CCARDESA

Centre for Coordination of Agricultural Research and Development for Southern Africa

SOUTHERN AFRICAN DEVELOPMENT COMMUNITY

SADC

TOWARDS A COMMON FUTURE

Compendium of Technical Briefs on Climate Smart Agriculture (CSA)

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INTRODUCTION

Climate change continues to pose significant challenges to agricultural systems across Southern Africa. Rising temperatures, erratic rainfall patterns, prolonged droughts, floods, soil degradation, and declining soil fertility are placing immense pressure on farmers, food systems, and rural livelihoods. These impacts threaten food security, reduce agricultural productivity, and undermine economic stability in a region where agriculture remains central to sustainable development.

Climate Smart Agriculture offers a practical and integrated response to these challenges. It seeks to sustainably increase agricultural productivity and incomes, strengthen resilience and adaptive capacity to climate variability, and, where possible, reduce or remove greenhouse gas emissions. It promotes farming systems that are productive, resource efficient, environmentally responsible, and socially inclusive.

This Compendium of Technical Briefs has been developed to provide farmers, extension officers, researchers, policy makers, and development practitioners with concise and practical guidance on soil fertility and crop management practices that support Climate Smart Agriculture outcomes.

Each Technical Brief includes:

- An overview of the practice or technology
- Suitable agro ecological conditions
- Required inputs and enabling environments
- Step by step technical application guidance
- Potential socio economic and ecological impacts
- Benefits, drawbacks, and key considerations
- Additional reference materials for further learning

The practices featured in this compendium, such as composting, green manure application, biochar use, organic fertilizers, lime treatment, intercropping, relay cropping, crop rotation, and integrated soil fertility management, have been carefully selected for their relevance to both smallholder and commercial farming systems across Southern Africa. These practices are adaptable to diverse climatic zones, soil types, and farm sizes, and can often be implemented using locally available resources.

Importantly, this document serves as a general guide. The information provided should be contextualized to local environmental conditions, available resources, socio economic realities, and institutional support systems. Strong collaboration among farmers, extension services, research institutions, and community leadership is essential to maximize the effectiveness and long term sustainability of these practices.

By strengthening soil health, improving nutrient management, diversifying cropping systems, and promoting sustainable land management, these climate smart approaches contribute to resilient agricultural systems capable of supporting both present and future generations.

This Compendium serves as a practical tool to support informed decision making and the scaling up of Climate Smart Agriculture across Southern Africa.

The Technical Briefs were developed with support from GIZ and were first released in 2019. All 67 briefs are also accessible through the CCARDESA Mobile Learning Application.

Compost

Technical Brief 01

Compost is a biological process where micro-organisms recycle decaying or decomposing organic matter to produce a soil conditioner that can be applied as an additive to improve soil conditions. Composting takes place in the presence of oxygen (aerobic conditions), and with adequate temperature and moisture, transforming organic matter into plant-available nutrients. Compost can comprise organic plant and/or animal matter, and/or residues including leaves, dead roots, manure, urine, bones, and nematodes, amongst other organic materials. As it is generally rich in nutrients, the application of compost can naturally fortify soils, acting as a fertiliser, with soil humus or natural pesticide increasing the resistance of plants to diseases, foreign species and insects. The amount of organic matter in different soils depends on the soil type, vegetation species, and other environmental conditions, such as moisture and temperature. Thus, the application of compost may add important nutrients to soils that can benefit vegetation growth. Rainfall, temperature changes and other biophysical factors may result in a diminishing return of compost benefits to soil health. Therefore, the application of compost to soils should be a continuous practice, in order to increase physical, chemical and biological benefits. There are two main composting systems: Open Systems (compost piles or pits) or Contained Composting – see technical application below. This is a climate smart approach as it recycles readily available organic materials from a farm for use within the farming system, plus it avoids the use of chemical fertilisers. Composting is a climate smart approach as it reduces the need for chemical fertilisers, contributes to soil amendments that support adaptation to climate change, and helps retain soil fertility, which in turn aids agricultural productivity.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | **No**

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator			
Return on Investment Realisation Period	**Short**	**Medium**	Long
Crop production	Negative	Neutral	**Positive**
Fodder production	Negative	**Neutral**	Positive
Farm income	Negative	Neutral	**Positive**
Household workload	**Negative**	Neutral	Positive
Food security	Negative	Neutral	**Positive**

Ecological Impacts Positive or Negative

Indicator			
Soil quality/cover	Negative	Neutral	**Positive**
Biological diversity	Negative	Neutral	**Positive**
Flooding	Negative	Neutral	**Positive**
Crop/livestock water availability	Negative	**Neutral**	Positive
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	Neutral	**Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively undertake composting :

- **Step 1:** gather compostable materials - rests of harvests, animal manure and dung, organic kitchen waste (fruit and vegetable waste), other food waste, edible oils and fats, wood shavings, paper products (not printed), hair cut waste. Avoid non-compostable materials such as chemical residues, glass, metals, plastics, carcasses, cooked leftovers or meat.
- **Step 2:** Chop/cut materials to achieve optimum particle size is between 5 – 20 cm – this will assist decomposition. Wire mesh can be used to sift smaller non-organic particles.
- **Step 3:** Add water regularly using a watering-can to assist decomposition, ensuring that the materials do not become water logged.
- **Step 4:** Using a pitchfork or shovel, turn-over or rotate compost materials regularly as oxygen is a key component to the decomposition process.
- **Step 5:** If available, add earthworms (known as vermiculture) to compostable material, which enriches soil, enhances plant growth (hence yields) and suppresses disease.
- **Step 6:** Once compost material has been decomposed (three months to two years, depending on climate and composting material) it will be a fine, dark material. Screen the material to remove large particles and mix with soils in gardens or fields prior planting and around plants throughout growing period.
- **Step 7:** If compost does not include animal manure/waste it can be applied to crops as an organic fertiliser at any point up to harvest. If it does include animal waste, it can be incorporated into soil not less than 120 days prior to harvest, especially where edible portion of crops has been in contact with the soil surface.

Additional notes

- For Open Composting System (Piles): select a level area or dig a pit with a level bottom away from developed areas, chop collected materials into piles, turn over or rotate and add water to material regularly (weekly or bi-monthly). Cover pile if there is heavy rain to prevent materials from washing away and becoming water-logged.
- -For Contained Composting Systems: construct a container unit from mesh, wooden panels, bricks and other suitable building materials, fill the container with chopped material, turn over or rotate, and add water to material regularly (weekly or bi-monthly). Keep compostable material covered.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Retaining or improving soil fertility to ensure increased or sustained agricultural productivity.
- As climate change places increased pressure on land management, compost can contribute to soil amendments to aid adaptation.
- Use of compost to amend soil avoids the use of chemical fertilisers and reduces greenhouse gas emissions.

SUMMARY/KEY ISSUES

Benefits

- Composting is an effective and low-cost option to recycle organic matter that can improve soil nutrient health.
- Composting in scalable, based on need and available organic materials.
- Moisture and oxygen are very important. Ensure that compost materials are moist and regularly rotated to optimise decomposition conditions.
- Cover during extreme weather events (heavy rain, extreme heat, high wind etc.).
- Add earthworms to the material to increase decomposition and speed up process.
- Compost should be regularly added to soils to increase soil organic nutrients.

Drawbacks

- Developing productive compost material, with beneficial nutrient is not a quick process, and can take up to two years for productivity to reach optimal outputs.
- Faster methods require more energy and inputs as significant amounts of organic material is needed, material must be shredded/chipped, and compost piles need to be turned every three days.
- While composting is scalable, the amount of available organic material may be a limiting factor.
- Composting plant material must include removal of any diseased plant material and weed seeds should be avoided.
- Earthworms will need to be sourced to improve the productivity of composting operations

Earthworms can be sourced from a worm farm – if worm farms are not available, you can create your own by purchasing worms from an agricultural supplier. Worm farms can also be purchased as kits.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA KP16 – Climate Smart Manure Management Options for Livestock.

Additional Information

- US Composting Council 1999. Home Composting: Recycling In Your Own Back-Yard . FAQ.
- Food and Agricultre Organisation. 2015. Farmer's Compost Handbook: Experiences in Latin America. Rome, Italy.
- eXtension 2019. Making and Using Compost for Organic Farming.

Green Manure

Green manure (otherwise known as cover crops), is a climate smart fertiliser process that involves growing plants (mainly legumes) and distributing uprooted or sown crop-parts to wither and cover soil. It provides soil coverage to enhance biological, physical and chemical properties of soil while mitigating soil erosion, supressing weed growth, adding biomass to soils, improving soil structures, promoting biological soil preparation, and reducing pests, diseases and weed growth. These functions can increase economic return, reduce the need for herbicides and pesticides, while increasing productivity and potentially the quality of crops. It can also increase soil nitrogen, improve soil fertility, conserve soil humidity and reduce fertiliser costs. Green manure also has low management costs, presents good conservation characteristics, and improves biodiversity. Green manure is a feasible and sustainable option for farmers to improve soil quality and productivity, depending on local context and availability of different leguminous plants that best fit for farmers' cropping systems. Examples of leguminous plants that can be used in southern Africa include: Mucuna *(Mucuna pruriens);* Sunhemp *(Crotalaria juncea),* Lab-lab *(Lablab purpureus);* Pigeon pea *(Cajanus cajan);* Cowpea *(Vigna unguiculata)* and Butterfly pea *(Clitoria ternatea).* Green manure has climate smart benefits as contributes to sustainable maintenance of agricultural production without the use of chemical fertilisers and depending upon the cover crop can contribute to adaptation of agricultural practices to climate change. Furthermore, coverage of soil with additional plant material can assist with carbon sequestration in soil. Not only does growing a secondary green manure crop provide a soil amendment benefit, but the crop can also be used as fodder for livestock. As the most common green manure plants are legumes, the pods and seeds can be fed to livestock while leaving the crop residue to perform the cover crop function in in the fields.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period

Short | Medium | Long

Crop production

Negative | Neutral | Positive

Fodder production

Negative | Neutral | Positive

Farm income

Negative | Neutral | Positive

Household workload

Negative | Neutral | Positive

Food security

Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover

Negative | Neutral | Positive

Biological diversity

Negative | Neutral | Positive

Flooding

Negative | Neutral | Positive

Crop/livestock water availability

Negative | Neutral | Positive

Wind Protection

Negative | Neutral | Positive

Erosion control

Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively apply a green manure approach, the following should be considered::

- **Step 1:** Select legumes that grow well under local conditions and in local soils. Green manure crops should be resilient and require few crop management practices. A thorough investigation should be made to ensure that green manure crops are appropriate for the local conditions in terms of rainfall, climate, soil pH and texture, and salt tolerance.
- **Step 2:** Identify the appropriate time for planting the green manure crop to ensure growth, but not impacting the primary crop. Especially if the secondary crop is a climber/creeper. Main crop may need to be mature before planting the manure crop, as if a creeper, it may outcompete or constraint growth of maize or sorghum plants.
- **Step 3:** If seeking to enrich soil properties, the farmer must allow crop residue to remain in the soil longer. This is particularly relevant with multiple uses – e.g. soil amendments and livestock fodder. In these cases, pods can be harvested for fodder, and the remaining plant residue left in the field to cover the soil.
- **Step 4:** Crop planting should be alley cropped between the primary crop rows, allowing management of the primary and secondary crops, also reducing the competition between the primary and the secondary crop. If the secondary crop also has pest management properties, it may be beneficial to consider boundary planting.
- **Step 5:** When harvesting the secondary crop, the farmer should consider leaving the residue in the ground. If it is uprooted, it should left on the soil surface. A common mistake is to remove it from the field and accumulate it in one location, missing the benefits of cover-crops, and exposing the residue to decay.

Unless local examples are available, small test plots should be used to test different cover crops to determine which is the most appropriate, and if necessary, demonstrate value to farmers and communities. As the secondary (green manure) crop is not a direct cash-crop, you may need to ensure expectations are measured. It may take several years to develop enough green manure crop to contribute to crop production; hence, crop production has to fit around existing cash/subsistence crops. Furthermore, benefits may not be realised within a single planting season., e.g. Nitrogen may only be available in the soil in the subsequent season.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Green manure can maintain or increase agricultural productivity through improved soils.

Adjustment of practices to include cover crops allows farmers to diversify crop types, and produce their own fertilisers.

Reduction in carbon released from soil.

SUMMARY/KEY ISSUES

Benefits

- Green Manure is a non-tillage method that promotes soil fertility through enhancement of soil organic content. In doing so, it mitigates erosion, maintains soil humidity, and promotes biological activity.
- Many green manure plants can be used to feed livestock if there is an excess
- Green manure cover crops also make organic matter to apply – compost requires work and time to develop, whereas this approach sees it added immediately.
- Cover crops can reduce weed competition by shading soil.
- If using legumes, they can thrive in poor quality soils.
- Cover crops such as Cow pea can also be used for animal and human consumption.

Drawbacks

- Require access to seedbanks for legumes and other viable cover crops
- May require the testing of crops in test plots prior to implementation.
- If so, community action may be required to test varieties and make decisions.
- Farmers may require more land to plant the same amount of the main crop, as they need to be intercropped with the cover crop. This can be unattractive to some farmers.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA 2019. KP06 Climate Smart Soil Amendment Options for Maize and Sorghum. Gaborone, Botswana.
- CCARDESA 2019. KP07 Climate Smart Planting Options for Maize and Sorghum. Gaborone, Botswana.
- CCARDESA 2019. KP08 Climate Smart Land Preparation Options. Gaborone, Botswana.
- CCARDESA 2019. Technical Brief 7. Intercropping. Gaborone, Botswana
- CCARDESA 2019. Technical Brief 8. Relay Cropping. Gaborone, Botswana

Additional Information

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- Motis 2016. A "2:4:2" Maize/Legume Intercropping Pattern. ECHO Development Notes Issue 133.
- Odhiambo, J. (2011). Potential use of green manure legume cover crops in smallholder maize production systems in Limpopo province, South Africa. African Journal of Agricultural Research. 6

Biochar

Biochar refers to a fine-grained charcoal, rich in organic carbon compounds, used to improve soil quality through enhanced nutrient and water holding capacity of soil, reducing total fertiliser needs. Biochar is a stable solid produced from the controlled burning of plant and waste feedstock, including wood chips and pellets, tree bark, crop residues (straw, maize stovers, nut shells and rice hulls), grain, sugarcane bagasse, chicken litter, diary manure, sewage and paper sludge. Biochar is used as a soil conditioner as part of soil amendment strategies, improving the workability of soil, particularly those with heavy clay components.. The application of biochar to soil is a strategy to minimise the climate and environmental impact of cropland systems, such as the application of synthetic fertilisers, and improve soil quality through enhancing its physical-chemical characteristics. This agricultural practice improves soil structure, nutrient cycling and water retention, and the high stability of biochar carbon compounds contributes to the reduction of green-house gas emissions by increasing carbon sequestering in soils. Biochar is shown to be effective in improving soil conditions in acidic, sandy and clay-rich soils, improving the physical characteristics, and is classified by the FAO classifies as an adaptation strategy and contributes to mitigation of climate change as the processes captures and stores carbon in soils create other secondary socio-economic benefits, through additional fuel sources, and economic opportunities for production. Biochar can either be purchased or produced on-farm on a small or large scale. Collective action may benefit communities, so discussion with neighbours and community leadership may be necessary, especially if a biochar.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

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MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

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Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

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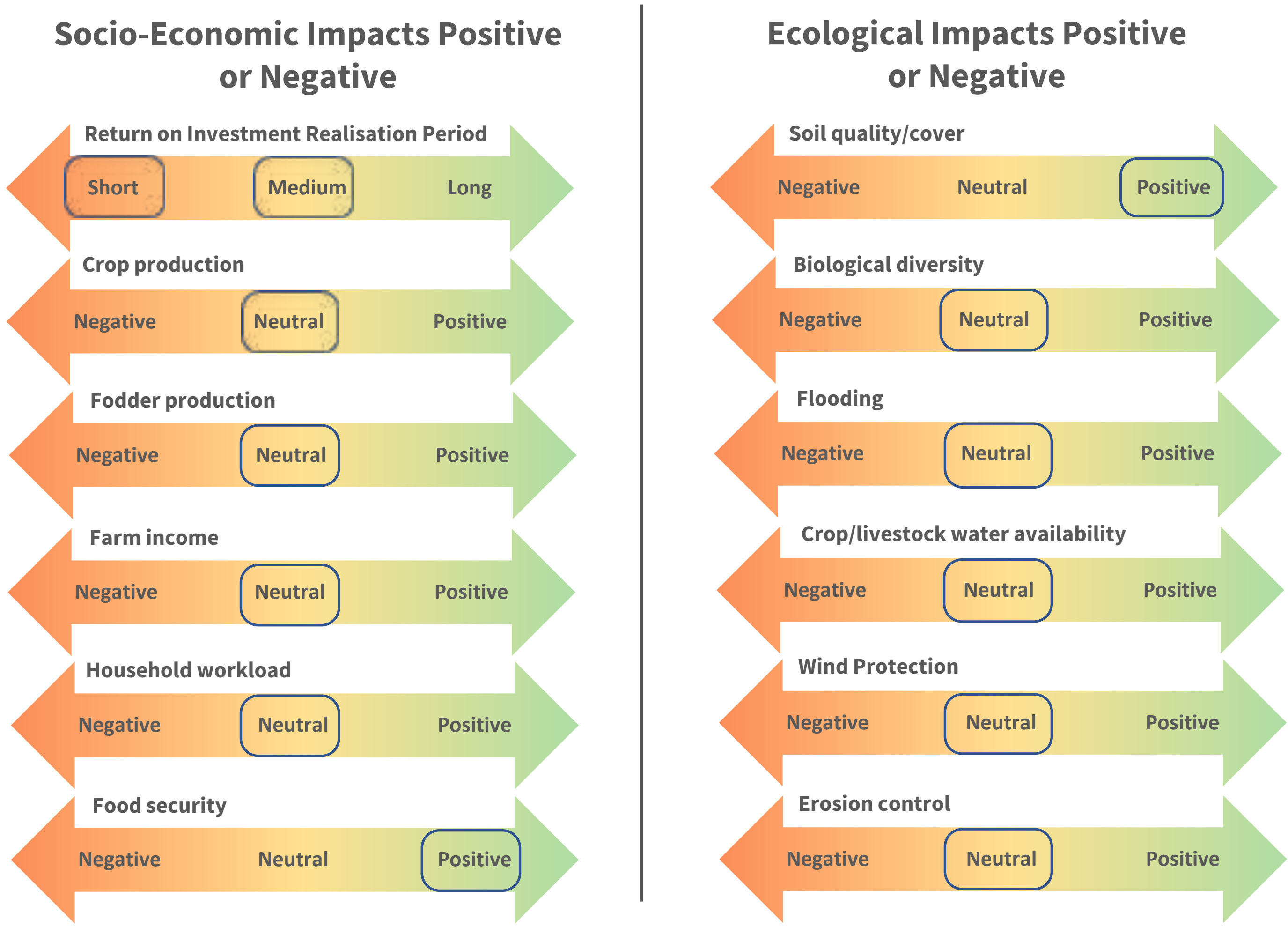
POSSIBLE IMPACT/OUTCOMES



These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement biochar the following should be carried out. Tools required – shovel and a metal sieve.

Step 1: Acquire charcoal from local vendor, and sieve or grate the charcoal into fine material in a pile. Biochar should not be applied to soil directly after production. It should be allowed to 'rest' for one to two months.
Step 2: Rotate the pile every 2-days for a period of up to 10-days (total).
Step 3: Prior to application, aim to wet (but not waterlog) biochar stock with water or preferably urine. If done when still warm, it will fracture the charcoal, increasing surface area for absorption.
Step 4: Spread the biochar evenly across soil prior to planting and let it settle or mix with the top layer of soil. One to three kg/m2 is recommended, depending on the degree of soil required.
Step 5: Regularly monitor soil pH, water retention and soil texture, keeping records if relevant to ensure that improvements are realised, and negative impacts do not arise.

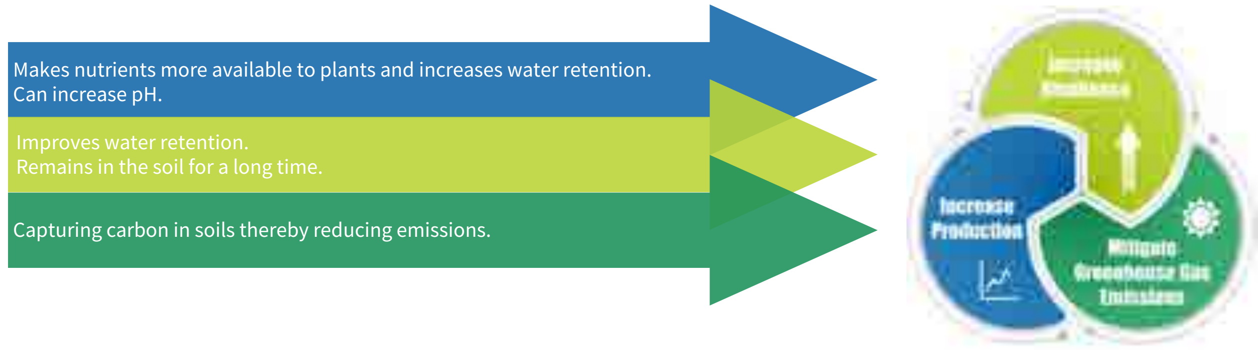
Biochar can be produced on-farm, but will require collection of plant and waste feedstock (see above). Biochar can be produced on-farm using a trench. A biochar trench is a dug recess where crop residues are burned to create charcoal. Tools required are a shovel and one or more roofing sheets (one-metre long).

Step 1: Dig trench 50 to 70 cm deep, and one to two metres long, ensuring that roofing sheets fully cover the trench void.
Step 2: Start a fire in one end of the trench, throwing in loose crop residue or other organic waste, keeping the fire under control (not creating large flames and smoke).
Step 3: Keep fire burning until trench is full of char.
Step 4: When the trench is full, and flames have burned-out, cover the trench with the roofing sheet, sealing edges with loose soil, trampling it down to ensure closure.
Step 5: Leave the covered trench for five to six hours to extinguish.

Technical Brief 03

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to
Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- The production and application of biochar reduces GHG emissions of cropland systems due to the properties of the biochar itself, and reduction in the application of synthetic fertiliser.
- Can improve physical and chemical composition of soil, especially in acidic, sandy and clay-rich soils; soil nutrient cycling and water retention.
- Can reduce fertiliser and irrigation requirements.
- Potential socio-economic opportunities for biochar producers, if not produced on-farm.
- Improved food security from production of secondary fuel source.
- Provides an appropriate and sustainable mechanism for dealing with crop residues and biomass.
- Can be mixed with compost during application to increase performance of soil amendments.

Drawbacks

- Requires sustainable non-wood supply of organic matter for production so as not to increase deforestation.
- Long-term impacts not fully understood.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA 2019. KP06 Climate Smart Soil Amendment Options for Maize and Sorghum. Gaborone, Botswana.

Additional Information

- Department of Environmental Affairs (South Africa) 2015. Assessment of the potential to produce biochar and its application to South African soils as a mitigation measure. Department of Environmental Affairs, Pretoria, South Africa.
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Organic Fertilisers

Soil fertility is one of the most critical factors needs to be maintained so farmers can continue to grow productive and nutritious crops, especially in southern Africa where soils are often fragile and lacking in plant nutrients. Soils are often quickly depleted if mismanaged, further exacerbated by natural biophysical processes such as rain, wind and/or heat. The use of organic fertiliser can help farmers to improve soil fertility, as they improve absorption of water and add nutrients into the soil, drastically improving crop production. Organic fertilisers are plant (crop residues) or animal-based materials, such as green manure, worm mouldings, compost, animal waste, and sewage residues, many of which may be readily available on the farm, or within a farming community. These products are potential counters to inorganic fertilisers - artificially manufactured chemicals (synthetic) mined from mineral deposits comprising minerals such as nitrogen, phosphorus and magnesium - which are often costly when few farmers can access credit needed to sustainably access such materials. Organic fertilisers are considered climate smart as they utilise (recycle) readily available organic materials to feed soil and crops simultaneously as they add nutrients into the soil and condition it, and thus increase productivity and resilience, while inorganic fertilisers add nutrients to the soil only, and are often expensive.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | Medium | Long

Crop production: Negative | Neutral | Positive

Fodder production: Negative | Neutral | Positive

Farm income: Negative | Neutral | Positive

Household workload: Negative | Neutral | Positive

Food security: Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | Positive

Biological diversity: Negative | Neutral | Positive

Flooding: Negative | Neutral | Positive

Crop/livestock water availability: Negative | Neutral | Positive

Wind Protection: Negative | Neutral | Positive

Erosion control: Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

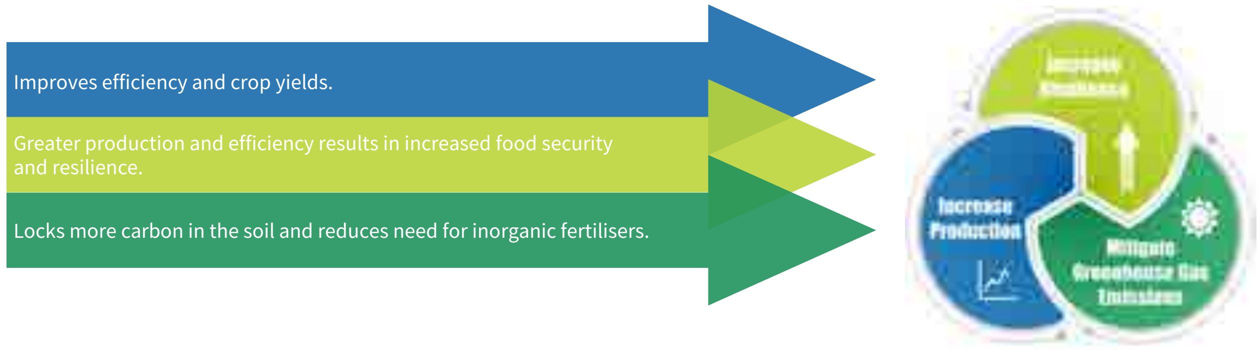
TECHNICAL APPLICATION

Organic fertilisers can be produced at the household level or purchased. On-farm production includes stock-piling animal manure, crop residues, and other organic waste, following appropriate guidance for processing and usage. To apply organic fertilisers the following should be considered:

- **Step 1:** Assess field area where fertiliser is to be applied, and fertiliser needs – poor crop performance, low organic matter content, etc.
- **Step 2:** Ensure that fertiliser is available in sufficient quantities for application in all target or priority fields.
- **Step 3:** Ensure organic fertiliser – especially green manure/crop residues – are broken-down/chopped to aid breakdown/integration with soil.
- **Step 4:** Monitor soil nutrient levels and crop performance (in the light of prevailing climatic conditions) to determine success of organic fertilisers.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Fertilisers can help restore soil nutrients, improve soil conditions and improve crop production if applied correctly.
- Organic fertilisers are plant or animal materials that can be produced locally or purchased for application.
- An appropriate strategy in rural and low-income communities with small holder farmers that can generally not afford synthetic pesticides and inorganic fertilisers.
- Collective action can minimise the financial cost of implementing organic fertilisers, in terms of shared transportation and storage costs, as well as bulk purchasing power.
- Use of organic fertilisers can help avoids the leaching of inorganic fertilisers into waterways, which can result in eutrophication.
- Where farmers do have access to financial resources and/or credit, organic fertilisers should be used in combinate with inorganic application.

Drawbacks

- Manure and other types of organic fertilisers require management, and relevant storage mechanisms. If not stored correctly, investment can be lost as nutrients can be lost due to exposure to the elements.
- It can be costly to transport if sourcing from off-farm
- Weed seeds can be present in manure, increasing labour requirements for weeding.
- If not produced on-farm, organic fertilisers, while beneficial can require access to sustainable financial resources or credit to implement correctly.
- Requires extension support to ensure that fertiliser requirements are being met.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA 2019. KP16 Manure Management.
- CCARDESA 2019. KP06 Climate Smart Soil Amendment Options for Maize and Sorghum. Gaborone, Botswana

Additional Information

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Lime Treatment of Soil

Soil acidification is a widespread problem across southern Africa, often driven by monocropping with cereals and occurring as a result of erosion, compost decomposition and soil leaching. Applying lime to soil is regarded as a key management practice in agriculture to balance pH, enhancing crop productivity, water penetration and absorption of major nutrients by crops. Most crops grow best in soils with a pH between 6.5 and 6.8. Acidity constrains crop growth below pH levels of 5.5. Agricultural lime is limestone mined as a rock that is crushed into various particle sizes ranging from course to fine particles and can be applied in areas where there is high soil-acidity due to high levels of manganese and iron. Lime texture also determines the speed of absorption in the soil; that is, fine-lime reacts more quickly than more granular lime. However, the use of lime must be managed appropriately to avoid losing other nutrients in the soil. This practice is considered climate smart as it assists with adaptation strategies through improvement of soil fertility, whilst improving productivity at modest application rates, noting that annual application is not recommended.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: ● Maize ● Sorghum ○ Rice ○ Livestock ● Other

Soil texture: ○ Light ● Medium ● Heavy

Climatic zone: ● Arid ● Semi-arid ● Sub-humid ● Humid

Water source: ● Rainfed ● Partly irrigated ● Irrigated

Annual average rainfall (mm): ● < 250 ● 250 - 500 ● 500 - 750 ● 750 - 1000 ● 1000 - 1500 ● > 1500

Topography: ● Flat to gentle slope (0 – 5 %) ● Moderate to rolling slope (6 – 15 %) ● Hilly slope (16 – 30 %) ● Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: ○ Yes ● **No**

Characteristics: ● Subsistence ● Commercial Small ● Commercial Medium ● Commercial Large

Farm size (ha): ● < 2 ● 2 to 5 ● 5 to 10 ● > 10

Mechanisation: ● Manual ● Animal ● Mechanised

Human resources

Labour intensity – level of effort: ● Low (household) ○ Medium (seasonal) ○ High (outside labour)

Gender/youth smart (low investment/low labour requirements): ● Yes ○ No

Financial resources

Initial investment: ○ Low ● Medium ○ High

Maintenance Costs: ○ Low ● Medium ○ High

Access to finance capital or credit required: ● Yes ○ No

Enabling Environment

Extension support: ● Yes ○ No

Access to inputs: ● Yes ○ No

Market access: ● Yes ○ No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator			
Return on Investment Realisation Period	**Short**	Medium	Long
Crop production	Negative	Neutral	**Positive**
Fodder production	Negative	Neutral	**Positive**
Farm income	Negative	Neutral	**Positive**
Household workload	Negative	**Neutral**	Positive
Food security	Negative	Neutral	**Positive**

Ecological Impacts Positive or Negative

Indicator			
Soil quality/cover	Negative	Neutral	**Positive**
Biological diversity	Negative	**Neutral**	Positive
Flooding	Negative	Neutral	Positive
Crop/livestock water availability	Negative	**Neutral**	Positive
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	**Neutral**	Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

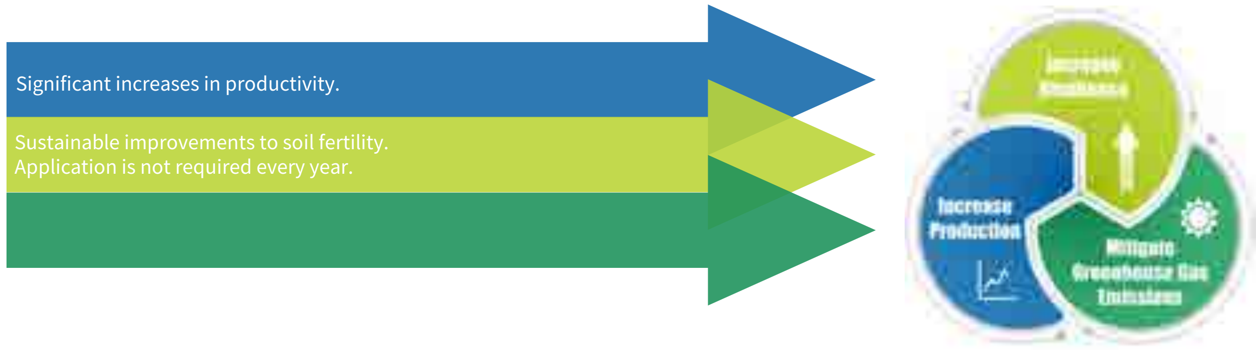
Before applying lime to increase lower soil pH the following should be considered. Equipment required: soil pH testing kit, protective goggles and mask, agricultural lime, shovels/forks/hoes, and disk harrow, drag harrow or hoe if available.

- **Step 1:** Use a pH testing strip to determine soil pH levels, making sure to test surface and sub-surface acidity.
- **Step 2:** Measure area of land to be treated in order to determine amount of lime for purchase. Application should be calculated as metric tonne per hectare, depending on soil pH and crop. Lime requirements will differ depending on soil type and level of acidity in the soil. Application volumes can be guided by suppliers.
- **Step 3:** Purchase lime according to requirements from agricultural supplier. Savings could be realised if purchasing as a group of farmers.
- **Step 4:** Apply lime to the soils at least two months prior to planting directly after harvesting to allow the lime to react with the soil, and positively impact the pH.
- **Step 5:** Mix lime and soil well in order to reduce soil acidity. This is normally achieved through disk tilling but can be done manually using a drag harrow or hoe. However, this can be an intensive process.
- **Step 6:** Test pH prior to planting to ensure amendments have improved soil pH.
- **Step 7:** Plant crops. Monitor crop performance, and harvest results with a view to understanding impact of lime treatment.
- **Step 8:** Following harvest, test soil pH again.

Application of lime can be part of an Integrated Soil Fertility Management (ISFM) practices.
While a practical solution, this soil amendment should be informed by research and discussion with extension officers and lime suppliers. On-farm storage and management of lime should be included in this dialogue.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Lime treatment can assist farmers to balance pH in acidic soils, optimising water and nutrient use for crop plant growth.
- A practical and effective way to combat the negative effects of erosion, compost decomposition and leaching on soil.
- Lime does not need to applied to soil every year.

Drawbacks

- Adding lime to soils is laborious and should not be considered a short-term solution to balancing soil pH.
- Over-application or overuse of lime can negatively affect soil quality.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA 2019. KP06 Climate Smart Soil Amendment Options for Maize and Sorghum. Gaborone, Botswana.

Additional Information

- Agricultural Research Council 2013. Maize Information Guide. Pretoria, South Africa.
- Agricultural Research Council 2007. Acid Soil and Lime. Pretoria, South Africa.
- Grain SA 2013. Liming requirement; misunderstanding the difference between efficiency and quantity concepts. Pretoria, South Africa.

ISFM

Technical Brief 06

Integrated Soil Fertility Management (ISFM) refers to a set of agricultural practices that can be applied simultaneously to improve agricultural productivity through increasing soil nutrients and improving crop water use. ISFM includes a broad range of agricultural practices that have all been adapted to local conditions to improve soil nutrients and include the combined application of the following approaches:

1) Utilisation of organic fertilisers such as green manure, compost and crop residues
2) Application of locally available soil amendment methods, such as lime and biochar.
3) Implementation of techniques like germplasm, agroforestry, crop rotation, intercropping etc.
4) Limited use of inorganic or mineral fertilisers – seen as the last option in ISFM, when other interventions are not achieving optimal results.

ISFM can be successful for most arable farmers and has been known to double productivity and increase farm-level incomes by 20 to 50 percent if implemented correctly. It focuses on a series of practical approaches to sustainable farm productivity through locally available and affordable options for maintaining soil fertility and productivity, and is seen as a viable approach to reduce over-reliance on inorganic fertiliser. ISFM permits short- and long-term increases in productivity of cash crops and food security, and is considered climate smart as the combined ISFM approach maximises fertiliser uptake and sequestration of carbon in soil, allowing sustainable agricultural intensification driven by improved soil structure and fertility.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period

Short | Medium | Long

Crop production

Negative | Neutral | Positive

Fodder production

Negative | Neutral | Positive

Farm income

Negative | Neutral | Positive

Household workload

Negative | Neutral | Positive

Food security

Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover

Negative | Neutral | Positive

Biological diversity

Negative | Neutral | Positive

Flooding

Negative | Neutral | Positive

Crop/livestock water availability

Negative | Neutral | Positive

Wind Protection

Negative | Neutral | Positive

Erosion control

Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

In addition to agricultural inputs and the following technical implementation steps, ISFM requires the farmer to consider farm size (land area), and property rights (land tenure) to ensure that investments are efficient and sustainable.
To implement ISFM approaches, the following should be considered:

- **Step 1:** Prepare a needs assessment based on understanding of farm challenges – low or declining productivity, soil fertility, low organic content, etc
- **Step 2:** Measure fields that require attention to understand volumes of inputs required.
- **Step 3:** Develop (or update) an agricultural calendar to use as a platform for discussion between farmer(s) extension officer(s).
- **Step 4:** Develop plan and schedule/programme of locally appropriate ISFM interventions between farmer(s) and extension officer(s), obtaining guidance from agricultural suppliers where necessary (lime application, etc). As ISFM is a blended approach, the plan should consider short and medium to long term interventions and outcomes.
- **Step 5:** Examine cost implications of the plan, revising where necessary based upon available resources, and if necessary/available apply for credit to fund investments.
- **Step 6:** Assess labour requirements within the ISFM plan to ensure that they can be fulfilled, and considerations of gender and youth have been accommodated – women are not expected to do the majority of work, and children are not missing school.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Improves soil structure. Increases soil fertility.

Aims at sustainable intensification, increasing resilience through more predictable production.

ISFM has the potential to reduce greenhouse gas emissions owing to greater uptake of Nitrogen-based fertilisers by crops and soil carbon sequestration.

SUMMARY/KEY ISSUES

Benefits

- Applying an ISFM approach can be a sustainable way to improve/rehabilitate soil fertility.
- ISFM is intended to optimise a combination of CSA strategies to achieve maximum outcomes.
- The focus should be on leveraging locally available materials and resources to improve productivity.
- ISFM should be seen as a scalable approach, involving a range of interventions that match available inputs and financial and human resources.

Drawbacks

- Lack of knowledge of applying the different strategies individually or in combination.
- Potentially high transaction costs as the process involves multiple interventions.
- Lack of credit facilities.
- Availability of labour.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA 2019. KP06 Climate Smart Soil Amendment Options for Maize and Sorghum. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana.
- CCARDESA 2019. Technical Brief 01. Compost. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana.
- CCARDESA 2019. Technical Brief 02. Green Manure. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana.
- CCARDESA 2019. Technical Brief 03. Biochar. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana.

Additional Information

- Sanginga, N. and Woomer, P.L. (eds.). 2009. Integrated Soil Fertility Management in Africa: Principles, Practices and Developmental Process. Tropical Soil Biology and Fertility Institute of the International Centre for Tropical Agriculture. Nairobi, Namibia.
- GACSA 200. Integrated Soil Fertility Management: Contributions of Framework and Practices to Climate-Smart Agriculture. Practice Brief Climate-smart agriculture. IITA, Nairobi, Kenya.
- CTA 2019. The Digitalisation of African Agriculture Report, 2018-2019. Centre for Tropical Agriculture, Wageningen, The Netherlands.

Intercropping

Intercropping is a process of growing multiple crops either together or in proximity to each other on one piece of land, thereby improving crop production, reducing and preventing land degradation and increasing crop output.

There are different methods of intercropping:

- Mixed intercropping – two or more crops are seeded together and harvested together.
- Row/strip intercropping – two or more crops planted on the same field but planted in alternate rows.

