CLIMATE RESILIENT AGRICULTURE: PRACTICES FOR SMALLHOLDER FARMERS VOLUME 2 PART 5 FARMER HANDOUTS: ENGLISH

E Kruger, MC Dlamini, T Mathebula, P Ngcobo, BT Maimela & S Ntonta

WATER RESEARCH COMMISSION

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Farmer Handouts: English

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Report to the

Water Research Commission

by

Mahlathini Development Foundation

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Volume 2 Part 1: Community Climate Change Adaptation facilitation: A manual for facilitation of Climate Resilient Agriculture for smallholder farmers. (WRC Report No. TT 841/2/20)
Volume 2 Part 2: Climate Resilient Agriculture. An implementation and support guide: Intensive homestead food production practices. (WRC Report No. TT 841/3/20)
Volume 2 Part 3: Climate Resilient Agriculture. An implementation and support guide: Local, group-based access to water for household food production. (WRC Report No. TT 841/4/20)
Volume 2 Part 4: Climate Resilient Agriculture. An implementation and support guide: Field cropping and livestock integration practices. (WRC Report No. TT 841/5/20)
Volume 2 Part 5: Climate Resilient Agriculture learning materials for smallholder farmers in English. (WRC Report No. TT 841/6/20)
Volume 2 Part 6: Climate Resilient Agriculture learning materials for smallholder farmers in isiXhosa. (WRC Report No. TT 841/7/20)
Volume 2 Part 7: Climate Resilient Agriculture learning materials for smallholder farmers in isiZulu. (WRC Report No. TT 841/8/20)
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Climate Resilient Agriculture: Practices for smallholder farmers

1 What is Climate Resilient agriculture (CRA)

Climate resilient agriculture aims to sustainability increase agricultural productivity and incomes while adapting our farming practices to the changed circumstances and also making sure that our farming is friendly to nature. It is about making changes to how we farm in a changing environment that will improve both our ability and the ability of the environment to cope with these changes

The emphasis is at farm/household level. CRA aims to improve aspects of crop production, livestock and pasture management, natural resource management, as well as soil and water management as shown in the figure below.

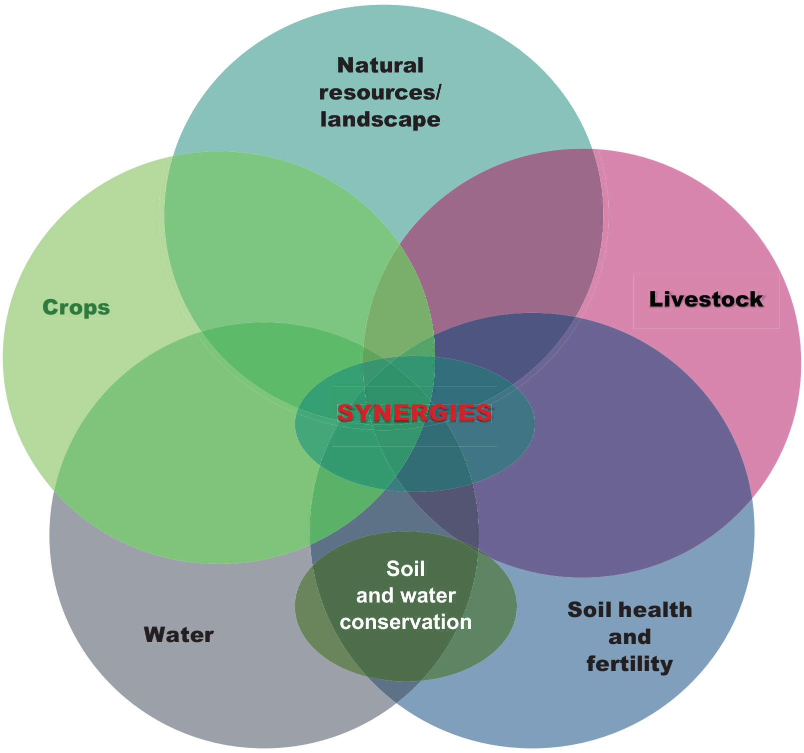


Figure 1: Household level implementation of CRA integrates across sectors (adapted from Arslan, 2014)

There are a range of farming practices that can be useful. The idea is that we try out the practices that are appropriate for us, where we live and compare them with what we are doing already, to observe the differences and to make decisions from there about changing our farming systems.

Combining a number of different practices will increase their effect.

The practices are briefly described below

Further information can be found on the following websites

www.mahlathini.org

www.amanziforfood.co.za

2 PRINCIPLES

The main principles or concepts that we have focused on in choosing the practices are the following:

- Minimize external inputs
- Maximise internal diversity
- Focus on soil health and natural soil building techniques
- Take care of the environment
- Use available water as efficiently as possible.
- Work together, learn together and plan together

All these practices have been tried out with smallholder farmers over the last three to eight years. We know they work, so good luck with trying them all out.

3 WATER MANAGEMENT (MANAGE AVAILABLE WATER AND INCREASE ACCESS TO WATER)

3.1 INFILTRATION DITCHES (RUN-ON DITCHES, DIVERSION DITCHES)

These are shallow ditches (30 cm wide and 15-30 cm deep) that are dug either to channel water to a specific area (diversion ditches) or to catch water an allow it to sink into the soil in a cropping area (run-on ditches); the latter are dug on contour.

Planting can be done on the ridges, adding manure/ compost and mulching of both the ridges and ditches is a good idea

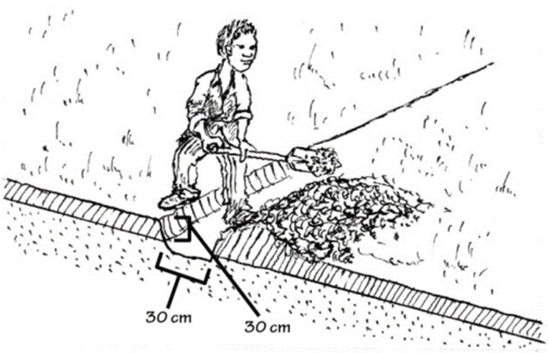
These ditches increase access to and availability of water in intensive food production.

REQUIREMENTS

- Rainfall: >150 mm/year
- Temperature: >5°C
- Topography: any slope
- Soil: 5-35% clay, depth >15 cm
-

IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha
- Low cost, local resources
- Easy to do and maintain; labour intensive



Diversion ditch, mulched and sweet potato planted on ridge

Digging a diversion ditch (1,5-5%slope; 30 cm wide and 30 cm deep with soil placed on upper slope

Preparing the ridge of the diversion ditch for planting – shaping and adding manure

3.2 CUT OFF DRAINS/ SWALES

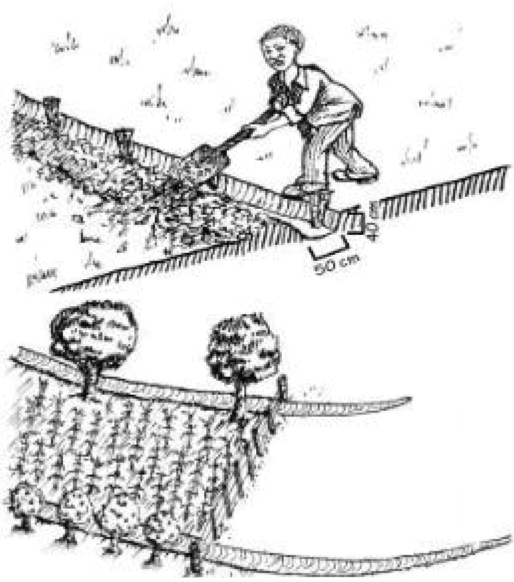
A swale is an earth bank constructed along the contour with a furrow (40 cm deep and 50 cm wide) on the up-slope side. The top of the earth bank is levelled off to allow planting. The swale intercepts runoff, spreads it out and helps it infiltrate deep into the ground. Typically, permanent crops (e.g. fruit trees) are planted just below the ridge of the swale, while seasonal crops (e.g. vegetables) are planted between the swales.

REQUIREMENTS

- Rainfall: >150 mm <1200 mm/year
- Temperature: >5°C
- Topography: 5%-25%
- Soil: all types – although soils that are too sandy or too clayey are difficult to manage

IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha, >2 ha
- Low cost, local resources,
- Labour intensive



Constructing a swale and a view of two swales indicating the flow of water

Digging the cut off drain/swale ditch. Soil is placed on the downslope

Mulching can also be placed in the ditch and crops planted both in the ditch and on the mound

Preparing trench beds below a swale

3.3 FURROWS AND RIDGES

Furrows are dug on contour and soil placed upslope in a mound. Planting is done on the mounds or ridges and irrigation or water, flows along the furrow. It is possible to create cross ties to ensure good irrigation – so water can accumulate in the furrow and seep into the ground. Mulching is a good idea.

REQUIREMENTS

- Rainfall: >150 mm/year
- Temperature: >5°C
- Topography: 0,5%-5%
- Soil: all types

Furrows and ridges used in field cropping; note the tied ridges to hold water in the furrows

IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha
- Low cost, local resources,
- Labour intensive

A vegetable garden laid out in furrows and ridges; planted to tomatoes, carrots and spinach. Note the trench bed in the front right of the picture

Mulched furrows in a garden planted to tomatoes. Flood irrigation is practiced in the furrows

Fruit trees can be combined into the beds in this system

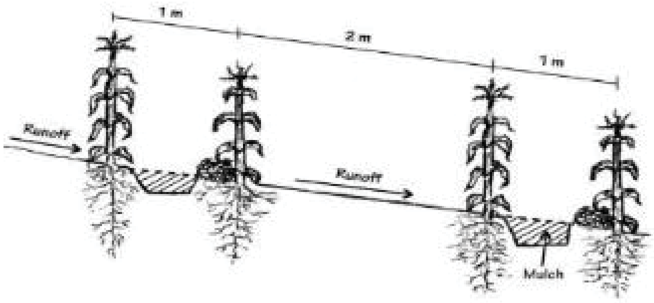
3.4 TIED RIDGES

This method increases the water that is available to plants by collecting rainfall from an unplanted sloping basin and catching it with a furrow and ridge. Planting takes place on either side of the furrow where the water has infiltrated. The slope of these basins needs to be

Basins are created by digging out shallow furrows along the contour lines of the slope and constructing ridges on the downside of the furrows. These are “tied” together by slightly lower ridges which are constructed at regular intervals along the furrows.

