

CLIMATE RESILIENT AGRICULTURE: PRACTICES FOR SMALLHOLDER FARMERS

FARMER HANDOUTS: ENGLISH

E Kruger, BT Maimela, H Hlongwane, Philisa Dunyana



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Climate Resilient Agriculture: Practices for smallholder farmers

Farmer Handouts: English

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- Climate resilience impact measurement for poor rural communities. A MERL (Monitoring, evaluation, reflection and learning) manual for community-based climate change adaptation (CbCCA) (**WRC report no. TT 967/3/26**)
- Community-owned water access: Guidelines and case studies (**WRC report no. TT 967/4/26**)
- Microfinance handbook for smallholder farmers in South Africa: A case study on small businesses (**WRC report no. TT 967/5/26**)
- Multistakeholder platform development manual: Guidelines for successful implementation (**WRC report no. TT 967/6/26**)
- Climate Resilient Agriculture: Practices for smallholder farmers. Farmer Handouts: isiXhosa (**WRC report no. TT 967/8/26**)
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CONTENTS

What is Climate Resilient Agriculture (CRA).....	1
Principles	2
1. Water management (manage available water and increase access to water).....	2
1.1 INFILTRATION DITCHES (RUN-ON DITCHES, DIVERSION DITCHES)	2
1.2 CUT OFF DRAINS/ SWALES	3
1.3 FURROWS AND RIDGES	4
1.4 TIED RIDGES	5
1.5 INFILTRATION PITS/ BANANA CIRCLES	6
1.6 MULCHING	7
1.7 SHADE CLOTH TUNNELS	8
1.8 RAINWATER HARVESTING AND STORAGE	9
1.9 RAINWATER HARVESTING STORAGE; JO-JO TANKS	10
1.10 SMALL DAMS	11
1.11 GREYWATER MANAGEMENT	12
1.11.1 Bucket drip kits	12
1.11.2 Tower gardens.....	14
1.11.3 14	
1.11.4 Keyhole beds.....	15
1.12 GRASSED WATERWAYS	16
2. Soil Management (erosion control, soil fertility, and soil health)	17
2.1 STONE LINES/BUNDS	17
2.2 CHECK DAMS	18
2.3 TERRACES	19
2.4 IMPROVED ORGANIC MATTER	20
2.5 PLANTING LEGUMES AND GREEN MANURES	21
2.6 TRENCH BEDS.....	22
2.7 SHALLOW TRENCHES.....	23
2.8 ECO-CIRCLES.....	24
2.9 TARGETED APPLICATION OF FERTILIZER AND LIME	25
2.10 ZAI PITS / PLANTING BASINS	26
2.11 CONSERVATION AGRICULTURE.....	27
2.12 STRIP CROPPING.....	29
3. Crop management (planting systems, crop health, propagation, fruit production)	30
3.1 LIQUID MANURES	30
3.2 PLANT BIO STIMULANTS.....	31
3.3 MIXED CROPPING	32
3.4 CROP ROTATION	34
3.5 NATURAL PEST AND DISEASE CONTROL	35
3.5.1 Garlic – An example	36
3.6 INTEGRATED WEED MANAGEMENT	37
3.7 NURSERIES AND PROPAGATION	38

3.8	SEED SAVING	39
3.8.1	SEED PROCESSING AND STORAGE	40
3.9	FRUIT PRODUCTION.....	41
3.10	ORGANIC MANGO PRODUCTION.....	42
4	Livestock Integration.....	43
4.1	AGROFORESTRY OPTIONS.....	43
4.2	AGRI-SILVIPASTORAL PRACTICES.....	44
4.3	CREEP FEEDING AND SUPPLEMENTATION.....	45
4.4	STALL FEEDING AND HAY MAKING	46
4.5	ROTATIONAL GRAZING	47
4.6	MULTIPURPOSE POULTRY BREEDS	48
4.7	PRODUCTION OF POULTRY FEED	49
4.8	FODDER PRODUCTION	50
4.9	PROTEIN BLOCK MAKING	51
5	Natural Resources	52
5.1	SPRINGS AND WETLANDS	52
5.1.1	Water access and management.....	52
5.1.2	Low-tech spring protection options.....	53
5.2	WETLAND REHABILITATION	56
5.3	CHECK DAMS	58
5.4	STONE LINES.....	59
5.5	BRUSH PACKING.....	59
5.6	PATH REHABILITATION	60

WHAT IS CLIMATE RESILIENT AGRICULTURE (CRA)

Climate resilient agriculture aims to increase agricultural productivity and incomes while adapting our farming practices to the changed circumstances, and 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 the 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.

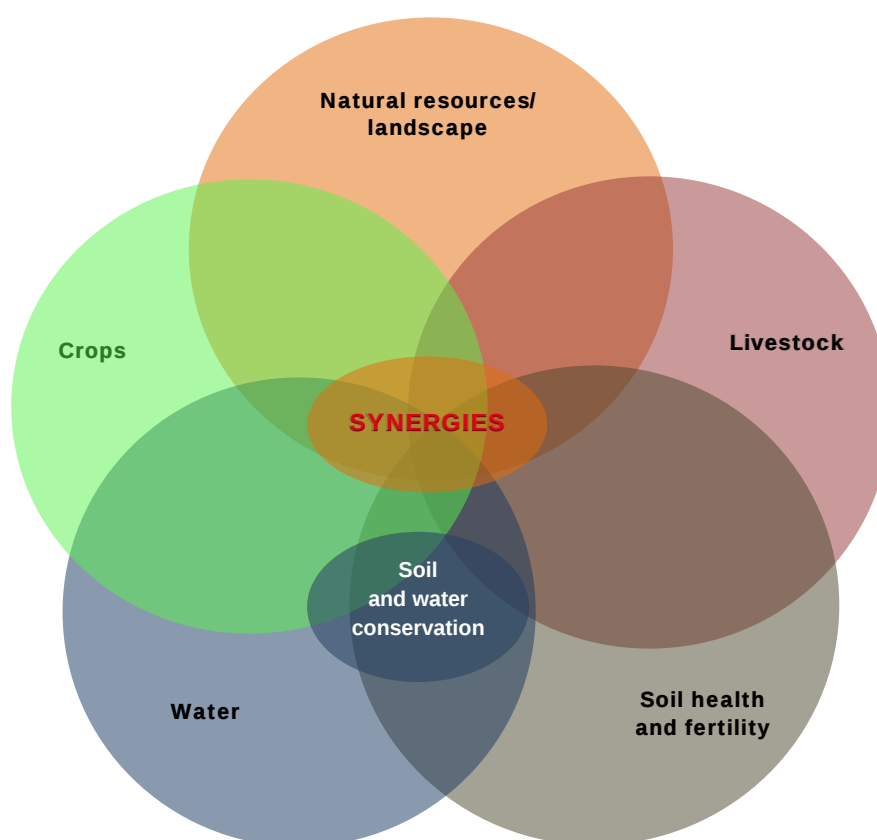


Figure 1: *Household-level implementation of CRA integrates across sectors (adapted from Arslan, 2014)*

There is 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

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.

