3.4 Soil Erosion: A Major Threat

Introduction
Soil erosion is one of the most serious and irreversible threats to soil fertility. It carries away the most fertile parts of the soil: the top soil and the finer clay fractions which are rich in humus and nutrients. Even low erosion rates which are almost invisible can over the years have a severe impact on soils. It is therefore of vital importance to protect the soil from erosion. Especially organic farming fully depends on the maintenance of the natural fertility of the soil. Therefore, this manual allots a full chapter to this topic. In areas, where soil erosion does not occur, or farmers are already familiar with how to prevent soil erosion, this topic may be dropped in training courses.

Many tropical countries have distinctly dry and wet seasons. During the dry season, ground vegetation usually gets scarce and thin, leaving the soil uncovered. As a result, when the rains arrive, large amount of valuable topsoil can be washed away, leaving the land uneven with gullies and with soil of low fertility. Not only steep slopes but plain fields are also prone to soil erosion, and can be severely affected. Besides rain, excessive irrigation can also cause soil erosion.

Lessons to be learnt
- *Awareness creation on the serious impact of soil erosion: it takes away the most fertile part of the soil*
- *There are several strategies for reducing the eroding impact of rain and wind*
- *Learning practical methods to reduce soil erosion*

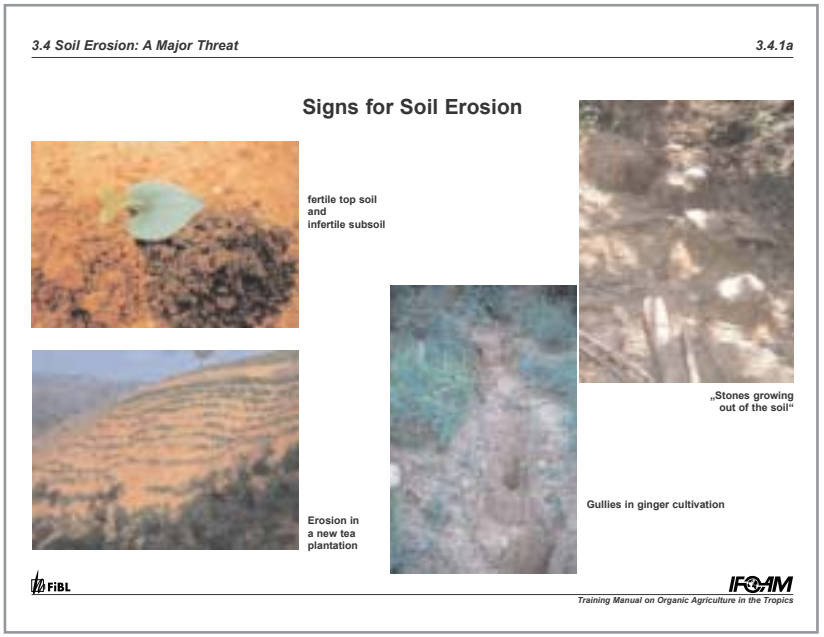
Note: Wind erosion
If appropriate, make the participants aware that in dry areas wind erosion also can have a strong negative impact on soil fertility. In an unprotected land, the wind carries away the fine clay and humus fractions of the soil, which are highly fertile. In these conditions, it is important to reduce the speed of the wind, for example, by planting hedges. This chapter focuses on soil erosion by rain.

3.4.1 How to Approach Soil Erosion

Signs for soil erosion

How can we identify whether a field is affected by soil erosion? There are some indicators:

- Deep gullies show severe and obvious soil erosion.
- Small grooves at the soil surface indicate significant losses of soil.
- A compact soil crust after a heavy rain is an indicator of probable soil erosion.
- Accumulation of fine soil material in trenches and depressions is an evidence of soil erosion in the immediate neighbourhood.
- Brown colour of the drainage water or streamlets during and after heavy rains is a reliable indicator of soil erosion in the watershed.
- Farmers say: «The stones are growing out of the soil!»
- Roots of trees are partially exposed.



Transparency 3.4.1a: Upper left: subsoil of low fertility and dark fertile topsoil; upper right: stones elevated from the soil due to erosion; bottom left: severe erosion in a new tea plantation; bottom right: Gully erosion in ginger cultivation.