Crops selected for intercropping should not have similar properties or compete but should be selected to complement one another and be mutually beneficial. For example, deep rooted crops can be intercropped with shallow rooted crops, so as to not compete for water or nutrients. Intercropping helps achieve ecological benefits not possible with monocropping systems. Intercropping is commonly practiced for maize-legume systems, where legumes introduce nitrogen into the soil benefiting maize production and improving soil fertility during crop growth. Furthermore, the legume crops can be utilised for fodder for livestock. This practice is particularly beneficial for smallholder farmers, who can grow multiple crops on small plots to receive multiple benefits including improving production/yields, and increasing household food security. Intercropping is also a climate-smart practice as it mitigates farmer risk to climate variations, through diversifying and increasing crop production, reduces threats of pests and disease, and increases carbon sequestration in soils and biomass production.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain
Maize | Sorghum | Rice | Livestock | Other

Soil texture
Light | Medium | Heavy

Climatic zone
Arid | Semi-arid | Sub-humid | Humid

Water source
Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)
< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography
Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action
Yes | No

Characteristics
Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)
< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation
Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort
Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)
Yes | No

Financial resources

Initial investment
Low | Medium | High

Maintenance Costs
Low | Medium | High

Access to finance capital or credit required
Yes | No

Enabling Environment

Extension support
Yes | No

Access to inputs
Yes | No

Market access
Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | Medium | Long

Crop production: Negative | Neutral | Positive

Fodder production: Negative | Neutral | Positive

Farm income: Negative | Neutral | Positive

Household workload: Negative | Neutral | Positive

Food security: Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | Positive

Biological diversity: Negative | Neutral | Positive

Flooding: Negative | Neutral | Positive

Crop/livestock water availability: Negative | Neutral | Positive

Wind Protection: Negative | Neutral | Positive

Erosion control: Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To implement intercropping practices:

- **Step 1:** Consider soil properties - has the soil been mono-cropped and/or is it leached?
- **Step 2:** Consider crop characteristics – will crops be competing for nutrients, water space, sunlight or will they be mutually beneficial adding nutrients
- **Step 3:** Prepare land through clearing and weeding. A no-tillage approach is recommended – see Technical Brief 12.
- **Step 4:** Select whether the farmer should undertake Mixed Intercropping (Good for smaller plots however plants compete) or Row/Strip Intercropping (crops less likely to compete). See also KP07 – Climate Smart Planting Options for Maize and Sorghum.
- **Step 5:** If mixed intercropping is selected, sow two crops simultaneously mixing seeds to together while planting. Harvesting may not be a simultaneous process as different crops have different growth rates and seasons.
- **Step 6:** If row/strip intercropping plant two or more crops in the same field but in separate rows patterns. Rows should be spaced 50 cm apart and can have a row of 1:1 or 2:1 ratio of cereal crop to legume.
- **Step 7**: Harvest as individual crops require, be careful not to disrupt other crops that have not yet matured.

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Higher levels of production from the same area of land, due to healthier soils.
- 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.

SUMMARY/KEY ISSUES

Benefits

- Increased and diversified crop yield.
- Food security/farm income increase.
- Nutrient fixing.
- Food security/farm income increase.

Drawbacks

- Competition between plants for nutrients, water, space, etc.
- Increase farmer workload as weeding, planting and harvesting are less efficient. Requires consideration especially if women's workload increases as a result.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 07, Decision Tool: Climate Smart Planting System Options for Maize & Sorghum
- CCARDESA, 2019. Knowledge Product 08, Decision Tool: Climate Smart Land Preparation Options..
- CCARDESA, 2019. Technical Brief 07: Intercropping.
- CCARDESA, 2019. Technical Brief 12: No Tillage.
- CCARDESA, 2019. Technical Brief 08, Relay Cropping

Additional Information

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- Southern African Development Community (SADC), 2011. SADC Region Agricultural Policy. Gaborone, Botswana.

Relay Cropping

CCARDESA

Technical Brief 08

Relay cropping is a form of intercropping where two or more crops are grown simultaneously during part of their life cycles. Intercropping often involves maize and legumes, which increases nitrogen fixing in soils and increased biomass production. The second (or succeeding) crop is planted after the reproductive stage (flowering) of the existing crop but before harvesting. Some of the advantages of relay cropping include better erosion control due to crop cover, reduced spreading of pests and diseases, and crop diversification, plus general soil health. As an added benefit, it mitigates the emission of greenhouse gases through reducing nitrate leaching and increasing carbon sequestration. There is also potential socio-economic benefits for farmers as in many cases relay cropping increases crop productivity.

However, this form of intercropping is not easily implemented in large-scale agricultural systems due to complications in weed control and challenges associated with operating mechanised equipment on fields with relay cropping.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: **Maize** · **Sorghum** · Rice · Livestock · **Other**

Soil texture: **Light** · **Medium** · **Heavy**

Climatic zone: **Arid** · **Semi-arid** · **Sub-humid** · **Humid**

Water source: **Rainfed** · **Partly irrigated** · Irrigated

Annual average rainfall (mm): **< 250** · **250 - 500** · **500 - 750** · **750 - 1000** · **1000 - 1500** · **> 1500**

Topography: **Flat to gentle slope (0 – 5 %)** · **Moderate to rolling slope (6 – 15 %)** · **Hilly slope (16 – 30 %)** · **Steep slope (> 30 %)**

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes · **No**

Characteristics: **Subsistence** · **Commercial Small** · **Commercial Medium** · Commercial Large

Farm size (ha): **< 2** · **2 to 5** · **5 to 10** · > 10

Mechanisation: **Manual** · **Animal** · Mechanised

Human resources

Labour intensity – level of effort: Low (household) · **Medium (seasonal)** · High (outside labour)

Gender/youth smart (low investment/low labour requirements): **Yes** · No

Financial resources

Initial investment: **Low** · Medium · High

Maintenance Costs: **Low** · Medium · High

Access to finance capital or credit required: Yes · **No**

Enabling Environment

Extension support: **Yes** · No

Access to inputs: **Yes** · No

Market access: Yes · **No**

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

- Return on Investment Realisation Period: Short · **Medium** · Long
- Crop production: Negative · Neutral · **Positive**
- Fodder production: Negative · Neutral · **Positive**
- Farm income: Negative · Neutral · **Positive**
- Household workload: Negative · **Neutral** · Positive
- Food security: Negative · Neutral · **Positive**

Ecological Impacts Positive or Negative

- Soil quality/cover: Negative · Neutral · **Positive**
- Biological diversity: Negative · **Neutral** · Positive
- Flooding: Negative · **Neutral** · Positive
- Crop/livestock water availability: Negative · **Neutral** · Positive
- Wind Protection: Negative · Neutral · **Positive**
- Erosion control: Negative · Neutral · **Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement relay cropping, the following steps should be carried out:

- **Step 1:** Test/experiment with locally available crops to determine if they are complementary and can grow concurrently - cereal crops and legumes are complementary and can generally grow concurrently.
- **Step 2:** Prepare land through clearing, weeding and a no-tillage approach (Technical Brief 12).
- **Step 3:** Plant cereal crop first according to normal planting season schedule –during rainy season. Space this cereal crop 70 cm by 50 cm apart.
- **Step 4:** Prior to cereal harvest, plant the legume crop between cereal crop rows with spacing based on legume planting efficiencies (researched prior to planting for optimum growth).
- **Step 5:** After cereal has been harvested, bend the dried stalks down to provide more ground cover.
- **Step 6:** When legumes are ready for harvest, collect the productive pod/seed/bean/nut and leave the stalk uprooted in the field to maximise ground cover.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- 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 reduces and dietary diversity is enhanced.
- Helps lock more carbon in the soil.

SUMMARY/KEY ISSUES

Benefits

- Increased and diversified crop yield.
- Improved soil quality preventing leaching, and introducing nutrients.
- Increased land cover reducing erosion and improving carbon capturing.
- Food security/farm income increase.

Drawbacks

- Weeding makes this approach labour intensive, and planting and harvesting can become less efficient. This requires consideration, especially if women's workload increases as a result.
- Carried out precisely to ensure crops are compatible, planting is undertaken at correct times and harvesting is low impact to avoid crop damage.
- Possible competition between plants for nutrients, water, space, etc.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 06. Climate Smart Soil Amendment Options for Maize and Sorghum.
- CCARDESA, 2019. Knowledge Product 07. Decision Tool: Climate Smart Planting System Options for Maize & Sorghum.
- CCARDESA, 2019. Technical Brief 07: Intercropping.
- CCARDESA, 2019. Technical Brief 12: No Tillage.
- CCARDESA, 2019. Technical Brief 15: Cover Crops.

Additional Information

- Frederick Baijukya, Lydia Wairegi, Ken Giller, Shamie Zingore, Regis Chikowo and Paul Mapfumo. 2016. Maize-legume cropping guide. Africa Soil Health Consortium .Nairobi.
- Food Agriculture Organisation (FAO). 1983. Fertilizer use under multiple cropping systems. Rome.
- The Food and Agriculture Organisation (FAO), 2001. Improving Nutrition through Hone Gardening, Rome.
- The Food and Agriculture Organisation (2015), Traditional Systems makes more Productive Use of Land. Rome.

Crop Rotation

Monocropping in one field for many subsequent years will cause nutrient depletion in that field and lead to less productive returns. Crop Rotation is the process of planning the planting and harvesting of different crops planted on the same field over subsequent growing seasons, allowing less nutrient depletion and if applied effectively, increasing soil nutrients through nitrogen fixing etc. This farming practice also assists with weed control, prevents soil erosion, and is the most efficient and economical way to break the biological cycles of plant pests and diseases, mitigating the effects of pests/disease as they become more prevalent due to climate change and helping farmer diversify crop production. Research has shown that rotation between nitrogen consuming crops such as maize and nitrogen depositing plants such as soybeans can provide a healthy balance of nutrients. This farming practice is advantageous for smallholder farmers who are less able to leave fields fallow for extended periods of time, as well as for commercial farmers wanting to reduce pesticide use. It is seen as climate smart as it breaks pest and disease cycles, returning nutrients to the soil, thereby supporting more predictable yields in times of climate pressure, and locking more carbon in the soil.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain
Maize | Sorghum | Rice | Livestock | Other

Soil texture
Light | Medium | Heavy

Climatic zone
Arid | Semi-arid | Sub-humid | Humid

Water source
Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)
< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography
Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action
Yes | No

Characteristics
Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)
< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation
Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort
Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)
Yes | No

Financial resources

Initial investment
Low | Medium | High

Maintenance Costs
Low | Medium | High

Access to finance capital or credit required
Yes | No

Enabling Environment

Extension support
Yes | No

Access to inputs
Yes | No

Market access
Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator	Scale	Selected
Return on Investment Realisation Period	Short – Medium – Long	Short, Medium
Crop production	Negative – Neutral – Positive	Positive
Fodder production	Negative – Neutral – Positive	Neutral
Farm income	Negative – Neutral – Positive	Positive
Household workload	Negative – Neutral – Positive	Neutral
Food security	Negative – Neutral – Positive	Positive

Ecological Impacts Positive or Negative

Indicator	Scale	Selected
Soil quality/cover	Negative – Neutral – Positive	Positive
Biological diversity	Negative – Neutral – Positive	Neutral
Flooding	Negative – Neutral – Positive	Neutral
Crop/livestock water availability	Negative – Neutral – Positive	Neutral
Wind Protection	Negative – Neutral – Positive	Neutral
Erosion control	Negative – Neutral – Positive	Neutral

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

An example of crop rotation is maize, followed by a legume. Grain SA has reported a 12 % increase in maize production following rotation with legumes such as cowpea. Furthermore, the legume yields often increase following rotation with the grain crop, and sometimes responding differently to the crop type. For example, soybean yield has been measured at 20 % higher following sorghum than maize. To effectively undertake crop rotation:

- **Step 1:** Determine which cereal crops and legumes are available in the area of interest.
- **Step 2:** Prepare land through clearing, weeding. No-tillage approaches are preferable (Technical Brief 12).
- **Step 3:** Plant a leafy cereal crop (maize or sorghum) and let the crop mature and harvest once ready. Once harvested, bend stalks over to increase biomass.
- **Step 4:** If possible, allow field to fallow for a short period. If this is not possible, practice cover cropping (Technical Brief 15).
- **Step 5:** Prepare land again, and sow second crop, usually a legume to improve soil structure and fertility. Harvest crop once ready.
- **Step 6:** Repeat process. It is possible to include more than two crops into crop rotation if desired.

It is advisable to carefully monitor yield for demonstration purposes, run test plots if necessary

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Breaks pest and disease cycles. Returns nutrients to 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.

SUMMARY/KEY ISSUES

Benefits

- Improved soil fertility and protect soil.
- Effect and cost-effective way to break pest/disease cycle.Food security/farm income increase.
- Food security/farm income increase.
- Nutrient fixing.

Drawbacks

- Time should be allowed between harvest and planting of different crops.
- Cultural shift away from traditional crops.
- Limited market opportunities for non-traditional crops.

REFERENCE MATERIAL

CCARDESA Related Content

- -CCARDESA, 2019. Knowledge Product 07, Decision Tool: Climate Smart Planting System Options for Maize & Sorghum
- CCARDESA, 2019. Technical Brief 12: No Tillage
- CCARDESA, 2019. Technical Brief 15: Cover Cropping.

Additional Information

- The Food and Agriculture Organisation (FAO), 2010. Green manure/ cover crops rotation in Conversation Agriculture on small farms. Rome, Italy.
- FAO 1995. Sustainable dryland cropping in relation to soil productivity FAO soils bulletin 72 (Chapter 4 – sustainable crop rotations). Rome, Italy.
- Nel A. A. (2005) Crop rotation in the summer rainfall area of South Africa, South African Journal of Plant and Soil, 22:4, 274-278

Crop Diversification

Technical Brief 10

Many farmers grow one crop repeatedly on the same field over-and-over again. Crop diversification is the cultivation of several crops of a different species or variety (of one crop) in one plot at any given point in time. The main advantage of implementing crop diversification is that it enhances household climate resilience through reducing risk of monocrop failure due to pests, disease, low rainfall and other climate risks.

Employing crop diversification may also provide opportunity of more diversified income sources and dietary diversity. Farmers can simultaneously grow both food crops, fodder and cash crops in an attempt to increase household food security and improve household incomes. There are also indications that crop diversification can increase crop productivity, which for poorer households can have significant positive impacts. For better capitalised farms, return on specialisation may be higher, and will likely not realise the desired returns.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain
Maize | Sorghum | Rice | Livestock | Other

Soil texture
Light | Medium | Heavy

Climatic zone
Arid | Semi-arid | Sub-humid | Humid

Water source
Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)
< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography
Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action
Yes | No

Characteristics
Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)
< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation
Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort
Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)
Yes | No

Financial resources

Initial investment
Low | Medium | High

Maintenance Costs
Low | Medium | High

Access to finance capital or credit required
Yes | No

Enabling Environment

Extension support
Yes | No

Access to inputs
Yes | No

Market access
Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | Medium | Long

Crop production: Negative | Neutral | Positive

Fodder production: Negative | Neutral | Positive

Farm income: Negative | Neutral | Positive

Household workload: Negative | Neutral | Positive

Food security: Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | Positive

Biological diversity: Negative | Neutral | Positive

Flooding: Negative | Neutral | Positive

Crop/livestock water availability: Negative | Neutral | Positive

Wind Protection: Negative | Neutral | Positive

Erosion control: Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively undertake crop diversification:

- **Step 1:** Identify potential market opportunities for alternative crops in local/sub-national/national area.
- **Step 2:** Determine crops that farmer wishes to plant and the purpose whether it be household food stuff, cash crop or fodder crop.
- **Step 3:** Establish local demonstration plots at the local level growing non-traditional crops that have market demand and can be incorporated into local farming systems.
- **Step 4:** Prepare smaller plot through clearing and weeding. CCARDESA recommends a no tillage approach (Technical Brief 12).
- **Step 5:** Secure seeds of desired crops and follow planting guidance if the crop has not been previously grown. Sow seeds on small plot.
- **Step 6:** Track progress of crop and harvest and process as required.
- **Step 7:** Discuss cost benefit of growing diversified crops with farmers.
- **Step 8:** Farmers should gradually integrate a new crop(s) into their farming system to ensure that they are comfortable with diversifying at a greater scale.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- 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 in the soil, especially if fallows or cover crops are incorporated.

SUMMARY/KEY ISSUES

Benefits

- Diversification provides opportunity to increase farmer resilience.
- Substantial opportunity for increased crop productivity
- Food security, farm income, household nutrient improvements.
- Scaled up as farmers gain confidence.

Drawbacks

- Farmer hesitation
- Require enough space to introduce additional crop.
- Failure in diversified variety/species may dissuade farmers in the future.
- Not encouraged for better capitalised farms, as returns to specialisation can be higher.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 07, Decision Tool: Climate Smart Planting System Options for Maize & Sorghum.
- CCARDESA, 2019. Technical Brief 12: No Tillage

Additional Information

- The Food and Agriculture Organisation, 2017. Is crop diversification a panacea for climate resilience in Africa. FAO Agricultural Development Economics Policy Brief 2. Rome, Italy.
- FAO 2018. Crop diversification increases productivity and stabilizes income of small-holders. FAO Agricultural Development Economics Policy Brief 8. Rome, Italy.
- The Southern African Development Community (SADC), 2012. Agriculture and Food Security. Gaborone, Botswana.

Erosion Control

Erosion control measures are practices designed to reduce runoff water and wind erosion that wash away top soil and nutrients, degrading soil biodiversity and reducing agricultural productivity. Erosion is a natural, biophysical process resulting from rainfall, water flows, wind, or storm runoff. Erosion is integral to the formation of soils, however human and animal activity, including agriculture and clearing of land, can accelerate erosive processes, drastically impacting landscapes, soils (e.g. quality) and watercourses. In addition, erosion control measures can contribute to reducing rainfall runoff, increased water infiltration into the soil, and attenuates flooding. The intensity of rainfall is directly correlated with the severity of soil erosion; hence, this is a significant problem across the Southern African region as much of the rainfall in the region is episodic, and intense. To prevent or reduce erosive processes control measures can be incorporated into farming systems to reduce or reverse degradation and potentially restore or improve soil quality. Erosion control measures aim to mitigate soil erosion and improve soil fertility by reducing flow and speed of run-off to avoid soil being washed away. Erosion control can be initiated through a number of interventions, including, but not limited to, intercropping (e.g. planting cover crops), mulch, conservation tillage and reforestation, as well as terracing, soil bunds, etc.. Example: Stone Bunds. Lessons learned from West Africa show that stone bunds constructed along contour lines in fields and in key run-off locations can significantly reduce run-off, particularly in steeper agricultural fields. The stone lines reinforce the soil structure in the field following the contours of the land, reducing the speed and volume of run-off, thereby reducing the likelihood of erosion. This is an appropriate technology to implement on slopes up to 15 to 20 degrees. This is considered a climate smart practice as it maintains soil structure and nutrients, in turn retaining carbon in soil, enabling farmers to adapt to climate changes and sustain agricultural productivity.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | No

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

- **Return on Investment Realisation Period:** Short | **Medium** | **Long**
- **Crop production:** Negative | Neutral | **Positive**
- **Fodder production:** Negative | Neutral | **Positive**
- **Farm income:** Negative | Neutral | **Positive**
- **Household workload:** **Negative** | Neutral | Positive
- **Food security:** Negative | Neutral | **Positive**

Ecological Impacts Positive or Negative

- **Soil quality/cover:** Negative | Neutral | **Positive**
- **Biological diversity:** Negative | Neutral | **Positive**
- **Flooding:** Negative | **Neutral** | **Positive**
- **Crop/livestock water availability:** Negative | Neutral | **Positive**
- **Wind Protection:** Negative | **Neutral** | **Positive**
- **Erosion control:** Negative | Neutral | **Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

Without a topographic survey, this technology may require trial and error to begin with, to see how rainfall and run-off responds to the contouring. To effectively implement erosion control measures the following should be carried out:

- **Step 1:** Perform a thorough local study of the landscape, soils, land use and erosive processes that most impact the area: steep slopes, flood plains, high winds etc.
- **Step 2:** Source a large number of stones, preferably five to ten centimetres square blocks (from a quarry) or five to ten-centimetre diameter cobbles (from a river-bed). You will need 30 to 50 tonnes of stone per hectare for contour bunds approximately 300 metres long.
- **Step 3:** Mark out contours, as discussed in Technical Brief 16 Contour Planting.
- **Step 4:** In larger fields with shallower slopes, place stones in rows of two along contour line, interlocking alternately, burying the lower half. The bunds can be between 25 and 40 metres apart. On steeper slopes, stack and bury stones against or in vertical/near vertical walls of contours much closer together (five to ten metres apart) to reinforce them.
- **Step 5:** Make sure that stone bunds follow the contours from one side of the field to the other, ensuring that no 'pour' points (larger gaps) exist along the way, lining the drainage channel or weir from one contour to the next with stones to avoid or reduce scouring in these locations.
- **Step 6:** Following, and if possible, during rainfall events, check the stability of the slope, adjusting stone bunds where necessary.
- **Step 7:** At the end of the rainy season and again following harvest, review the performance of the technology, and prepare for the next growing season.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Increased water infiltration can extend growing period and mitigates short dry spells. Can reduce flood risk downstream.
- Increased production due to improved nutrient availability and higher nutrient use efficiency.
- Depending on practices used, may lock more carbon into the soil.

SUMMARY/KEY ISSUES

Benefits

- Erosion control measures prevent the loss of top soils and nutrients.
- Can help farmers adapt to changes in climate that have include increased rainfall amounts and intensity.
- Can reduce the impact of wind erosion.

Drawbacks

- Erosion is a natural process that can be increased due to human and animal activity.
- Requires substantial labour inputs to construct bunds and other erosion control measures
- Maintenance is also needed.

REFERENCE MATERIAL

CCARDESA Related Content

- Centre for Coordination of Agricultural Research & Development for Southern Africa (CCARDESA), 2019. Knowledge Product 08, Decision Tool: Climate Smart Land Preparation Options.
- CCARDESA 2019. Technical Brief 16 Contour Planting. CCARDESA, Gaborone, Botswana
- CCARDESA 2019. Technical Brief 18 Terracing. CCARDESA, Gaborone, Botswana.

Additional Information

- The Food and Agriculture Organisation of the United Nations (FAO), 1990. Keeping the land alive. Rome, Italy
- FAO, 2019. Soil degradation definition. Rome, Italy
- FAO, 1996. Land Husbandry – Components and strategy. Rome, Italy
- CCAFS 2017. Contour Stone Bunds for soil erosion control in the Sahel of West Africa. CSA Guide, CCAFS, Wageningen University, The Netherlands.
- Rural 21, 2011. Stone Lines Against Desertification. Rural 21 Website.

No Tillage

Technical Brief 12

No-tillage or reduced-tillage farming involves growing crops without ploughing or reducing the use of machinery in preparing fields for planting. Excessive tillage can have major impacts on soils and the environment including loss of organic matter and soil organisms, increased soil erosion and pesticide runoff, reduced soil fertility, loss of soil structure, etc. Thus, implementing no- or reduced-tillage can help farmers in conserving soil quality and in many cases, increase crop production.

In implementing no-tillage processes, land is not or is minimally disturbed and crop residues are normally left on the soil surface with minimal use of implements. Reduced tillage practices include technological changes such as using more efficient ploughing tools and/or implementing strip-till, zone-till or ridge-till processes. Most reduced tillage systems are implemented in conjunction with cover crops and mulches to protect soil structure. Tilling by hand or animal means are considered reduced tillage methods.

The adoption of no or reduced tillage practices reduces the amount of fossil fuels consumed by farmers and increases carbon sequestration as soil carbon is not exposed or released in the atmosphere and is thus a climate smart practice.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period

Short | Medium | Long

Crop production

Negative | Neutral | Positive

Fodder production

Negative | Neutral | Positive

Farm income

Negative | Neutral | Positive

Household workload

Negative | Neutral | Positive

Food security

Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover

Negative | Neutral | Positive

Biological diversity

Negative | Neutral | Positive

Flooding

Negative | Neutral | Positive

Crop/livestock water availability

Negative | Neutral | Positive

Wind Protection

Negative | Neutral | Positive

Erosion control

Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

Switching to no-till or reduced tillage should be planned at least a year in advance so preparations can be made necessary implements can be obtained. Implements should match farm labour availability. You will also need to decide if no till or reduced tillage methods are appropriate based on farm area and desired crops, and start with a small area to determine feasibility. Cereal and legume crops are suitable for no tillage while vegetables and other crops often require some tillage – i.e. reduced tillage.

There are two forms of no-tillage, **conventional** and **organic. Conventional no-tillage** includes the application of herbicides to manage weeds, prior to and after planting. **Organic no-tillage** does not incorporate the use of herbicides, but includes other methods for controlling weeds, including **cover crops, crop rotation** and free-range livestock. Organic no-tillage is more suitable as it assists mitigate any climate change impacts on the farm.

No till

- **Step 1:** Prepare fields using conventional (herbicide application) or organic processes include cover crop (Technical Brief 15) and crop rotation (Technical Brief 09).
- **Step 2:** Test soils – aiming to balance nutrient and pH levels. In the case of acidic soils, add small amounts of lime each year.
- **Step 3:** Avoid soils with bad drainage, as they become water-logged.
- **Step 4:** Level the soil surface, removing uneven areas to assist even seed planting.
- **Step 5:** Eliminate soil compaction.

Reduced Till

- **Step 1**: This approach is similar to regular tillage, but with significantly less disturbance of the soil. Tilling is only done where needed, and the rest of the soil is undisturbed.
- **Step 2**: Strip-tillage or zone-tillage involves tilling and seeding in 15 cm strips leaving areas in-between undisturbed.
- **Step 3**: Ridge-tillage involves preparing ridges post-harvest and letting them settle over time to be planted the next seeding period; with ridges not more than 60 cm apart.

More information of each of these specific practices should be sought prior to implementation.
Crop rotation is a complimentary farming method when practicing no-tillage, as it promotes maximum biomass levels for permanent mulch cover, while controlling weeds (with pre- and post-emergent herbicides), pests, and diseases, as well as improving soil nutrition and fertility.

Technical Brief 12

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- 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 fuel inputs required

SUMMARY/KEY ISSUES

Benefits

- Increased soil fertility, organic matter and soil structure, and beneficial organisms (earthworms, etc
- Reduced compaction of soils.
- Prevention of soil erosion.
- Reduction in fossil fuel consumption.
- Increased soil carbon sequestration.

Drawbacks

- A positive response can be delayed for up to three years.
- Effective weed management may require the application of herbicides.
- Possible decreases in crop productivity if not carried out effectively.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 08, Decision Tool: Climate Smart Land Preparation Options.
- CCARDESA, 2019. Technical Brief 09: Crop Rotation.
- CCARDESA, 2019: Technical Brief 15: Cover Crops.

Additional Information

- African Conservation Tillage Network, 2013. No Tillage Systems.
- CGIAR, 2014. Limited potential of no-till agriculture for climate change mitigation. Montpellier, France.
- The Food and Agriculture Organisation, 2001. Zero tillage development in tropical Brazil. Rome, Italy.
- Cornell University, 2013. Zone/Strip Tillage. Agronomy Face Sheet Series. Fact Sheet 79.
- Bucholz, D., Palm, E., Thomas, G., and Pfost, D., 1993. No-Till Planting Systems. Extension University of Missouri.

Mulching

Technical Brief 13

Mulching is the process of introducing vegetative material to the surface of soil in fields to provide soil cover, reduce evaporation, maintaining an even soil temperature and ultimately improve organic content in soil. These materials can include grasses, crop residues, tree bark and other plant materials, even including seaweed if it is available. These materials should be well decomposed, and mixed well into the top soil when the growing season is over. Mulching improves soil fertility by creating a positive soil environment favouring microbial activity and other promoting beneficial organisms such as earthworms, increases moisture retention, stabilises soil temperatures (protecting soils from both heat and cold), reduces soil erosion and restricts weeds. The temperature control keeps roots and plant bulbs cool in the summer and warm in the winter. It can be utilised on all scales of farm, depending upon the availability of input mulch materials. It is considered a climate smart approach as it sequesters carbon in the soil and promotes soil health which in turn maintains agricultural productivity and the ability of a farmer to adapt to climate changes. In some cases, shredded plastic is sometimes used as a synthetic soil cover, but this is not considered climate smart, as it does not integrate organic matter to the soil, instead introducing plastics.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | No

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Impact			
Return on Investment Realisation Period	Short	**[Medium]**	Long
Crop production	Negative	Neutral	**[Positive]**
Fodder production	Negative	**[Neutral]**	Positive
Farm income	Negative	**[Neutral]**	Positive
Household workload	Negative	Neutral	**[Positive]**
Food security	Negative	Neutral	**[Positive]**

Ecological Impacts Positive or Negative

Impact			
Soil quality/cover	Negative	Neutral	**[Positive]**
Biological diversity	Negative	Neutral	**[Positive]**
Flooding	Negative	**[Neutral]**	Positive
Crop/livestock water availability	Negative	**[Neutral]**	Positive
Wind Protection	Negative	**[Neutral]**	Positive
Erosion control	Negative	Neutral	**[Positive]**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively undertake mulching the following should be carried out. Tools required: shovel, scissors or shears.

Step 1: Gather organic materials from the farm and other external sources if possible. grasses, crop residues, wood chips, tree backs and other plant materials.

Step 2: Prepare a location to stock-pile mulch material. A large farm will need a substantial area or pit to achieve this. For smaller operations, mulch can be stored in open-topped barrels and bags punctured for air holes. Storage must allow moisture to contribute to the decomposition process, but no become waterlogged.

Step 3: Chop/shred organic material and add to the stock-pile. With larger amounts of material, a motorised, or pedal driven chopper/shredder is useful.

Step 4: Allow materials to decompose, but do not leave for extended periods as nutrients and minerals will be lost.

Step 5: At the end of the growing season, remove any remaining weeds from the soil surface.

Step 6: Spread mulch material over the surface approximately two centimetres deep.

Step 7: In firmer or more compacted top soils, lightly work the mulch into the upper soil.

Step 8: Lightly water area where mulch has been applied.

Mulch should be applied annually as mulching materials will decompose.

Technical Brief 13

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Improving soil health through practices such as mulching promotes productivity.
- In changing climates, with shifting rain patterns, and increasing temperatures, practices such as mulching help retain soil health.
- Mulching provides soil cover, promoting retention of carbon in the soil, and also introducing organic content to the soil itself.

SUMMARY/KEY ISSUES

Benefits

- Mulching improves soil structure, fertility and quality, stabilising soil temperature and retaining moisture.
- Mulching can increase nutrient content in the soil
- Mulch can contribute to reducing soil erosion
- Mulching contributes to preventing weeds from growing.
- If not used, mulch can be sold to other farmers

Drawbacks

- Despite positive benefits, requires substantial labour inputs, hence the need for on-farm labour resources, or the ability to hire
- Mulch can spoil if not managed correctly
- Considerable quantities of mulch are needed to cover fields.
- Again, if not managed correctly, can harbour pests, diseases and weeds (seeds)
- If over-applied, can result in a toxic environment

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. KP19 Climate Smart Pest and Disease Control for Maize and Sorghum. CCARDESA, Gaborone, Botswana
- CCARDESA 2019. Technical Brief 02. Green Manure. Gaborone, Botswana.
- CCARDESA 2019. Technical Brief 04. Organic Fertilisers. Gaborone, Botswana.
- CCARDESA 2019. Technical Brief 14. Trash Lines. Gaborone, Botswana.

Additional Information

- FAO 2019. Soil cover. Sustainable Agriculture Platform. Rome, Italy.
- Hosbeg N.D. Advantages and disadvantages of mulch. Hosbeg website.
- Farmer's Weekly 2014. Mulching: what is it and how to do it properly. Farmer's Weekly website. South Africa.
- CCAFS 2019. Climate Smart Agriculture 101. CSA Portal. Wageningen, The Netherlands.

Trash Lines

Technical Brief 14

Trash lines are the incorporation of lines of organic materials spread across contours of hilly agricultural fields - strips of heaped straw or weed materials that have been collected during primary cultivation of the land. Trash lines have been found to direct runoff in field and act as an erosion control method. Through decomposition, the trash line material acts as a type of compost adding nutrients to the soil, adding more organic material year on year, should the farmer continue to build this line. This is a climate smart approach as it contributes to soil health, capturing more nutrients and carbon in the soil, and in turn promoting sustainable agricultural productivity. In changing climates, implementation of this practice can contribute to adaptation strategies.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: **Maize** | **Sorghum** | Rice | Livestock | **Other**

Soil texture: **Light** | **Medium** | **Heavy**

Climatic zone: Arid | **Semi-arid** | **Sub-humid** | **Humid**

Water source: **Rainfed** | **Partly irrigated** | **Irrigated**

Annual average rainfall (mm): **< 250** | **250 - 500** | **500 - 750** | **750 - 1000** | 1000 - 1500 | > 1500

Topography: **Flat to gentle slope (0 – 5 %)** | **Moderate to rolling slope (6 – 15 %)** | **Hilly slope (16 – 30 %)** | **Steep slope (> 30 %)**

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | **No**

Characteristics: **Subsistence** | **Commercial Small** | Commercial Medium | Commercial Large

Farm size (ha): **< 2** | **2 to 5** | 5 to 10 | > 10

Mechanisation: **Manual** | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | **Medium (seasonal)** | High (outside labour)

Gender/youth smart (low investment/low labour requirements): **Yes** | No

Financial resources

Initial investment: **Low** | Medium | High

Maintenance Costs: **Low** | Medium | High

Access to finance capital or credit required: Yes | **No**

Enabling Environment

Extension support: Yes | **No**

Access to inputs: Yes | **No**

Market access: Yes | **No**

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | **Medium** | Long

Crop production: Negative | **Neutral** | Positive

Fodder production: Negative | **Neutral** | Positive

Farm income: Negative | **Neutral** | Positive

Household workload: Negative | **Neutral** | Positive

Food security: Negative | **Neutral** | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | **Neutral** | Positive

Biological diversity: Negative | **Neutral** | Positive

Flooding: Negative | Neutral | **Positive**

Crop/livestock water availability: Negative | **Neutral** | Positive

Wind Protection: Negative | **Neutral** | Positive

Erosion control: Negative | Neutral | **Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively undertake trash lines:

- **Step 1:** Collect straw, stalks, picked weed or other organic materials from field or surrounding area.
- **Step 2:** Establish contour lines using method identified in contour planting (Technical Brief 16)
- **Step 3:** Contour lines for trash lines should be spaced between 5 to 10 m apart.
- **Step 4:** Heap straw along contour lines on hilly or sloped fields to be approximately 0.5 m wide and up to 0.3 m in height.
- **Step 5:** Trash should be piled on annually or as the field is prepared. Lines can be maintained for a few years and then decomposed materials can be mixed into the soil.

Technical Brief 14

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Contribute to soil health and therefore agricultural productivity.
- In changing climates, strategies such as this can contribute to retain and improving soil health.
- Helps retain carbon in soil.

SUMMARY/KEY ISSUES

Benefits

- Low cost option for soil and water conservation on sloped fields.
- Increase of organic materials in fields.
- Green manure (Technical Brief 02) production in the field.

Drawbacks

- Increased workload to implement trash lines but low effort to maintain.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 08, Decision Tool: Climate Smart Land Preparation Options.
- CCARDESA, 2019. Technical Brief 02: Green Manuer.

Additional Information

- WOCAT, 2011. Improved trash lines. Uganda.
- The Food and Agriculture Organisation, 2001. Conservation Agriculture Case Studies in Latin America and Africa. Rome, Italy.

Cover Crops

Technical Brief 15

Cover Crops are incorporated into farming systems and planted in between growing seasons with the primary purpose of preventing soil erosion and improving nutrient content, and promoting soil quality in general, rather than being planted as a regular food or cash crop. Cover crops can also be utilised for food stuff, fodder or cash crops; but these outcomes are usually secondary to the main aim of improving/retaining soil quality. An additional benefit from growing cover crops is reduction in weed growth, and pests and diseases; increases in water availability in the soil; and increased soil biodiversity. Additional benefits are recognised from cover crops in areas with steep slopes, as the retained plant cover contributes to reducing erosion. Cover crops can be combined with other practices including intercropping practices and erosion control measures to further enhance soil quality and structure. Incorporating cover crops into farming systems increases farmers resilience to climate impacts through improving soils, reducing fossil fuel consumption, and increasing soil carbon sequestering. Extension guidance can be beneficial when selecting relevant cover crops to achieve the above outcomes.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain
● Maize ● Sorghum ○ Rice ● Livestock ● Other

Soil texture
● Light ● Medium ● Heavy

Climatic zone
● Arid ● Semi-arid ● Sub-humid ○ Humid

Water source
● Rainfed ● Partly irrigated ● Irrigated

Annual average rainfall (mm)
● < 250 ● 250 - 500 ● 500 - 750 ○ 750 - 1000 ○ 1000 - 1500 ○ > 1500

Topography
● Flat to gentle slope (0 – 5 %) ● Moderate to rolling slope (6 – 15 %) ● Hilly slope (16 – 30 %) ● Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action
○ Yes ● No

Characteristics
● Subsistence ● Commercial Small ● Commercial Medium ● Commercial Large

Farm size (ha)
● < 2 ● 2 to 5 ● 5 to 10 ○ > 10

Mechanisation
● Manual ● Animal ● Mechanised

Human resources

Labour intensity – level of effort
○ Low (household) ● Medium (seasonal) ● High (outside labour)

Gender/youth smart (low investment/low labour requirements)
● Yes ○ No

Financial resources

Initial investment
● Low ○ Medium ○ High

Maintenance Costs
● Low ○ Medium ○ High

Access to finance capital or credit required
○ Yes ● No

Enabling Environment

Extension support
● Yes ○ No

Access to inputs
○ Yes ● No

Market access
○ Yes ● No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator	Scale	Selected
Return on Investment Realisation Period	Short / Medium / Long	Medium
Crop production	Negative / Neutral / Positive	Positive
Fodder production	Negative / Neutral / Positive	Neutral
Farm income	Negative / Neutral / Positive	Neutral
Household workload	Negative / Neutral / Positive	Neutral
Food security	Negative / Neutral / Positive	Neutral

Ecological Impacts Positive or Negative

Indicator	Scale	Selected
Soil quality/cover	Negative / Neutral / Positive	Positive
Biological diversity	Negative / Neutral / Positive	Positive
Flooding	Negative / Neutral / Positive	Neutral
Crop/livestock water availability	Negative / Neutral / Positive	Neutral
Wind Protection	Negative / Neutral / Positive	Positive
Erosion control	Negative / Neutral / Positive	Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement cover crops:

- **Step 1:** Research whether locally available crops (especially legumes) provide potential options for cover crops.
- **Step 2:** Establish a demonstration plot could provide farmers with an example of how cover crops function.
- **Step 3:** Plant cover crops between primary crop growing systems to improve soil fertility, quality and nutrients.
- **Step 4:** Monitor soil structure, nutrient levels, and field integrity to ensure efficacy.
- **Step 5:** Incorporate cover crops with other climate smart practices enhance soil, including: Intercropping (Technical Brief 07), Crop Rotations (Technical Brief 09) Reduced/No-tillage Options (Technical Brief 12) etc

Technical Brief 15

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Cover crops improve soil conditions, providing an enabling environment for agricultural productivity.
- In changing climates, cover crops can contribute to adaptation strategies, improving soil health.
- Retains and improves soil quality, including carbon sequestration.

SUMMARY/KEY ISSUES

Benefits

- Cover crops protect soils from erosion and prevent soil nutrient loss.
- Preventing weed growth, control pests and disease, increase water availability in the soil and increase soil biodiversity.
- Cover crops may be non-traditional food crops, fodder and/or cash crops.
- Low cost option for protecting soils and improving soil fertility.

Drawbacks

- May take time to determine suitable to improve soils
- May increase labour demands as new or unfamiliar crops are incorporated into farming systems.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 08, Decision Tool: Climate Smart Land Preparation Options.
- CCARDESA, 2019. Technical Brief 07: Intercropping.
- CCARDESA, 2019. Technical Brief 09: Crop Rotations.
- CCARDESA, 2019. Technical Brief 12: Reduced/ No0-tillage Options.