REQUIREMENTS

- Rainfall: 400-700 mm/year
- Temperature: >5°C
- Topography: 0,5%-7%
- Soil: Soils should be relatively stable. The best soils are clay or soils with a relatively permeable topsoil over a less permeable subsoil



IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha
- Low cost, local resources,
- Labour intensive

Mulched furrows in a garden laid out with tied ridges

Water collecting in the furrows, in a maize field with tied ridges

A small field laid out with tied ridges planted to sweet potatoes and maize, Free State

3.5 Infiltration pits/ banana circles

Basins are dug in the soil along water flow lines (to catch and slow water). These basins are filled with organic matter (large amounts) mixed with soil and bananas or other water loving crops are planted in the basins

A variation of this is that one pit or basin is dug in a water flow line and slowly filled with organic matter (green and manure) – for slow composting. Here bananas or other crops are planted on the edges.

REQUIREMENTS

- Rainfall: >350 mm/year
- Temperature: >5°C
- Topography: 1,5%-25%
- Soil: all types (5-30% clay) and depths (>30 cm)

IMPLEMENTATION

- Gardens
- <0,1 ha,
- Low cost, local resources
- Easy to do and maintain; labour intensive

Smaller, separate basins can be made; basins are dug out and filled with organic matter

A mulched banana circle, mixed with herbs

Step wise basins along a drainage line in a homestead garden. Tied ridges are made between the basins

3.6 MULCHING

Soil is covered by a variety of crop residues and organic matter, to save water, reduce soil temperatures, and increase soil health

REQUIREMENTS

- Rainfall: >350 mm/year
- Temperature: >5°C
- Topography: 1,5%-25%
- Soil: all types (5-30% clay) and depths (>30 cm)

IMPLEMENTATION

- Gardens
- <0,1 ha,
- Low cost, local resources
- Easy to do and maintain; labour intensive

Leaf litter mulch of trench bed

Lucerne or grass mulch of dryland. Conservation agriculture plot

Napier fodder/ sugar cane, stover mulch of vegetable beds

Grass mulch of furrows and ridges planting system

3.7 SHADE CLOTH TUNNELS

40% Grey shade net tunnels of 4.2 m x 6 m, 2 m high in size are constructed using 'kits' and local materials. The hoops are made of conduit piping which is bent using a "jig" – a metal frame. These hoops are placed directly into the soil – avoiding any construction and then the netting is placed over the hoops and sewn on. The tunnel is anchored on both sides

Inside the tunnel are three trench beds 1 m x 5 m and each is supplied with a 20 L bucket drip kit. Mixed cropping is practiced in the tunnel and greywater can also be used.

These tunnels are appropriate anywhere where cropping is possible, trench beds can be dug and some irrigation can by supplied.

A recently completed tunnel with bucket drip kits installed and spinach planted

IMPLEMENTATION

- Gardens
- <0,1 ha,
- Medium cost, medium skills, including learning and mentoring
- Low maintenance

Line 1 Above left to right: Using a rope template to mark out the tunnel and arch position; Using a hollow metal bar to make the holes for the metal arches; Bending the arches using a jig; and joining the bent halves of the arches with a standard connector.

Line 2 Above left to right; 'Planting" the arches in their holes; Sewing the netting for the end panels onto the two end arches before putting them up; Pulling and tightening the netting over all arches once they have been put up; then anchoring the arches and putting the final touches to the structure once the netting around the bottom the edges have been buried for added structural protection against wind forces.

Line 3 Above left and right: Examples of completed tunnels, with the three bucket drip kits installed.

3.8 RAINWATER HARVESTING AND STORAGE

Generally, smallholders collect water in available basins, drums and JoJo tanks. This does not provide a lot of water.

Underground tanks can store a lot more water. These tanks collect runoff water form structures, roads and the general area, to store large amounts of water (25 000-40 000 litres); enough water for a 100-200 m^2 garden for 4-6 months.

Local RWH storage options in Limpopo; basins, 210 L drums, 1000 L containers and Jo-Jo tanks, these hold little water

Large holes need to be dug and then tanks are constructed – either ferrocement, blocks and plaster or geofabric and bitumen.

REQUIREMENTS

- Rainfall: >450 mm/year
- Temperature: >5°C
- Topography: 1,5%-25%
- Soil: all types (5-30% clay), and depths (>30 cm)

IMPLEMENTATION

- Gardens
- <0,1 ha, 0,1-1 ha, .2 ha
- High cost and or high labour requirements for storage structures
- High levels of skill and knowledge (outside support and training initially required
- Medium maintenance and effort. Water needs to be taken out by bucket, or pumped. Silt needs to be removed from time to time

A ferrocement underground tank with brick wall for placement of a roof structure under construction

An example of an underground tank (18 m^3), with a removable metal roof (Acornhoek).

The silt trap for a 25 000 L underground tank to reduce silt load of stored water

A completed geofabric tank with brick wall and roof for safety. The inlet furrow for water is in the foreground

3.9 Rainwater harvesting storage; Jo-Jo tanks

Jo-Jo tanks can be used for harvesting water off roofs (usually 2500 L-5000 L in size). It is important to make sure proper gutters and pipes are installed.

It is also possible to use partially buried Jo-Jo tanks as an option to harvest water off steep slopes. Here the water can be gravity fed from the tanks and no pumps or buckets re required

And there are options for using Jo-Jo tanks underground, although in this case they need to be strengthened. This is easier than constructing tanks.

Month	Average Monthly rainfall (mm)	Roof area (m^2)	Runoff coefficient	Runoff volume (litres)
Jan	115	43.6	0.9	4513
Feb	123	43.6	0.9	4827
Mar	109	43.6	0.9	4277
Apr	78	43.6	0.9	3061
May	61	43.6	0.9	2394
Jun	35	43.6	0.9	1373
Jul	30	43.6	0.9	1177
Aug	35	43.6	0.9	1373
Sep	55	43.6	0.9	2158
Oct	60	43.6	0.9	2354
Nov	80	43.6	0.9	3139
Dec	95	43.6	0.9	3728
TOTAL	876			34374

A small table showing the amount of water that can be harvested for a small IDP house

A home-made suction pump can be used to get water out of underground tanks

Gutters and inlet pipes are important when using Jo-Jo tanks to collect water from roofs

Partially buried Jo-Jo tanks for harvesting water off slopes

Jo-Jo tanks buried for underground water storage

3.10 Small dams

Small dams can be dug in soils that can hold water (more than 25% clay). They tend to lose water and only stay full for a short period, but provide a lot of water to the soil profile in the area. Usually they are dug in places where small springs can fill them up on a continuous basis, or where overland water flow or run-off is prevalent.

It is possible to line these small dams/ponds with plastic, but only if there is a reasonable chance that they will stay full, as the plastic decays easily in the sun.

It is also possible to line the small dams with bentonite to seal them, again only when ponds are likely to remain full of water most of the time.

Three examples of small dams/ponds dug in soil that will hold water — >25% clay to be sure. The one on the right is a 'large' dam fed by a spring slightly higher up the slope. The dam in the central picture is fed by a pipe gravity fed from a river

A small pond lined with bentonite (the yellowish clay inside the pond,) being filled up. Note the angle of the pond walls, the slope of the pond walls, that allows for the bentonite to be stamped into sides and bottom of the pond to seal it.

A small pond dug in a community garden fed by run-off water from the road and lined with plastic

3.11 Water access

Management, and development of local water sources, with reticulation to homesteads and gardens is possible for small local community groups:

- Community level groups work together to agree upon who will be involved (not more than 20 people), who need to be actively involved in farming and in close proximity to each other
- They identify a local water source in the vicinity; a spring or potential borehole sites and ratify their use of this source with the local authorities
- Then a system is designed to provide for a header tank filled from the source and then gravity fed reticulation to all the involved households and gardens.
- The water committee designs and implements the rules for water allocations to each household and manages any finances and payment involved
- All participating members are expected to contribute financially, to do the labour for the installations themselves and to proactively manage the water with the other members in their group
- All permissions from the water services authorities and local authorities need to be obtained and arrangements need to be made for ongoing maintenance.

REQUIREMENTS

- Rainfall: >150 mm/year
- Temperature: >5°C
- Topography: any slope
- Soils: Any
- Sources of water; springs, ground water

IMPLEMENTATION

Households and gardens

- <0,1 ha
- High cost, external and local resources
- Labour and skill intensive; need for local training and technical support

A spring dug out to form a small dam. The spring protection consists of a slotted pipe buried in a ditch dug below the dam and which is then covered with gravel, shade netting and soil, to be protected. In this way a spring can be protected, without major construction

An example of a header tank from where water is gravity fed to the households

An example of a household connection. These drums are interlinked and have a float valve to ensure the water stops running when the drums are full

Drilling of boreholes and laying of pipes form the header tank to the households

3.12 Greywater management

Greywater is water used for washing in a household (clothes, dishes, people), but does not include blackwater (toilet water, sewage). Greywater is generally high in soap content of various types and organic matter. Dangers in use include microbial contamination, nitrification from soap and crusting on top of the soil if it is used in the same place often. Management for safe use and disposal of greywater is important. Mostly this consists of using ash and other substances such as moringa seed to bind and flocculate some of the soap, and irrigation practices that avoids the greywater from touching the leaves of the crops.

Three methods for using grey water are described here.

1. Bucket drip kits

These are small drip irrigation systems made for individual beds, around 1 m wide and 5 m long and a 20 L bucket. The drip kit is assembled on site making your own string drippers and choosing width of lines and spacing of drippers. Usually two dripper lines are used; 30 cm apart. Watering is done on a daily basis.