1. WATER MANAGEMENT (MANAGE AVAILABLE WATER AND INCREASE ACCESS TO WATER)

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

These are shallow ditches (30cm wide and 15-30cm deep) that are dug either to channel water to a specific area (diversion ditches) or to catch water and 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

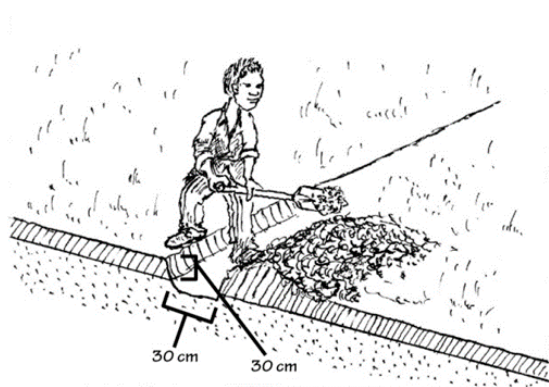
These ditches increase access to and availability of water in intensive food production.

REQUIREMENTS

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

IMPLEMENTATION

- Gardens, fields
- <0,1ha, 0,1-1ha
- 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; 30cm wide and 30cm deep) with soil placed on upper slope



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

1.2 CUT OFF DRAINS/ SWALES

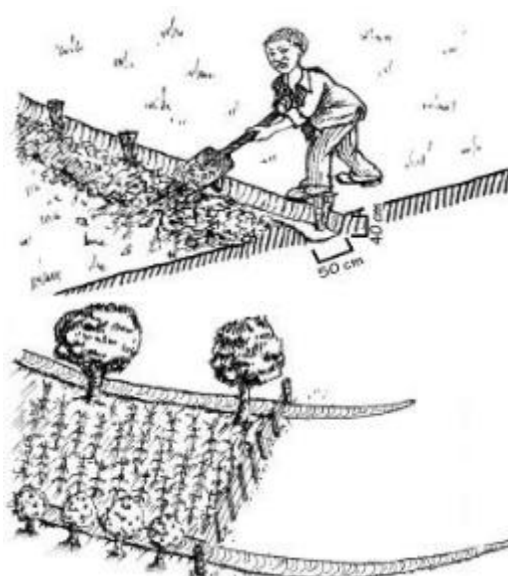
A swale is an earth bank constructed along the contour with a furrow (40cm deep and 50cm wide) on the up-slope side. The top of the earth bank is levelled off to allow planting. The swale intercepts runoff, spreads it out, and helps it infiltrate deep into the ground. Typically, permanent crops (e.g.,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

REQUIREMENTS

- Rainfall: >150mm <1200mm/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
- <0,1ha, 0,1-1ha, >2ha
- 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

1.3 FURROWS AND RIDGES

Furrows are dug on contour, and soil is 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: >150mm/year
- Temperature: >5°C
- Topography: 0,5%-5%
- Soil: all types

IMPLEMENTATION

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



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



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



Fruit trees can be combined into the beds in this system

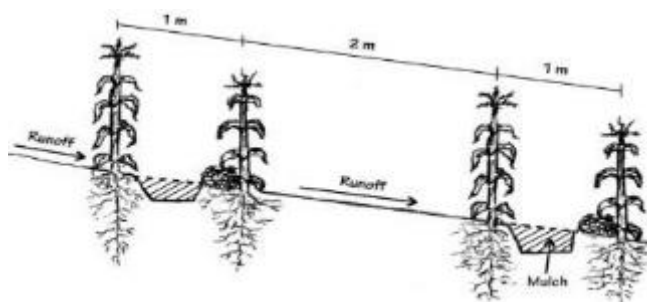
1.4 TIED RIDGES

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: 400-700mm/year
- Temperature: $>5^{\circ}\text{C}$
- 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
- $<0,1\text{ha}$, $0,1\text{--}1\text{ha}$
- 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

1.5 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: >350mm/year
- Temperature: >5°C
- Topography: 1,5%-25%
- Soil: all types (5-30% clay) and depths (>30cm)

IMPLEMENTATION

- Gardens
- <0,1ha,
- 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

1.6 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: >350mm/year
- Temperature: >5°C
- Topography: 1,5%-25%
- Soil: all types (5-30% clay) and depths (>30cm)

IMPLEMENTATION

- Gardens
- <0,1ha,
- 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

1.7 SHADE CLOTH TUNNELS

40% Grey shade net tunnels of 4.2mx6m, 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, 1mx5m, and each is supplied with a 20L 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 be supplied.

IMPLEMENTATION

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



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



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.

1.8 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 from structures, roads, and the general area, to store large amounts of water (25 000-40 000 litres); enough water for a 100-200m² garden for 4-6 months.

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



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

REQUIREMENTS

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

IMPLEMENTATION

- Gardens
- <0,1ha, 0,1-1ha, .2ha
- 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 (18m³), with a removable metal roof



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



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

1.9 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 are 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 RDP 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

1.10 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

1.11 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 the 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 avoid the greywater from touching the leaves of the crops.

Three methods for using grey water are described here.

1.11.1 Bucket drip kits

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



Wetting circles produced by the string drippers



Greywater in a bucket drip system

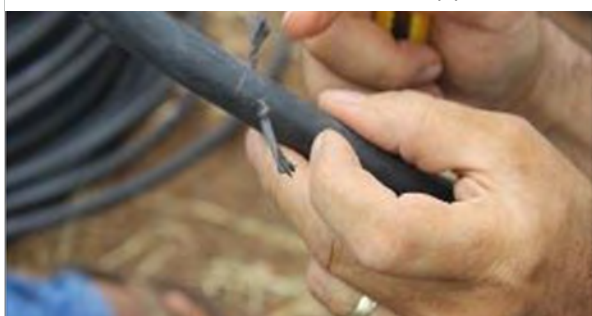
The pictures below provide a visual description of how these small drip systems are assembled.



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 30cm 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"

1.11.2 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 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
- <0,1ha,
- 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

1.11.4 Keyhole beds

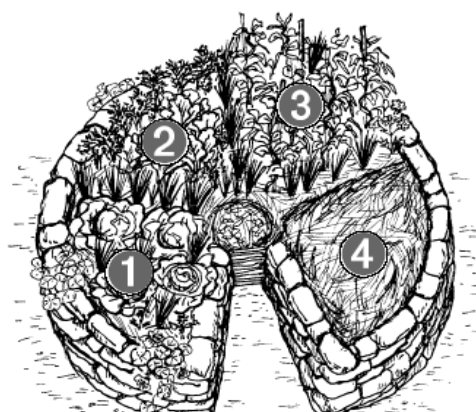
These are intensive built-up beds with a central compost basket/column for watering and greywater application. They are easy to manage. The bed is circular (3m diameter), with a keyhole in the upper slope side to provide access to the compost basket, which is filled continually and used for watering.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

IMPLEMENTATION

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

1.12 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.

