KP07
Knowledge Product 07

CCARDESA
Centre for Coordination of Agricultural Research and Development for Southern Africa

DECISION TOOL:
Climate Smart Planting System Options for Maize & Sorghum

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


Sam Fentress, 2006

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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:** 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?

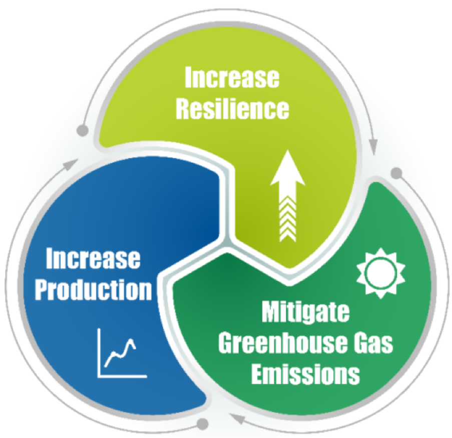
1. CSA places greater emphasis on **hazard and vulnerability assessments** and **emphasises weather forecasting** (short term) and **climate scenario modelling** (long term) in the decision-making process for new agricultural interventions
2. **CSA** promotes the **scaling up of approaches** that achieve **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. To make climate smart decisions on which climate smart planting system for maize/ sorghum best suits your farmers, you need to explore and analyse:
   - The farming system
   - The current status of the soil
   - Trends in rainfall and temperature
   - Trends in extreme events (droughts, floods, etc.)
   - Farmer priorities
   - Gender dynamics in the farming system
2. Climate smart planting system options include:
   - Intercropping
   - Relay cropping
   - Crop rotations
   - Diversification.

Entry Points for CSA

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



CLIMATE SMART PLANTING SYSTEM OPTIONS FOR MAIZE & SORGHUM

This **Decision Tool** aims to help field-level extension staff in making **climate smart decisions** on which planting system 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. References 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 Planting System Options** for Maize and Sorghum production in the Southern African Development Community (SADC) region.

These are just some of the many options available. 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 farmer priorities is required in order to make these options **Best Fit** to individual farmer's needs.

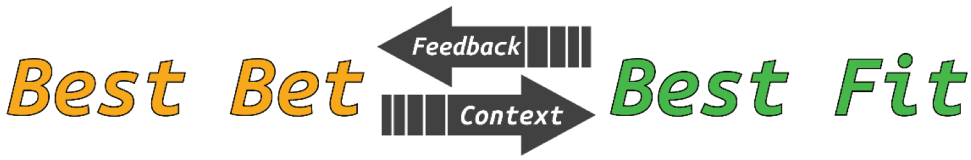


Table 1: Best Bet Climate Smart planting system options that have potential to address climate risks across the SADC region.

Climate Smart Planting System Option	What is it?	3 Pillars of CSA		
		Increase production	Resilience/ adaptation	Mitigate GHG emissions if possible
Intercropping/ cover-cropping	The planting of another crop (usually a legume) within or between rows of maize/sorghum in the same field	Higher levels of production from the same area of land	Reduces losses due to pests and diseases, and can mitigate losses due to drought as they increase organic matter – with increased water holding capacity – and stimulated bacterial growth	Helps lock more carbon in the soil and plants
Relay cropping	Planting a follow-on crop before the sorghum/maize has been harvested/ removed	More efficient use of available resources Increased yield from the same field	If legume–maize/sorghum relays are employed, the risk of crop loss is reduced and dietary diversity is enhanced	Helps lock more carbon in the soil
Crop rotations	Alternating a fixed number and type of crops on the same field in different seasons. Rotations are usually of 2-4 different crops, and may include a fallow period	Breaks pest and disease cycles Returns nutrients to the soil	More predictable yields from each crop, and a reduced risk of crop loss	Helps to lock more carbon into the soil if fallow/cover crops/green manure is included Can reduce fertiliser requirements
Diversification	Diversifying the number of crops in a rotation and/or the number of cultivars of maize/sorghum in a field	Increased yields of rotated crops due to lower incidence of pests/ diseases	Help reduce exposure to pests/diseases and drought/heat stresses and market fluctuations, by having greater diversity	Potential to lock more carbon into the soil, especially if fallow periods or cover crops are incorporated

WHICH CLIMATE SMART PLANTING SYSTEM OPTION IS BEST SUITED FOR YOUR FARMER(S)?

