The Federal Democratic Republic of Ethiopia Regional State of Tigray Bureau of Water Resource Development

Misrar Teli Irrigational Diversion Irrigation Project

(South Eastern zone, Enderta wereda)

Feasibility report of watershed management

Client: Tigray Regional State Bureau of Water Resource

Address: Telephone: +251-344-406677/78

P.O.Box: 520, Fax: +251-344-406410/419637

Mekelle

Consultant: Tigray Water Works Study, Design and Supervision Enterprise

Address: Telephone: + 251(0)344418583

P.O.Box: 957, Fax: +251-344-400139

Mekelle

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1. Executive summary

The main objective of this paper is to assess the soil and water conservation aspects of the irrigation system found in the Misrar Teli watershed.

Water scarcity and in efficient utilization of the available water resources are the most important problem of the region, with poor intensity and distribution of rainfall that production reduction are commonly occurred. This leads to the lower living standard of the community members forcing them to put rather pressure on land worsening the problem. Based on this, devising new water harvesting techniques and improvement of the existing water resources and the system to irrigate the land is found a critical issue being the only to raise productivity and attain food security.

The Misrar Teli watershed, which is found in the south eastern zone of Tigray, Enderta Wereda, is identified to contain a number of traditional irrigation systems with poor utilization of the existing water and land resources. The study and design team of the enterprise has dealt in a multi disciplinary manner with the largest river Misrar Teli traditional irrigation system, with the catchment area focusing at assessing and evaluating the potentials, problems and possible solutions.

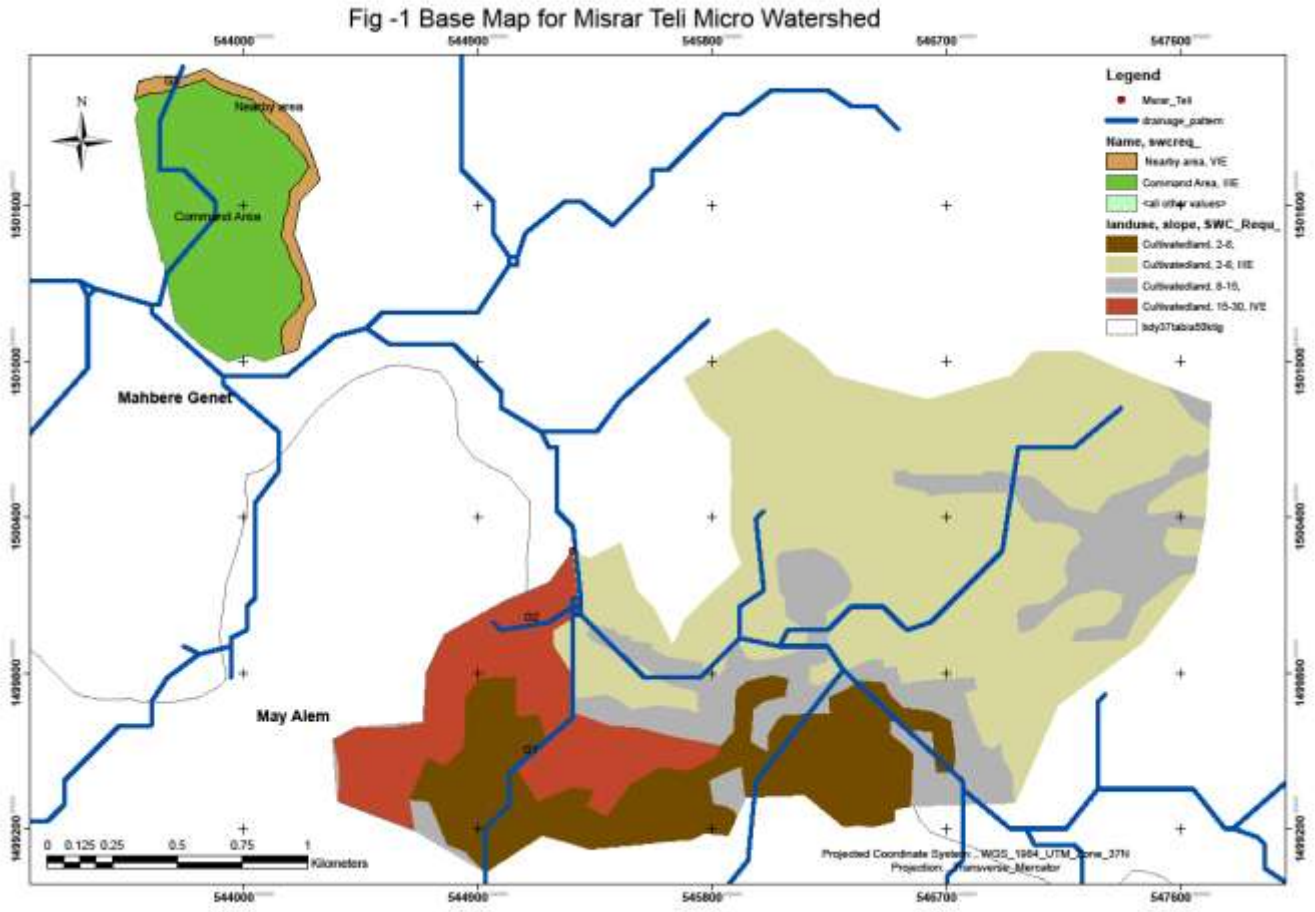
This watershed having a dominant topographic feature of sloping hillsides and found under poor land management although it has a few vegetation cover at some irrigable areas. It is exposed to sever soil erosion. It has also poor ground vegetation cover on the cultivated and free grazing land. Most of the rocks are fragile, weathered basaltic rocks and lime stone. The major problems of this watershed are lack of effective water harvesting techniques, deforestation, soil erosion, fuel wood shortage, and problem of drinking water and production reduction.

