NATURAL RESOURCES CONSERVATION AND DEVELOPMENT

NTQF Level -II

Learning Guide #41

Unit of Competence: - Participate in Indigenous Soil and Water Conservation Practices

Module Title: - Participating in Indigenous Soil and Water Conservation Practices

LG Code:- AGR NRC2 M09 LO4-LG#41

TTLM Code: AGR NRC2 TTLM 0919v1

LO 4: - Implement and maintain Indigenous erosion control structures

Instruction Sheet	Learning Guide #41

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Constructing indigenous/introduced soil and water conservation practices
- Notifying and reporting breaches of erosion control
- Applying Industry practices for erosion control
- Inspecting maintenance schedule

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Construct indigenous/introduced soil and water conservation practices
- Note and report breaches of erosion control
- Apply Industry practices for erosion control
- Inspect maintenance schedule

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the "Information Sheets 1". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the "Self-check 1" in page 5.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
7. Submit your accomplished Self-check. This will form part of your training portfolio.
8. Read the information written in the "Information Sheet 2". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
9. Accomplish the "Self-check 2,3,4,etc" in page ______.
10. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).

11. Read the information written in the “Information Sheets 3 . Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page 11.
13. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page 12. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
15. Read the “Operation Sheet 1” and try to understand the procedures discussed.
16. If you earned a satisfactory evaluation proceed to “Operation Sheet 2” in page 13. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
17. Read the “Operation Sheet 2” and try to understand the procedures discussed.
18. If you earned a satisfactory evaluation proceed to “Operation Sheet 3” in page 14. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
19. Read the “Operation Sheet 3” and try to understand the procedures discussed.
20. Do the “LAP test” in page 15 (if you are ready). Request your teacher to evaluate your performance and outputs. Your teacher will give you feedback and the evaluation will be either satisfactory or unsatisfactory. If unsatisfactory, your teacher shall advice you on additional work.

Information Sheet-1	Constructing indigenous/introduced soil and water conservation (SWC) practices

1.0 Constructing indigenous/introduced soil and water conservation (SWC) practices

1.1. Indigenous soil and water conservation (SWC) practices

Introduction

For quite a long time, soil and water conservation has been considered a more or less technical issue, based on years of dominantly biophysical problem-oriented research on factors such as climate, soils, topography, vegetation, etc. Consequently, many SWC guidelines were published with dominantly technical character. Much less information is available concerning solution-oriented research including that addresses, among other things, also negative side effects, about the compatibility of technical solutions with prevailing socio-cultural and economic settings of a specific area, and about the process of adapting SWC to such settings.

In the 1980s, SWC in Ethiopia focused on preventing further decline of the remaining soil resources and to rehabilitate already degraded soils. It was most unfortunate that the issue of resource management was split into different tasks addressed by different ministries and departments – e.g. controlling soil erosion (Community Forestry and Soil Conservation Department; SCRP) and agricultural production (Agronomic Development Department, Institute of Agricultural Research) – without appropriate coordination. In the course of the political changes in 1991, Ethiopian farmers began on a large scale, removing and modifying SWC schemes that were previously established by the government under the food for work program. These reactions can be seen as an eye-opener for many SWC experts who had to learn that SWC could only be made effective if it’s economic viability and social acceptability is given the same attention as ecological soundness and technical feasibility.

Particularly under subsistence farming, successful SWC interventions faced a common challenge: if the measures were viable for the farmer, they were often insufficiently controlling erosion; if they controlled erosion effectively, they were often too costly and no longer viable, leave alone acceptable. It seems difficult if not impossible to develop standard solutions fulfilling all requirements simultaneously (soundness, feasibility, viability, acceptability). In this context, it should not be forgotten that “assessment” means personal judgment, that farmers and experts have different aims and perceptions, and that they may not always agree on the same assessment criteria! Instead, SWC seems always to be a compromise under the given local conditions.

What is indigenous knowledge?

As quoted by the World Bank (1997), Warren (1991) and Flavier (1995) present typical definitions by suggesting: Indigenous knowledge (IK) is the local knowledge – knowledge that is unique to a given culture or society.

Why is indigenous knowledge important?

In the emerging global knowledge economy a country’s ability to build and mobilize knowledge capital, is equally essential for sustainable land management as the availability of physical and financial capital (World Bank, 1997). The basic component of any country’s knowledge system is its indigenous knowledge. It encompasses the skills, experiences and insights of people, applied to maintain or improve their livelihood.

Significant contribution to global knowledge have originated from indigenous people, for instance in human and veterinary medicine, with their intimate understanding of their environments, local people had developed knowledge systems that contributed to modern medicine and health care. Indigenous knowledge is developed and adapted continuously to gradually changing environments and passed down from generation to generation and closely interwoven with people’s cultures and values. Indigenous knowledge is also the social capital of the poor, their main asset to invest in the struggle for survival, to produce food, to provide for shelter or to achieve control of their own lives.

Indigenous knowledge is part of the lives of the rural poor

The livelihood of the rural poor depends almost entirely on specific skills and knowledge essential for their survival. Accordingly for the development process, indigenous knowledge is of particular relevance for the following sectors and strategies:

- Agriculture
- Animal husbandry and ethno-veterinary medicine
- Use and management of natural resources
- Primary health care, preventive medicine and psychosocial care
- Savings and lending
- Education
- Community development
- Poverty alleviation through self-help and societal care

Indigenous knowledge is relevant on three levels for the development process

1. It is, obviously, most important for the local community, in which the bearers of such knowledge live and produce, to make a living under the given biophysical, social, economic and cultural conditions.

2. Development agents (Community Based Organizations (CBOs), Non Governmaen-tal Organizations (NGOs), governments, donors, local leaders, and private sector initiatives) need to recognize it, value it and appreciate it in their interaction with the local communities. Before incorporating it in their approaches, they need to understand it and critically validate it against the usefulness for their intended objectives (Kibwana et al., 2001b).

3. Lastly, indigenous knowledge forms part of the global knowledge. In this context, it has a value and relevance in itself. Indigenous knowledge can be preserved, transferred, or adapted elsewhere.

The development process interacts with indigenous knowledge

Three scenarios can be observed when designing or implementing development programs or projects. A development strategy either:

1. relies entirely or substantially on indigenous knowledge,
2. Over rides indigenous knowledge, or
3. incorporates indigenous knowledge.

Planners and implementers need to decide which path to follow. Rational conclusions are based on determining whether indigenous knowledge would contribute to solving existing problems and achieving the intended objectives. In most cases, a careful amalgamation of indigenous and external knowledge would be most promising, leaving the choice, the rate and degree of adoption and adaptation to the clients.

External knowledge does not necessarily mean modern technology, it includes also indigenous practices developed and applied under similar conditions elsewhere.

These techniques are then likely to be adapted faster and applied more success-fully. To foster such a transfer, a sound understanding of indigenous knowledge is needed. This requires means for the capture and validation, as well as for the eventual exchange, transfer and dissemination of indigenous knowledge.

Indigenous soil and water conservation (ISWC)

Indigenous SWC is used to describe a practice or an idea which has either been generated locally or which has been introduced and then transformed and incorporated by the local people into their farming systems to improve their livelihood (UNDP/RELMA/Sida, 1999).

In many publications the term “local” and “traditional” are used synonymously with “indigenous”. Those who discover the new techniques (not inherited from family or imposed by extension system) are the innovator farmers who could be acting as groups or as individuals in a given community (Yohannes, 2001). Obviously and with less oversimplification of the issue, every farmer is to some degree an innovator considering the wide-ranging diversity of farm operational activities at plot level. In real time situation no two plots of land possessed by a farmer are treated identically by the same farmer, let alone by different farmers because not only of the needs and requirements of the diverse plots (physiochemical properties of the soils and land quality differences), but also the farming knowledge developed by the farmer for each specific plot (Yohannes and Herweg, 2000). This is why the SWC schemes imposed in the 1980s that could not consider such site specificities faced some problems of acceptance and adoption in the Ethiopian highlands.

(1) Initially, experts observed soil erosion concluding that traditional SWC was not effective. This led them to design the imposed SWC schemes (2), which had one major purpose: soil conservation. After facing several negative side effects under these schemes, farmers first started to selectively remove structures (3) and finally integrated introduced measures with indigenous knowledge (4),The new scheme serves more than only for conservation. It may involve other functions as well, such as demarcating field borders, drain specific parts, enrich top soil at other parts, etc. Only the basic principles of a technology remained the same.

Common Indigenous ISWC practices category

- **Biological (Vegetative and agronomic) practices**, such as contour plowing (retain water and reduce surface run-off), fallow (fertility improvement and source of fodder), crop rotation (fertility improvement and pest and disease control), manuring (soil fertility maintenance and the challenge of competition with fuel wood), mixed cropping, grass strips, trash lines (sorghum / maize straw and stubble), Agro-forestry, perennial plants such as coffee, chat and multi-purpose trees such as moringa are planted at the foot of the bunds. .

- **Structural (mechanical or physical) practices**, such as permanent and temporal stone bunds (site specific), traditional ditches (ox plow), cut-off drains (ox plowing and human labor), Konso bench terraces, Micro basins locally called by Konso "kaha", check dams(Irob: dams to trap silt and water locally named "daldal"),etc.

- **Any combinations of the above measures:** e.g. Terrace (structural) with grass strips and trees (vegetative) and contour ridges (agronomic).

- **Management measures:** change of land use type (e.g. area enclosure); change of management / intensity level (e.g. from grazing to cut-and-carry); major change in timing of activities; control / change of species composition.

Characteristics of ISWC measures

The following major features characterize most of the indigenous SWC technologies:

- **Site specificity**: due to the heterogeneous nature of the farming plots (soil, micro-climate, slope, etc.) owned by an individual farmer, different technologies and techniques are applied in each locality.
- **Flexibility and dynamics**: in a single plot usually different supplementary technologies and techniques are applied (agronomic, vegetative and structural). The techniques are also changing with the seasonal rainfall pattern; they can be permanent and temporary.
- **Multi-functionality**: the measures applied are not only confined to SWC but also to different other functions. For example, structures can serve as a fence, can improve fertility by accumulation of top soil, safe drainage of excess water, etc.
- **Combining both short- and long-term benefits**: production and protection elements are systematically integrated. For example, "moving" bunds and permanent bunds constructed within a plot have a synergy effect: short-term increase of production and long-term soil protection.
- **Integration in to the farming practice**: ISWC technologies are integrated to the farming system, and thus do not face problems of viability and acceptability, as introduced practices. For example, traditional ditches and grass strips are constructed during plowing. The construction of traditional bunds is integrated in

other farm activities, such as plowing and weeding, and does not cause tremendous extra costs.

- **Reduced risks:** consequently, ISWC as part of the regular farming operation using local tools and materials, implies a lower risk than introduced technologies.
- **Involvement of local institutions**: in most of the farming and conservation activities local institutions (self-help groups, neighborhood) are involved in both labor mobilization and application§ of rules and regulations.

Generally, the indigenous SWC technologies are coined to harmonize ecological benefits (minimizing soil loss and run-off), economic benefits (sustaining and increasing production), and social benefits (preventing out-migration and brain drain). Nevertheless, unequal distribution of indigenous knowledge within the community is one of the fundamental limitations of indigenous technicalities.

Potential roles of ISWC programs/projects to community are:

- More income
- Reduced vulnerability
- Improve food security
- Increase well-being
- More sustainable use of natural resource base

Strategies for erosion control

The aim of soil conservation is to reduce erosion to a level at which the maximum sustainable level of agricultural production, grazing or recreational activity can be obtained from an area of land without unacceptable environmental damage. Since erosion is a natural process, it cannot be prevented. But it can be reduced to a maximum acceptable level or soil loss tolerance. This should be considered as a performance criterion that erosion-control measures are expected to achieve.

Indigenous SWC practices in Ethiopia

1. Physical/ Mechanical /Structural/ ISWC measures

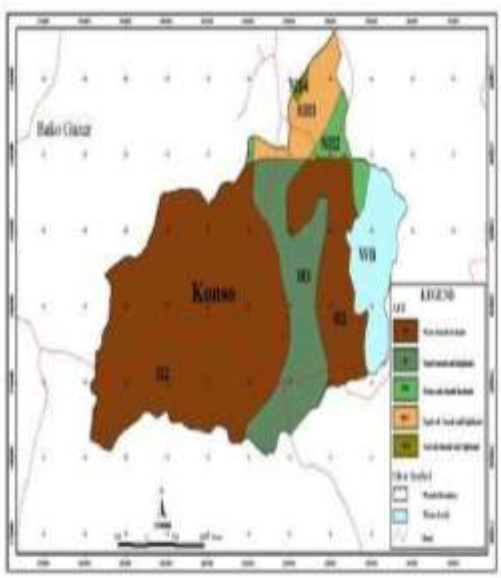
Mechanical field practices are used to control the movement of water and wind over the soil surface. A range of techniques is available and the decision on which to adopt depends on whether the objective is to reduce the velocity of runoff and wind, increase the surface water storage capacity or safely dispose of excess water. Mechanical methods are normally employed to support agronomic measures and soil management.

I. Konso Bench terrace (Konso)

Common Name of SLM Technology: Terrace

Local name: Kawata (Konso)

Associated approach: Voluntary labor assistance and labor-share (Debo/Wenfel)



Agro-ecological map of Konso *Location of Konso*

Definition

A stone embankment placed along the contour with land leveling in between two terrace walls to control soil erosion and increase rainwater retention.

Description

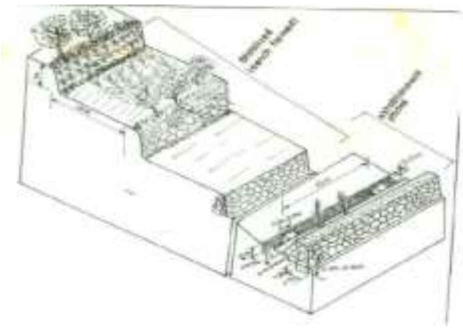
It is a traditional SLM practice whose wall is constructed from stones and supported at the down slope side by trees and legumes such as pigeon pea, coffee, moringa, etc. It is constructed by social organization (Debo) or labour wage (Parga). The purpose of the structure is to break the slope length and reduce flow concentration to control soil erosion and enhance moisture conservation. The first step during establishment is to dig foundation up to 30 cm and place the stones on the trench to form the foundation of the stonewalls. The height of the terrace wall is in the range of 1.5-2 m high above the ground, and in some cases even more. The Technology area is characterized by steep slopes, high percentage of surface stoniness, low rainfall, shallow and shallow to moderately deep soils.

