8

Conserving soil and water

EROSION AND lack of rainfall are problems that many African farmers face. Conservation agriculture can help overcome both by conserving soil and by storing water in the soil. If erosion is severe, you can combine conservation agriculture with other techniques to control erosion. In drier areas, you can combine it with water-harvesting methods to make more water available to the crop.

This chapter describes various erosion control and water management methods that you can combine with conservation agriculture. It does not describe these approaches in detail. You can find this information in many other manuals (see, for example, Critchley et al., 1991 – full details in the *Resource materials* section in Chapter 14)

Measures that control erosion and conserve soil almost always help to conserve water too. And techniques designed to conserve water may help reduce soil erosion. Choose from the techniques below, and combine and adapt them to suit your needs.

Soil conservation techniques

Erosion can be a severe problem in conventional farming, especially on steep slopes. Conservation agriculture helps control erosion in several ways:

- **Protective cover** Cover crops and mulch on the surface protect the soil against heavy rain. They prevent rainsplash from dislodging fine particles and from forming a surface crust.
- **Soil structure** Undisturbed by ploughing, the soil structure stays intact. Organic matter holds the soil particles together, making it harder for water to carry them off, or for wind to blow them away. Roots bind the soil and hold it in place.
- **Less runoff** More water sinks into the soil through cracks and pores, so less runs off and causes erosion. Ripping and planting along the contour helps prevent runoff. So does using planting basins, which collect water and allow it to sink in.

If your field is on a steep slope or is badly eroded, you should not expect conservation agriculture, on its own, to remedy the situation quickly. You will have to take special measures to prevent erosion before starting conservation agriculture. These measures may include:

- **Contour and cutoff ditches**
- **Gully treatment**
- **Grass strips**
- **Stone lines**
- **Level contour bunds**
- ***Fanya juu* terraces**
- **Bench terraces**.

You should start by **stabilizing gullies** and **digging cutoff drains** to prevent runoff from upslope from washing your soil away. Then, beginning at the top of the slope, mark out **contour lines** running across the slope. You can use an A-frame, line-level or water-tube level to do this. Establish **grass strips** (or trash lines, or whatever other form of **bunds** or **terraces** you have chosen) along the contour lines.

Building terraces takes a lot of work and can be expensive. Terraces can be hard to maintain. So it may be better to choose a simpler, cheaper option such as grass strips and stone lines.

If your land already has terraces, bunds or other erosion-control structures, you can practise conservation agriculture on the terraces or the land between the bunds. Plant crops using **no-till methods** (Chapter 3), keep the soil covered with **cover crops** or **crop residues** (Chapter 5), and **rotate crops** from season to season (Chapter 6). Make sure you maintain the terraces, and keep other structures in good repair.

Contour and cutoff ditches

A **contour ditch** is a ditch dug along the contour to stop water from running down the slope and causing erosion. Water stays in the ditch and gradually sinks into the soil. Contour ditches are useful to harvest water in dry areas.

A **cutoff ditch** is like a contour ditch but has a slight slope (about 1%), so water drains slowly away. Cutoff ditches are useful to protect fields from uncontrolled runoff and to divert water away from gullies.

If your field is on an eroded hillside, dig a contour ditch or cutoff ditch at the top end first to protect it. You can then start using conservation agriculture on the field.

Soil and water conservation techniques that are difficult to combine with conservation agriculture

Some commonly used soil and water conservation techniques are difficult to combine with conservation agriculture because they involve disturbing the soil or removing the soil cover. Here are some of them:

- **Trash lines** (laying stalks and other crop residues in lines along the contour to slow down erosion). This leaves the rest of the soil bare.
- **Contour ploughing** (ploughing along the contour). This aims to reduce runoff – but it means disturbing the soil and removing the soil cover.
- **Tied ridges** and **tied furrows**. These are semipermanent ridges along the contour, with short cross-ties to prevent water from flowing along the furrows between the ridges. In tied ridges, the crops are planted on the ridges; in tied furrows, they are planted in the furrows. These techniques also involve disturbing the soil. The ridges interfere with planters and other conservation agriculture equipment.

How to set your A-frame to measure a slope

You want to dig a cutoff drain with a slope of 1%. How do you know where to dig it?