Additional Information

- CTA, 2000. Website covers crops. Spore 89. CTA Wageningen. The Netherlands.
- WOCAT, 2017. Cover Crops. Kenya.

Contour Planting

Technical Brief 16

Contour planting is a planting strategy for sloping fields, where crop rows follow slope contours rather than planting in rows up- and down-slope. The primary aim of this strategy is to slow the downhill flow of water and encourage the infiltration of water into the soil. Slowing the flow of runoff water reduces soil erosion and therefore also nutrient loss.

Contour Ridges are created by tilling, ploughing or hoeing soil to establish ridges along contour lines, acting as a barrier to downhill water runoff and other erosive processes - the higher the ridge height, the more effective the barrier is to preventing soil erosion. **Contour Strips** involves use of vegetative barriers e.g. planting of strips of grass or hedges and other species to secure soil and further prevent erosion. These practices are labour intense and require extension support, especially as contour lines are not straight but follow slope characteristics, correctly identifying contour lines is important and can be done using the 'low-technology' options that are identified in the Technical Application section of this Technical Brief.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | Medium | Long

Crop production: Negative | Neutral | Positive

Fodder production: Negative | Neutral | Positive

Farm income: Negative | Neutral | Positive

Household workload: Negative | Neutral | Positive

Food security: Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | Positive

Biological diversity: Negative | Neutral | Positive

Flooding: Negative | Neutral | Positive

Crop/livestock water availability: Negative | Neutral | Positive

Wind Protection: Negative | Neutral | Positive

Erosion control: Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively undertake contour planting:

- **Step 1:** Construct an A-frame that has a plumb-line with a rock hanging down the centre. The base of the A-frame should be 90 cm. See Figure 1.
- **Step 2:** Calibrate the A-frame on flat ground. Ensure that both legs are on the ground. Mark where the plumb line meets the cross bar.
- **Step 3:** On a slope, working perpendicular to the slope, plant one leg of the A-frame and swing the other leg around until the plumb line meets the mark on the cross bar. Drive a stake into the ground where the first 'planted' leg is and continue the process across the slope.
- **Step 4:** Once the extent of the contour has been staked, tie a string from post-to-post across the slope; this identifies the contour to be planted.
- **Step 5:** Plant selected crops, develop contour ridges or plant contour strips along the contour line.
- **Step 6:** Subsequent contours should be spaced 3-5 m up or downhill of the preceding contour line. To determine the length between contour lines, measure off the top of each stake to a stake up or downhill with a tape measure or accurately measured third stick.
- **Step 7:** Contour ridges can be implemented like Water Spreading Bunds (Technical Brief 28) to form ridges of soil that are formed by tilling or ploughing and can be left after land preparation to further prevent erosive forces. Crops can be planted between these ridges.
- **Step 8:** The planting of contour strips can be implemented by planting grasses or hedges 20 m (shallow slopes) to 10 m (steeper slopes) apart up or downhill, similar to Trash Lines (Technical Brief 14). This intercropping allows for erosion control and can be used as fodder for livestock.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Retaining soil structure enables farmers, particularly those planting on sloping fields to maintain productivity.

This land management practice aid farmers to maintain soil structure in the face of changing climates and shifting rainfall patterns.

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

SUMMARY/KEY ISSUES

Benefits

- Contour planting prevents erosion on sloped fields and efficiently trap runoff water.
- Contour planting improved water infiltration and contour ridges improve water retention.
- Contour planting can be integrated with intercropping contour strips of grass or hedges to help maintain soil structure.

Drawbacks

- Contour lines are extremely labour intensive and take a significant amount of time to implement.
- During contour measuring and development, land may be exposed to erosive forces.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 08, Decision Tool: Climate Smart Land Preparation Options.
- CCARDESA, 2019. Technical Brief 14: Trash Lines.
- CCARDESA, 2019. Technical Brief 28: Water Spreading Bunds.

Additional Information

- The Food and Agriculture Organisation, 1992. The Food and Agriculture Organisation. Soil and Water Conservation (SWC) Technologies and Agroforestry Systems. Rome, Italy.
- The Food and Agriculture Organisation, 2003. Soil and Water Conservation, With a Focus on Water Harvesting and Soil Moisture Retention. Rome, Italy.

Agroforestry : Alley Cropping

Agroforestry is a land management practice that combines the planting and management of trees and shrubs with crops and pasture, providing benefits of soil health, crop yields, resilience to climate change, biodiversity and economic opportunities. Agroforestry encompasses numerous practices, including silvo-pasture, agro-silvo cultural, and agro-silvo-pastural. One successful agro-silvo-cultural practice is alley cropping, where the farmer plants rows of trees, shrubs or hedges between crop rows. Usually hedges comprise leguminous plants intended to fix nitrogen in the soil and provide leaf litter and prunable biomass. The hedges are pruned with the pruned material spread on the ground, to reduce shading and competition with the primary crop. Timing of pruning is important to ensure that the pruned biomass releases nutrients to the soil at a time when the primary crop needs them for maximum crop productivity; e.g. when alley-cropping maize, the pruned biomass needs to breakdown with and release beneficial nutrients into soil from two and eight weeks after planting the maize crop. This approach has proven to be highly successful, with examples in Malawi where gliricidia was alley-cropped with maize where the prunings created a three-fold increase in maize production, which was increased a further 29 % when fertilisers were added. This fertilisation could be achieved with green manure, and other climate smart soil amendment approaches. The space and number of hedge rows to primary crop is dependent upon the field size and the regular growth height of the shrub/hedge. The hedge must not be planted so close that it shades the primary crop. In larger fields, larger deep-rooted timber trees can be planted between groups of rows of primary crop, providing soil benefits, reducing wind-speeds/erosion, and providing timber products.

This approach is considered climate smart as it increases productivity, provides a mechanism for more climate resilient farming, whilst increasing soil carbon levels.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

(● = applicable, ○ = not applicable)

Value chain: ● Maize ● Sorghum ○ Rice ● Livestock ● Other

Soil texture: ● Light ● Medium ● Heavy

Climatic zone: ○ Arid ○ Semi-arid ● Sub-humid ● Humid

Water source: ● Rainfed ● Partly irrigated ● Irrigated

Annual average rainfall (mm): ○ < 250 ○ 250 - 500 ○ 500 - 750 ● 750 - 1000 ● 1000 - 1500 ● > 1500

Topography: ● Flat to gentle slope (0 – 5 %) ● Moderate to rolling slope (6 – 15 %) ● Hilly slope (16 – 30 %) ● Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: ○ Yes ● No

Characteristics: ● Subsistence ● Commercial Small ● Commercial Medium ○ Commercial Large

Farm size (ha): ● < 2 ● 2 to 5 ● 5 to 10 ● > 10

Mechanisation: ● Manual ● Animal ● Mechanised

Human resources

Labour intensity – level of effort: ○ Low (household) ○ Medium (seasonal) ● High (outside labour)

Gender/youth smart (low investment/low labour requirements): ● Yes ○ No

Financial resources

Initial investment: ○ Low ● Medium ○ High

Maintenance Costs: ● Low ○ Medium ○ High

Access to finance capital or credit required: ○ Yes ● No

Enabling Environment

Extension support: ● Yes ○ No

Access to inputs: ○ Yes ● No

Market access: ○ Yes ● No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator			
Return on Investment Realisation Period	Short	**[Medium]**	Long
Crop production	Negative	**[Neutral]**	Positive
Fodder production	Negative	Neutral	**[Positive]**
Farm income	Negative	**[Neutral]**	Positive
Household workload	Negative	**[Neutral]**	Positive
Food security	Negative	**[Neutral]**	Positive

Ecological Impacts Positive or Negative

Indicator			
Soil quality/cover	Negative	Neutral	**[Positive]**
Biological diversity	Negative	Neutral	**[Positive]**
Flooding	Negative	Neutral	**[Positive]**
Crop/livestock water availability	Negative	**[Neutral]**	Positive
Wind Protection	Negative	Neutral	**[Positive]**
Erosion control	Negative	Neutral	**[Positive]**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

While agroforestry practices are deemed highly beneficial and climate smart, it is important to ensure that proposed practices are appropriate for the specific context – the benefits of the agroforestry practice match the needs of the farmer - and are fit for purpose. Obtain advice from an agroforestry expert before embarking on secondary crop/hedge species selection.
To effectively implement alley-cropping the following should be carried out:

- **Step 1:** Clearly understand the objectives of the intervention and identify an appropriate species for intercropping. For maize and sorghum in a smaller subsistence farm setting, selection and growth of hedge rows of a legumes such as cowpea or Gliricidia can provide sustainable benefits in terms of soil quality and secondary fodder/food products. In larger fields, timber trees can be planted every five to ten crop rows, depending on the height of the mature tree, and the shade-tolerance of the crop.
- **Step 2:** Identify and understand key conditions, such as prevailing wind direction, and sunlight to ensure that the field is planted in an appropriate configuration, with primary crop and secondary (hedge/shrub/tree) crops planted in such a way as to benefit the primary crop and not compete with it. East to west row orientation should maxmise sunlight, topography permitting.
- **Step 3:** For beneficial hedgerow growth with legume species such as Leucaena, cliricidia, and Sesbania sesban, the trees should be planted in rows between two and four metres apart, with individual trees planted as close as possible - between 10 to 15 cm apart. If planted closely, the trees will favour leaves over step growth, creating more mulch to prune for cover. Note that if rows are planted too closely, the secondary crop can dominate the available crop land reducing productivity. Furthermore, the closer the hedges, the more shade will present, which can depress crop growth, and also start to compete for soil water and nutrients, which is not beneficial.
- **Step 4:** Once reaching sufficient maturity, after approximately six months (one-metre tall for legumes)– hedges should be pruned to generate mulch for working into the soil. Then the primary crop (maize) can be planted. Pruning once per month thereafter provides cover and ensures that light penetration is maintained. Planting legumes approximately six months before planting the primary crop can ensure that sufficient pruned material is available to incorporate into the soil to enhance growth.
- **Step 5:** After harvesting the primary crop, hedgerows can be left to grow taller so that shade reduces weed grown, and to develop material to prune and incorporate into the soil again during the following crop cycle. However, hedges should not be allow to grow too high or dense as their roots will dominate the soil and out-compete primary crops for water and nutrients.

Before implementing any of these technologies, further research may be required beyond the guidance provided here. The World Agroforestry Centre (ICRAF) has many resources, toolkits and success stories that can support such research.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Alley cropping and pruning of leguminous hedges increases productivity of primary crops such as maize.
- Helps farmers to be more resilient to climate change, by sustaining productivity and controlling soil health, especially when faced with changing climates.
- The planting of alley hedge rows of legumes and the introduction of pruned material contributes more carbon to the soil.

SUMMARY/KEY ISSUES

Benefits

- Trees, shrubs, and hedges are incorporated into farming systems and have many different biophysical and socio-economic benefits
- Use of leguminous hedges no only provides pruned materials to provide cover, but they also help fix nitrogen in the soil.
- Hedges planted in alleys can also provide other benefits such as edible seed pods for human or animal consumption.
- Hedges and trees can reduce soil erosion from run-off or wind erosion.
- Alley cropping can provide opportunities for diversified income – selling secondary crops and/or timber.
- Alley cropped timber trees can provide building materials fire wood.

Drawbacks

- Initial labour requirements will likely be significant; however, this will be primarily at the earlier stages of the intervention.
- Ongoing maintenance such as pruning and maintenance of hedges will be needed, although relatively minimal.
- There may be some costs involved in obtaining hedge seedlings.
- Use of trees rather than hedges and shrubs introduces more labour, but yields more benefits.

REFERENCE MATERIAL

CCARDESA Related Content

- Centre for Coordination of Agricultural Research & Development for Southern Africa (CCARDESA), 2019. Knowledge Product 12, Decision Tool: Climate Smart Agroforestry Options for Maize, Sorghum & Rice.

Additional Information

- The Food and Agriculture Organisation (FAO), 2015. Agroforestry Definition. Rome, Italy.
- FAO, 2013. Agroforestry, food and nutritional security. Rome, Italy
- Muschler, R.G. 2016. Agroforestry: Essential for Sustainable and Climate-Smart Land Use. Chapter in: Pancel L, Köhl M (eds.) 2016. Tropical Forestry Handbook. 2nd ed. Springer-Verlag. Pp. 2013-2116. 2 Volumes. 3633 pp.
- Rahman, S., 2018. Agroforestry: Why don't farmers plant more trees? Forest News Website. CIFOR
- University of Missouri Centre for Agroforestry, 2015. Agroforestry Academy: Chapter 3: Alley Cropping. University of Missouri, Columbia, Missouri, USA.

Terracing

Technical Brief 18

Terraces are cross-slope barriers that have been cut into slopes offering surfaces that are flat or slightly sloped. Terraces are designed to minimise erosion and increase the infiltration of runoff water. In addition, terracing allows for a maximum of area for farming and cropping by cutting into slopes, creating steps on a hillside. Riser walls are retained by growing trees or grasses, using stones or compacted soil to manage runoff and ensure stability. Terracing involves significant planning and labour to implement and maintain. Labour should be coordinated and planned to ensure that terracing is not carried out in an ad hoc manner, and labour to maintain the terraces is available annually. Terracing is suited to areas with severe erosion hazards, deep soils, on slopes that do not exceed 25 degrees and are not too stony. Community action is often required, as terracing is a landscape-level solution that can only be implemented if all parties agree and convert slopes together. Implementing individual terraces or terraced sections can negatively impact the entire hillside.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

● Maize ● Sorghum ● Rice ○ Livestock ● Other

Soil texture

○ Light ● Medium ● Heavy

Climatic zone

○ Arid ○ Semi-arid ● Sub-humid ● Humid

Water source

● Rainfed ● Partly irrigated ○ Irrigated

Annual average rainfall (mm)

○ < 250 ○ 250 - 500 ● 500 - 750 ● 750 - 1000 ● 1000 - 1500 ● > 1500

Topography

○ Flat to gentle slope (0 – 5 %) ○ Moderate to rolling slope (6 – 15 %) ● Hilly slope (16 – 30 %) ● Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

● Yes ○ No

Characteristics

● Subsistence ● Commercial Small ○ Commercial Medium ○ Commercial Large

Farm size (ha)

● < 2 ● 2 to 5 ● 5 to 10 ● > 10

Mechanisation

● Manual ● Animal ○ Mechanised

Human resources

Labour intensity – level of effort

○ Low (household) ○ Medium (seasonal) ● High (outside labour)

Gender/youth smart (low investment/low labour requirements)

○ Yes ● No

Financial resources

Initial investment

○ Low ○ Medium ● High

Maintenance Costs

○ Low ○ Medium ● High

Access to finance capital or credit required

● Yes ○ No

Enabling Environment

Extension support

● Yes ○ No

Access to inputs

○ Yes ● No

Market access

○ Yes ● No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period

Short | Medium [boxed] | Long [boxed]

Crop production

Negative | Neutral | Positive [boxed]

Fodder production

Negative | Neutral [boxed] | Positive

Farm income

Negative | Neutral [boxed] | Positive

Household workload

Negative [boxed] | Neutral | Positive

Food security

Negative | Neutral [boxed] | Positive

Ecological Impacts Positive or Negative

Soil quality/cover

Negative | Neutral | Positive [boxed]

Biological diversity

Negative | Neutral [boxed] | Positive

Flooding

Negative | Neutral [boxed] | Positive

Crop/livestock water availability

Negative | Neutral | Positive [boxed]

Wind Protection

Negative | Neutral [boxed] | Positive

Erosion control

Negative | Neutral | Positive [boxed]

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively approach to terracing construction:

- **Step 1:** Measure slope angle – should not exceed 25 degrees and soils should be at least 0.5 metres deep. See diagram below for calculating slope.
- **Step 2:** Plot the contours – see Technical Brief 16 Contour Planting for instructions for staking-out contours, and the diagram below for use of a t-stick to measure the distance between contours.
- **Step 3:** Start at the lowest terrace. Dig a trench vertically below the next contour, and then dig outwards to the lowest contour. Remove soil and place downhill below the lowest contour.
- **Step 4:** Compact soil on constructed terrace.
- **Step 5:** Work should then progress upslope, emptying top-soil on to the terrace below to provide soil for planting.
- **Step 6:** Strengthen riser buttress walls (back-walls) with stones, compacted soil, or by planting grass or trees.
- **Step 7:** Terrace-end drainage should also be considered, so water does not pool too heavily. The down-field gutters can be lined with stones to reduce erosion

Detailed diagrams and tables for calculating terrace dimensions are provided in Peace Corps 1986, Soil conservation techniques for hillside farming.

Additional guidance can be sought from videos provided by Access Agriculture: SLM02 Fanya Juu terraces. The Kenyan example provided is also up-slope terrace construction but using a different method where a trench is dug, and the loose topsoil is thrown up-hill (fanya juu in Kiswahili) which forms a ridge that flattens over time.

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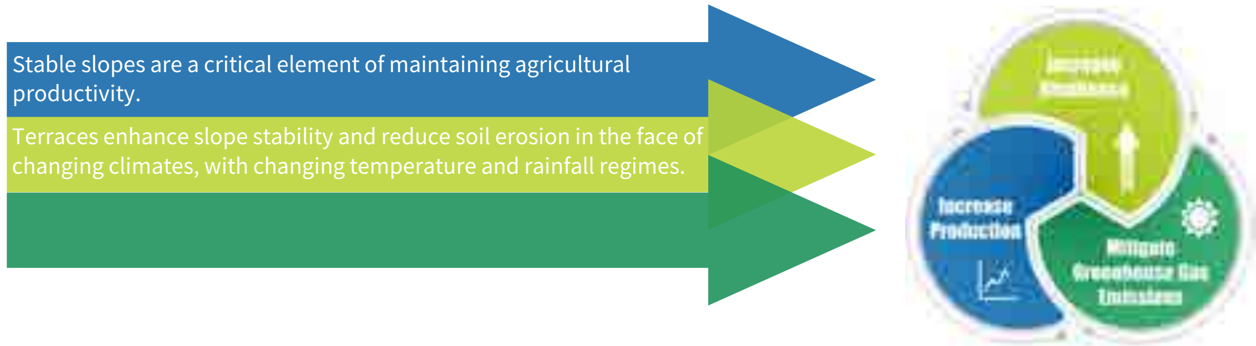
CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Terracing prevents erosion and can act as a rainfed irrigation system
- Terracing is a labourious process to implement and takes significant effort to maintain.

Drawbacks

- Requires professional advice on implementing terracing
- If implemented incorrectly, can have negative impacts including more erosion than without terracing

REFERENCE MATERIAL

CCARDESA Related Content

- Centre for Coordination of Agricultural Research & Development for Southern Africa (CCARDESA), 2019. Knowledge Product 08, Decision Tool: Climate Smart Land Preparation Options.

Additional Information

- The Food and Agriculture Organisation, 1990. Watershed management field manual. Continuous Types of Terraces. Rome, Italy.
- The Food and Agriculture Organisation, 2011.Cross – Slope Barriers. Rome, Italy.
- Journal of Environmental Engineering and Landscape Management, 2010. Ridged terraces – functions, construction and use. Taylor and Francis Online website.
- WOCAT, 2017. Terracing on the hill slop areas. Tajikistan.
- Peace Corp 1986. Soil conservation techniques for hillside farms. Washington DC.
- Shamba Shape-up Series 1, Episode 2, 2012. Arid Farming, Irrigation, Ploughing.
- Access Agriculture: Sustainable Land Management 02. Fanya Juu terraces. Countrywise Communication, CIS Vrije Universiteit Amsterdam.

Weed Control

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Weeds are any unwanted plant species that compete with crops for sunlight, water, nutrients, air and space, hindering crop growth and in some cases are even toxic to crop plants. Weed control measures can be applied in an integrated manner to help prevent the growth and spread of weeds in agricultural systems. An integrated weed management approach aims to restrict weed growth until a crop is well established and can outcompete weeds. This integrated approach includes biological, chemical, cultural and/or physical tactics to combat weed spread and growth and these practices can be more cost effective than herbicide applications. Integrated weed management is climate smart as it combines multiple climate smart practices that increase farmers resilience, limits GHG releases and increases productivity. Options for weed control include crop rotation, intercropping, cover crops (which can be used as green manure or mulch), mulching, seed-bed preparation, livestock grazing, seed/variety selection, mowing, and hand-weeding.

The application of integrated weed control is climate smart as it reduces herbicide application and reduction in machinery usage (i.e. through no-tillage practices).

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | No

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator	Scale	Selected
Return on Investment Realisation Period	Short – Medium – Long	Short, Medium
Crop production	Negative – Neutral – Positive	Neutral
Fodder production	Negative – Neutral – Positive	Neutral
Farm income	Negative – Neutral – Positive	Positive
Household workload	Negative – Neutral – Positive	Neutral
Food security	Negative – Neutral – Positive	Positive

Ecological Impacts Positive or Negative

Indicator	Scale	Selected
Soil quality/cover	Negative – Neutral – Positive	Positive
Biological diversity	Negative – Neutral – Positive	Positive
Flooding	Negative – Neutral – Positive	Neutral
Crop/livestock water availability	Negative – Neutral – Positive	Neutral
Wind Protection	Negative – Neutral – Positive	Neutral
Erosion control	Negative – Neutral – Positive	Neutral

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

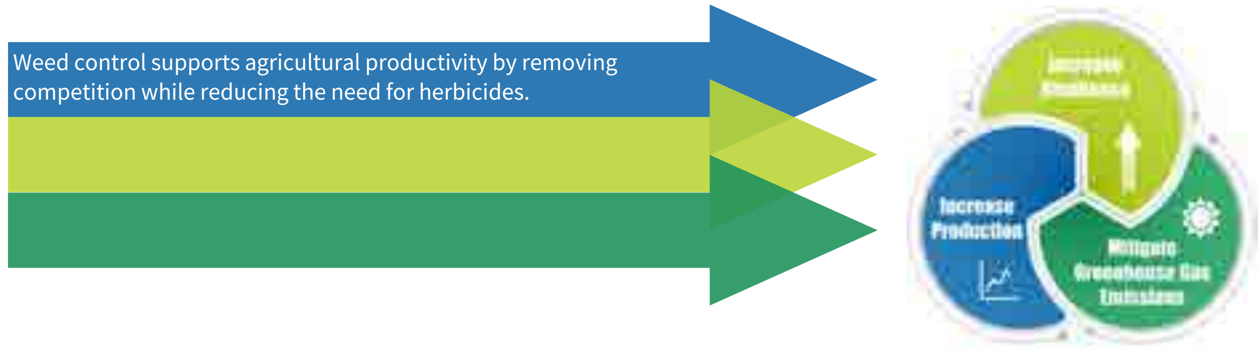
TECHNICAL APPLICATION

To effectively undertake weed control measures:

- **Step 1:** Review weed control measures - crop rotation, intercropping, cover crops, mulching, seed-bed preparation, livestock grazing, seed/variety selection, mowing, hand-weeding and adjustments to tillage practices - and determine which methods are available and appropriate for the farming system and farmer. Two or more of these techniques can be applied to assist in ensuring farmers have more chance of success. Understand possible negative impacts of each weed control method.
- **Step 2:** Improve weed identification knowledge in specific areas.
- **Step 3:** Prevent weeds from spreading – clean clothes, animals, machinery, vehicles to limit weed transport; use only well stored/rotted manure (4-5 months) (Knowledge Product 16), include fencing, irrigation and other farm 'breaks' where possible
- **Step 4:** Apply a combination of weed control methods including – cover crops (Technical Brief 15), mulching, intercropping (Technical Brief 07), crop rotation (Technical Brief 09), livestock grazing, seed selection (Technical Brief 20), mowing, hand-weeding. Try to avoid the application of herbicides, tillage and burning.
- **Step 5:** monitor and document most effective weed management strategies for each farmer, and use lessons learned from the area with other farmers where applicable.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Integrated weed management involves employing two or more climate smart practices.
- Reduced consumption of chemicals
- Cost effective methods that do not require additional inputs.

Drawbacks

- More time consuming than applying herbicides or other more destructive methods.
- Strategy requires careful planning
- May not be 100% effective

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 08, Decision Tool: Climate Smart Land Preparation Options.
- CCARDESA, 2019. Technical Brief 07, Intercropping.
- CCARDESA, 2019. Technical Brief 09, Crop Rotation.
- CCARDESA, 2019. Technical Brief 12, No Tillage.
- CARDESA, 2019. Technical Brief 15, Cover Crops.
- CCARDESA, 2019. Technical Brief 20, Variety Selection.

Additional Information

- The Food and Agriculture Organisation (FAO), 2019. Integrated Weed Management (IWM). Rome, Italy.
- Food and Organisation (FAO), 2006. Recommendations for improved weed management. Rome, Italy.
- Crop Life International, 2012. Implementing Integrated Weed Management for Herbicide Tolerant Crops.

Crop Variety Selection

Selecting crop varieties is a key resilience strategy for farmers facing changing climatic conditions. There are two types of seed varieties: traditional varieties and improved varieties. Traditional varieties have been selected by farmers for their special characteristics and due to many years of selecting the strongest seeds over generations, they are generally adapted to local natural conditions. In some respects, these seeds increase the chance of getting a return on investment in stable environments, but are less likely to mitigate GHG emissions. Traditional crop varieties are usually selected by small scale farmers due to their relatively low cost and availability and can be saved and replanted for further growing seasons. Improved varieties are seeds that have been altered by scientific processes to incorporate desired characteristics using techniques such as following pure line breeding, classical breeding, hybridisation and molecular breeding. Desirable characteristics include higher yields, shorter growing seasons, drought resistance, salt tolerance, etc. Improved varieties are selected when facing adverse conditions such as higher temperatures and/or less predictable rainfall and normally result in the efficient use of water reducing use of energy for irrigation systems. While these seeds offer improvements they are usually commercial products and as a result can be expensive. Furthermore, as they are sold by seed companies availability is driven by demand. Most seed companies protect enhancements using intellectual property rights that legally limit seed saving and replanting of seeds. In fact, many of these seed varieties have been designed to prevent plants to be reseeded. Thus, seed varieties afford farmers the opportunity to incorporate crops that can be planted to exploit their unique characteristics – traditional or improved, assisting farmers to grow crops that are resilient to changing climates to produce crops that are market-appropriate.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain
Maize | Sorghum | Rice | Livestock | Other

Soil texture
Light | Medium | Heavy

Climatic zone
Arid | Semi-arid | Sub-humid | Humid

Water source
Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)
< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography
Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action
Yes | No

Characteristics
Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)
< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation
Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort
Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)
Yes | No

Financial resources

Initial investment
Low | Medium | High

Maintenance Costs
Low | Medium | High

Access to finance capital or credit required
Yes | No

Enabling Environment

Extension support
Yes | No

Access to inputs
Yes | No

Market access
Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | Medium | Long

Crop production: Negative | Neutral | Positive

Fodder production: Negative | Neutral | Positive

Farm income: Negative | Neutral | Positive

Household workload: Negative | Neutral | Positive

Food security: Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | Positive

Biological diversity: Negative | Neutral | Positive

Flooding: Negative | Neutral | Positive

Crop/livestock water availability: Negative | Neutral | Positive

Wind Protection: Negative | Neutral | Positive

Erosion control: Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively undertake leverage traditional seed characteristics, or improved crop varieties the following should be carried out:

- **Step 1:** Prior to selecting seed varieties, perform a Cost Benefit Analysis (CBA) to identify how crops will perform and their benefits compared to the costs of the seed, considering the following:
  - o Local farming system(s): land availability per household, crops traditionally grown, access to inputs such as fertilisers,
  - o Local environmental conditions: soil conditions, disease, pests, climatic conditions, occurrence of flooding/droughts and other natural disasters.
  - o How climate change has impacted or will impact the farming system and how crop variety selection can be a climate- smart practice.
  - o Local access to seeds – is seed collected at the householder level, do neighbours exchange seeds, do farmers have access to commercially produced seeds? Are the costs for accessing commercial, improved seeds manageable or prohibitive?

  The CBA should weigh the benefits of a new seed against perceived actual or transactional costs for selecting a new seed.
- **Step 2:** Obtain information and guidance from local experts, lead farmers, and government regarding best varieties to grow.
- **Step 3**: Evaluate results of the CBA and select appropriate seeds that match the farm system/requirements, and available financial resources/access to credit.
- **Step 4:** Plant test plots of selected seeds to understand if benefits are realised and demonstrate outcomes with farmers, showing possible alternatives and discuss implementation.
- **Step 5:** Following full demonstration and discussion with farmers, implement at farm level – planting the first crop in accordance with guidance provided by seed provider, or traditional knowledge.

Consider in-country seed sources to access different varieties through local extension or research services. When buying seeds ensure that the seeds are adequately dry and look for seed that is certified by a national seed laboratory to ensure that the variety is the highest quality possible. Seeds should be properly stored to avoid high temperatures and humid air to reduce chances of early germination.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Selecting improved seed varieties allows the farmer to maintain agricultural productivity as the climate changes.

Selection of improved varieties may assist farmers adapt agricultural production to assist adaptation to climate change.

SUMMARY/KEY ISSUES

Benefits

- Exploring crop variety is a key way for farmers to grow more resilient crops within the context of changing climatic conditions. Drought resistant or faster maturing varieties, for example, allow you to respond to reduced rainfall conditions.
- Improved crop varieties have been altered by scientific processes to incorporate desired characteristics
- Understanding local context is important when researching the best crop variety for the area.

Drawbacks

- Improved crop varieties are commercially sold and can be expensive as they often require additional inputs (inorganic fertilisers etc.)
- Traditional crops have generally adapted to local climatic and landscape conditions, are widely available and are cost effective for local populations; however, these varieties may not be resilient to climatic changes, and are less likely to mitigate GHG emissions.

REFERENCE MATERIAL

CCARDESA Related Content

- Centre for Coordination of Agricultural Research & Development for Southern Africa (CCARDESA), 2019. Knowledge Product 09, Decision Tool: Climate Smart Seed Selection for Sorghum, Maize & Rice Options.

Additional Information

- Food and Agriculture Organisation (FAO), 2014. Appropriate Seed Varieties for Small-scale Farmers. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2005. Horticulture Marketing. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2014. Management of Crop Diversity. Rome, Italy.

Saving Seeds

The process of saving one's own seed involves the collection of seeds from the best performing (most yield, largest size, early maturing or other desired traits, etc.) plants from one season to plant them in the next cropping season. The aim of this practice is to select seed from parent plants in the hope that desired characteristics are replicated in the next generation of plants. Seeds that have been selected will likely be adapted to local farming conditions including soil types and rainfall amounts. The seed most likely to carry intergenerational traits (size, colour, water use efficiency, and other biophysical traits) are open-pollinated (those plants pollinated by birds, insects, wind, etc.) seed varieties as they are cross-pollinated by the same type of crop. Different crops have different reproduction cycles with some species flowering or producing seeds annually, biennially or on a perennial basis. Thus, understanding seeding time is important for farmers aiming to save their own seeds. Almost as important as selecting the correct seeds is seed storage, which must be done correctly to avoid spoiling and losses. Seed saving is a cost-effective measure for farmers to employ and helps them avoid having to buy seeds at market on an annual basis. Seed trading or community seed banks provide a climate resilience strategy as they secure farmers access and availability of diverse, locally adapted crops and varieties while enhancing indigenous knowledge. Often crops from hybrid seeds or improved varieties do not generate viable seeds ensuring that seeds cannot be saved and must be purchased on an annual basis.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | No

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator			
Return on Investment Realisation Period	**[Short]**	**[Medium]**	Long
Crop production	Negative	Neutral	**[Positive]**
Fodder production	Negative	**[Neutral]**	Positive
Farm income	Negative	Neutral	**[Positive]**
Household workload	Negative	**[Neutral]**	Positive
Food security	Negative	Neutral	**[Positive]**

Ecological Impacts Positive or Negative

Indicator			
Soil quality/cover	Negative	**[Neutral]**	Positive
Biological diversity	Negative	Neutral	**[Positive]**
Flooding	Negative	**[Neutral]**	Positive
Crop/livestock water availability	Negative	**[Neutral]**	Positive
Wind Protection	Negative	**[Neutral]**	Positive
Erosion control	Negative	**[Neutral]**	Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively undertake seed saving:

- **Step 1:** Communicate with national agricultural extension and local farmers regarding seed harvesting timing and practices for local crop species.
- **Step 2:** Clear field and sow desired crop using climate smart agriculture practices.
- **Step 3**: Monitor plant life cycle and ensure that seeds are extracted correctly and are not spoiled in the process. Employ local expertise to ensure seed harvesting is carried out correctly.
- **Step 4:** Post-harvest, seeds should be adequately dried and then transferred to proper storage facilities.
- **Step 5:** store seeds in dry, cool, and dark locations. This will prevent them from spoil. Different strategies for seed storage are implemented around the region so local expertise should be sought**.**
- **Step 6:** Ensure that pests are excluded from storage areas to prevent loss or spoil (Technical Brief 61-65).
- **Step 7:** Community seed banks or seed trading should be established to allow farmers to integrate different varieties into their farming system that are resilient to local climatic conditions

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Can reduce losses from pests and diseases.
- More predictable yields.
- N/A.

SUMMARY/KEY ISSUES

Benefits

- Climate resilient method for crop diversification.
- Many farmers have been using this technique for generations and this should be encouraged.
- Cost effective method for sustainable crop growth.

Drawbacks

- Attention must be closely paid to plant lifecycle and seeds should be collected at appropriate time.
- Storage methods should be employed to manage pests and rot.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 9, Decision Tool: Climate Smart Seed Selection for Sorghum, Maize & Rice.
- CCARDESA, 2019. Technical Brief 65: Integrated Pest Control Management.
- CCARDESA, 2019. Technical Brief 61: Bottle Traps.
- CCARDESA, 2019. Technical Brief 62: Encouraging natural predators.
- CCARDESA, 2019. Technical Brief 63: Use of organic or chemical control.
- CCARDESA, 2019. Technical Brief 64: Flooding.
- CCARDESA, 2019. Technical Brief 65: Integrated Pest Management.

Additional Information

- The Food and Agriculture Organisation (FAO), 2014. Appropriate Seed Varieties for Small-scale Farmers. Rome, Italy.
- Biodiversity International (2018), Seeds of adaptation. CIFOR.

Solar Irrigation

Technical Brief 22

Solar irrigation systems utilise solar energy to pump water to fields and distribute it through drip irrigation or other systems. Solar irrigation is a low-emission agricultural technology that replaces fossil fuel irrigation pumps reducing greenhouse gas emissions. This approach has the potential to reduce energy costs for irrigation and provide energy independence in rural areas. It provides opportunities to increase productivity by shifting from rainfed to irrigated agriculture in some areas. Solar irrigation systems require intensive management and regular monitoring to ensure the sustainable use of water resources. It requires maintenance of solar panels and irrigation equipment but can quickly yield a positive return on investment. Solar irrigation can be implemented for crop irrigation and livestock watering schemes and can improve food security, produce high value crops for sale, reduce energy costs and drive rural development. Although an expensive technology, solar irrigation can introduce significant operational savings if managed and maintained appropriately. It is considered a climate smart option as it can increase productivity, enable farms to adapt t climate changes and improve resilience, and the use of solar power reduces the use of on-grid, or diesel generator power, reducing emissions.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | Medium | Long

Crop production: Negative | Neutral | Positive

Fodder production: Negative | Neutral | Positive

Farm income: Negative | Neutral | Positive

Household workload: Negative | Neutral | Positive

Food security: Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | Positive

Biological diversity: Negative | Neutral | Positive

Flooding: Negative | Neutral | Positive

Crop/livestock water availability: Negative | Neutral | Positive

Wind Protection: Negative | Neutral | Positive

Erosion control: Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

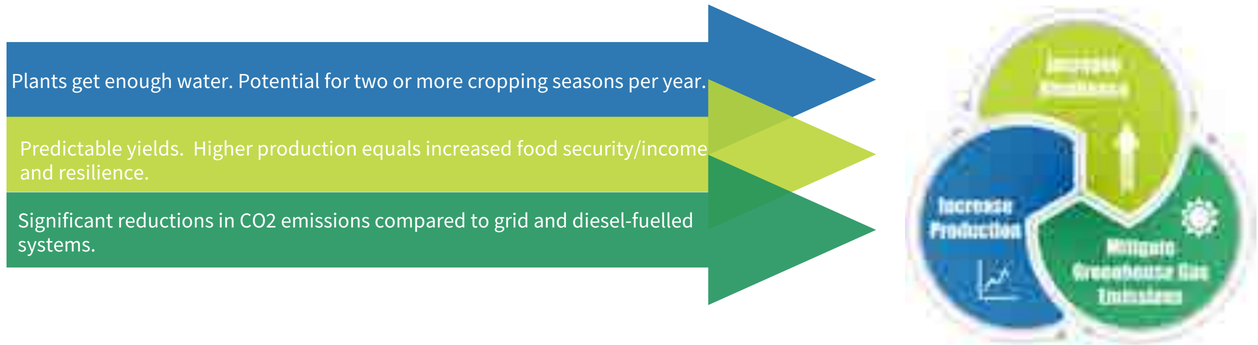
To effectively implement solar irrigation:

- **Step 1:** To determine the solar pump system Crop water requirements, location, water sources etc. Do required research. Is water sourced from an above ground or below ground source?
- **Step 2:** Source required materials to implement a solar irrigation system from regional or international suppliers including:
  - Photovoltaic (PV) panels to generate electricity (80-300 W system depending on context);
  - a structure to mount the panels;
  - a pump controller;
  - a surface or submersible water pump; and
  - a distribution system or storage tank for water.
- **Step 3:** Identify funding sources as initial costs, as well as maintenance costs, must be considered and modelled prior to purchasing a system. There are regional and international solar irrigation producers. These costs differ dramatically given the complexity of the context, starting at costs approximately USD $2,400 for equipment only. If drilling is necessary the cost increases significantly depending on depth, substrate etc. Community-based investment, micro-leasing and rental services can be possible funding models to explore.
- **Step 4:** Determine whether there is sufficient solar irradiation for the proposed area – consult and specialist; and/or the national meteorological service.
- **Step 5:** Identify area suitable to install solar panels. The area should be easily accessible, and all trees/bush should be cleared. To determine most appropriate site and angle of panels, etc, consult an expert.
- **Step 6:** The availability of technical expertise must be considered before implementation to ensure that any technical issues do not result in long period of service disruption.

Maintenance costs and expertise should be considered before installing solar irrigation systems. A detailed cost benefit analysis is advisable. Other key technical considerations include: Legal permits to extract water from the source as water extraction may impact community watershed levels.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Energy independence will introduce significant cost savings for farmers
- Solar powered irrigation can significantly boost productivity, due to increased ability to sustainably irrigate crops
- Consistent irrigation can help to mitigate climate impacts, and aid adaptation
- Reduces operational costs for diesel or on-grid power to pump water
- Reduces greenhouse gas emissions.

Drawbacks

- Solar irrigation is expensive to implement and there are costs for maintenance. Therefore, savings or access to credit will be required.
- Access to solar equipment, spares and parts, and the transportation of the above may be complicated and/or expensive.
- Over and above cost and access technology, other issues such as access to land and water sources are important factors.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 10, Decision Tool: Climate Smart Water Management Options for Maize & Sorghum. Gaborone, Botswana
- CCARDESA, 2019. Knowledge Product 11, Decision Tool: Climate Smart Water Management Options for Rice. Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 64, Flood Irrigation. Gaborone, Botswana

Additional Information

- The Food and Agriculture Organisation (FAO), 2018. Water Scarcity Initiative (WSI), Solar Powered Water Lifting for Irrigation in the Nile Delta, Egypt. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2018. Solar–Powered Irrigation Systems: A clean – energy, low – emission option for irrigation development and modernisation. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2018. The benefits and risks of solar-powered irrigation – a global overview. Rome, Italy.

