

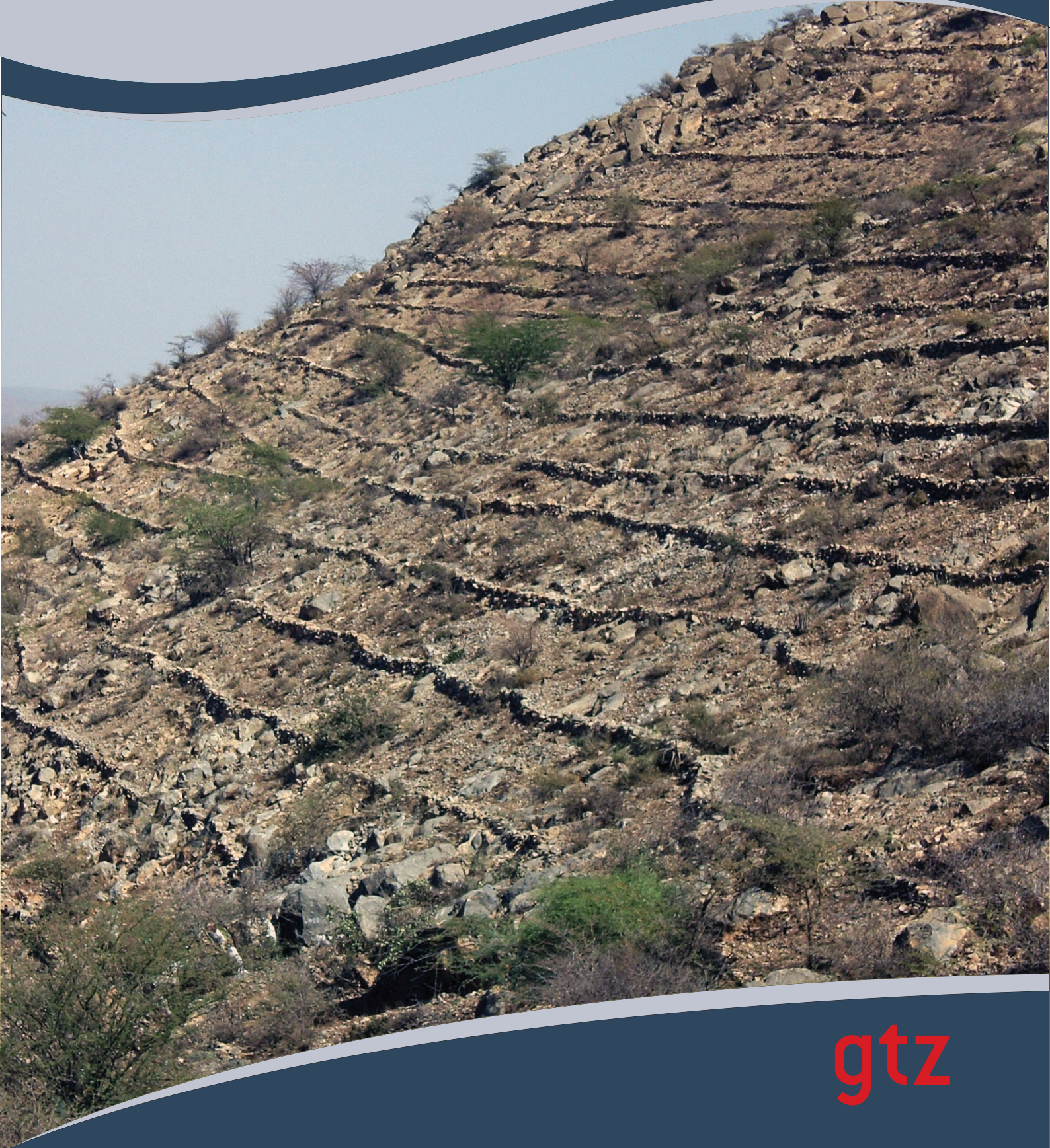


**Sustanet E.A.**

Sustainable Agriculture Information Initiative

Technical Manual

# **SOIL AND WATER CONSERVATION**



**gtz**





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Sustainable Agriculture Information Initiative is a regional network, non-profit non-governmental organization that promotes sustainable agriculture along value chains to improve the quality of lives of the rural poor through participatory approaches, documentation, lobbying and advocacy, knowledge and information management and sharing, and capacity building with stakeholders in the Eastern Africa region.