These buckets can also be adapted to include sand filters to filter greywater and or dirty warty irrigation water. In this case a layer of gravel is placed in the bottom of the bucket, followed by a layer of rinsed, clean river sand. The sand is placed inside a muslin bag to avoid mixing when the buckets are filled with water. These 'filters' need to be replaced from time to time as the flowrate from the bucket drip systems starts slowing down. The drip irrigation pipes also need to be 'flushed' by opening the end clamps and allowing the flow of water to wash out any accumulated silt and debris

Gravel layer in the bottom of the bucket

Both the gravel and sand is rinsed prior to use, to make sure they are clean and to avoid clogging up of the system 2015)

Sand placed in a closed muslin bag on-top of the gravel, to avoid sand being washed into the dripper lines

Example of the two drip lines, 30 cm apart

Wetting circles produced by the string drippers

Greywater in a bucket drip system

The pictures below provide a visual description of how these small drip systems are assembled.

A small hole is made at the bottom of the 20 L bucket to connect the elbow connector and the down pipe

The bucket is placed on a stand and a down pipe is connected, to ensure there is pressure in the dripper lines

Holes are made through the dripper pipe, from side to side and some plastic string is threaded through the holes and tied with knots to create the "drippers"

A group of ladies, practising to make their string drippers

Two dripper lines, around 30 cm apart are connected to the down pipe

The pipe is sealed at the end by bending it over and clamping it

Once made, the system is tested to ensure that evenly sized wetting circles are produced by each "dripper"

2. Tower gardens

Tower gardens are built up from the ground by using four poles and wrapping a tube of 80% shade cloth around these poles. In the centre of the bed, a stone column is built up using a bottomless bucket as a ring. The bed is filled in with a pre-prepared mixture (1/3 soil, 1/3 manure, 1/3 ash (It needs a lot of ash to clean the greywater used). Small holes are made in the side of the bag and seedlings are planted vertically into these small holes – usually spinach or another leafy vegetable. The top of the bed can be used for planting other crops – tomatoes are good as they can be staked to the poles. The bed is watered by pouring the greywater onto the stone column in the middle

IMPLEMENTATION

- Greywater management
- Gardens
- <0,1 ha,
- Low-medium cost, low-medium skills, including learning and mentoring, local resources
- Low maintenance – but bags will need to be replaced after some time (3-5 years)

Making the soil, manure ash mixture for filling the tower garden

Placement of the stone column – in the small bottomless bucket in the middle of the bed

Building up the tower – filling in the soil mix around the stone column and moving it up

Making the small holes in the side of the bag for planting seedlings

Watering into the central stone column

A 'mature' tower garden planted to spinach, kale, spring onions

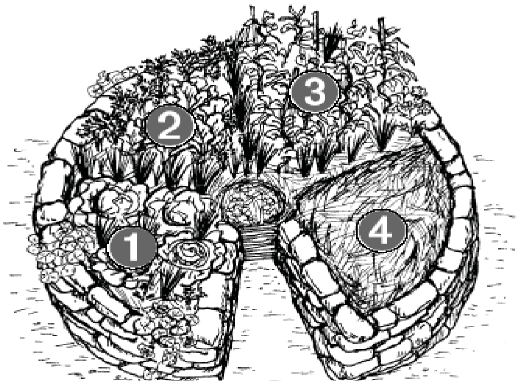
3. Keyhole beds

These are intensive built-up beds with a central compost basket/column for watering and greywater application. They are easy to manage. The bed is circular (3 m diameter), with a keyhole in the upper slope side to provide access to the compost basket which is filled continually and for watering. The walls are built 60 cm-80 cm high and the bed is filled with a pre-prepared mix of soil, compos/manure (at least 20% by volume) and ash. Lime and bone-meal can also be added. The bed is planted to mixed crops or divided into sections where crops are rotated

IMPLEMENTATION

- Gardens
- <0,1 ha,
- Low cost, low-medium skills, including learning and mentoring, local resources (stone should be easily available as 500-800 kg is required)
- Low maintenance

A recently constructed keyhole bed. Here the central column is of gravel or small stones inside the bed – rather than a compost basket



A drawing showing a keyhole bed form the top with the central compost basket divided into four sections for crop rotation (fruit-leaf-root-legume)

A 'mature' keyhole bed planted to a mixture of crops

3.13 GRASSED WATERWAYS

Grassed waterways are broad, shallow and typically saucer-shaped channels designed to move surface water across farmland without causing soil erosion. These channels are used for the safe disposal of excess runoff from the crop lands to some safe outlet such as rivers or streambeds.

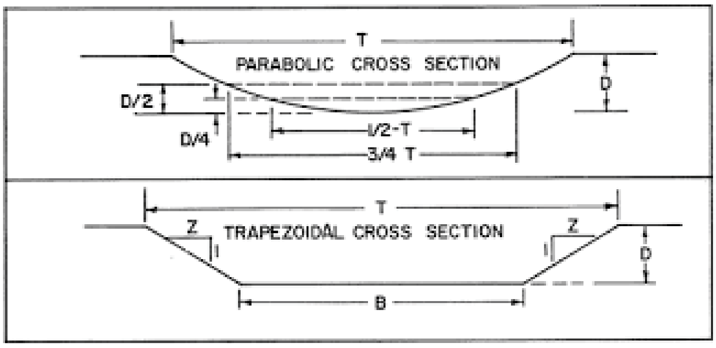
- The vegetative cover in the waterway slows the water flow and protects the channel surface from the eroding forces of runoff water.
- Planting of creeping and perennial grasses such as Paspalum, Fescue, Kikuyu and couch grass are better than planting tall upright, annual grasses
- Make the cross section of the waterway either trapezoidal or parabolic, and never V-shaped and be sure waterways are at least 30-40 cm deep and the slope of the sidewalls should never be steeper than 1 in 4.

REQUIREMENTS

- Rainfall: >450 mm/year
- Temperature: >5°C
- Topography: 1,5%-25%
- Soil: all types (5-30% clay), and depths (>30 cm)

IMPLEMENTATION

- Fields
- 0,1-1 ha, >1 ha
- Low cost, local resources
- Easy to do and maintain, but labour intensive



Parabolic or trapezoidal shapes appropriate for grassed water ways. Note the banks are along a shallow gradient. (Michigan State University, (MSU Extension 2015)

Left: Erosion caused by run-off in a wheat field (MSU Extension. 2015)

The same field with a grassed waterway installed a few years later, (MSU Extension, 2015)

Paspalum (Bahia Grass) is a good option for waterways – it is tough and drought resistant

Tall Fescue remains green throughout winter

Couch grass (Elymus repens), is considered a weed, in cropping land but it grows well even in poor soils and provides good cover for a waterway

4 Soil Management (erosion control, soil fertility and soil health)

4.1 Stone lines / bunds

Stone lines are packed on contours to control water movement and provide for a bit of build-up of soil and silt behind the lines. The stones are keyed into a shallow ditch and larger stones are packed downslope from the smaller stones to avoid stone lines form breaking and also to allow slow movement of water though the stone lines. Planting can be done below the stone line as more water accumulates there, or just above the stone line in the accumulated silt and soil.

REQUIREMENTS

- Rainfall: >150 mm/year
- Temperature: >5°C
- Topography: 0,5%-5%
- Soil: all types – where stones and rocks are easily available

IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha, >2 ha
- Low cost, local resources,
- Labour intensive

Stone lines are constructed on contour and can be done at any scale.

A view showing the stones keyed into a ditch with larger stones downslope of the smaller stones.

Small stone lines are used to control run-off from a road and channel water into the gardens

Brinjals planted in accumulated silt above a garden level stone line

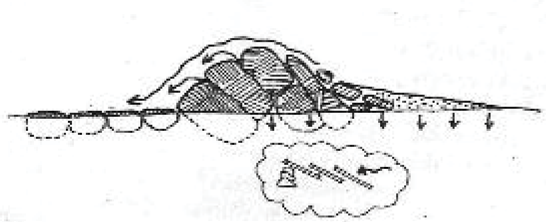
Bananas planted below a substantial stone line

4.2 CHECK DAMS

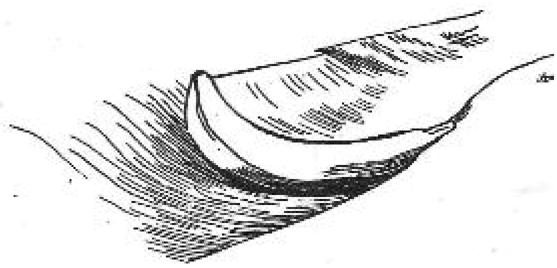
A check dam is a small, sometimes temporary, dam constructed perpendicularly across a drainage ditch, or waterway to counteract erosion by reducing water flow velocity and allowing sedimentation of silt. Different materials can be used including soil, stones, wood and vegetation. The stones or other materials, are keyed into the slope, on contour, to reduce erosion caused by overland flow of water. The outcome is the formation of small benched terraces of fertile soil for plant growth.

Check dams are mostly placed across drainage lines where water flows after rainfall; but does not flow permanently. They are also placed across eroding gullies. They work well to stabilise roads or paths that cross drainage lines. Angular, rather than round rocks should be used and the bottom layers should be large 30 cm-60 m wide and around 5-9 kg in weight. The smaller stones at the top and for the apron can be 15 cm-22 cm in diameter. Ideally a series of check dams should be placed heel-to toe; where the level terrace of accumulated sediment and soil behind each check dam extends to the downstream end of the check dam higher up.

REQUIREMENTS
- Rainfall: >150 mm/year
- Temperature: >5°C
- Topography: 1,5%-25%
- Soil: all types – where stones and rocks are easily available



IMPLEMENTATION
- Gardens, fields
- <0,1 ha, 0,1-1 ha, >2 ha
- Low cost, local resources,
- Labour intensive



Gulley forming in a field

Digging the ditch for keying in the stones for the check dam

An example of a completed check dam with the apron below the wall and the banana shape of the wall visible.

