministry extension workers) will follow-up and backstop on-going farmer run field schools preferably on monthly basis.

Exercise – Field Observations: Conducting an Agro Ec0 – System Analysis (AESA)

Objective:

Participants should be able to exhibit confidence and good understanding of the AESA process in the farmer field school implementation.

Methodology:

- Carry out an observation/AESA exercise and report to the plenary for AESA synthesizing and decision making
- Facilitators should identify at least 2 different actuve crop fields
- Participants are divided into small groups of 4 to 6
- Participants select a group secretary
- Randomly select at least 3 portions of a field crop, each measuring 2m x 2m.
- Each group of farmers and/or acting as farmers will conduct field observations following the steps as described above.
- The trainers will assume the role of facilitators and will confront the participants with questions about the “WHAT”, “WHY” and “HOW” of their observations.
- Each small group of 4 to 6 will be given an opportunity to observe in each of the three different crop fields
- At the end of the observations each group will list their observations on flip chart paper and stick on the wall for everyone to observe and notice differences
- During plenary session, facilitators to ask participants how the observations exercise went. What were the main challenges? And how the challenges could be addressed.

Materials: Markers, Flip Chart paper, Wall Sticker, Small Note Books, pencils

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