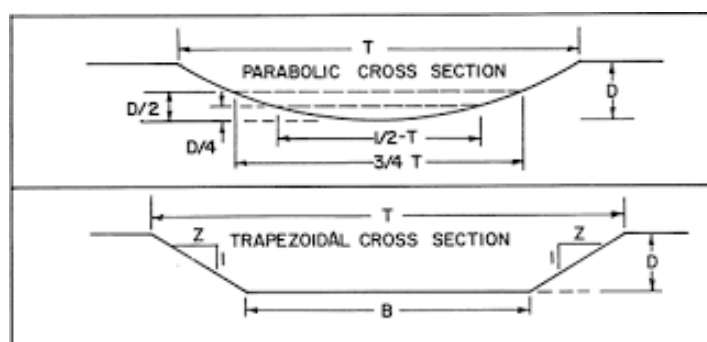
- The vegetative cover in the waterway slows the water flow and protects the channel surface from the eroding forces of runoff water.
- Planting of creeping and perennial grasses, such as Paspalum, Fescue, Kikuyu, and couch grass, is better than planting tall, upright, annual grasses
- Make the cross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

REQUIREMENTS

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

IMPLEMENTATION

- Fields
- 0,1-1ha, >1ha
- 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

2. SOIL MANAGEMENT (EROSION CONTROL, SOIL FERTILITY, AND SOIL HEALTH)

2.1 STONE LINES/BUNDS

Stone lines are packed on contours to control water movement and provide for a bit of buildup 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 from breaking and also to allow slow movement of water through 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: >150mm/year
- Temperature: >5°C
- Topography: 0,5%-5%
- Soil: all types – where stones and rocks are easily available



IMPLEMENTATION

- Gardens, fields
- <0,1ha, 0,1-1ha, >2ha
- 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

2.2 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.

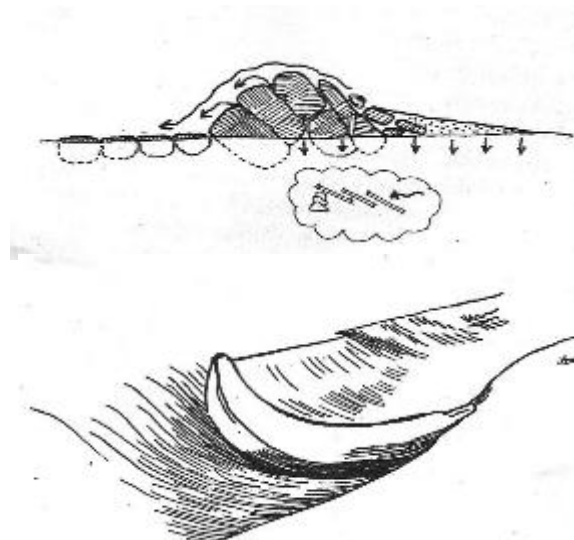
Check dams are mostly placed across drainage lines where water flows after rainfall, but does not flow permanently. They are also placed across eroding gullies. They work well to stabilise roads or paths that cross drainage lines. Angular, rather than round rocks, should be used, and the bottom layers should be large, 30cm- 60cm wide and around 5-9kg in weight. The smaller stones at the top and for the apron can be 15cm-22cm 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: >150mm/year
- Temperature: >5°C
- Topography: 1,5%-25%
- Soil: all types – where stones and rocks are easily available

IMPLEMENTATION

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



Gully 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

2.3 TERRACES

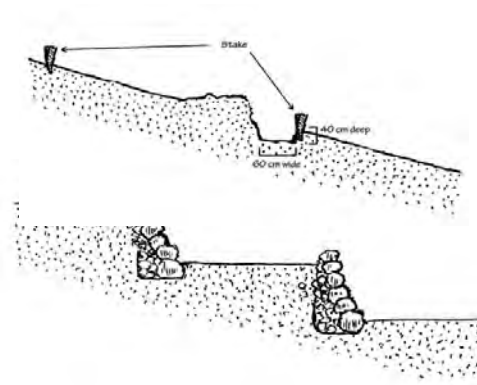
A terrace is a level strip of soil built along the contour of a slope and supported by an earth or stone bund, or rows of old tyres. Terraces create flat planting areas and stabilize slopes that would otherwise be too steep for crop production. A series of terraces creates a step-like effect that slows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

REQUIREMENTS

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

IMPLEMENTATION

- Gardens, fields
- <0,1ha, 0,1-1ha, >2ha
- 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



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



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



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

2.4 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 as bedding material, and piling this up and covering the pile with grass or plastic. This is left for a minimum of 5-7 days before 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: >350mm <1200mm/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
- <0,1ha, 0,1-1ha, >2ha
- 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

2.5 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 the 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: >150mm <1200mm/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
- <0,1ha, 0,1-1ha, >2ha
- 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

2.6 TRENCH BEDS

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

- A bed is dug out to 60-80cm, around 1 m wide and 1-10m 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: >350mm/year
- Temperature: >5°C
- Topography: 0,5%-5%
- Soil: all types

IMPLEMENTATION

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



Trenches are dug 60cm-1m 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

2.7 SHALLOW TRENCHES

Shallow trenches are an easier version of trench beds. They are dug out to around 30cm and filled with a mixture of organic matter: manure, dry and green plant materials. They are then filled 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: >350mm/year
- Temperature: >5°C
- Topography: 0,5%-5%
- Soil: all types

IMPLEMENTATION

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



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



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

2.8 ECO-CIRCLES

These are small circular, double-dug beds with the 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: >350mm/year
- Temperature: >5°C
- Topography: 0,5%-5%
- Soil: all types

IMPLEMENTATION

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



Digging out the eco-circle, 1-1,5m in diameter and 30cm deep with a further 15 cm loosened and 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 2L bottle in the centre and planted to herbs

2.9 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: >450mm/year
- Temperature: >5°C
- Topography: 1,5-10%
- Soil: all types – depending on fertilizer recommendations

IMPLEMENTATION

- Gardens, fields
- <0,1ha, 0,1-1ha, >2ha
- 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 2cm away from the seed



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



Measuring fertilizer with a

2.10 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. After the first rainfall, the matter is covered with a thin layer of soil, and the seeds are placed in the middle of the pit.

REQUIREMENTS

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

IMPLEMENTATION

- Gardens, fields
- 0,1ha-1ha, >1ha
- 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



Zai pits dug in an eroded field, with composting material ready to be added (from Chris Reij, 20100



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

2.11 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

REQUIREMENTS

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

IMPLEMENTATION

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



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



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 Knapick no- till planter with animal traction

PRINCIPLE 2: Soil cover



Good soil cover from crop residues

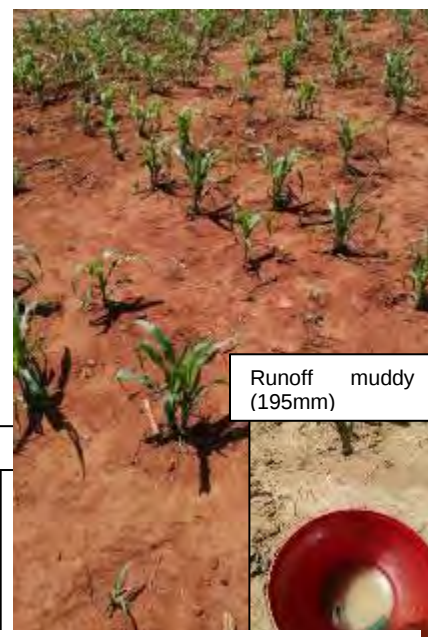


Mulching a CA plot to provide for soil cover



Runoff clear (42mm)