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Promotion of Private Sector Development in Agriculture (PSDA) is a bilateral development programme jointly implemented by GTZ and the agriculture sector ministries in Kenya. PSDA is supporting SUSTAINET to scale up Conservation Agriculture along the value chain in Western Kenya



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The Food Agriculture Organization (FAO) of the United Nations leads international efforts to defeat hunger. Since 2004 and together with partners such as ACT and governments, it has been implementing a project in East Africa entitled 'Conservation Agriculture for Sustainable Agriculture and Rural Development (CA-SARD)' during which training constituted a major project activity.



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The ACT Network promotes the sharing of information and experiences and facilitates the adaptation and adoption of conservation agriculture technology across Africa.

ACT collaborates with SUSTAINET in implementation of Conservation Agriculture projects in Eastern Africa.

Published 2010 by Sustainable Agriculture Information Initiative

Design & Layout: Skyward Design & Marketing Ltd.

Printed in 2010 by Assup Enterprises P.O. BOX 67275-00100, Nairobi, Kenya.

#### **Correct citation**

SUSTAINET EA 2010. Technical Manual for farmers and Field Extension Service Providers: *Soil and Water Conservation*. Sustainable Agriculture Information Initiative, Nairobi.

ISBN 978-9966-1533-8-8



# TABLE OF CONTENTS

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<b>PREFACE .....</b>	<b>v</b>
<b>1.0 Introduction .....</b>	<b>1</b>
Overview.....	1
Definitions. ....	1
1.1 What is soil conservation? .....	1
1.2 What is water conservation?.....	1
1.3 Benefits of soil and water conservation .....	1
<b>2.0 Types of conservation measures .....</b>	<b>1</b>
2.1 Agricultural conservation measures .....	1
2.2 Crop management .....	1
2.1.2. Soil management .....	1
2.1.3: Agro-forestry.....	2
2.1.4: Contour farming practices – .....	2
2.2: Physical soil conservation measures .....	2
2.2.1: Cut – off drains. ....	2
2.2.2: Retention ditches .....	2
2.2.3: Infiltration ditches .....	2
2.2.4: Water-retaining pits.....	3
2.2.5: Broad beds and furrows.....	3
2.2.6: Terraces - Fanya Juu, Fanya Chini, Bench terraces, Stone terraces .....	3
<b>3.0 Challenges in soil and water conservation .....</b>	<b>4</b>
<b>Soil conservation on the slopes of Mt. Kilimanjaro .....</b>	<b>5</b>



## PREFACE

There are several initiatives in Eastern Africa to promote sustainable agriculture practices as environment-friendly and alternative to conventional agriculture. However, little has been done to document the good agricultural practices or even lessons learnt from these initiatives. Farmers today still lack access to information on sustainable agriculture practices. Sustainable agriculture seeks an environmentally sound, socially equitable and economically viable ways to produce to meet the needs of the present without compromising those of future generations.

SUSTAINET EA as a regional Network operating in Eastern Africa endeavours to bridge the information gap on Sustainable Agriculture to reach smallholder farmers through publication of simplified technical manuals on good agricultural practices. These manuals contain useful technical information on good agricultural practices that offer practical answers to questions normally asked by farmers of what, why, how. The manuals' focuses are on:

1. Agroforestry practices
2. Dairy Goat Improvements
3. Soil and Water Conservation
4. Conservation Agriculture
5. Nine-seeded Hole
6. Integrated Agriculture System
7. Organic pineapple production
8. Certification of organic products
9. Groundnut Production
10. Farmer Field School.

This manual is part of SUSTAINET's effort to promote sustainable agriculture in the region. It is developed to reflect the experiences and views sustainable agriculture practitioners (farmers, researchers, member organizations and institutions of higher learning).

This manual is intended primarily for farmers and field extension service providers. It is written in simple English language with illustrations, and easy to understand.

The process of documenting and publishing the manuals was supported by funding from GTZ, and FAO. We thank our member organizations and collaborators for their useful contributions to the manuals' development.

### **Manual Development Process.**

This manual was prepared from good agricultural practices (GAPs) documented and published in 2006. The process was participatory and interactive among the key stakeholders. This interactive process culminated into a writeshop that was held in Naivasha. The writeshop process was facilitated by Chancery Media.