Supplemental Irrigation

Supplemental irrigation (SI) , also referred to as Deficit Irrigation, is the application of water below full crop-water requirements, generally in drylands to assist crop growth in areas that experience low rainfall (300-500 mm/year). Supplemental irrigation involves adding limited amounts of water to rainfed crops to improve and stabilise yields when rainfall is insufficient for plant growth. Supplemental irrigation is a valuable and sustainable production strategy in dry regions or when experiencing irregular climatic conditions. This practice requires understanding of the yield response to water and the economic impact of loss in harvest. The aim of this technique is to ensure that the minimum amount of water is available during critical stages of crop growth.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | No

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator			
Return on Investment Realisation Period	Short	**Medium**	Long
Crop production	Negative	Neutral	**Positive**
Fodder production	Negative	Neutral	**Positive**
Farm income	Negative	Neutral	**Positive**
Household workload	Negative	Neutral	Positive
Food security	Negative	**Neutral**	**Positive**

Ecological Impacts Positive or Negative

Indicator			
Soil quality/cover	Negative	**Neutral**	Positive
Biological diversity	Negative	**Neutral**	Positive
Flooding	Negative	**Neutral**	Positive
Crop/livestock water availability	Negative	**Neutral**	Positive
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	**Neutral**	Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

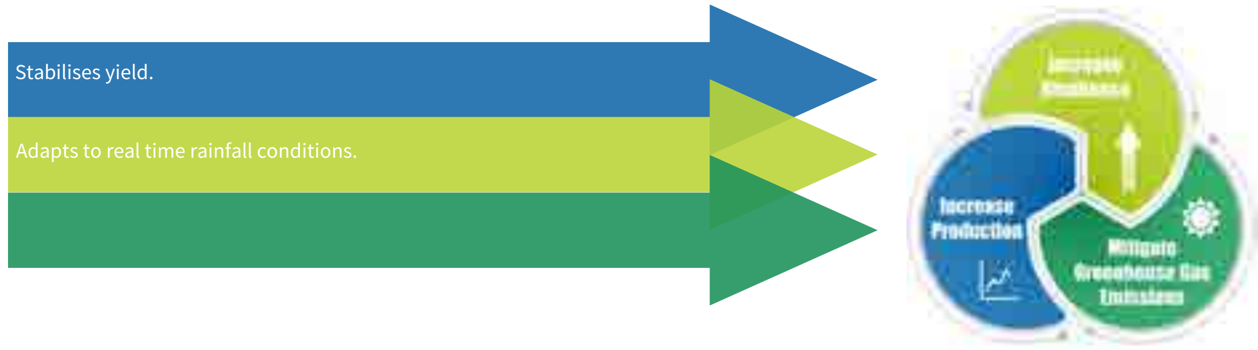
TECHNICAL APPLICATION

To effectively undertake deficit irrigation:

- **Step 1:** Determine critical growth cycle of desired crops.
- **Step 2:** Experiment with SI strategies to determine critical watering times prior to upscaling.
- **Step 3:** Strict management is required to determine the level of transpiration deficiency allowable without significant reduction in crop yields.
- **Step 4:** Farmers capable of implementing deficit irrigation must have access to the minimum required water to implement deficit irrigation.
- **Step 5:** Farmers must have access to a reliable water source, irrigation systems, including water distribution system, sprinklers and/or drip irrigation system.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Increase crop production in dry areas or those experiencing drought.
- Assist farmers manage crops at optimal times (low rainfall).

Drawbacks

- Farmers must have access to enough water to meet minimum water requirements.
- Require water distribution system that is functional.
- Close management of crops to ensure that SI is implemented at critical crop production moments.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 10, Decision Tool: Climate Smart Water Management Options for Maize & Sorghum

Additional Information

- The Food and Agriculture Organisation, 2000. Deficit Irrigation Practices. Water Reports.
- The Food and Agriculture Organisation, 2018. Supplemental Irrigation: A Promising Climate-Smart Practice for Dryland Agriculture. Practice Brief Climate-smart agriculture.
- CGIAR, Research Program on Dryland Systems, 2016. Effect of deficit irrigation on growth and yield of garlic, Technical Report of Experimental Activities. North-Western Ethopia.

Drip Irrigation

Technical Brief 24

Drip irrigation is a method of slow delivery of water to crops, through highly-controlled flow management, applied along the soil or at the sub-surface level directly to crop root systems. Drip irrigation is an effective system for conserving water while ensuring that it is used optimally without losing it to evaporation through high efficiency water delivery. Drip irrigation involves establishing a network of tubes, values and pipes connected to water source by a pump, along crop rows. A water source is required which is a drawback as many dryland areas lack these water sources. Drip irrigation is a climate smart option as it increases farmer resilience to the effects of climate change.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | Medium | Long

Crop production: Negative | Neutral | Positive

Fodder production: Negative | Neutral | Positive

Farm income: Negative | Neutral | Positive

Household workload: Negative | Neutral | Positive

Food security: Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | Positive

Biological diversity: Negative | Neutral | Positive

Flooding: Negative | Neutral | Positive

Crop/livestock water availability: Negative | Neutral | Positive

Wind Protection: Negative | Neutral | Positive

Erosion control: Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement drip irrigation:

- **Step 1:** A reliable water source must be available - natural (natural or through rain-water harvesting).
- **Step 2:** Acquire a pump system (approximately $US 100) that maintains enough pressure to deliver water through the system or an elevated tank.
- **Step 3:** Connect lines or hoses and laterals that run from the pump system across the planted fields.
- **Step 4:** Run lines or hoses with emitters (drippers) or small punctures at the surface level along planted crops or just below the surface providing water to the roots system of the plants.
- **Step 5:** Once the system is operable, the pump can be turned on and water dispersed as required by the nature of the crop and can also be implemented with supplemental irrigation strategies (Technical Brief 23).
- **Step 6:** Monitor the irrigation system regularly to ensure there are no malfunctions and the system is maintained.

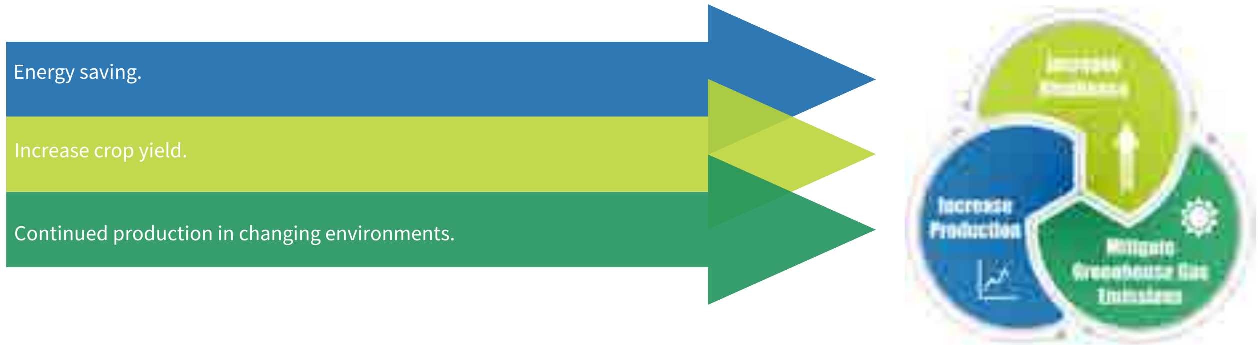
  Crops that receive regular water can develop shallow root systems and any prolonged disruptions in service could have significant impacts.
- **Step 7:** If applying drip irrigation in sloped conditions, follow the contours of the slope as outlined in Technical Brief 16.

Once a drip irrigation system is up and running, farmers can explore fertigation, the addition of soluble fertilisers into the irrigation system water for distribution directly to plants.

Technical Brief 24

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Maximises efficiency in crop irrigation in dryland or variable climate conditions.
- Minimizes the loss of water to evaporation.

Drawbacks

- Requires consistent water source.
- Costs of establishing the system, pump and lines/hoses can be significant depending on configuration, etc.
- Requires continual monitoring and may need regular maintenance.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 10, Decision Tool: Climate Smart Water Management Options for Maize & Sorghum.
- CCARDESA,2019. Technical Brief 16: Contour Planting.
- CCARDESA, 2019. Technical Brief 23: Supplemental Irrigation.

Additional Information

- The Food and Agriculture Organisation, 2007. Pressurized Irrigation Techniques - Drip Irrigation.
- The Food and Agriculture Organisation, 1998. Irrigation Water Management. Irrigation Methods.
- JLIFAD, 2014. Water for Agriculture. Ethiopia.
- JLIFAD, 2014. Fact Sheet - A market approach to drip irrigation. Investing in Rural People.

In Field Water Harvesting

Technical Brief 25

In-field water harvesting is the practice of increasing water infiltration and moisture retention in the soil. The agricultural technique involves the collection of rainwater runoff from fields that is collected and stored for future needs. This water can be stored in infiltration pits and later used to water the same crops, other crops through an irrigation system (usually high value crops, including fruit trees), or used for domestic purposes. Factors like soil, water, and plant type influence the effectiveness and productivity of rainwater harvesting. This type of water harvesting is generally implemented in areas of very low rain (semi-arid) conditions. In-field water harvesting entails establishing micro-catchments at the farm scale, where sloped areas have been cleared or cropped to direct rainwater to the water storage area (a pit that has been dug to store/hold water). Utilising strip cropping to growing crops while providing a method for directing rain is sometime practiced. The soil type has a limiting factor in collecting in-field water due the infiltration rates. In-field water harvesting saves rainfall water that can be used over a longer period than during and immediately after a rainfall event, reduces the risks of crop failure due to no or limited rainfall, and increases rain water productivity.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

- Return on Investment Realisation Period: Short | **[Medium]** | Long
- Crop production: Negative | Neutral | **[Positive]**
- Fodder production: Negative | Neutral | **[Positive]**
- Farm income: Negative | Neutral | **[Positive]**
- Household workload: Negative | **[Neutral]** | Positive
- Food security: Negative | Neutral | **[Positive]**

Ecological Impacts Positive or Negative

- Soil quality/cover: Negative | **[Neutral]** | Positive
- Biological diversity: Negative | **[Neutral]** | Positive
- Flooding: Negative | **[Neutral]** | Positive
- Crop/livestock water availability: Negative | Neutral | **[Positive]**
- Wind Protection: Negative | **[Neutral]** | Positive
- Erosion control: Negative | **[Neutral]** | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively In Field Water Harvesting techniques, the following steps should be carried out:

- **Step 1:** Land is cleared, berms are developed, and crops are planted in order to direct water to the infiltration point.
- **Step 2:** The catchment areas should be sloped no more than 5 % and the area should be cleared to promote catchment as much as possible.
- **Step 3:** The infiltration pit (where water is stored) should be dug at the lowest point of the catchment areas and line infiltration pits with plastic or concrete roofing to limit water loss, and can be used as a source of irrigation for fruit trees and other high value crops.
- **Step 4:** Paths can be built of soil to guide water to the infiltration pit.
- **Step 5:** Alley cropping, or strop cropping can be used, with areas between trees and crops dug deeper like a trough to direct water to the infiltration pit.
- **Step 6:** To access water from infiltration pits, farmers can introduce a pumping system and water can be distributed around the farm as necessary

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Water is available to plants when it is needed. Reduced nutrient leaching.
- Mitigate dry spells.
- Can lock more carbon in the soil. More efficient use of fertilisers.

SUMMARY/KEY ISSUES

Benefits

- Harvested water used in irrigation systems
- In-field water harvesting saves rainfall water that can be used over a longer
- Reduces the risks of crop failure due to no or limited rainfall
- Increases rainwater productivity

Drawbacks

- Major issues with a dug-out infiltration pit is evaporation and seepage. Evaporation can be combated by the addition of mulch to water and seepage can be prevented by including some kind of liner (plastic sheet, concrete, etc.). In addition, large plastic, steel or concrete container can be built or sunk below surface to prevent major seepage. Roofs can be built over infiltration pounds or built containers to limit the loss of water to evaporation

REFERENCE MATERIAL

CCARDESA Related Content

- Related CCARDESA Knowledge Products.
- Centre for Coordination of Agricultural Research & Development for Southern Africa (CCARDESA), 2019. Knowledge Product 10, Decision Tool: Climate Smart Water Management Options for Maize & Sorghum.

Additional Information

- The Food and Agriculture Organisation (FAO), 1991. A Manual for the Design and Construction of Water Harvesting Schemes for Plant Production. Italy,Rome.
- CGIAR 2011. In-field rainwater harvesting: A climate-smart sustainable production practice . Montpellier, France.

Zai Pits

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Zai pits are based on a traditional technology approach originating from West Africa that assists farmers working on marginal and degraded land. This approach involves the concentration and conservation of nutrients and water at the crop root systems through the digging of small pits (Zai pits) and filling them with compost, with the aim of increasing soil fertility and water infiltration. Zai pits are dug between planting season and filled with organic fertilisers/composts, which attract worms, termites and other insects, creating mix of material that can be used to fertilise crops. Farmers plant crops directly in these pits, prior to rains and water will infiltrate the pits more easily than the surrounding soil. Applying this technology is laborious to implement, but it has been found to assist farmers in times of drought or in arid conditions to produce successful crops by maximising the resources available. Zai pits allow for mitigation of desertification in degraded land and an economic use of resources in conditions of scarcity, especially in resource constrained environments

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period

Short | Medium | Long

Crop production

Negative | Neutral | Positive

Fodder production

Negative | Neutral | Positive

Farm income

Negative | Neutral | Positive

Household workload

Negative | Neutral | Positive

Food security

Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover

Negative | Neutral | Positive

Biological diversity

Negative | Neutral | Positive

Flooding

Negative | Neutral | Positive

Crop/livestock water availability

Negative | Neutral | Positive

Wind Protection

Negative | Neutral | Positive

Erosion control

Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement Zai Pits the following should be carried out:

- **Step 1:** Zai pits should be dug with a diameter of 30 cm to 40 cm and 10 cm to 15 cm deep.
- **Step 2:** Pits should be spaced 70 cm to 80 cm apart resulting in approximately 10,000 pits per hectare.
- **Step 3:** The farmer should place 2 – 3 handfuls (200 g to 600 g) of organic fertilisers or compost in each pit.
- **Step 4:** Holes that are dug between planting seasons will trap wind eroded soils, which are fertile and form good soils for plating crops.
- **Step 5:** It is recommended that 3 tonnes of fertiliser/compost per hectare be available.
- **Step 6:** Farmers should consider planting crops in these pits prior to periods of rain.
- **Step 7:** Repeated application of Zai pit technology on an annual basis will increase productivity of degraded land in the long term.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Increased soil fertility from zai pit implementation improves agricultural productivity.

This approach to fertilising crops and enhancing nutrient content can aid adaptation, especially in arid and semi-arid climates.

SUMMARY/KEY ISSUES

Benefits

- Earth that is excavated from the hole dug can be used to form a ridge around each pit to help capture and retain water
- Zai pit technology can be applied to marginal or degraded land or in semi-arid to arid conditions to allow farmers to rehabilitate soil/land and productively grow crops.
- Zai pits allow for nutrient concentration and water infiltration that provides improved conditions for crops to grow
- Land that was previously degraded can become productive through the use of zai pits

Drawbacks

- Implementing zai pits is laborious and takes significant people power to implement – but may be the only option in marginal environments

REFERENCE MATERIAL

CCARDESA Related Content

- Centre for Coordination of Agricultural Research & Development for Southern Africa (CCARDESA), 2019. Knowledge Product 10, Decision Tool: Climate Smart Water Management Options for Maize & Sorghum.

Additional Information

- CGIAR, 2014. Climate – smart soil water and nutrient management options in semiarid West Africa: a review of evidence and analysis of stone bund and zai techniques. Montpellier, France.
- The Food and Agriculture Organisation (FAO). 2016. Strengthening agricultural water efficiency and productivity on the African and global level. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2016. Farmers to Farmer Spread of Agroecology in the Eastern Region of Burkina Faso. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2018. The Climate – Smart Agriculture Training Manual. Rome. Italy.
- WOCAT, 2017. Zai or tassa planting pits. Niger.

Half Moon Pits

Half-moon Pits are water harvesting techniques that assists crop growth in harsh climatic conditions, improving water and nutrient availability, promoting biodiversity and restoring the fertility of the degraded soil. The technique is similar to Zai pits in terms of its purpose. Half-moons are semi-circular wide-open basins used to collect runoff water. The mouth of the half-moons must face a slope where rainwater will flow during precipitation events. Water will be trapped in the pit to irrigate crops. Stones are used to support the half-moon curve to avoid being washed away during rain. The amount of fertilisers required in farming systems decreases when this technique is adopted by farmers. Areas with lots of rainfall are not suitable for this technique as it may lead to water logging effect.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | **No**

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator			
Return on Investment Realisation Period	**Short**	**Medium**	Long
Crop production	Negative	Neutral	**Positive**
Fodder production	Negative	**Neutral**	Positive
Farm income	Negative	Neutral	**Positive**
Household workload	Negative	**Neutral**	Positive
Food security	Negative	Neutral	**Positive**

Ecological Impacts Positive or Negative

Indicator			
Soil quality/cover	Negative	Neutral	**Positive**
Biological diversity	Negative	**Neutral**	Positive
Flooding	Negative	**Neutral**	Positive
Crop/livestock water availability	Negative	Neutral	**Positive**
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	Neutral	**Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

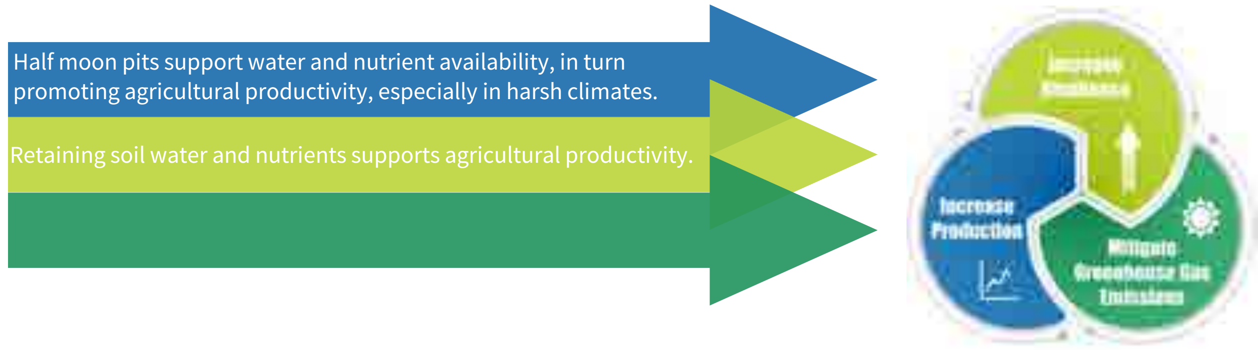
TECHNICAL APPLICATION

To effectively implement Half-moon techniques, the following steps should be carried out: :

- **Step 1:** Farmers should consider the diameter of the half-moon between 2 m – 3 m, with a total surface area of approximately 1.5 sqm and 3.5 sqm.
- **Step 2:** Pits should be dug to a depth of between 15 cm to 30 cm.
- **Step 3:** Excavated material can be piled around the curved section of the half-moon.
- **Step 4:**The curved section of the half-moon can be reinforced by stones to prevent washouts of the half-moon.
- **Step 5:** 35 kg of organic fertilisers/compost should be evenly distributed in the half-moon.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Pits are left to sit while fertiliser/compost material converts to productive soil material
- Half-moons allow for nutrient concentration and water infiltration that provides improved conditions for crops to grow
- Land that was previously degraded can become productive through the implementation of half-moons

Drawbacks

- Implementing half-moons is very laborious and takes significant people power to implement

REFERENCE MATERIAL

CCARDESA Related Content

- Centre for Coordination of Agricultural Research & Development for Southern Africa (CCARDESA), 2019. Knowledge Product 10, Decision Tool: Climate Smart Water Management Options for Maize & Sorghum..

Additional Information

- The Food and Agriculture Organisation (FAO), 2017. Impact of agroecological techniques on soil fertility and productivity of sorghum and pearl millet in Burkina Faso. Rome, Italy.
- The Food and Agriculture Organisation, (FAO), 2018. Climate-Smart Agriculture, Training Manual. Rome, Italy.

Water Spreading Bunds

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Water spreading bunds are barriers used on gradual slopes to slow down surface water and slow filter runoff, increasing the chance of infiltration, capturing runoff sediment, and decreasing soil erosion. Bunds can be built of different materials including packed earth or stones. Bunds can be spread across fields or used in micro-settings around individual trees or plants and should be applied in semi-arid or arid conditions. Bunds efficiently spread rainwater across the system and prevent streams from developing. Implementing bunds in areas with adequate rainfall or irrigation, may cause waterlogging and adversely affect crop growth.
Different types of bunds include:

- Contour bunds: ridges of soil that follow slope contours and can be implemented at a large scale. Crops are cultivated between bunds.
- Semi-circle bunds: ridges of varying size build in a half-moon or semi-circle. They are generally applied to rehabilitate rangelands and/or in the production of fodder.
- Contour stone bunds: lines of stones laid in a shallow dug out areas that slow down the flow of runoff

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: **Maize** | **Sorghum** | **Rice** | Livestock | **Other**

Soil texture: **Light** | **Medium** | Heavy

Climatic zone: **Arid** | **Semi-arid** | **Sub-humid** | Humid

Water source: **Rainfed** | **Partly irrigated** | Irrigated

Annual average rainfall (mm): **< 250** | **250 - 500** | **500 - 750** | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | **Moderate to rolling slope (6 – 15 %)** | **Hilly slope (16 – 30 %)** | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | **No**

Characteristics: **Subsistence** | **Commercial Small** | **Commercial Medium** | Commercial Large

Farm size (ha): **< 2** | **2 to 5** | **5 to 10** | > 10

Mechanisation: **Manual** | **Animal** | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | **Medium (seasonal)** | High (outside labour)

Gender/youth smart (low investment/low labour requirements): **Yes** | No

Financial resources

Initial investment: **Low** | Medium | High

Maintenance Costs: **Low** | Medium | High

Access to finance capital or credit required: Yes | **No**

Enabling Environment

Extension support: Yes | **No**

Access to inputs: Yes | **No**

Market access: Yes | **No**

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

- Return on Investment Realisation Period: Short | **Medium** | Long
- Crop production: Negative | Neutral | **Positive**
- Fodder production: Negative | Neutral | **Positive**
- Farm income: Negative | Neutral | **Positive**
- Household workload: Negative | **Neutral** | Positive
- Food security: Negative | Neutral | **Positive**

Ecological Impacts Positive or Negative

- Soil quality/cover: Negative | **Neutral** | Positive
- Biological diversity: Negative | **Neutral** | Positive
- Flooding: Negative | Neutral | **Positive**
- Crop/livestock water availability: Negative | Neutral | **Positive**
- Wind Protection: Negative | **Neutral** | Positive
- Erosion control: Negative | **Neutral** | **Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively Water Spreading Bunds the following should be carried out:

- **Step 1:** Farmers should consider making earth bunds by hand, animal ploughs or mechanised ploughs.
- **Step 2:** Contour bunds:
  - Contour lines must be plotted and marked prior to developing the bund
  - A 40 cm deep infiltration pit is dug directly above where the bund will be plotted
  - Bunds should be spread 5 m to 10 m apart
  - Material from the infiltration pit will be piled and compacted to form a 25 cm to 30 cm in height with a base of 75 cm
  - Soil is piled to form a ridge along the contour. The more significant the slope, the closer the bunds must be plotted
- **Step 3: Semi-circle bunds:**
  - Contour lines must be plotted and marked prior to developing the bund
  - A centre point is chosen as diameter for the bund is selected (this could be 3 m or 30 m depending on the available space). From the centre point a string is used to stake out an even semi-circle.
  - Excavate a small trench before the bund and pile the excavated material. Pile and compact a bund wall, wetting it often to form the wall
- **Step 4:** Contour stone bunds:
  - Developed on less steep slopes
  - Must have access to local stones
  - Dig out a shallow ditch, 10 cm to 15 cm in depth
  - Lay largest stones at the bottom of the ditch and pile smaller stone upward.
- **Step 5:** Regular monitoring of bunds should take place, especially after rain events or after significant periods of time. Repairs should be done if any damage is found.

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Reduces soil erosion and enables farmers to maintain agricultural productivity.
- Reduces soil erosion in higher rainfall environments, especially relevant as climates change.

SUMMARY/KEY ISSUES

Benefits

- Water spreading bunds are implemented on slopes of varying degrees to slow the flow of surface water, increasing infiltration and nutrient capture
- Bunds capture water and spread it across an area more evenly, preventing streams, erosion channels and gullies from forming at depression points.

Drawbacks

- Developing bunds can be laborious
- Bunds in areas with adequate rainfall or irrigation may cause waterlogging and affect crop growth

REFERENCE MATERIAL

CCARDESA Related Content

- Centre for Coordination of Agricultural Research & Development for Southern Africa (CCARDESA), 2019. Knowledge Product 10, Decision Tool: Climate Smart Water Management Options for Maize & Sorghum.

Additional Information

- The Food and Agriculture Organisation (FAO), 1991. Water Harvesting. Rome, Italy.

Permeable Rock Dams

Technical Brief 29

A permeable rock dam is a water harvesting technique where flooding rain water is collected in valley bases or other depressions to irrigate crops later/elsewhere, filling in gullies, controlling water flows, increasing crop production and reducing soil erosion.. Permeable rock dams are long and relatively shallow to reduce erosion while accumulating silt and distributing water. They comprise of long low rock walls with smooth crests so that water can spread to avoid overflow from the dam. However, this technology is site specific; it cannot be practiced in areas where there are no rocks/stones and means of transporting these building materials. The impoundment of silt prior to runoff entering a watercourse can be beneficiary to downstream users and can contribute to improved water quality in the catchment

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: ● Maize · ● Sorghum · ● Rice · ○ Livestock · ● Other

Soil texture: ○ Light · ● Medium · ● Heavy

Climatic zone: ○ Arid · ● Semi-arid · ● Sub-humid · ○ Humid

Water source: ● Rainfed · ● Partly irrigated · ○ Irrigated

Annual average rainfall (mm): ○ < 250 · ○ 250 - 500 · ● 500 - 750 · ● 750 - 1000 · ○ 1000 - 1500 · ○ > 1500

Topography: ● Flat to gentle slope (0 – 5 %) · ● Moderate to rolling slope (6 – 15 %) · ○ Hilly slope (16 – 30 %) · ○ Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: ● Yes · ○ No

Characteristics: ● Subsistence · ● Commercial Small · ● Commercial Medium · ● Commercial Large

Farm size (ha): ● < 2 · ● 2 to 5 · ● 5 to 10 · ● > 10

Mechanisation: ● Manual · ● Animal · ● Mechanised

Human resources

Labour intensity – level of effort: ○ Low (household) · ○ Medium (seasonal) · ● High (outside labour)

Gender/youth smart (low investment/low labour requirements): ○ Yes · ● No

Financial resources

Initial investment: ○ Low · ○ Medium · ● High

Maintenance Costs: ● Low · ○ Medium · ○ High

Access to finance capital or credit required: ○ Yes · ● No

Enabling Environment

Extension support: ● Yes · ○ No

Access to inputs: ● Yes · ○ No

Market access: ○ Yes · ● No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator	Scale	Rated (boxed)
Return on Investment Realisation Period	Short / Medium / Long	Medium, Long
Crop production	Negative / Neutral / Positive	Positive
Fodder production	Negative / Neutral / Positive	Positive
Farm income	Negative / Neutral / Positive	Positive
Household workload	Negative / Neutral / Positive	Neutral
Food security	Negative / Neutral / Positive	Positive

Ecological Impacts Positive or Negative

Indicator	Scale	Rated (boxed)
Soil quality/cover	Negative / Neutral / Positive	Positive
Biological diversity	Negative / Neutral / Positive	Neutral
Flooding	Negative / Neutral / Positive	Neutral
Crop/livestock water availability	Negative / Neutral / Positive	Positive
Wind Protection	Negative / Neutral / Positive	
Erosion control	Negative / Neutral / Positive	Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement Permeable Rock Dam practices, the following steps should be carried out:

- **Step 1:** Consider constructing a permeable rock dam across relatively wide and shallow valleys.
- **Step 2:** Permeable rock dams should consist of long, low rock walls with level crest along full length although farmers should consider central spillways where water course has cracks.
- **Step 3:** The dam should be between 50-300m in length and 1m in height within a gully.
- **Step 4:** Consider making the dam wall flatter on the downslope side than on the upslope side
- **Step 5:** A foundation of small stones should be set in the trench.
- **Step 6:** An apron of large rocks is essential to split the erosive force of the overflow.
- **Step 7:** Downstream banks of the water stream should be shielded by stone pitching to prohibit the increase of the gully.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Supports agricultural productivity as soil structure is retained and provides access to more sustainable water supplies.
- Supports adaptation strategies in climate changes scenarios with improved access to water for irrigation and reducing soil erosion.

SUMMARY/KEY ISSUES

Benefits

- Permeable rock dams increase crop production
- Reduce soil erosion
- The system increases groundwater recharge

Drawbacks

- The technology is site specific; should be on a site where rocks and stones are present.
- Need for large quantities of stone.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 10, Climate Smart Water Management Options for Maize & Sorghum.

Additional Information

- The Food and Agriculture Organisation (FAO), 1991. Water harvesting. Rome ,Italy.
- The World Bank, 2010. Water harvesting for plant production - volume II : case studies and conclusions for sub-Saharan Africa (English). NW Washington.
- UNEP-IETC, 1998. Sourcebook of Alternative Technologies for Freshwater Augmentation in Africa. 182p.

Rainwater Harvesting

Technical Brief 30

Rainwater harvesting is an agricultural technique of collecting and storing rainwater or runoff in tanks or natural reservoirs. This practice is mostly practiced in arid or semi-arid areas with temporal and spatial variability of rainfall mostly lost as surface runoff or evaporation. Runoff is harvested and utilised as a preventative measure for soil erosion, as well as a water management strategy for irrigating crops and for livestock water. This technique enables farmers to capture and store rainwater during times of plenty for use during times of scarcity. Rainwater harvesting is a technology that maximises the use of existing freshwater resources and is a useful technology for water resource planners and managers in both governmental and non-governmental organisations, institutions and communities.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain
Maize | Sorghum | Rice | Livestock | Other

Soil texture
Light | Medium | Heavy

Climatic zone
Arid | Semi-arid | Sub-humid | Humid

Water source
Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)
< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography
Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action
Yes | No

Characteristics
Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)
< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation
Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort
Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)
Yes | No

Financial resources

Initial investment
Low | Medium | High

Maintenance Costs
Low | Medium | High

Access to finance capital or credit required
Yes | No

Enabling Environment

Extension support
Yes | No

Access to inputs
Yes | No

Market access
Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period
Short | Medium | Long

Crop production
Negative | Neutral | Positive

Fodder production
Negative | Neutral | Positive

Farm income
Negative | Neutral | Positive

Household workload
Negative | Neutral | Positive

Food security
Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover
Negative | Neutral | Positive

Biological diversity
Negative | Neutral | Positive

Flooding
Negative | Neutral | Positive

Crop/livestock water availability
Negative | Neutral | Positive

Wind Protection
Negative | Neutral | Positive

Erosion control
Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

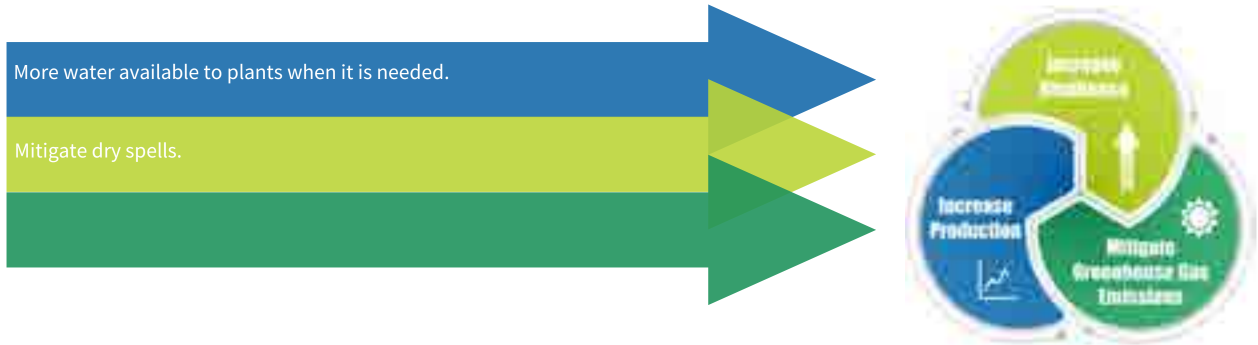
To effectively implement Rainwater Harvesting practices:

- **Step 1:** Create a water collection zone connected to a gutter system.
- **Step 2:** Install filters to the water collection zone.
- **Step 3:** Connect a hose pipe for easy distribution of irrigation water.
- **Step 4:** If a farmer intends to use water for human consumption other than flushing toilets, etc, water quality must be frequently tested using reliable and low-cost/low-tech solutions.
- **Step 5:** Use of filters can be considered to reduce particulate and other pollutants but should be thoroughly investigated – as a separate subject – by the extension officer and the farmer, otherwise it could lead to illness. It is recommended that farms utilise harvested rainwater for irrigation and other farming activities only.

Technical Brief 30

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Rainwater harvesting acts as a source of water at a point where it is needed, usually stored in a tank
- Works as an alternative water source in cases of drought or irrigation system breakdown.
- Rooftop rainwater catchment construction is simple.
- Success in rainwater harvesting depends on frequency and amount of rainfall.

Drawbacks

- Asphalt, tar and wood roofs may contaminate the water making it unsafe for direct human consumption.
- For potable water collection, lead containing gutters should not be used.
- Harvested water may be contaminated by animal waste.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 10, Climate Smart Water Management Options for Maize & Sorghum.
- CCARDESA, 2019. Knowledge Product 11, Climate Smart Water Management Options for Rice.

Additional Information

- Die Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, 2018. How to Protect Our Water Resources from Climate Change.
- The Food and Agriculture Organisation (FAO), 1985. Role of forestry in combating desertification. Germany. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2016. Strengthening agricultural water efficiency and productivity on the African and global level. Rome, Italy.

Alternate Wetting and Drying

Technical Brief 31

Alternate wetting and drying also called intermittent flooding is a technique developed by the International Rice Research Institute (IRRI) to control water consumption in rice fields (CGIAR 2014). This technology saves water throughout the year in areas of variable rainfall. It is designed as a pick-up water system in cases when water consumption is cut. Water levels are monitored and controlled by the removal of excess water, leaving enough water to sustain crops. Alternate wetting and drying reduces greenhouse gas emissions especially methane, which is emitted from flooded rice fields (FAO 2016). The drying phase helps to sustain and develop plant roots. Moreover, costs on fuel used for irrigation are reduced.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | No

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Impact			
Return on Investment Realisation Period	Short	**Medium**	Long
Crop production	Negative	Neutral	**Positive**
Fodder production	Negative	Neutral	**Positive**
Farm income	Negative	Neutral	**Positive**
Household workload	Negative	**Neutral**	Positive
Food security	Negative	**Neutral**	Positive

Ecological Impacts Positive or Negative

Impact			
Soil quality/cover	Negative	Neutral	**Positive**
Biological diversity	Negative	**Neutral**	Positive
Flooding	Negative	**Neutral**	Positive
Crop/livestock water availability	Negative	**Neutral**	Positive
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	Neutral	**Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement Alternate Wetting and Drying practices:

- **Step 1:** Alternate wetting and drying should be considered by the farmer after two weeks of rice transplant.
- **Step 2:** The farmer should consider digging half of 30 cm tube into soil to monitor water level.
- **Step 3:** When the water level is 15 cm below the soil surface the field should be irrigated again with a depth of 3 to 5 cm before water drains.
- **Step 4:** This cycle should be repeated until flowering stage to avoid disturbing reproduction because at this stage the crops are sensitive to water stress.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to
Climate Smart Agriculture outcomes

- Cost of production reduced through less use of water.
- Maintain production with reduced inputs. Predictable yields.
- May reduce GHG emissions from irrigation pumps.

SUMMARY/KEY ISSUES

Benefits

- Alternate wetting and drying maintains rice yields in areas with variable rainfall/irrigation water supply.
- Reduces greenhouse gas emission such as methane.
- The technology can be carried out in regions prone to heavy rainfall.

Drawbacks

- Water levels need to be monitored carefully to avoid water stress which might decrease yield.
- Not recommended in areas with potential salinity stress as reduced water inputs might aggravate salinity levels and cause yield decline.

REFERENCE MATERIAL

CARDESA Related Content

- CCARDESA, 2019. Technical Brief 11, Climate Smart Water Management Options for Rice.

Additional Information

- CGIAR, 2014. New irrigation technique can ease drought effects for rice farmers. Montpellier, France.
- Food and Agriculture Organisation (FAO), 2016. Impact of alternate wetting and drying (AWD) on rice pest and the environment. Rome, Italy.

System of Rice Intensification (SRI)

Technical Brief 32

System of Rice Intensification (SRI) is an agro-ecological practice for increasing the productivity of irrigated rice cultivation by changing the management of water, plants, soil and nutrients. SRI promotes the growth of root systems, increases the abundance and diversity of soil organisms by keeping the soil moist but not flooded, and provides frequent aeration and conditioning of soil with organic matter. This agro-ecological practice stimulates plant growth by transplanting young seedlings, avoiding disturbance to roots and providing crops with wider spacing to encourage greater root and canopy growth. The agricultural methodology is based on well-founded agro-ecological principles which have been successfully adapted to upland rice and have shown increased productivity over current conventional planting practices.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | Medium | Long

Crop production: Negative | Neutral | Positive

Fodder production: Negative | Neutral | Positive

Farm income: Negative | Neutral | Positive

Household workload: Negative | Neutral | Positive

Food security: Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | Positive

Biological diversity: Negative | Neutral | Positive

Flooding: Negative | Neutral | Positive

Crop/livestock water availability: Negative | Neutral | Positive

Wind Protection: Negative | Neutral | Positive

Erosion control: Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement SRI practices:

- **Step 1:** Consider separation of high-quality seeds from low-quality seeds through soaking them in plain or salt water and the unviable seeds will float on the surface of the water.
- **Step 2:** Plant the seeds on an unflooded, raised bed with adequate drainage and fertile soil.
- **Step 3:** After 8-12 days, transplant single young seedlings into a grind pattern with wide spacing between hills (25 cm x 25 cm).
- **Step 4:** During crop growth period, control the flooding and research and follow alternate wetting and drying irrigation practices.
- **Step 5:** Consider application of compost and mineral fertiliser for nutrient enhancement.
- **Step 6:** Use a mechanical weeder for the control of weeds and maximisation of soil aeration.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Reduced inputs for greater yield.
- Predictable yields. Higher production equals increased food security/income and resilience..
- May reduce GHG emissions from irrigation pumps.

SUMMARY/KEY ISSUES

Benefits

- Increased and diversified crop yield resulting in increased farm income
- Improved food security
- SRI reduces GHG emissions
- Existing water availability patterns to accommodate the irrigation schedule.

Drawbacks

- SRI is a labour-intensive agricultural practice.
- Occurrence of methane emissions from rice fields caused by flooding.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 11, Climate Smart Water Management Options for Rice.

Additional Information

- Global Alliance for Climate-Smart Agriculture (GACSA), 2016. The System of Rice Intensification (SRI): Revisiting Agronomy for a Changing Climate.
- Food and Agriculture Organisation (FAO), 2013. System of Rice Intensification (SRI). Rome, Italy.