Group work: Soil erosion in our area

Discuss the following questions in groups or in the plenum:

- *What sort of soil erosion problems do we observe in our area?*
- *What are the reasons for these problems?*
- *What attempts have been made to solve these problems?*
- *What were the success and failures of these attempts?*

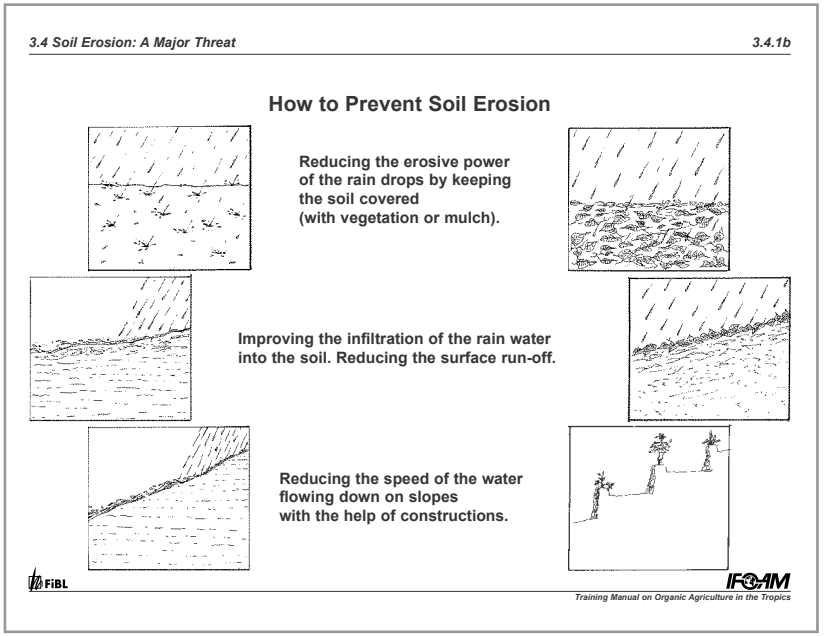
Each group shall present the main points of their discussion. Note down the most important aspects on a paper chart or on cards.

How to prevent soil erosion?

There are three general strategies for preventing soil erosion:

1. Reducing the erosive power of the rain drops by keeping the soil covered (with vegetation or mulch).
2. Improving the infiltration of the rain water into the soil.
3. Reducing the speed of the water flowing down the slopes with the help of constructions.

On sites that are highly prone to erosion, these three strategies ideally should be combined. The following two chapters will give some ideas on how these strategies can be implemented.



Transparency 3.4.1b: Three strategies to reduce soil erosion. The sketches on the left side show reasons for soil erosion, the ones on the right show approaches to reduce soil erosion.

3.4.2 Plant Cover

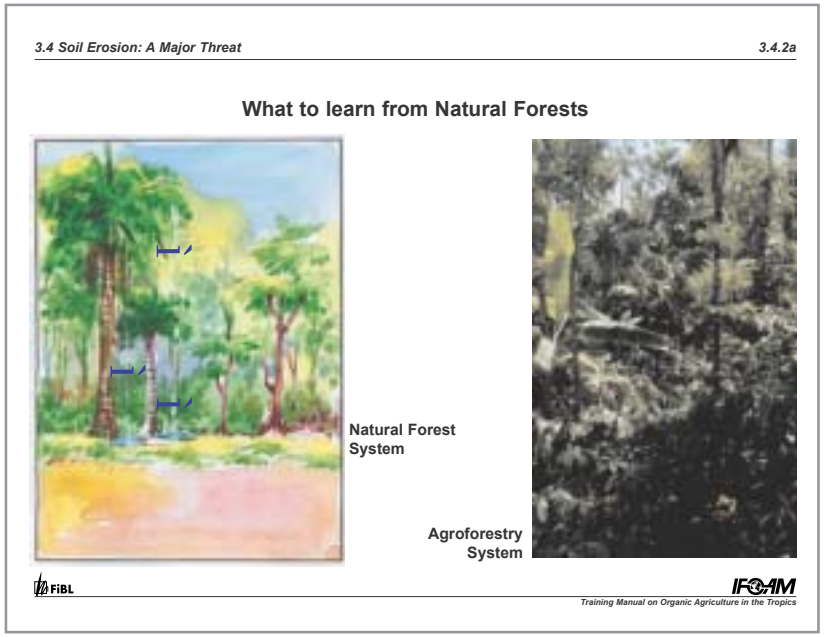
What to learn from natural forests

In natural forests, several mechanisms ensure that no erosion of the scarce and valuable top soil occurs. Several layers of dense canopy break the speed of the rain drops falling on the ground. Large drops formed on leaves of the tree-tops are caught by the canopy of shrubs and ground vegetation. The water drops reach the soil at less speed and thus have a lesser smashing effect on soil crumbles. The ground is directly covered with living plants like ferns, mosses or seedlings, and with a mixture of rotten plant materials (leaves, bark, twigs, branches etc.). The top soil is intensively penetrated by roots, fungus and algae and is rich in humus. A large number of soil organisms such as earthworms maintain a loose and stable structure where rainwater can infiltrate easily.