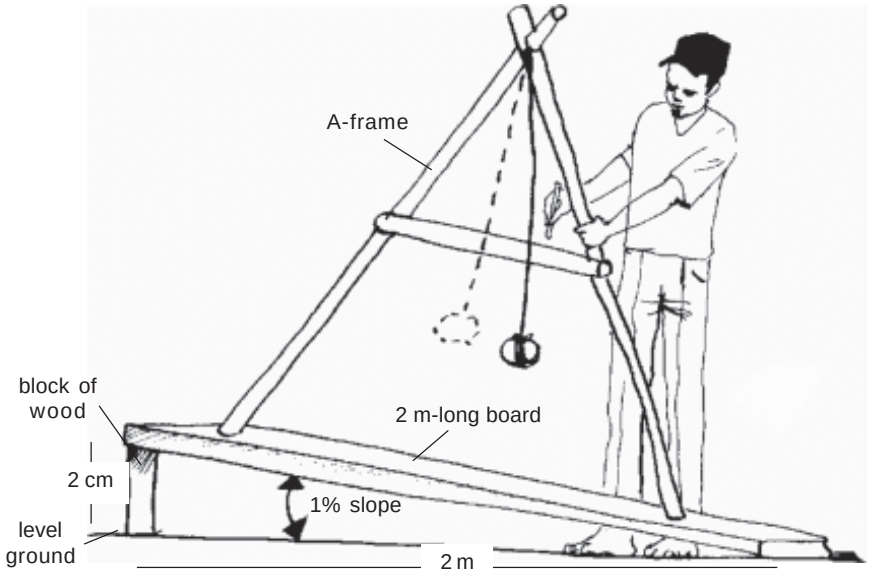
Simple: use your A-frame. You can mark the A-frame so it shows a slope of 1%. Here's how.

1 Cut a small block of wood 2 cm thick.

2 Put it on a level piece of ground, then put one end of a straight, 2 m long board or pole on top of it, so the other end of the board rests on the ground.

3 Stand the A-frame on the board, and mark where the string touches the crossbar of the A-frame. This mark shows a slope of 1% (2 cm is 1% of 2 m).

4 You can now use the A-frame to mark out a 1% slope in the field. Position the legs of the A-frame so the string touches the mark you have made.



You can also use a line-level or a water-tube level to measure slopes as well as contours.

A-frames for different gradients

If you want the A-frame to mark a different slope, you can use blocks of wood of different thickness:

Slope	Thickness of block	
0% (level)	no block	
0.5%	1 cm	(0.4 inch)
1%	2 cm	(0.8 inch)
2%	4 cm	(1.6 inches)
3%	6 cm	(2.4 inches)
4%	8 cm	(3.2 inches)

The board must be exactly 2 m long for these measurements to work.

Put cross-ties in contour and cutoff ditches to slow the flow of water and to encourage the water to sink into the ground. Plant grasses to protect the sides of the ditch from erosion and to provide fodder for livestock.

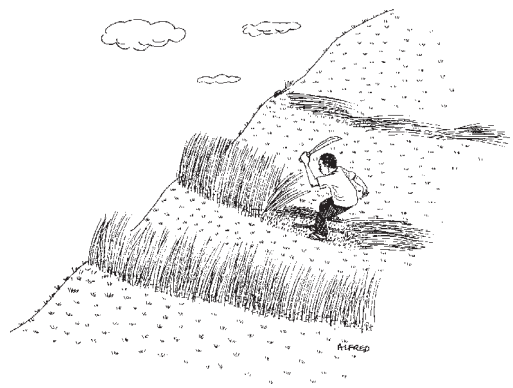
Gully treatment

To control a gully, you must first stop water from flowing into it. Dig a cutoff ditch above the head of the gully to divert water safely away. Then build check-dams from rocks or wooden stakes across the gully floor to slow down any water that still flows down the gully and to encourage sedimentation. Plant trees and grass in the gully and on its sides to stabilize them.

Vegetative strips

A vegetative strip is a strip planted with grass, shrubs or trees that runs across the slope. It slows down water flowing down the slope, and catches sediment that has been eroded uphill. Over time, soil may build up behind the strip, forming a terrace.

Vegetative strips are cheap and easy to establish. Once they are growing, they are easy to maintain, and they can provide valuable fodder for animals. You can practise conservation agriculture on the land between the strips. You can cut mulch from the strips and use it to cover the land in between.