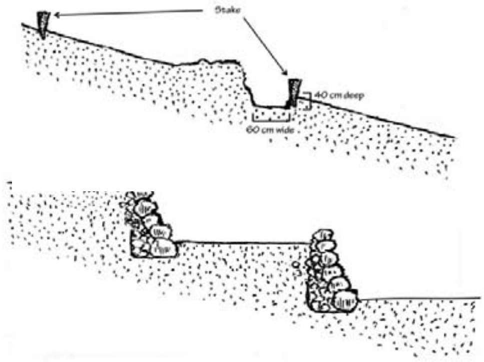
Starting to pack the check dam. Large rocks go at the bottom

4.3 Terraces

A terrace is a level strip of soil built along the contour of a slope and supported by an earth or stone bund, or rows of old tyres. Terraces create flat planting areas and stabilize slopes which would otherwise be too steep for crop production. A series of terraces creates a step-like effect which slows down runoff, increases the infiltration of water into the soil, and helps control soil erosion. Terraces are built on steeper slopes.

REQUIREMENTS

- Rainfall: >350 mm/year
- Temperature: >5°C
- Topography: 10%-40%%
- Soil: all types – where stones and rocks are easily available



IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha, >2 ha
- Low cost, local resources
- Labour intensive

Slope		Distance between terraces (meters)
Percent	Ratio	
10%	1:10	8.0
15%	1:6.7	5.3
20%	1:5	4.0
25%	1:4	3.2
30%	1:3.3	2.7
35%	1:2.8	2.3
40%	1:2.5	2.0

Stone terraces for field cropping

Terraces can also be built using old tyres in areas where stones are scarce

A view of a slope where field terraces have been made for maize production (~20% slope)

A view of garden level terraces on a steep bank. (~40% slope)

4.4 Improved organic matter

Improving the organic matter content of the soil is important at any scale of operation. Methods include:

- Adding manure; improved manure quality through collecting manure that contains urine from kraals, where grass or straw is used bedding material and piling this up and covering the pile with grass or plastic. This is left for a minimum of 5-7 days prior to use.
- Adding compost; layers of dry material, green material, manure and soil built up and well wetted.
- Crop residues; (from grains, grasses, legumes, brassicas and chenopods) and
- deep/sheet mulching;

Finding sources of organic matter with high levels of required nutrients such as Nitrogen and Carbon is important. Some plant residues and manures also contain high levels of specific elements such as potassium (comfrey) and silicon (stinging nettle).

REQUIREMENTS

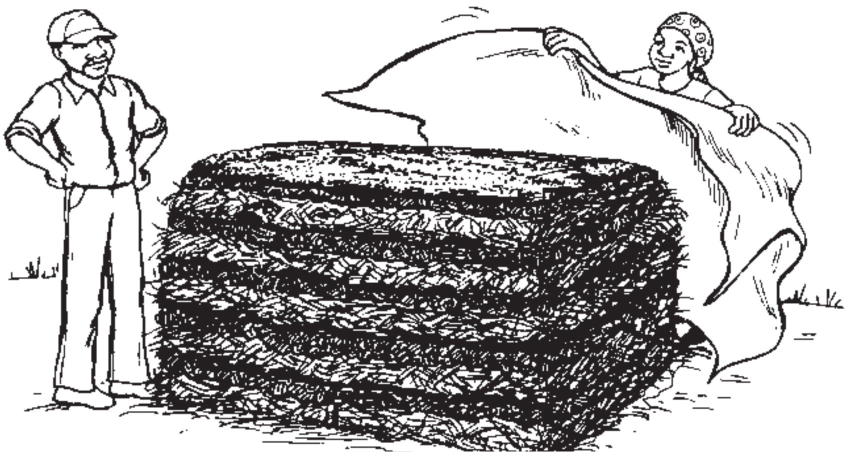
- Rainfall: >350 mm <1200 mm/year
- Temperature: >5°C
- Topography: 5%-25%
- Soil: all types – although soils that are too sandy or too clayey are difficult to manage

IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha, >2 ha
- Low cost, local resources,
- Labour intensive

Kg/Ton	Cow	Horse	Goat	Sheep	Pig	Chicken	Rabbit	Purchased compost
N (Nitrogen)	5	6	14	7	5	13	18	5
P (Phosphorous)	2	3	2	3	4	11	13	2
K (Potassium)	3	6	6	4	6	20	6	8

Goat pen with grass bedding to make improved manure



A compost pile made from layers of dry and green plant material, manure and soil, well wetted and then covered

Comfrey, residues of grasses and maize and a growing mixture of cover crops – sunflower, millet and Dolichos beans

4.5 Planting legumes and green manures

Legumes are important, as they fix Nitrogen from the air and improve soil fertility and soil health for neighbouring and following crops. They can be planted with other crops or in rotation.

Examples of warm season legumes are sugar beans, runner beans, cowpeas, Jugo beans, ground nuts, Dolichos (Lab-Lab), Velvet beans (Mucuna), Jack bean, mung beans, chickpeas, lentils, Lucerne and Sun hemp. Examples of cool season legumes are; peas, broad beans, vetch, and clover.

Green manures are planted to be incorporated into the soil, just before flowering to maximise the nutrients (including Nitrogen) that can be added to the soil for following crops. Green manures are often legumes (such as vetch and clover), grains and grasses (such as black oats and fodder rye), brassicas (such as forage radish, turnips, mustard and canola) and chenopods (such as Amaranthus).

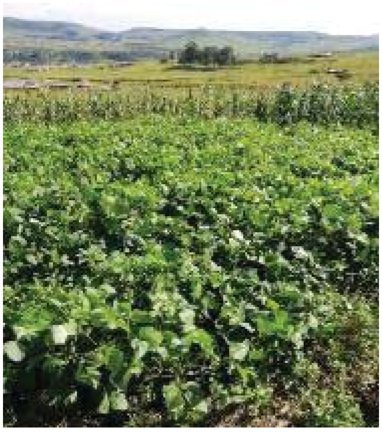
REQUIREMENTS

- Rainfall: >150 mm <1200 mm/year
- Temperature: >5°C
- Topography: 5%-25%
- Soil: all types – although soils that are too sandy or too clayey are difficult to manage

IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha, >2 ha
- Low cost, local resources,
- Labour intensive

Cowpeas intercropped with maize



Dolichos (lab-Lab) beans planted as a green manure cover crop in rotation with maize

Green manure cover crops; cool season – Saia oats, fodder rye and fodder radish

Broad beans, Amaranthus, Lucerne and red clover

4.6 Trench beds

These are intensive gardening beds, dug out and filled with material for in situ composting.

- A bed is dug out to 60-80 cm depth, around 1 m wide and 1-10 m long.
- It is filled with a range of organic matter; manure, dry material, green material and soil
- Other layers could include tins at the bottom for iron and water holding, or sticks
- Bone meal and lime can be added to increase fertility
- Bones, skins and feathers can be added for P
- Ash can be added for K
- The bed is built up in a small basin, planted and mulched

REQUIREMENTS

- Rainfall: >350 mm/year
- Temperature: >5°C
- Topography: 0,5%-5%
- Soil: all types

IMPLEMENTATION

- Gardens
- <0,1 ha,
- Low cost, local resources
- Easy to do and maintain; labour intensive

Trenches are dug 60 cm-1 m deep. The bottom layer is made up of old tins or branches

Then layers of organic matter are added – e.g. maize stover, leaves, weeds, grass

Then a layer of manure is added, followed by some top soil. This is watered and the process is started again

If available, a layer of green organic matter, e.g. weeds, leaves, vegetable peelings and remains is added after the layer of dry organic

The trench beds are built up with a shallow ditch around it and a basin inside the bed and planted to seeds and seedlings

4.7 Shallow trenches

Shallow trenches are an easier version of trench beds. They are dug out to around 30 cm and filled with a mixture of organic matter; manure, dry and green plant materials. They are then filled up with soil and planted.

Shallow trenches are often used when making furrows and ridges, which give long narrow lines of more fertile soil – most appropriate for larger gardens and fields. For trenches, mulching is important, as is mixed cropping or crop rotation systems. These beds last 3-8 years before needing to be re-packed.

REQUIREMENTS

- Rainfall: >350 mm/year
- Temperature: >5°C
- Topography: 0,5%-5%
- Soil: all types

IMPLEMENTATION

- Gardens
- <0,1 ha,
- Low cost, local resources
- Easy to do and maintain; labour intensive

Digging out a shallow trench 30 cm wide and 15 cm deep on a contour line in a

Starting to fill the trench with manure, green and dry plant material

A garden with shallow and deep trench beds with mixed cropping and mulching

4.8 Eco-circles

These are small circular, double-dug beds with addition of manure or compost, as well as mulch. They are drip irrigated using a 2-litre bottle with small holes drilled into the sides, which is 'planted' in the centre of the bed.

Eco-circles are appropriate for small gardens and also as a practice to introduce the benefits of increased soil depth for rooting, organic matter, mulch and irrigation management.

REQUIREMENTS

- Rainfall: >350 mm/year
- Temperature: >5°C
- Topography: 0,5%-5%
- Soil: all types

IMPLEMENTATION

- Gardens
- <0,1 ha,
- Low cost, local resources
- Easy to do and maintain; labour intensive

Digging out the eco-circle, 1-1,5 m in diameter and 30 cm deep with a further 15 cm loosened an mixed with manure, before replacing the rest of the soil which is also mixed with manure or compost

A completed eco-circle bordered by a row of stones. A wooden tripod is used to plant climbing crops such as beans or tomatoes

An eco-circle, mulched, with the 2 L bottle in the centre and planted to herbs

4.9 TARGETED APPLICATION OF FERTILIZER AND LIME

Fertilizers are added according to soil fertility recommendations, targeted next to growing plants rather than spreading or banding. This saves on fertilizer use and also provides fertilizer only where it is required, increasing efficiency. Lime can be added in basins or rows as surface applications – to reduce soil acidification and maintain low acid saturation; or lime can be ploughed into a field/ plot prior to CA interventions

REQUIREMENTS

- Rainfall: >450 mm/year
- Temperature: >5°C
- Topography: 1,5-10%
- Soil: all types – depending on fertilizer recommendations

IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha, >2 ha
- Medium cost; reduction of external inputs through efficient use
- Labour intensive

Ploughing in lime prior to starting conservation tillage

Applying surface lime in rows for bean production

Applying lime in basins using a bottle cap as measure

Placement of fertilizer (LAN) below and about 2 cm away from the seed

Using a planter to help dispense seed and fertilizer at the same time

Measuring fertilizer with a teaspoon

4.10 Zai pits / Planting basins

A zai is a hole or planting pit, usually with a diameter of 20-40 cm and a depth of 10-20 cm. The Zai pits capture rain and surface run-off water and protect the seeds and organic matter from being washed away. They also help to concentrate water and nutrients for the crops. Pits are dug during the dry season. The excavated earth is ridged around the demi-circle to improve the water retention capacity of the pit. After digging the pits, composted organic matter is added at an average, recommended rate of 0.6 kg/pit and, after the first rainfall, the matter is covered with a thin layer of soil and the seeds placed in the middle of the pit.