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



Runoff muddy (195mm)

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),

2.12 STRIP CROPPING

Strip cropping is a cultivation practice in which different crops are sown in alternate strips to prevent soil erosion and optimise nutrient uptake. Planting of strips has 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: >350mm/year
- Temperature: >5°C
- Topography: 1,5%-15%
- Soil: all types (clay percentage 5%-35%)

IMPLEMENTATION

- Gardens, fields
- <0,1ha, 0,1-1ha, >2ha
- 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

3. CROP MANAGEMENT (PLANTING SYSTEMS, CROP HEALTH, PROPAGATION, FRUIT PRODUCTION)

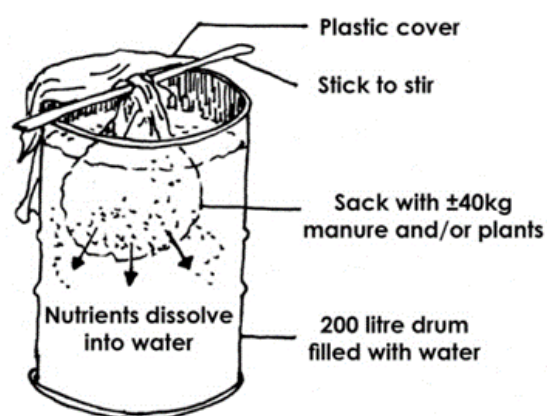
3.1 LIQUID MANURES

Liquid manures are water-based extracts made from animal- and plant-based materials, that are fermented and then diluted before 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 before use.

IMPLEMENTATION

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



from: Production without Destruction



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

3.2 PLANT BIO STIMULANTS

Bio stimulants are substances or microorganisms that, when applied to seeds, plants, or in the rooting zone, enhance flowering, plant growth, fruit set, crop productivity, and nutrient use efficiency. They are also able to improve the tolerance of crops against a wide range of abiotic stressors, such as heat and drought.

The most popular ingredients include humic substances (humic and fulvic acids), seaweed extracts, beneficial bacteria (such as N-fixing bacteria), and beneficial fungi (such as Arbuscular mycorrhizal fungi).

These preparations are generally bought, diluted, and sprayed onto the soil or crops at regular intervals during the growing season.

They are important for larger areas, where farmers are moving towards more organic options and are concerned about soil health.

Regen-Z (<https://regenz.co.za>) is an agricultural services business focusing on regenerative agricultural practices and innovative farming solutions, and has tailored bio-stimulant products to improve soil health and fertility with the aim of reducing and ultimately replacing chemical fertilizer inputs in conservation agriculture farming systems.



Above: the six principles of regenerative agriculture (Zylem-Regen-Z)



Above: A range of plant bio-stimulants produced by Zylem (regen-Z) for assisting soil health and crop growth in regenerative agriculture systems

3.3 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 the risk of shortages due to crop failure.

The choice of crops is based on the following:

- o 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 an 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.
- o 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).
- o Pest-repellent crops such as coriander, garlic chives, and other herbs such as rosemary and thyme.
- o Legumes and protein-rich vegetables such as beans, peas, and turnips.
- o Perennial multipurpose plants such as wormwood, lemongrass, bulbinella, and comfrey.
- o 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, nor 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?												
	Mrch	April	May	Jun	Jul	Aug	Sept	Oct	Nov	Too hot to plant!		
Baby marrows												
Basil												
Beetroot												
Brinjal												
Cabbage												
Carrots												
Chilli												
Green beans												
Green pepper												
Kale and other morogo e.g. amaranthus												
Lettuce												
Leeks, spring onions												
Mustard spinach												
Onions												
Parsley												
Peas												
Tomatoes												

IMPLEMENTATION

- Gardens, fields
- <0,1ha, 0,1-1ha, >2ha
- 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 and



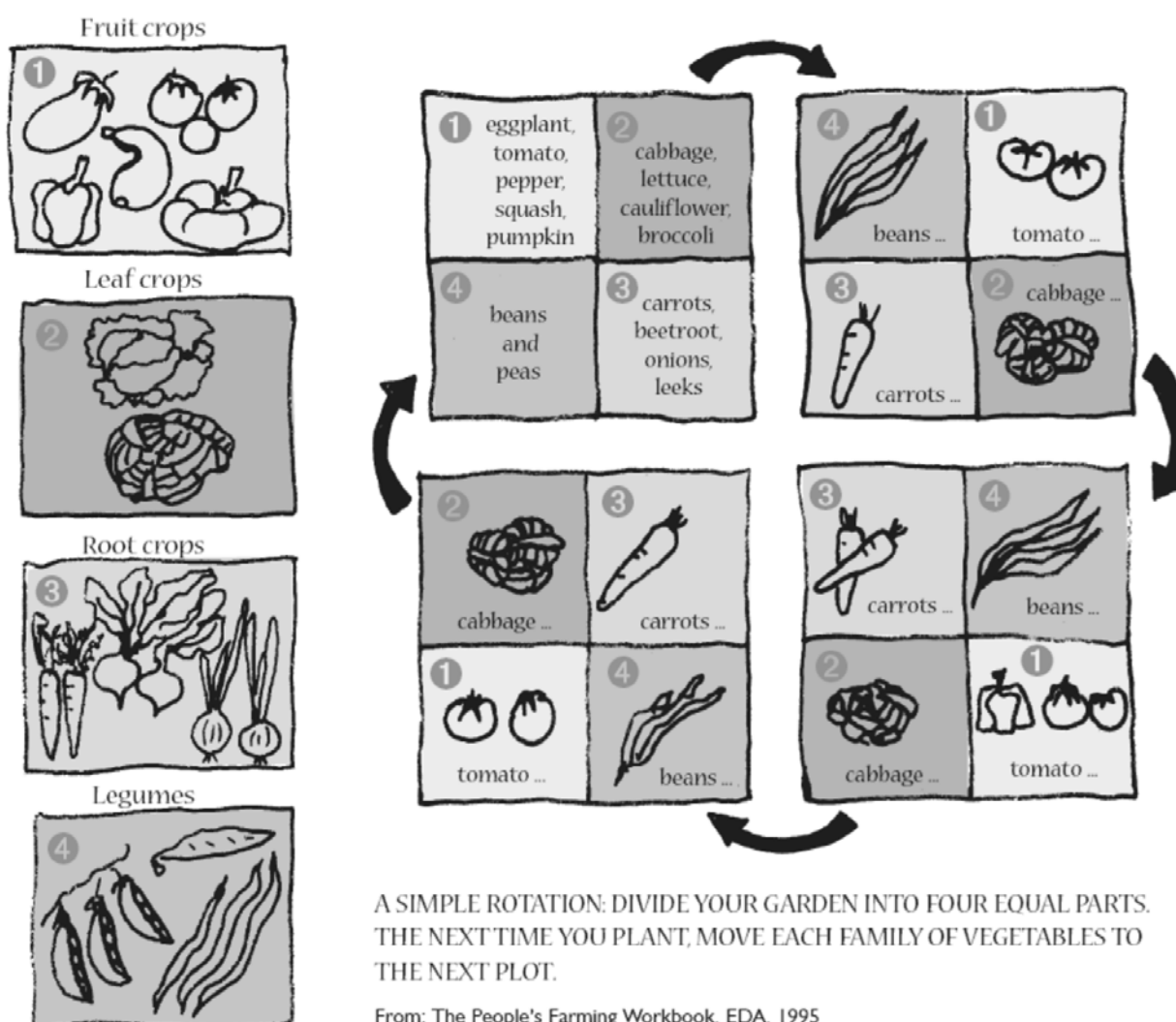
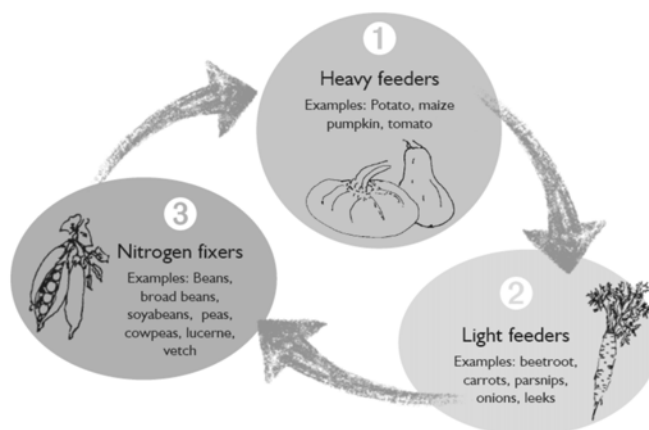
Alex Makgopa (Sedawa)- spring onions, spinach, carrots and marigolds