To make **climate smart decisions** on the planting system best suited to your farmer(s), it is key to understand the local context, including the following:

A. The local soil conditions

B. Required and predicted rainfall

C. Pests and diseases prevalent in the area.

A. Know your soil

Different crops and combinations of crops are better suited to different soils. Understanding existing **soil conditions**, which **crops** are suited to these, and what might be done to **improve** them is key to selecting the most appropriate and climate smart cropping system for your situation.

Legumes are the most frequently used crops in **rotations** and intercropping systems. This is primarily due to their **nitrogen fixing** ability, but they are not the only crops that can be used. There is a wide range of other crops that can be used, depending on soil conditions. The following crops are suited to rotations or intercropping in low fertility soils: pigeon pea, calapo, jack bean, sword bean, butterfly pea, *Desmodium*, *Leucaena*, birdsfoot trefoil, yellow lupin, black mucuna, hairy vetch, cowpea, Italian ryegrass, and rye.

Apart from making nitrogen more available in the soil, the decision on which crop to introduce in a rotation/intercropping system might be influenced by the following soil characteristics:

- Erosion potential (wind or rain) – Cover crops can reduce erosion
- Organic matter content – If the soil is deficient in organic matter, a crop that produces a high volume of biomass might be suitable
- Moisture retention capacity – Will there be enough moisture in the soil to sustain a cover crop, or can a drought-tolerant crop be selected?
- Hardpan formation – Select a crop with a deep tap root that will break the hardpan
- pH – Is this a limiting factor on crop choice?

See KP06 – Climate Smart Soil Amendments for the recommended soil types for maize and sorghum, and for climate smart soil amendment options.

B. Required and predicted rainfall distribution

Knowing crop water requirements and matching these to predicted rainfall and temperatures is critical in selecting appropriate crops for rotations/intercrops. The next step is to understand the local context in terms of rainfall and temperature ranges, and extreme events:

- Do your farmers think that there will be enough rain in the next season?
- How likely is the rain to come during the critical growth stages?
- What are the probable temperature ranges during each crop's growing season (day and night)?
- What is the likelihood of an extreme event such as drought, cyclone and/or flooding?
- What information sources are farmers using to make these assumptions on rainfall and temperature?

The Participatory Integrated Climate Services for Agriculture (PICSA) field manual is an excellent resource to help you work with your farmers to estimate the probability of certain levels of rainfall in your area over the coming season, using the most locally available data. PICSA helps you in supporting farmers to make more informed decisions based on accurate, location-specific climate and weather information as well as crop, livestock and livelihood options. Your local **Met Office and Disaster Management Office** should be able to provide you with some basic information that can help your farmers make more informed, and climate smart decisions. In any case, ask farmers about their past observations on rainfall, seasons, access to water, and extreme events. You can consider collecting, with your farmers, 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. Over time, you can build up a picture of the trends locally. This will help you and your farmers in making climate smart decisions, and reducing risks in hazardous situations.

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C. Know pest and disease prevalence in your area

There are many types of insects, weeds, diseases and other pests that can affect maize and sorghum, and identifying them is not always easy. It is important to know exactly what pests and/or diseases are most common in the area before selecting the most appropriate planting system for your farmer(s). If you are not sure about the main pests and diseases in the target area, it is important to find out. Fields should be visited regularly during the season so that new infestations can be identified. There are several tools available to help you in identifying pests, diseases, and nutrient deficiencies. These range from colour sheets to mobile apps.

The Plantwise Factsheet Library allows you to search for factsheets on various pests, diseases and nutrient deficiencies in multiple languages.

Plantwise Factsheet Library

CABI

(Free)

Farmer priorities

Understanding the local context is critical in any climate smart decision. To make climate smart decisions on planting system options for maize/sorghum, it is vital to understand the soil type, probable seasonal rainfall, and prevalent pests and diseases. This understanding needs to be balanced with the farmer's own priorities.

The farmer's decision on whether they should choose an intercrop, relay or rotation planting system, is significantly influenced by her/his context. This includes:

- The need to gain **maximum return per unit area** in a single season
  - Most farmers want to achieve this, but where plot sizes are very small and a farmer needs to produce enough food/cash crops to survive, a rotation with two or more crops (especially if a fallow is included) may not be feasible

- The need to **maximise use of residual moisture**
  - Where farmers have **limited land** and **need to plant maize/sorghum** on it each year for subsistence and there is enough residual moisture/rainfall to extend the growing season (but not enough for a second full growing season), **relay cropping** may be an option
  - Choosing an **earlier maturing variety** of maize or sorghum and a fast maturing relay crop is key to maximising the use of any residual moisture
  - This may also be an option for larger farmers who wish to maximise returns

- The need to **maximise yield for the maize/sorghum crop that is to follow**
  - **Rotation** will be the most likely option here, if the farmer has enough land to follow this practice .