REQUIREMENTS
- Rainfall: >350 mm/year
- Temperature: >5°C
- Topography: 1,5%-25%
- Soil: all types (5-30% clay), and depths (>30 cm)

IMPLEMENTATION
- Gardens, fields
- 0,1 ha-1 ha, >1 ha
- Low cost, local resources
- Easy to do and maintain; labour intensive

Zai pits in Kenya, planted to maize and then mulched for increased moisture holding and soil fertility (from permies.com, 2017)

Zai pits dug in an eroded field, with composting material ready to be added (from Chris Reij, 2010)

Maize planted in Zai pits, in Kenya (from Inadesforum.net

4.11 CONSERVATION AGRICULTURE

A method of field cropping using the following principles:

- Minimal soil disturbance; no ploughing, just opening planting holes, basins and or rows
- Cover the soil; crop residues are left on the soil surface as a mulch, and crops are kept in the field for as long as possible to provide canopy cover of living plants
- Crop diversification: Inter cropping, crop rotation and inclusion of summer and winter cover crop mixes.

CA improves soil health and soil fertility, crop yields and water holding capacity of the soil. It reduces run-off and erosion as well as soil temperatures. It reduces soil crusting and compaction

Different planters; Mbli (hoe-type hand), Haraka (Wheel), Matracca (jab) and animal drawn planters, (Knapik – below)

REQUIREMENTS

- Rainfall: >350 mm/year
- Temperature: >5°C
- Topography: 1,5%-15%
- Soil: all types (clay percentage 5%-35%)

IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha, >2 ha
- Medium cost (Seed, fertilizer, agrochemicals), planters, local resources
- Labour intensive

PRINCIPLE 1: Minimal soil disturbance

Planting furrows and basins by hand using hand hoes and MBLI planters – without ploughing

A tractor drawn two row no-till planter

Using a Haraka wheel planter – this planter can “plant” a range of different seeds, but does not allow for fertilizer placement at the same time

Using a Knappick no-till planter with animal traction

PRINCIPLE 2: Soil cover

Good soil cover from crop residues

Mulching a CA plot to provide for soil cover

A CA plot with some crop residue. Run-off from the plot is clean and low

A ploughed plot with no crop residue. Run-off from the plot is muddy and high

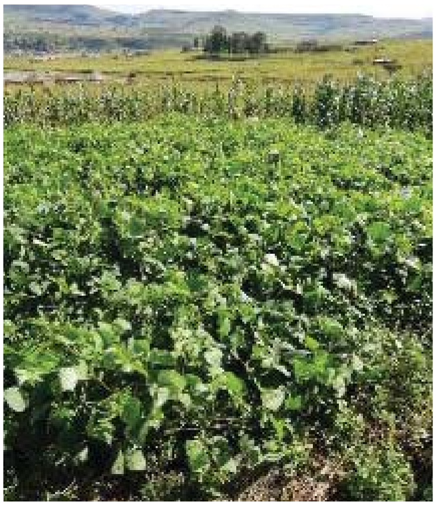
PRINCIPLE 3: Crop diversification

A maize and cowpea intercropped plot – using tramlines (double rows) and close spacing

A maize and bean intercropped plot – using tramlines (double rows) and close spacing

Winter cover crops; saia/black oats, forage sorghum and fodder radish

Summer cover crops; sunflower, millet and Sun hemp



Lab-Lab bean (dolichos),

4.12 STRIP CROPPING

Strip cropping is cultivation in which different crops are sown in alternate strips to prevent soil erosion and optimise nutrient uptake. Planting of strips have to be across the slope or on contour.

Crops need to be chosen to have a mixture of rooting depths and nutrient requirements. Strip cropping of multifunctional species is a good idea. Agroforestry species such as Pigeon Pea, Moringa, Sesbania sesban, Leuceana, etc. work well. Grasses such as vetiver, lemon grass and Napier fodder can also be used, as well as Rhodes-Smutsfinger (Digitaria) mix, Paspalum notatum and Tall Fescue.

REQUIREMENTS

- Rainfall: >350 mm/year
- Temperature: >5°C
- Topography: 1,5%-15%
- Soil: all types (clay percentage 5%-35%)

IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha, >2 ha
- Low cost (Seed, local resources)
- Labour intensive

Maize and Lucerne or Lespedeza strip cropping

Strip cropping of maize with Paspalum and Digitaria

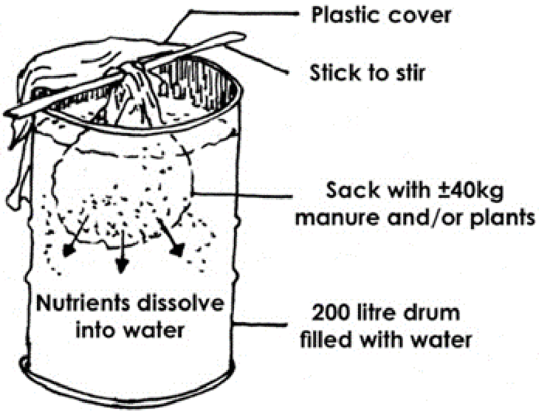
Grass strips on contour in between maize

Strip cropping Pigeon pea/Leuceana and maize

5.1 LIQUID MANURES

Liquid manures are water-based extracts made from animal- and plant-based materials that are fermented and then diluted prior to spraying on plants or the soil around plants as an additional fertility enhancement measure. Liquid manures add and balance nutrients in plants and also add microbial mixes for increased disease and pest resistance in plants.

Common sources for liquid manure are animal manures (preferably fresh, still containing the urinary fraction) such as cattle, goat, horse, sheep and poultry manure, and/or plant materials such as dark green leafy weeds (for Nitrogen), banana stems (for potassium and phosphate), comfrey and stinging nettle (both provide silicon in addition to macro and micro nutrients for disease resistance in plants). These brews are usually diluted 1:4 prior to use.



from: Production without Destruction

IMPLEMENTATION

- Gardens
- <0,1 ha,
- Low cost, local resources, low labour
- Easy and quick to do


Chopping banana stems as the basis of a green tea or plant based liquid manure


Chopping weeds to add to a liquid manure brew


Animal manure used as liquid manure; chicken, goat and cattle manure are good sources – the fresher the better


Liquid manure containers need to be covered to avoid evaporation of some of the important nutrients

5.2 MIXED CROPPING

Mixed cropping in a gardening context, is a combination of inter-cropping, crop rotation and companion planting. The intention is to have as many different types of crops (including medicinal, pest repellent and multi-purpose plants) in your vegetable and fruit production systems as possible, throughout the year, to ensure a healthy food supply, improve pest, disease and weed management and reduce risk of shortages due to crop failure.

The choice of crops is based on the following:

- Being able to harvest food from a garden for household use throughout the year. This means a focus on crops that can be harvested for extended period such as leafy greens, leaf lettuces, and spring onions and leeks, and de-emphasising crops such as cabbage and onions that have long waiting periods without producing food.
- Crops high in Vitamin A; such as dark green leafy vegetables (such as spinach, mustard, rape and kale), carrots, traditional greens (such as Amaranthus and pumpkin leaves) and herbs (such as parsley).
- Pest-repellent crops such as coriander, garlic chives and other herbs such as rosemary and thyme.
- Legumes and protein rich vegetables such as beans, peas and turnips.
- Perennial multipurpose plants such as wormwood, lemongrass, bulbinella and comfrey.
- Flowers such as marigolds and calendula.

In addition, attention is given to not planting crops of the same family together in one bed to reduce the spread of common diseases and nutrient competition. Thus, tomatoes, brinjals, potatoes and peppers are not planted together, neither are brassicas such as cabbage, broccoli, cauliflower and kale, or chards such as swiss chard and beetroot.

Crop rotation is introduced both in terms of alternating heavy feeders such as cabbage with light feeders such as swiss chard and lettuces, as well as the well-known rotation of leaf-root-legume-fruit.

Cropping calendars are developed to suit localities and changing climatic conditions.

Below is a cropping calendar jointly designed with participants from Limpopo, which experiences warm winters and hot summers. In KZN and the Eastern Cape where winters are cool to cold, standard cropping calendars are still mostly appropriate.