With such poor condition of protection, the area makes produce much run off and water carrying much transported sediment materials with large boulders. This

erodes and destroys the productive part of the command land. As a result of this, the effectiveness and well being of the existing and improved components of the system has been highly affected.

Based on this, urgent and decisive protective strategies are specfically described on this paper at micro watershed level. The conservation measures recommended for such area are check dams, stone bunds, hillside terrace and tree plantation. These measures are expected to assure the well-being and efficiency of the improved irrigation system, thereby raising and sustaining production in a protective environment.

Figure 1 Base Map of Misrar Teli MicroWatershed



2. Background information

In Tigray region there is less developed water harvesting system. The local farmers have faced failure of crop production due to shortage of rainfall and occurrence of erratic rainfall.

The irrigation system employed in this watershed is with poor water harvesting technique because they don't have capacity to build large and permanent diversion structures to harvest the flowing water generated from the watershed during dry season for irrigation purpose.

Based on this, assessment of traditional irrigation sites at this watershed has been done aiming at improving such systems and evaluating the constraints and potential of the site at micro watershed level.

Within this watershed, one site was studied. This diversion site is river Misrar Teli. It is found in south eastern Tigray, Enderta Wereda and Tabia Mahbere Genet. The local farmers have used the selected diversion site for irrigation traditionally for many years with less effective and inefficient utilization of the water that flows throughout the year, and with less protective of the surrounding area.

Some of the subwatershed has been existed in sever soil erosion condition. Much more sediments with large boulders were transported from the steep hillsides. This will damage both the structures and the command lands which is placed in the lower plain area.

3. Objectives

Effective utilization of the existing water and protection of the surrounding area has not been yet occurred in the traditional irrigation. As a result of this, existence of sever soil erosion, wastage of much more water, reduction in productivity and lowering the living standard of the people are the common problem disseminated in the Misrar Teli watershed.

Therefore the main objective of the study is

1. To describe the Bio-physical and socio economical nature of the watershed.
2. To assess the existing potential and problems of the irrigation activities found within this watershed.
3. Based on the findings, some protective measures to the specific degraded catchment area and some command area have been proposed to protect siltation of the weir and rehabilitate the watershed to reduce soil erosion and sediment transportation.
4. Develop action plan and estimate project budget requirement to implement the planned activities

4. Materials and Methods

4.1 Data collection methods

Various data collection methods were used for Misrar Teli watershed management study. The methods were aimed at enabling to look at different levels in the system hierarchy of the land resources of the watershed in relation to diversity, coverage and constraints. The materials and methods used during data collection process are depicted as follows:

4.1.1 Desk works

In the desk work, the watershed boundary and topographic features was delineated, measured and interpreted using 1: 50, 000 scale topographic map, spot image (5*5) and DEM data with the resolution of 30m *30m using the GIS software applications, global mapper and google earth. Subsequently, secondary information on biophysical features, existing problems and potentials has been collected through review of relevant studies and base map was prepared for field works.

4.1.2 Field works

Field visits were carried out in the watershed to collect and ascertain the collected data on biophysical and socio-economic features required for the watershed management study. Accordingly, various data have been collected through direct observation, discussion with watershed communities and relevant experts in the target Weredas of agricultural and rural development offices.

- **Field observations and measurements**

Field observations were conducted in the watershed which included topographical features, soil texture, land use diversification and socio economical aspect of the watershed. The tools used in collecting the data were direct observation, measurements, Cross referencing with secondary data and conducting interviews with some local farmers. Through transect walk data have been collected and measured on land use/land cover types, soils, vegetation types, topographic features

soil erosion and land degradation problems, types of practiced SWC measures and farming practice. In soil texture and soil type assessment, which is described in annex five in detail, the ESRDF (CFCDD 1986) manual of soil assessment at field level had been employed. By moistening the soil sample and rolling it the soil in to different shapes, the result of soil texture will be read from the manual that is described in annex five. However if there is an efficient and effective laboratory service, it will be better to use lab method; but this is a limitation in our region that more than 100 samples for a given catchment can't reach on the required time. As a result of this analysis and design of schemes will be delayed and the project will not be accomplished based on the given schedule.