Motivation: Soil erosion in forests?

Ask the participants: «Why don't natural forests on slopes become subject to soil erosion? What are the mechanisms that prevent erosion in a forest?»

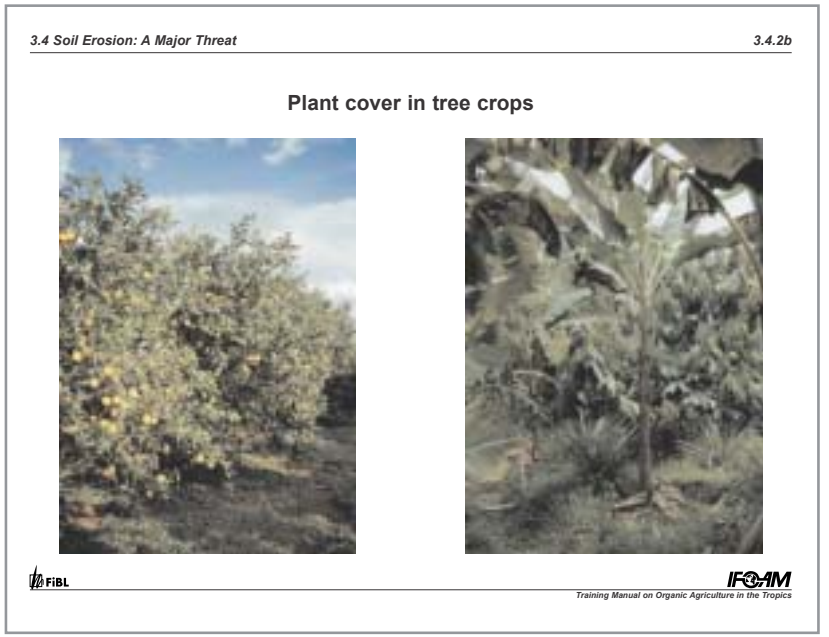
Note the answers of the participants in keywords on a board. At the end of the session, come back to the collected points for concluding.



Transparency 3.4.2a: Left: sketch of a forest section, illustrating the functions preventing soil erosion; right: photo of a agroforestry system in India (coffee, pepper, banana, coconut, timber etc.)

Dense vegetation protecting the soil
In perennial plantations such as orchards, dense vegetation can be achieved by growing legumes, grass or creepers between the trees. In new tree plantations, fodder grass and arable crops (such as tubers, pineapple, beans etc.) can be grown until the trees develop a dense canopy.
Not only crops but also grass and weeds can provide the protecting cover. If possible, weeding should be avoided before and during the rainy season, as weeds help to protect the soil. If it is necessary to cut the weeds because the competition with the crops is too strong, the cut weeds should be kept on the spot as a protecting mulch layer.

Mulching means covering the soil with cut plant material of any kind (details are described in chapter 3.6.). Owing to its multiple functions, mulch is very effective in protecting the soil from erosion. Even a few leaves or stalks will reduce the erosive power of rain drastically.



Transparency 3.4.2b: Left: photo of a citrus orchard with cover crops (Cuba), right: photo of a new cultivation of coconut and cocoa, intercropped with banana, densely covered with fodder grass and pineapple (India).

Field demonstration: Simulation on soil erosion
You can simulate the effect of rain on the soil protected by vegetation as compared to the unprotected one. Before you take the participants out (a small walk can be a nice ice-breaker), you should prepare the demonstration site:
Select an area of about one square meter on a nearby slope which is densely covered by grass, weeds or other vegetation. Remove the vegetation on half the area with a hoe. Below the selected area, dig a small ditch. Get two watering cans filled with water.

Now you can demonstrate to the participants how strong rainfall affects the two small pieces of soil. Take a watering can and intensely shower the part covered with vegetation. Observe the colour of the water flo-

wing down into the ditch. Now, shower the uncovered part with the same amount of water and again observe the colour of the water.

If the demonstration works, the water trickling down the covered site should be more or less clear, while the other from the bare soil should be more or less dark colour. The darker the water is and the more soil particles it contains, the more this specific site is prone to erosion.