When can I plant vegetables?									Too hot to plant!		
	Mrch	April	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Baby marrows						■	■	■	■			
Basil	■	■	■			■	■	■				
Beetroot	■			■	■	■						
Brinjal						■	■	■				
Cabbage	■	■	■	■	■	■						
Carrots				■	■	■	■					
Chilli						■	■	■	■			
Green beans	■	■					■	■	■			
Green pepper						■	■	■				
Kale and other morogo e.g. amaranthus	■	■	■	■	■	■	■	■				
Lettuce	■	■	■	■	■	■						
Leeks, sping onions	■	■	■	■	■	■	■					
Mustard spinach	■	■	■	■	■							
Onions	■	■					■	■	■			
Parsley	■	■	■	■	■	■	■					
Peas	■	■	■	■	■							
Tomatoes	■	■	■	■	■	■						

IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha, >2 ha
- Low cost (Seed and plants), local resources,
- Easy to do


Mrs Mcanyana (Gobizembe) – broccoli, Chinese cabbage, spinach, coriander and marigolds


Magdelina Malepe (Sedawa), marigolds, thyme, parsley, spinach and kale


Christina Thobejane (Sedawa) – maize, okra, tomatoes kale and marigolds


Trench bed with a mixture of herbs – fennel, coriander, parsley and chives

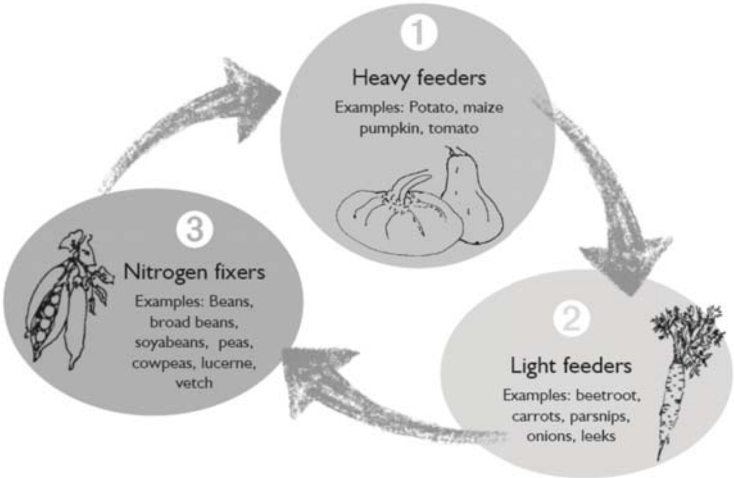

Phumelele Hlongwane (Ezibomvini) – beetroot, mustard spinach, spring onions


Alex Makgopa (Sedawa) – spring onions, spinach, carrots and marigolds

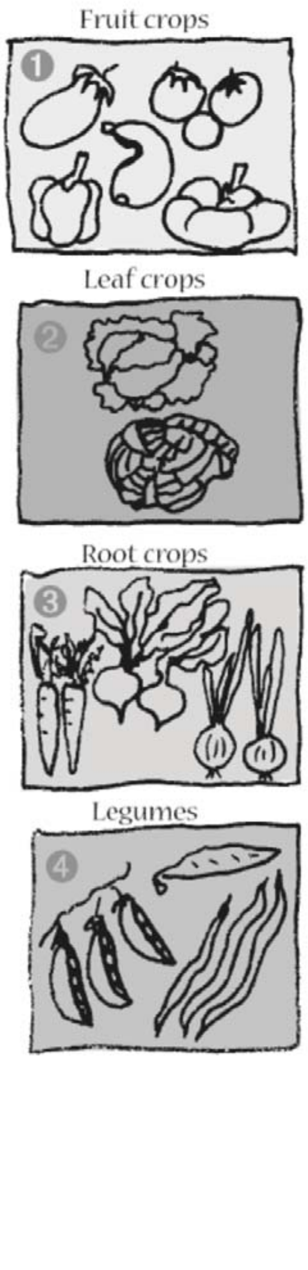
5.3 CROP ROTATION

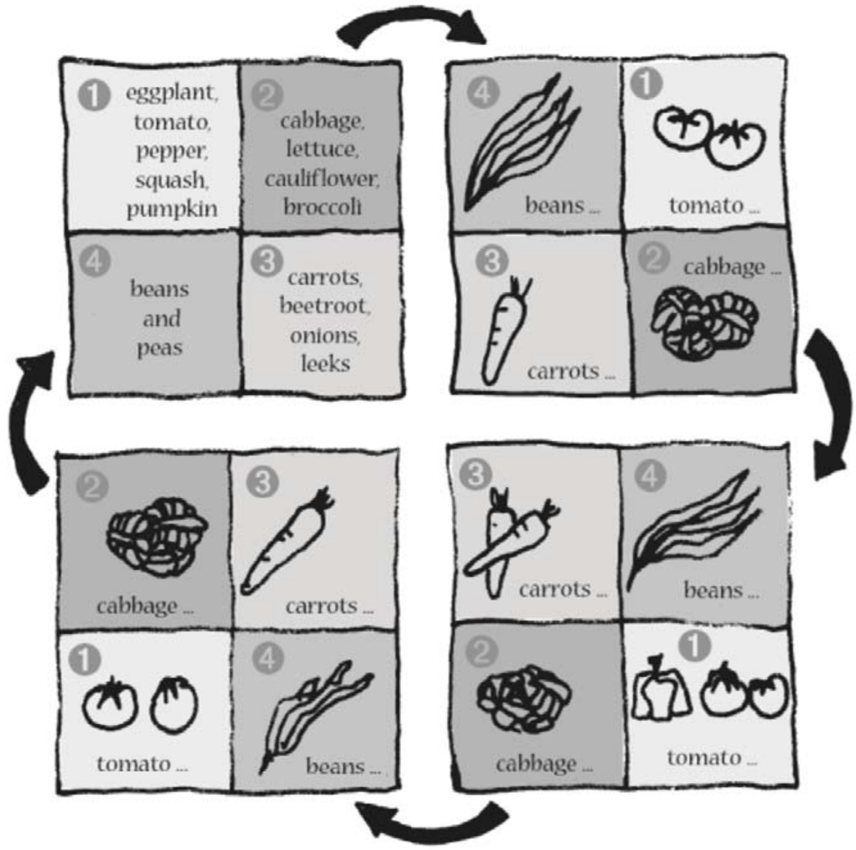
Crop rotation is an important management strategy for both gardens and fields. Crop rotation reduces pest and disease build up in the soil and the environment balances nutrient removal from the soil and maintains and improves soil health.

Work with a minimum of 3-year rotations in field crops. An example is Maize (*heavy feeder)* rotated with a cover crop mix (such as Sun hemp, millet and sunflower) (*light feeder)* rotated with legumes (such as dry beans, cowpeas and Dolichos) *(legume)*



Work with a 3-4 season rotation in vegetable production. One system is to move through the following sequence after digging a trench or adding compost; Fruit; leaf; root; legume.





A SIMPLE ROTATION: DIVIDE YOUR GARDEN INTO FOUR EQUAL PARTS. THE NEXT TIME YOU PLANT, MOVE EACH FAMILY OF VEGETABLES TO THE NEXT PLOT.

From: The People's Farming Workbook, EDA, 1995

5.4 NATURAL PEST AND DISEASE CONTROL

Natural pest and disease control in an intensified homestead food production system context consists of a combination of the following four approaches:

- Improvement of soil fertility, soil health and soil water holding capacity to produce vibrant, healthy plants, working form the assumption that stressed plants are more susceptible to pest and disease attacks.
- Mixed cropping and garden sanitation; to reduce the concentration of pests and diseases that occur in mono cropping systems as well as the potential for re-infestation and infection through safe removal of diseased plant material and removal of breeding grounds for pests. And to promote the presence of pest predators and bees which are natural predators of common garden pests.
- Planting of multi-purpose species, both annual and perennial, to include plants that have pest repellent and pest control properties. These include for example;
    - flowers such as marigolds and calendula;
    - herbs such as lavender, rosemary, coriander, parsley, thyme, fennel, basil, rocket, lemon grass and garlic chives;
    - medicinal species such as wormwood bulbine and bulbinella species, aloe spp, comfrey, stinging nettle; and
    - leguminous trees such as Sesbania sesban, moringa, pigeon pea and Acacia spp.
- Making of brews/ teas with pest and disease control properties. Here common household recipes include combinations of chilli, garlic, onion and green bar soap (for soft bodied insects such as aphids), paraffin and onion (for hard bodied insects such as beetles and grasshoppers) and tobacco (only for pernicious and very heavy pest infestations). There are however many other options as well.

IMPLEMENTATION

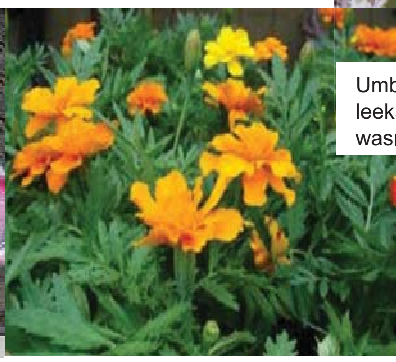
- Gardens, fields
- <0,1 ha, 0,1-1 ha
- Low cost; local resources,
- Easy to medium labour intensity, knowledge intensive

Integrated garden management; water and soil management, diversified crops, perennial and annual mix

Pest predators control pests by ingesting them and or laying eggs

Umbelliferae – such as onions and leeks attract pest predators – e.g. wasps

Pest control brews; soap chilli garlic mixes, paraffin and onions mixes – for soft bodied insects



Marigolds protect against root knot nematodes

Garlic – An example

METHOD

Chop some cloves finely (one large bulb, or two medium bulbs) and soak in 2 teaspoons of oil for one day or in liquid paraffin for two days. Use a glass jar, not a tin. Mix with half a litre of soapy water and filter. Mix 1 part solution with 10 parts of water and use as a spray. Shake well before applying

TARGETS

Insects in general: mosquitoes, cotton stainers, aphids, flies, army worms, ticks, ants, beetles, caterpillars, diamondback moths, false codling moths, grubs, mites, peach borers and termites.

Fungi: Scab, mildew, bean rust and tomato blight.

Alternaria – fruit rot, early blight, purple blotch, leaf spot.

Cercospora – leaf mould, leaf spot, early blight, frog-eye.

Colletotrichurn – leaf spot, anthracnose, fruit rot, smudge.

Ba**cteria:** *Xanthomonas* spp.

Garlic bulbs

False codling moth larvae and moth

Bacterial blight on strawberries caused by Xanthomonas campestris

Symptoms of anthracnose (caused by Colletotrichum) on capsicum fruit

5.5 INTEGRATED WEED MANAGEMENT

Weeds are plants, both annuals and perennials, that grow freely and vigorously in fields and gardens and compete with crops for nutrients, space and water.

Different soils and climate, cultivation and weeding methods mean that often certain weeds flourish and become very difficult to deal with. As an example, nut grass and sedges prefer high clay soils and can take over completely if weeds are managed by cutting above ground growth only, through hoeing. This weed multiplies primarily through corms under the ground.

Aggressive annual weeds such as black jack and Amaranthus take over if the late season weeds are not removed, as they seed vigorously and seed can survive long dry periods.