Fodder production on vegetative strips

Mark out contours with an A-frame, line-level or water-tube level. If your field has stones, you can lay these along the contours as an additional barrier. Then plant the strips with grass and (if you want) trees. Here are some options:

- If you need fodder for your livestock, plant grasses such as **Napier grass** (elephant grass, *Pennisetum purpureum*). Do not allow animals to graze the strips; instead, cut grass and carry it to the animals. Caution: Napier grass can compete with the crop growing next to it, so keep it under control.
- **Makarikari grass** (*Panicum coloratum mararikariense*) is a popular grass for barrier strips in East Africa. It is quite drought resistant and can be fed to livestock in the dry season.
- **Vetiver grass** (*Vetiver zizanioides*) forms a dense hedge and grows well even if it is cut for fodder.
- Cash crops such as **pumpkins** and **melons** may also be grown in vegetative strips.

- An alternative to grass is a hedgerow of leguminous trees such as **gliricidia** and **leucaena**. You can feed the leaves to livestock, or prune the trees and spread the branches on the ground as mulch.
- One option is to allow **natural vegetation** to grow in the strips. Make sure that you control weeds in these strips.

One problem with vegetative strips is that they can create alternating bands of fertile and infertile soil. Rich sediment builds up just behind the barrier, so crop yields here are good. Further back from the barrier, though, yields are poorer because the topsoil here has been eroded. These bands may last for some time, until the land between the strips is levelled. Conservation agriculture can help to prevent such bands from developing.

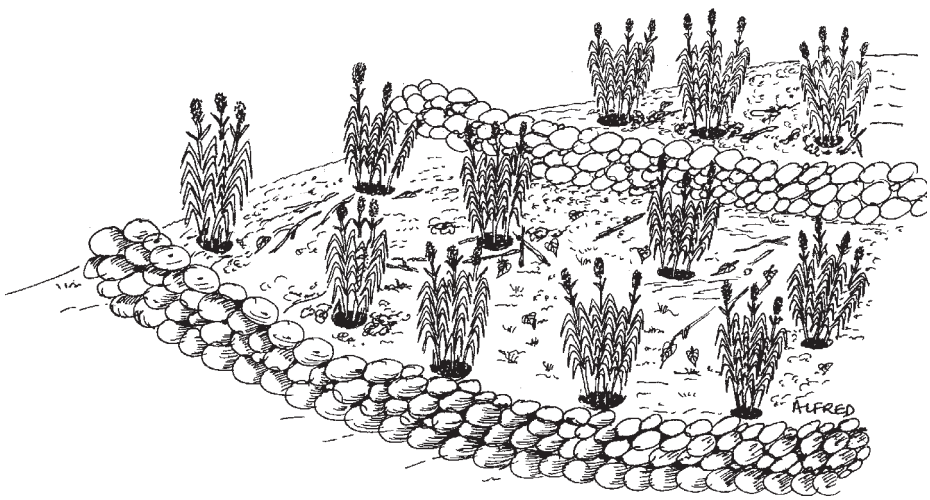
Stone lines

Stone lines are common throughout Africa, in both dry and humid areas. They are used wherever there are loose stones in the field. In the Sahel (especially Burkina Faso and Niger), they are small – at most three stones wide, and one or two high. They slow down runoff, and soil gradually builds up behind them.

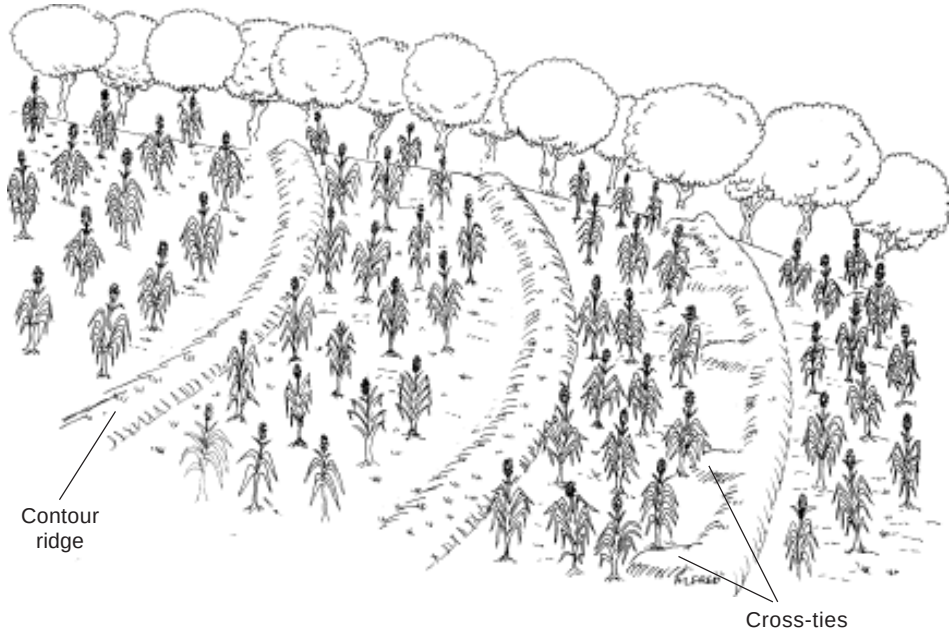
The distance between the lines depends on the slope and how many stones are available. On 2–5% slopes they are often 25–50 m apart.