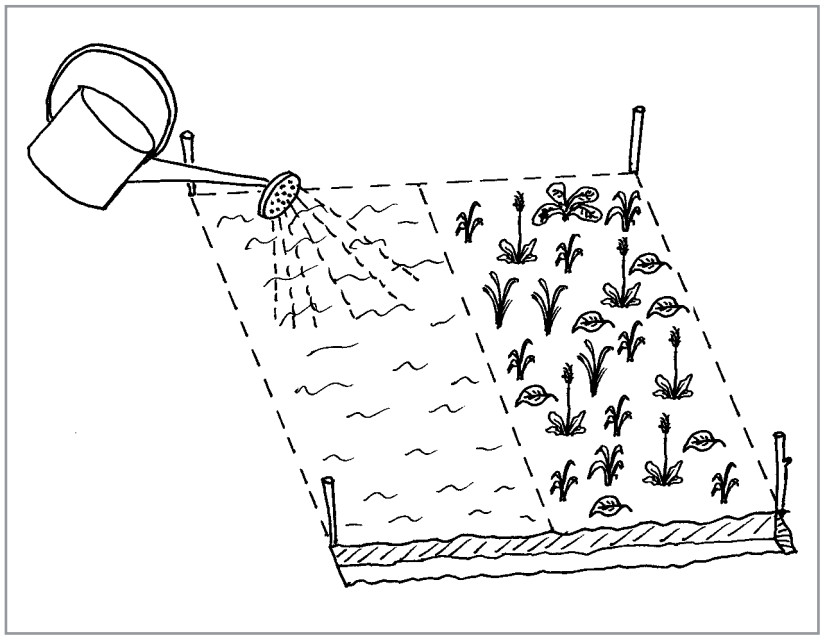


Illustration: Demonstration on soil erosion and the protective effect of plant cover

Cover crops

Every plant which covers the soil and improves soil fertility can be a cover crop. It could be a leguminous plant with other beneficial effects, or it could be a weed characterised by its rapid growth and enormous production of biomass. The most important property of cover crops is their fast growth and the capacity of maintaining the soil permanently covered.

The following characteristics make an ideal cover crop:

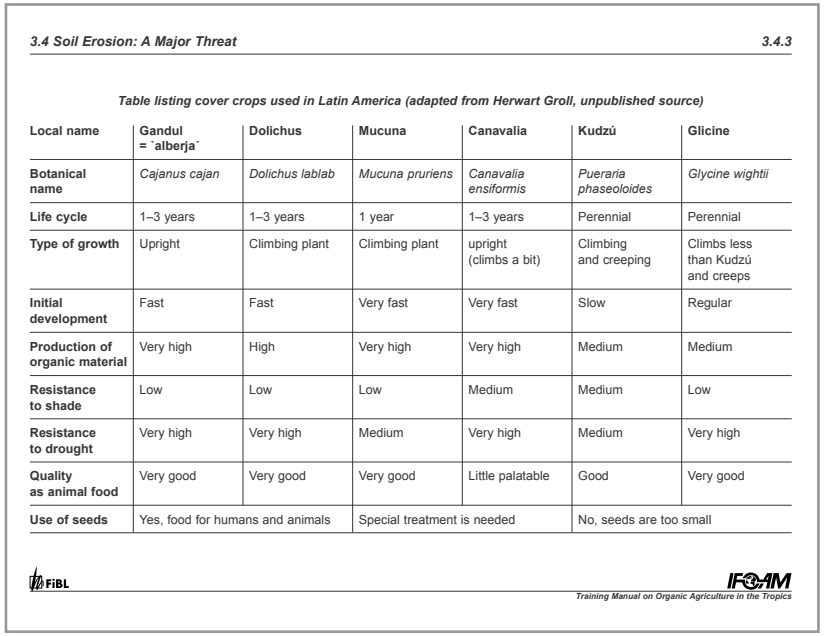
- The seeds are cheap, easy to get, to harvest, to store and to propagate.
- Be of rapid rate of growth and be able to cover the soil in short time.
- Be resistant against pests and diseases.
- Produce large amounts of organic matter and dry material.
- Fix nitrogen from the air and provide it to the soil.
- Have a de-compacting root system and regenerate degraded soils.
- Easy to sow and to manage as single crop or associated with other crops.
- Can be used as fodder, grains as food grains.