Integrated weed management includes a number of different practices such as improving soil structure and soil health, mulching, cover crops, crop rotation and close spacing. It also includes mechanical and or chemical weed control methods. Composting also kills weeds and if done properly, can reduce the seed load of weeds in an environment. Weeding late in the season, to reduce the seed load of annual weeds is a very important practice.

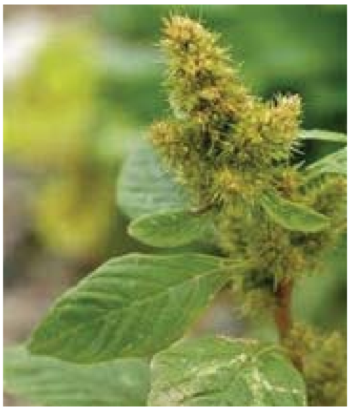
IMPLEMENTATION

- Gardens, fields
- <0,1 ha, 0,1-1 ha
- Low cost; local resources,
- Easy to medium labour intensity, knowledge intensive

A cropping field almost entirely over-run by nut grass – due to repeated shallow hoeing as a weed control method

A maize and bean intercropped plot, where weeds have almost entirely out-competed the crops.

Close spacing and intercropping protect against crops being overrun by weeds – on the left is a maize crop with little weeding on the right a close spaced intercrop planted at the same time, under a similar weed control regime



Dock (below indicates acidic soils, amaranthus (above left) indicates fertile soil with bad structure, and black jack (above right can take up nutrients unavailable to crops

Composting kills weed seeds and is a good way to treat manures before use as it also increases the nutrient value of the manure

Sedges and nutgrass indicate a lack of air in the soil, due to compaction and lack of soil structure

5.6 NURSERIES AND PROPAGATION

Small household-based nurseries for propagating crops (vegetables, herbs and fruit) and multifunctional plants (medicinal and pest control species) from seed, cuttings, division, bulbs and corms are important in maintaining and increasing diversity in the garden. They do not need any specialist equipment, expect potentially planting medium, planting bags and or speedling trays and can be set up under a shady tree in the homestead.

Seedling beds are made to be deep (30-60 cm) with lots of organic matter (compost and manure) and should be shaded-to keep seed moist (but not too wet), during germination and early growth. Nurseries using speedling trays require intensive management and are difficult to do organically. It is better and easier to grow your seedlings in the ground and transplant them from there.

IMPLEMENTATION

- Gardens
- <0,1 ha,
- Medium cost (Seed, plants, containers), local resources,
- Labour intensive

Seedling production in well composted dedicated beds, with shade and plastic structures to protect the seedlings

Small household nurseries under shade trees for propagation of fruit, multipurpose trees and shrubs and herbs. Here mangoes and Moringa are being grown

Shade netting structures for propagation of vegetables and herbs

Sugar cane and mangoes being propagated in the ground in small nurseries

Tubs and basins can be used – they are easy to manage and move

5.7 Seed Saving

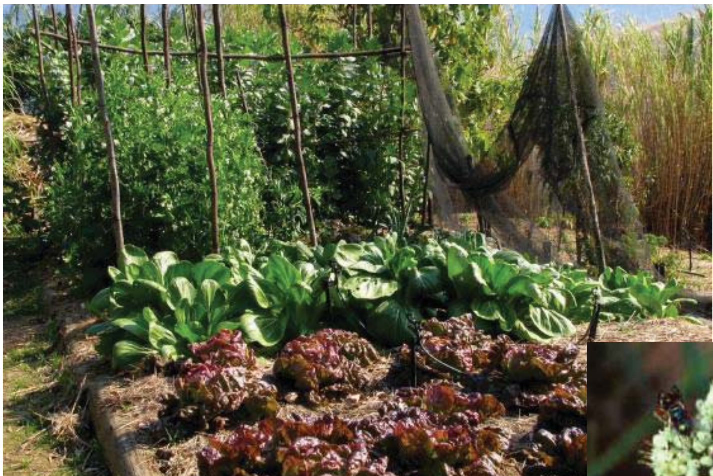
Seed saving is both a common practice among smallholders and a dwindling one. Seeds are kept from one year to the next and due to increasingly difficult growing conditions, many participants have reported losing most of their seed stock. Increasingly, smallholders will buy seed and attempt to keep seed from those crops when harvested; meaning a substantial attrition in the availability of seed of traditional crops. Seed saving is a very important practice for safe-guarding traditional crops and farmer preferred open pollinated varieties (not hybrids), that are locally adapted to climate, pests and diseases.

Some aspects to keep in mind when saving seed are the following:

- It is important to promote pollinators (insects that distribute pollen) by grow numerous types of flowering plants and keep diversity in and around gardens and fields high and reducing pesticide use
- Keep seed from strong healthy plants only; never from plants that are bolting (seeding early)
- Choose between 6-24 plants to keep seed from
- Never keep seed from diseased plants
- Seed must mature and dry on the plant as long as possible and
- Plants that easily cross pollinate need to be separated (e.g. brassicas, maize, peppers and chillies, pumpkins, lettuce, etc.) in space, or time or use caging.

IMPLEMENTATION

- Gardens, fields,
- <0,1 ha, -0,1-1 ha, >2 ha
- Low cost, local resources
- Easy to do and maintain; somewhat labour and knowledge intensive



A garden for seed production, with structures for caging, and 6-24 of each variety planted for seed saving – different plant families are planted close together to

Flowers and plants for promotion of pollination; by bees, hornets, butterflies, etc.

Pollinators love flowers – many different

Hand pollination of maize for seed selection

A caged chilli plant to ensure pure seed that is true to type

5.7.1 Seed Processing and Storage

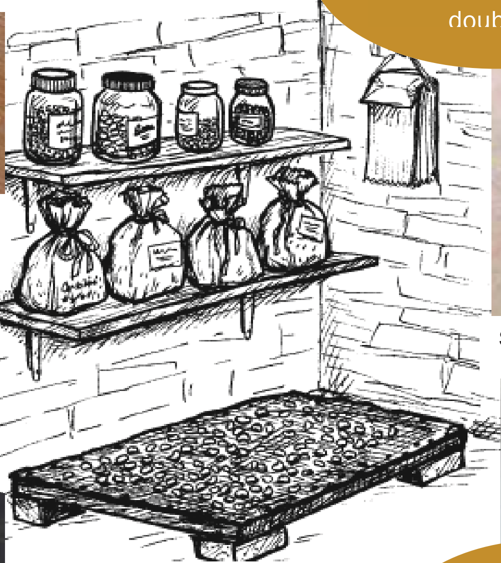
Overall, seed needs to remain evenly cool, dark and dry to keep their viability as long as possible. If seed is stored under varying humidity and temperature, they will quickly lose their ability to germinate. Below are a few crucial pointers to good storage practices for seed.

- Humidity; Seed will absorb moisture from the air. Seed needs to be stored at <10% moisture content in dry or airtight environment
- Avoid plastic packets and containers
- Light shortens seed life; Sote seed in dark jars and/or a dark room. Continual darkness is required,
- Temperature; Seeds last longer in cold but not freezing conditions
- Seeds such as tomatoes and cucumbers are covered in a jelly that stops seed from germinating. This jelly needs to be removed, prior to storage and germination of seed. The jelly can be fermented with water and sugar and then the seed is rinsed and dried
- Further drying of seed can be done with silica gel
- Storage with ash, lime, and crushed dried leaves of certain plants, e.g. aloe is recommended to avoid damage from storage pests.

Fermentation of tomato and gooseberry seed for storage and good germination

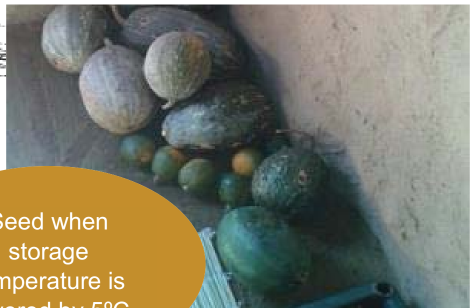
For every 1% less moisture in the seed the seed life doubles.

Use silicon to draw water from seed and ash for storage of dry seeds



Layout of a small home-based seed bank; drying racks, paper packets and glass jars

Store seed in glass containers



Seed when storage temperature is lowered by 5ºC

Store seed and gourds in a cool, dry, dark place

5.8 Fruit production

Producing a range of fruit at homestead level, which can ripen over a large part of the year is an important aspect of both diversification and resilience. Fruit can be produced form seed, cuttings, root and sucker divisions and grafting. Fruit trees need to be planted in deep, fertile basins and need irrigation, especially when young. They need to be protected from wind and should be pruned in winter (deciduous fruit such as peaches, plums and apples) or pruned for optimum fruit bearing (evergreen trees such as citrus, mangoes and avocados). Organic remedies can be used to control the main pests (e.g. fruit fly, ants, aphids and scale) and diseases.

Use organic remedies such as pyrethrum, mineral oil and lime sulphur. Use rooting powder for propagation of cuttings

Different fruit types are more suitable for different agroecological regions. Mainly, there are those that need cold winters (sub-tropical fruit), such as apples, pears, plums, grapes and peaches and tropical fruit which do not survive cold winters such as mangoes, bananas, avocadoes and litchis. Citrus can deal with a very wide range of temperatures, but needs to be well irrigated

IMPLEMENTATION

- Gardens, orchards
- <0,1 ha, 0,1-1 ha >1 ha
- Medium cost (Seed and plants), local resources,
- Labour and knowledge intensive

Irrigation of orange trees, basins and bunds hold more water

Tree tomatoes are propagated form seed are high in Vitamin C and fruit in March-May when there is very little other fruit

Propagate from seed; granadillas, avocados, mangoes, gooseberries, and tree tomatoes

Use bunds and basins to make full use of rainwater for trees

A home-made fruit fly trap using oranges and sugar water

Plant trees in deep holes filled with compost and create a basin for irrigation with mulching

5.9 Organic mango production

Mangoes are very hardy and do well in areas with moderate winters and warm to hot summers. There are 'wild' varieties that can easily be grown from seed. More modern varieties grown to be larger, sweeter and fibre-less are grafted trees, where the desired fruit bearing scions are grafted onto hardy, disease resistant rootstocks. Examples of names of varieties that are presently common are Keit, Kent, Shelley and Tommy Atkins. These varieties are sold as fruit, juice, dried mango and as fruit leather.