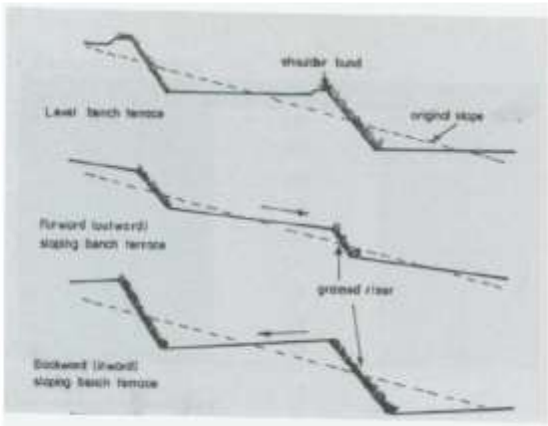
Picture of the technology

Bench terraces and inter terrace rainwater management measures in Konso (Photo 2006)

Stone terraces on a process of being converted to bench terraces (Photo 200

Technical drawing





Erosion due to water is controlled in the cultivated terraced lands but erosion is serious on cultivated lands that are not terraced or where terraces are not adequately maintained.

Land degradation

Problems: Shortage of rainfall and the erratic nature are the main constraints to agricultural and natural resources development and management. Lack of labor, food shortages and very little access to oxen plough, land shortage, moisture stress, soil fertility decline, shallow soil depth, high cost of farm inputs and pests are the constraints that limit agricultural productivity. Konso cropping system is largely multiple cropping and it is basically practiced for averting risk of crop failure. Without this technology crop failure is most likely and in case of shortage of rainfall one of the crops has the chance to survive and provide production. Leguminous crops are intentionally grown for soil fertility improvement along with other practices such as terrace maintenance. Introducing effective use of rains received, increased use of manure and compost, water harvesting structures and the use of energy efficient methods of land cultivation could solve the problems stated.

Types of land degradation on the land surrounding the SLM area

Land use	Type of degradation	Degree	%	Landform (s)
Cultivated land	Water erosion	Slope	80	HFR
Cultivated land	Chemical deterioration		80	HFR

Source: Woreda Agricultural Office

Technical function

Main	Secondary
Control of dispersed runoff	Reduction of slope angle
Increase and maintain water stored in soil	Sediment harvesting
	Increase of infiltration
	Improvement of soil structure

Status

The technology is indigenous and it has been practiced since long time (over 500 years according to elders in the area). The Konso Bench is practiced with the objective of reducing soil erosion and retain soil moisture. Today, the indigenous SLM is continued and maintained. The appearance of the applied technology is gradually changing over time from stonewalls to bench terraces laid out on contour lines.

Construction and maintenance

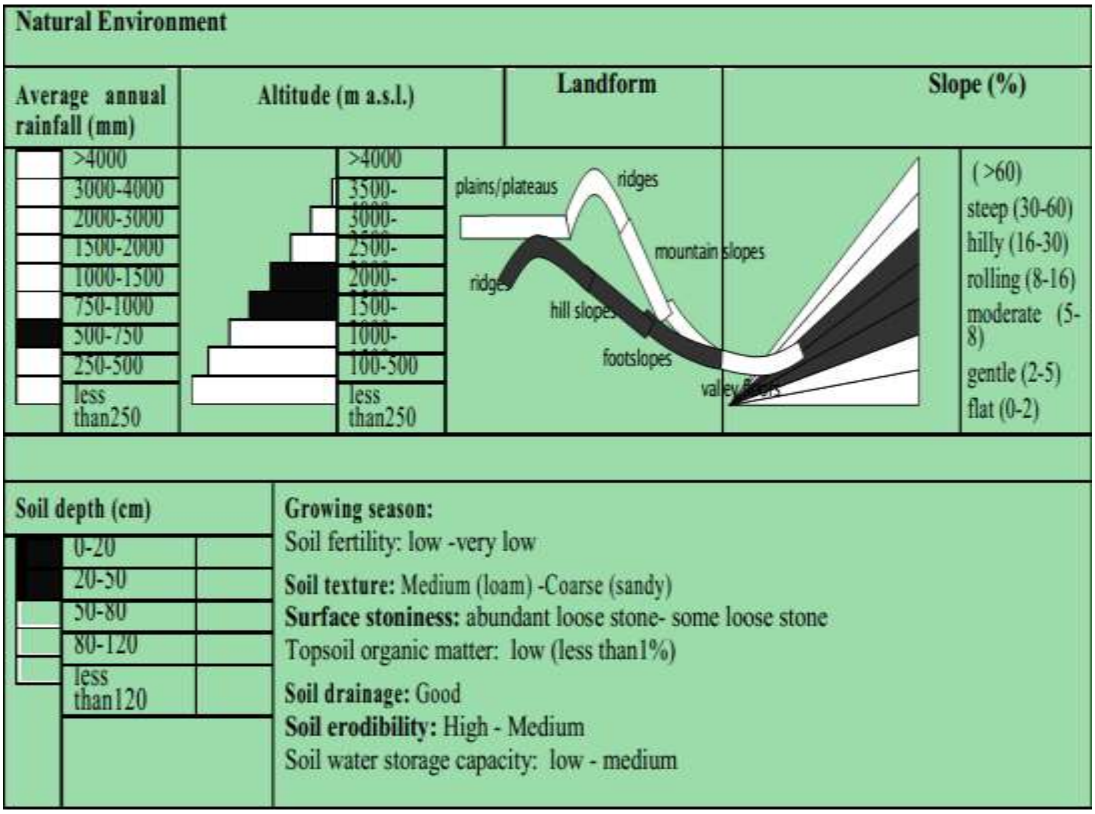
Activity	Energy	Equipment	Timing	Frequency
Field activities for agronomic measures				
Land preparation, sawing / planting, weeding / cultivation and manure application	Manual labor	Hoe	Dry season and beginning of rainy season	1-3 a year
Construction activities for structural measures				
Survey / lay out, collecting stones, digging foundation, land leveling and piling stones	Manual labor	Water level, poles, scoop hoe, spade	Dry season	Once a year

Maintenance activities for structural measures

Maintenance activities for structural measures

Stabilizing by putting additional stones, planting multiple crops, reparing breached terrace parts, and replanting of vegetative materials	Manual labour	Cowbar, hammer, hoe and spade	December-February and April-June	1-2 year

Soil moisture is the main constraint to crop and livestock production and is followed by lack of labor and access to oxen plough. Introducing water harvesting measures and the use of oxen for land preparation would solve the constraints prevailing in respect to crop production.



Human environment and land use

Typical household size of the land users is 7 persons. Population density is 50-100 persons/km^2 and the annual population growth is 2-3 %. Land ownership and land use rights did not affect SLM because the Konso bench has been practiced since long (over 500 years). Similarly, subdivision of land did not affect the implementation of the SLM Technology.

There is a moderate difference between the better-off and poor in how they practice SLM. The average and relative rich can implement SLM by hiring labor, but the poor do it by themselves if they are able otherwise the land is not treated. Off-farm income for the land users who apply the SLM technology is less than 10% of all income.

Level of technical knowledge required for implementation of the technology is moderate for field staff / extension workers and as well as for land users. Percent land users that cannot read and write is 80%. The technology is traditional and hence the inability to read and right has no effect on it.

Cropping system and major crops

Land cultivation is performed by manual labor using the hoe. Major cash crop is coffee. Major food crop is sorghum followed by maize. Other crops grown include: sunflower, pigeon peas, beans and millet. Water supply is rain fed and the type of cultivation is continuous cropping. Intercropping is greatly practiced. Crops that are intercropped include: Pigeon pea, Sorghum, Sunflower, Maize, Millet, Coffee, Cassava, Rahmanus (Gesho) etc. Sequence of crops: Sorghum/maize-Oil crops /pulses – sorghum/Teff (Maize - pulses. Konso is known for its local beverage called Chaka which is made from Sorghum and maize. Chaka is the staple local drink prepared by almost all households regularly and often used by the Konso community.

Benefits, advantages and disadvantages

With or without SLM	Main plant	Production (t/ha)
Without	Sorghum	0.4
With		0.6

Information mainly based on estimates and some previous reports

Finances

Cost details	Input (unit)	Quantity	US$	% borne by land user
Materials	Stone (m3)	200	300	100
Equipment	Tools (no)	35	70	10
Labor	Person-days	1650	1790	100

Economic analysis

Gross production value in US dollars per hectare per year without SLM around the SLM Technology area is less than 100. With SLM Technology, the gross production value of the land per hectare per year is greater than 200 US$ / ha / yr.

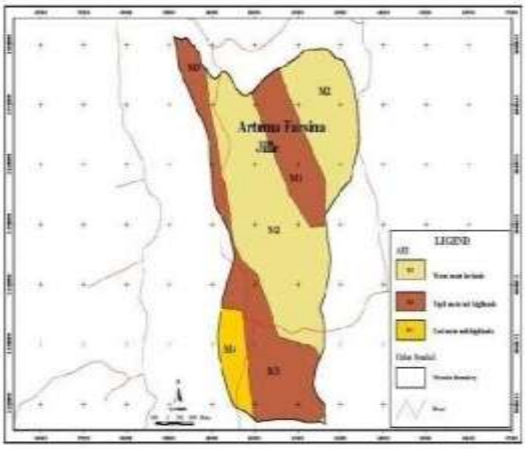
Adoption and adaptation

Land users who have implemented the technology, have done it wholly voluntarily, without any incentives other than technical guidance are 90% of land users that have applied the SLM Technology and this accounts for 95% of the technology area.

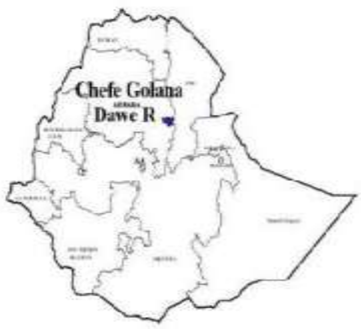
Supportive measures: Tie ridges are made up of stone and earth for moisture harvesting

II. Stone terraces and check dams (DewaChefa, Amhara)

Common name of SLM Technology: Stone terraces
Local name: Kiter
Associated approach: Labor share and labor assistance



Agroecology of Dewa Chefa woreda



Location of Dewa Chefa woreda

Definition

It is majorly a structural measure constructed by stone across a gully or dissected farmlands to control erosion, trap runoff and sediment to create favorable conditions for crop cultivation.

Description

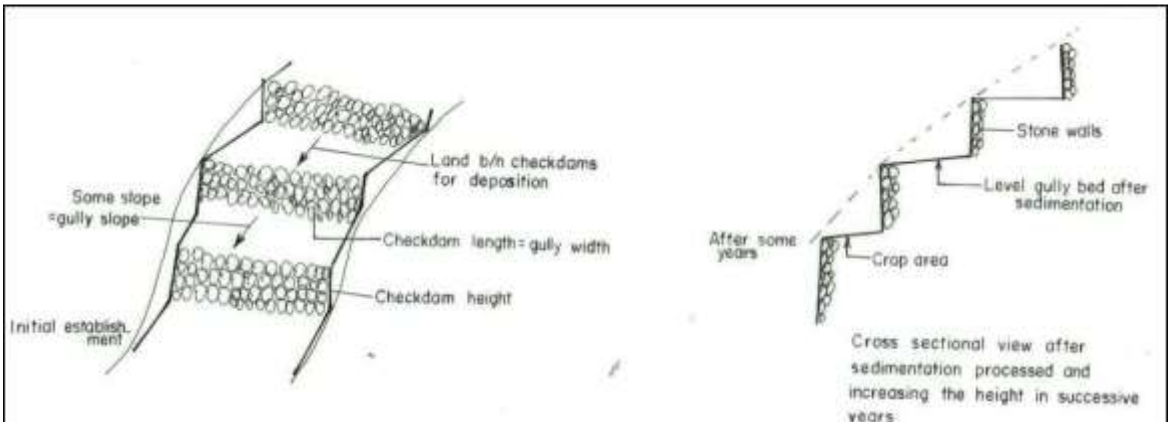
The technology has been practiced for more than a century in the Dewa Cheffa woreda. The area is seriously affected by gully erosion and the technology is widely practiced by farmers. Unlike other check dams its construction starts from the bottom of the gully and proceeds upslope with varying dimensions. The height of the check dam depends on the depth of the gully and it is increased from year to year. On the average, the top width is 1 m and the height is 1.80m. The length of the check dam is the width of the gully and it ranges from 2-15 m. The technology is applied to: develop big gullies and for the treatment of small gully like depressions, change of slope to enhance land productivity, improve crop production and to conserve soil and water. The construction of stone check dams starts with small gullies and proceeds by increasing additional height every year until the intended height is reached. The increase in height is also made during maintenance. The major objective of the technology is to stop gully expansion, trap sediment and retain water running down the gully. In the course of increasing the height, the area for sediment deposition becomes wider.

The technology is suitable to areas with low rainfalls under rugged steep topographic conditions. It can be applied in semiarid and arid agro-ecological zones. It consists of structural, vegetative, agronomic and management measures. The technology allows meeting the objectives of moisture harvesting, rehabilitation and improving productivity of rehabilitated gully. It is mostly practiced in the eastern escarpments of the woreda which experience low and erratic rains.

Types of degradation mainly addressed by the technology include: Water erosion (loss of topsoil by water, gully erosion and chemical deterioration), fertility decline and reduced organic matter. The technology combats land degradation by reducing slope angle, reducing slope length, increasing infiltration, maintaining water stored in soil and sediment harvesting. Applying methods of soil improvement such as planting fast growing trees, green manure, trees and shrubs, helps in further improving productivity of the gully.