Boundary Planting

Boundary planting, also known as live fence planting, is a technique used to protect crops from the interference of people and animals that can disturb plant growth. Trees/shrubs are a good example of this approach as they can form a shield when planted along the boundaries of the garden or surrounding a planted field. The trees/shrubs act as wind break to shield plants against strong winds causing physical damage to plants themselves, or the removal of soil (erosion). Additional benefits include the use of branches for firewood or building materials, and the other parts of trees can be used as fodder, fruit or leave harvested for consumption, or for medicinal use. Tree/shrub spacing is critical, as trees that have dense canopies can conversely cause destructive down-drafts, negating the intended benefits. Boundary planting helps limit global warming by mitigating GHG emissions through reducing harmful gases such as, carbon dioxide, from the atmosphere and releasing oxygen.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: ● Maize ● Sorghum ○ Rice ● Livestock ● Other

Soil texture: ● Light ● Medium ● Heavy

Climatic zone: ● Arid ● Semi-arid ● Sub-humid ● Humid

Water source: ● Rainfed ● Partly irrigated ● Irrigated

Annual average rainfall (mm): ● < 250 ● 250 - 500 ● 500 - 750 ● 750 - 1000 ● 1000 - 1500 ● > 1500

Topography: ● Flat to gentle slope (0 – 5 %) ● Moderate to rolling slope (6 – 15 %) ● Hilly slope (16 – 30 %) ● Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: ○ Yes ● No

Characteristics: ● Subsistence ● Commercial Small ● Commercial Medium ● Commercial Large

Farm size (ha): ● < 2 ● 2 to 5 ● 5 to 10 ● > 10

Mechanisation: ● Manual ● Animal ○ Mechanised

Human resources

Labour intensity – level of effort: ● Low (household) ○ Medium (seasonal) ○ High (outside labour)

Gender/youth smart (low investment/low labour requirements): ● Yes ○ No

Financial resources

Initial investment: ● Low ○ Medium ○ High

Maintenance Costs: ● Low ○ Medium ○ High

Access to finance capital or credit required: ○ Yes ● No

Enabling Environment

Extension support: ○ Yes ● No

Access to inputs: ○ Yes ● No

Market access: ○ Yes ● No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: **Short** | **Medium** | Long

Crop production: Negative | Neutral | **Positive**

Fodder production: Negative | Neutral | **Positive**

Farm income: Negative | **Neutral** | Positive

Household workload: Negative | **Neutral** | Positive

Food security: Negative | **Neutral** | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | **Positive**

Biological diversity: Negative | **Neutral** | Positive

Flooding: Negative | **Neutral** | Positive

Crop/livestock water availability: Negative | **Neutral** | Positive

Wind Protection: Negative | Neutral | **Positive**

Erosion control: Negative | Neutral | **Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement Boundary Planting practices:

- **Step 1:** Plant long lines of two fast growing trees, *Caesalpinia velutina* trees, between a *Bombacopsis quinate* and a *Swietenia humilis* to be replaced over time
- **Step 2:** Consider planting the boundary trees 1.5 metres apart along pre-existing fences.
- **Step 3:** Attach metal fencing to the trees to support the large trees without endangering their growth. Harvest fodder when the tree is overgrown.
- **Step 4:** Prune lower brunches to encourage upward growth of trees and reduce shed on the plants.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Increases availability of tree shrub products (nuts, fruits, timber etc.) and biomass, which improves soil fertility, and thus production.

Reduces erosion of soil and evaporation. Increases water retention and infiltration. Diversifies income sources. Improves yield stability.

Locks more carbon in plants and in the soil.

SUMMARY/KEY ISSUES

Benefits

- Live fence planting is cost effective, conserves soil moisture, acts a windbreak and reduces soil erosion. These trees have various benefits such as medicinal use, mulch, livestock feeds, fruits, bee forage, timber and firewood.
- Maintenance of boundary trees is low with short, medium and long ecological and economic benefits.

Drawbacks

- Boundary planting occupies more land than a single row.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 12, Climate Smart Agroforestry Options for Maize, Sorghum & Rice.

Additional Information

- Food and Agriculture Organisation (FAO), 2001. Improving Nutrition through Home Gardening. Rome, Italy.
- Food and Agriculture Organisation (FAO), 1998. Non-Wood Forest Products in Zambia. Lusaka, Zambia.
- World Agroforestry Centre (ICRAF), 1994. Agroforestry Extension Manual for Kenya. Nairobi, Kenya.

Agroforestry: Silvo-Pasture

Technical Brief 34

Agroforestry is a land management practice that combines the planting and management of trees and shrubs with crops and pasture, providing benefits of soil health, crop yields, resilience to climate change, biodiversity and economic opportunities. Agroforestry encompasses numerous practices, including silvo-pasture, agro-silvo cultural, and agro-silvo-pastural. One such successful agroforestry practice is silvo-pasture – the planting of trees and shrubs within livestock grazing pasture lands. Not to be confused with agrosilvopasture (combination of crops, shrubs/trees and livestock, silvopasture is the combination of trees and shrubs with pastural grazing land. The trees can be regularly or irregularly placed, and in addition to improving soil conditions in pasture lands, also provide production of protein-rich tree fodder for on farm feeding and for cut-and-carry fodder production. If growing larger species of tree, coppicing can also produce timber for building materials and firewood.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: ○ Maize, ○ Sorghum, ○ Rice, ● Livestock, ○ Other

Soil texture: ● Light, ● Medium, ● Heavy

Climatic zone: ● Arid, ● Semi-arid, ● Sub-humid, ● Humid

Water source: ● Rainfed, ● Partly irrigated, ● Irrigated

Annual average rainfall (mm): ● < 250, ● 250 - 500, ● 500 - 750, ● 750 - 1000, ● 1000 - 1500, ● > 1500

Topography: ● Flat to gentle slope (0 – 5 %), ● Moderate to rolling slope (6 – 15 %), ○ Hilly slope (16 – 30 %), ○ Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: ○ Yes, ● No

Characteristics: ● Subsistence, ● Commercial Small, ● Commercial Medium, ● Commercial Large

Farm size (ha): ● < 2, ● 2 to 5, ● 5 to 10, ● > 10

Mechanisation: ● Manual, ● Animal, ○ Mechanised

Human resources

Labour intensity – level of effort: ○ Low (household), ● Medium (seasonal), ○ High (outside labour)

Gender/youth smart (low investment/low labour requirements): ● Yes, ○ No

Financial resources

Initial investment: ● Low, ○ Medium, ○ High

Maintenance Costs: ● Low, ○ Medium, ○ High

Access to finance capital or credit required: ○ Yes, ● No

Enabling Environment

Extension support: ○ Yes, ● No

Access to inputs: ● Yes, ○ No

Market access: ○ Yes, ● No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Impact	Scale	Indicated
Return on Investment Realisation Period	Short / Medium / Long	Medium
Crop production	Negative / Neutral / Positive	Neutral
Fodder production	Negative / Neutral / Positive	Positive
Farm income	Negative / Neutral / Positive	Positive
Household workload	Negative / Neutral / Positive	Negative
Food security	Negative / Neutral / Positive	Positive

Ecological Impacts Positive or Negative

Impact	Scale	Indicated
Soil quality/cover	Negative / Neutral / Positive	Positive
Biological diversity	Negative / Neutral / Positive	Positive
Flooding	Negative / Neutral / Positive	Neutral
Crop/livestock water availability	Negative / Neutral / Positive	Positive
Wind Protection	Negative / Neutral / Positive	Positive
Erosion control	Negative / Neutral / Positive	Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement hedge planting:

- **Step 1:** Purchase saplings of selected tree species from a local nursery or grow saplings in separate on-farm nursery. If growing on-farm, saplings should be held-up with an upright support bamboo/wooden pole. Ideally, the farmer should begin exploring silvopasture tree species beginning with indigenous trees, such as acacias, and other local trees. It is worth considering a mixture of species, as well as mixed shallower and deeper rooted trees.
- **Step 2:** Once at a meter or over in height, transplant to pastures, surrounding each individual sapling with a wire mesh cage-tube or insert into five-centimetre diameter PVC pipe to protect from browsers. Plant at least ten to twenty meters apart, in either a random or uniform pattern. This is a matter of preference.
- **Step 3:** Once saplings are planted, only allow grazing livestock (cows, sheep, ducks, geese, chickens) in the silvopasture, avoiding browsers (goats, etc), which will strip, damage or destroy the saplings.
- **Step 4:** Once mature and above browsing height, two plus meters, remove protective cage or pipe.
- **Step 5:** Depending on species, pruning, coppicing etc should be performed every two months to ensure that trees remain healthy and productive, while maximising outputs for in-field and cut and carry fodder.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Diversified agricultural outputs supports sustainable agricultural productivity, providing multiple streams of revenue, reducing labour and cost for land clearance and maintaining healthy pasture land.

As climate change alters local grazing land, silvopasture can reduce overgrazing and land degradation. Trees introduced into pasture can create a more positive environment for livestock, including shade in warmer climates, and shelter during rainfall.

Retaining trees within pasture land and minimising complete conversion of land reduces greenhouse gas emissions and retains carbon in the soil.

SUMMARY/KEY ISSUES

Benefits

- Presence of trees can be beneficial to livestock in terms of shade and shelter, as well as enhancing carbon storage and enriching biodiversity.
- Manure from livestock can improve soil health in grazing land.
- Leaf litter and pruned material also add organic matter to soil, improving productivity and drainage
- Presence of trees can contribute to reducing soil erosion.
- Trees can produce numerous forest products, including timber for firewood and construction.
- There is an opportunity to diversify income for small-holder farms and increase food security.
- Tree trimmings and leaf litter can also be used for in-field or cut and carry fodder.

Drawbacks

- Requires some investment in terms of purchase of seed and/or saplings.
- May require adjustment for mixed grazing and browsing livestock patterns
- If dietary requirements of livestock are not complete, animals may strip bark from trees. This can be avoided by ensuring that pasture stocking is not too high, and best efforts are made to encourage pasture health and supplementing livestock feed with the necessary minerals, energy and protein.

REFERENCE MATERIAL

CCARDESA Related Content

- - Centre for Coordination of Agricultural Research and Development in Southern Africa (CCARDESA), 2019. Knowledge Product 12, Climate Smart Agroforestry Options for Maize, Sorghum & Rice. CCARDESA, Gaborone, Botswana
- - Centre for Coordination of Agricultural Research and Development in Southern Africa (CCARDESA), 2019. Knowledge Product 15, Climate Smart Pasture/Rangeland Management Options for Livestock. CCARDESA, Gaborone, Botswana
- - Centre for Coordination of Agricultural Research and Development in Southern Africa (CCARDESA), 2019. Technical Brief 17, Agroforestry: Alley Cropping. CCARDESA, Gaborone, Botswana

Additional Information

- Balehegn, M., 2017. Silvopasture Using Indigenous Fodder Trees and Shrubs: The Underexploited Synergy Between Climate Change Adaptation and Mitigation in the Livestock Sector. Chapter from book The Need for Transformation: Local Perception of Climate Change, Vulnerability and Adaptation Versus 'Humanitarian' Response in Afar Region, Ethiopia (pp.493-510). ResearchGate.
- Jose, S. & Dollinger, 2019. Silvopasture: a sustainable livestock production system. Chapter in J. Agroforest Syst (2019) 93: 1. https://doi.org/10.1007/s10457-019-00366-8

Farmer Managed Natural Regeneration

Farmer Managed Natural Regeneration (FMNR) is a technique of restoring degraded land and monitoring restoration of the land involving the systematic regeneration and management of trees and shrubs from tree stumps, roots and seed. Degraded arid land often features left over indigenous plants, which if maintained and promoted to grow can improve pasture and crop lands while simultaneously encouraging re-growth of seeds, roots and shrubs. Key to this practice is the existence of living stumps, tree roots and seed that, if encouraged, will regrow. The land is protected from being completely cleared or further grazed and this allows trees to grow without disturbance. Once the stumps and trees start to grow, pruning and trimming of trees is required to allow space between trees and promote healthy long tree trunks. Once the trees have matured, intercropping can take place or livestock can be re-introduced to graze.

While requiring some investment in terms of effort, FMNR has climate smart advantages such as controlling rainfall/irrigation run-off, supporting water quality improvements, providing sources of timber or fodder, supporting habitant regeneration for pollinator insect species, acting as sun shade, and reducing soil erosion.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | No

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Impact			
Return on Investment Realisation Period	**[Short]**	**[Medium]**	**[Long]**
Crop production	Negative	**[Neutral]**	Positive
Fodder production	Negative	Neutral	**[Positive]**
Farm income	Negative	**[Neutral]**	Positive
Household workload	Negative	**[Neutral]**	Positive
Food security	Negative	**[Neutral]**	Positive

Ecological Impacts Positive or Negative

Impact			
Soil quality/cover	Negative	Neutral	**[Positive]**
Biological diversity	Negative	Neutral	**[Positive]**
Flooding	Negative	**[Neutral]**	Positive
Crop/livestock water availability	Negative	**[Neutral]**	Positive
Wind Protection	Negative	Neutral	**[Positive]**
Erosion control	Negative	Neutral	**[Positive]**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement Farmer Managed Natural Regeneration :

- **Step 1:** Degraded land needs to be identified and living stumps, roots and seeds need to be encouraged to regrow. This may include periodic watering. Focus should be on indigenous species, and present tree species (existing stumps)
- **Step 2:** Consider leaving the field un-grazed to promote tree growth.
- **Step 3:** Select tree stumps and the tallest and straightest stems to grow into trees.
- **Step 4:** Prune and manage by removing stems and unwanted side branches.
- **Step 5:** Maintain the process by occasionally pruning side branches.
- **Step 6:** Manage the land consistently to avoid overgrazing, which can lead to further degradation.
- **Step 7:** Consider rotational grazing to allow seeds, stumps and underground shrubs to re-grow. This will reduce the cost of replanting. Shrubs and growing trees and saplings need to be protected before introducing livestock. Shrubs and growing trees and saplings need to be protected before introducing livestock.

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Increase availability of biomass, which improves soil fertility and thus production. The trees/shrubs can be a source of income and reduce costs.

Reduces erosion of soil and evaporation. Increases water retention and infiltration. Diversifies income sources. Improves yield stability.

Locks more carbon in plants and in soil.

SUMMARY/KEY ISSUES

Benefits

- FMNR improves soil quality and reduces soil erosion
- Improved dry-season pasture
- Agricultural management practices such as pruning, and trimming are carried out appropriately in turn improving growth and air circulation
- Higher livestock productivity
- Provides protection from wind and shade for livestock, when introduced
- Increased availability of firewood, thatch and other non-timber forest-products/materials

Drawbacks

- The land needs to be managed consistently to avoid overgrazing

REFERENCE MATERIAL

CCARDESA Related Content

- Related CCARDESA Knowledge Products: CCARDESA, 2019. Technical Brief 12, Climate Smart Agroforestry Options for Maize, Sorghum & Rice.

Additional Information

- Food and Agriculture Organisation (FAO), 2015. The social, environmental and economic benefits of Farmer Managed Natural Regeneration (FMNR). Rome, Italy.
- Food and Agriculture Organisation (FAO), 2012. Land rehabilitation on the central plateau of Burkina Faso and Building resilience to climate change through farmer-managed natural regeneration in Niger. Rome, Italy.
- Food and Agriculture Organisation, 2018. Advancing the Role of Natural Regeneration in Large-Scale Forest and Landscape Restoration in the Asia-Pacific Region. Rome, Italy.

Best Practice Harvesting Techniques

Technical Brief 36

Best Practice Harvesting Techniques are formalised harvesting practices intended to reduce breakage and bruising of crops during collection and storage. These techniques minimise harvest losses and maintain the quality of the produce. To maximise this approach, factors such as moisture content, cleanness of the grain, colour, odour and potential pest infestation need to be considered during harvest periods. Considering each of these factors will increase grain value as quality standards are directly related to grain price. Harvesting can be performed manually or mechanically, with obvious cost implication of employing the latter.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | **Medium** | Long

Crop production: Negative | Neutral | **Positive**

Fodder production: Negative | **Neutral** | Positive

Farm income: Negative | Neutral | **Positive**

Household workload: Negative | **Neutral** | Positive

Food security: Negative | Neutral | **Positive**

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | **Neutral** | Positive

Biological diversity: Negative | **Neutral** | Positive

Flooding: Negative | **Neutral** | Positive

Crop/livestock water availability: Negative | **Neutral** | Positive

Wind Protection: Negative | **Neutral** | Positive

Erosion control: Negative | **Neutral** | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

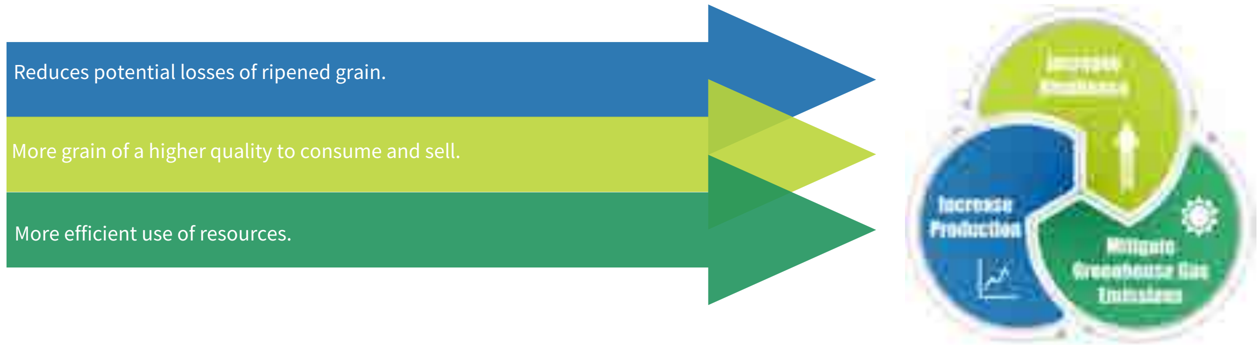
To effectively implement Best Practice Harvesting Techniques:

- **Step 1:** Obtain equipment and supplies needed for the harvest and post-harvest activities, e.g. clean sacks, drying mats, etc
- **Step 2:** Allocate drying and threshing areas, ensuring the areas are swept, dry, and there is no/limited access for livestock or rodents. If in a dry climate or season, drying outside is optimal. If necessary, construct drying cribs elevated from the ground with rodent guards on legs can reduce access for rodents.
- **Step 3:** Allocate sufficient storage space for the harvested crop
- **Step 4:** Clear weeds from the farm to prevent weed seeds from contaminating the harvest
- **Step 5:** Place the harvested crop directly onto clean mats and bags to avoid contact with the soil, which may lead to moisture uptake and also prevent contamination with tiny Striga.

Technical Brief 36

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Best practice harvesting techniques improve grain quality and minimise post-harvest loses.

Drawbacks

- Lodging can cause significant losses as well as contamination.

REFERENCE MATERIAL

CCARDESA Related Content

- Related CCARDESA Knowledge Products: CCARDESA, 2019. Technical Brief 13, Climate Smart Post-Harvest Management Options for Maize, Sorghum & Rice.

Additional Information

- Food and Agriculture Organisation (FAO), 1994. Agricultural engineering in development-Post Harvest losses. Italy, Rome.
- Food and Agriculture Organisation (FAO), 2002. Post-harvest losses: discovering the full story. Overview of the phenomenon of losses during the Post-harvest System. Italy, Rome.

Changing Harvest Time

Technical Brief 37

Changing harvest time refers to adjusting harvest time to focus on optimal moisture conditions, thereby avoiding losses from mould, decay and possible disease, while also considering optimal maturity of the crop. This approach encourages the reduction in potential losses of ripened grain and increases potential higher quality grain for consumption or market. Harvesting of crops when physiologically mature can minimise losses during transportation to the homestead. Physiological harvesting refers to the time when a grain (fruit, etc.) can be separated from its parent plant and continues to ripen over time. Farmers should consider planting earlier or later or consider planting faster or slower maturing varieties to avoid issues of post-harvest loss. This is a climate smart practice because it reduces potential losses of ripened grain, increase the quality of grain harvested, and is overall a more efficient use of resources, all while mitigating the spread of diseases and reducing GHG emissions.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | No

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator	Scale	Boxed
Return on Investment Realisation Period	Short – Medium – Long	Short, Medium
Crop production	Negative – Neutral – Positive	Positive
Fodder production	Negative – Neutral – Positive	Neutral
Farm income	Negative – Neutral – Positive	Positive
Household workload	Negative – Neutral – Positive	Neutral
Food security	Negative – Neutral – Positive	Positive

Ecological Impacts Positive or Negative

Indicator	Scale	Boxed
Soil quality/cover	Negative – Neutral – Positive	Neutral
Biological diversity	Negative – Neutral – Positive	Neutral
Flooding	Negative – Neutral – Positive	Neutral
Crop/livestock water availability	Negative – Neutral – Positive	Neutral
Wind Protection	Negative – Neutral – Positive	Neutral
Erosion control	Negative – Neutral – Positive	Neutral

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement Changing Harvest Time practices:

- **Step 1:** Consider researching recent rainfall records and consult national meteorological services to as accurately predict start of rainy season as possible.
- **Step 2:** Farmers should consult data provided by the African Post Harvest Loss Information System (APHLIS), which provides information on harvest loss and additional resources to consult.
- **Step 3:** Consult with national agricultural extension and research to determine growing periods of chosen crops. Request information about quicker or slower maturing seeds.
- **Step 4:** Plant crops at the right time so as to avoid harvesting during rainy season.
- **Step 5:** Harvest as soon as crops are physiologically mature.
- **Step 6:** Wait 24 hours after a rain period to harvest if rain is unavoidable. This may take several days, however, harvesting crops after one rain is better than leaving it for an entire rainy season.
- **Step 7:** Crops should be transported to the storage for immediate drying

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Reduces potential losses of ripened grain.
- More grain of a higher quality to consume and sell.
- More efficient use of resources.

SUMMARY/KEY ISSUES

Benefits

- Reduces the potential loss of ripened grain and increases potential higher quality grain for consumption or market.
- It improves crop production, food security and farm income.

Drawbacks

- Moisture from rainfall at harvest time can risk crop degradation post-harvest, due to mould, decay and disease.
- Different crops have different growing seasons, and this should be known and monitored constantly, specifically as climate change has been shown to alter growing seasons, which will in turn impact harvesting times.

SUMMARY/KEY ISSUES

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 12, Climate Smart Post-Harvest Management Options for Maize, Sorghum & Rice.

Additional Information

- APHLIS News, 2019. African Post Harvest Post Harvest Loss Information System. Washington D.C.
- Food and Agriculture (FAO) ,2016. Information on Post-Harvest Operations (INPhO). Italy, Rome.
- World Food Programme, 2012. Training Manual for Improving Grain Post-Harvest Handling and Storage. University of Greenwich.

Drying Techniques

Technical Brief 38

Drying techniques are agricultural practices applied to assist with the balance of moisture in grains post-harvest, determined by a combination of ambient temperature and relative humidity. Spoiling due to insufficiently dried grain is one of the main causes of grain deterioration, loss in grain quality, and thus market value. Grains have the capability to absorb or evaporate moisture, and a balance of moisture content in the air and grains should be sought to achieve an Equilibrium Moisture Content (EMC). EMC prevents the formation of moulds that may affect the quality of grains, spread of pests and germination of grain seeds. After harvest, transportation and threshing, grain needs to be further dried to be preserved. Natural drying techniques are based on ambient air circulation to reduce the moisture content of the grain before storage. Artificial drying techniques apply fans and/or heating elements to move air and maintain constant temperatures .Natural drying (sun drying) is the preferred, commonly used agricultural technique in southern Africa and does not require use of machinery. Drying techniques preserve the contents of seeds thus assuring sustainable agricultural productivity and the practice as climate smart.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period

Short | Medium | Long

Crop production

Negative | Neutral | Positive

Fodder production

Negative | Neutral | Positive

Farm income

Negative | Neutral | Positive

Household workload

Negative | Neutral | Positive

Food security

Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover

Negative | Neutral | Positive

Biological diversity

Negative | Neutral | Positive

Flooding

Negative | Neutral | Positive

Crop/livestock water availability

Negative | Neutral | Positive

Wind Protection

Negative | Neutral | Positive

Erosion control

Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement Drying Technique practices:

- **Step 1:** Harvest crops.
- **Step 2:** Consider the number of different crops that need to be dried.
- **Step 3:** Dry the crops naturally using air temperature or direct sunlight or artificial drying through using fans or other mechanical means.
- **Step 4:** Never place crops directly on the soil but rather on a cement area, woven mats or a layer of sacks.
- **Step 4:** Livestock should be kept away from drying grains to prevent contamination and loss.
- **Step 5:** Farmers should consult storage life charts that will help determine dry crop characteristics and approximate times for drying.
- **Step 6:** Cover all drying grain at night to prevent loss or damage.
- **Step 7:** Sorghum should be left on the seed, maize should be de-husked and left on the cob, grain and pulses are normally left in their pods.
- **Step 8:** Monitor the stored grain by checking at least every two weeks.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Reduces potential losses of ripened grain.
- More grain of a higher quality to consume and sell.

SUMMARY/KEY ISSUES

Benefits

- Prevents loss in grain quality
- Outside on a flat surface, drying system costs less
- The drying crib system can be used for many years
- Forced air/hot air dryer systems are not weather dependent

Drawbacks

- Imbalanced EMC leads to low quality seed, possible mould/decay and possible germination of grain seeds
- The natural drying technique is not suitable for humid climates as EMC is difficult to achieve without artificial drying

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 13, Climate Smart Post-Harvest Management Options for Maize, Sorghum & Rice.

Additional Information

- Food and Agriculture Organisation (FAO), 1994. Agricultural engineering in development. Italy, Rome.
- Food and Agriculture Organisation (FAO), 2001. Rural structures in the tropics. Design and development. Chapter 16 Grain crop drying, handling and storage. Italy, Rome.
- World Food Programme (WFP), 2012. Training Manual for Improving Grain Postharvest Handling and Storage. Italy, Rome.

Physical Storage Option

Grains are stored to reduce the opportunities for loss, damage or infestation by pests. On the farm grain storage can be short-term (>3 months) before it is moved to the supply chain, long term (3-12 months) while farmers store it for home consumption, to sell when prices are more favourable or for planting in the next season. During this phase of post-harvest processing, grains can be stored in bags, silos or other bulk storage containers. Bag storage utilises permeable sacks that will allow air movement in and out of the bag. Structures can be built to store grains and solid-wall bins or silos should be used in areas where grains can be dried properly. Other options include airtight underground pits, steel bins, while concrete silos and warehouses can also be used as storage options. While storing grains to ensure favourable storage, facilities should be kept clean, covered, and never exposed to the elements. However, pest control measures need to be established, such as adhering to acceptable grain moisture content levels at storage to deter insect infestation, as pests (rodents, insects, etc.) can devastate grains in storage. Physical storage options are built to meet the demand and supply of grains season-to-season and to make seeds available for the next planting season.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | No

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator	Options	Boxed
Return on Investment Realisation Period	Short / Medium / Long	Short, Medium
Crop production	Negative / Neutral / Positive	Positive
Fodder production	Negative / Neutral / Positive	Neutral
Farm income	Negative / Neutral / Positive	Positive
Household workload	Negative / Neutral / Positive	Neutral
Food security	Negative / Neutral / Positive	Positive

Ecological Impacts Positive or Negative

Indicator	Options	Boxed
Soil quality/cover	Negative / Neutral / Positive	Neutral
Biological diversity	Negative / Neutral / Positive	Neutral
Flooding	Negative / Neutral / Positive	Neutral
Crop/livestock water availability	Negative / Neutral / Positive	Neutral
Wind Protection	Negative / Neutral / Positive	Neutral
Erosion control	Negative / Neutral / Positive	Neutral

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement Physical Storage Options:

- **Step 1:** When making a choice of which storage option to choose, farmers must consider the type of crop to be stored, storage requirements of the crop and the form in which the crop must be stored (for 0-6months/3-12months).
- **Step 2:** Grains must be stored in a dry place with a constant temperature.
- **Step 3:** Crops should be dried and have low moisture content prior to storage.
- **Step 4:** Airtight containers should be used to avoid insect infestation.
- **Step 5:** Based on farmer resources and time of storage, there are a number of containers that can be utilised to store harvested crops including metal silos, polythene sacks (that can be layered), mud silos, plastic bags.
- **Step6:** As a last measure, insecticides in the form of a powder can be applied to harvested crops. The powder comes in pre-measured packets and are low dosage so generally safe to handle. Information is provided on each packet and should be read before integrating it into the crop. **Grain needs to be cleaned before consumption**

Technical Brief 39

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Reduces losses during storage.
- Storage that is protected from flooding, extreme rain and heat will protect grain. Potential to store until prices are higher and increase income.
- More efficient use of resources.

SUMMARY/KEY ISSUES

Benefits

- Storage options can support food security and assist farmers respond to supply and demand, leveraging favourable market prices and conditions.
- Suitable for short- and long-term storage.

Drawbacks

- Uncontrolled grain moisture may lead to insect infestation and loss in grain.
- Insect fumigation may contaminate grains.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 13, Climate Smart Post-Harvest Management Options for Maize, Sorghum & Rice.

Additional Information

- Food and Agriculture Organisation (FAO), 1994. Agricultural engineering in development. Rome, Italy.
- Food and Agriculture Organisation (FAO), 2011. Rural structures in the tropics: design and development – Chapter 16, Grain crop drying, handling and storage. Rome, Italy.

Non-Conventional Feeds

Technical Brief 40

Non-Conventional Feeds (NCF) are either traditional or commercial animal feed-types that are not traditionally utilised as animal feed. These feeds are generally in one of two categories: by-products of agroecological industrial processes, or plants/plant materials from other processes. Examples of industrial by-products include groundnut cake, molasses and cotton seed meal, which are outputs from other processes and are found in proximity of manufacturing points, but often have a short shelf-life. Plant materials can be vegetable peels or locally available crop residues such as maize stalks and other remaining parts of harvested plants not consumed by humans. NCF decrease the demand of land to grow fodder, act as an alternative source for animal feed, resulting in the decrease of food competition between animals and humans ensuring food security. Furthermore, the use of bi-products optimises the use of raw materials and can increase profitability for the producer and the farmer.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain
Maize | Sorghum | Rice | Livestock | Other

Soil texture
Light | Medium | Heavy

Climatic zone
Arid | Semi-arid | Sub-humid | Humid

Water source
Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)
< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography
Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action
Yes | No

Characteristics
Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)
< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation
Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort
Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)
Yes | No

Financial resources

Initial investment
Low | Medium | High

Maintenance Costs
Low | Medium | High

Access to finance capital or credit required
Yes | No

Enabling Environment

Extension support
Yes | No

Access to inputs
Yes | No

Market access
Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period
Short | Medium | Long

Crop production
Negative | Neutral | Positive

Fodder production
Negative | Neutral | Positive

Farm income
Negative | Neutral | Positive

Household workload
Negative | Neutral | Positive

Food security
Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover
Negative | Neutral | Positive

Biological diversity
Negative | Neutral | Positive

Flooding
Negative | Neutral | Positive

Crop/livestock water availability
Negative | Neutral | Positive

Wind Protection
Negative | Neutral | Positive

Erosion control
Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement NCF practices:

- **Step 1:** Determine potential sources of NCFs in the local area and consider if the potential products are suitable (provide enough energy, are digestible, palatable to livestock animals, etc) and require additional investment to access or use.
- **Step 2:** Collect for free/negotiate lower rates with producers of agroecological industrial process biproducts or plant materials to gain access to their 'waste' materials.
- **Step 3**: Determine how sustainable and consistent the supply will be from the providers. If possible, identify a range of suppliers to mitigate potential losses of stockpiled NCFs.
- **Step 4:** Before being used as feed, NCF's from agroecological processes must be appropriately processed - (grinding (8 mm) and pelleting) and mixed into a uniform blend. Hence, labour requirements may increase. This could be mechanised.
- **Step 5:** Livestock should be monitored when these feeds are introduced to ensure digestibility of the product for the animals.
- **Step 6:** Based on advice from the suppliers of agroecological industrial process biproducts, ensure appropriate storage of materials to avoid loss of nutrition, pests and waste.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Can supplement conventional feed to enhance productivity.
- Reduces pressure on land to produce fodder.
- As these are by-products of industrial processes, no additional inputs to produce fodder are required.

SUMMARY/KEY ISSUES

Benefits

- The use of NCFs could be a cheap and good source of nutrients for livestock.
- NCF act as an alternative source for animal feed, resulting in a decrease of food competition between animals and humans.

Drawbacks

- NCF's need to be handled properly to avoid formation of moulds that are not good for animal health.
- Farmers need to acquire skills on how best to conserve these residues for animal consumption, like drying before storing to avoid the loss of nutritional value.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 14, Climate Smart Diet Management Options for Livestock.

Additional Information

- Food and Agriculture Organisation, 1990. Animal Feed Resources in Asia and the Pacific. Rome, Italy.
- CGIAR, 2002. Evaluation of non-conventional agro-industrial by-products as supplementary feeds for ruminants: In vitro and metabolism study with sheep. Montpellier, France.
- Food and Agriculture Organisation, 1985. Non-Conventional Feed Resources in Asia and the Pacific. Rome, Italy.

Improved Digestibility, Improved Protein Content

Improved protein content in animal feed can positively impact productivity, such as the quality and quantity of meat and milk. With the increase in global demand for meat and dairy products, the increase of protein in livestock diets is extremely important. Key to the absorption of protein in livestock diets is the improved digestibility of protein. For protein to be utilised efficiently by livestock i.e. consumed and converted into body protein and resulting in bigger and better-quality meat, certain amino acids need to be present. Thus, to maximise protein deposition in livestock, the required amino acids must also be included in the feed. Amino acids have been added to livestock feed for over 40-years. The most common amino acids added to feeds are Methionine, Lysine, Threonine, and Tryptophan. With the expansion of inexpensive plant-based proteins (soybeans etc.) and increasing demands for meat, plant-based proteins offer an alternative or supplement to amino-acids, contributing to greater efficiency of conversion of proteins from feed to meat. Plant-based proteins also require less monitoring than synthetic additives, but amino acids are often needed to maintain digestibility. Improved livestock productivity and conversion is climate smart because there is more efficient conversion of food to weight gain and less livestock pressure on land, supporting a more efficient value chain.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator			
Return on Investment Realisation Period	**Short**	Medium	Long
Crop production	Negative	**Neutral**	Positive
Fodder production	Negative	**Neutral**	Positive
Farm income	Negative	Neutral	**Positive**
Household workload	Negative	**Neutral**	Positive
Food security	Negative	Neutral	**Positive**

Ecological Impacts Positive or Negative

Indicator			
Soil quality/cover	Negative	**Neutral**	Positive
Biological diversity	Negative	**Neutral**	Positive
Flooding	Negative	**Neutral**	Positive
Crop/livestock water availability	Negative	**Neutral**	Positive
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	**Neutral**	Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement Improved digestibility, Improved protein content:

- **Step 1:** Inform farmers of the possible benefits of increased dietary protein in their livestock in order to implement dietary supplements.
- **Step 2:** Identify a supplement contain the key amino acids - Methionine, Lysine, Threonine, and Tryptophan, in consultation with suppliers and veterinarians.
- **Step 3:** Added supplements to green plant residue (silage) as guided on packaging or by supplier to increase the efficiency of protein in livestock. Ensure that supplement amounts are suitable for animals and the type of feed being supplemented.
- **Step 4:** Ensure that supplements sourced will be consistently available from suppliers in the region. These supplements can be purchased at most agricultural shops, including rural areas.
- **Step 5:** As a low-cost option, farmers can formulate rations specific to their livestock. These rations are only for domestic use and not commercial.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Less feed is required to reach the same levels of production. Potentially this means less livestock pressure on land.

Less is required to reach the same levels of production. Potentially this means less livestock pressure on land.

SUMMARY/KEY ISSUES

Benefits

- Protein absorption in livestock contributes to increased meat and milk production.
- Less livestock pressure on land.

Drawbacks

- Synthetic amino acids require constant monitoring.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 14, Climate Smart Diet Management Options for Livestock.

Additional Information

- CGIAR, 2011. Animal feeds component: Background proposals for the CGIAR Research Program on Livestock and Fish. Montpellier, France.
- Food and Agriculture Organisation (FAO), 2002. Protein Sources for the Animal Feed Industry. Rome, Italy.

Use of Feed Supplements

General Feed Supplements are used to increase nutrients in livestock diets, with the aim of maintaining or improving livestock health through adequate animal nutritional balance and therefore productivity of milk or meat. These supplements include vitamins, amino acids, minerals, and other nutrients. Supplementary feeding can becoming either a regular part of the production cycle to help match feed demand to feed supply, assisting livestock farmers meet production requirements as defined by market specifications, or reserved for times of shortage during dry spells and/or droughts. The extent to which supplementary feeding is applied depends on the farm/business objectives and seasonal conditions. This is especially true in areas of low-quality crop residues and low quality pasture land.

Feed supplements are presented in granular, powder or block form and used during milk production and fattening stages for meat production. However, if consumed in excess feed supplements can be harmful to livestock causing toxicity and if persistent, death.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | Medium | Long

Crop production: Negative | Neutral | Positive

Fodder production: Negative | Neutral | Positive

Farm income: Negative | Neutral | Positive

Household workload: Negative | Neutral | Positive

Food security: Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | Positive

Biological diversity: Negative | Neutral | Positive

Flooding: Negative | Neutral | Positive

Crop/livestock water availability: Negative | Neutral | Positive

Wind Protection: Negative | Neutral | Positive

Erosion control: Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement Improved digestibility, Improved protein content:

- **Step 1:** Inform farmers of the possible benefits of increased dietary protein in their livestock in order to implement dietary supplements.
- **Step 2:** Identify a supplement contain the key amino acids - Methionine, Lysine, Threonine, and Tryptophan, in consultation with suppliers and veterinarians.
- **Step 3:** Added supplements to green plant residue (silage) as guided on packaging or by supplier to increase the efficiency of protein in livestock. Ensure that supplement amounts are suitable for animals and the type of feed being supplemented.
- **Step 4:** Ensure that supplements sourced will be consistently available from suppliers in the region. These supplements can be purchased at most agricultural shops, including rural areas.
- **Step 5:** As a low-cost option, farmers can formulate rations specific to their livestock. These rations are only for domestic use and not commercial.

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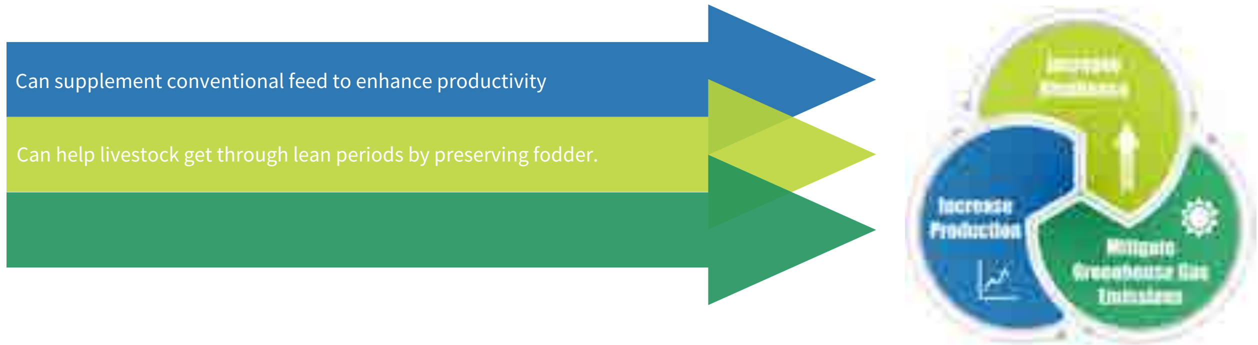
CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Feed supplements are used to balance animal nutrition, resulting in high market value and quality of livestock.
- They help improve animal productivity and nutrition.
- Beneficial in areas of poor pasture or during drought seasons where animal feeds are scarce.