You can make stone lines from stones in your field, though some farmers bring them in by donkey cart or lorry from up to 10 km away. Line them up along the contour, and plant grass or trees on either side.

Planting pits are often used in combination with stone lines. This is a traditional form of conservation agriculture.



Planting pits in combination with stone lines



Contour ridges

Contour ridges

Contour ridges are ridges of soil that run along the contour. Like other contour barriers, they slow down water flow and catch sediment before it is washed away.

You can make small ridges (called "cross-ties") at right angles to the contour to make the contour ridges more effective at trapping water. These cross-ties prevent the water from flowing along behind the contour ridge and collecting at the lowest point – where it may break through the ridge and start a gully. Space the cross-ties 10 m apart (closer on steeper slopes and in areas with heavy rainfall).

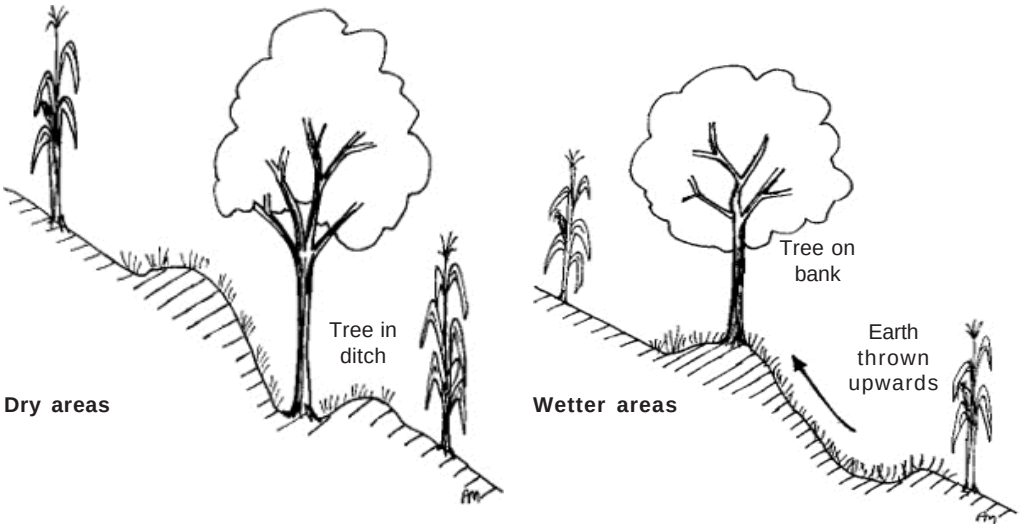
Fanya juu terraces

Fanya juu terraces are made by digging a drainage channel and throwing the soil uphill to make a ridge (*fanya juu* means "throw soil uphill" in Swahili). The channel is usually 50–60 cm deep and may have cross-ties at 10 m intervals.

Grass planted on the ridges helps stabilize the ridges, prevents erosion, and can be used to feed livestock or as mulch.

In drier areas, *fanya juu* terraces may be built along the contour, and trees planted in the ditches.

In high-rainfall areas, it may be better to build them with a slight gradient so the water drains slowly away. Trees can be planted on the banks.



