KP08

Knowledge Product 08

CCARDESA

Centre for Coordination of Agricultural Research and Development for Southern Africa

DECISION TOOL: Climate Smart Land Preparation Options

CLIMATE SMART AGRICULTURE

KNOWLEDGE PRODUCTS FOR EXTENSION WORKERS

Customised Information Tools for Agricultural Professionals

Audience: Local Level Extension Staff (Government, NGO/Civil Society, Private Sector)

Maize | Sorghum | Decision Point | Gender | Youth | Climate Smart | Practice


Tilling, United Soybean Board

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

german cooperation
DEUTSCHE ZUSAMMENARBEIT

WHAT IS CLIMATE SMART AGRICULTURE (CSA)?

CSA comprises three interlinked pillars, which need to be addressed to achieve the overall goals of food security and sustainable development:

1. **Productivity:** Sustainably increase productivity and incomes from agriculture, without negative impacts on the environment
2. **Adaptation:** Reduce exposure of farmers to short- term risks, while building capacity to adapt and prosper in the face of shocks and longer-term stresses (resilience). Attention is given to protecting ecosystem services, maintaining productivity and our ability to adapt to climate changes
3. **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 unit of agricultural product (e.g., through decreasing use of fossil fuel, improving agricultural productivity and increasing vegetation cover).

CSA = Sustainable Agriculture + Resilience – Emissions.

How is CSA Different?

1. CSA places greater emphasis on **hazard and vulnerability assessments** and **emphasises weather forecasting** (short term) and **climate scenario modelling** (long term) in the decision-making process for new agricultural interventions
2. CSA promotes the **scaling up of approaches** that achieve **triple wins** (increase **production**, increase **resilience** and [if possible] **mitigate GHG emissions**), while at the same time **reducing poverty** and **enhancing ecosystem services**
3. CSA promotes a systematic approach to:
   a. Identifying **best bet** opportunities for agricultural investment
   b. Contextualising **best bet** options to make them **best fit** their specific context through learning and feedback loops
   c. Ensuring the **enabling environment** is in place so that farmers (and other stakeholders) can invest in CSA practices and technologies to catalyse adoption.

Key Messages:

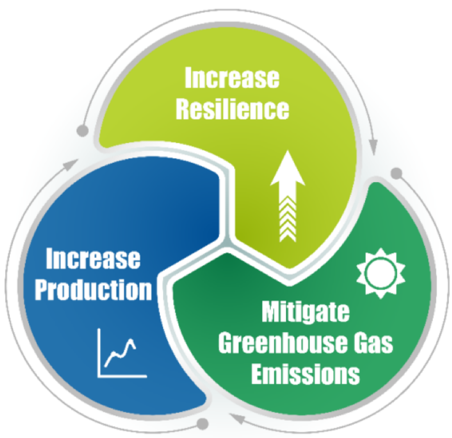
1. How land is prepared for planting can have a significant impact on soil health. Good soil is the foundation of climate smart farming

   Healthy Soil = Healthy and Productive Sorghum and Maize

2. To make climate smart decisions on how to improve your soil, you need to understand:
   a. The current status of the soil
   b. Trends in rainfall and temperature
   c. Farmers' priorities
3. Climate smart land preparation options include:
   a. Erosion control
   b. Reduced tillage
   c. No tillage.

Entry Points for CSA

- CSA practices and technologies
- CSA systems approaches
- Enabling environments for CSA.



CCARDESA

CLIMATE SMART LAND PREPARATION OPTIONS

This **Decision Tool** aims to help field level-extension staff make **climate smart decisions** on which land preparation option best suits their farmers' context. This tool is not designed as a technical guide to implementation. It is designed to assist extension staff in making climate smart decisions on improvements to their farming systems with their clients/farmers. Reference to technical guides relevant to the practices/technologies outlined are included at the end of the tool. The tool focuses on some of the **Best Bet Climate Smart Land Preparation Options** for maize and sorghum production in the Southern African Development Community (SADC) region.

They are listed in no particular order and have been selected as best bet for the following reasons:

- They are climate smart (see Table 1)
- They are applicable in multiple agro-ecological zones across the region
- They have high potential to address major constraints to maize and sorghum production in the region (Table 1).

These are best bet options. An understanding of the local context and farmers' priorities is required in order to make these options **Best Fit** to individual farmer's needs.

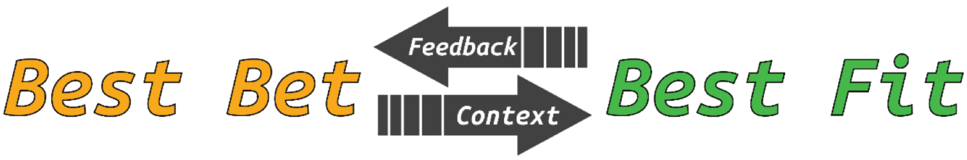


Table 1: Best Bet Climate Smart Land Preparation Options that have potential to address climate risks across the SADC region.