It is important to remember that there is no one-size-fits-all approach, and that the climate smart planting system to be selected may be influenced by a wide range of other factors – specific to the farmer's own context including, but not limited to, the following:

- **Availability of labour** at key times during the cropping cycle – Who does what (men/women/children) and when?
- **Ownership of land** – Farmers may be less willing to invest in soil improvements if they have short-term leases
- **Cultural norms** – Is it usual to allow livestock to graze the land after the maize/sorghum harvest, and how will this influence choices?
- **Access to markets** for buying inputs and selling produce
- **Access to finance** for buying inputs
- **Poverty status** – Poorer households are less likely to take risks on new climate smart planting systems than wealthier ones.

DECISION POINT

Making climate smart decisions requires an understanding of probable local weather conditions (climate), knowledge of the physical and chemical properties of the soil, and prevalent pests and diseases. This understanding needs to be balanced with farmers' own priorities, which may not always be driven by increases in production.

Understand context	**Soil Type / Predicted Total Rainfall and Distribution / Prevalent Pests and Diseases / Risk of Extreme Events**		
Farmer priorities	**Maximum return per unit area – small farm size**	**Maximise use of residual moisture**	**Maximise yield for follow-on crop**
Climate Smart planting system options	**Intercropping**	**Relay cropping**	**Rotations**

BEST BET PLANTING SYSTEM OPTIONS FOR ADDRESSING CLIMATE RISKS IN MAIZE/SORGHUM PRODUCTION

Below are four climate smart planting system 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. All four systems have similar advantages over monoculture maize or sorghum on the same piece of land season after season:

1. Better control of weeds. Crop rotation is intended to break the life cycle and suppress the growth of weeds. The sequential planting of different crops may check the development of weed species and reduce weed growth.

2. Better control of pests and diseases. Some pests and causal organisms of plant diseases are host-specific. They attack certain crop species or those belonging to the same family, but not others. Planting a crop from a different family disrupts the build-up of the pest in the field.

3. Improved soil structure and organic matter content. The alternate planting of deep and shallow-rooted plants will break up the soil and reduce the effects of plough pan. Green manures will add significant amounts of organic matter to the soil, as will crops like pigeon pea that produce a crop as well as high volumes of biomass.

4. Improved soil fertility. With crop rotation, soil fertility will be promoted through alternate planting of crops having different nutrient needs. This will prevent the depletion of any one essential element present in the soil. Legumes (such as groundnuts and beans) fix nitrogen in the soil. When their green parts and roots rot, this nitrogen can be used by other crops such as maize/sorghum. The result is higher, more stable yields, without the need to apply expensive inorganic fertiliser.

INTERCROPPING

Intercropping is almost always recommended with a legume. The legume will not compete with the sorghum/maize plants for nitrogen (N), which is critical in their development.

The advantage of intercropping over sole-cropping is commonly expressed in terms of the land equivalent ratio (LER). This is simply the relative area required by sole crops to produce the same yield as intercrops. A LER value of >1 indicates an overall advantage of intercropping. Crops should be grown at their optimal densities in both sole stands and mixtures, otherwise the advantages of intercropping may be overestimated.

Box 1: Calculating LER.

The benefit of growing maize/sorghum and legume intercrops can be assessed by calculating the **Land Equivalent Ratio** (LER) where:

$$\text{LER} = \left[\frac{\text{yield of intercrop maize}}{\text{yield of sole crop maize}}\right] + \left[\frac{\text{yield of intercrop legume}}{\text{yield of sole crop legume}}\right]$$

This equation provides the means to compare the yield of intercrop with the yield of sole crops per unit area. The LER is greater than 1 when the intercrop yields more than sole crops grown on the same area. For example, if the yield of sole maize is 2 tonne/hectare and sole legume yield is 0.5 tonne/hectare and the intercrop yield is 1.5 tonne/hectare maize and 0.25 tonne/hectare legume, the LER is:

$$LER = \left[\frac{1.5}{2.0}\right] + \left[\frac{0.25}{0.5}\right] = 1.25$$

In this example, the overall yield is greater in the intercrop compared with the sole crops. This means that an area planted as a sole crop would require 25 % more land to produce the same yield as the same area planted in an intercrop combination.