3.4 CROP ROTATION

Crop rotation is an important management strategy for both gardens and fields. Crop rotation reduces pest and disease buildup 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.



3.5 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 from 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:
 - o flowers such as marigolds and calendula,
 - o herbs such as lavender, rosemary, coriander, parsley, thyme, fennel, basil, rocket, lemon grass, and garlic chives,
 - o medicinal species such as wormwood, bulbine and bulbinella species, aloe spp, comfrey, stinging nettle; and
 - o 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
- <0,1ha, 0,1-1ha
- 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



3.5.1 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.

Colletotrichum - leaf spot, anthracnose, fruit rot, smudge.

Bacteria: *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

3.6 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 blackjack 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 several 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
- <0,1ha, 0,1-1ha
- 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 outcompeted 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 blackjack (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

3.7 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, except 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 (30-60cm) with lots of organic matter (compost and manure) and should be shaded to keep the 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
- <0,1ha,
- 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

3.8 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 safeguarding traditional crops, and farmer preferred open pollinated varieties (not hybrids), which 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 growing numerous types of flowering plants and keeping 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 the seed from
- Never keep seed from diseased plants
- The 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

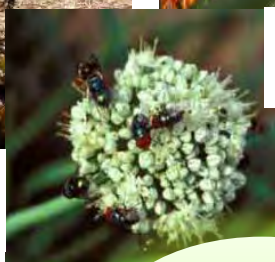
- Gardens, fields,
- <0,1ha, -0,1-1ha, >2ha
- Low cost, local resources
- Easy to do and maintain; somewhat labour and knowledge intensive



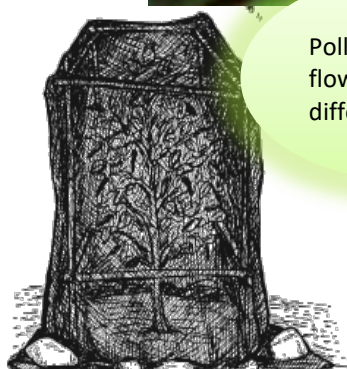
A garden for seed production, with structures for caging, and 6-24 of each variety planted for seed saving – different plant families are planted close together to reduce cross



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



Hand pollination of maize for seed selection



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

Pollinators love flowers- many different kinds!!



3.8.1 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 a dry or airtight environment
- Avoid plastic packets and containers
- Light shortens seed life; store 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 the seeds from germinating. This jelly needs to be removed before storage and germination of the seed. The jelly can be fermented with water and sugar, and then the seed is rinsed and dried
- Further drying of the 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.



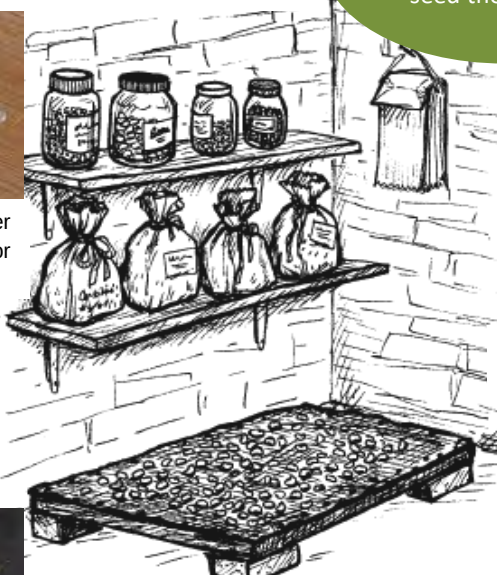
Fermentation of tomato and gooseberry seed for storage and good germination



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



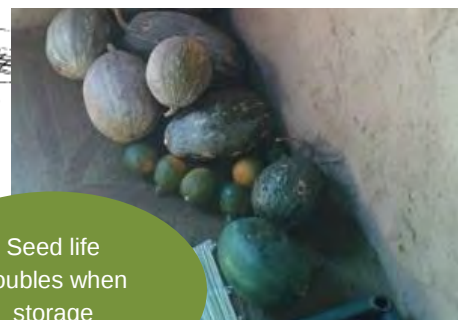
Use silicon to draw water from seed and ash for storage of dry seeds



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



Store seed in glass containers



Seed life doubles when storage temperature is

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

3.9 FRUIT PRODUCTION

Producing a range of fruit at the 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 from 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.

Different fruit types are more suitable for different agroecological regions. Mainly, some 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, avocados and litchis. Citrus can deal with a very wide range of temperatures, but needs to be well irrigated

IMPLEMENTATION

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



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



Irrigation of orange trees, basins and bunds hold more water



Tree tomatoes are propagated from 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

3.10 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.

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 60cm by 60cm 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



Value adding through juicing and drying of mangoes

REQUIREMENTS

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

IMPLEMENTATION

- Gardens and orchards
- <0,1ha, 0,1- 1ha
- 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

4 LIVESTOCK INTEGRATION

These are aspects of livestock management that either overlap with cropping 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

4.1 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: >350mm/year
- Temperature: >5°C
- Topography: 1,5&-15%
- Soil: all types

IMPLEMENTATION

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



Examples of different ways of planting trees in a landscape



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



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

4.2 AGRI-SILVIPASTORAL PRACTICES

An Agri-silvicultural system is a collection of agroforestry practices that involve combining crops and trees with the 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 the 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 several 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
- <0,1ha, 0,1-1ha >1ha
- 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 Mhlabyalingana, KZN: combination of fruit trees, vegetables and crop



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

4.3 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 the form of alternative fodder species. This involves growing of species with higher/better nutritional value compared to the present fodder. Most of these species are planted to provide high-quality green fodder in 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, are 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.