Land users are organized by groups of self help to undertake the technology. The use of mulch and small water storing structures helps in maintaining good standards of the measures and improve land productivity. Land users have nurseries to produce appropriate seedlings to be planted on gullies. Some of the seedlings used in the gully plugging include: papaya, mango and avocado. Enclosure and fencing, planting in time and early planting methods improve productivity of the gully treated.

Technical design



Land degradation

Land degradation (degree, land form)

Land degradation (degree)	Land Use	Land form	Quantity
S= severe	C= cultivated	R = ridges	s = small
VS = very severe	G=grazing	P = plateau/ plain	l = large
L=light	F= forest	V= valley floors	m =medium
M== moderate	M = mixed	M=mountain slopes	
		H= hilly	

Types of land degradation on the land surrounding the SLM area

Land use	Type of degradation	% area affected	Land form
Mixed land	Water erosion	75	P, R, H, V
Forestland		50	R, H
Grazing land		75	H, R
Cropland		80	P, R, H, V

Source: Field observation

The SLM area is situated in a rugged hilly terrain with a chain of ridges dividing it from north to south. The western part of the ridge has a relatively better rainfall and the eastern part has a very low rainfall.

Purpose and classification

Land use problems in the area without SLM are: increase in human and animal population, overgrazing and expansion of cultivated lands to areas, which are not suitable to cultivation. Owing to rapid gully expansion and because of the absence of preventive and control measures, there is considerable loss of soil from grazing and cultivated lands. Considerable area is getting out of production in the SLM Technology area where the technology has not been implemented.

Characterization and purpose

The technology is not intended to provide off-site benefits but it provides significant contribution for reducing sediment movement to downhill cultivated lands. The technology provides significant off-site benefits especially during the long rainy seasons where often cultivated and grazing lands at the valley bottoms are flooded. The sediment load from the eastern escarpments where the technology is applied has substantially reduced to the rivers flowing on the valley bottoms.

A pond constructed just below a hill treated with land management measures (photo 2009)

The SLM Technology is indigenous and is used for generations. The technology is developed by land users themselves. The aim of the technology is to increase soil water holding capacity, trap sediment, and increase crop and livestock production. Today the traditional SLM is used more. The technology is expanding to neighboring woredas and more land users are experiencing it. It has shown promising results in crop production because the technology lets more water to be stored in the soil. The appearance of the applied technology has gradually changed over time from stone embankments which are vertical, but now inclined and strengthened by vegetation at the down slope side.

Crop residue management and planting nitrogen fixing trees and shrubs is carried out on the gully sidewalls. Constraints include labor for constructing stone check dams, maintenance and upgrading. Proper SLM measures for soil improvement include: use fast growing trees and shrubs, manure application and green manure and these are also recommended to curb land problems. Land users are organized by groups of self-help. Mulch and small water storing structures are applied in between the structures to make them effective in controlling erosion.

Specification of vegetative measures

Vegetative measures	Material	Plants/ha	Vertical interval (m)	Spacing	Interval (m)	Width (m)
Aligned and contour	Trees	1500	1-1.8	8-10	1-2	1 x 1
	Grass		1-1.8	8-10	1-2	
	Fruits	2000	1-1.8	8-10	1-2	1 x l

Constraints during establishment include high seedling transportation cost, poor handling while planting and transporting, livestock interferences, and moisture stress. Constraints during maintenance are: uncontrolled livestock movement hindering proper growth and survival of plants. Improvement measures for this include: establishing nurseries for production of seedlings in the nearby plantation sites, practicing area enclosures and fencing and planting in time or early planting.

Specification of structural measures

Dimensions of each structure (check-dam) (m)

Measures	Material	Vertical interval	Spacing	Depth	Width	Length	Height
Check dam	Stone	1	8	0.3	1	5	0.5-1, 1, 5

Construction and maintenance

I) Field activities for agronomic measures			
Activity	**Energy**	**Tools**	**Timing**
Clean crop residue	Manual labor	Sickle	Early January
Primary digging		Hoe	Feb-March
Harrowing		Hoe	March
Manure application		Shovel	March
Planting		Hoe	April
Weeding and cultivation		Hand	June-August
Harvest		Sickle	Nov. -December

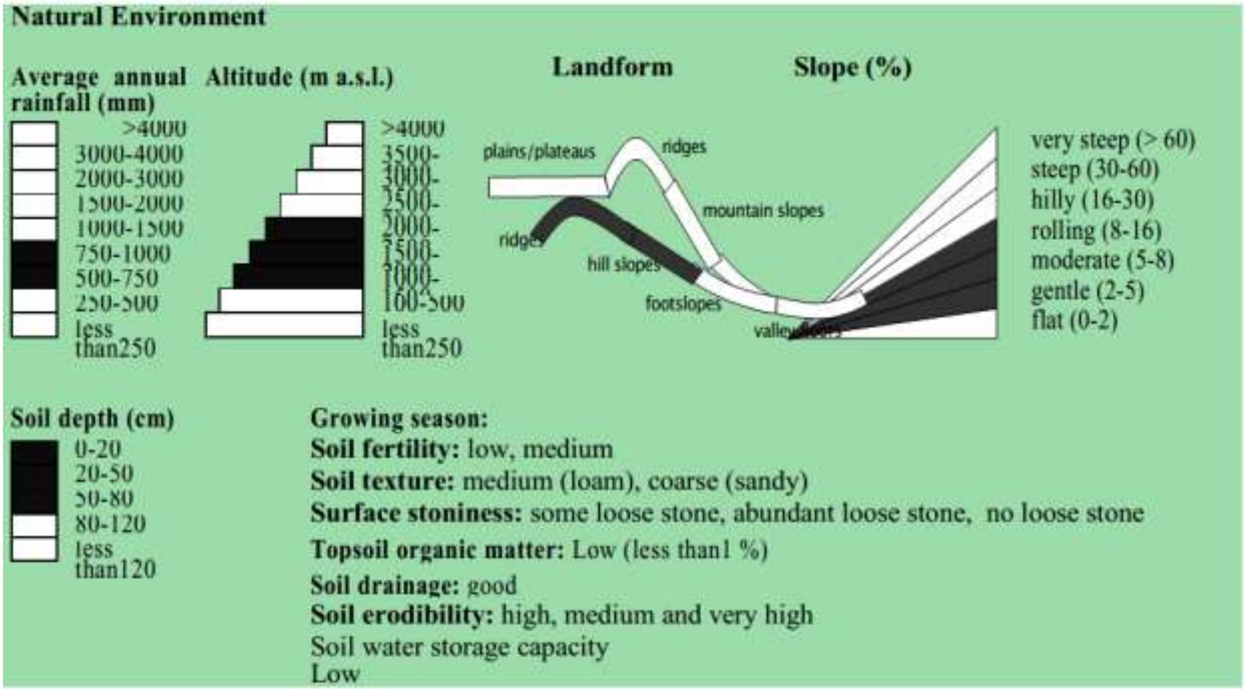
Re-vegetation practices

Seedling production	Manual labor	Hoe / spade	Nov. - June
Planting			June and July
Replanting		Hoe	During rains
Pruning and thinning		Axe	Dry season

Gully protection

Excavation	Manual labor	Hoe	Dry season
Stone collection		Hand	Dry season
Construction			dry season
Stone collection			
Placing the stones where manual labor maintenance is required			Dry season
Replanting		Hoe	After plantation
Repairing breaks in fences		Axe	Before replanting

Check dams are regularly maintained, when breaks are observed and are continuously upgraded to increase the height until the desired check dam height is attained. The establishment is a gradual process and continues until the check dam height allows maximum possible width for cultivation. Constraints during establishment are lack of hand tools and labor. Constraints for maintenance are lack of labor. Regular maintenance and upgrading are required. Avoid building high check-dam initially and at one go.



Human environment and land use

Typical household size of the land users is 5 persons. Population density is 100 persons/km^2. The annual population growth is 2.5%. The land size per household shows decreased trend because of population growth.

There is no marked difference between the better-off and poor in how they practice SLM. Off-farm income for the land users who apply the SLM technology is less than 10% of all income. Level of technical knowledge required for implementation of the technology is high for extension workers and is moderate for land users. The technology is highly relevant to smallholder farmers, who depend on conservation of runoff for crop production and for domestic uses under subsistence farming. Gullies and depressions plugged by stone check dams trap fertile soils coming from upslope. The trapped soil stores more water and supports healthy crop production.

Crop and livestock production

Number of heavy storms of water per year is 15-20. They mainly occur in the beginning and mid of the growing season. Rainfall in the longer rainy season is sufficient but not well distributed and in the short rainy season it is insufficient and not reliable. The number of growing seasons per year is 2.

Growing period	Length in days	Month
Longest	180	May – Nov
2nd longest	90	Feb- April

Land cultivation is performed by manual labor mostly and in some cases by animal traction. Type of cultivation is continuous cropping, rain fed and mixed farming. Planting perennial crops mixed with annual crops is a common practice and intercropping of cereals with pulses and trees is also known in the area.

The current trend in herd types is more small stock. Large stocks require more land area for grazing and land holdings are decreasing. The number of livestock units per household is 4 small stock and 3 large stock. The current trend in livestock numbers shows slight reduction due to decline in feed and fodder. Livestock production is decreasing primarily because of decreasing grazing lands. The main reason is that the number of livestock is the most important factor for herd owners than the quality. The land users like to own more number of livestock. More extension work will be needed to promote the awareness of livestock owners so that they give emphases to the quality of their herd.

The natural forest and woodlands are decreasing mainly due to expansion of cultivation and also to high demand for fuel and construction wood. However, owing to plantations on gullies, hillside closures and woodlots there is a positive trend of increasing wood availability as more trees are being planted.

Establishment and recurrent costs (Birr)

Category	Input	Establishment			Recurrent		
		Quantity	**Cost**	**% borne by land users**	**Quantity**	**Cost**	**% borne by land users**
Materials	Stone (m^3)	3315		100	331		100
Equipment	Tools	20	120	95	5	30	100
Labor	Person days	6630	4625	90	663	624	100
Total			4750	95		654	100
			470 US$			65 US$	

Labor, slope and depth of the gully, width of the gully and availability of construction material are factors affecting cost of establishment. The establishment cost considers the cost incurred during the 15 years of construction, maintenance and upgrading.

The major objective is to stop expansion of gully in width and depth and to trap sediment and retain water running down the gully. In the course of increasing the height, the area for sediment deposition gets wider and this allows for more area to come under plantation. Uncontrolled livestock movement hinders proper growth and survival of seedlings planted.

Cost recovery

I: Crops cultivated: (20% Coffee, 30% Chat and 50% Sorghum)/ on a hectare

Year	Costs (Birr)								Benefit (Birr)			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	1188		27	14	10	10	12	1261	105	59	164	-1097
2			27	14	8	10	12	71	120	59	179	+108
3		297	27	14	8	10	12	368	821	59	880	+512
4	950		27	14	8	10	12	1021	821	60	881	-140
5			27	12	8	10	12	69	826	60	886	+817
6		19	27	12	10	11	13	92	826	60	886	+794
7	950		27	12	18	11	13	1031	826	60	886	-145
8			27	10	10	11	13	71	831	60	891	+820
9	713		27	10	10	11	13	784	831	60	891	+107
10			27	10	10	12	13	72	836	60	896	+824
Total	3802	319	273	126	105	112	132	4848	6852	607	7451	-1370
Total US$	380	31						484	685	60	745	-

Note: *1= establishment, 2= upgrading, 3=recurrent costs, 4=land preparation, 5 = manure application, 6= seed/seedling, 7= herbicides, 8= total cost, 9= crop yield, 10= crop residue, 11= total benefit and 12= net profit*

The cost benefit analysis for sorghum with cereals showed negative profit in the first three years of investment but for sorghum in combination with coffee, papaya chat and fodder crops starting from the fourth year showed substantial increase in the amount and quality with the resulting increase in income of land users. For cropping patterns which consider field crops in combination with cash crops the return is the highest.

For the technology to provide a high positive return it takes at least 15 years as indicated in the table above. Farmers nevertheless are encouraged to invest on the technology because without it cultivating land for all kinds of crops becomes impossible.

Benefits, advantages and disadvantages Estimates of production

With or without SLM	Main plant type	Production (t/ha/yr)
Without SLM	No plantation	Very negligible (less than 2 q/ha/yr)
With SLM	Coffee	3-4 q/ha/yr

On-site and off-site benefits of the technology

Production and socioeconomic benefits	Socio cultural benefits
Crop yield increase	Community institution strengthening
Fodder production/quality increase	National institution strengthening
Wood production increase	Improved knowledge SLM/erosion
Farm income increase	
Off-site benefits	**Ecological disadvantages**
Soil cover improvement	Loss of land
Increase in soil moisture	Increased labor constraints
Reduced downstream flooding	Increased input constraints
Increased stream flow in dry season	Hindered farm operations
Soil loss reduction	
Biodiversity enhancement	

Economic analysis

Without SLM gross production value in US$ per hectare per year around the SLM Technology area is 100 US$. With SLM Technology, the gross production value of the land per hectare per year is 330 US$/ha/yr.

Compared to the situation without conservation estimated percentage gross production value increase in 10 years after implementing SLM is over 300%, considering the land occupied by conservation measures and in assuming current input and prices.

Adoption and adaptation

Farmers are trained on laying out check dams on a contour wherever gully width allows this. A change in spacing is made in order to make possible cultivation by oxen. Land users who have applied the SLM Technology have done it without any incentives from the beginning but food for work support was provided when there are production shortfalls at times of draught since 1970s. The number of land user families is 2500. It is practiced in 70 % of the SLM Technology area.

All land users who have implemented the technology, have done it voluntarily, without any other incentives other than technical guidance. Trend towards spontaneous adoption of the technology is high. Reclaiming gullies for agricultural land (crop and livestock production) is very useful. There is enough local skill and support to expand the SLM Technology. Farmers have all the skills to perform the activities.