Drawbacks

- Excessive consumption of supplements can be toxic to animals and can lead to death if over consumption persists.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 14, Climate Smart Diet Management Options for Livestock in the SADC region.

Additional Information

- Food and Agriculture Organisation (FAO), 2007. Feed Supplementation Blocks. Rome, Italy.
- Food and Agriculture Organisation (FAO), 2002. Protein Sources for the Animal Feed Industry. Rome, Italy.

Carrying Capacity Improvement

Technical Brief 43

Carrying capacity defines the number of Animal Units (AU; head of cattle or number of sheep, goats or other animals) that can graze in a rangeland unit without exhausting the vegetation and soil quality – essentially optimally utilising resources. Optimum carrying capacity is where a given unit of rangeland can support healthy populations of animal species, while allowing an ecosystem to regenerate, thus creating a sustainable balance. The stocking rate - defined as the number of animal species grazing a unit of rangeland for a limited period - must be kept fixed on an average year, meeting the carrying capacity to allow regeneration, the fallen seeds to rejuvenate and the soil to recover. However, stocking rates can fluctuate depending on the nature of the vegetation, rainfall variability, herd composition and management system. If the conditions are not favourable for vegetation growth during drought season, the number of livestock or the grazing period must be adjusted to avoid overgrazing. Moreover, the purpose of livestock keeping, i.e. for milk, meat, or wool production, will determine the carrying capacity of a rangeland unit. Factors such as climatic zone, rainfall dependency, class of livestock (steer, dry cow, calves, lactating cow and bull, etc), health of grassland and animal species affect the stocking rate. While relevant in all climatic zones, it is more applicable in arid and semi-arid zones where rainfall is most scarce. This climate smart practice increases production (meat/dairy), increases pasture resilience to extreme climate hazards (drought) and enhances soil fertility.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator			
Return on Investment Realisation Period	Short	**Medium**	Long
Crop production	Negative	**Neutral**	Positive
Fodder production	Negative	Neutral	**Positive**
Farm income	Negative	Neutral	**Positive**
Household workload	Negative	**Neutral**	Positive
Food security	Negative	Neutral	**Positive**

Ecological Impacts Positive or Negative

Indicator			
Soil quality/cover	Negative	Neutral	**Positive**
Biological diversity	Negative	Neutral	**Positive**
Flooding	Negative	**Neutral**	Positive
Crop/livestock water availability	Negative	Neutral	**Positive**
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	Neutral	**Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement Carrying capacity improvement:

- **Step 1:** There is no standard equation to determine the carrying capacity of an area, as many variables apply and factors relevant within each context including size of land unit, amount, frequency and timing of rainfall seasons, type of vegetation, species of animal, etc.
- **Step 2:** Extension officers should aim to support farmers to continuously monitor rangeland status and realise the impacts of over-grazing and the benefits of finding an equilibrium.
- **Step 3:** Constant monitoring of the pasture and animals must be carried out throughout the year to check if stocking rate aligns with the carrying capacity of the land unit. If land degradation is identified, adjustments to stocking rates should be considered, in the context of season and landscape regeneration.

- For communal grazing land, it is ideal to use Animal Units (AU) to calculate the relative grazing impact of different kinds and classes of domestic livestock and/or even common grazing wildlife species for one month (AUM = Animal Unit Months). This information should support collective decision-making regarding rangeland resources.

  Using a conversion table of, the AUE (Animal Unit Equivalent) and the formula:

  1) multiply the number of animals to be grazed on the pasture by AUE to determine total AU, then

  2) multiply the total AU by the number of months planned to graze (see formula below or

  Worksheet A of the Range Calculator).

  Formula: ____________ x ____________ = ____________ x ____________ = ____________

  # Animals AUE(table) Animal Units (AU) Months (M) AUM

- **Step 4:** One option for effectively responding to carrying capacity challenges is shift or changing grazing species if high consumption species are placing pressure on a particular unit of land.

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Higher meat and/ or dairy production per unit area.
- Improved pasture (through proper management) allow higher numbers without retrogression, thus more resilient even to drought conditions, erosion, flooding, etc.
- Increases soil organic matter and plants-thus locks more carbon (c-sequestration).

SUMMARY/KEY ISSUES

Benefits

- Identifying, achieving and maintaining optimal carrying capacity helps to avoid rangeland degradation including vegetation depletion and soil erosion, bush encroachment, and optimises resource use.
- Effectively monitoring carrying capacity can allow communities to respond to climate change impacts, resulting from shifting rainfall patterns and temperature regimes.

Drawbacks

- Rainfall dependency, class of livestock and quality of grassland affect stocking rate.
- The stocking rate must be monitored to avoid animal overcrowding, which might cause diseases to spread quickly.
- It is important to monitor the plant species in your pasture and or rangelands to be able to determine its health and trend.
- Reseeding should be considered in areas when land is degrading.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 15, Climate Smart Pasture/Rangeland Management Options for Livestock in the SADC region.

Additional Information

- The Food and Agriculture Organisation (FAO), 1997. Livestock and the environment: Finding a balance. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2013. Carrying capacity tools for use in the implementation of an ecosystems approach to aquaculture. Rome, Italy.

Fodder Shrubs & Trees

Technical Brief 44

Fodder is the agricultural term for animal feed. Fodder trees and shrubs play an important role in bridging the gap between livestock feed requirements and the low quality and quantity of feeds available to many farmers. As well as providing feed or acting as a feed supplement for livestock, fodder trees and shrubs supply other benefits, such as firewood and erosion control. Fodder trees are either grown in-situ, from seed, and others are planted in nurseries and then transplanted to the field at the beginning of the rainy season. The transplanting method can be more successful than the direct planting - as high as 34 % better, but with a 24 % increase in cost per plant. Benefits of using fodder trees and shrubs as a dietary supplement include improved growth, health and reproductive capacity, and increased milk and meat production, mostly through increased protean uptake. Fodder trees and shrubs can be planted as living fences, field boundaries and in tree/shrub plantations. Popular species include African acacias, and *Atriplex nummularia, Cassia petersiana, C. mopane, D. cineria, F. albida, Julbernadia paniculata, P. reclinata, Piliostigma thonningii, Swartizia madagascariensis and Trema orientalis.*

Farmers of all categories can use this climate smart sustainable approach to produce both livestock and field crops to obtain improve benefits, improving nutrition for livestock animals, improving soil health, reducing cost of livestock feeding, and as a result increasing income

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | **Livestock** | **Other**

Soil texture: **Light** | **Medium** | **Heavy**

Climatic zone: Arid | **Semi-arid** | **Sub-humid** | **Humid**

Water source: **Rainfed** | Partly irrigated | Irrigated

Annual average rainfall (mm): **< 250** | **250 - 500** | **500 - 750** | **750 - 1000** | **1000 - 1500** | **> 1500**

Topography: **Flat to gentle slope (0 – 5 %)** | **Moderate to rolling slope (6 – 15 %)** | **Hilly slope (16 – 30 %)** | **Steep slope (> 30 %)**

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: **Yes** | No

Characteristics: **Subsistence** | **Commercial Small** | **Commercial Medium** | Commercial Large

Farm size (ha): **< 2** | **2 to 5** | **5 to 10** | > 10

Mechanisation: **Manual** | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | **Medium (seasonal)** | High (outside labour)

Gender/youth smart (low investment/low labour requirements): **Yes** | No

Financial resources

Initial investment: Low | **Medium** | High

Maintenance Costs: Low | **Medium** | High

Access to finance capital or credit required: Yes | **No**

Enabling Environment

Extension support: **Yes** | No

Access to inputs: **Yes** | No

Market access: **Yes** | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

- Return on Investment Realisation Period: Short | **Medium** | Long
- Crop production: Negative | **Neutral** | Positive
- Fodder production: Negative | Neutral | **Positive**
- Farm income: Negative | Neutral | **Positive**
- Household workload: Negative | **Neutral** | Positive
- Food security: Negative | Neutral | **Positive**

Ecological Impacts Positive or Negative

- Soil quality/cover: Negative | Neutral | **Positive**
- Biological diversity: Negative | **Neutral** | Positive
- Flooding: Negative | **Neutral** | Positive
- Crop/livestock water availability: Negative | **Neutral** | Positive
- Wind Protection: Negative | Neutral | **Positive**
- Erosion control: Negative | Neutral | **Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively carry out fodder tree-shrub production using a nursery environment – a covered or exposed separate planting area, often close to the farm so saplings can be tended easily - consider the following steps:

- **Step 1:** Identify one or more suitable species for fodder production, looking at suitable climatic, soil requirements, nutritional value and palatability, also considering source-plant (for cuttings) or seed availability.
- **Step 2:** Take cuttings of up to *1 metre in length from mature trees, cutting at an angle. Cutting should be planted within three days, and if transported, cutting end should be covered in wax or petroleum jelly.
- **Step 3:** Cuttings should be planted in 10 to 15 cm of soil either directly where they will grow or shallower in polythene planting cups.
- **Step 4:** Fodder crops should be planted as the rainy starts, providing sufficient water and mobilising enough nutrients to assist rapid growth.
- **Step 5:** Harvesting is again species specific*, and it is important to determine if drying prior to feeding, affects palatability or nutritional value.
- **Step 6:** Harvesting frequency should also be determined independently*as plants mature to ensure sustainable production that does not stunt long-term growth and productivity.
- **Step 7:** The farmer should consider how much fodder needs to be consumed immediately, how much dried as hay, and how much chopped and compressed to make silage.

Length of cutting, period prior to transplantation, and harvest quantities vary from species to species. Seek guidance from an agroforestry specialist or farmers that have experience with the process when selecting species, and how specifically to plant, manage and harvest fodder crops. An important element to understand is the volume of tree or shrub-based fodder each animal will require.

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Higher meat and/or diary production per unit area of land.

Diversification of diet can mitigate the effects of drought on availability of fodder in pasture/ rangeland. Co-benefits in improving soil fertility and reducing erosion.

Woody shrubs and trees lock carbon.

SUMMARY/KEY ISSUES

Benefits

- Fodder trees and shrubs can be highly beneficial sources of feed and nutrition for livestock, augmenting, or completely replacing traditional grazing.
- Can be utilised when over-grazing has occurred, to allow range land to regenerate.
- Fodder trees and shrubs add vital nutrients to the soil
- Fodder trees and shrubs can provide other benefits, including acting as living fences, and wind-breaks, as well as supplying firewood.
- Crop rotation is important and fodder crops often act as nitrogen fixers (legumes) as well.
- Fodder crops can also act as cover crops protecting and maintaining soil quality.

Drawbacks

- Growing fodder can be laborious
- The number of fodder trees and shrubs may be extensive, therefore sufficient land is required.
- Not only does the gathering of fodder require additional labour, but the harvested crop also requires management

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 15, Climate Smart Pasture/Rangeland Management Options for Livestock in the SADC region.
- CCARDESA 2019. Technical Brief 07. Intercropping. Gaborone, Botswana
- CCARDESA 2019. Technical Brief 08. Relay cropping. Gaborone, Botswana
- CCARDESA 2019. Technical Brief 09. Crop rotation. Gaborone, Botswana
- CCARDESA 2019. Technical Brief 33. Boundary Planting. Gaborone, Botswana
- CCARDESA 2019. Technical Brief 46. Cut and Carry. Gaborone, Botswana

Additional Information

- Franzel, S., Carsan, S. Lukuyu, B, Sinja, J. Wambugu, C. 2014. Fodder trees for improving livestock productivity and smallholder livelihoods in Africa. Current Opinion in Environmental Sustainability. 6
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Increased Palatability

Technical Brief 45

Palatability - referring to plant features or conditions that encourage animals to feed on the plant when given a choice – is important as the ability or willingness of animals to feed on specific forage determines the efficiency of production of animal products. When feed is consumed in larger quantities, depending on its nutritive value, it helps increase milk and/or meat production. Plants with stiff and harsh leaves are generally not palatable to animals, unlike those with softer leaves and grass. The nutritive value of the plant matters when it comes to palatability. Palatability will be determined by the texture, aroma, succulence, hairiness, leaf percentage, sugar content and other factors. Moreover, leaves are more palatable than stems. Palatability of plants can be increased by grazing livestock at the optimal grass growing stage before seed formation, using a High Intensity, Low Frequency (HILF) grazing pattern which allows uniform grazing of pastures and gives an allowance for regrowth and thus overall, uniform soil cover. Addressing palatability is often of greater concern during dry season, when grazing/pasture is less common, and farmers have to rely on stored silage.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain
Maize | Sorghum | Rice | Livestock | Other

Soil texture
Light | Medium | Heavy

Climatic zone
Arid | Semi-arid | Sub-humid | Humid

Water source
Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)
< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography
Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action
Yes | No

Characteristics
Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)
< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation
Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort
Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)
Yes | No

Financial resources

Initial investment
Low | Medium | High

Maintenance Costs
Low | Medium | High

Access to finance capital or credit required
Yes | No

Enabling Environment

Extension support
Yes | No

Access to inputs
Yes | No

Market access
Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator	Scale			Boxed
Return on Investment Realisation Period	Short	Medium	Long	Medium
Crop production	Negative	Neutral	Positive	Neutral
Fodder production	Negative	Neutral	Positive	Positive
Farm income	Negative	Neutral	Positive	Positive
Household workload	Negative	Neutral	Positive	Neutral
Food security	Negative	Neutral	Positive	Positive

Ecological Impacts Positive or Negative

Indicator	Scale			Boxed
Soil quality/cover	Negative	Neutral	Positive	Neutral
Biological diversity	Negative	Neutral	Positive	Positive
Flooding	Negative	Neutral	Positive	Neutral
Crop/livestock water availability	Negative	Neutral	Positive	Neutral
Wind Protection	Negative	Neutral	Positive	Neutral
Erosion control	Negative	Neutral	Positive	Neutral

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

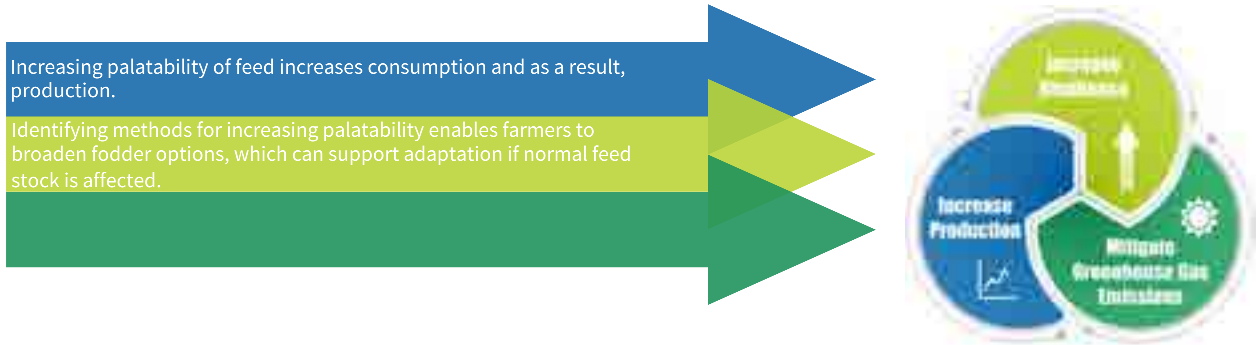
TECHNICAL APPLICATION

Traditional knowledge can also yield positive results in identifying sources of alternative dry season feeds, especially specific types of tree leaves and grasses. In mixed maize and livestock farming system, maize stovers can be utilised for more palatable feed supplements. To effectively improve palatability, the following steps should be carried out:

- **Step 1:** Where possible, mix grazing species to include browsers and grazers for uniform pasture use. Mixing livestock will reduce overgrazing on certain plants or plant types, distributing grazing pressure. This is a preventative measure. Over-seeding can be used to fill in bare patches in fields, improve the density of pasture, establish improved grass varieties and enhance your grass vigour. It's an easy way to improve an existing old or worn out, diseased or insect prone pasture by planting of grass seed directly into existing pasture, without tearing up the pasture, or the soil
- Step 2: **Speak to agricultural suppliers as palatability can be improved by enhancing the quality of the feed through addition of feed supplements.**
- **Step 3:** If using silage from high moisture crops, it may be worth exploring feed flavourants as they mask the odours and flavours of alcohol formed as plant material ferments. Natural flavourants can include garlic, anise and black cumin, but artificial flavours are also available. Ratios for addition to fodder is very low - 0.5 to 1.5 %.
- **Step 4:** If using dry grass for feed, chopping and addition of molasses and other concentrates can improve palatability of drier grasses; however, as it needs to be mixed with urea and water, guidance should be sought in terms of mix-ratios from a veterinarian to ensure that urea intake does not exceed recommended amounts.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Over-sowing increases forage quality and productivity.

Drawbacks

- Pasture palatability is affected by factors such as taste, smell and starch content.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 15, Climate Smart Pasture/Rangeland Management Options for Livestock in the SADC region.

Additional Information

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Cut and Carry

Technical Brief 46

Cut and carry is the agricultural practice of cutting and carrying fodder crops away from the field that they are grown in to feed to livestock. Fodder trees, shrubs or grasses are sources for livestock feed in this practice. Cut and Carry is a key CSA practice where overgrazing is a problem. This practice takes pressure off grazing land at critical periods, reduces land degradation caused by livestock and increases soil organic matter, while still feeding livestock for productive outcomes. This practice can also be used in more intensive livestock production where livestock are kept housed for periods stretching from half a year to a year and improved nutrition is required. However, fodder production can be costly in terms of cultivation, requiring significant management over and above the livestock themselves. Fodder is collected from sites where it grows naturally, or it can be grown in fodder banks, hedges, boundaries, etc. Feeding livestock using this approach can ensure the supply of a large quantity of high quality and palatable fodder within a short time, as well ensuring soil is not disturbed through open grazing systems, thus a good CSA practice. It can be adapted to the farmer's needs and can provide a way of introducing the farmer to the concept of improving livestock at the same time as conserving soil.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | Medium | Long

Crop production: Negative | Neutral | Positive

Fodder production: Negative | Neutral | Positive

Farm income: Negative | Neutral | Positive

Household workload: Negative | Neutral | Positive

Food security: Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | Positive

Biological diversity: Negative | Neutral | Positive

Flooding: Negative | Neutral | Positive

Crop/livestock water availability: Negative | Neutral | Positive

Wind Protection: Negative | Neutral | Positive

Erosion control: Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement cut and carry systems:

- **Step 1:** Cut and carry commences with the cutting of the crop.
- **Step 2:** Cut crop when plants are fully mature (vegetative growth and plant sugars are at their peak). This ensures that protein, digestible energy and dry matter percentage are at their highest potential.
- **Step 3:** Fodder can be fed directly or dried as hay or preserved as silage to conserve its value and be fed to livestock during the dry season or other critical times throughout the year.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Fodder can be harvested on multiple occasions during times of plenty and preserved for later, rather than leaving as standing hay.

Reduces pressure of grazing by limiting period livestock tread on land causing denudation at critical periods (with less cover).

SUMMARY/KEY ISSUES

Benefits

- Improves fodder production and farm income.
- Growing fodder crops in rainy seasons encourages fodder conservation for dry season feeding.
- Can be combined with crop rotation and intercropping to form part of positive farm management practices.
- Cut and carry can relieve pressure from pasture and grazing land, contributing to control of over-grazing, while improving soil quality.
- Can create job opportunities and income generation for youth farmers.

Drawbacks

- The practice will require additional labour resources.
- Can be costly in terms of management.
- Farmers must have enough land to grow fodder on or have access to communal land.
- Soil condition in the fodder fields must be carefully monitored to ensure that soil nutrients aren't depleting.
- Fodder storage must be monitored to ensure bacteria and mould do not affect the quality of feed.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 15, Climate Smart Pasture/Rangeland Management Options for Livestock in the SADC region.

Additional Information

- Food and Agriculture Organization (FAO), no date. Alternatives to Fencing Grazing Systems. Rome, Italy.
- Shamba Shape Up, 2014. Biogas, ECF, Seeds & Fodder. eries 7, Episode 10.

Rotational Grazing

Rotational grazing is a practice of moving livestock between different units of pasture in regular sequence to allow the recovery and regrowth of pasture plants after grazing. This facilitates management of the nutritional needs of the various types of livestock whilst maintaining pasture productivity. Management of intensive grazing/controlled grazing is a climate smart practice as it results in improved forage harvest, soil fertility, resistance to drought, reduced pasture weeds establishment, reduced wastage of forage and soil compaction.

Rotational grazing can also be combined with cut and carry approaches - when managed correctly; rotational grazing can provide enough forage growth early in the grazing season for producers to harvest feed for later use in some paddocks as rotation continues. Farmers can use temporary fence systems to manage the size of, and access to pastures.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | No

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator			
Return on Investment Realisation Period	Short	**Medium**	Long
Crop production	Negative	**Neutral**	Positive
Fodder production	Negative	Neutral	**Positive**
Farm income	Negative	Neutral	**Positive**
Household workload	Negative	**Neutral**	Positive
Food security	Negative	Neutral	**Positive**

Ecological Impacts Positive or Negative

Indicator			
Soil quality/cover	Negative	Neutral	**Positive**
Biological diversity	Negative	Neutral	**Positive**
Flooding	Negative	**Neutral**	Positive
Crop/livestock water availability	Negative	Neutral	**Positive**
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	Neutral	**Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively carry out rotational grazing practices:

- **Step 1:** Plan livestock grazing system, based on livestock types, stocking density, pasture crop hardiness and production, rainfall, soils and available alternative pasture fields and space, focusing on the nutritional and forage needs of the animals.
- **Step 2:** Use temporary electric fence systems to manage the size of the paddock.
- **Step 3:** Move livestock between paddocks every set number of days (two days; one week; one month).
- **Step 4:** Assess forage quality and quantity, regulating the acreage of access and control by implementing the electric fence system, which uses electrified fencing to determine which parts of the pasture that the livestock will access.
- **Step 5:** Monitoring efficacy of the system, changing rotation periods and extend recovery time for grazed land, if land becomes degraded.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Increased and more productivity per unit area.
- Gives land time to recover after grazing and hence, being more resilient to extremes.
- Increases vegetation cover and soil organic matter and locks carbon.

SUMMARY/KEY ISSUES

Benefits

- Controlled rotational grazing is an effective conservation practice to apply that improves animal management, increases soil fertility, forage productivity, and reduces soil nutrient depletion and soil erosion.

Drawbacks

- Appropriate land access is a issue, with farmers requiring substantial land or approval and agreement from the community to operationalise the approach.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 15, Climate Smart Pasture/Rangeland Management Options for Livestock in the SADC region.

Additional Information

- Food and Agriculture Organisation (FAO),2018. Restricted breeding and rotational grazing. Rome, Italy.
- WOCAT, 2008. Rotational Grazing, allowing livestock to graze in pasturelands in a periodic and regular manner. Turkey.

Manure Collection, Storage and Treatment

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Manure is organic matter that is used as an organic fertiliser in agricultural practices, conditioning and adding nutrients to soil, generally derived from animal faeces. Manure is the best source of fertiliser available to a farmer, as it can be readily available from livestock, and it a more environmentally friendly option over synthetic fertilisers. Animal manure, compost and green manure are the three different types of manure used in soil management. Manure is collected in different forms: liquid manure, slurry manure or solid manure, and treated in different systems depending on its state. Liquid and slurry manure are stored in liquid (slurry) manure storage systems whereas solid manure is stored in sacks in order to allow air and toxic vapours to move in and out, as well as to maintain the moisture content. The manure is collected and treated (as described below) in order to kill pests that may feed on crops during the application period. The manure is further cleaned to remove unwanted substances such as sticks, and large lumps formed in the manure.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: ○ Maize ○ Sorghum ○ Rice ● Livestock ○ Other

Soil texture: ● Light ● Medium ● Heavy

Climatic zone: ● Arid ● Semi-arid ● Sub-humid ● Humid

Water source: ● Rainfed ● Partly irrigated ● Irrigated

Annual average rainfall (mm): ○ < 250 ● 250 - 500 ● 500 - 750 ● 750 - 1000 ● 1000 - 1500 ● > 1500

Topography: ● Flat to gentle slope (0 – 5 %) ● Moderate to rolling slope (6 – 15 %) ● Hilly slope (16 – 30 %) ● Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: ○ Yes ● No

Characteristics: ● Subsistence ● Commercial Small ● Commercial Medium ● Commercial Large

Farm size (ha): ● < 2 ● 2 to 5 ● 5 to 10 ● > 10

Mechanisation: ● Manual ● Animal ● Mechanised

Human resources

Labour intensity – level of effort: ○ Low (household) ● Medium (seasonal) ○ High (outside labour)

Gender/youth smart (low investment/low labour requirements): ● Yes ○ No

Financial resources

Initial investment: ● Low ○ Medium ○ High

Maintenance Costs: ● Low ○ Medium ○ High

Access to finance capital or credit required: ○ Yes ● No

Enabling Environment

Extension support: ○ Yes ● No

Access to inputs: ● Yes ○ No

Market access: ○ Yes ● No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Impact	Options (boxed = applicable)
Return on Investment Realisation Period	[Short] [Medium] Long
Crop production	Negative / Neutral / [Positive]
Fodder production	Negative / Neutral / [Positive]
Farm income	Negative / Neutral / [Positive]
Household workload	Negative / [Neutral] / Positive
Food security	Negative / Neutral / [Positive]

Ecological Impacts Positive or Negative

Impact	Options (boxed = applicable)
Soil quality/cover	Negative / Neutral / [Positive]
Biological diversity	Negative / Neutral / [Positive]
Flooding	Negative / [Neutral] / Positive
Crop/livestock water availability	Negative / [Neutral] / Positive
Wind Protection	Negative / Neutral / [Positive]
Erosion control	Negative / Neutral / [Positive]

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement manure collection, storage and treatment:

- **Step 1:** Use gloves before handling animal manure from any livestock.
- **Step 2:** Use shovels and wheel barrows to load and transport the material.
- **Step 3:** Store manure in a contained area, with a solid bottom (cement pad) to prevent runoff and leaching into local waterbodies or groundwater.
- **Step 4:** Mix all types of manure with organic substances such as vegetable waste, garden debris, dead leaves, sawdust, wood ash, hay and straw etc. to add structure and other organic compounds to the soil.
- **Step 5:** Turn mixed manure over regularly to allow for combining of nutrients and further aeration.
- **Step 6:** Cut-up large particles of animal manure to no more than 10 cm in size.
- **Step 7:** Spread manure evenly on field a few weeks prior to planting or during planting. It can also be applied in micro-doses around crops and trees directly.

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Organic matter in manure can be used to fertilise crops, improving soil health and productivity.
- Manure collection and management can contribute to crop production.

SUMMARY/KEY ISSUES

Benefits

- The use of manure helps to maintain the organic-matter content of the soil, which can improve soil structure, increases nutrient availability and crop productivity
- An additional benefit is that it increases soil carbon and reduces atmospheric carbon levels
- Manure application can be spread across fields or in micro-doses.

Drawbacks

- Manure leachate can carry concentrated ammonia and other potentially harmful organic compounds. Therefore, it should be contained in one area to prevent possible negative environmental impacts from runoff.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 16, Climate Smart Manure Management Options for Livestock.

Additional Information

- CGIAR, 2016. Manure helps feed the world: Integrated Manure Management demonstrates manure is a valuable resource. Montpellier, France.
- The Food and Agriculture Organisation (FAO), 2018. Nitrogen inputs to agricultural soils from livestock manure. Rome, Italy.

Hybridisation Traditional Breeds

Technical Brief 49

Hybridisation is the agricultural practice of genetically manipulating flora and fauna that differ in heredity. Hybridisation and mutations are the main source of hereditary variation and can result in the increased growth rate, manipulated gender ratios, increased yields, sterile animals, improved flesh quality, increase disease resistance and improve environmental tolerance. Intraspecific hybridisation method is used for livestock breeding whereby individuals of different breeds or strains are mated. Distant hybridisation for livestock is difficult to accomplish as hybrids are usually sterile. Hybrid animals are extremely difficult to produce and specialists often spend their careers attempting to create a new breed of animal. Hybridisation is plant species is more common and has a greater success rate than animal species, however successfully creating a hybrid species remains difficult to achieve. Specialists are trained on the gene sequence and different methods for accomplishing hybridisation. The development of hybrid flora and fauna is often undertaken to address a problem or issue. For example, to address socio-economic challenges agricultural researchers may attempt to produce a species of chickens who lay lager eggs or cows who produce more milk. Hybridisation is also applied to address the challenges of a changing climate including producing crops that are more drought resistant. Due to the research and development of these hybrid species they are expensive to access and often not available in remote areas. Traditional breeds are pure individual species with no DNA alterations. They are often endemic to an area and because of this have evolved and adapted to the geophysical area they are found. Thus, traditional breeds are often found in certain areas, and through traditional knowledge have been incorporated into local farming systems for generations. With an increasingly globalised world, it is difficult to maintain distinct traditional breeds as trade in species, seeds etc. is increasingly prevalent. However, with a new focus and dedication of farmers and researchers to explore indigenous knowledge there is an increased focus on reinvigorating the incorporation of traditional breeds of both flora and fauna.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | No

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator				Boxed
Return on Investment Realisation Period	Short	Medium	Long	Medium
Crop production	Negative	Neutral	Positive	Positive
Fodder production	Negative	Neutral	Positive	Positive
Farm income	Negative	Neutral	Positive	Positive
Household workload	Negative	Neutral	Positive	Neutral
Food security	Negative	Neutral	Positive	Positive

Ecological Impacts Positive or Negative

Indicator				Boxed
Soil quality/cover	Negative	Neutral	Positive	Positive
Biological diversity	Negative	Neutral	Positive	Positive
Flooding	Negative	Neutral	Positive	Neutral
Crop/livestock water availability	Negative	Neutral	Positive	Neutral
Wind Protection	Negative	Neutral	Positive	Neutral
Erosion control	Negative	Neutral	Positive	Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively leverage hybridisation:

- **Step 1:** Contact national extension and research as they are often working on developing new species of flora and fauna to meet local challenges including climate variance and introduce them to local farmers.
- **Step 2:** Research best methods applied to the practice of hybridisation in the region.
- **Step 3:** Meet with national agricultural extension and research staff as well and local breeders to determine desirable characteristics and possible crossing of livestock differing in heredity. For example, the mating of two different goat breeds to obtain an improved breed.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Increased the milk yield or weight gain of animals, thus increasing the amount of food that farmers can produce within available resources.

Breeding for resilience to:
- Pests/disease
- Heat and drought

SUMMARY/KEY ISSUES

Benefits

- This agricultural practice is widely used in breeding to increase growth rate, manipulate sex ratios, produce sterile animals, improve flesh quality, increase disease resistance and improve environmental tolerance.

Drawbacks

- This agricultural practice is widely used in breeding to increase growth rate, manipulate sex ratios, produce sterile animals, improve flesh quality, increase disease resistance and improve environmental tolerance.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 17, Climate Smart Genetic Improvement Options for Livestock.

Additional Information

- FAO,2003. Community-Based Management of Animal Genetic Resources. Rome, Italy.
- FAO, 1964. Unasylva – FAO/IUFRO meeting on forest genetics. Rome, Italy.
- FAO, 2000. The use of inter-species hybrids in aquaculture and their reporting to FAO. Rome, Italy.

Assisted Reproduction

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Assisted reproduction refers to artificial insemination, where semen is deliberately introduced to fertilise eggs in domestic animals. Artificial insemination helps in obtaining genetic improvements that yield higher production levels. This practice is more expensive but more efficient than natural reproduction. Artificial insemination reduces the risk of disease transmission and injuries or accidents during mating. Sperm duplication can be done from a single ejaculation to make hundreds of doses and distributed across farmers to have variety of breeds rather than off-spring from single bulls. This prevents inbreeding and promotes hybrid vigour among farmers'. In the southern African context, where most grazing is communal, use of bulls to improve breeds can be challenging as it is difficult to adopt a grazing system that will ensure good quality breeds are able to pass their progeny to the next generation, as young and likely non-superior bulls are likely to mate with cows during grazing. To achieve genetic improvement using open grazing requires controlled grazing systems, e.g. by use of paddocks to manage bulls grazing and mixing with cows.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period

Short | Medium | Long

Crop production

Negative | Neutral | Positive

Fodder production

Negative | Neutral | Positive

Farm income

Negative | Neutral | Positive

Household workload

Negative | Neutral | Positive

Food security

Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover

Negative | Neutral | Positive

Biological diversity

Negative | Neutral | Positive

Flooding

Negative | Neutral | Positive

Crop/livestock water availability

Negative | Neutral | Positive

Wind Protection

Negative | Neutral | Positive

Erosion control

Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement assisted reproduction using artificial insemination:

- **Step 1:** A qualified veterinarian or service provider should be readily available and preferably contracted to carry out the procedure as they should have the necessary training, instruments and facilities to carry out procedures;
- **Step 2:** The farmer should suggest the type of breed for his animal, and the veterinarian should advise the farmer on the feasible breed for the cow.
- **Step 3:** The farmer has to identify the cow on heat by observing the heat signs (uneasiness, making loud unusual noise, mounting others, standing when mounted, producing mucus discharge from the vulva, etc.)
- **Step 4:** The identified animal is isolated from the rest of the animals
- **Step 5:** Communicate with the veterinarian or trained service provider to carry out the procedure by determining the readiness of the cow to undergo the AI service (stage of heat cycle). Early reporting increasing chances of successful conception
- **Step 6:** The veterinarian or service provider then carries out the procedure to the cow after confirming readiness of the animal

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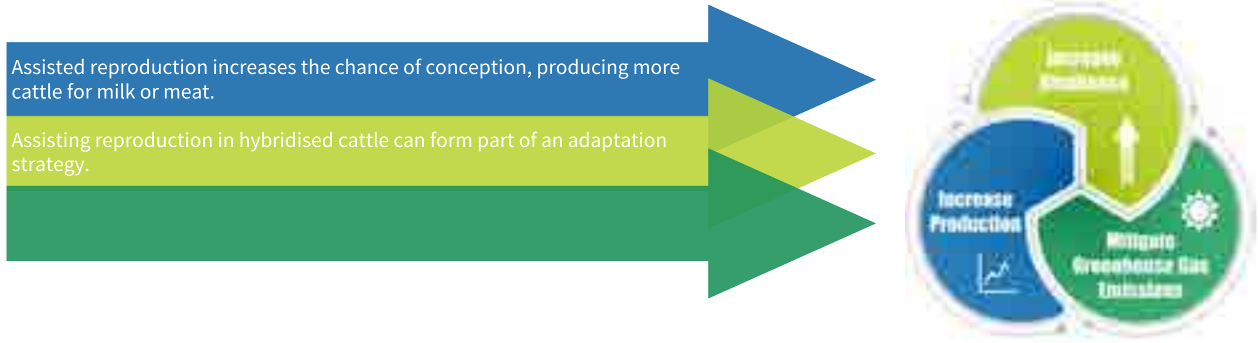
CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- Artificial insemination reduces injuries and accidents during mating, especially with heavier animals such as cattle.
- Farmers can collect semen and sell it to other people to obtain cash that will assist them in their daily activities to manage livestock.

Drawbacks

- It is more expensive but more efficient than natural processes.

SUMMARY/KEY ISSUES

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 17, Climate Smart Genetic Improvement Options for Livestock.

Additional Information

- Food and Agriculture Organisation (FAO) of the United Nations, 2002. Animal Production and Health Paper 154. Rome, Italy.
- Food and Agriculture Organisation (FAO) of the United Nations, 1991. Animal Genetic Resources. Rome, Italy.
- Food and Agriculture Organisation (FAO) of the United Nations,1993. Animal Zootechnie Zootecnia. Rome, Italy.

Alternative Breeds

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The Alternative breeds approach involves substitution of breeds, introducing a new (alternative) breed with a current breed to potentially increase production levels in a farm. Breed substitution involves genetic improvement of cattle and goats especially in dairy farming and meat production. Alternative breeds are introduced in order to ascertain competition between breeds based on health, fertility, performance, profits and management requirements. The substitution breeds are picked because there some traits that may be lacking in current breeds at the farm. For example, some farmers in Malawi who have introduced the Black Australop breed of chicken, either by crossbreeding with local chickens or replacing the local chicken altogether. This breed produces much more meat and lays more eggs, which increases farm production and income. This is a climate smart option as it introduces breeds that may require less water or can manage with lower quality feed – thereby reducing costs, and risks.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain
Maize | Sorghum | Rice | Livestock | Other

Soil texture
Light | Medium | Heavy

Climatic zone
Arid | Semi-arid | Sub-humid | Humid

Water source
Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)
< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography
Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action
Yes | No

Characteristics
Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)
< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation
Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort
Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)
Yes | No

Financial resources

Initial investment
Low | Medium | High

Maintenance Costs
Low | Medium | High

Access to finance capital or credit required
Yes | No

Enabling Environment

Extension support
Yes | No

Access to inputs
Yes | No

Market access
Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator			
Return on Investment Realisation Period	Short	**[Medium]**	Long
Crop production	Negative	**[Neutral]**	Positive
Fodder production	Negative	**[Neutral]**	Positive
Farm income	Negative	**[Neutral]**	Positive
Household workload	Negative	Neutral	**[Positive]**
Food security	Negative	Neutral	**[Positive]**

Ecological Impacts Positive or Negative

Indicator			
Soil quality/cover	Negative	**[Neutral]**	Positive
Biological diversity	Negative	**[Neutral]**	Positive
Flooding	Negative	**[Neutral]**	Positive
Crop/livestock water availability	Negative	**[Neutral]**	Positive
Wind Protection	Negative	**[Neutral]**	Positive
Erosion control	Negative	**[Neutral]**	Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively leverage alternative breeds:

- **Step 1:** Consult with national agricultural research and extension services to identify adaptable breeds available in the country/region, noting type of traits suitable for the particular ecological zone, and how to access stock. Traits to focus-on include health, milk production, disease tolerance, fertility, economic performance and adaptation to climate change and climate variability. Assisting with sourcing potential alternative breeds is a key role for Extension Officers.
- **Step 2:** Before selecting a substitution breed, the current breed must be evaluated to identify traits that are lacking, as well as compatibility. This will help in identifying traits that need to be improved.
- **Step 3:** Determine the cost effectiveness of the new breed to the area and or farmer, in terms of feed conversion rates, disease resistance, environmental conservation etc.
- **Step 4:** Consistently keep record of the livestock performance and behaviour for discussion with other farmers and extension officers.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Switching to alternative breeds can increase productivity in meat, milk and egg production.
- Changing to alternative breeds can form part of a successful adaptation strategy as climates change.

SUMMARY/KEY ISSUES

Benefits

- Alternative breeds are used to improve the genetic qualities of livestock.
- This agricultural practice improves biological diversity, ensures food security, increases farm income and most importantly reduces risk as cross breeds in future will be more resilient to climatic variations.

Drawbacks

- Requires research to identify suitable breeds.
- Livestock will require frequent monitoring to ensure cross-breeding is yielding required results.
- Replacement breeds should also be monitored to ensure they are adjusting to the local conditions.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 17, Climate Smart Genetic Improvement Options for Livestock.

Additional Information

- Journal of Animal Breeding Genetics, 2011. Community based alternative breeding plans for indigenous sheep breeds in four agroecological zones of Ethiopia. Ethopia.
- The Food and Agriculture Organisation (FAO), 2010. Breeding strategies for sustainable management of animal genetic resources. Rome, Italy.