Climate Smart Land Preparation Option	What is it?	3 Pillars of CSA		
		Increase Production	Resilience/ Adaptation	Mitigate GHG Emissions if possible
Erosion Control	Physical and/or agronomic practices that reduce or eliminate the amount of soil lost due to wind and/or water erosion	Increased production due to improved nutrient availability and higher nutrient-use efficiency	Increased water infiltration can extend growing period, and mitigate short dry spells. Can reduce flood risk downstream	Depending on practices used, may lock more carbon into the soil
Reduced Till	Preparing small planting stations by hand and reusing these each year OR, if using traction, using shallow tillage equipment to prepare a seed-bed and not ploughing	Improved soil structure and increased microbial and invertebrate activity in the soil makes nutrients more available to plants	Increased water infiltration and soil biodiversity mitigates the effects of short-term dry spells	Locks more carbon in the soil. Reduced 'passes' in mechanised systems reduces the fuel inputs required
No Till	Using dibble sticks or jab planters to place seed/fertiliser in the soil by hand Using rippers to make shallow, narrow furrows in which to plant seeds	Improved soil structure and increased microbial and invertebrate activity in the soil makes nutrients more available to plants	Increased water infiltration and soil biodiversity mitigates the effects of short-term dry spells	Locks more carbon in the soil. Reduced 'passes' in mechanised systems reduces the fuel inputs required

WHICH CLIMATE SMART LAND PREPARATION OPTION IS BEST SUITED TO YOUR FARMER(S)?

To make **climate smart decisions** on the land preparation options best suited to your farmer(s), it is key to understand the local context:

- **Soil type and climatic conditions** – Rainfall/wind intensity and duration – should always be considered in the selection of any climate smart agronomic practice(s)

    - **Water** and **wind erosion** are major factors contributing to the loss of soil nutrients. Recent studies indicate that annual erosion losses in low-input production systems in Sub Saharan Africa (SSA) are about 10 kg nitrogen (N)/ha, 2 kg phosphorus (P)/ha and 6 kg potassium (K)/ha

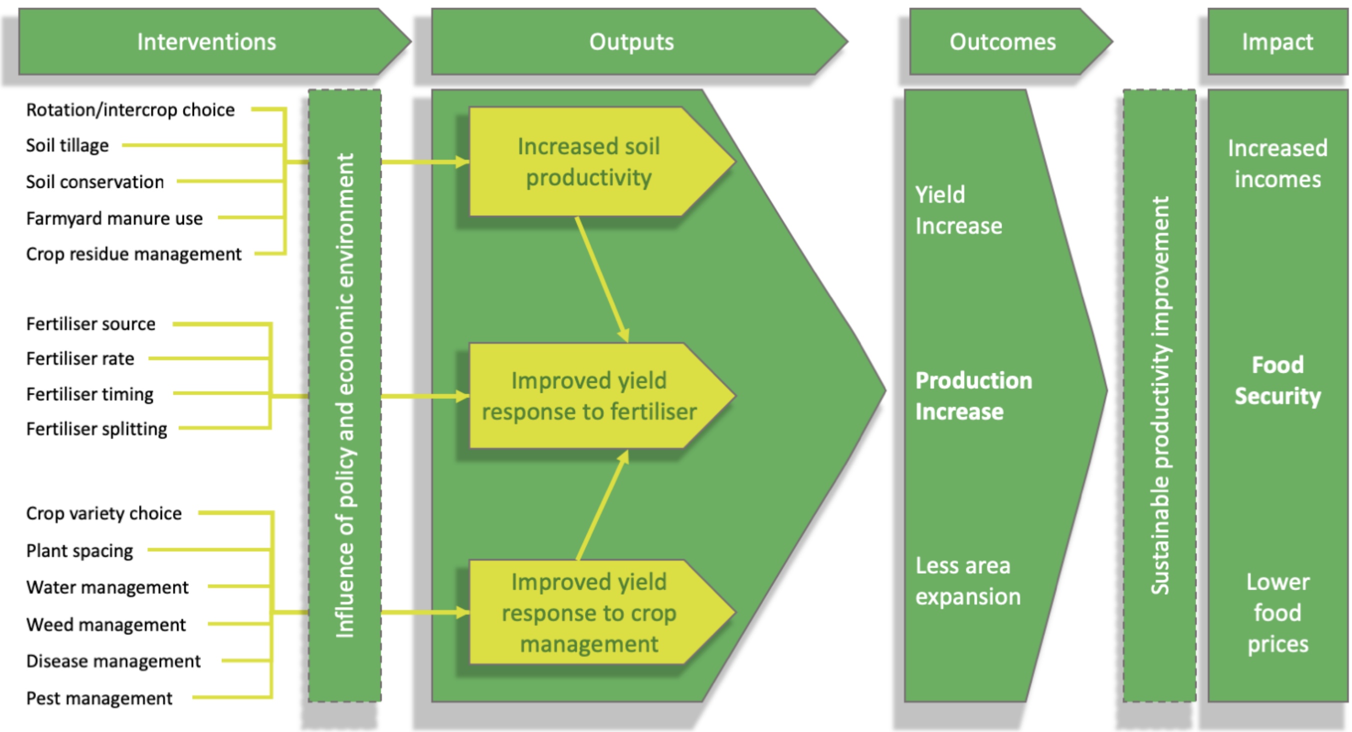
Losses may be greater in high-input systems, or where rainfall is very high[1]

- **Land preparation** is just one agronomic practice that can influence soil fertility. Integrated Soil Fertility Management (ISFM) should be practised to ensure climate smart and sustainable production. The concept of ISFM is outlined in Figure 1.