Maintenance

Land users have adequately maintained and managed what has been done for many years

Strength and weakness

Strength	Sustain/improve
Reduce runoff velocity	Exercise frequent maintenance and stabilize the structures with vegetative measures
Reduce soil loss	Increase height of the checkdams
Moisture retention	Soil trapped provides more space for water to be stored. Reduce slope length by raising the gully bed
Land reclaimed	Fertility of soils to be increased by accumulated top soil from other areas

Supportive measures

Technologies	Functions
Trenches and microbasin	Reduce flood hazards
Hillside terraces	Catchment stabilization and rehabilitation
Cutoff drains	Remove excess water

Photo 1

Photo 2

Photo 1: Family managing this land need labor assistance from neighbors or relatives (Photo 2005)

Photo 2 : Labor intensive SLM activities, which require labor assistance from other land users (Photo2005)

III. **Micro- basin**,

Locally by konso people named "*kaha"*, is constructed within the stone terraces during the land preparation activities, for the purpose of harvesting and concentrating water nearer to growing plants.

Definition, specifications and purpose

Micro-basins, half moons and other micro catchment technologies are mainly used in dry areas for water conservation. In semi arid and sub humid areas micro basins are mainly found in forest areas and on steep slopes or very shallow soils. Such structures are often constructed manually, using earth and stones, outlined in lines of staggered formation. Runoff water is collected within the basin from the area above and impounded in the structure. Excess water is discharged around the tips and is intercepted by the next row of micro basins. Normally the semi-circles are of about 4-12 m in radius with a height of about 30 cm and a base width of about 80 cm. The percentage of enclosed cultivated area depends on the rainfall regime of the area.

Potentials, benefits

- Rain-fed plant growing is possible in areas with less than 300 mm of annual rainfall
- Top-soil sediments are also trapped in the structures gradually improving soil fertility

Limitations, weaknesses

- Establishment of half-moons is labor intensive
- Construction requires know-how and experience

Photo: micro-basin

IV. Irob: dams to trap silt and water

The practice of trapping silt and harvesting water in narrow valley bottoms is developed by the Irob people in northern Tigray, on the border with Eritrea. Irob is a land of depths and heights, of droughts and floods, of frost and scorching sun. The altitude varies from 900 to 3200 m a.s.l, however most people live in areas situated between 1500 and 2700 m. Rainfall in the mainly habited area is low (200-600 mm annually) and highly variable in space and time. The Irob used to be a pastoral people, moving with their goats and cattle from the mountains on the eastern escarpment of the Ethiopian highlands to the lower plains. It was not until two or three generations ago that the Irob began to give attention to crop production (Mengistu, 2002), because they could no longer obtain enough cereals in exchange to their livestock products.

The landscape is mountainous, rugged and stony, with steep slopes and deep narrow valleys curved out the plateau by flush floods making the land less suitable for cultivating crops. In response to the ruggedness and the need for reclaiming land for crop cultivation, the Irob developed specific and site-appropriate methods of land management to capture soil and water. They build a series of check dams in the seasonal watercourses and raised and lengthened the walls every year. Through this process of building, they have created step-like terraces that are now about 8 m wide and up to 10 m high, with about 20 m in between dams. This innovation is locally known as *daldal* and requires year-round effort over many years or even decades (Hagos and Asfeha, 1997).

The innovative *daldal* technique is a best practice because it is an indigenous land management scheme that has been recognized by many Irob people and by others living under similar harsh conditions as a way of creating land to produce food and obtain a supply of clean water (Asfaha and Waters-Bayer, 2001). The practice is sustainable in environmental terms, as it reduces soil erosion and makes use of soil and water that would otherwise have flowed into barren depressions and been wasted.

Family members maintain it independently, but when the *daldal* becomes bigger and larger community groups take the task of maintaining the common resources (Waters-Bayer and Mengistu, 2002).

V. Diversion ditch (Gorf meqlbesha boi)

Diversion ditch / cut-off drain: a graded channel with a supportive ridge or bank on the lower side. It is constructed across a slope and designed to intercept surface runoff and convey it safely to an outlet or waterway.

VI. Waterways (Gorf mafsesha boi)

Waterways: are needed to convey runoff safely from hill slopes to valley bottoms where it can join a stream or river.

2. Biological(Agronomic & Vegetative) ISWC measures

2.1. Agronomic ISWC measures

- **Trash-lines** are prepared at the ridges of the bunds and micro- basins, using the straw & stubble from maize & sorghum. They serves as mulch (to reduce the rain drop splash effect & minimize evaporation), & to improve soil fertility along the bund & micro- basins through the eventual decomposition of the stubble .Trash farming involves spreading the crop residues on the surface as normal mulching ploughing in and cultivating in the usual way**.**

Figure: Indigenous sorghum straw trashlines & drainage ditch

Figure: Indigenous trashlines for water harvesting

- **Mulching:** It is the covering of the soil with dead plant residues; straw, banana leaves, maize stalk or grass. The cover protects the soil from rain drop and increase the infiltration rate as the pores of the soil are not clogged. It is useful in dry areas where insufficient rain prevents the establishment of a ground cover before the onset of heavy rain. In semi humid areas, the side effect is lowering soil temperatures and increased soil moisture are beneficial may increase yield. Mulching poses special problem for the arable farmer because tillage tools become clogged with residues, weed and pest control are more difficult.

Figure: Mulching

- **Contour cultivation._**Carrying out ploughing, planting and cultivation on the contour on gentle slope can reduce the soil loss by half compared with cultivation up and down the slope. On gentle slopes,or whenever the erosion risk does not warrant major earth moving works, it may be sufficient to slow down surface runoff by tillage operations on the contour. Another protection method which may serve where the erosion is not severe is to use grass strips. Strip of grass+legumes are planted or close growing vegetation(grass)are left unploughed between bands of crop land. Surface runoff moving down the slope is intercepted by strips, the velocity is slowed and silt deposited in the grass strip.

Figure: Contour cultivation

Figure. Contour farming reduces erosion and improves soil productivity in sloping fields

- **Crops:** Early planting: early planting is important in East Africa, as much of the rain comes during the beginning of the rainy season. An early planting during the rainy seasons will develop and give protection against erosion. Choice of crop: on erodible soils the choice of crop for cultivation has to be considered. The soil loss through erosion varies according to the type of plant, providing that it is well established.
- **Mixed cropping /Multiple cropping**:- involves growing different types of crops simultaneously, such as maize ,sorghum , millet , wheat , barley , beans & sun flower as a component of land use intensification with no apparent spatial arrangement . The seeding rate depends on the level of soil moisture, which is assessed by the farmers. If the farmers assume that moisture is sufficient, more seeds are planted than under dryer conditions. Selective thinning is practiced during periods of moisture stress within the growing period. The thinned plants & weeds serve as fodder for livestock. The aim of multiple cropping is the production from the land whilst providing protection of the soil from erosion. The method involves either sequential cropping, growing of two or more crops a year in sequence, or intercropping, growing two or more crops on the same unit of land at the same time. Multiple cropping is a traditional practice often involves a mixture of the two. eg.maize +beans. The effects on erosion of multiple cropping of maize with haricot beans at Gunuo research station, Sidamo, and maize, sorghum, beans and peas in Harar Ethiopia also examined. Although multiple cropping led to reduced soil loss in both cases compared with monoculture in neither instances was the erosion below the soil loss tolerance level which was set at 1kg/m^2/y.

Figure: Mixed cropping

- **Crop rotation:** It may be cheaper on big commercial farm to apply fertilizer than to grow a legume,but the peasant farmer often has no choice-he can only afford to ease demand by rest crop(fallow) and rotation. Rotation is the simplest way to combine different crops grow them consecutively in rotation. Suitable crops for use in rotations are legumes and grass. These provide good ground cover,help to maintain or even improve the organic status of the soil, thereby contributing to the soil fertility ,and enable a more stable aggregate structure to develop in the soil. These effects are often sufficiently long lasting as to reduce erosion and increased yield. Even if the frequency of rotation depends on the severity of erosion, rotational periods should be short. Usually a rotation in three year period is recommended.
- **Strip cropping:** Rows of crops and protection effective crops are growing in alternating strips aligned on the contour or perpendicular to the wind direction in case of wind erosion. The soil which is removed from crop strips is trapped in the next strip down slope which is generally planted grass or grass+legumes strip. The practice is good measure on permeable soil preferably not exceeding 15-20% slope. If wide strips of perennial grass+legumes cannot be alternated with a strip of annual crops,or grass cannot be rotated for normal strip cropping narrow strips of grass or

grass+legumes can be used. Grass strips are widely used practice on slops 5-15% usually with the width of 1 or 2m but not exceeding 4m.

- **Zero-tillage**

Commonly practiced in Berta and Gumuz society of the Beneshangul Gumuz reginal state. Tillage practices serve as conservation agriculture. Sorghum, okra and maize cultivations are their common crops farming.

- **Cicata**

It is the kind of soil fertility management techniques by rotating the fence (locally named in Afan Oromo “dalla”) for animals on their land after 2 to 3 days. It is the cows dung and their urine maintains soil fertility. This practice is very common in Wollega and Beneshangul Gumuz regional state.

- **Multiple Cropping**

Multiple cropping is a system where a single crop species is grown more than once or different crops are simultaneously planted on the same field during the same sea-son a year. It is a popular practice among small farmers in developing regions (e.g.,

Africa) because it allows an integration of food crops, farm animals, conservationgrass buffers, and trees into the same piece of land. Planting several crops extendsthe harvest season either with earlier or later ripening crops while providing greatervegetative surface cover and diverse crop produce over a long period of time. Underappropriate climatic (e.g., water supply) and soil conditions, multiple cropping isa source of year-round supply of grains, fruits, and vegetables. The advantage of multiple cropping is that it comprises all the interactive variables and factors of different plants and the environment. The number, selection, and combination of crops (e.g., corn, soybean, vegetables) depend on local soil, climate, and ecosystem conditions.

Multiple cropping is advantageous because it:

- allows the production of diverse food crops,
- offers better soil erosion control by continuous growing of crops with variable biomass production and rooting systems,
- reduces risk of total loss of crops from adverse climate conditions (e.g., drought resistant) or diseases,
- provides diversified farm products from a small piece of land, reducing production costs.
- improves soil fertility and reduces soil erodibility by planting grass, grain crops, and legumes,
- reduces disease pressure and use of synthetic fertilizers, herbicides, and pesticides by dense planting and intensive management, and
- allows planting crops in different seasons, spreading the harvest and supply of produce.

In a few cases, multiple cropping may exacerbate pest invasion and survival because pests can move from one crop to another. Land fractionation in small plots may not accommodate mechanized farming and row crop planting with large farm equipment. Overall, multiple cropping is a more intensive management and more profitable farming system than single or one crop per year. Double cropping, intercropping, and relay cropping are among the most common multiple cropping systems.

2.2. Vegetative ISWC measures

- **Agro-forestry**:

Perennial plants such as coffee, chat and multi- purpose trees such as moringa are planted at the foot of the bunds. Trees are important in soil conservation and soil improvement. The term agro-forestry is a collective name for land use system in which woody perennials (trees,shrubs) are growing in association with crops and /or live stock to achieve both ecological and economic interactions between trees and non tree components of the system. Multi-purpose trees and shrubs for soil conservation; trees on soil erosion structure such as trees on terraces, trees on grass strips and trees as a barrier hedge are few role of trees for protection and fertility maintenance. Agro-forestry is a broader field and the role of trees in soil conservation will be discussed in a separate topic community/agroforestry.

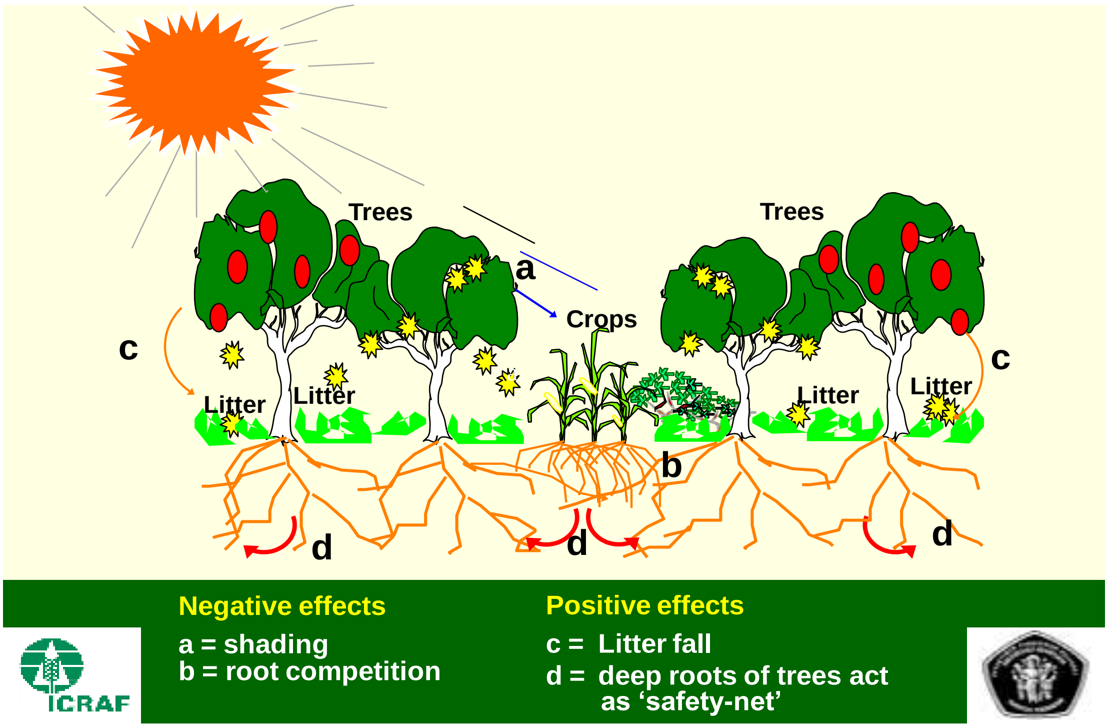


Figure: Agro-forestry

- **Grass strip (fodder)**

A grass strip is a ribbon-like band of grass laid out on cultivated land along the contours. Usually, grass strips are about 1 meter wide and spaced at 1m vertical intervals. They are mainly used to replace physical structures on soil with good infiltration (sandy, salty) on gentle slopes. Cattle must be excluded from this measure all year long to provide for sufficient length of the grasses to slow runoff and retain soil sediment.