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



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.

4.4 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
- 0,1-1ha >1ha
- 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 (soybean) stover

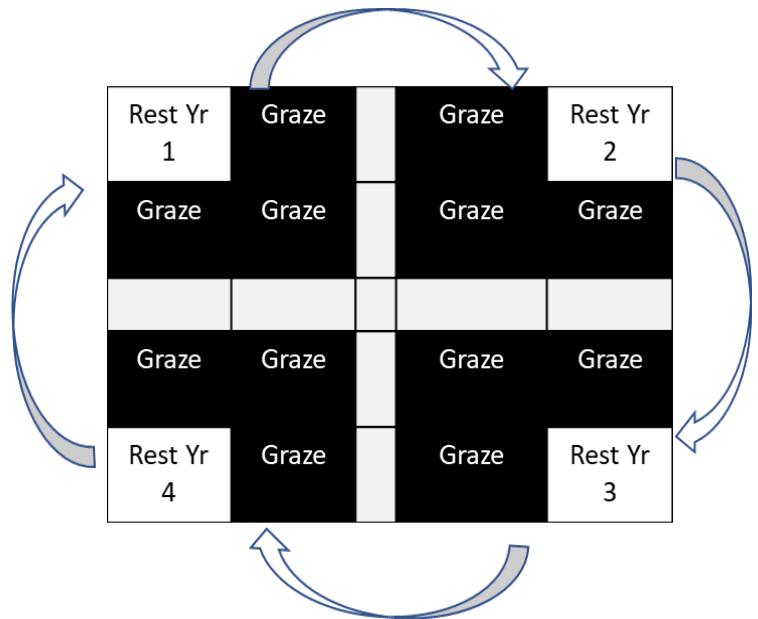
4.5 ROTATIONAL GRAZING

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. Livestock owners need to work together to develop a rotational resting system.

IMPLEMENTATION

- Livestock
- >1ha
- 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

4.6 MULTIPURPOSE POULTRY BREEDS

There is a need for poultry breeds that are heat-tolerant, generally tough in the face of different stresses, and multipurpose. There is also a need for breeds that can be locally reproduced and can thrive on locally produced feed rations. Multipurpose means a breed that is good both for laying and for meat.

The Boschveld chicken (www.boschveld.co.za) is a multipurpose breed originating from Limpopo and is a cross between the Venda, Ovambo, and Matabele chickens. The main aim of breeding was to produce a hardy, no-fuss chicken, which provides both meat and eggs. They can continue laying eggs for at least two and a half years with inbred disease resistance and hardiness. The roosters are ready for slaughter at 12 weeks, with hens ready to lay eggs at 18 weeks.

Boschveld chickens are good for free-range situations and can adapt to a range of management systems. They do perform better when provided proper housing, feeding, and vaccination. For maximum performance and laying, Boschvelders are managed in the same way as layers and are provided with pullet starter and grower mash/pellets, and later layer mash/pellets. They need to be provided with nesting boxes to lay well.

REQUIREMENTS

- Rainfall: >250mm/year
- Temperature: >5°C, <40 °C

IMPLEMENTATION

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



Boschveld chickens perform well if provided clean and suitable housing with some free-range options. They should be provided with high-quality feed. Meat from these chickens is comparable to that of conventional broilers.



Boschveld chickens lay as well as conventional layers if provided with the correct feed, ample water and good laying boxes. They continue to lay for around 2 years,

4.7 PRODUCTION OF POULTRY FEED

Although it can be quite tricky to produce and mill full feed rations for poultry, it is good to supplement commercial feed with grit, grains, grubs, and greens produced locally.

- Grain is a seed such as sorghum, millet, oats, maize, or sunflower seeds. And seeds with high levels of protein, such as soya, Sun hemp, cowpeas, mung beans, or sugar beans. Yellow maize is a good and cheap source.
- Greens: Chickens can get for themselves if you let them scavenge during the day, or you can feed them cabbage, comfrey, herbs, vegetable scraps and most kinds of fruit
- Grit is small stones that help digestion. Good sources of grit are coarse sand and small pebbles, as well as clean gravel. Chickens can collect their own grit if they have somewhere to scratch around.
- Grubs: Bugs and insects provide the chickens with most of the protein that they need so that they can grow.

Chicks and pullets can be fed on demand, and fully grown chickens need around 1/4cup of dry feed per day for hens and 1/3 cup for roosters.



Above left to right: GRAINS: Maize, sorghum, and sunflower



Above left to right; GREENS; High in Vitamin A- clover, stinging nettle and lucerne



Above left and right: Herbs that are good GREENS for poultry include comfrey, parsley and coriander

4.8 FODDER PRODUCTION

An element of sustainable livestock production is the production of livestock fodder for feed supplementation for livestock (cattle and goats) grazing on low-quality natural veld. Sourveld in higher altitude and rainfall areas is of low quality in winter months and in all smallholder farming regions due to sustained over-grazing. The best option is to include fodder species in a multi-cropping Conservation Agriculture field cropping process to allow for soil and environmental benefits, while also producing food and cash crops.

Two different options are available: annual and perennial fodder crops. Examples of annual summer and winter cover crops are Sun hemp, sunflower, sorghum, millet, Dolichos, cowpeas, turnips, fodder radish, black oats, and examples of perennial cover crops are Lucerne, Lespedeza, and Tall fescue.

REQUIREMENTS

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

IMPLEMENTATION

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



Above left to right; Summer cover crops (sunflower, Sun hemp, and sorghum), Strips of cowpeas and maize, and winter cover crops (Saia oats, fodder rye and fodder radish).



Above left and right: Bird resistant sorghum and Lespedeza strips

4.9 PROTEIN BLOCK MAKING

These can be provided as licks to cattle during winter and can either be pre-bought or made locally. Moulds for making cement or earth bricks, which are commonly used, work well for making these blocks. Protein licks improve livestock health and fertility by supplementing deficient nutrients in dry pastures, which stimulates appetite and increases forage intake and digestibility. They provide essential minerals and trace elements, prevent weight loss, enhance microbial action in the rumen, and increase calving and conception rates, making them crucial for performance, especially during winter grazing or on poor-quality veld.

Making the licks oneself is generally much cheaper than buying the blocks, but it is a little bit labour-intensive. The ingredients also need to be sourced. Below is a table outlining the requirements. They are all mixed together well and then pressed into the moulds. After a few hours, the blocks will have 'set' and can be removed and used.