Example: Cowpea as a cover crop

Cowpea (Vigna unguiculata, French: Niébé) is an important grain legume throughout the tropics and subtropics. It has some properties which make it an ideal cover crop:

- It is drought tolerant and can grow with very little water.
- It can fix nitrogen and grows even in very poor soils.
- It is shade-tolerant and therefore compatible as an intercrop.
- It yields eatable grains and can be used as an animal fodder rich in protein.
- It is quite resistant to pest attack.

Subsistence farmers in sub-Saharan Africa usually intercrop cowpea in maize, sorghum, millet and cassava.



3.4 Soil Erosion: A Major Threat *3.4.3*

Table listing cover crops used in Latin America (adapted from Herwart Groll, unpublished source)

Local name	Gandul = ˙alberja˙	Dolichus	Mucuna	Canavalia	Kudzú	Glicine
Botanical name	*Cajanus cajan*	*Dolichus lablab*	*Mucuna pruriens*	*Canavalia ensiformis*	*Pueraria phaseoloides*	*Glycine wightii*
Life cycle	1–3 years	1–3 years	1 year	1–3 years	Perennial	Perennial
Type of growth	Upright	Climbing plant	Climbing plant	upright (climbs a bit)	Climbing and creeping	Climbs less than Kudzú and creeps
Initial development	Fast	Fast	Very fast	Very fast	Slow	Regular
Production of organic material	Very high	High	Very high	Very high	Medium	Medium
Resistance to shade	Low	Low	Low	Medium	Medium	Low
Resistance to drought	Very high	Very high	Medium	Very high	Medium	Very high
Quality as animal food	Very good	Very good	Very good	Little palatable	Good	Very good
Use of seeds	Yes, food for humans and animals		Special treatment is needed		No, seeds are too small	

FiBL IFOAM *Training Manual on Organic Agriculture in the Tropics*

Transparency 3.4.2c: Table listing cover crops used in Latin America (adapted from Herwart Groll, unpublished source)

Experience sharing: Suitable cover crop varieties

Which cover crops do participants know? Note them down on the board in a table, including their main characteristics. Discuss their suitability in organic farming in the region.

Designing Cropping Systems

Cropping systems should be designed in such a way that the soil is almost permanently covered with plant canopy. In arable crops, careful timing of sowing and planting can help to avoid uncovered soil being washed away during the rainy season. After the main crops are harvested, a green manure crop may be sown (see chapter 4.5). On slopes, crops should be grown in lines

across the slopes (along contour lines) rather than vertically. This can contribute enormously to reduce the speed of surface water.
In crops which take some time to develop a protecting canopy, intercropping of fast growing species such as beans or clover can help to protect the soil in the initial stage of the main crop.

Possible measures to ensure a permanent plant cover may have focus on:
- Timing of soil cultivation
- Timing of planting or sowing
- Producing seedlings and transplanting them
- Mixed cultivation
- Associating crops
- Cover crops
- Mulching
- Timing of weeding
- Sowing of a green manure crop in the off-season

The following aspects must also be taken into account:
- expected effect on yields
- availability of suitable species
- costs of seeds
- availability of water
- availability of labour
- additional use of side-crops
- reduction of the risk
- food security

Group work:
Cropping systems which allow a more or less permanent cover of the soil can only be designed based on the nature of local crops and conditions. If the participants are not very familiar with the cropping practices of the selected region, farmers may be invited as resource persons for the following group work:

Each group shall select a main crop in which soil erosion is found in the region. Alternatively, the critical crops may already be identified by the organisers. The groups shall draft an agricultural calendar on a paper chart in which they mark the typical agricultural activities related to the crop, such as digging, planting, weeding, harvesting, sowing a second crop etc. Indicate the dry and rainy seasons, and the periods when the soils are most affected by soil erosion. The availability of farm labour should also be taken into account. Based on this calendar, the group shall discuss options of how to adapt the cropping pattern in order to avoid soil erosion. The proposed alterations can be marked in the calendar, e.g. with a different colour. Each group presents the selected cropping system and their proposed alterations based on the calendar. Conclude with a discussion.