- **Area of Application;**

1. Agro climatic Zones ;Moist and Wet Wurch, Moist band Wet Dega, Moist and Wet Weina Dega, Moist kolla
2. Local Situation: a) Slope Range:Slopes of less than 15% gradients b) Soil Range: All

- **Specifications**:

  Grass strips are planted along the contour or along Cut-off Drain (CoD).Spacing with 1 metre vertical interval means that on a 3% slope, grass strips will be 33m apart, and on a 15% slope, only 7m apart, still sufficient for ploughing between the strips.

- **Effects:**

  Grass strips help to reduce runoff and to filter out sediments carried by runoff. They are especially suitable on soil with good infiltration and where the climate is not too dry for dense grass development. If grazing is totally prevented, the grass strips will effectively build up into terraces and provide good fodder for cattle, which can be used with CUT AND CARRY.

- **Combinations**:

Use Cut and carry system for grass land (range land) management. Sometimes, CoD between grass strips is useful for safey reasons if heavy storms occur. Revegetation as for bunds can be applied to improve grass strips.

- **Materials**:

  Local grass sods from well developed grassland for planting. Digging instruments, line level, stakes for marking strips. Grass seeds if available or collected nearby.

- **Management and Maintenance**:

  Select grass carefully and consult farmers. Runner grass will disturb the crops. Introduced grass may be used, but generally the local spices known to the farmers will do. Grass strips can be improved to ALLEY CROPPING. Every farmer maintains the grass strips on his own land and he is allowed to CUT AND CARRY. Care must be taken that the strips are not narrowed with every ploughing. Width of one meter is the absolute minimum required for effectiveness.

➢ **Shelterbelts/wind break/**

Field shelter by planting windbreaks is widely practiced on both agricultural and horticultural croplands and pastoral farmland. There are 3 principal methods for reducing the impact of wind velocity on ground surface which are

I. Vegetative measures
II. Tillage practices
III. Mechanical/structural measures

Windbreaks are placed at right angles to erosive winds to reduce wind velocity and, by spacing them at regular intervals; break up the length of open wind blow. Windbreaks may be inert structures, such as stone walls, slat and brush fences and cloth screens, or living vegetation. Living windbreaks are known as **shelterbelts**. In addition to reducing wind speed, shelterbelts result in lower evapotranspiration, higher soil temperatures in winter and lower in summer, and higher soil moisture; in many instances, these effects can lead to increases in crop yield. Windbreaks have been multipurpose, providing livestock shelter and enhanced crop growth, in addition to mitigating wind erosion. Considerable research has been directed at windbreak design and performance, suitable species, the advantages of shelter, and its costs and benefits.

Design

The **requirements for each windbreak** site within a designed shelter system should be carefully examined. The resulting windbreak design should incorporate experience resulting from previous designs, the best local knowledge of species performance, and consideration of the following factors:

- **Height of windbreak**

A significant reduction in wind velocity is obtained for a distance of 10-15 times the height of the windbreak. The maximum reduction occurs at a distance of 1-4 times the height, depending on the permeability.

- **Permeability (density)**

Very dense impenetrable windbreaks can result in severe turbulence in the lee of the shelterbelt and a resumption of unhindered wind velocity at a relatively short distance form the shelterbelt.

Permeable shelterbelts provide a greater reduction in wind velocity further out from the shelterbelt but less reduction very close to the shelterbelt. The optimum density for a permeable windbreak is between 40% and 50%.

This may be obtained by:

- ❖ Planting trees of the appropriate natural density, e.g. pines have a dense crown, gums and poplars have light crowns;
- ❖ Varying the spacing of trees within the row;
- ❖ Varying the number of rows of trees [multiple rows];
- ❖ Tending, including side trimming, pruning, and thinning.

- **Continuity of shelter**

All species have a limited life and must be replaced before they become over-mature. Continuity can be obtained by planting at least two rows of trees, each row having a different rotation length, or by replacing alternate shelterbelts at different time, as part of an overall management plan for the property.

- **Stability of windbreaks**

Wind throw occurs in areas with shallow soils, which experience high velocity winds. The risk of wind throw can be decreased by:

- ❖ Good design, e.g. two rows of species which have different growth rates are combined to give additional stability to the windbreak: the slower growing species is established on the windward side to reduce movement of the root plate of the fast growing species;
- ❖ Good establishment techniques, e.g. the use of high quality tree stocks with some form of deep cultivation and careful planting;
- ❖ Good management: the milling and replacement of trees nearing the end of a rotation is the most significant step that can be taken to reduce future wind throw.

A shelterbelt is designed so that it rises abruptly on the windward side and provides both a barrier and a filter to wind movement. A complete belt can vary from a single line of trees to one of two or three tree rows and up to three shrub rows, one of which is placed on the windward side. Belt widths vary from about 9 m for a two-row tree belt with associated shrubs to about 3m for single-row hedge belts. These widths mean that belts can occupy about 3 per cent of the land they are protecting. The density of the belt should not be so great as to form an impermeable barrier nor so sparse that the belt is transparent. The correct density is equivalent to a porosity of 40–50 per cent. More open barriers do not reduce wind velocity sufficiently. Where only a single row of trees is used, it is important that the branches and foliage extend to ground level to give the required level of porosity in the lower metre where most of the sediment movement by saltation takes place. With denser barriers there is a much greater reduction in wind speed initially but, since the velocity increases more rapidly with distance downwind than is the case for more porous barriers, they are effective for only short distances.

The reduction in wind velocity by a shelterbelt begins at a distance of about five times the height of the belt upwind and reaches a maximum of about 40 per cent of the original wind velo-city at a distance of about three times the height of the belt downwind. Velocity then increases again, returning to the original wind speed at a distance of about 30 times the barrier height (Marshall 1967). **Shelterbelts** are designed to maintain the wind velocity at about 80 per cent of the open wind velocity. **Wind tunnel studies** by Woodruff and Zingg (1952) showed that tree **belts at right angles to the wind afford this level of protection** for distances up to 17 times their height for open wind velocities up to 44 km h-1. Allowing for variations in wind speed and deviations in wind direction, they developed the following formula for determining shelterbelt spacing:

$$L = 17H(V_t/V)\cos\alpha \quad (10.7)$$

where L is the spacing or distance of area protection (m),H is the height of the belt (m),Vis the actual or design wind velocity measured at a height of 15 m above the ground surface (km h-1),Vt is the threshold wind velocity for particle movement, taken as 34 km h-1,and alpha is the angle of deviation of the prevailing wind from a line perpendicular to the belt. Effective protection in the field rarely reaches this theoretical level of 17H, however, being reduced in unstable air and by variable growth and poor maintenance of the trees. A distance of 10 or 12 times the height of the belt is more realistic. Where 5–7 m high hedges are used, the effective distance protected increases to about 30 times the barrier height but, because of their lower height, the absolute distance protected is much less and more frequent spacing is required.

Belt lengths should be a minimum of 12 times the belt height provided that the belt is at right-angles to the wind. To allow for deviations in wind direction, a longer length is desirable and a length of 24His generally recommended (Bates 1924). For winds ranging from ±45° from the perpendicular, the effective area protected by the belt increases rapidly with belt length. Figure 10.9 (Olesen 1979) shows that for 2 m tall hedges, the area protected is 156 m2 when the belt is 25 m long but increases to 2500 m2 when the belt is 100 m long.

Where there is a dominant erosive wind from a single direction, the best protection is obtained by aligning the shelterbelts in parallel rows at right angles to it. Where erosive winds come from several directions, grid or herringbone layouts may be necessary. The requirement is to provide maximum protection averaged over all wind directions and all wind velocities above the thresh-old level. This may be achieved by a scheme in which complete protection is not obtained for any single wind direction. The effectiveness of shelterbelt layouts can be evaluated using eqn 3.8. This is first applied to obtain a measure of wind erosivity with no protection. A measure is then obtained for the shelterbelt layout by reducing the values of t by the ratio Vx/Vo ,where Vx is the wind velocity at distance x from the belt, with x measured in units of barrier height, and Vo is the wind velocity in the open field. Values of Vx/Vo can be determined for a belt with 40 per cent porosity by the equation:

$$V_x/V_o = 0.85 - 4e^{-0.2H'} + e^{-0.3H'} + 0.0002H'^2 \qquad (10.8)$$

where H'=x/sin b when b is the acute angle of incident wind (Skidmore & Hagen 1977).

The greatest effect of shelterbelts is found where, as a result of farmer collaboration in a collective belt planting scheme, a regional framework exists of belts placed along property boundaries in a coordinated way so that they form part of a parallel series of main line barriers, 200–400m apart. Within this framework, individual farmers are free to plant additional hedges. Collective shelterbelt schemes are encouraged by Hedeselskabet (Danish Land Development Service) to control erosion on the sandy soils (Olesen 1979).

The plant species selected for shelterbelts should be rapid growing, tolerant of wind and light and frost resistant where necessary. Their growth habit should give the required level of porosity at the time of year of greatest erosion risk and a conical or cylindrical shape, avoiding top-heavy crowns. The branches should be pliable so that they bend with the wind instead of breaking off.

The root system should provide a firm anchorage to the soil. Preference should be given to local rather than imported species. The shelterbelt system developed by Hedeselskabet meets these requirements and, at the same time, provides for an ecological succession to give an effective barrier within three to four years and one with a life of 50–80 years. The belts are made up of three parallel rows, 1.25–1.5 m apart, each row comprising: nurse trees, such as alders and willows, which are fast-growing and provide the early protection; durable trees, such as oaks, sycamore, elm, maple and rowan, which take longer to grow but provide the long-term protection; and shade-tolerant bushes to provide undergrowth in the lower levels of the belt. The mixture of species provides a belt that is less vulnerable to attack by diseases and pests, visually more attractive and able to give a varied habitat for wildlife. The belt needs to be protected in its early years against damage by livestock and spray drift. After about five years and then at an interval of every three to four years, mechanical cutting of the sides of the belt is required to maintain the necessary shape, particularly the sharp rise from the ground on the windward side.

Windbreaks of brushwood or plastic meshes with about 50 per cent porosity are often used to help to stabilize mobile sand dunes and, thereby, provide a more suitable environment for vegetation growth. The windbreaks, sometimes termed sand fences, are placed at right angles to the wind (Savage & Woodhouse 1968). Deposition occurs windward of the barrier for a distance of 0.4–2.0 times the barrier height and in the lee of the barrier for a distance up to four times the height. Once the sand has accumulated and almost buried the fence, a second fence is built on top of the newly formed dune. Further fences are added until the dune is reformed by the wind into a streamlined shape so that air flows over it without loss of transport capacity. Where wind velocities exceed 18 m s-1, double or triple fence systems are used, spaced at intervals of four times the barrier height.

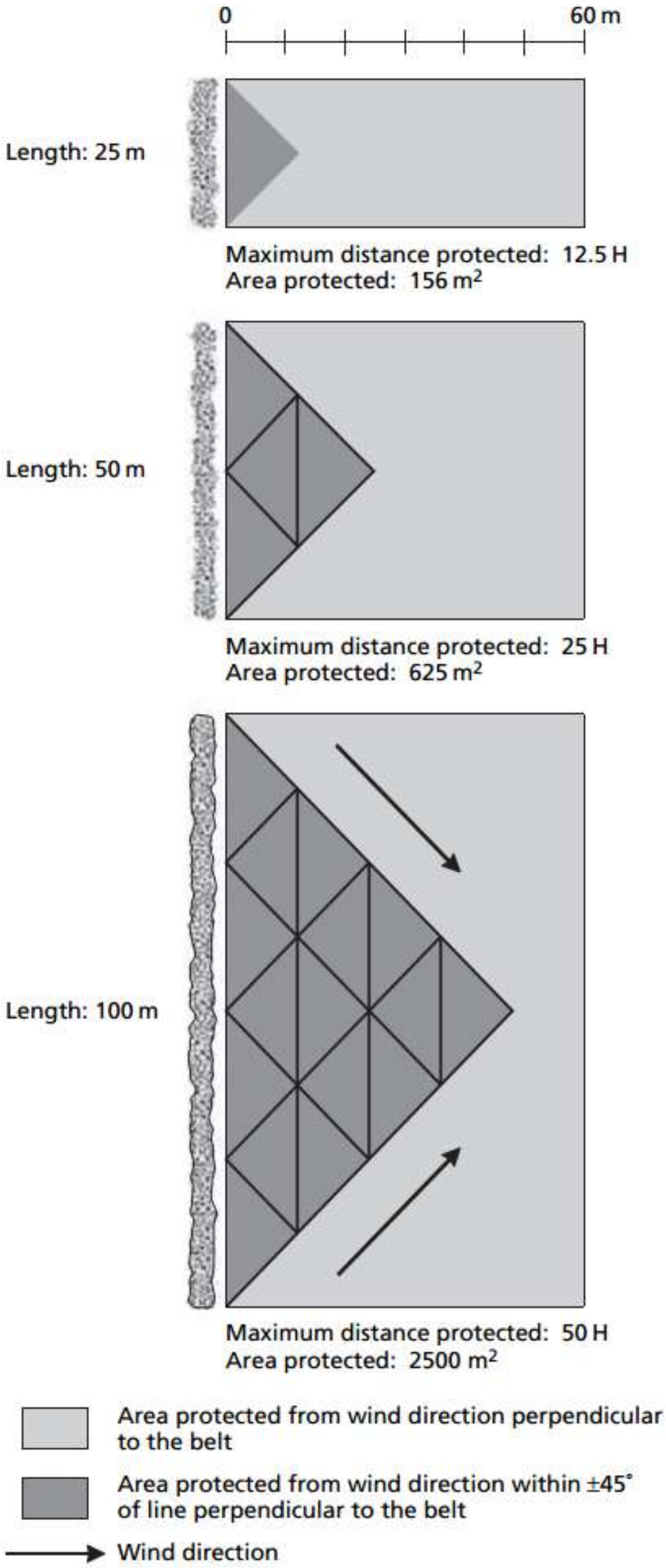


Fig. 10.9 Effect of shelterbelt length on size and shape of area protected by a 2-m tall hedge belt (after Ole 1979).