Fanya juu terraces

Fanya juu terraces in Makanya

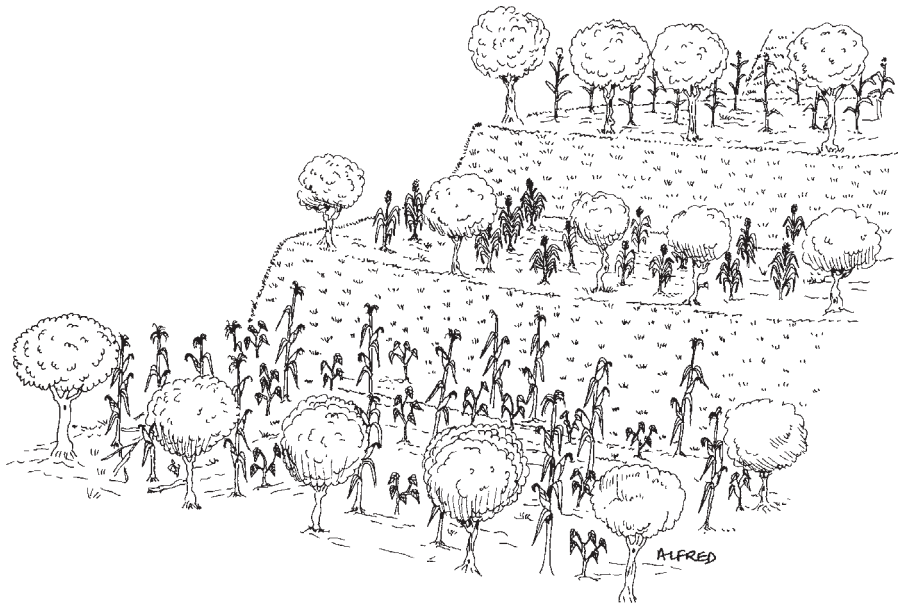
Farmers in Makanya, a dry, hilly area in northeastern Tanzania, use *fanya juu* terraces to conserve water and control erosion. They use a line-level to mark contours in their fields, then dig trenches 50 cm wide and 60 cm along the contours. They pile the earth in ridges upslope of the trenches, and plant fodder grass on the ridges.

They grow maize on the land between the trenches. They used to harvest less than 1.5 t/ha using conventional ploughing. But when they used an animal-drawn Magoye ripper, the yield rose to 2.4 t/ha. Applying manure and planting dolichos as a cover crop raised it still more, to 3.6 t/ha.

Bench terraces

Bench terraces are usually found on medium to steep slopes. They consist of beds which are more or less level, and risers (walls or bunds). It is easy to grow crops on the beds because they are fairly level.

Bench terraces can be made by moving soil from one place to another on the slope. Moving large amounts of soil takes a lot of work: 1500 person days or more to terrace a single hectare on a steep slope. To make this worthwhile, bench terraces must produce much higher yields than before. This is not always the case, so building new bench terraces is going out of fashion. If you do want to build bench terraces in a field, you should do so before starting conservation agriculture.



Bench terraces

Bench terraces may also develop gradually as soil builds up behind a vegetative strip, contour bund or stone line.

To be effective, bench terraces must be well maintained. Keep the risers planted with grass, and repair them if necessary. Use conservation agriculture on the beds to conserve the soil, encourage water to sink in, and maintain fertility.

Water harvesting and conservation

In areas with poor rainfall, there may not be enough water to grow crops reliably. But even in dry years in these areas, more than half the precious rainwater may be lost through evaporation or because it runs off. Conservation agriculture helps conserve water and use it efficiently in at least five ways:

- **More water in the soil** Crop residue or a cover crop protects the soil, prevents crusting on the surface, and slows runoff. Roots, earthworms and other soil life maintain cracks and pores in the soil. Less water runs off, and more sinks into the soil. Ripped furrows and planting basins collect and store water.
- **Less evaporation** Reduced or no tillage means the soil is not turned and does not dry out. The cover protects the soil from wind and direct sun (you can often feel the temperature difference with your hand). Because there is no hardpan, water can sink deeper into the soil.
- **Better use of season's rainfall** Ripping during the dry season allows farmers to plant earlier – right at the start of the rains.

More crop per drop

Over the last two decades, smallholder farmers in Babati District, Tanzania, have adopted conservation agriculture. Instead of disc ploughs, they now use animal- and tractor-drawn rippers and subsoilers. Their yields have more than doubled since the mid-1980s.

That means farmers get more crop for every drop of rain: an extra millimetre of rain now produces as much as 4 kg more grain per hectare. Before, each millimetre produced only 1.5 kg of grain.

It is easy to see – or rather, to feel – the effects of conservation agriculture. Several weeks after the last rains, the soil in ploughed fields is hard and dry. On conservation agriculture fields, however, the soil is still soft and moist. Even after a prolonged dry spell, the crops are still vigorous and do not show signs of water stress.