- **Public consultations**

Many discussions were conducted with the target community members in different Tabias which is described above. Many community members were participated representing from different social groups such as community leader, officials, elders, women and youths. The discussions were facilitated by the development agents and experts in the target Wereda. The communities' discussions helped to understand perception of the local people on land degradation situation and their willingness on watershed management interventions. This has also helped to identify the watershed problems and solutions on the bases of community views and priorities.

- **Discussions with Wereda staffs and secondary data collection**

Following to field observation and the community discussion, brief discussions were conducted with the target Weredas of agricultural development staffs represented from their natural resources conservation and development core processes heads and case team experts. The discussion points were encompassed major problems of the watershed and their causes, adapted intervention and strategies, sustainability of the implemented SWC measures, implementation of the performed land use proclamations and possible options for future management of the watershed resources. These discussions have helped for cross-checking the issues raised by the

community and fill data gaps. This has also assisted to understand the institutional capacity and organizational structures of the core implementing institutions.
In addition to this, secondary data have been collected from the target Wereda with the designed format and discussions with the relevant experts.

4.2 Data analysis methods

The collected data have been analyzed using system analysis method. In the system the land based resources data of the watershed were collected and interpreted using standard descriptions with respect to diversity, coverage and constraints in relation to land management. Likewise socio-economic and institutional factors which are relevant for watershed management are identified and analyzed as integral component which have helped in identifying appropriate solutions for sustainable management of the watershed resources. The soil loss of the watershed area was estimated using previous studies and universal soil loss equation adapted to Ethiopian condition. Land classification has been carried using the USDA land capability classification method modified to Ethiopian condition to have identified the soil and water conservation requirement class. Finally based on the biophysical and socio economic information and analyzed results possible watershed management intervention and strategies have been proposed together with the implementation strategies and estimated budgets.

4.3 Approaches and procedures

The feasibility study of the watershed management was undertaken considering the following approaches and procedures:

- Delineation of watershed boundary using topographic map and DEM of 30m by 30m resolution.
- Inferring the physiographic features (slope and contour) of the watershed interpreted by using GIS software application tools.

- Collection of available data through review of the previous data and existing satllite image.
- Data collection through field observation and discussion with communities and target Weredas staffs.
- Conducting land capability classification to determine the soil conservation requirement classes around the diversion schemes and command area.
- Analysis of the resources and identification of opportunities and constraints.
- Propose integrated watershed management intervention.

5. Biophysical description of the watershed

The Misrar Teli diversion site is found in the Mahbere Genet administration area having good potential of perennial water that can irrigate more than 50ha during dry season.

For the detailed bio-physical description of the area including its location, topography, climate, soil, vegetation, land use types, land capability classification problems of the area, and the like has been given below.