3.4.3 Constructions against Soil Erosion

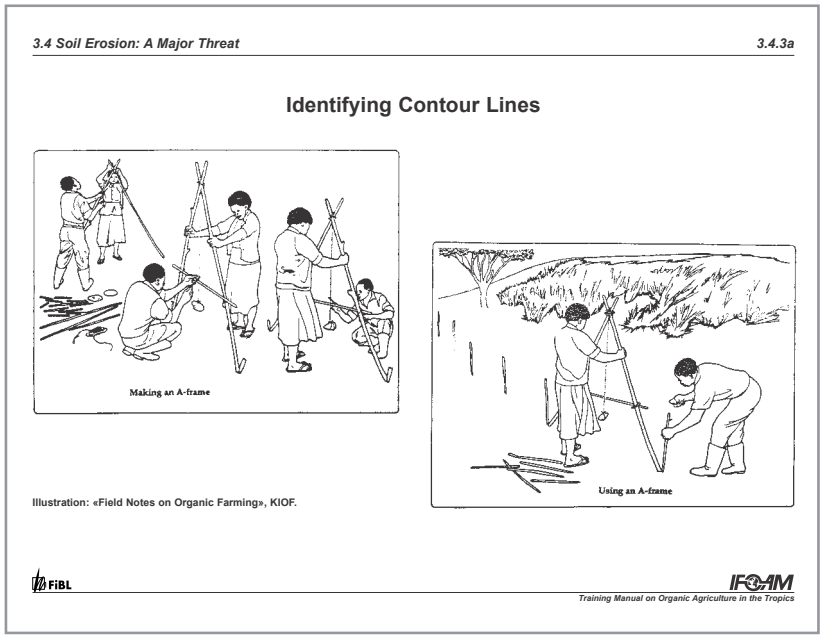
Cultivated slopes are extremely prone to soil erosion. In order to reduce the speed of water flowing down during heavy rains, constructions along contour lines are useful. Contour lines are imaginative horizontal lines across a slope.

Constructions against soil erosion aim at reducing the slope and consequently the speed of surface water. In addition, they catch and accumulate the soil eroded from above. To be effective, all constructions against soil erosion (bunds, stone walls, living barriers, trenches, terraces) must be arranged along the contour lines of a field.

There is a lot of good publications on how to plan and implement constructions against soil erosion (see "Recommended Readings"). Therefore, we provide here only a basic introduction.

Identifying Contour Lines
A simple way to identify contour lines on a slope is to use the «A-frame». The A-frame is a simple tool made from three poles, some rope, a stone and a supply of stakes.

How to build and use an A-frame
1. Fix three poles of about 2.5 meters long each in a position forming an even «A». If rope is not sufficient to tie the ends, use nails.
2. Tie one end of a piece of cord to the top of the A and fix a stone tied to the other end so that the stone is at some distance from both the ground and the crossbar.
3. Put the A-frame upright and mark the position of both legs. Then, mark the point where the string passes the crossbar of the "A".
4. Turn the A-frame so that the placement of the legs is reversed. Again mark the point where the string passes the crossbar. If the two marks are not at the same point, mark a third point with a knife exactly halfway between the first two.
5. Drive the first stake at the edge at the top of the field. Place one leg of the A-frame above and touching the stake. Place the other leg in such a position that the string passes the level position point on the crossbar.
6. Drive another stake into the ground just below the second leg. Move the A-frame and continue in the same way across the field.
7. The next contour line is placed 3 to 6 meters below the first line, depending on the slope of the site. The steeper it is, the closer the lines should be.



Transparency 3.4.3a: Building and using an A-frame for identifying contour lines (source: "Field Notes on Organic Farming", KIOF).

Field demonstration: Using the A-frame
The construction and use of an A-frame can easily be demonstrated following the above guide. Take the group to a slope and try to identify the contour lines with the A-frame. This demonstration can also be combined with the field demonstration below.

Some constructions against soil erosion

Wooden barriers and stone walls

- Simple barriers can be constructed using tree trunks and branches. They accumulate eroded soil behind them, thus preventing it from being washed away.
- The construction of stone walls needs more time, but they last longer and the maintenance work is rather less. They are suitable on steep slopes and in areas where plenty of stones are available.