Source: ASHC 2016

Profitability and **LER** are not the same thing. More inputs will be required (labour/seed) in an intercropped system. To assess if these extra inputs paid off and if the increased yields were profitable, it is important to compare benefits and costs – **gross margins analysis**. If LER is <1 then there is no economic benefit from intercropping. The farmer may still decide to intercrop with the aim of improving soil conditions or for other socio-economic reasons.

There are many ways that maize/sorghum and legumes can be planted in intercrops, including the following options:

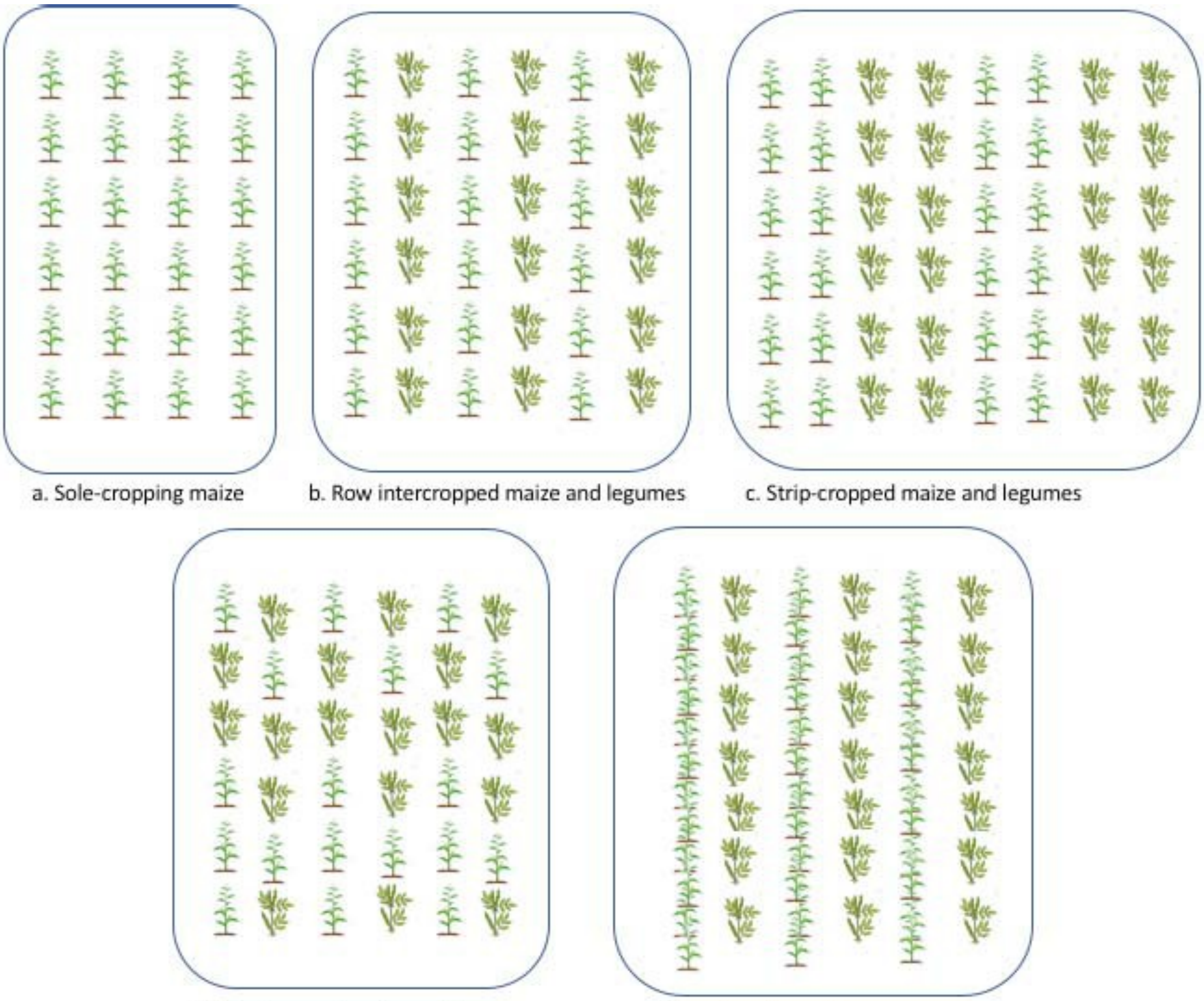
- **Within row intercropping** is when maize/sorghum and legumes are planted in alternate planting stations within rows

- **Row intercropping** is when maize and legumes are grown in alternate rows – option C in Figure 1

- **Strip intercropping** is when two or more rows of maize are alternated with two or more rows of legumes (also called the *Mbili system*); close enough to allow interaction between the crops, but wide enough to allow their separate cultivation – option C in Figure 1.