Species Diversification

Species diversification involves a shift from a single species of livestock to more species in an attempt to manage risk and explore more resilient livestock farming options. Species diversification can be introduced in response to changes in local environment/climate conditions, including increasing temperatures, unreliable sources of water and availability of pasture, etc. The aim of this approach is to explore the introduction of species that may be more viable and adaptable in changing local conditions thus improving production levels by keeping animals that will be productive under harsh weather conditions and sustain the quality of the produce. Diversification as a climate smart practice assists farmers with utilising available resources more effectively, e.g. mixing grazers and browsers. Species that react well to changing climatic conditions may cause a shift of demand from grazers to browsers. This practice mitigates disease control, can improve soil fertility and increase water management. Government policies can also influence farmers in diversifying their species with many countries dedicating agricultural research and extension to explore the introduction of different species (e.g. cattle to goats) to assist farmers. It is important that species that are introduced do not have an adverse impact on local fauna or the surrounding environment.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: Short | Medium | Long

Crop production: Negative | Neutral | Positive

Fodder production: Negative | Neutral | Positive

Farm income: Negative | Neutral | Positive

Household workload: Negative | Neutral | Positive

Food security: Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | Positive

Biological diversity: Negative | Neutral | Positive

Flooding: Negative | Neutral | Positive

Crop/livestock water availability: Negative | Neutral | Positive

Wind Protection: Negative | Neutral | Positive

Erosion control: Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement species diversification:

- **Step 1:** Research possible species of livestock that may be productive in the climate of the surrounding area and compatible with existing livestock.
- **Step 2:** Communicate with national agricultural extension/neighbouring farmers and research to gain an understanding of which breeds have been identified as having potential locally and which are available in the region. Other farmers in the area may have information and experiences to share.
- **Step 3:** Inform neighbouring farmers of the potential species that they may be interested in including into their farming system.
- **Step 4:** Outline the positive and possible negative aspects of incorporating different species into their system.
- **Step 5:** Identify how farmers can access different species and whether they are available at local markets or if these species need to be imported from other areas of the country/region.
- **Step 6:** Monitor introduced species to ensure that impacts – positive and negative – are understood.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Utilises available resources more effectively to maintain agricultural productivity.

Diversification can be an adaptation strategy, identifying species with beneficial traits under changing climate conditions.

SUMMARY/KEY ISSUES

Benefits

- Species diversity can assist farmers become more climate resilient by adjusting livestock holdings more adaptable species (camels, goats, etc) as other species can survive on less water and lower feed demands.
- Diversification may have significant impacts on household food security, income and be more productive.
- Different species may have traits that are more adaptable to harsh conditions including temperature increases, resistance to disease, drought tolerant, allowing more sustainable productivity (continue to produce milk, eggs meat etc.) and staying in line with market demands during harsher conditions.

Drawbacks

- Introduction of exotic species can have negative impacts and may push traditional breeds out or have adverse effects on local fodder, water sources etc. if not managed correctly.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 17, Climate Smart Genetic Improvement Options for Livestock.

Additional Information

- The Food and Agriculture Organisation (FAO), 2016. Livestock Diversity Helps Cope with Climate Change. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2015. The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 1997. World animal review - Revue mondiale de zootechnie - Revista mundial de zootecnia. Rome, Italy.

Biological Control Vectors

Vectors are organisms that carry diseases from one living being to another without showing symptoms of the diseases themselves. Some of the most common forms of vectors are blood sucking insects such as mosquitos, fleas, lice, ticks and other similar insects, and rats/rodents. Places such as stagnant water and dumping sites can be ideal habitats for vectors to reside and transmit. The use of natural vector predators can help reduce or eliminate vector populations. The most common vectors in southern Africa are insects (tsetse flies-trypanosomiasis), animals (foot and mouth disease through cattle or people with contaminated shoes), tick-borne relapsing fever (TBRF) and Crimean-Congo haemorrhagic fever (CCHF). Sanitising the life-cycle of vectors, implementing pest traps and introducing pest predators are means of reducing the spread of disease. The impacts of climate change, especially increased heavy rainfall and higher temperatures can encourage vector populations to grow quicker than normal. Simple strategies to control vectors includes keeping livestock surroundings clean, avoiding livestock access to stagnant water, fencing areas off, restricting animal access to certain locations, can all control biological vectors and assist in reducing vector spread.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | **No**

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Impact			
Return on Investment Realisation Period	Short	Medium	**Long**
Crop production	Negative	Neutral	**Positive**
Fodder production	Negative	Neutral	**Positive**
Farm income	Negative	Neutral	**Positive**
Household workload	Negative	**Neutral**	Positive
Food security	Negative	Neutral	**Positive**

Ecological Impacts Positive or Negative

Impact			
Soil quality/cover	Negative	Neutral	**Positive**
Biological diversity	Negative	Neutral	**Positive**
Flooding	Negative	**Neutral**	Positive
Crop/livestock water availability	Negative	Neutral	**Positive**
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	**Neutral**	Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement biological control vectors:

- **Step 1:** Research common vectors in the local area and ensure that farmers are informed about the kinds, description, lifecycle and common habitats of these vectors, such as tsetse flies, ticks, biting flies.
- **Step 2:** Avoid allowing livestock access to dirty and damp environments as well as very bushy areas as these locations are common habitats for vectors.
- **Step 3:** Use of traps or even introduction of vector predators to livestock to manage vector spread could be used. This could include introducing epsilon traps for tsetse flies to promote vector control.
- **Step 4**: If rodents are found in or around livestock, introduce rodent control methods such as traps and/or rodent predators (cats, etc) and bury any remains far from livestock areas.
- **Step 5:** Fence off areas of high vector prevalence, such as stagnant water, ensuring that livestock do not access these areas.
- **Step 6:** Examine any rangeland to determine whether there are vectors in the vicinity such as biting insect, or locusts that may damage maize crops and fruit flies that damage tomatoes.
- **Step 7:** Community radio can be an effective method for extension officers to inform communities about outbreaks, or impending infestations.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Reduces incidence of disease results in healthier, more productive animals.
- Reduces risk of secondary infections in livestock. Sale of livestock is a common coping strategy so having more/better livestock to sell increases resilience.
- Potential for more efficient conversion of feed into meat/diary which can reduce emissions per unit production.

SUMMARY/KEY ISSUES

Benefits

- Identifying the common vectors in the area is a key first step to understanding how to manage them.
- Using vector traps and introducing vector predators can also help manage livestock exposure.

Drawbacks

- Biological vectors transport disease that can have devastating impacts on livestock.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 17, Climate Smart Genetic Improvement Options for Livestock.

Additional Information

- The Food and Agriculture Organisation (FAO), 2009. The Use and Exchange of Biological Control Agents for Food and Agriculture. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2007. The Sustainable Management of Biodiversity for Biological Control in Food and Agriculture: Status and Needs. Rome, Italy.

Resistant Breeds

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Resistant breeds Disease resistance is the reduction of pathogen growth in or in a plant or animal; denoting less disease development in a particular breed than that which is relatively susceptible and is specific to a particular strain of disease or attribute. Breeding resistant breeds . Resistance" means the animal actively fights infection by various means. Building resistant breeds can be done through selection. Selective breeding, sometimes called artificial selection, where different breeds of animals with desired characteristics or attributes like resistance to. drought, heat, cold, salinity, flood, submergence and pests can be developed by selective breeding and thus able to relatively thrive in some conditions which would otherwise not be able to, e.g. This assists in the reduction of diseases, results in healthier productive animals and reduces risk of secondary infections in livestock. These breeds create a potential for more efficient conversion of feed into meat or diary, and thus a climate smart attribute since by reducing emissions per unit of production (proportionately less faeces are dropped per unit consumption of feed) as well as contributing to food security.,. In the Southern African Development Community (SADC) region, local breeds are more resistant to many of the pests and diseases and may be the best option for some farmers in the Arid and semi-arid areas of the region.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period

Short | Medium | Long

Crop production

Negative | Neutral | Positive

Fodder production

Negative | Neutral | Positive

Farm income

Negative | Neutral | Positive

Household workload

Negative | Neutral | Positive

Food security

Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover

Negative | Neutral | Positive

Biological diversity

Negative | Neutral | Positive

Flooding

Negative | Neutral | Positive

Crop/livestock water availability

Negative | Neutral | Positive

Wind Protection

Negative | Neutral | Positive

Erosion control

Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement resistant breeds:

- **Step 1:** Breed livestock with increased resistance against pathogens or other environmental stressors (heat stress).
- **Step 2:** Select animals of higher general disease resistance (resistance to several diseases) using a heritable indicator such as natural antibodies.
- **Step 3:** Keep record of good performing animals; unhealthy or easily prone of weak animals should not be used for mating; males should be castrated leaving best specimen to breed in subsequent seasons.
- **Step 4:** Breed or inseminate the selected cows with desired or selected bulls or semen of the desired traits.

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Reduces incidence of disease, results in healthier, more productive/efficient animals.

Sale of livestock is a common coping strategy so having more/better livestock to sell increases resilience.

Potential for more efficient conversion of feed into meat/diary which can reduce emissions per unit production, thus less GHG emissions.

SUMMARY/KEY ISSUES

Benefits

- With resistant breeds, selecting of male breeds is a long-term climate smart adaptation because they are likely the most resistant.
- Farmers should identify females in heat and isolate them with selected male animals. This results in productivity increase, higher resilience and cost effectiveness.

Drawbacks

- Breeding should be controlled to achieve best practice results and farmers should be able to detect when female animals are on heat.
- Parental performance records should be kept at all times.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 18, Climate Smart Pest & Disease Management Options for Livestock.

Additional Information

- The Food and Agriculture Organisation (FAO), 2005. Animal genetic resources and resistance to diseases. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2015. Selecting and breeding for insect and disease resistance. Rome, Italy.

Vaccination Campaigns

Technical Brief 55

Vaccination is the administration of immunisation injections to animals in order to prevent, control spread of diseases. Vaccination campaigns involve administration of vaccine doses to a large population over a short period of time. The veterinary services departments or equivalent of respective countries normally gives free vaccinations to the farming community's animals for diseases which are of either economic significance to people's livelihoods or those that maybe of zoonotic importance (communicable to man from animals). These campaigns are usually fully funded by the government, NGOs to reduce disease outbreaks, prevent spread of an outbreak or improve national herd productivity, and are designed to reach as much livestock as possible. In most countries, free vaccinations are offer for the following diseases: Anthrax(-Cattle), Quarter evil or black quarter disease (Cattle), Contagious abortion (Cattle), Rabies (Dogs & Cats), Foot and Mouth Disease(Cattle)_ as per OIE designation in Disease Control Zones.

For the message to reach farmers, community radios and involvement of traditional leadership can be used to encourage farmers to participate in vaccination campaigns. This will help to gain trust and confidence from farmers for the campaign to be successful. Vaccination campaigns is a climate smart practice as it ensures a healthy population able to utilize feed efficiently with a reduced population discharge thus reduced GHG emission.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | No

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator	Scale	Boxed
Return on Investment Realisation Period	Short – Medium – Long	Medium, Long
Crop production	Negative – Neutral – Positive	Neutral
Fodder production	Negative – Neutral – Positive	Neutral
Farm income	Negative – Neutral – Positive	Positive
Household workload	Negative – Neutral – Positive	Neutral
Food security	Negative – Neutral – Positive	Positive

Ecological Impacts Positive or Negative

Indicator	Scale	Boxed
Soil quality/cover	Negative – Neutral – Positive	Neutral
Biological diversity	Negative – Neutral – Positive	Neutral
Flooding	Negative – Neutral – Positive	Neutral
Crop/livestock water availability	Negative – Neutral – Positive	Neutral
Wind Protection	Negative – Neutral – Positive	Neutral
Erosion control	Negative – Neutral – Positive	Neutral

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement vaccination campaigns:

- **Step 1:** Networks that notify farmers about upcoming vaccination campaigns must be established to promote the significance of vaccinating animals across the country. This can be promoted through government bulletins and community radio, utilising extension networks, village level administration, and traditional leadership.
- **Step 2:** Vaccination parks for cattle can be set up by veterinary officials to restrain livestock movement that might increase disease spreading.
- **Step 3:** Goats and sheep can be vaccinated at their locations where officials will move from one village to another to reach more population**.**
- **Step 4:** Training of personnel is important to ensure that vaccination is carried out before seasonal outbreaks and prevent the spread of disease.
- **Step 5:** Commence campaigns one month prior to the season when outbreaks are most common or upon notice of a disease incidence.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to
Climate Smart Agriculture outcomes

- Reduces incidence of disease results in healthier, more productive animals.
- Reduces risk of secondary infections in livestock. Sale of livestock is a common coping strategy so having more/better livestock to sell increases resilience.
- Livestock population with a potential for more efficient conversion of feed into meat/diary which can reduce emissions per unit production.

SUMMARY/KEY ISSUES

Benefits

- The objectives of vaccination campaigns are to reduce the number of animals that are affected by disease outbreaks and prevent treatable diseases from reducing national herd population which may affect farm income.
- Awareness must be established in order to gain farmers trust and involvement for the campaign to be successful.

Drawbacks

- No 100% guarantee of protection of animals/birds.
- Postpone vaccination campaigns if an outbreak is in progress.
- For ring vaccinations upon outbreaks, proper delineation of the perimeter is important.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 18, Climate Smart Pest & Disease Management Options for Livestock.

Additional Information

- The Food and Agriculture Organisation (FAO), 2018. Urgent livestock vaccination campaign in South Sudan in jeopardy without more support. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2015. Emergency cattle vaccination campaign underway along Syria-Lebanon border. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2016. Foot and mouth disease vaccination and post-vaccination monitoring. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2017. Linking community-based animal health services. Rome, Italy.

Continuous Long Term Proactive Practices

Technical Brief 56

Cultural pest control practices Are pest control management measures to control pests (insects, diseases, weeds) by manipulation of the environment or implementation of preventive practices including using plants that are resistant to pests, raising the mowing height of pastures to shade out weeds, aerating pastures to reduce compaction and plant stress. Several beneficial cultural practices can meet both demands, helping with pest and disease control and minimizing the use of toxic chemicals. In the insect pest management context, cultural practices may be considered as specific crop production practices that may be implemented either in the initial stages of the organic farm plan but also as a continuous plan to reduce the likelihood of insect pest infestation to a crop and damage. They form part of the Integrated Pest management (IPM) Practices and are based on tactics to disrupt pest infestation of crops by having the crop unavailable to pests in space and time, making the crop unacceptable to pests by interfering with host preference or location, reducing pest survival on the crop by enhancing natural enemies, altering the crop's susceptibility to pests. The tactics or methods used in IPM include one or a combination of the following: Cultural control (crop rotation, use of locally adapted or pest resistant/tolerant varieties, sanitation, manipulating planting/harvest dates to avoid pests). Cultural pest control or IPM results in reduced pests/diseases and increased yields and is a climate-smart practice as its emphasis of prevention helps to control pests and diseases before they occur; its continuous long-term practices without use of chemicals encourage healthier and more pest resilient crops and landscapes, encouraging the use of beneficial insects making it an adaptation benefit. The possibility of prediction and recognition of pest outbreaks enables earlier management consultations and decisions. The reduction in losses results in lower GHG emissions per tonne produced.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period

Short | Medium | Long

Crop production

Negative | Neutral | Positive

Fodder production

Negative | Neutral | Positive

Farm income

Negative | Neutral | Positive

Household workload

Negative | Neutral | Positive

Food security

Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover

Negative | Neutral | Positive

Biological diversity

Negative | Neutral | Positive

Flooding

Negative | Neutral | Positive

Crop/livestock water availability

Negative | Neutral | Positive

Wind Protection

Negative | Neutral | Positive

Erosion control

Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

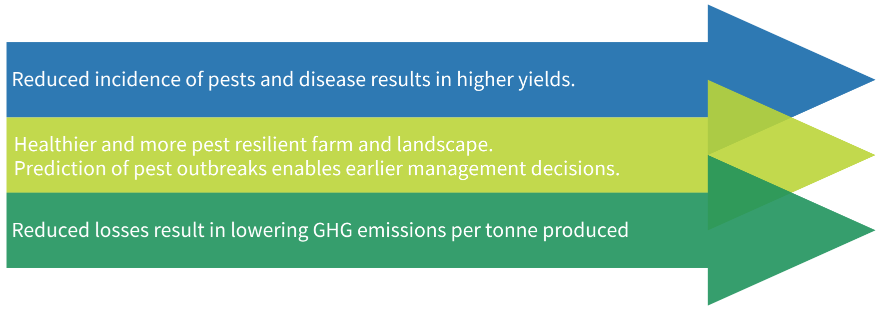
TECHNICAL APPLICATION

To effectively implement continuous long-term use of cultural practices, the following steps, as part of the Integrated Pest Management (IPM) should be carried out, but before taking any pest control action, IPM first sets an action threshold, a point at which pest populations or environmental conditions indicate that pest control action must be taken:

- **Step 1:** Inspection. The cornerstone of an effective IPM program is a schedule of regular inspections. This should be regular to identify any new visitors to your crop.
- **Step 2:** Preventive Action: regular inspections reveal vulnerabilities in your pest management program, steps can be taken to address them before they cause a real problem. One of the most effective prevention measures is exclusion, i.e., performing structural maintenance e.g by closing potential entry points revealed during inspection thereby physically keeping pests out and hence reducing the need for chemical control.
- **Step 3:** Identification: Different pests have different behaviours. By identifying the problematic species, pests can be eliminated more efficiently and with the least risk of harm to other organisms. Professional pest management always starts with the correct identification of the pest in question .
- **Step 4:** Analysis: Once you have properly identified the pest, you need to figure out why the pest is in your facility, e.g. food debris or moisture accumulation that may be attracting it? What about odors, through floors or cracks, etc.
- **Step 5:** Treatment Selection: Cultural or IPM stresses the use of non-chemical control methods, such as exclusion or trapping, before chemical options. When other control methods have failed or are inappropriate for the situation, chemicals may be used in least volatile formulations in targeted areas to treat the specific pests- use the right treatments in the right places, and only as much as you need to get the job done.
- **Step 6:** Monitoring: Constantly monitoring your facility for pest activity and facility and operational changes can protect against infestation and help eliminate existing ones. Your agricultural extension officer can assist you in technical advice to keep pests away.
- **Step 7: Documentation: Up-to-date pest control documentation is important and could include scope of service, pest activity reports, service reports, corrective action reports, trap layout maps, lists of approved pesticides, pesticide usage reports and applicator licenses**

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes



SUMMARY/KEY ISSUES

Benefits

- This practice increases yield production, improves soil erosion, enhances soil quality and biological diversity.
- Reduces pollution of soil, water, allows for pollinating insects to thrive, encourages microbe activity in soil formation
- Assists with mitigation of GHG emissions.

Drawbacks

- Consistent management of pest monitoring, pest prevention and agro-ecosystem management.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 19, Climate Smart Pest & Disease Control Options for Sorghum & Maize.

Additional Information

- The Food and Agriculture Organisation (FAO), 2003. Weed Management for Developing Countries. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 1985. Cultural control and the use of resistant varieties in integrated pest management of rice insect and rodent pests. Rome, Italy.

Resistant Varieties

Resistant varieties are new crop varieties that improve yield production, are resistant to pests and diseases, more tolerant to drought, salinity or other changing or undesirable environmental conditions. Crop plants used within this practice are usually only resistant to a limited number of undesirable characteristics e.g. pests or drought – but usually not both, and some other desirable traits may be lost while others may be strengthened. Hence, careful selection of candidate species must be undertaken. Resistance varieties common in southern Africa include drought resistant maize, sorghum, rice and cowpea (beneficial legume for intercropping) strains, striga (witch weed) resistant sorghum and maize strains, and others all help farmers adapt to changing climate conditions, by being able to farm crops that survive the increasingly variable climate, which can result in less rainfall, or the presence of new pests. Striga results in crop losses totalling over USD 1 billion per year, whereas research has shown that planting climate resilient maize varieties can lead to up to a 25 % increase in crop yields.

Exploring new pest or drought resistant varieties in a regional will require demonstration and testing in 'test plots', so extension workers can ensure that the outcomes are aligned with farmers wants/needs/tastes, and so farmers are familiar with the new varieties before they are mainstreamed. Acceptance of new varieties, and any changes is traits will be critical, as resistant varieties is a key intervention for climate adaptation in southern Africa, as they will allow farmers to remain productive for longer under challenging conditions, and while different crops altogether are investigated.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain
- ● Maize
- ● Sorghum
- ● Rice
- ○ Livestock
- ● Other

Soil texture
- ● Light
- ● Medium
- ● Heavy

Climatic zone
- ● Arid
- ● Semi-arid
- ● Sub-humid
- ○ Humid

Water source
- ● Rainfed
- ● Partly irrigated
- ● Irrigated

Annual average rainfall (mm)
- ● < 250
- ● 250 - 500
- ● 500 - 750
- ● 750 - 1000
- ○ 1000 - 1500
- ○ > 1500

Topography
- ● Flat to gentle slope (0 – 5 %)
- ● Moderate to rolling slope (6 – 15 %)
- ● Hilly slope (16 – 30 %)
- ● Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action
- ○ Yes
- ● No

Characteristics
- ● Subsistence
- ● Commercial Small
- ● Commercial Medium
- ● Commercial Large

Farm size (ha)
- ● < 2
- ● 2 to 5
- ● 5 to 10
- ● > 10

Mechanisation
- ● Manual
- ● Animal
- ● Mechanised

Human resources

Labour intensity – level of effort
- ● Low (household)
- ● Medium (seasonal)
- ○ High (outside labour)

Gender/youth smart (low investment/low labour requirements)
- ● Yes
- ○ No

Financial resources

Initial investment
- ○ Low
- ● Medium
- ○ High

Maintenance Costs
- ● Low
- ○ Medium
- ○ High

Access to finance capital or credit required
- ● Yes
- ○ No

Enabling Environment

Extension support
- ● Yes
- ○ No

Access to inputs
- ● Yes
- ○ No

Market access
- ● Yes
- ○ No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period
Short | **Medium** | Long

Crop production
Negative | Neutral | **Positive**

Fodder production
Negative | Neutral | **Positive**

Farm income
Negative | Neutral | **Positive**

Household workload
Negative | Neutral | **Positive**

Food security
Negative | Neutral | **Positive**

Ecological Impacts Positive or Negative

Soil quality/cover
Negative | Neutral | **Positive**

Biological diversity
Negative | Neutral | **Positive**

Flooding
Negative | **Neutral** | Positive

Crop/livestock water availability
Negative | **Neutral** | Positive

Wind Protection
Negative | **Neutral** | Positive

Erosion control
Negative | Neutral | **Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively leverage resistant varieties, the following should be carried out:

Step 1: Survey farmers and meet with other local and national level extension officers to determine key interventions required – drought tolerance, prevalence of certain pests, etc.

Step 2: Research and meet other local extension officers to discuss best methods applied to the agricultural practice of resistant varieties in the region.

Step 3: Talk to the agricultural dealers and seed manufacturers about the varieties being offered and their characteristics.

Step 4: Talk to the agricultural research departments about best opportunities under climatic change in your specific area.

Step 5: Either independently or in partnership with seed manufacturers, establish test plots of viable resistant varieties in key locations to act as demonstration plots for farmers to visit, observe growth and harvest, and test the outcomes. Many conditions may come into play when attempting to mainstream resistant varieties, including visual aspects, harvesting and processing differences, palatability and taste, etc. All of these issues must be discussed with farmers during testing and roll-out to ensure resources are not wasted with varieties that will fail.

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Reduced incidence of pests and disease results in higher yields.

Healthier and more pest resilient farm and landscape.
Prediction of pest outbreaks enables earlier management decisions.

Reduced losses result in lowering GHG emissions per tonne produced

SUMMARY/KEY ISSUES

Benefits

- The practice is widely used to increase yield production, produce pest and disease resistant varieties and improve environmental tolerance.
- Further combines the best traits of the parental forms resulting in some strengths and weaknesses, resulting in a variation of crops species.

Drawbacks

- May require investment and/or access to credit, as new seeds will not be in farmer seed banks/stores and may be expensive to kick-start implementation.
- May take time to launch new varieties and gain acceptance from farmers/consumers/markets.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA 2019. KP19 Climate Smart Pest and Disease Control for Maize and Sorghum. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana
- CCARDESA 2019. KP20 Climate Smart Pest and Disease Control in Rice. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana
- CCARDESA 2019. Technical Brief 20. Crop Variety. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana.
- CCARDESA 2019. Technical Brief 21 Saving Seeds. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana.
- CCARDESA 2019. Technical Brief 58 Push-Pull Systems. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana.

Additional Information

- CIMMYT, 2017. New crop varieties that counter climate change: a best bet for farmers. Mexico City, Mexico.
- The Food and Agriculture Organisation of the United Nations (FAO), 2005. Status of Research and Application of Crop Biotechnologies in Developing Countries. Rome, Italy.
- CIMMYT 2015. Maize Variety Options for Africa: Angola. International Mazie and Wheat Improvement Centre. Nairobi, Kenya
- DTMA 2015. Drought Tolerant Maize: A quarterly bulletin of the Drought Tolerant Maize for Africa Project. Nairobi, Kenya
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- ReliefWeb 2019. Becoming Drought Resilient: Why African Farmers Must Consider Drought Tolerant Crops. ReliefWeb website.
- AATF 2006. Empowering African farmers to eradicate Striga from maize croplands. The African Agricultural Technology Foundation. Nairobi, Kenya.
- Cairns, J.E. and Prasanna, B.M. 2018. Developing and deploying climate-resilient maize varieties in the developing world. Current Opinion in Plant Biology, 45: 226-230

Push and Pull Systems

A push pull system is a technique that repels parasitic plants and pests that attach themselves to the crop roots and feed on them.. In push-pull, a cereal crop is intercropped with a leguminous plant like desmodium or molasses grass, while a popular fodder crop, Napier grass, is planted as a border around the field. Desmodium produces volatile chemicals that attract predators of the cereal e.g of maize pests. More importantly, by giving a false distress signal to the moths that the area is already infested, these chemicals 'push' the egg laying moths away from the crop to seek out habitats where their larvae will face less competition for food. Napier grass also produces volatile chemicals that 'pull' the moths towards them, and then exudes a sticky substance that traps the stem borer larvae as they feed. Few larvae survive. Napier grass attracts stem borer predators. The intercropping is a climate smart practice as it mitigates emission of Greenhouse gases through the reduced need for pesticides. The push-pull system improves food security and boosts farm income.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | No

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period

Short | Medium | Long

Crop production

Negative | Neutral | Positive

Fodder production

Negative | Neutral | Positive

Farm income

Negative | Neutral | Positive

Household workload

Negative | Neutral | Positive

Food security

Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover

Negative | Neutral | Positive

Biological diversity

Negative | Neutral | Positive

Flooding

Negative | Neutral | Positive

Crop/livestock water availability

Negative | Neutral | Positive

Wind Protection

Negative | Neutral | Positive

Erosion control

Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement push and pull systems:

- **Step 1:** Plant Napier and a legume like Desmodium or molasses grass between every three rows of maize/sorghum as barriers to repel stemborers away from crops.
- **Step 2:** Plant the Desmodium first as soon as the rains begin, so it immediately repels the stalk borers before the maize/sorghum emerge.
- **Step 3:** Plant three rows of Naiper grass around the borders of maize field.
- **Step 4:** Allow pest enemies such as ants and spiders to enter the field to feed on stemborers.
- **Step 5:** Cut grass and fed to animals as forage.
- **Step 6:** Abandon areas that are heavily affected by stemborers until treated.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- A push-pull system supports sustainable productivity by reducing the need for expensive pesticides, and boosting farm income.
- A sustainable and environmentally friendly method for maintaining soil health and productivity while controlling pests.
- Reduced application of synthetic fertilisers reduces greenhouse gas emissions.

SUMMARY/KEY ISSUES

Benefits

- Reduces the need for pesticides.
- Improves food security and boost farmers' income.
- The green technique deals with trapping the pests (pull) and repelling them (push) by planting Napier and desmodium or molasses grass next to cereal crops.
- The relationship between insect-plant and insect-insect (introducing pest enemies such as ants/spiders) is achieved in order to kill stemborers.
- Grass planted next to crops can be salvaged and used as forage.

Drawbacks

- Naiper grass take up space on the field.
- Cost and lack of availability of Desmodium seed.
- Difficulty in establishing the Desmodium crop, hence practice not suitable for all farmers.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA 2019. KP19 Climate Smart Pest and Disease Control for Maize and Sorghum. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana
- CCARDESA 2019. KP20 Climate Smart Pest and Disease Control in Rice. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana
- CCARDESA 2019. Technical Brief 07 Inter-cropping. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana.
- CCARDESA 2019. Technical Brief 20. Crop Variety. Centre for Coordination of Agricultural Research and Development in Southern Africa, Gaborone, Botswana.

Additional Information

- FAO 2017. PRACTICE BRIEF Climate-smart agriculture Climate-Smart Pest Management: Implementation guidance for policymakers and investors. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2015. 'Push-Pull' fights pests, boosts milk production. Rome, Italy.
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- The Food and Agriculture Organisation (FAO), 2018. Integrated management of the Fall Armyworm on maize. Rome, Italy.
- Pickett, John & Woodcock, Christine & Midega, Charles & Khan, Zeyaur. (2014). Push-pull farming systems. Current opinion in biotechnology. 26C. 125-132. 10.1016/j.copbio.2013.12.006.
- Push-Pull 2017. Climate-Smart Push-Pull Technology for Food Security, Safety and Environmental Sustainability African Insect Science for Food and Health.

Short Term Reactive Practices

Short-term reactive practices are control options for pests and diseases once they have reached a level where the economic loss are likely to be greater than the cost of controlling the pest/disease outbreaks and can be used to maintain or increase production. Pests and diseases are better detected at an earlier stage to make it easier to act and prevent severe crop losses and prohibit the spread of pests and diseases throughout the whole field, achieved through regular and systematic field inspections. The practice is considered climate smart as it reduces losses, which in-balance lowers greenhouse gas emissions per tonne of crop produced, it retains agricultural productivity through management of pest infestation and/or disease outbreaks, and is applicable as it can assist farmers adjust to changing climate, and the threat of new and changing pest diseases.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | Rice | Livestock | Other

Soil texture: Light | Medium | Heavy

Climatic zone: Arid | Semi-arid | Sub-humid | Humid

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography: Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | **No**

Characteristics: Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha): < 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation: Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes | No

Financial resources

Initial investment: Low | Medium | High

Maintenance Costs: Low | Medium | High

Access to finance capital or credit required: Yes | No

Enabling Environment

Extension support: Yes | No

Access to inputs: Yes | No

Market access: Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period		
Short	**Medium**	**Long**

Impact			
Crop production	Negative	Neutral	**Positive**
Fodder production	Negative	Neutral	**Positive**
Farm income	Negative	Neutral	**Positive**
Household workload	Negative	**Neutral**	Positive
Food security	Negative	Neutral	**Positive**

Ecological Impacts Positive or Negative

Impact			
Soil quality/cover	Negative	Neutral	**Positive**
Biological diversity	Negative	Neutral	**Positive**
Flooding	Negative	**Neutral**	Positive
Crop/livestock water availability	Negative	**Neutral**	Positive
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	Neutral	**Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement short term reactive practices:

- **Step 1:** Inspecting the crop regularly and systematically by walking through the field following an M-shaped pattern will ensure that the farmer does not just look around the edges, but also inspects in the middle of the field.
- **Step 2:** Farmers should carefully examine the crops for any signs of pests/diseases. They may be able to identify the presence of pests or disease through observing the following:
  - o If the plant is wilted.
  - o Are the leaves more yellow than usual?
  - o Are the crops smaller than usual?
  - o Do the leaves have spots?
  - o Have parts of the plan died?
- **Step 3:** Once the foreign specie has been identified, the farmer should employ a method to eradicate the issue thoroughly and immediately.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Reduced losses result in lower GHG emissions per tonne produced.
- Reduces losses due to management of pest/disease outbreaks.
- Farmers can make informed decisions resulting in sustainable losses.

SUMMARY/KEY ISSUES

Benefits

- Short term reactive practices eradicate the pest or disease.
- The aim is to protect the long-term health of the field/herd for the next season or growing period.

Drawbacks

- Pests and disease can have devastating impacts on both crops and livestock and can persist throughout growing seasons.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Technical Brief 19, Climate Smart Pest & Disease Control Options for Sorghum & Maize.

Additional Information

- CGIAR, 2017. Climate-Smart Pest Management: Implementation guidance for policymakers and investors. Montpellier, France.
- CIAT, 2016. Crop Protection – What we do: We work to combat the following pests and diseases.
- Kuivanen K., Alvarez S., Langeveld, C.,2015. Climate Change in Southern Africa: Farmers' Perceptions and Responses, Review report, Farming Systems Ecology, Wageningen University, Netherlands.

Weeding by Hand/Hoe

A weed plant is an unwanted plant that grows among and competes with crops for water, air, sunlight, nutrients and space. The removal of such plants from fields – known as 'weeding' - is vital to enhancing crop growth. They can be removed by cutting their roots either by hand or using an implement such as a hoe. Some cereal crops like rice and maize attract weeds that are herbicide resistant; hence, the use of a hoe in removing the weeds is the most effective practice. However, as mechanic weeding can result in release of weed seeds into the soils as the hoe makes contact with the plant, weeding by-hand is the best way for weed removal to prevent weed seeds from falling onto the ground for further germination; this can increase the labour intensity of weeding considerably. This is a climate smart practice as it mitigates the emission of greenhouse gases from herbicides into the atmosphere, land and water systems. Furthermore, weeding helps maintain sustainable agricultural productivity, when considered an integral part of farm management and operations. However, weeding has been identified as one of the largest labour inputs for subsistence agriculture, accounting for between 30 and 50 % of on-farm labour requirements.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain
Maize | Sorghum | Rice | Livestock | Other

Soil texture
Light | Medium | Heavy

Climatic zone
Arid | Semi-arid | Sub-humid | Humid

Water source
Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)
< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography
Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action
Yes | No

Characteristics
Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)
< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation
Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort
Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)
Yes | No

Financial resources

Initial investment
Low | Medium | High

Maintenance Costs
Low | Medium | High

Access to finance capital or credit required
Yes | No

Enabling Environment

Extension support
Yes | No

Access to inputs
Yes | No

Market access
Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period
Short | Medium | Long

Crop production
Negative | Neutral | Positive

Fodder production
Negative | Neutral | Positive

Farm income
Negative | Neutral | Positive

Household workload
Negative | Neutral | Positive

Food security
Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover
Negative | Neutral | Positive

Biological diversity
Negative | Neutral | Positive

Flooding
Negative | Neutral | Positive

Crop/livestock water availability
Negative | Neutral | Positive

Wind Protection
Negative | Neutral | Positive

Erosion control
Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement mechanical weeding:

- **Step 1:** Farmers should be able to identify weeds resistance to herbicides.
- **Step 2:** Examine fields to understand level of weed infestation – can they be easily and effectively removed using a hoe, without spreading seeds, or will manual weeding be necessary.
- **Step 3:** Attempt to quantify the amount of labour needed. Can the work be completed by the adults on the farm, or will additional labour be required? Will youths be involved in weeding? Will they miss school?
- **Step 4:** Begin removal of weeds, ensuring that weeds are uprooted and removed from the field to avoid regeneration. A hoe must have a long handle to be able to work effectively and the hoe blade must not be too sharp in order to cut weeds without going through crops and spreading seed and cuttings.
- **Step 5:** Weeding should take place a **minimum of three times** over the growing season – one week before planting crops, three weeks after planting (when the crop has two to three leaves), and two months after planting (milk-stage). The aim is to reduce or eliminate the product of seeds in the weed plants.
- **Step 6: Draft animal-drawn cultivators** can reduce labour requirements but should only be used to cultivate soil to a shallow depth, retaining soil structure, but not disturbing soil. Weeds should be collected by hand afterwards. Deeper tilling or turning of the soil with the wrong implement may cause more harm than good.
- **Step 7:** Weeding must be sustained **year on year** to reduce prevalence. It is important to caution farmers that results may not be seen in significant reduction of plants until year-two of a weeding programme.
- **Step 8:** Obnoxious weeds – such as Striga, etc – should be burned once pulled, preferably away from the field, in order to eradicate their presence.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Weeding by hand is an effective method of controlling weeds, and ensuring maximum productivity.
- A regular and diligent weeding strategy will maintain productivity in a changing climate.
- Mitigates emission of greenhouse gases from release of herbicides into the atmosphere.

SUMMARY/KEY ISSUES

Benefits

- Weeding can reduce competition for crops in terms of water, air, sunlight, nutrients and space, making a crop more productive.
- Weeding is cheaper than the use of herbicides.
- Weeding by hand or hoe reduces the use of chemicals however, it is as effective as using herbicides.
- Some weeds produce noxious gases which can have negative impacts on crop growth.

Drawbacks

- Some of the cereal crops attract weeds that are resistant to herbicides
- Manual and mechanical weeding can be physically demanding and may require additional labour resources for larger fields.
- Manual weeding requires approximately 25 % more labour than using herbicides.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. KP02 Best Bet Climate Smart Agriculture Options for Maize in SADC. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. KP03 Best Bet Climate Smart Agriculture Options for Sorghum in SADC. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. KP08 Climate Smart Land Preparation Options for Maize in SADC. CCARDESA, Gaborone, Botswana

Additional Information

- The Food and Agriculture Organisation (FAO), 2003. Weed Management for Developing Countries. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2015. Crops, Weeds and Pollinators Understanding Ecological Interaction for better Management. Rome, Italy.
- Lee, N. & Thierfelder, C. 2017. Weed control under conservation agriculture in dryland smallholder farming systems of southern Africa. A review. Agron. Sustain. Dev. 37: 48.

Mechanical Bottle Traps

Bottle traps are an agricultural technology used to lure insects inside containers (bottles) containing bait of either food or chemical attractants. The objective is to lure pest insects to identify them for pest control, as part of overall pest monitoring, including field walks, observation and crop inspections. In larger fields they are used solely for pest identification. In smaller fields a number of traps can be used as a pest control method, trapping the insects, but this is not a common approach. Bottle traps must be installed in locations close to or amongst crops and across the farm in order to attract insects for identification and should be used throughout all cropping season to ensure that pests can be identified earlier. As a component of Integrated Pest Management, bottle traps with different lures or baits can be used to attract and identify most types of aphids and mites, fruit flies, stem borers, and fall army worm. While many of the lures and baits can be made at home or on the farm, pheromone-based baits need to be purchased from agricultural suppliers. While this introduces costs, bottle traps and lures can contribute significantly pest management, through early identification so appropriate action can be taken. This technology can contribute to climate smart agriculture objectives, as bottle traps and lures can reduce the amount of pesticides used, reducing greenhouse gas emissions; they can help with identifying new pests and insects as climates shift; and as pests are identified or reduced, productivity can increase. It is important for farmers and workers to keep records of pests identified to ensure that appropriate responses are enacted. There could be cases where infestation levels are low and the cost of taking action may be more that nominal crop losses. However, the opposite may be true, but decisions cannot be made without relevant information for extension workers to discuss with farmers.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize, Sorghum, Rice, Livestock, Other

Soil texture: Light, Medium, Heavy

Climatic zone: Arid, Semi-arid, Sub-humid, Humid

Water source: Rainfed, Partly irrigated, Irrigated

Annual average rainfall (mm): < 250, 250 - 500, 500 - 750, 750 - 1000, 1000 - 1500, > 1500

Topography: Flat to gentle slope (0 – 5 %), Moderate to rolling slope (6 – 15 %), Hilly slope (16 – 30 %), Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes, No

Characteristics: Subsistence, Commercial Small, Commercial Medium, Commercial Large

Farm size (ha): < 2, 2 to 5, 5 to 10, > 10

Mechanisation: Manual, Animal, Mechanised

Human resources

Labour intensity – level of effort: Low (household), Medium (seasonal), High (outside labour)

Gender/youth smart (low investment/low labour requirements): Yes, No

Financial resources

Initial investment: Low, Medium, High

Maintenance Costs: Low, Medium, High

Access to finance capital or credit required: Yes, No

Enabling Environment

Extension support: Yes, No

Access to inputs: Yes, No

Market access: Yes, No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Impact	Scale	Boxed rating
Return on Investment Realisation Period	Short – Medium – Long	Medium
Crop production	Negative – Neutral – Positive	Positive
Fodder production	Negative – Neutral – Positive	Positive
Farm income	Negative – Neutral – Positive	Positive
Household workload	Negative – Neutral – Positive	Neutral
Food security	Negative – Neutral – Positive	Positive

Ecological Impacts Positive or Negative

Impact	Scale	Boxed rating
Soil quality/cover	Negative – Neutral – Positive	Neutral
Biological diversity	Negative – Neutral – Positive	Neutral
Flooding	Negative – Neutral – Positive	Neutral
Crop/livestock water availability	Negative – Neutral – Positive	Neutral
Wind Protection	Negative – Neutral – Positive	Neutral
Erosion control	Negative – Neutral – Positive	Neutral

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively use mechanical bottle traps, the following should be carried out:

Bottle-trap

- **Step 1:** Obtain 2L plastic water or soft-drink bottles
- **Step 2:** Rinse bottles thoroughly to avoid contents affecting lure.
- **Step 3:** Cut bottle horizontally using sharp scissors or knife, ensure that the top-half is slightly shorter than lower-half.
- **Step 4:** Turn the shorter top-half upside down and insert into lower-half ensuring the top- half does not touch the lower surface of the bottom-half.
- **Step 5:** Poke holes in both sides, penetrating both layers (top and bottom halves) and insert string, cord, or wire to create a handle.
- **Step 6:** Hang on tree branches or on thick wire or wooden stands around field perimeter and in larger fields within fields.