5.1 Location

Administration location

Region - Tigray

Zone – South eastern

Wereda – Enderta

Tabia – Mahbere Genet

Kushet – Adi Shara

Geographical location

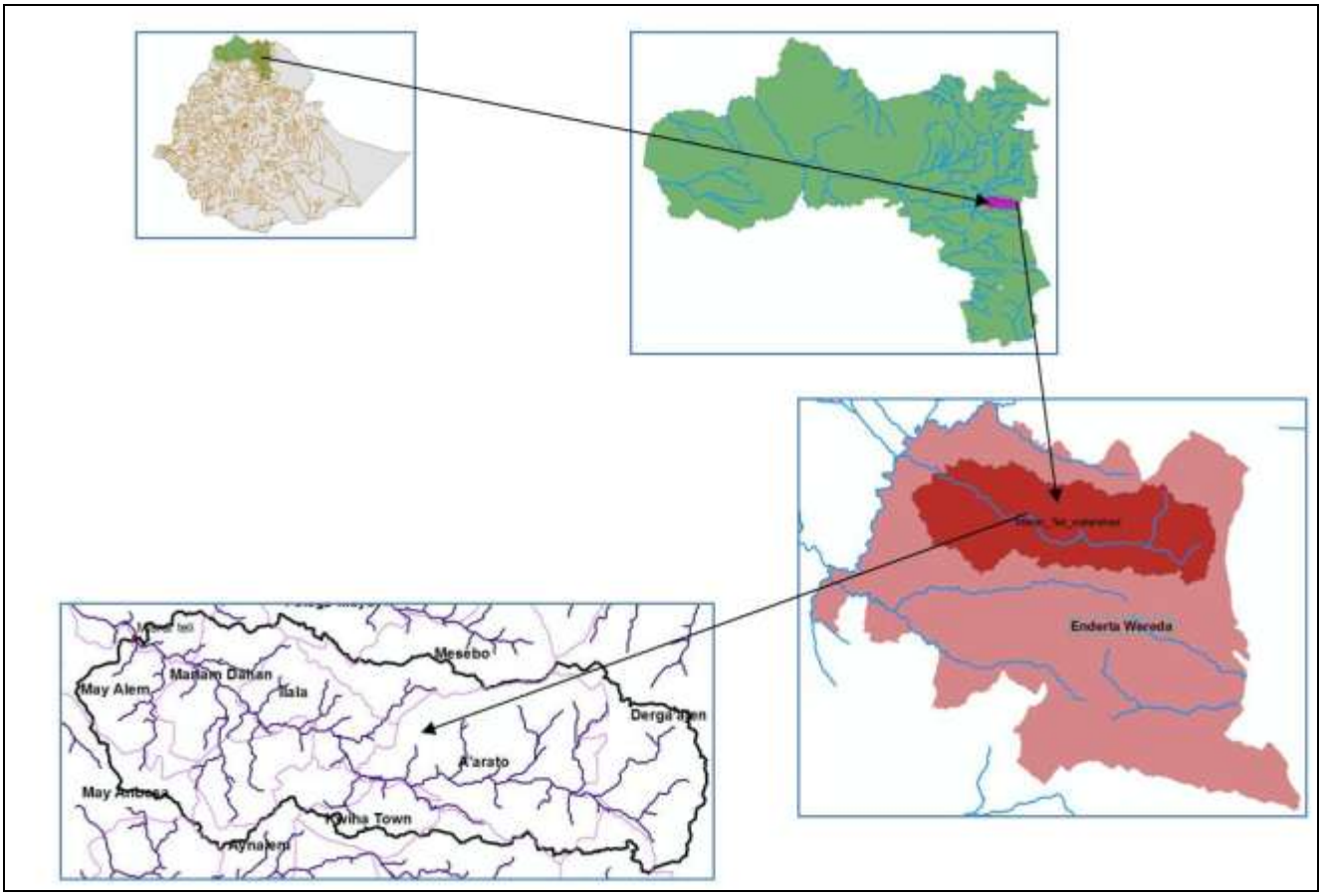
Latitude: 1500099N

Longitude: 545155E

Elevation: 1870m above sea level

The site is located 12-km north west of Mekelle and it has the total catchment area of 322.68km^2.

Figure 2 Location Map of Misrar Teli Watershed



5.2 Topography

Very steep sloped to gentle slope is found at this very large and moderately degraded catchment area. Past deforestation and overgrazing practices have caused to have bare land on some steeper parts. The dominant topography in this watershed is sloping. Such topographic feature is commonly found at the lower and middle part of the watershed. It covers 39.28% of the total catchment area. The gentle sloping landscapes are largely found at the lower part of the catchment that is commonly used as cultivated lands and homesteads. Such topographical feature covers 33.38% of the total area. The moderately steep topographies that are commonly found at the upper and the periphery of the watershed occupy 23.16% of the total area. It is commonly used as cultivated land and free grazing lands.