Spatial arrangement depends on farmer priorities for maize/ sorghum, or legume production – the relative (economic) value of the two crops, but above all on which legume crop is grown. The major grain legumes have different varieties, with a wide-range of growth habits (from erect bush varieties to creeping, runner or climbing varieties) and growth durations (from as short as 60 days to maturity to up to 270 days). The amount of nitrogen fixed in the soil also differs between legume crops. Some common legumes are listed in Table 2 along with their average and potential yields, and nitrogen fixation capacity.

Figure 1: Examples of intercropping systems for maize and legumes.



a. Sole-cropping maize b. Row intercropped maize and legumes c. Strip-cropped maize and legumes d. Mixed cropped maize and legumes e. Relayed maize and legumes

Source: ASHC,Maize-Legume Cropping Systems, 2015

Table 2: Examples of intercropping systems for maize and legumes.

Selection criteria	Common bean	Soybean	Groundnuts
Yield	Average yields in SSA 530 kg/ha Yield potential exceeding 2,000 kg/ha	Average yields in SSA 830 kg/ha Yield potential of 5,000 kg/ha	Average yields in SSA 950 kg/ha Yield potential of 2,500 kg/ha
Nitrogen fixation capacity	Bush bean: 35 kg N/ha Climbing bean: up to 125 kg N/ha	>200 kg N/ha	150 kg N/ha

Source: ASHC, Maize-Legume Cropping Systems.

Box 2: Maize-pigeon pea intercropping.

Medium and late maturing pigeon pea varietals are ideally suited to grow as an intercrop with maize, as they develop slowly in the seedling stage and therefore do not compete for water or nutrients – unlike early-maturing pigeon pea, which would compete. Medium and later maturing pigeon pea should be sown at the same time as maize, in a mixed or row intercropping arrangement. The pigeon pea continues to grow into the dry season, after maize is harvested.

The impacts of maize–pigeon pea intercropping can be spectacular! For example, after three years continuous cropping with no fertilizer added, mono-cropped maize in Mozambique was yielding less than 0.5 tonnes per hectare due to infestation with witchweed (*Striga asiatica*). By contrast, intercropped maize yielded almost 5 tonnes per hectare with an additional 0.3 tonnes per hectare of pigeon pea.

In this example, an NGO was previously recommending intercropping maize with pigeon pea by substituting rows of maize, which gave less than half the maize yield (<2 tonnes per hectare) than when pigeon pea was grown within the maize rows in an additive design. In the additive mixed intercrop design, three maize plants are planted per station – rather than evenly spaced within the row. This leaves space for stations of three pigeon pea plants in between. This locally-adapted planting arrangement gives the same maize plant population as when maize is evenly spaced within the row, but gives space for planting a legume intercrop. Perhaps surprisingly, the yield of maize when grown in these clusters of three plants was the same as if the same number of plants was spaced individually – i.e., the competition effect on the maize was minimal.

The benefit of the pigeon pea to maize is due to the large amount of nitrogen-rich pigeon pea leaves that fall to the ground as the crop matures, adding organic mulch (and nitrogen) to the soil for the next crop.

This means that the choice of legume variety is also important when considering what planting arrangement to choose.

Intercrop planting arrangements often involve the substitution of maize/sorghum with the legume so that the total number of maize plants per hectare is decreased. Other arrangements are additive, where the sorghum/maize is maintained at the same population density as in the sole crop (and the legume is simply planted in between). A good example of an additive maize-legume intercrop is maize/pigeon pea intercropping, as outlined in Box 2.

When selecting the legume (or another crop) to include in an intercropped system, the farmer should consider the following characteristics of the intercrop:

- **Root type** – Will the crop compete with maize/sorghum for available nutrients in the soil?
- **Shade tolerance** – Some crops do well in shade, while others do not. If the crop is less tolerant of shade, strip-cropping might be a better option than inter-row cropping or planting in the same stations as the maize/sorghum
- **Tolerance of trampling** – Depending on when the intercrop emerges it may get trampled while performing tasks such as weeding. How well will it be able to recover from this?
- **Crop maturity** – How long will the crop take to reach maturity?
  - If the crop has vigorous early growth will it compete with maize/sorghum?
  - Should the planting be staggered to allow for this?
  - When the crop is mature will it be possible to harvest without damaging the sorghum/maize?
  - Will it be possible to harvest the sorghum/maize without damaging the intercrop?
- **Climbing or bush varieties** – Does the intercrop require the maize/sorghum crop to support it?