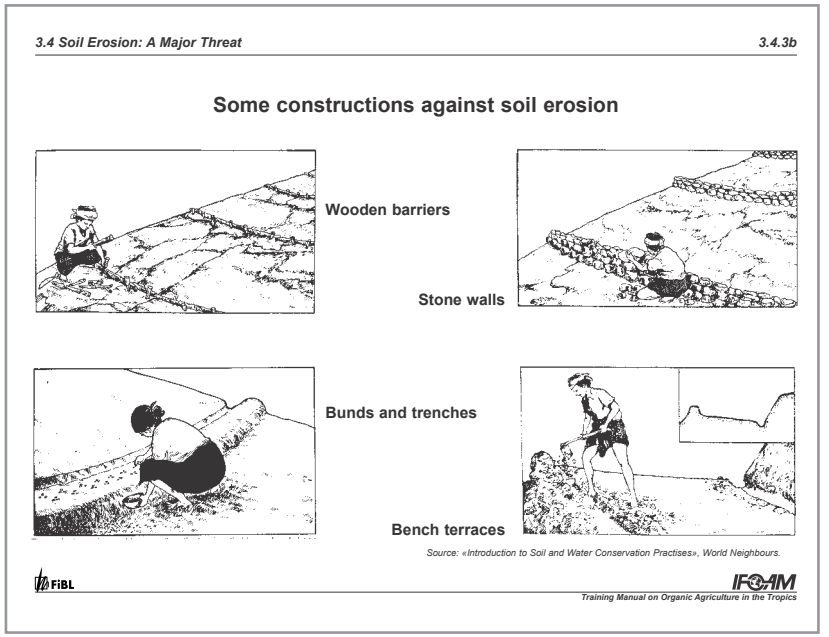
Bunds and trenches

- Earth or mud bunds are comparatively easy to build, but need more efforts for maintaining them. In addition, fodder grass, hedges, pineapple or other crops can be planted on them.
- The bunds can be combined with contour trenches. They help to keep back eroded soil and increase the infiltration of water.

Bench terraces

- Constructing bench terraces requires time and energy, but the terraces are very efficient in erosion control and help to build up soil fertility.
- When digging the terraces, it is important that the fertile top soil is kept aside and later spread on the finished terrace.

The following section gives an overview on some types of constructions against soil erosion. Depending on the local conditions, put more or less emphasis on a specific type. Refer to examples of constructions in the area.



Transparency 3.4.3b: Sketches of wooden barriers, stone walls, mud bunds and bench terraces.

Field demonstration: Constructions against soil erosion

The decision on which construction to use for preventing soil erosion on an affected site, several aspects should be taken into account. Discuss with the participants what must be taken into consideration when planning constructions against soil erosion. Note down their suggestions on a board and complement them.

Living Barriers

Constructions alone will not be sufficient to prevent soil erosion unless they are combined with plants. Plant roots help to enforce the walls, dikes and trenches, thus preserving them from destruction by heavy rains.

- If constructions are planted on with fodder grass, hedges, pineapple or other suitable crops, they are no longer a loss of space for the farmer and therefore they provide double use.
- When hedges are grown very densely along contour lines, they themselves can become a living barrier without any construction work. On light slopes, they can contribute to terracing and levelling the site over the years, as eroded soil gets accumulated at the hedges.

Andropogon gayanus: A suitable grass species in African Sahel

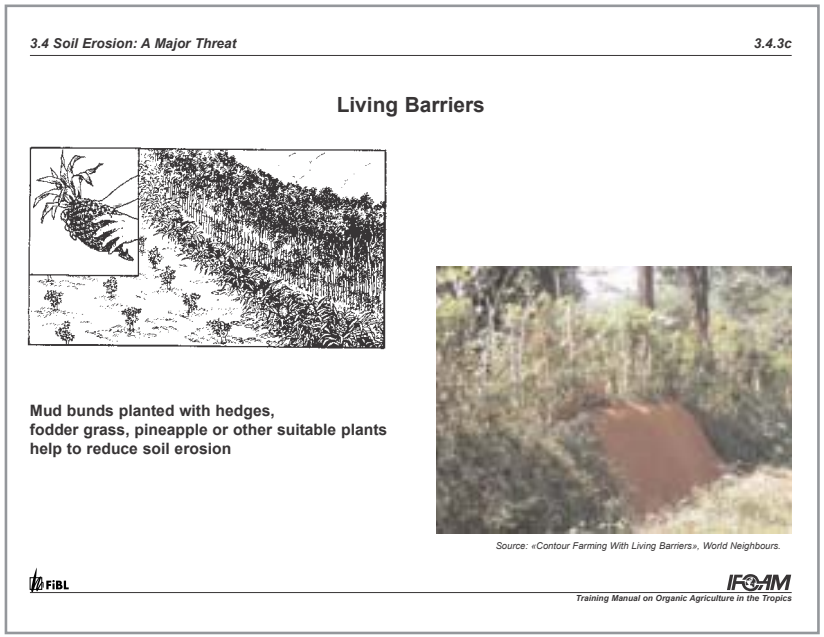
An example of a useful grass species is Andropogon gayanus, an African perennial grass. It spreads naturally from the Southern Sudanian area to Sahel. The following characteristics make it a very suitable variety for living barriers and soil covers:

- Deep and strong rooting
- Resistant to fire, termites and drought
- Grows in clay soils as well as in sandy soils
- Abundant and fast growth
- Stems reach lengths between 1 and 2.5 m
- Tolerates cutting

It can be cultivated either by direct sowing at the site or by transplanting saplings, preferably at the beginning of the rainy season to avoid additional work with watering. When planted on the contours, it limits erosion by water and wind and increases water infiltration. In addition, it is an excellent fodder and also helps exhausted soils to recover.