5.3 Climate

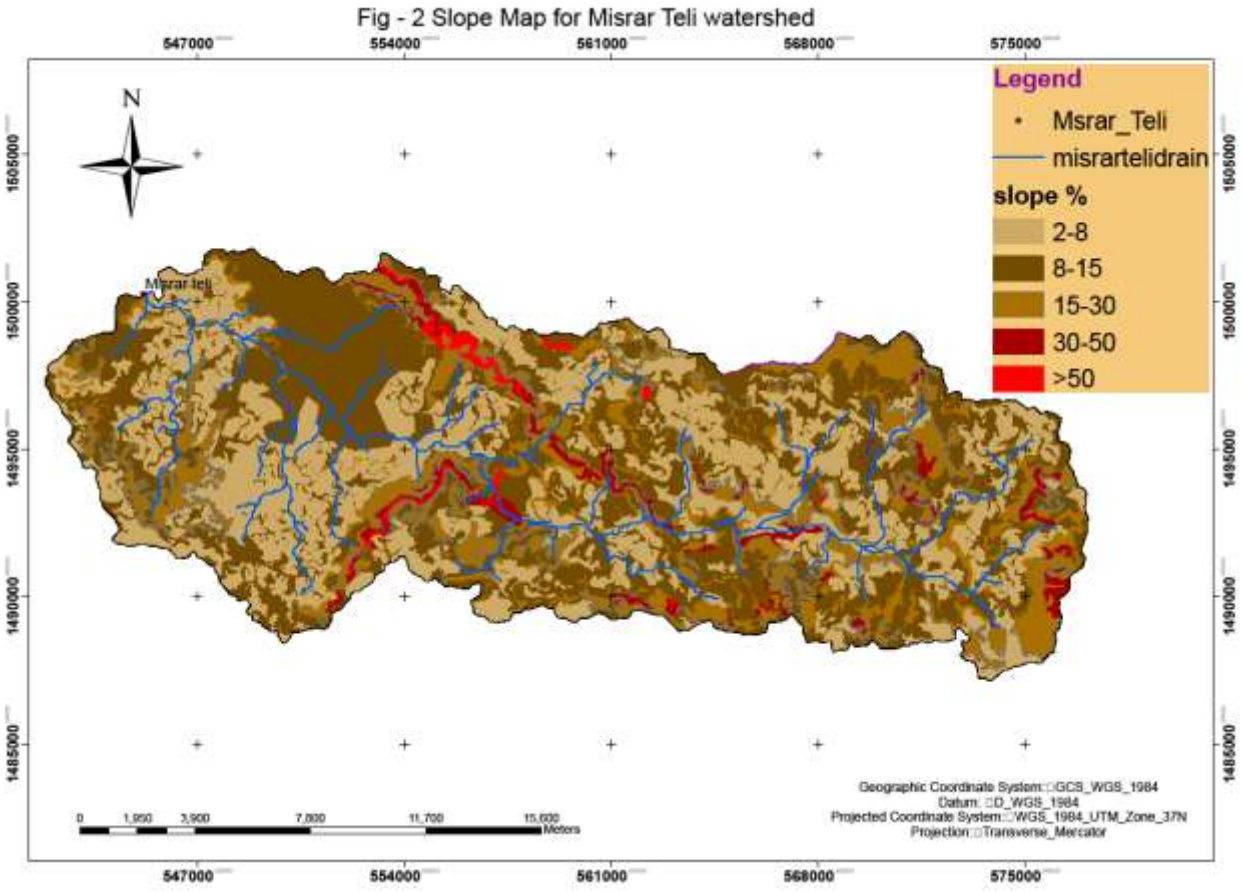
The watershed is placed largely in dry Weyna Dega agro climatic zone. The annual rain fall of the watershed is 542.7mm. The average monthly maximum temperature is 30.90 0C and minimum monthly temperature is 12.60 0C

Table 1 Meteorological data for Misrar Teli diversion site

Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	unit	Total
Rain mean	2.49	7.29	22.51	36.93	32.57	33.20	192.23	226.88	31.37	6.07	5.69	0.74	mm	542.7
Max.Tem.0c	26.9	28.1	29.0	29.6	30.5	30.9	27.2	26.4	28.1	27.2	26.7	26.3	oc	28.1
Min.temp.0c	12.6	13.6	14.8	15.8	17.2	17.0	16.5	16.5	15.5	14.7	13.7	12.7	oc	15.1
P.eff.	-8.5	-5.6	3.5	12.2	9.5	9.9	128.8	156.5	8.8	-6.4	-6.6	-9.6	mm	292.6
P.eff.Mod.	0.0	0.0	3.5	12.2	9.5	9.9	128.8	156.5	8.8	0.0	0.0	0.0	mm	329.2

Source: Mekelle airport meteorological station

Figure 3 Slope Map for Misrar Teli watershed



5.4 Soil

The major soil textures found in this watershed are clay, clay loam, loam and silt loam. From such type of soils, the dominant one is clay, which covers 59.99% of the total area. Such soil type is commonly found in gentle slope of cultivated land and homesteads. It has soil depth of ranging 0.5m up to 5.5m. In such soil type, where there is moderate vegetation cover, gully erosion is commonly occurred affecting the existing land resource.

The second soil texture, which covers about 22.32%, is clay loam. This soil type is situated in in diversified land use types such as Grazing land, cultivated land and homesteads with soil depth range of 0.50m up to 2.5m. In such soil type, where there is moderate vegetation cover, gully erosion is commonly occurred affecting the existing

land resource. The loam soil texture that covers6.63 % is commonly found in steep and moderately steep terrain. It is found in grazing lands, homesteads and forest lands

5.5 Vegetation

The Misrar Teli watershed has large catchment area and it is placed largely in agro-climatic zone of dry Weyna Dega and some Dega agro climatic zone and it has poor vegetation cover in most landscapes. Specifically the lower and middle part of this catchment area is less vegetation cover but in the upper, peripheries and central of the watershed following the natural drainage has a better natural vegetation cover dominated with the woody acacia species and shrubs. In the place where the area has been occupied with area closures and churches has better coverage of trees and shrubs. Currently the ground vegetation covers of the watershed has been decreasing in fast rate due to the existence of deforestation and thereby sever soil erosion although some conservation measures are applied in very small areas. The existing forest land coverage is 0.8%.