The following are disadvantages of growing maize and legumes as intercrops:

- **Limited scope for some agronomic operations in intercrops:** Carrying out operations, such as weeding and even harvesting, can be more difficult than for sole crops
- **Depending on the intercrops, competition for water, light and nutrients may give lower yields:** This is why it is important to select the correct spatial arrangement for the intercrop being grown to minimize competition between the two crops, e.g., adopting the *Mbili* (strip) system instead of planting alternate rows.

RELAY CROPPING

This is a **combination of intercropping and rotations**. In relay cropping, the relay crop(s) are planted into the developing sorghum/maize crop and become a sole crop once the maize/sorghum is harvested and removed from the field. The succeeding crop is usually planted after the flowering, but before the harvesting of the sorghum/ maize. Relay cropping may be an option where sequential cropping (rotations) within the same calendar year are no longer an option due to shorter rainy seasons or where there is enough residual moisture from the sorghum/maize crop. Factors affecting the choice of crop for relay cropping include the following:

- **Purpose of the crop**:
  - **Cover crop** – suppress weeds, fix N in the soil, add organic matter
  - **Break up hardpan** – crops with deeper tap roots. These can also access some nutrients that may have been leached into deeper soil layers
  - **Food crop** – legume, vegetable, etc.
  - **Fodder crop** – for grazing or for harvest and storage
  - **Break pest/disease cycles** – is there a specific disease/pest that is a problem (e.g., *Striga* or stem borers)
  - **A combination of the above**
- **Length of growing season**
  - Choose an early maturing variety if residual moisture will not last long after the sorghum/maize is harvested
- **Shade tolerance**
  - Will the crop establish well under the sorghum/ maize canopy?
- **Drought tolerance**
  - Varieties of cowpea, pigeon pea and groundnut can require as little as 400 – 600 mm of rainfall for their growing season
- **Access to markets and finance**
  - To buy seeds/fertiliser and to sell produce.

There are many options that need to be considered when choosing the most appropriate relay crop. It may be easier to start with an assessment of what potential crops are available locally and which of these might suit the farmer before looking for new varieties. This can be done by developing a simple matrix, with desirable traits across the top row and listing the different crops in the first column.

It may also be beneficial to calculate the LER for relay crops to assess the expected returns. If the LER is <1 then the farmer will need to decide if the other benefits of growing a relay crop (soil improvements, weed management, etc.) are worth the reduction in returns.

ROTATION

Crop rotation has been around for centuries, and is one of the three central components of conservation agriculture.

There are **three fundamental principles of crop rotation**:

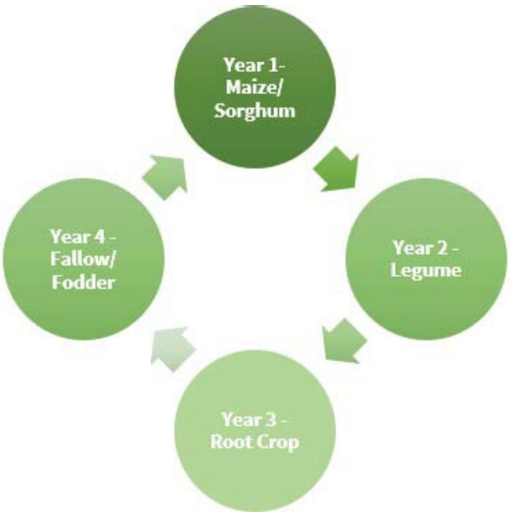
1. Rotation is better than monoculture, even when plants of the same family are cultivated

2. The most efficient rotations are those that include legumes

   - Legumes should always be included in crop rotations due to their residual benefits. These benefits enhance the growth of sorghum/maize grown in the next cropping season

3. Crop rotation as an isolated practice is generally not enough to maintain stable productivity for many years; the addition of some external nutrients is necessary.

Rotations can be of two (sorghum/maize and a legume) or more crops, depending on the farming system. Many rotations include a fallow period and a fodder crop for livestock, as well as a legume crop. The ideal four-crop rotation includes: maize/sorghum, a legume, a root crop and then a fallow/ grazing crop.