- **Roots can reach more water** Breaking the hardpan with a subsoiler allows roots to reach water deeper in the soil.
- **Water concentrates in planting lines or pits** Rainwater collects in ripped planting lines or planting basins, where it sinks into the soil – just where the crop needs it.

In wetter areas, conservation agriculture can also help manage water. It can reduce runoff and erosion, make springs run more steadily, and reduce pollution in rivers.

Conservation agriculture helps conserve water, but it may not be enough in dry areas. You can use various other techniques to harvest extra water, either in the field itself, or by bringing water in from outside to where the crops are growing.

Techniques to manage water include:

- **Broad beds and furrows**
- **Planting basins or pitting**
- **Permanent strips**
- **Contour bunds and catchment strips**
- **Bunds and runoff strips**
- **Road catchments**
- **Half-moon microcatchments**

One word of caution: cover crops also use water. In dry areas, you should consider using other types of mulch, such as crop residues or plant remains brought in from outside the field. That will help conserve moisture in the soil where it can be used by the crop.

Broadbeds and furrows

Broadbeds are flat beds about 1–1.2 m wide, separated by furrows. The width of the broadbeds and furrows depends on the crops grown. In areas prone to waterlogging, the furrows drain water away from the beds. In drier areas, they can be used to bring water harvested elsewhere into the field.

Crops such as maize can be grown on the broadbeds, while rice can be planted in the furrows. It is necessary to make the beds only once, before starting conservation agriculture. Afterwards, plant the seeds directly on the beds through the soil cover without tilling, using the techniques described in Chapter 3.

Planting basins or pits

Planting basins (see Chapter 3) collect water and give it time to sink into the soil. Stagger the rows, so basins in one row catch the water that does not fall into basins in the row upslope. Add manure or compost to the basins to improve the soil fertility.

Planting pits (known as *zai* in Burkina Faso and *tassa* in Niger) are a variation on the idea of planting basins. They are hand-dug circular holes which collect water and store it for use by the crop. Each pit is about 20 cm across and 20 cm deep. After planting, the holes are left partly open so they collect water.

Planting pits take a lot of work to dig when the soil is dry. But they produce good yields in areas where otherwise crops might die because of a lack of water.

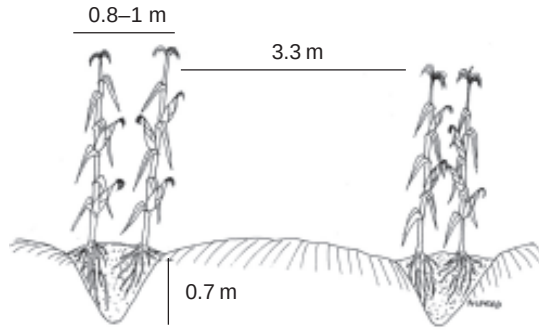
Once made, the pits can be used again, season after season. Leave the soil covered, and add compost or fertilizer to the pits to increase their fertility.

Zai holes with sorghum plants: typical of the Sahel

Permanent strips in Botswana

In very low rainfall areas, it is possible to grow crops by planting them in strips. By sloping the ground in between towards the strips, rainwater will flow towards the strips, close to the crop.

A farmer in Botswana makes his cropped strips 0.8–1 m wide and 3.3 m apart. He subsoils these strips using a tractor-powered subsoiler to a depth of 0.7 m. He shapes the land between the strips so it slopes towards the cropped strips, so rainwater will flow towards the crop. He plants two rows of maize in each strip, and sows a cover crop such as cowpea in between the strips.



Maize in permanent strips

The strips are permanent: they can be used to grow crops season after season. The tractor never drives over them, so there is no risk of compaction or hardpan formation. The soil in the strips gradually improves in fertility as crop residues accumulate there. Rotating maize with a legume crop will improve the soil fertility further. The farmer has been able to grow up to 6 t/ha of maize with less than 400 mm/season of rain.