There are various types of natural vegetation in this project area. The dominant species in this watershed area are acacia species. The common tree and shrub species that are found in this watershed includes: Acacia etbaica, Acacia tortolis, Acacia nilotica, Prosopis spp, Aloe species Echinops gigantean, Rumex nervosus, Olea africana, Ficus vasta, Rhus natalensis, Juniperus procera, Acacia seyal, and various local grasses such as Hyperhenia spps, Cynodon dactylon, Eragrostic spps, and Elusine foloccifolia.

5.6 Geology and Geomorphology

Two main particular landscape features dominate the geomorphology of the study area. These are flat plain land that includes the weir site and the command area and steep to very steep volcanic mountains and sedimentary hills that incorporate most part of the catchment area. The flat plain is characterized by alluvial deposit, which is composed of all grain sizes. Clay, silt, sand and gravels constitute the upper parts of these deposits while coarse gravels and occasional cobble beds found at the bottom. Several intermittent rivers drain the plain area and the catchment.

The main river Misrar Teli is a very meandering type and matured river. This large catchment is characterized with diversified geological formation. It is dominated with basaltic, and limestone parent rocks. The basalt rock is commonly placed in upper most of the catchment with the steep and rugged volcanic mountains and some dolerite hills. These rocks are black, fine-grained and very strong in depth. The degree of weathering varies from place to place. It is fresh to slightly weathered. The limestone with stratum rocks is found lower and middle part of the watershed facing upstream.

5.7 Present land use type

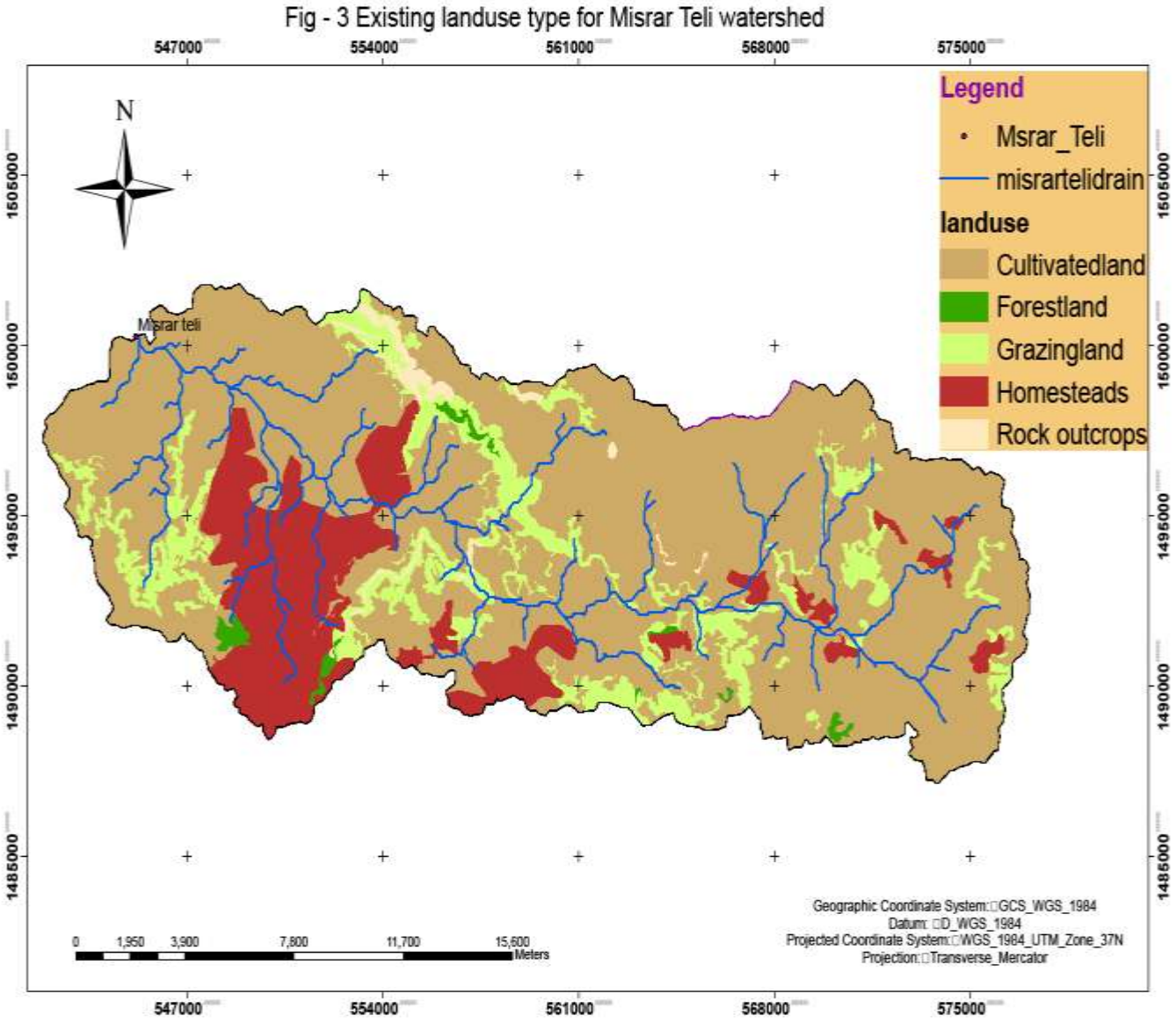
The major land use types in this watershed area are cultivated land, grazing land, forest land, homesteads and miscellaneous land. The dominant land use type is cultivated land that covers 72% of the total area. It has poor vegetation cover. The second largest land use type is homesteads including Mekelle city that covers 14.46% of the watershed. The free grazing land, which covers 11.83%, is situated dominantly at steep terrains. The forest land that includes shrubs, bush and woodlands has coverage of 0.8% of the total catchment area. The miscellaneous land and waste lands together has an area of 417 ha represents areas occupied with rock-outcrops.