As shown in Figure 1 below, ISFM combines appropriate soil management, fertiliser use, and crop agronomy interventions to realise increased yield and productivity – depending to a significant extent upon market economics and government policy. Successful implementation of ISFM can see that productivity is increased, achieve a given level of production with less land, promote the sustainable improvement of food security, increase farm incomes, and lower food prices – with the benefits carried over to urban populations (ASHC, ISFM Handbook, 2012).

[1] *ASHC – Integrated Soil Fertility Management Handbook, 2012*

Figure 1: Overview of ISFM.



Source: ASHC, ISFM Handbook, 2012.

KNOW YOUR SOIL

Different land preparation methods are better suited to different soils (e.g., clay soils are more susceptible to compaction than sandy soils). Figures 2 and 3 illustrate some characteristics of healthy and poor soils.

Figure 2: A healthy top soil showing abundant earthworm activity. Earthworms are good indicators of soil biological activity and are almost completely absent from tilled soils.

Source: Patrick Wall, CIMMYT

Some questions to consider are:

- What is the **soil texture** (clay/silt/sand)?
- What is the **soil structure** – does it hold together well when placed in water?
- How much **organic matter** is in the soil?
- Is there a **hardpan** and if so, **how deep** is it?
- Is there a soil crust?

Figure 3: A field-test of aggregate stability. Small clods from a ploughed field (right) and virgin land (left) have been dropped carefully into water. The lighter coloured clods from the ploughed field disintegrate, while the clods from the virgin soil stay intact.

Source: Christian Thierfelder, CIMMYT

UNDERSTAND RAINFALL, WIND PATTERNS & FLOODING

The next step is to understand the local context in terms of rainfall, wind and the risk of flooding, as these affect soil erosion as well as crop growth:

- When is rain expected to fall, and with what intensity throughout the season?
- Is wind a problem at certain times of year?
  - For example, is it windy during the dry season when the land is not covered with crops and is being grazed by livestock?
- Is flooding to be considered as a risk at certain times of the year?

Work with your farmers to build a seasonal calendar that depicts the incidence of rainfall, wind and flooding. Farmer accounts should be cross-checked with actual data from the local weather station, where possible. If reliable data is not available locally, work with your farmers to record rainfall data – especially documenting dates on which it rained, duration and intensity.

If you have access to a rain gauge, this will be even more accurate. Access to an anemometer will enable accurate collection of wind data (direction and intensity). Over time, you will build up a picture of local trends.

Decisions on climate smart land preparation practices will also depend on:

- The slope of the land
- Labour availability
- The distribution of tasks among men and women
- The socio-economic status of the farmer.

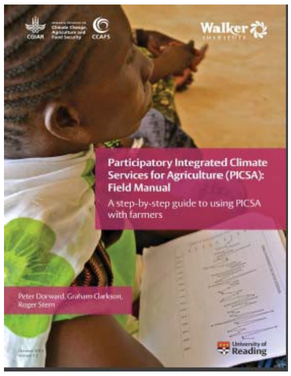


Figure 4: The PICSA tool is a useful guide for extension staff to help define probable rainfall.

UNDERSTAND THE FARMING SYSTEM AND SOCIO-ECONOMIC FACTORS

There are numerous variables that need to be considered when making climate smart decisions on land preparation options:

- The presence or absence of **livestock** in the farming system
- The **priority** within the household/farming system for crop production
  - Are crops produced more for social reasons, while most household income is obtained off the farm?
- The **planned use** of the maize/sorghum crop
  - Consumption, sale
- The **size of the farm**
- The **available labour**
  - Who does what and when during the crop calendar?
- The farmers' **physical and financial** access to inputs and markets
- Potential **yield** and **return on investment**
- The current **farming system** and system of **land preparation**.

Conventional Land Preparation

Conventional tillage involves cultivating the soil, using either a hand hoe or ox/tractor pulled tools such as ploughs and harrows. In this process, the soil is physically loosened and broken down into a fine tilth. Usually the soil is turned over, surface layers are incorporated, and deeper layers of soil brought to the surface. Crop residues and weeds are buried. Most smallholder farmers in Africa practise conventional tillage, many using hand hoes. There is now broad consensus that conventional tillage systems cause a range of problems:

- Leaving **soil exposed** to rain, wind and sun, leading to soil losses
- **Destruction of soil organisms**
- **Soil compaction**, especially if using heavy tractors or draft animals
- Increased **water evaporation**
- In the **long-term, soil crusting**, which impedes rainfall infiltration, increases surface runoff, reduces groundwater recharge and development of a hardpan at the bottom of the ploughed or hoed layer, which reduces water infiltration and root penetration.