Product	Description	Amount
Voermol Procon 33	This is a urea-free high-protein concentrate for home mixing of high-quality animal feeds.	32 kg
Coarse salt	Needs to be feed grade -can be bought from supermarkets. An important mineral in livestock feed.	4kg
Maize meal	Bought from supermarkets. Helps to maintain weight and lactation for cattle	14kg
Whitewash	Hydrated lime – bought from building supply stores. In the protein block, it assists in making the protein more palatable. It supplies calcium and acts as a hardener for the block	8kg
Molasses	Molasses improves appetite and digestion, and provides energy for the cattle	16L



Above Left and right: Mixing the ingredients together and the final protein lick blocks produced after turning them out of their moulds.

5 NATURAL RESOURCES

This section includes aspects of both natural and water resources management. Restoration and erosion control in the landscape, as included as is local water access

5.1 SPRINGS AND WETLANDS

5.1.1 Water access and management

The revised and updated Water Act (2023) allows for various levels of self-supply options in collaboration with water service authorities for local-level water supply. Multipurpose use of water is important as households in rural communities need more than the 25 litres per person per day of drinking water, which is the present free allocation being used by Water Service Authorities. Water for health and hygiene, and productive purposes, is also required. For these systems, point-of-use purification is recommended - thus at the household level.

Self-supply options can take several forms:

- **Self-supply** is 100% user-funded, governed, and operated. A community-based and informal organisation is usually established. Users decide on the most appropriate technology, financing arrangements, cost-recovery strategy, and type of services they want. Spring water protection and small piped water schemes that use gravity to feed small reservoirs are preferred options.
- **Blended self-supply** provides for an arrangement where communities are supported by organisations (mostly NGOs) and funders in their local water supply schemes. This allows for a more formal community-based institutions, a coherent process for full community participation and capacity development in taking some project management roles as well as operations and maintenance roles post project completion. This approach is more appropriate for small, reasonably isolated rural communities.
- **Collaborative/co-managed water management** between communities and mandated Government stakeholders is presently considered a good option. In this approach, communities and the Water Service Authority (WSA) and water service providers (WSP) jointly negotiate and outline each party's role in the water provision and management process. Generally, the community will undertake day-to-day management, upkeep, and maintenance of a water supply scheme installed by the WSP after full negotiation with the community about the particulars of the scheme. The WSA holds the responsibility for major repairs and refurbishment of the system.

An initial assessment or hydro census is required to identify sources of water in the community, to understand how this water is presently being used and by whom, to identify existing challenges, and to start to think about possible solutions. The prioritization of water sources (springs, small streams, and or boreholes) depends on the strength of the source, the location, whether appropriate protection and use options can be implemented for this source, how it can be reticulated, and who can have access. In reality, these local sources are generally limited in terms of the number of households that can be supplied. Thus, it is important to look at the whole landscape to design a patchwork of local options that can supply water equitably to the larger community, while also protecting the environment and these sources from overuse and contamination.

A community meeting to assess options for the use of different water sources, facilitated through an NGO.



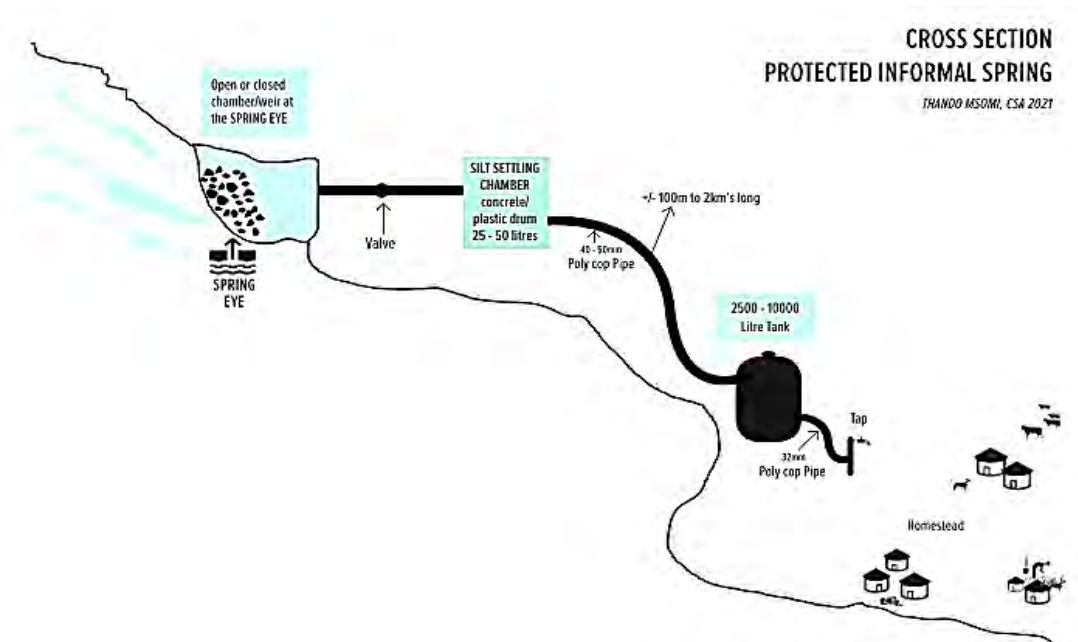
5.1.2 Low-tech spring protection options

Springs occur in a landscape when underground water is pushed to the surface. This occurs most frequently in and around wetlands and streams, and also as seepages along gradients. Springs can be either seasonal or perennial and vary in strength. To protect a spring, its flow rate needs to be no less than 10l/second.

Generally, all protected springs will have the following key elements in their design: the eye, a silt or settling chamber, and a collection or storage chamber with a tap or access point. The actual structures can differ greatly.

The eye is the point where the water emerges from the ground. An **intake chamber** is usually built around this point. The **silt chamber** allows for the settling of sediment. An upper outlet draws cleared water out, and a lower outlet scours and cleans out sediment from the tank. The **storage chamber** stores the water or directs it to larger storage structures. It needs an overflow.

There are two routes to follow: the more formal structural process of installing a spring box or V-box as the intake chamber, or a less formal route where the intake is protected with gravel or stones, a weir is built, and the area is fenced.



Line drawing of an informally protected spring, showing an open/closed chamber/weir at the spring eye, the silt chamber, and the storage tank. (Rose, Mojela, Msomi, & Matandela, 2021)

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

IMPLEMENTATION

Households and gardens

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

Below is an example of an informal spring protection process undertaken by a group of community members in Ezibomvini, Bergville. It consisted of digging a small dam around the spring, burying a slotted pipe below the dam to collect the underground seepage, and piping this water by gravity to a header tank lower down.



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

An example of a header tank from where water is



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

Another, more informal option is to build a small V-box into a weir, rather than building a closed structure around the eye of the spring. This is a good idea when the eye of the spring tends to pop up in different places.

A surface water drainage ditch is dug above and around the spring area to divert surface water run-off from polluting the source. This should be dug a minimum of 8m from the source, preferably further away if possible. The area should then be fenced to keep animals and people out of the area. Below is a small example of how this construction process was used and adapted for a wetland spring protection and reticulation process for Costone village in Bergville, KwaZulu-Natal. In this case, the collection chamber was built into the catchment wall, the area behind the catchment wall/dam was filled with stones and small rocks, and the area was fenced off. The pictures below are indicative.