According to the land use, slope, soil texture and other land management conditions of the watershed, the weighted average run off coefficient is **0.36** and the weighted average of curve number is **80.63**. So based on the SCS method, the peak flood of the watershed is **220m^3/s**.

Table 2 Land use type and run off coefficient for Misrar Teli watershed of irrigation scheme

S/N	Land use type	Slope (%)	Area (km^2)	Soil texture	Runoff coefficient	weighted run off coefficint
1	Cultivated land	2-8	81.25	ligt clay	0.30	24.375
		8-15	110.56	Clay	0.35	38.696
		15-30	39.29	Clay loam	0.40	15.716
2	Grazing land	8-15	0.34	Clay loam	0.35	0.119
		15-30	29.90	Clay loam	0.40	11.96
		30-50	7.95	loam	0.45	3.5775
3	Forestland (area closures)	8-15	0.73	Clay loam	0.35	0.2555
		15-30	0.49	loam	0.35	0.1715
		30-50	0.46	silt loam	0.40	0.184
		>50	0.89	silt loam	0.45	0.4005
4	Homesteads	2-8	24.70	towns/hard surface	0.4	9.88
		2-8	1.76	Clay	0.35	0.616
		8-15	13.37	towns/hard surface	0.45	6.0165
		8-15	1.75	Clay loam	0.35	0.6125
		15-30	1.81	towns/hard surface	0.5	0.905
		15-30	3.26	loam	0.35	1.141
5	Miscellaneous land	___	4.17	Rock outcrops	0.45	1.8765
				Weighted Average run off coeff.		0.36
	Total		322.68			

Figure 4 Existing Land use Map for Misrar Teli Watershed



5.8. Land capability classification

The aim of soil and water conservation is not only to control erosion and moisture but also to use the land according its capability.

Land capability classification is an interpretative system used to group and classify areas of land with the same capability to insure permanent productivity of land without severs deterioration of resources, to maximize high contribution of land use system under the existing constraints.

Land capability classification for Misrar teli micro watershed was accomplished by collecting all the relevant data, which enables its collection to one of the several soil conservation requirement classes.

Most of the data collected were related to the physical land resources and soil properties, which includes slope, soil depth, past erosion, infiltration, soil texture, water logging and stoniness.

During the field assessment for land capability classification of the study area, the necessary information of the land classifying criteria is taken on each land use type using the required or outlined methodologies, and the land is classified in to soil conservation requirement classes (SCRC) based on the FAO land classification for use in soil conservation which is adapted to the experience and local condition of Ethiopia developed by Escobedo (1986). Basically, eight land classes are considered ranging from class I to class VIII. The risky of soil erosion increases through class I to class VIII as well as the requirement of soil conservation practices and exception of class V. The outcome of land capability classification for each land use type of the study area is summarized on the table below. Moreover, the information needed for land classification is attached in the annex three.

Table 3 Land Capability classification for Misrar Teli Micro watershed

Land units	Land use	Slope (%)	Area (ha)	slope	soil depth	Past Erosion	Water logging	infiltn.	texture	stoniness	**Land capability**
A. Upper stream of the micro watershed											
1	Cultivated land	2-8	51	L2	D2	E1	W0	I0	T6	S1	IIIE
2	Cultivated land	8-15	82	L3	D3	E2	W0	I1	T6	S1	IVE
3	Cultivated land	15-30	6	L4	D3	E2	W0	I2	T5	S2	IVD
Total			**139**								
B. Downstream of the micro watershed											
1	Adjacent to Command area (grazing land)	15-30	17	L4	D3	E3	W0	I2	T5	S3	VID
2	Command area	2-8	52	L2	D2	E1	W0	I0	T6	S1	IIIE
Total			**69**								