Making climate smart decisions on land preparation requires an understanding of soil, climatic conditions, topography (slope), as well as the individual farmer's socio-economic context in order to balance decision making.

DECISION POINT

Know Your Soil: Know your soil. Know wind/rainfall distributionand intensity.

Slope	<2%	2%–5%		>5%	
Labour Availability	Available and/or Constrained	Available	Constrained	Available	Constrained
Possible Climate Smart Soil Amendment Options	Min./No till Plant across slope	Pit/basin planting (reduced tillage) Contour ridges (stone/earth)	Trash lines, Mulching/cover crops, grass strips, agroforestry, minimum till, zero till, etc.	Terracing and minimum till	Minimum/ zero till with agroforestry, contour planting, trash lines, cover crops, etc.

BEST BET LAND PREPARATION OPTIONS FOR ADDRESSING CLIMATE RISKS IN MAIZE/SORGHUM PRODUCTION

Below are three climate smart land preparation options for sorghum/maize. They are listed in no particular order. All are broadly applicable across the SADC region. While these are best bet options, they are not universally applicable. CSA is context specific and each of these options will need to be tested under local conditions and adapted to make it **Best Fit** the local context.

EROSION CONTROL OPTIONS

This option is in fact a collection of climate smart practices that can be used on their own, or in combination to help prevent soil erosion.

Erosion can be controlled using physical and agronomic practices. Physical erosion control should ideally be planned at the catchment or micro-catchment level with all members of the community. Physical erosion control options are predominantly used on steeper slopes (>5%), but may also be relevant on slopes of 2%–5%. These options aim to reduce runoff through increased water infiltration into the soil. There are various types of infrastructure that can be used to impede runoff from catchments. This decision tool focuses solely on climate smart options that can be applied within the field , including the following:

- Terracing
- Contour ridges
- Tied ridges.

Physical erosion control is **labour intensive** and involves the movement of **large volumes of soil and/or rocks**. An understanding of the household context, in terms of labour availability and the value (social or economic) of the crop being grown, is required before making recommendations on physical erosion control.

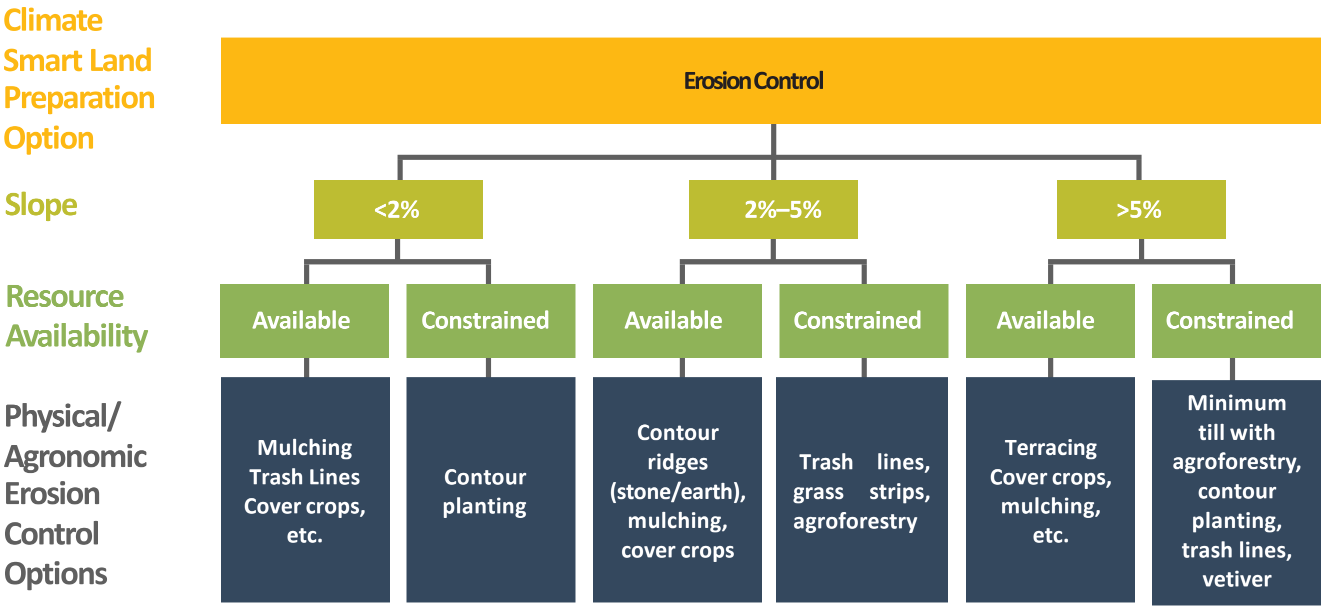
Climate smart **agronomic** erosion-control practices can be used on any slope, and should be used in conjunction with physical erosion control on steeper slopes. Agronomic practices that can be used during land preparation to reduce soil erosion include:

- **Planting grass** (such as vetiver), trees, or fodder crops on tied contour ridges or strips
- **Trash lines** of crop residues (or other plant residues) laid perpendicular to the slope
- Maintaining a **layer of mulch** on the soil throughout the year
  - If winds are strong they can blow away lighter plant residues. This can be combatted by cutting maize/sorghum about 30 cm above the ground and laying the residues between the upright stalks
  - Another alternative is to use ‘heavier’ mulch material that takes longer to decompose, such as *Tephrosia* or *Gliricidia sepium*
  - Mulch should always be laid perpendicular to the slope
- **Green manure/cover crops**
  - These can be for fodder or to increase soil biomass, or both depending on the farming system
    - »Use of legumes as a cover crop is recommended as this can have multiple co-benefits
  - Green manure/cover crops can be intercropped, relay cropped or rotated with the maize/sorghum crop (See KP 07 – Climate Smart Planting System Options)
- **Agroforestry** (see KP 12 – Climate Smart Agroforestry Options)
  - Planting and/or managing the regeneration of trees to help stabilise soils.

Making decisions on which erosion control option is best suited to your farmers is heavily influenced by the slope of the land and the availability of resources, especially labour.

Climate Smart Erosion Control measures are essentially components of **Integrated Soil Fertility Management (ISFM).** They can be used in conjunction with minimum tillage and zero tillage. Figure below illustrates the factors that might influence decisions on which physical or agronomic erosion control option might best suit a certain context.

DECISION POINT



MINIMUM TILL

Minimum tillage is the practice of disturbing the soil as little as possible during land preparation. in mechanised systems, this means using a 'one pass' system that prepares a shallow seedbed and plants the seed all in one operation. This minimises soil compaction and wind erosion, as well as reducing the amount of fossil fuels used. Most smallholder farmers do not have access to mechanised tillage equipment.

In most minimum tillage systems, planting stations are dug by hand. Alternatively, an ox or tractor pulled ripper is used to cut narrow furrows. The soil between the narrow furrows (or planting holes) is left undisturbed. Even in the furrows the soil is not turned over as it is in conventional tillage. The seed is then planted along the ripped furrow. Plant residues are left on the surface of the soil to be naturally broken down and incorporated in the soil. To minimise soil disturbance, it is recommended to use the same planting stations each year, with nutrients (fertiliser and organic matter) applied directly to the planting stations – as opposed to being broadcast across the whole field or applied (banded) in rows (See KP 21 – Climate Smart Fertiliser Application Options).

This approach can reduce the amount of labour required in land preparation. This may, however, be offset by extra labour needed for weeding. Many practitioners think that a major disadvantage of minimum till is that far more effort is needed to control weeds during the growing season. One solution to this problem is to use herbicides, such as glyphosate, at planting time. Many farmers and extension workers believe that minimum till is only viable if farmers have access to appropriate herbicides. However, using herbicides brings additional challenges – the availability and cost of purchasing them and the equipment (sprayers) to apply them, and the knowledge about how to use them in a safe and effective way.

TIP

If using herbicides, always read the label and follow **ALL** safety instructions.

Weeds can also be controlled using a combination of climate smart practices that if used properly every year, can drastically reduce the amount of weed seeds in the soil.

- **Mulching** is one of the most effective means of controlling weeds
  - If a deep enough layer of mulch is applied to a field immediately after harvesting, it can almost completely cut off light penetration to the soil and stop weed growth. When weeds do appear through the mulch, they can easily be picked by hand before they go to seed
  - A significant amount of mulch is required to effectively manage weeds. In the first year of practicing minimum till it, may be advisable to start with a small area of the field that is heavily mulched. This area can be expanded year-on-year as more and more plant biomass becomes available from improved maize/sorghum crops
  - A study of female farmers in Malawi showed that practising minimum tillage and applying a thick layer of mulch material to maize and legume crops reduced women's labour inputs by over 30 days per year
  - If plant material has been infected by particular pests/diseases in the previous season, it may not be suitable for mulching and may have to be removed and burned or fed to livestock
  - There may be competing needs for plant residues such as fuel, fencing, fodder and mulching. Understanding the farmers' priorities will help you make climate smart decisions on how best to utilise plant residues
  - Some mulch material can 'lock' nitrogen in the soil, reducing its availability to plants. To avoid this issue, mulch should be applied immediately after harvest. This will ensure decomposition is well under way by time of planting, and that nitrogen will be available

TIP

Weed management in the short-term will pay off in the long-term.

One year's weeds = seven years' seeds!!