The writeshop began with presentation of the GAPs by the facilitators. The participants included extension staff from various organizations in East Africa, ACT and SUSTAINET staff, research scientists from Nairobi and Sokoine universities, and artists. The participants were divided into groups to discuss the GAPs and develop them into manuals. This was followed by plenary presentations where participants gave positive critiques. Another groups' discussion to include comments from the participants were held, followed with plenary presentations. Chancery Media then refined the language and presentations.



Tom Apina  
Executive Secretary SUSTAINET E.A





## 1.0 INTRODUCTION

### Overview

Because water is a scarce commodity in many parts of East Africa, its conservation and sustainable use is important to farmers. Sustainable agriculture therefore conserves water in the soil through a variety of methods almost similar to the methods used to control soil erosion. There are several techniques to conserve top soil and prevent it from being washed or blown away.

### Definitions.

#### 1.1 What is soil conservation?

It is the prevention and reduction of the amount of soil lost through erosion. It seeks to increase the amount of water seeping into the soil, reducing the speed and amount of water running off. Erosion is prevented by keeping enough vegetation to protect the soil surface and binds the soil together and maintains soil structure.

#### 1.2 What is water conservation?

This is a way of tapping as much water as possible and storing it in tanks or reservoirs. It allows water to sink into the soil increasing soil moisture levels. It ensures a protective cover of vegetation on the soil surface, slowing down the flow of running water and spreads the water over a large area.

#### 1.3 Benefits of soil and water conservation

- Conserving water makes it available for crops, livestock and domestic use over a longer period
- Controlling soil erosion improves crop and pasture yields.
- Conservation measures improve the supply of fuel and forest products.
- They increase the value of the land.
- Terraces make cultivating steep slopes easier.
- More and better livestock fodder is available.

## 2.0 TYPES OF CONSERVATION MEASURES

### 2.1 Agricultural conservation measures

These are practices such as mixed cropping, contour cultivation, mulching, and manuring

### 2.2 Crop management

Good crop management reduces soil erosion by water and wind and improves soil fertility.

#### Crop selection.

Perennial crops are more effective in soil conservation than annual crops. Tea, fodder grasses, sugar cane and sweet potatoes are among the most effective.

#### Early planting.

This ensures that the crop shoots from the ground within one or two weeks after the onset of the rains and protects the ground against raindrop impact.

#### Crop rotation.

Crop rotation ensures the addition of humus, soil fertility, control of erosion and reduction of pests and diseases.

#### Inter-cropping.

Fast growing legumes such as beans and cowpeas provide soil cover early in the season before maize or cotton develop a canopy to shield the soil from impact of raindrops.

#### Cover cropping

- This is the growing of crops to cover cultivated ground, reducing erosion by raindrop splash and overland flow.
- It protects the soil from excessive heat and creates a good environment for microorganisms.
- The fallen leaves of the cover crop decompose and add organic matter to the soil.

#### Strip cropping

This is growing alternate strips of different crops in the same field. It controls water and wind erosion.

Contour strip cropping combined with crop rotation and minimum tillage is an effective method of soil and water conservation.

### 2.1.2. Soil management

Inappropriate land use activities often cause changes in soil conditions, which in turn contribute to soil erosion. Soil management is to create optimum conditions for plant growth through improved soil fertility and structure. It increases infiltration rates, improve water-holding capacity, and reduce runoff and erosion.

#### Use appropriate tillage practices:

Tillage aims to optimize soil physical and biological conditions for crop production and to ensure timely

seedbed preparation, planting and weed control. Use an appropriate tillage practice that;

- Does not make the surface soil too fine and powdery; and
- Breaks up the hardpan if necessary.

The main tillage methods are slash and burn, hand hoeing, ploughing and harrowing, conservation or minimum tillage, deep tillage.

### Applying organic manures and mineral fertilizers

- Adding manure and fertilizers to the soil provides the required plant nutrients for vigorous crop growth.
- Fast growth gives quicker cover to the ground and higher yields.
- Inorganic fertilizers provide major plant nutrients - nitrogen, phosphorus, potassium, and occasionally sulphur - that are needed by plants.
- Inorganic fertilizers are no substitute for organic matter, and therefore should be used in combination. Sources of organic fertilizers include farmyard manure, compost, and green manuring.