More information: Gus Nilsson

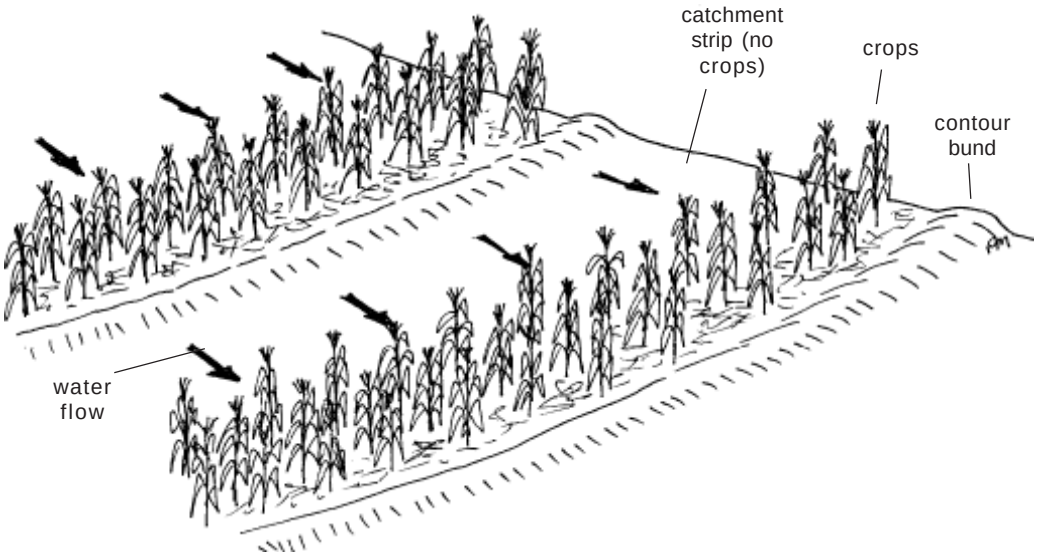
Contour bunds and catchment strips

In areas with low rainfall, there may not be enough water to grow a crop over the whole area. On gentle slopes (less than 3%), one possibility is to use contour bunds and catchment strips. Catchment strips are areas where no crops are planted. When rain falls on this ground, it flows downslope and is trapped by the contour bund. Plant rows of crops behind the bund to use this water. This can produce a good yield even with very little rain.

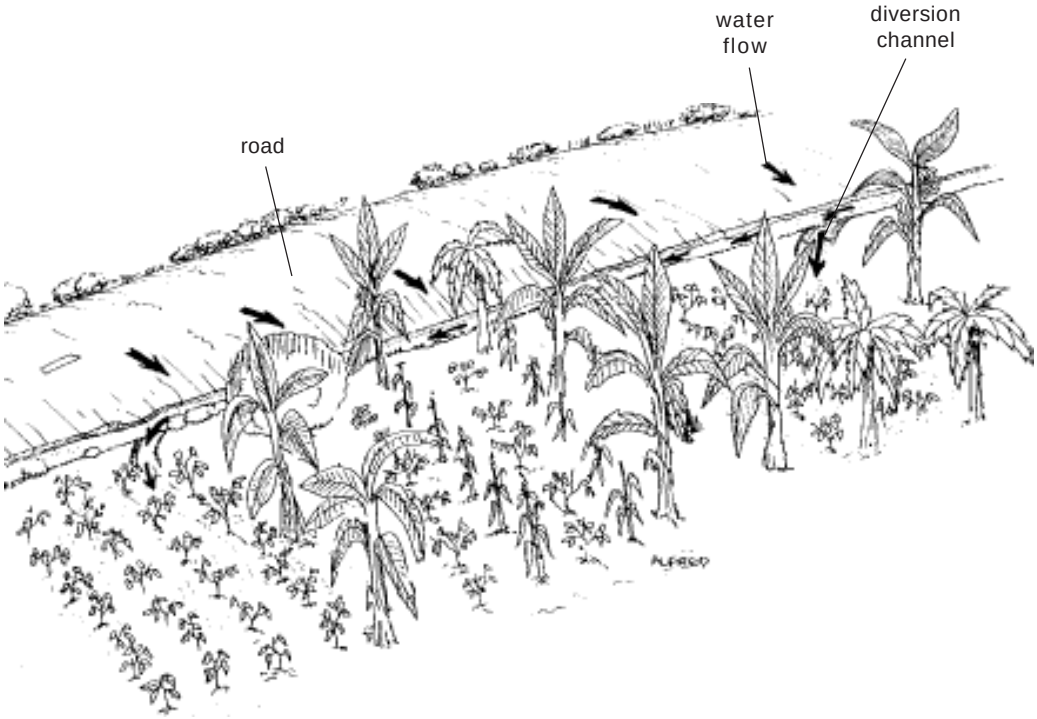
Mulch the cultivated area with crop residues to prevent erosion, help water sink in, and slow evaporation. Plant crops using conservation agriculture practices such as ripping, pitting or direct planting through a soil cover.