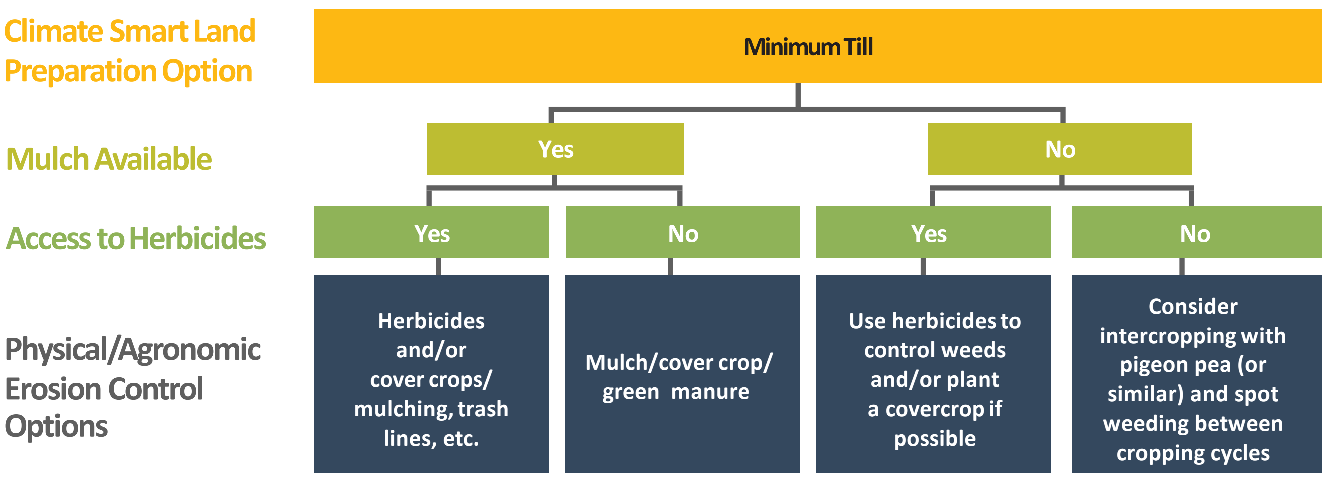
- **Cover crops/green manure**
  - These can perform the same function as mulch in controlling weeds, and have the added benefit of producing fodder for livestock and as food for the household and/or as a cash crop
  - Extra labour is required to manage these crops, and they may only be an option where there is enough residual moisture, rainfall or irrigation available.

Managing weeds using the above methods has been shown to be effective, but results vary and are not always observed in the first year.

The fiigure below illustrates possible decision pathways that might influence the choice of weed control options required if choosing minimum tillage as a climate smart land preparation option. It is important to consider both men's and women's roles in crop management, especially weeding, when making decisions on whether or not minimum tillage is a suitable climate smart option in your farmers' context.

If choosing minimum tillage, weeds may need to be controlled using other methods. Access and availability of mulch material and/or herbicides and labour availability are key influencers in the decision-making process.