Example: Find out the distance of protection from a wind break of 18mheight.The angle of deviation of the prevailing wind perpendicular to the wind break is 22^0.The actual wind velocity at 15m height is 14km/h and the minimum wind velocity at 15m height, capable of moving the soil fraction is 18km/h.

L=?

H=18m, $\theta=22^0$, The actual wind velocity at 15m height is 14km/h, the minimum wind velocity at 15m height is 18km/h.

L=17*18m*(18kmph/14kmph) cos 22^0.

L=364.78m

Example: Calculate the area of protection from a wind break of 250m in length and 15m height. The angle of deviation of the prevailing wind perpendicular to the barrier is 25^0.The actual wind velocity is 13.5kmph at 15m height and minimum wind velocity that is capable of moving the soil fraction is 15kmph at 15m height.

H=15m,Length of wind break(W)=250m, $\theta=25^0$,

The actual wind velocity is 13.5kmph at 15m height,

The minimum wind velocity that is 15kmph at 15m height.

L=17*15m*(15kmph/13.5kmph)*cos 25^0.

L=256.78m

Area of protection (A)=L*W=256.78m*250m=64195m^2.

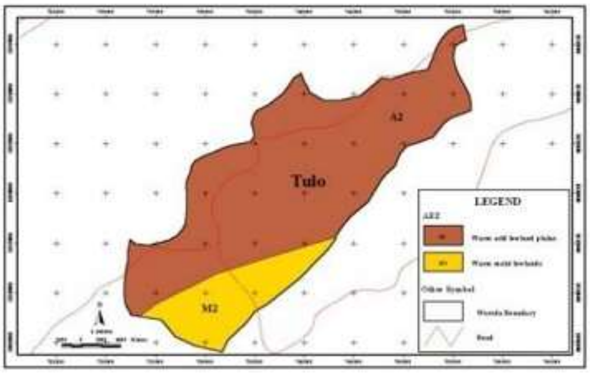
<u>**Exercise**</u>: Calculate the area of protection from a wind break of 150m in width and 16m height. The angle of deviation of the prevailing wind perpendicular to the barrier is 20^0.The actual wind velocity at 15m height is 14kmph at and minimum wind velocity that is capable of moving the soil fraction at 15m height is 16kmph.

3. Combined (vegetative, agronomic and physical) Indigenous SWC practices

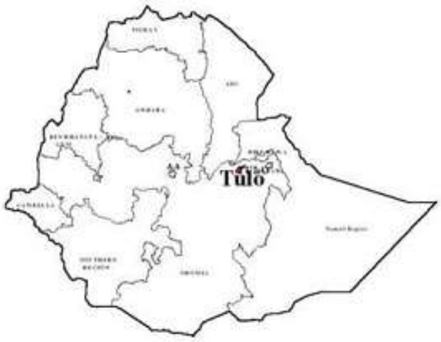
3.1. Ridges and furrows of sweet potato (Harerghie)

Common Name of SLM Technology: Sweet Potato Ridges

Local or other name(s): Daga (Oromifa)



Agro-ecological zones of Tulo Woreda



Location of Tulo Woreda

Definition

A technology involving light earth movement on a crop land by digging the earth to form a furrow where runoff is trapped to form an embankment by dug out soil to form a ridge where sweet potato is to be planted.

Description

Establishment: Sweet potato ridges are formed of soil dug out from the furrow. Farmers make the furrow and ridge by Dengora (Harerghie local hoe) and a Spade sometimes. In some cases oxen scoop is used to move the soil and form the ridge. Sweet potato is planted by cuttings. It is planted twice and the first plantation takes place during the short rains and the second during the end of the main rainy season. There are different methods employed in making ridges and furrows.

Objective

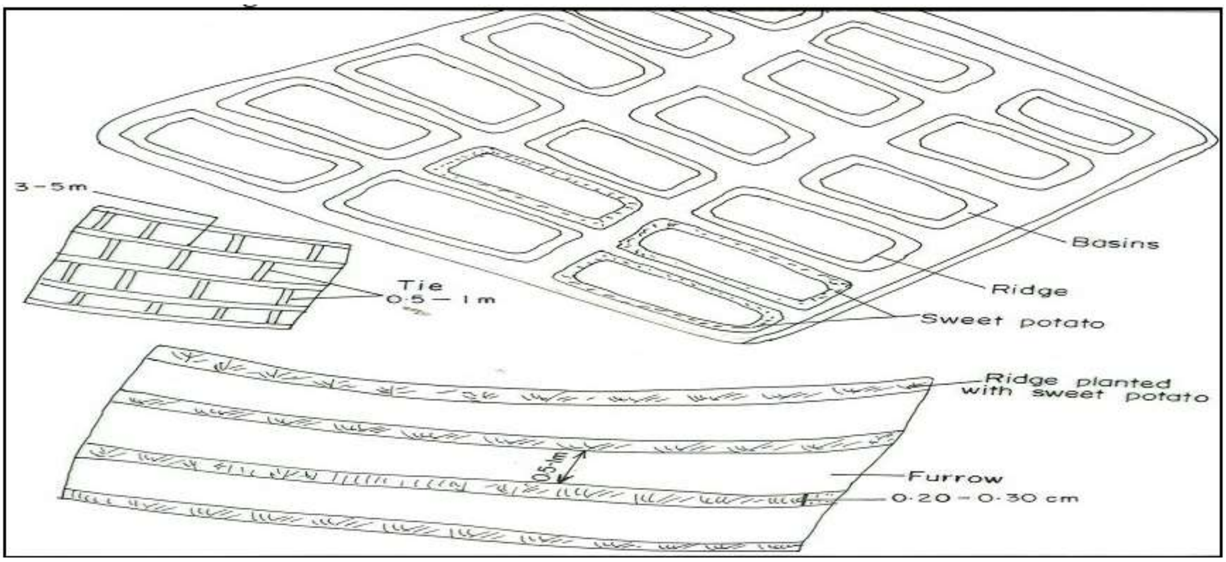
Is to store as much as possible the rain water received in the soil for potato production. To store more rain water, improvements are made on the structure to accommodate the amount of rainfall received, which varies from time to time. Mulches are applied in some cases in order to increase the effectiveness of the measures to control runoff movement and reduce evapotranspiration losses.

The furrows are meant to collect rainwater and the cuttings of sweet potato are planted on the ridge. The plant benefits from the soil water stored in the furrows. Sweet potato has primary and lateral roots which branch out to the sides and that go deep in search of soil nutrients and water. Forming the ridges and basin is quite laborious. The ridges are replaced new and in some cases the former ridges and furrows are maintained.

Picture of the technology

Methods of rainwater management by means of ridges and mini-basins in the Hararghie highlands (Photo 2005)

Technical drawing



Land degradation

Types of land degradation on the land surrounding the SLM area

Land use	Type of degradation	Degree (%)	Landforms
Mixed	Water erosion	60	PRH
Grazing land		100	
Cropland		80	

Observation and estimate

Purpose and classification

The major land use problems in the area without SLM are: soil moisture stress, erosion, high population density, shortage of rains, lack of finance for purchasing improved seeds and fertilizers.

Characterization and purpose

Land use type	% total area utilized by land users who applied the SLM Technology
Cropland: annual cropping	100

The technology combats land degradation by: increasing water stored in the soil, water collection, and control of dispersed runoff and reduction of slope length.

The technology is indigenous. It has originated locally from long-years of practice and improvements. The indigenous SLM technology has been used before the current SLM Technologies was introduced. Ridges formed by digging soil from a given area (2x2 –

5x5m meters) land area and the soil is embanked to form the ridge. The technology helps to trap rainwater, store and make it available to the plants. Today the indigenous SLM is used more. A number of farmers are experiencing the technology and it is expanding.

Improvements are made on the way the structures are constructed in order to increase effectiveness.

Land is prepared during the dry season immediately after the main rains withdraw and early at the beginning of short rains (belg). Sweet potato takes about 5-6 months to mature in the field and there are some varieties which can mature in 3-4 months. It is planted twice a year. The

SLM technology is designed by the land users themselves with some technical support from the extension services of the Ministry of Agriculture, research organizations and universities.

Although the technology is locally originated, some introduced elements have been incorporated such as placing the ridges along the contour and placing tie ridges at a given interval. Soil and stone bunds are included to reinforce the ridges and are widely spaced.

The appearance of the applied technology has gradually changed over time. Some years ago ridges were not combined with bunds but now bunds and ridges are integrated to reinforce the ridges. Household garbage, manure and kitchen ash are applied to fertilize the land and increase production.

Specification of vegetative measures

Type and alignment of vegetative measures (m)

Vegetative measures	Material	Plants / ha	Vertical interval	Spacing	Interval	Width
Aligned contour	Chat	1500	0.2	2.5	2	2.5

Construction and maintenance

Activity	Equipment	Timing	Energy
Tillage	Dengora	Dry season	Manual labor
	Oxen		Animal traction
Harrowing			Manual labor
Contour ridging	Dengora, spade	On set of rains	
	Scoop		Animal traction
Planting	Spade	Rainy season	Manual labor
Cultivation			Manual labor
Seedbed preparation	Spade	Dry season	
	Oxen	Onset of rains	
Pitting	Hoe	Dry season	
Manure application	Manual	Onset of rains	
Planting	Hoe	Wet soils	
Cultivation	Spade, hoe	During rains	
Reconstructing basins	Dengora	Onset of rains	
Ridges and tie			
Excavation (furrow formation)	Scoop and hoe	Rainy season	
Embankment (ridge forming)	Hoe		
Planting sweet potato			
Repair of ridges and furrows	Dengora, hoe	Before planting	
Placing of fertile soil on the Ridges	Spade, hoe		
	Dengora		
Applying manure		After planting	

The vegetative measures considered here include dispersed trees left on cultivated lands, Chat hedgerows and grass planted on bunds, constructed on farm boundaries. Use of manual drawn scoop for making ridges would reduce work burden.

Specification of structural measures

Type and layout of vegetative measures (m)

Structure	Material	Vertical interval	Spacing	Ditch		Bank
				Depth	Width	Length
Retention basin	Earth	1.5-2	0.2-0.5	0.2-0.3	0.5-1	
Ridge	Earth	2-3	0.3-0.5			50-70

Before the ridges and furrows are formed the land is tilled, harrowed and a fine seedbed is prepared. The soil is dug to form the furrow and ridge. While forming the ridge the better-off farmers use oxen plough and scoop and the poor use manual labor and Dengora.

Important constraint during establishment is labor. In some cases the soil is compacted and it is hard to dig. If some showers are received the digging becomes easier. Number of erosive water storms is less than 10. The rainfall in growing season is usually insufficient and not well distributed. The Number of growing seasons per year is 1.

Human environment and land use

Typical household size of the land users is 6. Population density is greater than 350 persons/km^2 and the annual population growth is 3 %. Land size per household is showing a declining trend owning to population pressure. Landownership and land use rights did not affect SLM. In East Hararghie farmers have a long time tradition of practicing soil and water management measures of which sweet potato ridge is one. Subdivision of land is widely practiced but it has not affected the implementation of the SLM Technology.

There is marked difference between rich and poor in how they practice the SLM Technology.

Although, all land users practice it, the rich do it more because they hire labor and get all their land implemented with the technology. Land users who have a wider area of chat plantations are economically better off and hence hire daily laborers to get the ridges formed which are essential for water harvesting. Off-farm income for the land users is less than 10% of all income of households who apply the SLM technology. The level of technical knowledge required for implementation of the technology is moderate for field staff / extension workers and also moderate for land users.

Crop and livestock production

Land cultivation is performed by hoe. Sweet potato is mostly planted on level and gentle slopes and hence land preparation is performed largely by hoe and sometimes supported by oxen plough. The ridges block concentration of surface flow and the furrows provide space for rainwater storage. Sweet potato improves the soil structure by initiating microbial activities and also improves water storage capacity of soils.

Type of cropping systems and major crops grown. The cropping is rainfed and it is often mono-cropping. Intercropping is practiced and crops intercropped include sweet potato-legumes-sorghum. Cropping system or sequence of crops is sorghum-sweet potato-maize-pulses. Croplands are well managed by applying the technology and land productivity is improving. Farmers are well aware of the importance of soil and water management in agricultural activities. Croplands are mostly conserved with various conservation measures which include bunds, soil bunds, hillside terraces and area enclosures. Types of animals:

Large stock; cattle, donkey, horses and the small stock: goat, sheep

Costs

Total labor expended to till the land, pulverize it, harrow and for making the ridges is given in the table below. The cost includes the monetary estimate of manure applied, tillage and purchasing of the sweet potato cuttings.

Agricultural activities	Input	Quantity	Costs US$	% Borne by the land user
Agricultural	Manure	70 (tons/ha)	50	100
Agricultural	Seedlings	15000	25	
Equipment	Plowing	120	35	
Labor	Pd	90	73	
Total			183	

Daily wage cost of hired labor to implement SLM is 0.81 US $ per person per day

Cost of establishment: Labor is the most constraining factor for the establishment. Duration of establishment phase is 1 year. Light textured soils are very simple for operation and least cost incurred. Loam soils are light with moderate cost of investment.

Benefits, advantages and disadvantages

Estimates of production, soil loss and runoff

With or without SLM	Plant	Production (t/ha)	Runoff as % of annual rainfall (t/ha/yr)
With	Sweet potato	4	50
Without		8	0

Soil loss and runoff are negligible on a field where sweet potato is planted on well managed ridges and furrow with additional reinforcement by soil or stone bund. Sweet potato is a very good cover crop, which considerably reduces rain impact and runoff.

On-site and off-site benefits of the technology

Production and socio-economic benefits		**Socio-cultural benefits**	
Crop yield increase	High	Community institution strengthening	High
Fodder production/quality increase		Improved knowledge on SLM and erosion	
Farm income increase			
Ecological benefits		**off-site benefits**	
Soil cover improvement	Medium	Reduced downstream flooding	High
Increase in soil moisture	High	Increased stream flow in dry season	
Efficiency of drainage		Reduced downstream siltation	
Increase in soil fertility			
Soil loss reduction			
Biodiversity enhancement	Negligible		
Production and socio-economic disadvantages		**Ecological disadvantages**	
Loss of land	Medium	Water logging	Negligible
Increased labor constraint	High		
Increased input constraints	Little		
Hindered farm operations	negligible		

Economic analysis

There is no data on the economic returns resulting from conservation measures. However, without SLM, the gross production value in US dollars per hectare per year around the SLM

Technology area is estimated to be 257 / ha / yr. With SLM Technology, the gross production value of the land per hectare per year is 450 US$ /ha / yr. Compared to the situation without conservation the percentage gross production value increase 10 years after implementing

SLM is 80% considering also the land occupied by conservation measures and in assuming current input and prices.