Above Left to Right: The original spring before protection in Stulwane, Bergville. The catchment wall has a V-box in the bottom corner and is covered with rocks, gravel, and sand towards the eye. Building in the overflow pipes. The protected spring has a fence around it to protect it and a small catchment area above the spring.

A supply pipe from the v-box in the catchment wall gravity feeds water to the storage tanks. Many different options are possible. In our example from Costone in Bergville, a cement base was constructed for the two linked 2500l Jo-Jo tanks. From there, pipes were laid towards 4 taps, to allow for household-level water access not more than 200m away from each homestead supplied by this small scheme.



Above Left to right: Construction of the cement platform for the tanks. The two joined 2500l JoJo tanks. Digging ditches and laying pipes for the community taps. An example of a community tap upon completion.

These localised community-managed water schemes (self-supply) are constrained by the topography of the areas, the strength of the source, and the distance to households. It is important to ensure that the schemes are designed to provide a reasonable amount of water (100-500l/day) to the participating households and that the whole community understands that the concept is to provide a patchwork of smaller supply schemes to specific households only, in a way that all households are eventually included from different sources. This is a model for managed equitable access, rather than open access. The original protected sources remain open for use by the community at large, and this needs to be planned into the design of the system. In addition, planning of livestock watering points is a further important element of these systems. The water committees looking after local water access schemes have the following roles and responsibilities:

- Responsible for any issues arising with the water scheme
- Fix problems with any people not following the rules
- Allocate the use of water and ensure everyone who is eligible gets
- Check regularly that the system is working and used properly
- Open a bank account for the financial contributions and undertake small maintenance activities.
- Call meetings with membership to report on usage and maintenance issues and get permission to use funds for specific activities.
- Communicate with the community level water committee and also the Traditional Authority and councilor.

5.2 WETLAND REHABILITATION

A wetland is land that is transitional between terrestrial and aquatic systems, where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and plants are adapted to saturated soil conditions.

Riverine and palustrine wetland complexes occur in mountainous areas. Palustrine wetlands are marshy areas without open water, such as swamps, marshes, and wet meadows. Riverine wetlands occur in small patches along water courses.

An example of a pristine and functionally intact small wetland – showing diverse vegetation and ground cover



Wetlands are important because they: clean water, provide hydrological buffering, flood and drought management in systems, provide for natural vegetation and wildlife corridors, provide resources for local livelihoods, and have spiritual and cultural value.

Wise use entails preserving the ecological function, while also allowing for local use and livelihoods. It is a careful balance that avoids the destruction of the wetlands.

Example of gulleys that have formed in mountainous riverine wetland patches due to over-use of resources and frequent burning.



IMPLEMENTATION

Natural resource management: erosion control

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

Typical rehabilitation measures include plugs/barriers in drainage channels, erosion control structures, removal of aliens, reduced burning, and reduced grazing pressure. Starting upstream of the wetland patches is a good idea.

Below is an example of an eroded stream with wetland patches that was rehabilitated using several different techniques: check dams, rock walls, erosion control blankets, and fencing.

The pictures alongside show 1- an eroded streambed and small upland wetland in winter, also indicating erosion and, overgrazing and damage from wildfires 2- the eco champs sculpting check dams in the streambed and 3 – the resultant stepped small ponds, which reduce the force of the water flow as well as the tumbling of rocks downstream.



Building of rockwalls along the gully and stream edges to reduce the slumping of soil into the streambed



The picture on the right shows a slumping bank along the stream where (far-right) erosion control blankets (made from shade-netting) were used on bank slopes. They slow down water flow, keep soil in place, and protect seeds from being swept away, while allowing water and light to pass through to encourage vegetation growth.

The area was also fenced off to reduce livestock traffic and damage in the area.



5.3 CHECK DAMS

A check dam is a small, sometimes temporary, dam constructed 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.

As the silt accumulates behind the check dams, they can either be renewed and made higher or grasses and other plants can be planted into the accumulated silt to further stabilise these structures.

Check dams are constructed by placing larger rocks on the downside, at the bottom of the ditch across the gully, and making an apron below the check dam.



REQUIREMENTS

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

IMPLEMENTATION

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

Two examples of check dams showing: 1- How the check dam is keyed into the bank and built at intervals along a gully and 2- how sediment builds up behind the check dam, allowing for re-vegetation.



5.4 STONE LINES

Stone lines are a variation on the concept of stone packs/check dams, and are smaller structures built on contour across a slope.

The same concept of keying in the stones into the slope needs to be employed. This means digging a shallow ditch for the bottom layer of larger stones to fit into, to avoid the rocks rolling down the slope. Again, the larger rocks are placed downslope and are filled in with smaller rocks upslope at a less steep angle.

It is possible to be flexible with the structures of stone lines to accommodate local erosion and topographical characteristics.



The two pictures above show different variants of stone lines used across slopes with multiple small channels, which are developing into a gully/donga.

5.5 BRUSH PACKING

This is another variation on the construction of a porous barrier on contour to reduce erosion. This is useful in areas where stones are not plentiful or easy to access. Brush packing involves using woody material in eroded areas and small gulleys to reduce water flow, increase sedimentation, and allow for re-grassing. Sediment is deposited behind the packs, and seed can be planted in these areas

- The first step is to smooth the edges of the gully and remove saplings/weeds
- Then A-frames are used to mark out contours, at a height difference of 1m – usually 4-5 m apart
- Brush from cleared wattle should be used. Two lines of pegs, around 30cm apart, are knocked into place along the contours measured, and the brush is packed in between these lines and held in place by the pegs.



Above: Pictures showing the smoothing of the bank edges, then the lines of pegs placed on contour and filled with brush from cleared wattle. The picture on the bottom right shows a brush pack after a period of time with siltation starting on the upslope of these packs.

5.6 PATH REHABILITATION

Paths in mountainous and wetland areas often become eroded over time and with heavy use. Nature-based solutions in re-constructing paths to reduce and avoid erosion include several options.

- Stone pitching: the path is changed into steps by digging in stones into the path surface, flat side up
- Soil inversion paths: In a 'bad land' patch where multiple small paths and gulleys are forming, the soil is dug out and placed sub-soil up, to create a raised path with drainage ditches on the side
- Water bars: These are logs secured at a 30° angle across a path with a water diversion ditch created just above it to lead water safely off the path.

REQUIREMENTS

- Rainfall: >350mm
- Topography: 1, 5%-25%
- Soil: all types – although soils that are too sandy or too clayey are difficult to manage

IMPLEMENTATION

- Natural resource management: erosion control
- 0,1-1ha >1ha
- Low cost, local resources,
- Labour-intensive

Stone pitching-creation of steps in eroded pathways. It may need a bit of sculpting of the soil and banks around the paths to create a flattish, reasonably sloped area where the path should be, and removing the smaller side paths formed by heavy traffic.



Soil inversion paths formed in badland patches or seasonally marshy areas.



Water bars: -Logs are secured across the path at an angle; a diversion ditch is dug above it and backfilled with small stones and gravel. An overflow apron of stones is created