DECISION POINT



Source: www.omafra.gov.on.ca

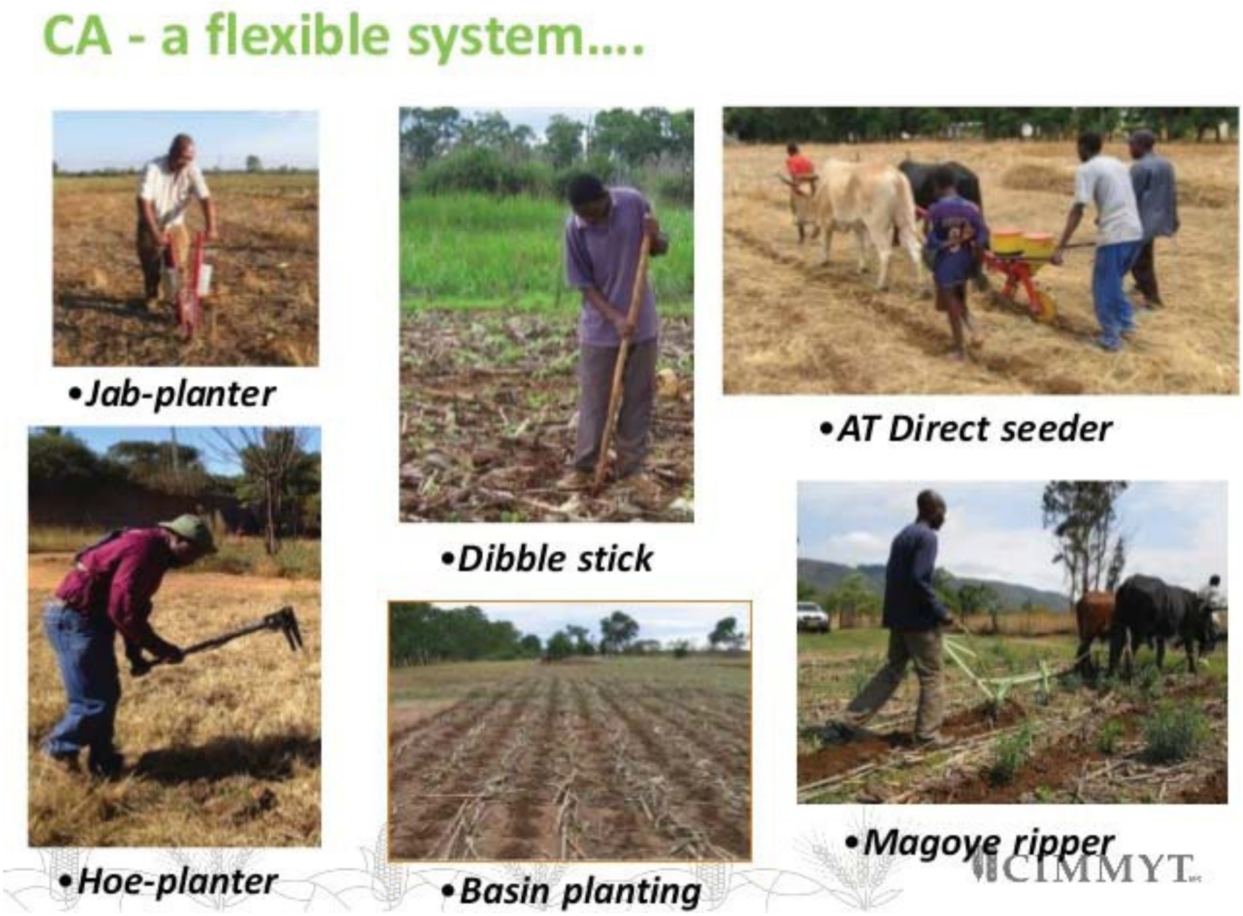
ZERO TILLAGE

Zero tillage is similar to minimum tillage; but in this practice, seeds are planted directly into the soil without any preparation of the seed bed (no planting stations are prepared). **Dibble sticks** or **jab planters** are used to manually sow seeds directly into the soil. This system further reduces labour requirements. It poses the same challenges as minimum tillage, and the same approaches can be taken to mitigating these issues. Figure 5 illustrates some of the different manual and mechanised minimum and zero tillage planting technologies available in the SADC region.

These technologies include the following:

- **Dibble sticks/jab planters** work best in loose, non-compacted soils. If ridges were used the previous season, it may be possible to sow directly into these (without any other cultivation) relatively easily
- **Zero tillage** is much harder to practise in hard ground
- **Jab planters** are not yet widespread in the SADC region and have not always performed well in trials.

Figure 5: Different planting technologies for minimum and zero tillage.



Source: CIMMYT

CCARDESA
german cooperation
DEUTSCHE ZUSAMMENARBEIT
giz

TESTING DIFFERENT OPTIONS

The benefits of erosion control, minimum tillage and zero tillage to soil structure and fertility are not disputed. However, there can be a lot of conflicting evidence on the benefits vs costs to the farmer. Promoters often focus on a single approach, or set of practices, and try to get all farmers to 'adopt' these. This rarely works as every farm is different.

It is vital that when selecting climate smart planting systems, different options (and combinations of options) are tested and evaluated so that farmers can choose for themselves the ones that work best in their context.

Tools for selecting the best options:

- If data is available at the start of the season, the predicted a**gronomic efficiency (AE)** can be calculated based on the expected increased returns and costs of extra inputs. This is done using a partial budget analysis (See the **ISFM Handbook,** ASHC)

- Developing a **cash flow and labour projections** record that fits with the seasonal calendar will also help farmers manage their resources more efficiently
    - It is vital that gender is assessed in relation to predicted labour requirements. Agronomic practices are often clearly divided between men and women (e.g., men do land preparation, women are responsible for weeding). As land preparation can have major effects on labour requirements throughout the crop lifecycle, it is vital to talk to both men and women and understand who does what and when. A reduction of labour for a group at a certain time of year might result in farmer uptake, even if yield responses are small

- Accurate data on inputs and labour should be collected throughout the year. This will enable analysis of agronomic efficiency after harvest. Farmers should be involved in the analysis of data and in decision making on the way forward

- The **Value:Cost Ratio (VCR)** is similar to **gross margins analysis**, but aims to compare the changes in costs and income when a farmer moves from current production practices to a new set of practices. It incorporates both agronomic (yield) and economic (price/cost) information. The VCR is calculated by estimating the value of additional production resulting from a change in practices (i.e., incremental output x market price) divided by the supplementary costs of moving to the new practice (costs of purchased inputs, additional labour use, etc.). The results of a VCR are interpreted as follows:
    - When **VCR = 1**, the farmer breaks even when moving to the new practices. Production may have increased, but there is no financial incentive for the farmer to adopt new practices
    - A **VCR between 1 and 2** implies that a farmer will earn some profit in making the change. The incentive for change is usually too small to stimulate adoption
    - A **VCR >2** has traditionally been the minimum acceptable VCR for introducing new practices or technologies
    - A **VCR ratio ≥2 provides a buffer**, offering farmers some protection against risks such as unfavourable weather conditions or pest attacks. In addition, farmers will initially achieve smaller yield responses than those obtained in research and demonstration trials that tend to be the sources of yield response data used to estimate the VCR ratio. It is important not to create expectations among farmers of responses that are unlikely to be attained on their plots, at least in the short term.