Adoption and adaptation

Many changes have been made to the technology since the technology has evolved. The technology evolved from the land users' needs of storing as much rainfall as possible.

Different methods for laying out and constructing the ridges and basins have evolved through time and at the moment there are very efficient methods and techniques. There is a growing trend towards spontaneous adoption of the technology. More land users are practicing the technology. There is enough local skill and support to expand the SLM Technology

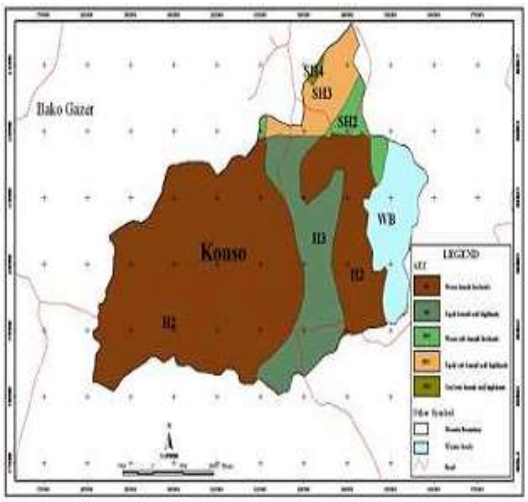
Maintenance

Land users have adequately maintained and managed what has been implemented

3.2. Trashlines (Derashe, SNNPR)

Common Name of SLM Technology: Trashlines

Local or other names: Mona (konso), Malduowa dorai (Gamo)



Agro-ecological map of konso *Location map of Konso*

Specification of the SLM Technology

Land use types: Cropland - annual and perennial mixed cropping

Main function: Water harvesting, fertility improvement, reducing evapotranspiration, and erosion control. Secondary function is to increase/maintain water stored in soil. Climatic regime: semi-arid.

Definition

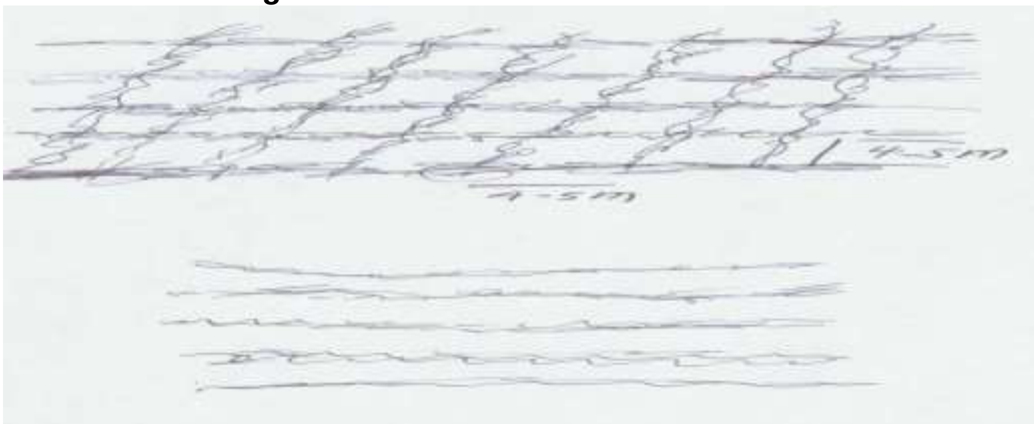
Trashlines are stalk and leaves of maize or sorghum uprooted after harvest and placed along the contour or on a line to form barriers for runoff and trap it in the soil.

Description

Trashlines are formed by sorghum, maize or teff straw pulled up after harvest and placed along and across the slope to form a rectangular basin. The main lines are constructed nearly along the contour. The trashlines are either placed on bunds and basins constructed before or are simply placed on the field without them. The technique is of multi uses and addresses the objectives for water harvesting, soil trapping, physical obstruction of runoff and soil and improves soil fertility. Trashlines perform best if placed on contour or nearly contour lines. The environment in relation to the technique is characterized by having low and erratic form of rainfall with high rates of evapo-transpiration.


Trashlines management for moisture conservation and erosion control, Derashe, SNNPR

Technical drawing



Sketch of Trashlines placed on cultivated lands immediately after harvest. Some are arranged in a rectangular form while others on a single line along the contour

Purpose and classification

The major land use problems in the area without SLM include: Farming on steep slopes, pests, human and livestock diseases and land shortage

Technical function

Main	Secondary
Water harvesting	Increase/maintain water stored in soil
Fertility improvement	Sediment harvesting
Soil erosion control	Increase of infiltration
	Improvement of soil structure

Land degradation

Types of land degradation on the land surrounding the SLM area

Land use(s)	Types of degradation	Degree	Land form(s)
Cultivated land	Water erosion	S	V
Cultivated and grazing	Chemical deterioration	M	M

Source of data: Observations on the site

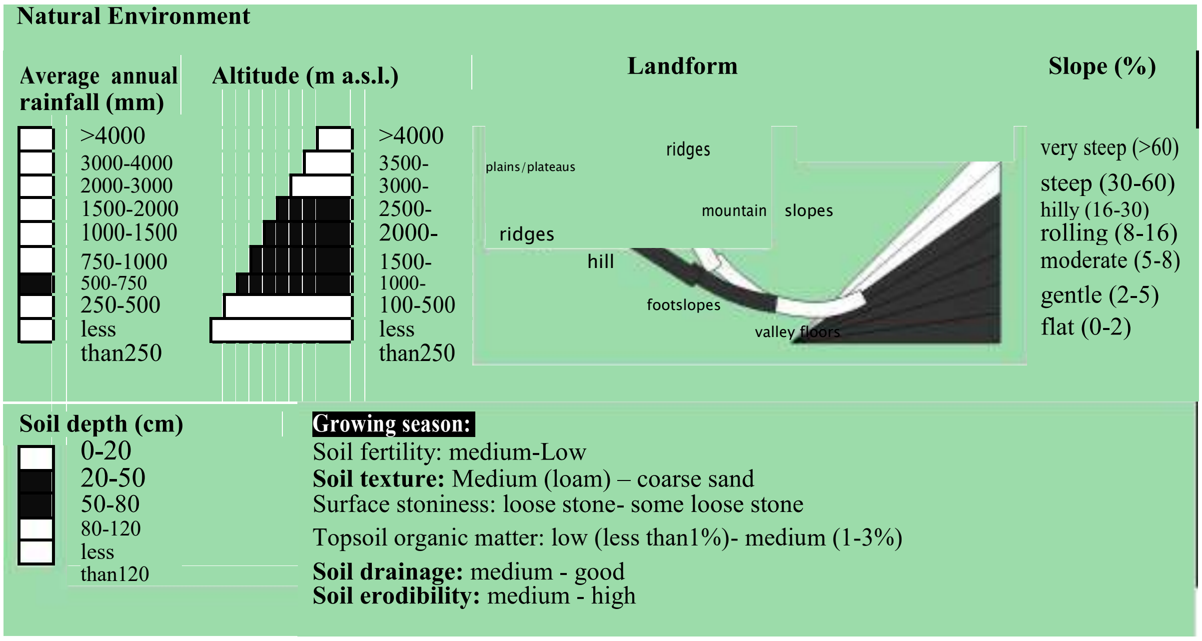
Trashlines are formed of sorghum, maize or teff straw arranged in different shapes (a rectangular, square or a trapezoidal basin) with the objective to retain rain water. Crop stalk / residues are heaped and aligned nearly on contour. The technology provides multi purposes such as water harvesting, soil trapping, and physical obstruction to runoff and soil fertility improvement.

The technology is well adapted in Gidole and the surrounding woredas in general. Trashlines have evolved from long year practicing of the land users. Initially, trashlines were practiced alone but at present being integrated with structural measures such as bunds and tied ridging. Recently, teff straw trashlines are being increasingly used.

There is a significant improvement in the way the technology is advancing.

Field activities for agronomic measures

Activity	Energy	Equipment	Timing	Frequency
Prepare crop residue or stalk to be trash lined	Manual labor	Sickle	Immediately after harvest	Twice a year
Collection of straw	Manual labor Donkey load	Hand	Immediately after harvest	Twice
Arrange the straw and stalk on a line	Manual labor		Dry season	



Important information on the natural environment where the technology is applied: The number of heavy storms of water per year is 10 -15. These occur at the beginning and mid of the growing seasons. Rainfall in growing seasons is usually insufficient and not well distributed. Number of growing seasons per year is 2.

Human environment and land use

Size of land per household is less than 1 ha for 60% of land users and 1-2 ha for 40% of land users in general. Typical household size of the land users is 7 persons. Population density is 200-250 persons/km$^{2.}$ Annual population growth is 2-3 %.

The trend in household land size shows a decreasing trend because of population growth. No indications appear to be seen towards privatization of land because land is owned by the state and the public. Nevertheless, land ownership did not affect SLM. Similarly, subdivision of land takes place but it did not affect the implementation of the SLM technology.

There is difference between rich and poor in how they practice SLM because poor farmers have limited access to participate in share-labor, which requires offering of food and drinks for people working. Poor farmers are unable to provide food and drinks and hence are unable to benefit from it.

Off-farm income is significant for the land users who apply the SLM technology and is about 50% of all income. Most farmers practice the technology and also are engaged in petty trades. The use of the SLM Technology is not hindered because land users cannot read and write. About 90% cannot read and write but still they practice the technology. Production is not subsidized for cropland and cropland mixed with another land use type. Land cultivation is performed largely by manual labor using the hoe. Cropping is rain fed mostly and in the majority of the cases land users cultivating the valley floors practice flood or runoff- farming by diverting runoff from hillsides and roads and directing it to the field. The type of cultivation is continuous cropping by rainwater and post-flooding. Intercropping is practiced widely. Crops intercropped include: Sorghum, maize, paper, cotton, and beans. The cropping system (e.g. sequence of crops. etc.) is of a pattern Sorghum - Maize – Beans.

Main canal for flood water irrigation on a maize field (Photo 2003)

Economic analysis

The gross production value in US dollars per hectare per year around the SLM Technology area is less than 100/ha/yr. Compared to the situation without conservation, estimated percentage gross production value increase in 3 years after implementing SLM taking into account any production losses due to the area rendered non-productive because of the presence of the SLM measures is over 100%.

Compared to the situation without conservation, estimated percentage gross production value decrease in 10 years after implementing SLM is 100 - 200%, by considering also the land occupied by conservation measures and in further assuming current input and prices.

Adoption and adaptation

Many changes have taken place in terms of improving the application of trashlines. These evolved through long time practice by the land users themselves. Initially trashlines were practiced alone but through time structural measures such as bunds and tied ridging are combined with trashlines and now these are being increasingly practiced. Recently, teff straw trashlines are also practiced. There is significant advance in the way the technique is improving. Land users who have implemented the technology with incentives are 0 % and cover 100% of the SLM technology area.

Percent land users who have implemented the technology and who have done it wholly voluntarily, without any incentives other than technical guidance is 100% of land users that have applied the SLM Technology in the 100 % of the area.

There is a very significant growing trend towards spontaneous adoption of the technology. Trashlines are localized to sorghum growing areas mostly at the moment but there are chances for expanding the technology to teff growing areas as well because there is emerging experience with teff trash lining. The technology is easily replicable. The SLM Technology is less durable but can be easily maintained and kept in good shape

Trashlines formed from teff stubble straw after harvest (Photo 2002)

Maintenance: land users have adequately maintained and managed what has been implemented. Maintenance is made regularly twice or once every year immediately after crop harvest and before land preparation.

Supportive measures: 1. Soil bund: earth embankment across the slope and 2. Tie ridges: are water-harvesting measures built in rectangular shape

4. Introduced structural SWC measures

The introduced SWC practices mentioned below will be offered in higher levels but the common practiced in Ethiopia are the following:

- Stone-faced trench bund (Tigray)
- Stone-faced bunds (Abay Gorge)
- Stone faced soil bund (Harerghie)
- Graded bunds with disposal structures (East Gojjam)
- Paved and grassed waterways (Farta-amhara)
- Cut-off drain
- Hillside Terrace
- Gabion/stone/post check-dams
- Area closure combined with hillside terraces (Tigray)
- Earth-check dams for gully reclamation (Damot Galle)
- Micro-basins with trenches for area enclosures, Lemo (Hadiya)
- Runoff and floodwater farming (DireDawa)
- Grazing land improvement (Chencha)
- *Agro-forestry systems for land management (Gedeo, Jima)*

Name: ___________________________ Date: ________________

Short Answer Questions

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. List the physical ISWC practices in Ethiopia.(3points)
2. The combined physical and biological SWC effective than physical measures alone. Why?(10 points)

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = ___________
Rating: ____________

Information Sheet-2	Note and reporting breaches of erosion control

Note and report Breaches (Violations) of erosion and sediment control legislations

Erosion and sedimentation can result in impacts to public infrastructure such as creating both nuisance and larger scale problems when streets, streams and storm drains are clogged with sediment and are then prone to flooding. These impacts can result in problems that affect public safety and result in permanent infrastructure damage such as road failure and pipeline damage, as well as environmental impacts. Uncontrolled erosion is costly; violates state and Federal pollution laws; and exposes developers, contractors, and landowners to legal liabilities.

- **Natural erosion** is generally considered to be due to the influence of climatic forces on the surface of the earth. While we can learn from the processes of natural erosion, the practice of erosion prevention is usually limited to sites where human activities accelerate this natural process.