At a minimum, the rotation should include a legume between crops of maize/sorghum. The choice of each type of crop in each stage of the rotation will be influenced by farmer priorities, including the following:

- **Legume:**
  - Does the farmer plan to harvest the legumes for food (consumption or sale)?
    - »Is there a market for the grain legume?
  - Is the legume being planted as a fodder/grazing crop for livestock?
  - Is the amount of N being fixed in the soil a critical factor for the crop to follow?
    - »Different legumes fix different amounts on N in the soil. Soybean fixes a lot of N (>200kg/ha) while common beans only fix about 35kg/ha
    - »Planting a legume can halve the amount of N required to be added through fertilisers in the crop that follows
  - Is the legume being planted primarily to increase soil organic matter?

- **Root crop (if included):**
  - Is there a hardpan and how deep is it?
  - Will the selected crop be able to break the hardpan?
  - Is the root crop being grown for consumption/sale/ fodder?
    - »Are markets available for the preferred root crop?
    - »Is storage available/accessible? And is the storage safe from natural hazards (fire, flooding, cyclones)?
  - What field preparation is required for the root crop?
    - »Are ridges/furrows/mounds required and is labour/mechanisation available to construct these?
  - What pests and diseases are prevalent for the preferred root crop?

- **Fallow/fodder crop (if included):**
  - If the fallow crop is a legume, then see as before
  - Will the fodder crop be grazed or harvested?
  - What animal(s) will graze/eat the fodder crop?
    - »What is the digestibility of the fodder crop?
  - Is the fallow crop primarily to increase soil organic matter?
  - When will the cover crop be removed for planting the following crop?
    - »It is important to **choose the right moment** to control vegetative cover, as most species used can regenerate if their growth is interrupted prematurely. Alternatively, seeds of the cover crop can germinate if the plants are able to mature, as may happen with oats, rye, chickpea, vetches, and forage radish. There are, however, species and rotations where cover crops are purposely brought to maturity to establish a seed bank, which will allow the cover crop to grow automatically once the cash crop is harvested
    - »The period between slashing, or other management practice, of the cover crop and seeding of the commercial crop (maize, beans, soya, etc.) can affect the production level of the crop. This is related to some of the substances that are released during decomposition of the cover crops. These can harm the germination of the crop seeds, or sometimes even delay the development of subsequent crops

Further aspects to consider in crop rotations:

- Include **green manure/cover crops** where possible, prioritising the production of biomass to improve soil cover and organic matter content
- The **same species should never be sown on the same** field in the following season
- The crops utilised should be **adapted to the region's microclimate**, **to the soil**, and to the **farmer's production system**, which should result in important benefits for cash crops.

Maize Rain Shelters, Steward, 2016

DIVERSIFICATION

Diversification helps to reduce risks associated with pest and disease outbreaks, and climatic changes such as unpredictable rainfall, extreme temperatures, droughts, flooding, and cyclones. In the context of planting systems, diversification refers to the following aspects:

- **Diversity of cultivars**
    - Growing several cultivars of the same crop in the same plot. Different cultivars may have different traits, such as resistance to pests or diseases and/or temperature, drought, and heat tolerances
    - When selecting different cultivars to grow together, the farmer should consider time-to-maturity and what the crop will be used for
        - »Harvesting may be difficult if cultivars mature at different times
        - »If the crop is being grown for market, consistency in quality will be an important factor in price determination, and having different cultivars may not be acceptable
    - This option is likely to suit subsistence farming more than commercial farming

- **Diversity of Crops**
    - Growing more types of crops in the same field
    - This is similar to intercropping, but instead of a legume the farmer might choose to grow sorghum and maize or sorghum and millet as well as an intercropped legume. If the maize/sorghum crop fails due to unfavourable climatic conditions or pest and disease outbreaks, then the farmer may still have sorghum/millet to fall back on
    - Diversifying the number of crops being grown is likely to increase labour demands with different harvesting/threshing techniques being required

- **Diversity of rotations**
    - A two-crop rotation should include at least a legume and maize/sorghum, but it can include many more crops and combinations of crops
    - Ideally plants from different families should be chosen. For example, brassicas (cabbage, kale, etc.) could be included in a four-crop rotation

TIP

Choosing legumes/root crops/cover crops that are adapted to the local context offers the best chance of success. Let the farmer choose which crops and which system they want to test. Your role is to facilitate and to help them analyse the results.