Value adding through juicing and drying of mangoes

Below are a few hints for growing organic mango trees:

- Make compost at least 4 to 6 months before planting
- Plant newly acquired trees in Spring in holes of 60 cm by 60 cm filled with a mixture of compost, soil, lime and bone meal. Construct an irrigation basin around the tree and provide mulching
- Compost is added annually, after fruiting
- Pruning is done annually after fruiting to ensure an open canopy for the tree, where all fruit can receive sunlight and
- Young trees need 20 to 40 L of water per week

REQUIREMENTS

- Rainfall: >350 mm/year
- Temperature: >5°C
- Topography: gentle slopes
- Soils: Any
- Irrigation; Some access to irrigation is required

IMPLEMENTATION

- Gardens and orchards
- <0,1 ha, 0,1-1 ha
- Medium cost, external and local resources; access to new varieties
- Easy to manage, but requires some technical skill

A pruned mango tree pushing out new growth, with compost added in the irrigation basin and mulching

A smallholder mango orchard in Limpopo, being inspected by a mango estate manager

Pruning, composting and irrigation basins added for an old mango tree to bring it back into production

6 LIVESTOCK INTEGRATION

These are aspects of livestock management which either overlap with cropping and or are part of integrating the farming system into one coherent system.

In this section we explore practices that can increase and improve fodder and grazing options for livestock

6.1 AGROFORESTRY OPTIONS

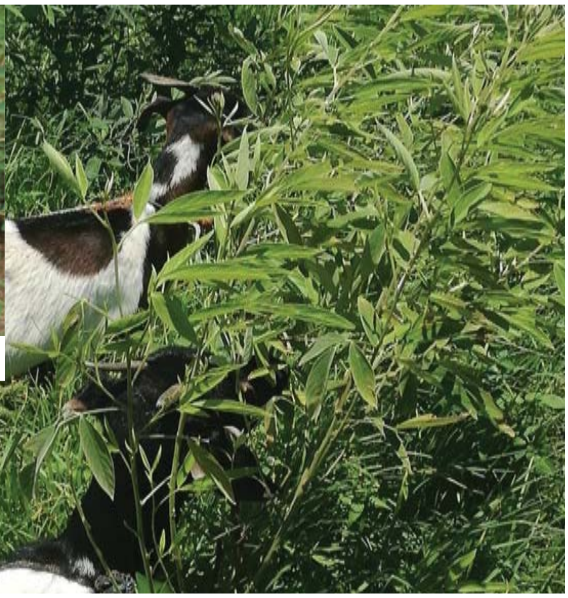
Tree crops are mixed into the farming system either as fallows, monocrops or between annual crops (usually as strip cropping in rows). Livestock fodder species such as pigeon pea (udali), acacia species (umhlalankwazi), Sesbani sesban (umsokosoko), Moringa olifeara and Leauceana spp are common.

REQUIREMENTS
- Rainfall: >350 mm/year
- Temperature: >5°C
- Topography: 1,5&-15%
- Soil: all types

Examples of different ways of planting trees in a landscape

IMPLEMENTATION
- Gardens, fields
- <0,1 ha, 0,1-1 ha, >2 ha
- Medium cost (Seed/planting stock), local resources
- Labour intensive


Sesbania plant growing in a field as a hedgerow


Goats grazing on a stand of pigeon peas


Moringas planted in lines in a small field


Leaucena hedgerow in a field planted to beans (foreground) and maize (background)

6.2 AGRI-SILVIPASTORAL PRACTICES

An Agri-silvicultural system is a collection of agroforestry practices that involve combining crops and trees with a purpose of maximising benefits per unit area. Practices found within this system include:

- Alley cropping; planting of woody species in hedges or crop species in alleys between hedges. Woody components are essential for improving soil fertility as well as the crops grown
- Improved fallows; woody species are planted and left to grow during fallow period. The woody species improve soil fertility and water holding capacity
- Home gardens; Intimate, multi-storey combination of various trees and crops around homesteads., which provide a number of functions such as shade, medicine, fruit and fodder
- Multipurpose-trees on croplands; trees are scattered or arranged in a systematic pattern on bunds, terraces or along field boundaries. These trees are chosen to fix nitrogen and provide fruit, firewood and fodder.

IMPLEMENTATION

- Gardens, fields, livestock
- <0,1 ha, 0,1-1 ha >1 ha
- Medium cost (Seed and plants), local resources,
- Labour and knowledge intensive

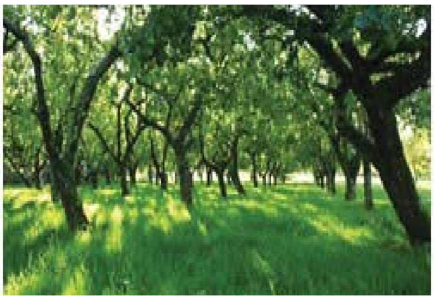
Sesbania sesban – maize alley cropping system in KwaZulu Natal

Maize planted after a two-year pigeon pea fallow in KwaZulu Natal

Leguminous shrubs planted in grazing areas, for browsing by livestock

Improved fallow: 1-year pigeon pea fallow, KwaZulu Natal

Home garden at Mhlabuyalingana, KZN: combination of fruit trees, vegetables and crop



Pastures planted in between trees in a nut orchard for grazing and shade for livestock

6.3 CREEP FEEDING AND SUPPLEMENTATION

Supplementary feeding is a livestock management practice used to provide animals with those nutrients that the pastures lack. This is important in winter, when there is a lack of grazing and also if grazing quality is low (i.e. has little to no protein) Options for supplementary feeding include:

- Protein meals and liquids such as Voermol Premix 450 (a powder) and LS 33 (a liquid)
- Grain and seed such as crushed maize, sorghum, etc.
- Lick blocks; both mineral and protein licks

Supplementation can also be in a form of alternative fodder species. This involves growing of species with higher/better nutritional value compared to present fodder. Most of these species are planted to provide high quality green fodder into late winter. Examples of these species include: Lucerne, fodder rye, black (saia) oats, vetch, Teff, fodder radish, Japanese radish, Kale, and turnips. Perennial grass species that remain green into winter such as kikuyu and Tall Fescue as also a good idea

Creep feeding is a simple management practice allowing calves unrestricted access to additional feed while they are still suckling the cow. Calves gain access to the feed supplement through a 'creep', which is a fence opening or a gate opening large enough for calves to pass through but too small for the cows.

IMPLEMENTATION

- Livestock
- 0,1-1 ha >1 ha
- Medium cost, local resources,
- Labour and knowledge intensive

Home-made protein lick blocks consisting of molasses, urea protein meal, a phosphorous source, water, a bit of cement and salt.

An example of a commercial creep feeding mechanism for calves.

A fodder supplement made from Dried Sesbania sesban leaves, crushed maize and salt

Japanese radish

LS 33 and premix 450

A relay crop of vetch and Saia oats into a field of maize for winter grazing.

6.4 STALL FEEDING AND HAY MAKING

Stall feeding is basically a cut and carry system of feeding livestock in their stalls/kraals, to reduce damage caused by livestock in fields and also to ensure better nutrition.

Hay is dried livestock feed and can be made from veld grass, specific species such as Lucerne, cowpeas, Teff, etc. or crop residues. Hay bales can be made on a small scale with a hand operated baler, appropriate for smallholder farmers.

Eragrostis Teff bale

Lucerne bale

IMPLEMENTATION

- Livestock
- 0,1-1 ha >1 ha
- Medium cost, local resources,
- Labour and knowledge intensive

Stall or kraal feeding

Maize stover

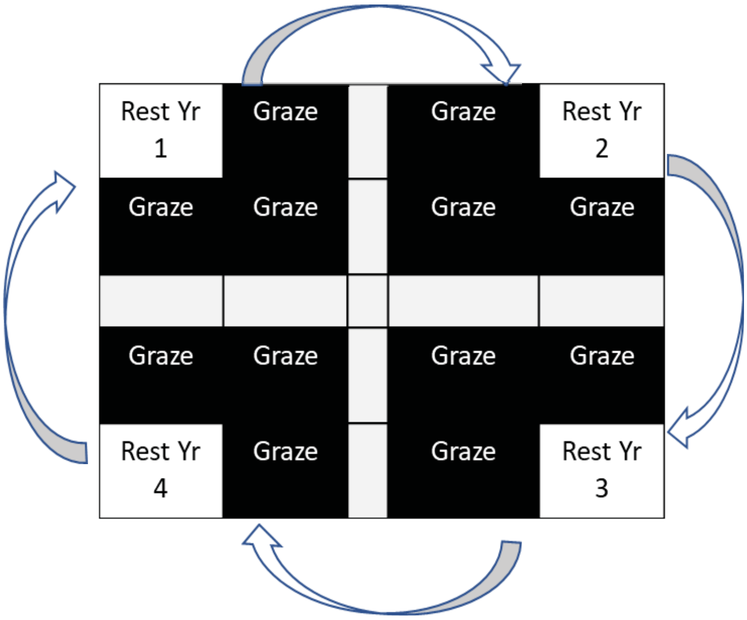
Hand operated baler, with a bale of veld grass made with this baler

Legume (soy bean) stover

6.5 ROTATIONAL GRAZING

Constant grazing of palatable grass species weakens them and allows unpalatable plants to dominate. To retain the productivity of grasslands it is necessary to rest a portion of the grazing area for a full growing season. This allows the grass plants to store nutrients in their root systems and make the grasses more nutritious.

Ideally one quarter of the veld should be rested every four years. It is important for livestock owners to work together to develop a rotational resting system.



IMPLEMENTATION

- Livestock
- >1 ha
- Medium cost, local resources
- Labour and knowledge intensive

Early season overgrazed veld – grass is all short, with evidence of erosion

Late season well managed veld; has a lot of red grass (Themeda triandra), shown by the red colouration of the seed heads. There is good grass cover, with a diverse range of grass species