### Mulching and the use of crop residues

Dead plant materials such as dry grass, straw, dry leaves, banana leaves, sugar cane trash, and other crop residues are spread on the bare soil surface or placed around the stem of the plants to control soil erosion and conserve moisture.

### 2.1.3: Agro-forestry

- Agroforestry involves planting trees or shrubs, or keeping those that are already there.
- Trees cushion the impact of raindrops on the soil, so reducing the amount of rain-splash erosion.
- They shade the soil, reducing the soil temperature and cutting the amount of water that would evaporate into the air.
- They break the wind, reducing the amount of wind erosion.
- They recycle nutrients from deep in the soil; leguminous trees fix nitrogen that benefits food crops.

### 2.1.4: Contour farming practices –

Contour farming involves ploughing, planting and weeding along the contour that is across the slope rather than up and down.

Contour farming reduces soil erosion by as much as 50% on gentle slopes.

- **Contour ridges** are used in semi-arid areas to harvest water, and in higher rainfall areas for growing potatoes.
- **Trash-lines** are constructed by laying plant residues in lines along the contour. Trash-line help in slowing down the runoff and trapping eroded soil.
- **Grass barrier strips** of Napier or other fodder grasses are planted along the contour.

## 2.2: Physical soil conservation measures

Physical soil conservation structures are permanent features made of earth, stones or masonry, designed to protect the soil from uncontrolled runoff and erosion and retain water where needed.

- Selection and design of structures depend on:
- Climate and the need to retain or discharge the runoff
- Farm sizes
- Soil characteristics (texture, drainage, and depth)
- Availability of an outlet or waterway
- Labour availability and cost
- Adequacy of existing agronomic or vegetative conservation measures.

Below are some of the physical conservation measures:

### 2.2.1: Cut – off drains.

Cut-off drains are dug across a slope to intercept surface runoff and carry it safely to an outlet such as a canal or stream. They are used to protect cultivated land, compounds, and roads from uncontrolled runoff, and to divert water from gully heads.

### 2.2.2: Retention ditches

These are dug along the contours to catch and retain incoming runoff and hold it until it seeps into the ground. They are an alternative to cut-off drains when there is no nearby waterway to discharge the runoff. They are often used to harvest water in semi-arid areas.

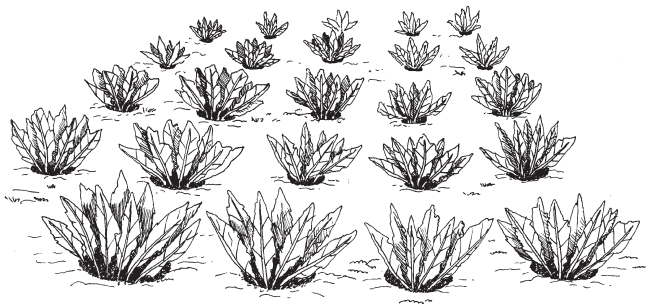
### 2.2.3: Infiltration ditches

This is a structure designed to harvest water from roads or other sources of runoff. They consist of a

ditch 0.7-1.5m deep, dug along the contour, upslope from a crop field. Water is diverted from the roadside into the ditch, which is blocked at the other end. Water trapped in the ditch seeps into the soil.

#### 2.2.4: Water-retaining pits

Water-retaining pits trap runoff and allow it to seep into the soil. A series of pits are dug into the ground where runoff normally occurs. The soil from the pit is used to make banks around the pits. Furrows carry excess water from one pit to the next. The size of the pit depends on the amount of runoff: a typical size is 2m square and 1m deep.



#### 2.2.5: Broad beds and furrows

In a broad bed and-furrow system, runoff water is diverted into field furrows (30cm wide and 30 cm deep). The field furrows are blocked at the lower end. When one furrow is full, the water backs up into the head furrow and flows into the next field furrow. Between the field furrows are broad beds about 170cm wide, where crops are grown.