Road catchments

Water from roads – and from other unproductive areas such as paths and homestead compounds – can be channelled onto fields. It may be possible to divert water from structures that already exist, such as the ditches below *fanya juu* terraces. Or special bunds can be built around fields close to the road. Another possibility is to direct the water into a pond, which can be used to irrigate crops.



Contour bunds and catchment strips



Rainwater harvesting using a road catchment

Harvesting rainwater in Kordofan

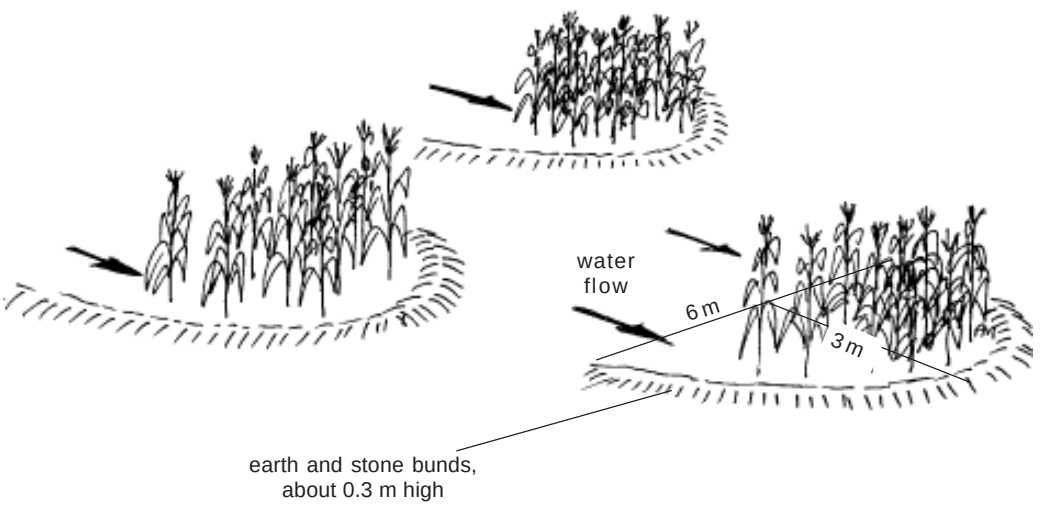
The Agricultural Research and Technology Corporation has tested contour bunds and catchment strips in Kordofan, western Sudan, since 1998. Soils in this area are sandy or sandy clay loams. Slopes are gentle – about 1%. Rainfall is erratic, varying from 140 to 625 mm a year in the period 1998–2002. Prolonged dry spells during the cropping season are frequent. The main crops are sorghum, millet, watermelon and groundnuts. With the first rains the soil surface becomes crusted. The precious water runs off and is lost.

Researchers and farmers have tried using parallel earth bunds, about 40 cm high, spaced 10 m apart. The upper half of the area between the bunds serves as the catchment. Most of the lower half is ripped and planted with sorghum, while cowpea or groundnuts and roselle are planted in the lowest part. This simple technique can triple or quadruple sorghum yields in normal years, and prevent total crop failure in dry years.

More information: Osman Afaldani

Half-moon microcatchments

Half-moon microcatchments are small, semicircular earth bunds. They are quite common on the desert margins of the Sahel, where they are called "demi-lunes". The half-moons catch water flowing down a slope. Crops such as sorghum, millet and cowpeas can be planted in the lower portion of the half-moons, using conservation agriculture techniques. Half-moons are helpful to rehabilitate degraded land.



Half-moon microcatchments

No-till irrigation in western Sudan

Farmers in the Khor Abu-Habil Agricultural Scheme in western Sudan grow crops using irrigation from the Khor Abu-Habil, a seasonal stream.

The fields in this scheme cover 2 ha each. They are surrounded with earth bunds, 1 m high. Water is diverted from the stream into a main canal, and from there through feeder canals and the fields. The fields are flooded to a depth of 80 cm for 15 days – which allows the water to sink 1 metre into the soil. The fields are then ready for sowing.

The farmers do not plough the soil. Instead, they direct-sow cotton, sorghum, sunflower, tomatoes and legumes. They weed the fields by hand.

The farmers of Khor Abu-Habil could improve their production further by introducing other aspects of conservation agriculture: a soil cover (such as cowpeas) and crop rotation or intercropping.

More information: Osman Afaldani