Depending on the local context, the following points may be relevant:

- *The site conditions (degree of slope, depth and stability of soil etc.).*
- *The availability of construction material (trunks, stones).*
- *The availability of labour.*
- *The costs of construction and maintenance.*
- *The additional value through planting grass, hedges or crops on the constructions.*



Transparency 3.4.3c: Left: sketch of a dense hedge and pineapple planted along contour lines; right: photo of a mud bund planted with a hedge in India.

Experience sharing: Identifying suitable grass species

Which grass species did participants use or observe in their area? Collect the local and/or scientific names of the varieties and discuss the advantages and disadvantages of each variety.

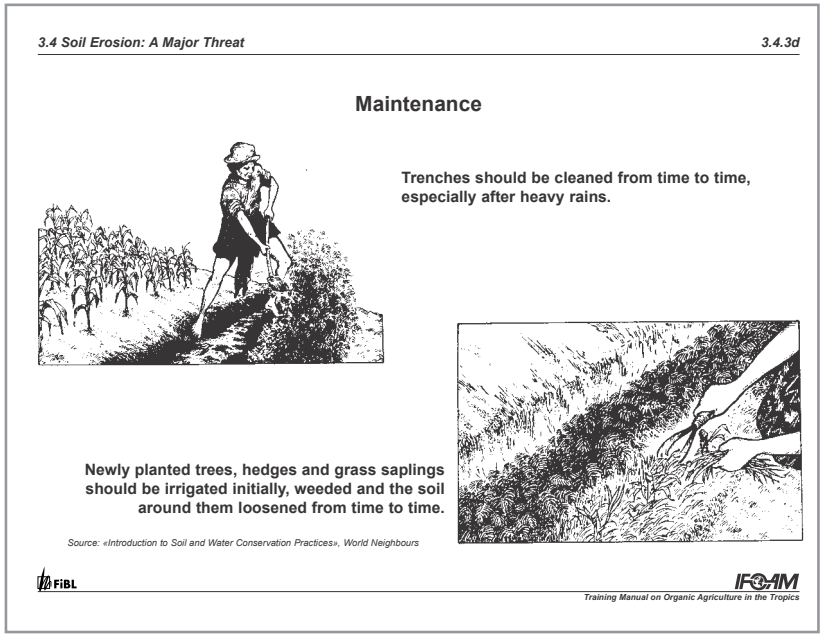
Field demonstration: Preventing soil erosion

An experimental site is selected on a slope, which shows signs of soil erosion or is not cultivated yet. Participants are divided into groups, each group gets a specific plot within the site, a resource person for a specific method (e.g. for dikes/trenches, cover crops, contour hedges, water harvesting etc.) and a selection of materials (A-frame, tools, tree saplings, grass slips, seedlings and seeds of cover crops, mulch material etc.). Each group shall discuss how their plot could be improved or developed, with focus on the respective method. They commonly design an appropriate cropping system and land development and start implementation on a few square meters. The effect of the measures can be tested with a watering can. If the sites are maintained with the respective approach for one or two years, they can be used as a demonstration plot for future trainings.

Maintenance

To be effective careful maintenance of the constructions is important. Walls and dikes should be repaired if damaged. Trenches should be cleaned from time to time, especially after heavy rains. The accumulated soil is of good fertility and should be returned to the fields. Newly planted trees, hedges and grass saplings should be irrigated initially, weeded appropriately and the soil around them loosened from time to time.

After heavy rains, the colour of streams and rivulets from an area is a good indicator for the degree of soil erosion at the site and therefore for the effectiveness of the measures.



Transparency 3.4.3.d: left: sketch of cleaning trenches; right: sketch of weeding between seedlings of a hedge on a mud bund.

Recommended Readings

- *«Introduction to Soil and Water Conservation Practises», Practical Guide to Dryland Farming I, World Neighbours*
- *«Contour Farming with Living Barriers», Practical Guide to Dryland Farming II, World Neighbours*