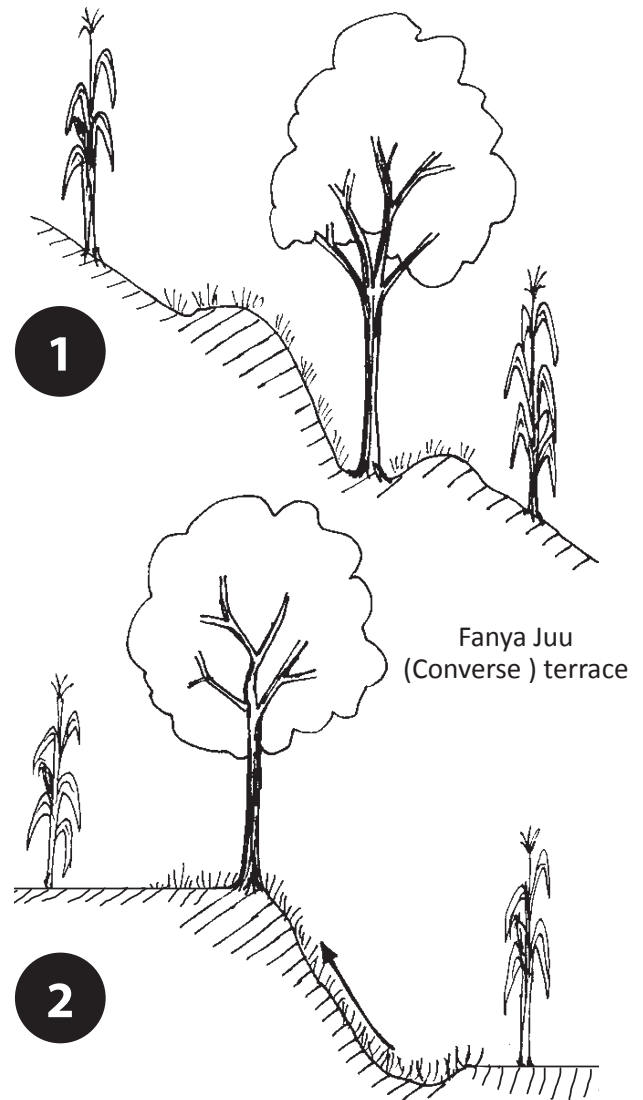
#### 2.2.6: Terraces - *Fanya Juu*, *Fanya Chini*, Bench terraces, Stone terraces

##### *Fanya Juu* (Converse) terrace

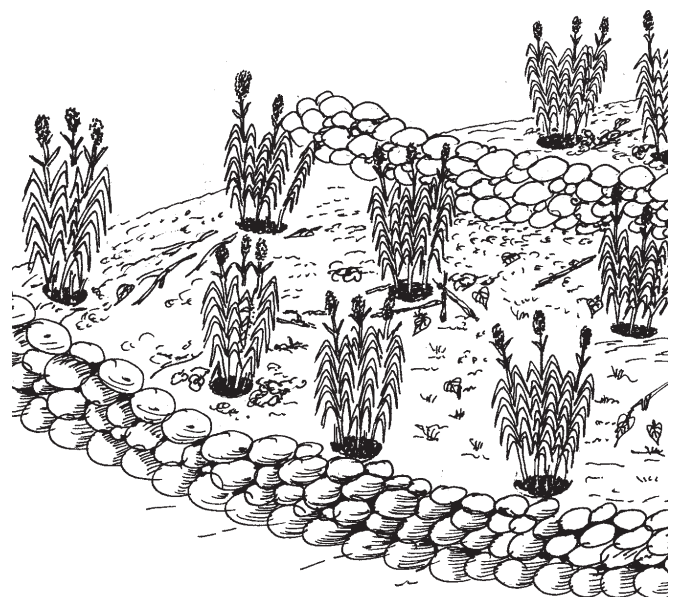
*Fanya juu* terraces are made by digging a trench along the contour and throwing the soil uphill to form an embankment. The embankments are stabilized with fodder grasses and in between cultivated portions. Over time, the *fanya juu* develop into bench terraces. Useful in semi-arid areas to harvest and conserve water. The measure is suitable for soil too shallow for level bench terracing and moderate slopes below 20%. However, they are not applicable on stony soils.

##### *Fanya chini* (narrow based channel)

*Fanya chini* are made by digging a trench along the contour and the soil is put on the lower side of the contour trench. It is used to conserve soil and divert



Fanya juu terraces after several years



Stone terraces and water retention pits

water. The embankment can be used to grow fodder. this is applicable on slopes of up to 20%.