TIP

If possible, estimate the potential of the climate smart land preparation options in comparison to existing practices. **ALWAYS** collect accurate data on inputs (including men's and women's labour), as well as weather and pest/disease outbreaks, etc., and discuss the gross margins based on all this data. Then **FACILITATE** farmers to make decisions on the way forward for the next cropping cycle.

KP08

TO SUMMARISE

STEP 1: Know Your Soil and Climate

- Texture/fertility
- Slope
- Hardpans/crust?
- Intensity/duration of rain, wind and flooding

STEP 2: Consider the Farmers' Context

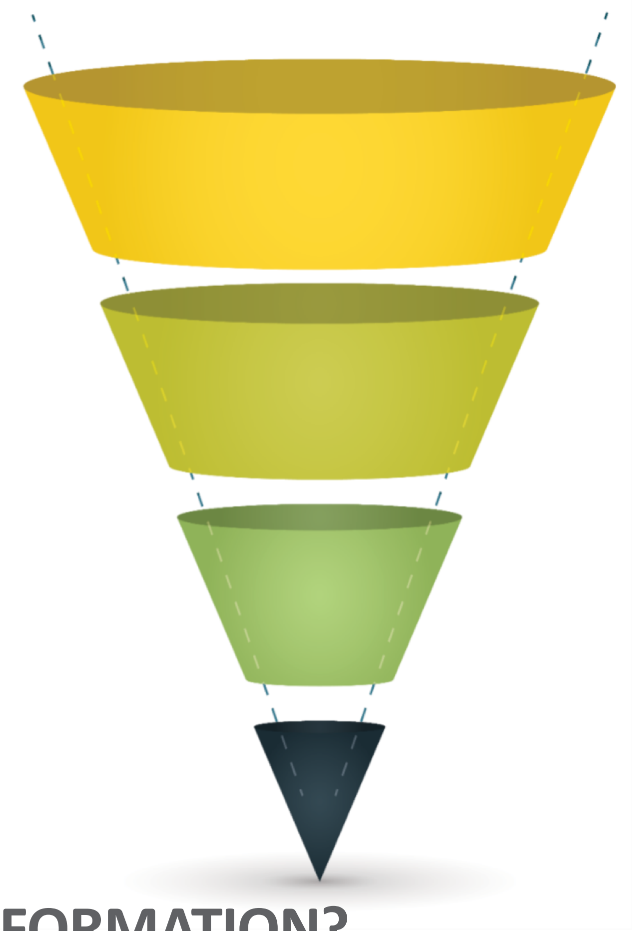
- Farmers' priorities
- Labour availability (male & female)
- The farming system
- Economic status
- Land ownership, etc.

STEP 3: Climate Smart Land Preparation Option

- Assess external factors such as markets
- Propose an option or combination of options
- Estimate potential 'value' of returns if possible

STEP 4: Collect and Analyse Data

- Analyse data with farmers to make decisions for the next cropping season.



WHERE CAN I FIND MORE INFORMATION?

The following resources, which were used as reference for the development of this Knowledge Product, provide valuable additional reading on this subject. Please also refer to the CCARDESA website (www.ccardesa.org), the full series of Knowledge Products, and associated Technical Briefs.

- See also CCARDESA KPs **6, 7, 9, 10, 12, 16 & 19** for more detail on specific climate smart practices and technologies included within Integrated Soil Fertility Management
- **African Soil Health Consortium (ASHC)** – Handbook For Integrated Soil Fertility Management
  - An excellent resource that every extension officer should try to access
- **ASHC** – Sorghum and Millet Nutrient Management
  - A very practical resource for anyone growing sorghum or millet
- **ASHC** – Maize-Legume Cropping Systems
  - A practical guide to growing maize and legumes. Excellent resource foe extension staff in the field
- **ASHC** –Sorghum-Legume and Millet-Legume Cropping Systems
  - A practical guide to growing maize and legumes. Excellent resource foe extension staff in the field
- **International Center for Tropical Agriculture (CIAT)** – Impact of Conservation Agriculture on Soil Health
  - A very useful infographic/poster that relates to soil health in general, not just conservation agriculture
- **International Maize and Wheat Improvement Center (CIMMYT)** – Manual and Animal Traction Seeding Systems in Conservation Agriculture
  - Short, simple, practical guide to different seeding system options
- **CIMMYT** – The role and importance of residues
  - Great resource to help explain why residues are important
- **CIMMYT** – Common Weed Species and their Chemical Control in Conservation Agriculture (CA) Systems
  - Short, simple guide to using herbicides
- **FAO** – Soil Compaction Leaflet
  - Good explanation of how soil gets compacted and how you can assess this with your farmers.

Citation: CCARDESA and GIZ 2019. Knowledge Product 08: Climate Smart Land Preparation Options. CCARDESA Secretariat, Gaborone, Botswana.