Specially designed all army worm traps can be purchased at agricultural suppliers. Farmers may also need a magnifying glass to identify insects**.**

Lures or bait

- **Step 1:** Identify the types of insect or pest you wish to lure, to ensure the correct mix.
  - o For fall army worms, use a pheromone lure – which should be purchased from an agricultural supplier
  - o For maize stalk/stem-borers, again pheromone bait is the most effective.
  - o Flies are attracted by sugar-based solutions, or protein (meat) based for carrion flies
  - o Fruit flies are attracted by ripe-fruit, cider vinegar, beer and wine.
- **Step 2**: Place 2 to 4 cm of lure at the bottom of the lower half of the bottle, depending on size of the bottle – the larger the bottle, the more lure. Ensure that the lure smell must be strong, but not too intense so that it attracts insects rather than chasing them away.
- **Step 3:** Use only one lure per bottle trap as more than one might cause contamination leading to ineffective attractants.
- **Step 4.** Clearly mark bottles indicating the type of lure in use – permanent marker pen.

Use of disposable gloves is advisable when handling lures .
Unopened pheromone lure packets should be kept in a cool, dry places – preferably a refrigerator.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Can lead to reduced usage of pesticides, hence reducing GHG emissions.
- As climate changes, pests and insects will also change. Bottle traps will help.
- The use of bottle traps can be used to identify pests for control, supporting productivity through appropriate pest control.

SUMMARY/KEY ISSUES

Benefits

- Bottle trapping is a cheap and effective method for monitoring insects on a farm and identifying those that may affect productivity and/or lead to significant losses.
- This technique can be used to identify the insect that are infesting the field and which areas they are more concentrated, providing information for targeted interventions.
- In smaller fields, or in times of intense infestation, bottle traps themselves can be used to lure and control pests

Drawbacks

- Precaution is required when handling chemical-based lures as they can be harmful to humans and animals, and can negatively impact crop yield if used incorrectly.
- Some lures can only be purchased at agricultural suppliers.
- Cannot be used operationally to control pests in larger fields.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. KP19 Climate Smart Pest and Disease Control for Maize and Sorghum. CCARDESA, Gaborone, Botswana

Additional Information

- Arthurs, S. Hunsberger, A. Do it Yourself Insect Pest Traps. University of Florida.
- The Food and Agriculture Organisation (FAO), 2016. Establishment of pest free areas for fruit flies (Tephritidae). Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2018. FAO Guidance Note 3 – Fall Armyworm Trapping. Rome, Italy.
- Dept of Agriculture and Rural Development, 2016. Insect pests of maize in Kwazulu-Natal. Kwazulu-Natal Province.
- Reliefweb 2017. Africa's most notorious insects – the bugs that hit agriculture the hardest. Reliefweb website.
- Livingseeds 2019. Inset traps and lures. Living Seeds website.

Biological Control Of Pests

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The use of chemical insecticides and pesticides can be expensive and therefore not an economically viable option for small scale farmers, while also not being climate smart – widespread use of pesticides and herbicides contributes to greenhouse gas emissions. Encouraging natural predators can be an effective method for controlling and managing pests in some instances. With governments across the globe discouraging the use of chemical insecticides and pesticide products, biological control of pests is preferred and encouraged - using living organisms to control pests. Natural predators are insects that feed on pests without damaging the crop and can be found throughout the crops. Encouraging natural predators helps in supressing pests during their early and late lifecycles, improving crop production and reducing pollution caused by pesticides use. The introduction of water-fowl, such ducks in rice systems can be a highly effective form of biological control of pests. They enjoy aquatic habitats, consume insects and can even contribute to weeding as tear up weed plants as they look for food. Insect predators have different roles in controlling pests, there are predators that will control pests in the early pest lifecycle where they feed on their larvae and eggs while some are present at the late pest cycle where they feed on mature insects. Some species of ants are natural predators of stemborer pests, and wasp and some fly species larvae are parasitoids (larvae that feed on a host organism) prey on fall armyworm. One such wasp is the tiny (3 mm in length) *Cotesia marginiventris* which feeds on FAW caterpillars. The minute (0.5 mm in length) *Trichogramma* was species lays it's eggs inside FAW eggs, killing the FAW larvae in the process. Earwigs (Dermaptera: *Forficulidae, Carcinophoridae),* ground beetles and ladybird beetles are also known to prey on FAW caterpillars. The issue with many of these solutions is volume of consumption, which may be too low to impact an infestation. Ants are the most important predators of FAW, as the communities consume larger quantities of FAW. However, pesticides drastically impact ant populations.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

Maize | Sorghum | Rice | Livestock | Other

Soil texture

Light | Medium | Heavy

Climatic zone

Arid | Semi-arid | Sub-humid | Humid

Water source

Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)

< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography

Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

Yes | **No**

Characteristics

Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)

< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation

Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort

Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)

Yes | No

Financial resources

Initial investment

Low | Medium | High

Maintenance Costs

Low | Medium | High

Access to finance capital or credit required

Yes | No

Enabling Environment

Extension support

Yes | No

Access to inputs

Yes | No

Market access

Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period

Short | Medium | Long

Crop production

Negative | Neutral | Positive

Fodder production

Negative | Neutral | Positive

Farm income

Negative | Neutral | Positive

Household workload

Negative | Neutral | Positive

Food security

Negative | Neutral | Positive

Ecological Impacts Positive or Negative

Soil quality/cover

Negative | Neutral | Positive

Biological diversity

Negative | Neutral | Positive

Flooding

Negative | Neutral | Positive

Crop/livestock water availability

Negative | Neutral | Positive

Wind Protection

Negative | Neutral | Positive

Erosion control

Negative | Neutral | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively leverage biological control and encourage natural predators:

- **Step 1:** Conduct regular monitoring using field walk-throughs and utilise bottle traps with various lures/baits to identify main pests on crops in order to identify any pests.
- **Step 2:** Once the pests have been identified, consult with national research institutes to identify the best natural predators, or biological control agents* to address the particular pests. It is critical to understand what options are available and costs associated with each option.
- **Step 3:** Implement according to advice received.
- **Step 4:** Monitor progress in terms of reduction in numbers and incidences.
- **Step 5:** Adjust the approach based upon observations from the fields.

A farmer must study the lifecycles of insect predators and be aware of pests that feed on his/her crops in order to identify the intervention that will the most effective in controlling pests at difference phases of their lifecycles. Farmers can create welcoming environments for certain predators to attract them to the field area

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

SUMMARY/KEY ISSUES

Benefits

- Encouraging natural predators helps improve crop production, reduces the use of pesticides which can pollute both the crop and environment.
- Introducing a natural predator, or biological control agent can reduce the risk of crop failure, and increase agricultural productivity
- Archytas, Winthemia and Lespesia flies prey on FAW eggs, with the fly-maggots feeding on the FAW larvae in order to grow. And ants can be highly effective predators of FAW.
- Ducks are highly effective in rice paddy fields.

Drawbacks

- Natural predators are often highly specific to a certain predator, and location/geography/climate; hence, research must be done to establish the most effective method of control.
- Some natural predators do not consume enough prey to reduce infestations, meaning despite best efforts, crops may still fail.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. KP19 Climate Smart Pest and Disease Control for Maize and Sorghum. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 58. Push Pull Systems. Gaborone, Botswana.

Additional Information

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Use of Organic/Chemical Control of Pests

Technical Brief 63

Locally/home-made organic pest control involves the use of home-made remedies to kill and control pests naturally without harming the crop or the environment. Some of the natural pesticides that farmers can use includes soap water, neem, chilli, vegetable oil spray and garlic. These natural remedies are cheaper than the use of chemicals but should be applied in specific amounts for them to be effective. The field must be kept clean to avoid weeds, which provide habitats for insects and weaker crops that are infected must be removed and disposed of away from the field area to avoid attracting further infestations. It is important to minimise disturbance of soil through digging or tilling if not necessary as this can introduce pests into the soil. Alternative approaches such as intercropping, crop rotation, and push/pull systems can also contribute to preventing the spread of pests. This is a climate smart option as it reduces the contribution of pesticides/insecticides to greenhouse gas emissions, and supports sustainable agricultural productivity. If organic insecticides are not effectively killing insects at the rate the farmer wants/needs, chemical controls can be used to halt pest infestation and avoid complete crop loss. However, chemical control of pests should always be the last resort, as chemical pesticides while often hugely effective, are expensive and must be applied precisely to be effective. Furthermore, if used inaccurately chemical pesticides can contaminate crops and the environment, and can impact the farmers' health. The use of chemicals destroys natural pest enemies and can lead to pest invasion and resistance to pesticides in future, driving continued reliance on chemicals. For example, ants can be a very effective biological control agent against Fall Armyworm (FAW); however, ant populations will also be affected by pesticides.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain

● Maize ● Sorghum ● Rice ○ Livestock ● Other

Soil texture

● Light ● Medium ● Heavy

Climatic zone

● Arid ● Semi-arid ● Sub-humid ● Humid

Water source

● Rainfed ● Partly irrigated ● Irrigated

Annual average rainfall (mm)

● < 250 ● 250 - 500 ● 500 - 750 ● 750 - 1000 ● 1000 - 1500 ● > 1500

Topography

● Flat to gentle slope (0 – 5 %) ● Moderate to rolling slope (6 – 15 %) ● Hilly slope (16 – 30 %) ● Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action

○ Yes ● No

Characteristics

● Subsistence ● Commercial Small ● Commercial Medium ● Commercial Large

Farm size (ha)

● < 2 ● 2 to 5 ● 5 to 10 ● > 10

Mechanisation

● Manual ● Animal ● Mechanised

Human resources

Labour intensity – level of effort

○ Low (household) ● Medium (seasonal) ● High (outside labour)

Gender/youth smart (low investment/low labour requirements)

● Yes ○ No

Financial resources

Initial investment

○ Low ● Medium ○ High

Maintenance Costs

● Low ○ Medium ○ High

Access to finance capital or credit required

○ Yes ● No

Enabling Environment

Extension support

● Yes ○ No

Access to inputs

● Yes ○ No

Market access

○ Yes ● No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator			
Return on Investment Realisation Period	Short	**Medium**	Long
Crop production	Negative	Neutral	**Positive**
Fodder production	Negative	Neutral	**Positive**
Farm income	Negative	Neutral	**Positive**
Household workload	Negative	**Neutral**	Positive
Food security	Negative	Neutral	**Positive**

Ecological Impacts Positive or Negative

Indicator			
Soil quality/cover	Negative	Neutral	**Positive**
Biological diversity	Negative	Neutral	**Positive**
Flooding	Negative	**Neutral**	Positive
Crop/livestock water availability	Negative	**Neutral**	Positive
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	**Neutral**	Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively leverage chemical use of organic control measures:

- Organic pesticides must be made based on the type of pests that attack the field along with their productivity rate.
- Equipment needed. Small measures (teaspoons or baking measures), plastic cup, plastic bucket (>1 litre), stirring rod or large spoon/spatula. Spray bottles or back-pack pump spray. Tools used in the field must be cleaned properly to avoid attracting other pests
- When spraying, wear goggles, gloves and disposable masks, and avoid spraying on windy or rainy days.
- It is recommended that any spray is tested before large-scale application. Spray and leave for 24 hours to see if treatment is effective.

a. Basic neem oil spray insecticide: effective against aphids, whiteflies, snails, nematodes, mealybugs, cabbage worms, gnats, moths, cockroaches, flies, termites, mosquitoes, and scale.

- **Step 1:** Mix 1 cup of vegetable oil with 1 tablespoon of liquid soap in a plastic beaker or cup (cover and shake thoroughly),
- **Step 2:** When ready to apply, mix oil spray mix with 1 litre of water,
- **Step 3:** Pour spray mix into a spray bottles or a back-pack pump spray,
- **Step 4:** Shake thoroughly, and spray directly on the surfaces of affected plants. The oil coats the bodies of the insects, effectively suffocating them, as it blocks the pores through which they breathe.
  - Use mixture within eight-hours.
- **b. Garlic spray:** a general organic insecticide that kills most insects.

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Use of organic pesticides/insecticides avoids the use of chemical compounds that contribute to greenhouse gas emissions.
- These can be effective tools to combat insect infestations as climates change.
- Effective control of insect pests can help maintain crop production and avoid crop losses.

SUMMARY/KEY ISSUES

Benefits

- The use of organic insecticides promotes biodiversity as it does not kill pest enemies unlike when using chemicals.
- Healthy soil is required by applying compost and manure in order to not attract pests.
- When handling chemicals, health precaution must be in place such as wearing gloves and nose masks to avoid contamination.

Drawbacks

- The natural remedies are cheaper than chemical control, but they do not kill pests as fast as chemicals.
- Inappropriate use of pesticides can be harmful to both farmers and food therefore, pesticide application guidelines must be followed to ensure efficiency.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. KP19 Climate Smart Pest and Disease Control for Maize and Sorghum. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. KP20 Climate Smart Pest and Disease Control for Rice. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 07 Intercropping. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 58 Push/pull systems. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 61 Bottle-traps. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 65 Integrated Pest Management. CCARDESA, Gaborone, Botswana

Additional Information

- The Food and Agriculture Organisation (FAO), 2014. Environmental and Social Management Guideline, Pest and Pesticides Management. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2017. Family Framing Knowledge Platform-How to make natural pesticide. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 1992. Towards integrated commodity and pest management in grain storage. Rome, Italy.

Flooding Irrigation

Flooding irrigation is a practice where water is pumped or allowed to flow into channels passing between crop rows in areas where farmers have level fields. This flooding system is an effective method of managing weeds and pests, preventing the completion of their lifecycles as they are either drowned or isolated from air and sunlight. This practice is applicable in areas where there are favourable climatic conditions with high rainfall amounts; and is not recommended in arid and semi-arid environments. Flooding is controlled using water pumps in order to reduce waterlogging problems, and fields should not be entirely flooded, with surges of periodic flooding used to distribute water and avoid wastage to run-off, evaporation and creation of anaerobic conditions in the soil. Flood waters can be filtered using a fine mesh to control pests and diseases from spreading to neighbouring fields. Sandy soil is not favourable for flood irrigation as it does not evenly distribute water across the field whereas loam and clay soils distribute water efficiently across the field.

It is considered a climate smart practice because it requires less energy, and can promote crop productivity, whilst controlling weeds and pests.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: Maize | Sorghum | **Rice** | Livestock | **Other**

Soil texture: Light | **Medium** | **Heavy**

Climatic zone: Arid | Semi-arid | Sub-humid | **Humid**

Water source: Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm): < 250 | 250 - 500 | 500 - 750 | **750 - 1000** | **1000 - 1500** | **> 1500**

Topography: **Flat to gentle slope (0 – 5 %)** | **Moderate to rolling slope (6 – 15 %)** | **Hilly slope (16 – 30 %)** | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | **No**

Characteristics: Subsistence | **Commercial Small** | **Commercial Medium** | **Commercial Large**

Farm size (ha): **< 2** | **2 to 5** | **5 to 10** | > 10

Mechanisation: **Manual** | Animal | Mechanised

Human resources

Labour intensity – level of effort: Low (household) | Medium (seasonal) | **High (outside labour)**

Gender/youth smart (low investment/low labour requirements): **Yes** | No

Financial resources

Initial investment: **Low** | Medium | High

Maintenance Costs: **Low** | Medium | High

Access to finance capital or credit required: Yes | **No**

Enabling Environment

Extension support: **Yes** | **No**

Access to inputs: **Yes** | No

Market access: Yes | **No**

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

- Return on Investment Realisation Period: Short | **Medium** | Long
- Crop production: Negative | Neutral | **Positive**
- Fodder production: Negative | Neutral | **Positive**
- Farm income: Negative | Neutral | **Positive**
- Household workload: Negative | **Neutral** | Positive
- Food security: Negative | Neutral | **Positive**

Ecological Impacts Positive or Negative

- Soil quality/cover: Negative | Neutral | **Positive**
- Biological diversity: Negative | Neutral | **Positive**
- Flooding: Negative | Neutral | **Positive**
- Crop/livestock water availability: Negative | Neutral | **Positive**
- Wind Protection: Negative | **Neutral** | Positive
- Erosion control: Negative | **Neutral** | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively leverage flooding irrigation:

- **Step 1:** prepare the field, digging parallel furrows and raising beds with the excess soil. Crops are planted in beds, and the irrigation water will flow in the furrows.
- **Step 2:** Using a pump or gravity fed water storage, allow water to flow into the field, flooding furrows.
- **Step 3:** Insert a fine mesh or introduce a hessian sack at the in-flow point to trap weeds and pests.
- **Step 4:** Water release should be moderated so as not to flow too fast and erode beds, and too slow such that it remains trapped at the in-flow point.
- **Step 5:** Water release can be more effective if released in surges, taking advantage of infiltration rates and capillary action in soil.
- **Step 6:** Observe progress. Avoid leaving soil crusts, which will make water rush over.
  - A sustainable water source must be identified and a pumping/irrigation system should be used.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

Less energy is required to irrigate crops, potentially reducing greenhouse gas emissions if generators used for pumping water.

Effective flood irrigation can increase

SUMMARY/KEY ISSUES

Benefits

- A flood irrigation system reduces weed growth and acts as preventive measure against spread of pests and diseases.
- Requires less energy, so reduces costs. Gravity does the work, so less need for pumping
- Flood irrigation can work with lower-quality water because the water doesn't contact with crop leaves, which is usually a concern with waste water.

Drawbacks

- Requires larger amounts of water than other types of irrigation – only suitable in wetter climates.
- Is considered more labour intensive as land must be closely managed, and prepared.
- Land must be level, or manually/mechanically levelled.
- Cannot effectively operate in sandy soils.
- Very clay-heavy soil can easily become water-logged.
- If not managed properly, can be very wasteful with respect to water.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. KP10 Climate Smart Water Management for Maize and Sorghum. CCARDESA, Gaborone, Botswana

Additional Information

- The Food and Agriculture Organisation (FAO), 1989. Guidelines for designing and evaluating surface irrigation systems. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 1985. Irrigation Water Management: Irrigation Methods. Rome, Italy.
- FAO 2014. Irrigation Techniques for Small-scale Farmers: Key Practices for DRR Implementers. Rome, Italy.
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- African Farming 2018. Saving water: flood irrigation explained. African Farming.com

Integrated Pest Management

Integrated Pest Management (IPM) is the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimise risks to human health and the environment, focusing on all practical options for reducing or eliminating pesticides. The practice of IPM for crop protection is widely encouraged, as the practice can enhance crop production and reduce risks associated with use, storage and management of pesticides. The integrated nature of this approach ensures that it is climate smart, as it utilises the best possible options to ensure sustainable productivity, which will in turn allow adaptation to climate change. However, as it may require the use of pesticides as one strategy, the climate-smartness may be affected.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain
Maize | Sorghum | Rice | Livestock | Other

Soil texture
Light | Medium | Heavy

Climatic zone
Arid | Semi-arid | Sub-humid | Humid

Water source
Rainfed | Partly irrigated | Irrigated

Annual average rainfall (mm)
< 250 | 250 - 500 | 500 - 750 | 750 - 1000 | 1000 - 1500 | > 1500

Topography
Flat to gentle slope (0 – 5 %) | Moderate to rolling slope (6 – 15 %) | Hilly slope (16 – 30 %) | Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action
Yes | No

Characteristics
Subsistence | Commercial Small | Commercial Medium | Commercial Large

Farm size (ha)
< 2 | 2 to 5 | 5 to 10 | > 10

Mechanisation
Manual | Animal | Mechanised

Human resources

Labour intensity – level of effort
Low (household) | Medium (seasonal) | High (outside labour)

Gender/youth smart (low investment/low labour requirements)
Yes | No

Financial resources

Initial investment
Low | Medium | High

Maintenance Costs
Low | Medium | High

Access to finance capital or credit required
Yes | No

Enabling Environment

Extension support
Yes | No

Access to inputs
Yes | No

Market access
Yes | No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Indicator			
Return on Investment Realisation Period	Short	**Medium**	Long
Crop production	Negative	Neutral	**Positive**
Fodder production	Negative	**Neutral**	Positive
Farm income	Negative	Neutral	**Positive**
Household workload	Negative	**Neutral**	Positive
Food security	Negative	Neutral	**Positive**

Ecological Impacts Positive or Negative

Indicator			
Soil quality/cover	Negative	Neutral	**Positive**
Biological diversity	Negative	Neutral	**Positive**
Flooding	Negative	**Neutral**	Positive
Crop/livestock water availability	Negative	**Neutral**	Positive
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	Neutral	**Positive**

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively leverage integrated pest management:

- **Step 1:** Identify damage and responsible pest. Regular crop monitoring is important, to ensure early identification. Bottle traps are useful for capturing samples to examine and identify a pest.
- **Step 2:** Learn about the pest and host life cycle and biology.
- **Step 3:** Monitor or sample environment for pest population.
- **Step 4:** Establish action threshold. If aiming to tackle weed infestation, intervention must occur before the weed matures and begins spreading seeds. Some thresholds are high. For example, if dealing with caterpillars, soya beans can tolerate a certain level of defoliation without it impacting crop yield.
- **Step 5:** Identify IPM response tactics.
  - o **Cultural methods** –planting crops that are adapted or suited to conditions and responding to their water, nutrient and shelter needs
  - o **Physical methods –** mechanical weeding, such as mechanical weeding or using organic or plastic mulch to cover the ground to reduce weed presence/success.
  - o **Genetic methods –** selecting modified or adapted pest-resistant varieties.
  - o **Biological methods –** using natural predators, push-pull approaches, intercropping, etc. and use of use of organic pesticides.
  - o **Chemical methods –** considering all levels of toxicity – from pheromone deterrents to conventional pesticides.
- **Step 6:** monitoring for ongoing efficacy, and adjustment of tactics where relevant/necessary. Aiming at all times to use chemical pesticides rationally and as a very last resort.

In the cases where chemical pesticides are used as part of an IPM strategy, the Agri-Intel website is an invaluable resource, which provides detailed chemical management advice: https://www.agri-intel.com

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- Practical reduction or elimination of pesticide use reduces or removes the contribution to greenhouse gas emissions.
- Practical reduction or elimination of pesticide use reduces or removes the contribution to greenhouse gas emissions.
- IPM maximises opportunities for agricultural productivity while minimising or eliminating the use of pesticides.

SUMMARY/KEY ISSUES

Benefits

- IPM is the agricultural practice of combining several practices to maximise benefits.
- Pesticides are used following the safety information given on the packaging, when other approaches are not effective

Drawbacks

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. KP19 Climate Smart Pest and Disease Control for Maize and Sorghum. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. KP20 Climate Smart Pest and Disease Control for Rice. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 07 Intercropping. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 08 Relay cropping. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 13 Mulching. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 15 Cover crops. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 19 Weed Control. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 56 Cultural Control Continuous Long-Term Practices. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 57 Resistant Varieties. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 58 Push/Pull Systems. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 60 Mechanical: Weeding. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 61 Bottle-traps. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 62 Biological: Encouraging Natural Predators. CCARDESA, Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 63 Chemical: Organic pesticides. CCARDESA, Gaborone, Botswana

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- CGIAR, 2017. Climate-Smart Pest Management: Implementation guidance for policymakers and investors.
- The Food and Agriculture Organisation (FAO), 2019. AGP – Integrated Pest Management. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2014. Environmental and Social Management Guideline, Pest and Pesticides Management. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 2017. Family Framing Knowledge Platform-How to make natural pesticide. Rome, Italy.
- The Food and Agriculture Organisation (FAO), 1992. Towards integrated commodity and pest management in grain storage. Rome, Italy.
- Heeb, L, Jenner, E, Cock, MJW. 2018. Climate-smart pest management: building resilience of farms and landscapes to changing pest threats. Journal of Pest Science (2019) 92:951–969.
- PennState Extension 2011. Steps of Integrated Pest Management. Pennsylvia State University.

Banding and Micro Dosing

Technical Brief 66

While rotating crops or leaving fields fallow for several growing seasons is good practice, some farmers do not have this luxury, needing to continue planting season upon season. However, this practice will soon see soils depleted of nutrients. In these cases, use of green manure, and organic fertilisers is recommended. In. the last-resort cases where chemical fertilisers must be used, banding and micro-dosing are approaches that rationalise or minimise application. Banding is the agricultural practice of placing fertiliser in a row below soil surface, covering with soil and planting seeds above the fertiliser, whereas Micro-dosing – sometimes referred to as ring-placement - is the practice of placing small, more affordable amounts of fertiliser around each crop plant. Banding is a common method used for basal fertiliser applications and uses less fertiliser than broadcasting as it is applied in rows rather than throughout the whole field. Micro-dosing is applicable where plants are widely spaced and where soil increases the chances of nutrient loss due to leaching. While the use of chemical fertilisers is not strictly considered climate smart, these practices promote economic and rationalised application of fertilisers, reducing greenhouse gas emissions, whilst improving resilience in the face of climate change, and providing options for maintain agricultural productivity.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: **Maize** | **Sorghum** | Rice | Livestock | **Other**

Soil texture: **Light** | **Medium** | **Heavy**

Climatic zone: **Arid** | **Semi-arid** | **Sub-humid** | **Humid**

Water source: **Rainfed** | Partly irrigated | Irrigated

Annual average rainfall (mm): **< 250** | **250 - 500** | **500 - 750** | **750 - 1000** | **1000 - 1500** | **> 1500**

Topography: **Flat to gentle slope (0 – 5 %)** | **Moderate to rolling slope (6 – 15 %)** | **Hilly slope (16 – 30 %)** | **Steep slope (> 30 %)**

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: Yes | **No**

Characteristics: **Subsistence** | **Commercial Small** | Commercial Medium | Commercial Large

Farm size (ha): **< 2** | **2 to 5** | **5 to 10** | **> 10**

Mechanisation: **Manual** | Animal | Mechanised

Human resources

Labour intensity – level of effort: **Low (household)** | **Medium (seasonal)** | High (outside labour)

Gender/youth smart (low investment/low labour requirements): **Yes** | No

Financial resources

Initial investment: **Low** | Medium | High

Maintenance Costs: **Low** | Medium | High

Access to finance capital or credit required: Yes | **No**

Enabling Environment

Extension support: **Yes** | No

Access to inputs: **Yes** | No

Market access: Yes | **No**

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POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Impact			
Return on Investment Realisation Period	Short	**Medium**	Long
Crop production	Negative	Neutral	**Positive**
Fodder production	Negative	Neutral	**Positive**
Farm income	Negative	Neutral	**Positive**
Household workload	Negative	**Neutral**	Positive
Food security	Negative	Neutral	**Positive**

Ecological Impacts Positive or Negative

Impact			
Soil quality/cover	Negative	Neutral	**Positive**
Biological diversity	Negative	**Neutral**	Positive
Flooding	Negative	**Neutral**	Positive
Crop/livestock water availability	Negative	**Neutral**	Positive
Wind Protection	Negative	**Neutral**	Positive
Erosion control	Negative	**Neutral**	Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively leverage banding and micro-dosing for maize and sorghum, the following should be carried out. When handling fertilisers, always ensure that safety precautions provided on the packaging are followed.

Banding – suitable when wishing to save on fertiliser expenditure, but still need to improve production of primary and secondary crops.

- **Step 1:** Plough the field using a draught animal-drawn or mechanised plough to carefully open furrows. Depending on availability of mechanised equipment, a narrow hoe can also be used if manual labour is favoured. This can reduce workload and minimise soil disturbance but may require more effort.
- **Step 2:** Count furrows and measure length to ensure that you have sufficient fertiliser for area, based on recommended application amounts (see packaging or see advice from supplier).
- **Step 3:** Apply fertilisers as a strip or line (band) along the furrow.
- **Step 4:** Turn furrow back over ensuring that the fertiliser is present at a depth of 5-8cm below the soil surface and covered by the soil. The basal fertiliser should not touch the seed as it may burn it and disturb its germination.

Micro-dosing: suitable when fertiliser is in short supply.

- **Step 1:** in the field, at the time of planting, prepare small pits 5 to 8 cm deep where each seed is to be placed.
- **Step 2:** measure approximately 6 grams of fertiliser using a bottle cap or a three-finger pinch.
- **Step 3:** place the micro-dose in the small pits
- **Step 4:** cover fertiliser with a small amount of soil, then place the seed. Cover fully with soil and water, or allow rain to wet the ground.

- Where manure is available, Zai pits can be used to improve organic matter at the same time. Prior to planting, dig the small pit and fill with manure. When rains begin, fertiliser and seed are placed in the hole and covered.
- The practice includes the advantage of banding by placing the fertiliser below the seed but at a single point instead of a row.

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CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- While seen as a last resort, these focused applications of chemical fertilisers can lead to sustained agricultural productivity.
- In some areas, use of fertilisers is unavoidable, especially in areas impacted by climate change.
- These economical uses of fertiliser minimise or rationalise fertilisers, reduce contributions to GHG emissions.

SUMMARY/KEY ISSUES

Benefits

- Banding is the most commonly used method for basal fertiliser applications, and it uses much less fertiliser as it is applied in rows.
- Micro-Dosing maintains and increases crop production with less fertiliser, crops become less susceptible to diseases/pests and reduces GHG emissions per kg of crop produce.
- Micro-dosing has been known to double or even triple yields and plant biomass.
- If using fertiliser, these approaches can save significantly on the cost of fertilisers, as is
- Can be used to supplement organic fertilisers if in short supply.
- Both techniques are more economic for smallholders.

Drawbacks

- Use of chemical fertilisers has a cost attached.
- Chemical fertilisers are not strictly a CSA approach.
- Requires a sustainable supply of fertilisers
- If small-holders are purchasing fertilisers, they are often only available in 50 kg bags, which often make them economically inaccessible. Agriculture for development projects have been lobbying manufacturers to also provider smaller bags.
- If 50 kg bags are purchased, fertiliser must be stored in cool dry place – following instructions on packaging.
- Micro-dosing can be very time and labour intensive.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 21, Decision Tool: Climate Smart Fertiliser Options. Gaborone, Botswana
- CCARDESA, 2019. Knowledge Product 06, Decision Tool: Climate Smart Soil Amendment Options for Maize and Sorghum. Gaborone, Botswana
- CCARDESA, 2019. Technical Brief 26, Zai Pits. Gaborone, Botswana
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Subsurface Fertilisation

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Subsurface fertilisation is the agricultural practice of placing compressed balls of fertiliser, known as briquettes, deep in the soil. The balls of fertiliser are known to gradually release nitrogen, feeding the crops with the desired nutrients. This practice is usually carried out in flooded fields and although originally used for urea application in irrigated rice, it can be used with other fertilisers and crop types. Sub-surface fertilisation prevents the loss of nitrogen during floods as the application is placed 7-10 cm deep in the soil, converted to ammonium, which is much less mobile than nitrates. Only about 4% of nitrogen is lost to the environment when applying in the sub-surface, as compared to 35% when nitrogen is applied using the broadcasting application practice. Urea briquettes are small (~2 cm diameter), and home-made manure briquettes – more practical and applicable for crops other than rice – are larger – up to 10 cm in diameter.

This fertiliser application technique is considered climate smart as it maximises fertiliser inputs, increasing productivity and providing a mechanism for adapting to climate change by amending soil properties to remain productive.

MOST SUITABLE AGRO-ECOLOGICAL CONDITIONS

Value chain: ● Maize | ● Sorghum | ● Rice | ○ Livestock | ● Other

Soil texture: ● Light | ● Medium | ● Heavy

Climatic zone: ● Arid | ● Semi-arid | ● Sub-humid | ● Humid

Water source: ● Rainfed | ○ Partly irrigated | ○ Irrigated

Annual average rainfall (mm): ● < 250 | ● 250 - 500 | ● 500 - 750 | ● 750 - 1000 | ● 1000 - 1500 | ● > 1500

Topography: ● Flat to gentle slope (0 – 5 %) | ● Moderate to rolling slope (6 – 15 %) | ● Hilly slope (16 – 30 %) | ● Steep slope (> 30 %)

MOST APPROPRIATE CONDITIONS AND REQUIRED INPUTS

Farming system

Does it require collective action: ○ Yes | ● No

Characteristics: ● Subsistence | ● Commercial Small | ○ Commercial Medium | ○ Commercial Large

Farm size (ha): ● < 2 | ● 2 to 5 | ○ 5 to 10 | ○ > 10

Mechanisation: ● Manual | ○ Animal | ○ Mechanised

Human resources

Labour intensity – level of effort: ○ Low (household) | ● Medium (seasonal) | ○ High (outside labour)

Gender/youth smart (low investment/low labour requirements): ● Yes | ○ No

Financial resources

Initial investment: ● Low | ○ Medium | ○ High

Maintenance Costs: ● Low | ○ Medium | ○ High

Access to finance capital or credit required: ● Yes | ○ No

Enabling Environment

Extension support: ● Yes | ○ No

Access to inputs: ● Yes | ○ No

Market access: ○ Yes | ● No

The purpose of this technical brief is to guide where this **practice, technology or strategy** could be applied. It may be applicable in other circumstances, but this brief focuses on where it is possibly **most suitable**. Content is general, and should be contextualised depending upon locality. The brief provides an overview, details of appropriate agroecological characteristics, appropriate conditions and inputs, possible outcomes and impacts, how the **practice, technology or strategy** should be applied, potential benefits and drawbacks, and provides suggestions for further reading in terms of CCARDESA materials and other sources, including those used to develop this technical brief.

*CCARDESA is a subsidiary of SADC, coordinating and harmonising agricultural research and development in Southern Africa. This **Technical Brief** is part of a series of materials designed to support **Knowledge Products on climate smart agriculture** available here: www.ccardesa.org/saaiks-knowledge-hub*

POSSIBLE IMPACT/OUTCOMES

Socio-Economic Impacts Positive or Negative

Return on Investment Realisation Period: **Short** | **Medium** | Long

Crop production: Negative | Neutral | **Positive**

Fodder production: Negative | Neutral | **Positive**

Farm income: Negative | Neutral | **Positive**

Household workload: Negative | **Neutral** | Positive

Food security: Negative | Neutral | **Positive**

Ecological Impacts Positive or Negative

Soil quality/cover: Negative | Neutral | **Positive**

Biological diversity: Negative | Neutral | **Positive**

Flooding: Negative | **Neutral** | Positive

Crop/livestock water availability: Negative | **Neutral** | Positive

Wind Protection: Negative | **Neutral** | Positive

Erosion control: Negative | **Neutral** | Positive

These descriptors indicate whether the practice, technology or strategy has a positive, neutral , or negative impact or outcome
Those with no box are deemed not-applicable

TECHNICAL APPLICATION

To effectively implement subsurface fertilisation, the following should be carried out. Use of briquette machines to produce 1 to 3 grams of briquettes that are larger than conventional fertiliser granules is recommended:

- **Step 1:** Prior to application, dig small holes 7 to 10 centimetres deep along planting rows in drained rice paddy or regular field, ideally located in the centre between a location where four plants will be planted.
- **Step 2:** Place the briquettes in the whole, below the soil surface, and cover with dug soil.
- **Step 3:** Crops should be planted within seven days of fertiliser application.

Following are the main steps for making your own briquettes. Making briquettes leading up to planting is more effective, as they are not stored for too long. A standard briquette machine can be purchased for between USD 3,000 and USD 6,000.

- **Step 1:** Collect manure from cow and/or horse waste.
- **Step 2:** Allow the manure to moderately dry (so it is possible to handle), but not for extensive periods, otherwise it will degrade. Keep manure out of direct sunlight, or when processing, remove the outer layer before manufacturing briquettes, and do not leave exposed, especially during rainy periods.
- **Step 3:** Press manure into briquettes using briquette press machine – see directions below to make your own home-press.
- **Step 4:** Allow the briquettes to dry in a cool, dry location, and store for later use.

To make your own large manure briquette press using household items, follow the instructions below:

- **Step 1:** Cut the top off a straight-sided 2-litre plastic soft drink bottle at the top of straight side.
- **Step 2:** Obtain a tinned food can that is just smaller than the diameter of the bottle. Preferably leave tin un-opened.
- **Step 3:** Line the bottle with a plastic bag
- **Step 4:** Place slightly damp manure (cow, horse or both) inside the bag, inside the bottle, filling the space.
- **Step 5:** Place tin on top of manure
- **Step 6:** Place small plank of wood on top of the tin
- **Step 7:** Place your foot on top of the piece of wood, and slowly apply pressure to the tin, pressing the manure down, adding more manure if it compresses further than the depth of the tin.
- **Step 8:** When the manure will compress no more, remove plank and tin, and draw the compressed manure from the bottle, removing the plastic bag to reveal a cylinder of compressed manure.
- **Step 9:** Slice with a sharp knife to discs 2 to 3 cm thick, and use a piece of 2 cm diameter metal or plastic pipe to punch a hole through each disc. Reuse the
- **Step 10:** Allow to air dry as individual rings in a cool dry place. As soon as they are strong enough, you can hang the rings on wire to continue to dry. Use in fields within a month of manufacture. The ring increases surface area, and speeds-up the drying process.

CLIMATE SMART AGRICULTURE OUTCOME(S)

Reflecting how this **practice, technology or strategy** contributes to Climate Smart Agriculture outcomes

- A highly effective soil amendment that increases nutrients and organic matter in soil, and in turn productivity.
- An effective mechanism for amending soil in the face of changing climates.
- If using fertiliser to amend soil, this approach retains substantially more of the fertiliser in the soil to augment nutrients; therefore, is more efficient.

SUMMARY/KEY ISSUES

Benefits

- This application preserves the nutrients deep in the soil and nourishes the soil making nitrogen available to the crops throughout their growth cycle.
- Maximises fertiliser application, as little is lost to the atmosphere.
- Farm waste such as manure can be repurposed into briquettes for subsurface fertiliser application
- Can provide a revenue generation opportunity for enterprising community members

Drawbacks

- Requires additional labour to gather material, and to make briquettes.
- There is a financial commitment for purchasing briquette-making equipment.
- Briquettes can be made by hand, but it requires additional labour and time.

REFERENCE MATERIAL

CCARDESA Related Content

- CCARDESA, 2019. Knowledge Product 6, Climate Smart Soil Amendment Options for Maize and Sorghum. Gaborone, Botswana
- CCARDESA, 2019. Knowledge Product 16, Climate Smart Manure Management. Gaborone, Botswana

Additional Information

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