**Bench terraces**

These are level or nearly level steps constructed or formed on the contour and separated by embankments known as risers. They are formed by excavation or developed from grass strips or fanya juu terraces. Suitable on slopes up to 55%.

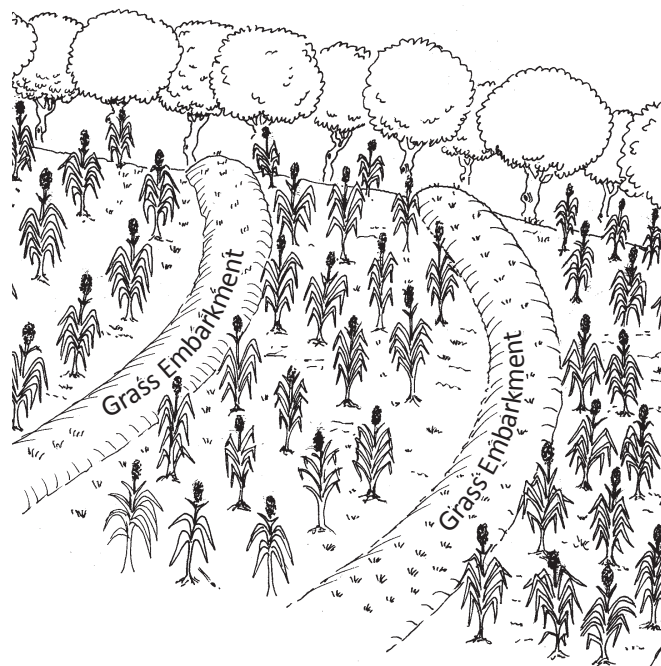
**Stone terraces**

Stone terraces are useful in areas with steep slopes but high population density and scarce land. The terrace risers are made of stones collected from the land.

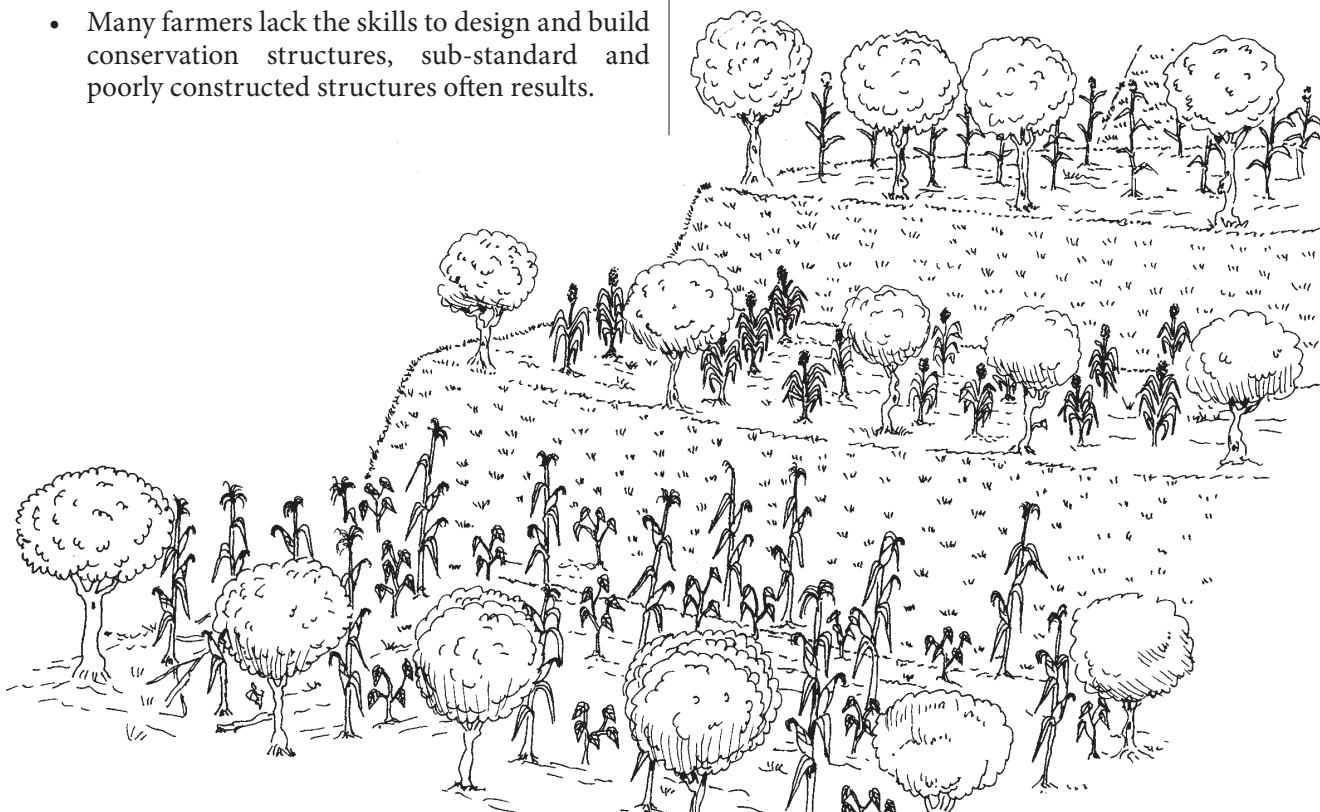
- Land tenure systems determine the ownership of the structures and influence farmers’ interest in conservation and in maintaining the structures.
- Irregular rainfall reduces the effectiveness of vegetative erosion-control practices.