Erosion problems can be accelerated by a variety of human activities, including unrestricted development, overtaxed resources, removal of surface cover (such as vegetation), increased imperviousness (such as paving and rooftops) that increases runoff, and poor stewardship. Accelerated erosion as man-induced, land-disturbing activities that result in increased sediment delivery to down slope/downstream water bodies. Sedimentation impacts on in-stream and off-stream water quality are illuminated along with other resource base, agricultural and air quality impacts. Consequently, it brings economic and environmental destruction. Therefore, such kind of activities should closely followed, noted, reported and treated according to erosion and sediment control legislations.

Breaches (Violations) of erosion and sediment control legislations refers to: an act of disregard /contrary of erosion and sediment control legislations such as a law, contract, or agreement, especially in a way that produces significant effects; disturb or interrupt something in a rude or violent way; treat something sacred with a lack of respect. Somebody who fails to respect erosion and sediment control legislations will be sentenced accordingly which will be allocated/imposed a punishment to somebody convicted of a crime, usually stating its nature and its duration.

Therefore reporting and noting violations of erosion and sediment control legislations would help to bring somebody who convicted of a crime against erosion and sediment control activities will in turn reduce the incidence of crime and correct the person who had convicted of a crime.

Name: ___________________________ Date: ________________

Short Answer Questions

Self-Check -2	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What does (Violations) of erosion and sediment control legislations mean?(10 points)

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = ___________
Rating: ____________

Information Sheet-3	Applying Industry practices for erosion control

3.1. Applying Industry practices for erosion control

3.1.1. Erosion and sediment impact

Describe impacts of erosion and Sedimentation

Damage from **sedimentation** is expensive both economically and environmentally.

Sediment deposition has the following impacts:

- destroys fish spawning beds
- reduces the useful storage volume of reservoirs
- clogs channels and streams
- may carry toxic chemicals, and requires costly filtration for municipal water supplies.
- Suspended sediment can reduce in-stream photosynthesis an ecology.
- Damage to infrastructures and buildings e.g fill culverts, damage bridges

Many environmental impacts from sediment are additive, and the ultimate results and costs may not be evident for years. The consequences of off-site sedimentation can be severe and should not be considered as just a problem to those immediately affected.

On-site erosion and **sedimentation** can cause costly site damage and construction delays. Lack of maintenance often results in failure of control practices and expensive cleanup and repairs.

While sedimentation is off-site effects of erosion, on-site effects include the following:

- Soil loss
- Reduction of soil depth
- Reduction of soil fertility
- Reduction of crop yield
- Dissection of farm lands, etc.

3.1.2. Erosion & sediment control principles

The following principles are not complex but are effective. They should be integrated into a system of control measures and management techniques to control erosion and prevent off-site sedimentation.

I. Fit the development to the existing site conditions

Ensure that development features follow natural contours. Steep slopes, areas subjected to flooding, and highly erodible s well-drained areas offer few restrictions. Any topography requires protection from erosion and sedimentation.

II. Minimize the extent and duration of exposure

Scheduling can be a very effective means of reducing the hazards of erosion. Schedule construction activities to minimize the exposed area and the duration of exposure. In scheduling, take into account the season and the weather forecast. Stabilize disturbed areas as quickly as possible.

III. Protect areas to be disturbed from stormwater runoff

Use dikes, diversions, lined channels, waterways and temporary slope drains, etc to intercept runoff and divert it away from cut-and fill slopes or other disturbed areas. To reduce on-site erosion, install these measures before clearing and grading.

IV. Stabilize disturbed areas

Removing the vegetative cover and altering the soil structure by clearing, grading, and compacting the surface increase an area's su measures as soon as possible after the land is disturbed. Plan and implement

temporary or permanent vegetation, mulches, or other protective practices to correspond with construction activities. Eg. seeding, mulching and matting, etc.

V. Keep runoff velocities low

Increasing vegetation cover and/or the surface roughness and reduces runoff velocities and volumes. Use measures that break the slopes to reduce the problems associated with concentrated flow volumes and runoff velocities and diverting stormwater at non erosive velocity to safe disposal area.

VI. Retain sediment on the site

Whenever possible, plan and construct sediment traps and basins before other land-disturbing activities.

VII. Inspect and Maintain

If not properly maintained, some practices may cause more damage than they prevent.

For example, a large sediment basin failure can have disastrous results; low points in dike can cause major gullies to form on a hill slope. Always evaluate the consequences of a measure failing when considering which control measure to use, since failure of a practice may be hazardous or damaging to both people and property. It is essential to inspect all practices to determine that they are working properly and to ensure that problems are corrected as soon as they develop.

Name: ___________________________ Date: ________________

Short Answer Questions

Self-Check -3	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. list erosion & sediment control principles(10points)
2. Describe impacts of erosion (on-site) and Sedimentation (off-site).(10points)

Note: **Satisfactory rating >10points** **Unsatisfactory - below 10 points**

Answer Sheet

Score = ____________

Rating: ____________

Information Sheet-4	Inspecting and maintaining SWC measures

4.1. Inspecting and maintaining SWC measures

4.1.1. Applying maintenance schedule

Maintenance schedule will be set based on the kind of SWC measures and season of the year.

4.1.2. Re-establishing operating effectiveness of indigenous SWC measures

Land owners must establish and maintain vegetative cover and structural practices in accordance with the Conservation Plan on file at the SWCD. Conservation plan maintenance includes any necessary replanting of vegetative cover and repair of structures. Amendments to the conservation plan must be agreed to by the landowner, the SWCD and the State.

Establishing the conservation practices identified in the Conservation Plan is arguably the single most important component of the easement process. The care taken to ensure the conservation practices are properly installed and maintained will provide healthy vigorous stands of vegetation and properly functioning engineering practices.

Any willful action by the landowner that is not in compliance with the Conservation Plan is considered a direct violation of the conservation easement.
Maintenance activities are very important in keeping each conservation practice identified on the easement area in good condition. Maintenance begins after successful development of the conservation practice and continues for the duration of the practice. Maintenance activities are the responsibility of the landowner.

The *owner* must ensure that all erosion and sediment control practices and all post-construction storm water management practices identified in the SWCD are maintained in effective operating condition at all times.

For construction sites where soil disturbance activities have been temporarily suspended (e.g. winter shutdown) and temporary stabilization measures have been applied to all disturbed areas.

Name: ___________________________ Date: ________________

Short Answer Questions

Self-Check -4	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Why is Inspecting and maintaining SWC measures?(10points)

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

Answer Sheet

Score = ____________
Rating: _____________

Operation Sheet 1	Level bund

Objective: - At the end of this practical session the learners will be able:-

- Construct Indigenous and introduced conservation practices
- Apply Industry practices for erosion control
- Site works maintenance

PROCEDURES

You will need an –frame or line level, digging tools, and stones for stone bunds. To stabilize the bund, you will need suitable grasses, legumes and tree seedlings.

Here is how to make a bund from soil.

1. Work out the gradient of the slope.
2. Decide on the spacing of bunds. Use pegs to mark out where to begin building each bund down the slope.
3. At the top of the slope, mark out a contour line (a line running at the same height across the slope) where you want to build the first bund.
4. Scrap the soil from either side of the contour line, remove the grass so the soil can be compacted and pile soil and stones up to form an embankment running along the line.
5. Compact the embankment and shape it so the top is level.
6. Move down the slope to where you want to build the next bund and repeat step 3-5.
7. Plant the grasses, fodder legumes and trees with the bunds to stabilize them and make them productive.

Operation Sheet 2	Graded bunds

PROCEDURES

How to make a graded bund

To make a graded bund You will need an –frame or line level, digging tools, and grasses, legumes and tree seedlings.

1. Measure the gradient of the slope and check the soil type. These will determine the safe gradient for the bund (see the previous page) and the spacing between the bunds (see next page). You can measure the slope gradient using a line level.

2. Go up water way or channel you want the bund to drain into, to the top of the slope. Starting here, use the line level to mark out where to build the bund.
3. Scrap the soil from either side of the line you have marked, remove the grass so the soil can be compacted and pile soil and stones up to form an embankment running along the line.
4. Compact the embankment and shape it so the top is level.
5. Move down the slope to where you want to build the next bund. Repeat steps 2-4.
6. Plant the grasses, fodder legumes and trees with the bunds to stabilize them and make them productive.

Operation Sheet 3	Micro basin

PROCEDURES

How to build a micro-basin

1. Decide where to plant the trees. Mark a pattern on the ground, staggering the basins on a slope to control runoff.
2. Dig a shallow basin around each planting site, piling the soil in to a ridge around the down slope side, 15 cm from the edge of the basin. Make the ridge 30-50 cm high and 60-90 cm wide.
3. Plant the seedling. In dry areas, plant it in the middle of the basin. In moist areas, plant it in the ridge of soil you have built on the lower side of the basin so it does not get waterlogged.

Operation Sheet 4	Bench terrace

PROCEDURES

How to build a level bench terrace

1. Measure the gradient of the slope using a line level. Check how deep the soil is. Using the table below, decide how wide the bench terrace should be.
2. At the top of the slope, use a stick mark where to build the first terrace wall, by using line level.
3. Measure the width of the bench and mark where to build next wall (point B in the diagram). Mark out a contour line from this point. Repeat this process to mark out the location of all the walls down the slope.
4. Measure half the distance between between the first and second lines (point X in diagram 1 on the diagram below).
5. Remove all the top soil from the whole area to be levelled, and pile it at a convenient place to one side. (Diagram 2).

Operation Sheet 5	Waterways.

PROCEDURES

How to make a grassed waterway

1. Decide where to make the waterway.
2. Decide how wide and deep the waterway should be (see the above table).
3. Cut out grass sods from the path of the waterway And put them to one side.
4. Dig a channel along the Planned path. Throw The soil on both sides to Form an embankment. Leave a 15-30 cm space to stop the soil from sliding back in to the channel.
5. Arrange the sods along the channel and on the ridges and fix them in place with pegs.
6. Leave the channel until grass has grown in the channel and on the ridges.

Operation Sheet 6	Gully controlling measures

PROCEDURES:
TASK 1

❖ **How to make wooden check dams**

1. Make a set of wooden posts, 5-10 cm in diameter and 1.5-2.5 m long. Sharpen one end of each post to make it easy to hammer in to the ground.
2. Hammer the posts 0.5-1 m apart, at least 60 cm deep in to the floor of the gully. The spacing between the posts depends on the height of the check dam: the higher the dam, the looser the posts. For a double row check dam, make two rows of posts, 50-60 cm between the rows.
3. Weave thinner branches between the posts to form a wall.
4. Dig the branches 50 cm or more in to the side of the gully.
5. Pack brush and other debris behind the wall (or between the rows in a double-row dam).
6. Tie the top of the structure with wire or rope, and anchor it to the ground using brushwood.

TASK 2

❖ **How to make stone check dams**

1. Dig a trench 40 cm wide and 40 cm deep across the gully, and extend it 40 cm in to the gully banks on both sides.
2. Put large stones in to the trench you have dug.
3. Use more stones to build a wall 1 m high and 1 m thick. The sides of the wall should be higher than the middle, so that water can flow over the middle.

4. Put more stones against the downstream side of the dam to break the flow of water falling over it.

TASK 3

- **How to make Gabion check dams**

  Gabion boxes come in two standard sizes: 2 m long × 1 m wide × 1 m high, and 2 m long × 1 m wide× 0.5 m high.

1. Dig a trench 1 m deep in the gully floor. The trench must be as wide as the gully and should be dug in to the wall to stop water from eroding around the sides of the dam.
2. Place gabion boxes in to the trench, fill them with stones and tie them with wire.
3. Add another layer of gabions on top to raise the height of the dam. Make the sides of the dam higher than the middle.

LAP Test	Practical Demonstration on **Participating in Indigenous Soil and Water Conservation Practices**

Name: ______________________________ Date: ________________

Time started: _________________________ Time finished: ________________

Instructions:

1. You are required to perform any of the following:

   1.1 Request your teacher to arrange for you to visit **field demonstration area**. Then, assess whether the **conservation field area** is clean and all materials and equipment's are properly handled.

   1.2 Request a set of Participating in Indigenous Soil and Water Conservation Practices equipment, then perform the following tasks in front of your teacher –

   Project 1: Show how to survey and construct **gabion check dams**

   Project 2: Show how to survey and construct soil bund,

Prepare **a report and submit** what kind of problem you faced while you Indigenous Soil and Water Conservation Practices.

2. Request your teacher for **evaluation and feedback**.

Name: ________________________ Date: _______________

LAP Test	Practical Demonstration

Name: ____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within --- hour.

Task 1.

Task 2.

Task N.

List of Reference Materials

1- BOOKS

Mitiku, H., Herweg, K., Stillhardt, B., 2006 *Sustainable Land Management – A New Approach to Soil and Water Conservation in Ethiopia*. Mekelle, Ethiopia: Land Resources Management and Environmental Protection Department, Mekelle University; Bern, Switzerland: Centre for Development and Environment (CDE), University of Bern, and Swiss National Centre of Competence in Research (NCCR) North-South. 269 pp.

MOARD. 2010. *Sustainable Land Management*- Sustainable Land Management Project (SLMP), Natural Resources Management Sector, Ministry of Agriculture and Rural Development of the Federal Democratic Republic of Ethiopia. Indigenous and introduced technologies to be scaled up in the various agro-ecological and farming practices of Ethiopia.321pp.

LAND DEGRADATION ASSESSMENT IN DRYLANDS (LADA) PROJECT.____. Manual for local level assessment of land degradation, sustainable land management and Livelihoods: part2 – Field methodology and tools.

Liniger, H.P., R. Mekdaschi Studer, C. Hauert and M. Gurtner. 2011. Sustainable Land Management in Practice – Guidelines and best Practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies (WOCAT) and Food and Agriculture Organization of the United Nations (FAO).

Humberto Blanco and Rattan Lal.2008. Principles of Soil Conservation and Management. Current address:Kansas State University Western Agricultural Research Center-Hays 1232 240th Avenue Hays, KS 67 601 USA; The Ohio State University 2021 Coffey Road Columbus OH 43210 422B Kottman Hall USA.

R. P. C. Morgan. 2005. *SOIL EROSION AND CONSERVATION* .3rd ed. published by Blackwell Publishing Ltd. ISBN 1-4051-1781-8 (pbk. : alk. paper): A catalogue record 2004009787.

2- WEB ADDRESSES (PUTTING LINKS)