FORECASTING AND ANALYSIS

It is important to have an idea of whether a new farming practice will be profitable before introduction, as well as assessing whether the technology was profitable after its introduction. The likely benefits of a new practice are calculated based on estimated data while actual benefits are based on actual data collected during implementation.

Smart decisions are made when useful information is available. There are many variables to consider when choosing climate smart planting options. The LER can be used as a forecasting tool to help guide decisions on intercropping/relay cropping. You should also meet with your farmers before the seasons starts to develop a seasonal calendar, and to forecast labour inputs and other considerations at various stages during the season.

Be sure to find out who is doing the labour so that nothing is missed. Accurate **data on labour and input costs** should be collected **throughout the year**, and **compared to the forecast**. This allows an assessment of **gross margins** at the end of the year. Gross margin is the return the farmer makes on his/her investment (money & labour). This will help the farmer to more accurately plan and forecast for the seasons to follow. It will also help the farmer in making decisions on which climate smart planting system option is best suited to her/him. Discussions on gross margins are crucial in helping farmers make improvements (climate smart decisions) on their farms.

TO SUMMARISE

STEP 1: Understand the context

- The farming system including your soil types
- Required and predicted total rainfall and distribution
- Risks of extreme events (drought, flooding, cyclones)
- Prevalent pests and diseases
- Roles, responsibilities and needs of men and women

STEP 2: Consider farmers' priorities

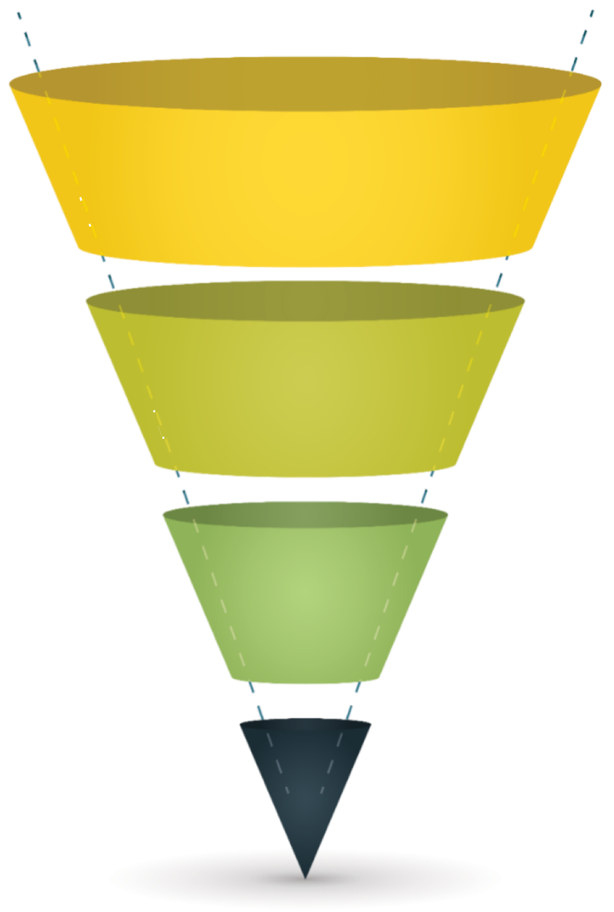
- Return per unit area
- Sale/consumption
- Grain/fodder
- Labour availability, etc.

STEP 3: Choose a Climate Smart planting system

- Intercropping
- Relay cropping
- Rotation

STEP 4: Forecast and assess

- Seasonal calendar
- Input/cash forecasting
- Document actual
- Calculate gross margins and discuss.



Always test different climate smart solutions with farmers and let them discuss which one is best suited to their conditions.

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 7, 8, 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** – Maize-Legume Cropping Systems
  - A practical guide to growing maize and legumes. Excellent resource for extension staff in the field
- **ASHC** – Sorghum and Millet Nutrient Management
  - A practical resource for anyone growing Sorghum or Millet
- **FAO/TECA** – Cover crop species with a special focus on legumes
- **FAO/TECA** – Crop Rotation in Conservation Agriculture
- **Food and Agriculture Organisation of the United Nations (FAO)** – Green manure cover crops and crop rotation in conservation agriculture on small farms: Integrated Crop management Vol 12, 2010
  - Focused on Paraguay and scientific in tone, but it covers all the principles behind the practices.

Citation: CCARDESA and GIZ 2019. Knowledge Product 07: Climate Smart Planting System Options for Maize & Sorghum. CCARDESA Secretariat, Gaborone, Botswana.