**3.0 CHALLENGES IN SOIL AND WATER CONSERVATION**

- Fragmented land ownership makes it difficult for farmers to invest optimally in soil and water conservation.
- Conservation structures need a lot of labour to build and maintain.
- Crop production in semi-arid areas involves many risks, including flooding. This makes it difficult for farmers to realize the full benefits of conservation.
- Many farmers lack the skills to design and build conservation structures, sub-standard and poorly constructed structures often results.



Bench terraces embarked with grass



Bench terraces embarked with trees

### **Soil conservation on the slopes of Mt. Kilimanjaro**

*Farmers growing crops along the slopes of Mt. Kilimanjaro are realizing increased productivity. Maize yields have increased from about 1.3 t/ha to 2.6 t/ha, sunflower from 0.6 t/ha to 1.1 t/ha and beans from 0.7 t/ha to 1.2 t/ha. Livestock fodder is no longer a problem. There is remarkable increase in milk production. The improvement in productivity is due to increased adoption of soil conservation measures by the farmers.*

*The good work was initiated by Himo Environment Management (HEM) Trust Fund, an NGO based near the town of Himo, in Moshi District, close to Mt. Kilimanjaro. Among other HEM's interventions around Mt. Kilimanjaro, soil and water conservation is the most important. HEM introduced the intervention by conducting a situation analysis and participatory rural appraisals in the 19 villages. Working through and with the existing local structure and Government agencies, HEM trained village leaders and village-level extension workers on soil and water conservation. The trained local leaders then trained the farmers. Through kazi jumuia strengthened by by-laws, all the farmers participated in the programme.*

*The 19 villages are the models in which soil and water conservation is practiced in the region. Some of the conservation measures adopted by the farmers are: contour farming, grass strips, mixed cropping, crop rotation, mulching, fanya juu, terracing and check dams.*

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## SUSTAINABLE AGRICULTURE

Sustainable agriculture is a farming practice that is economically viable and socially acceptable. Practice aims at conserving land, water and genetic resources for future generations.

This manual is for farmers and extension workers in Eastern Africa region. It is intended to assist farmers and extension workers to scale up identified and tested Good Agricultural Practices (GAPs) based on the farmer experience. The manual therefore contributes to improving agricultural productivity, conserving natural resource base and building resilience of farmers to the negative effects of climate change.

This manual is based on the experience and skills of innovative farmers practicing Good Agricultural Practices (GAPs) in Eastern Africa region. GAPs refer to practices which work particularly well and are therefore exemplary in character. For SUSTAINET EA, a GAP must have measurable output/results, transferrable to other regions, easily adaptable, sustainable and environmentally sound. Other characteristics are economic viability, and socio-cultural acceptability.

This manual is written in clear and simple easy-to-understand language with simple illustrations. Case studies in this book demonstrate how farmers have adopted and practised the Good Agricultural Practice in a sustainable way

ISBN 978-9966-1533-8-8



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