5.9. Soil loss estimation of the watershed

After collecting the relevant data through the outlined methodologies, the weighted annual soil loss (soil displacement) from each land unit for the watershed of Misrar teli was computed using the universal soil loss adapted to Ethiopia. Universal soil loss equation is an erosion prediction model for estimating the long time average of soil loss from a specified land in a specified cropping and management system. The weighted annual soil loss computed from the whole watershed is 95.93 tone/ha/year. So based on the (Hurni and Perich, 1992) and other research papers, the normal and protected watershed has a permissible soil loss range of 5-11 tone/ha/year. However the above result exceeds the normal ecological situation of the specified catchment. Therefore such watershed needs soil and water conservation treatment in the place where high soil erosion and sediment transportation is found.

The specified value for each parameters and the annual soil loss for each land unit is summarized on annex six. The equation for universal soil loss adopted for Ethiopia with its parameter estimation is described below.

Equation A = R*K*L*S*C*P (Tone/ha/year)

R = Rain fall erosivity

Annual rainfall (mm)	100	200	400	800	1200	1600	2000
Annual factor R	48	104	217	441	666	890	1115

K = Soil erodability

Soil color	Black	Brown	Red	Yellow
Factor k	0.15	0.2	0.25	0.3

L = Slope length

Length (m)	5	10	20	40	80	160	240	320
Factor L	0.5	0.7	1	1.4	1.9	2.7	3.2	3.8

S = Slope gradient

Slope (%)	5	10	15	20	30	40	50	60
Factor S	0.4	1	1.6	2.2	3	3.8	4.3	4.8

C = Land cover

Dense forest	0.001	Degraded grass	0 .05	Bad land hard	0.05
Other forests see grasses		Dense grass	0.01	Bad land soft	0.4
Fallow hard	0.05	Sorghum, maize	0.01	Ethiopia teff	0.25
Fallow ploughed	0.6	Cereals, pulses	0.15	Continuous fallow	1

P = Management factors

Plough up and down 1	Stripe cropping 0.8	Applying mulch 0.6
Stone cover 80% 0.5	Plough on contour 0.9	Stone cover 40% 0.8
Inter cropping 0.8	Dense inter cropping 0.7	

Source

Wischmeier and Smith, 1978

Adoptions: R correction, Hurni, 1985

K value from bono and seiler, 1983, 1984; and Welgal, 1985

5.10 Past conservation efforts

The ecological condition of the watershed has been disturbed due to the presence of less management of the natural resource like the vegetation, soil and water. Many of the indigenous trees and shrubs species have been deforested and much of fertile soil is washed away from the steep sloped hillsides. Such problem finally causes to have sever land degradation and hence reduction in production, thereby affecting the socio economic and environmental well-being of the community.

However, some efforts have been made to protect the erosion problem and increase the vegetation cover of the area. Some part of the watershed has got some soil and water conservation measures and good vegetation cover like fruit tree plantation cultivated land, stone bunds on some sloping lands and gabion check dams were constructed in some riversides. These conservation measures reduce soil erosion and sediment transportation thereby they minimize land degradation.

This is good endeavor and has great role in maintaining the ecological condition of the area and provides woodlots used for construction and fuel wood although it needs regular maintenance reduction of the expansion of deforestation on the steep free grazing land.

5.11 Major problems of the watershed

The major problems of the Misrar Teli watershed area are soil erosion, overgrazing, deforestation, fuel wood shortage, lack of effective water harvesting technique, scarcity of water and reduction in crop production.

The local administration mentioned that the population size of the Tabia has been increased from time to time. As a result of this, some lands have been occupied with cultivated land and homesteads by deforesting the existing natural vegetation. Furthermore, the fuel wood consumption is very high as compared with five years ago. As a consequence of this, some lands remain bare and exposed to sever soil erosion.

In most area, there is no an integrated watershed management which can reduce the expansion of land degradation. The steep hillsides devoid of conservation measures and has very low vegetation cover generate higher run

off with much more sediments. The fragile nature of the basaltic, granite and sandstone parent material is susceptible to soil erosion. This erosion process has led to greater risk of land degradation which needs an immediate treatment of the overall watershed with various conservation measures.

The washing away of fertile soils and poor land management system are resulted in reduction of agricultural products. Shortage of fuel wood for household use has been caused by the depletion of the natural vegetation through deforestation activity taken place in the past for longer period of time. This shortage of fuel wood has been also facilitating the cutting down of the available natural vegetation.

Another very important constraint, which is subject matter of this study, is lack of an effective water harvesting techniques. The run off generated from the catchment has not yet been effectively used for irrigation system during the rainy season for supplement irrigation. This brings about decreasing of the overall agricultural products and aggravating soil erosion at the surrounding area. Due to this problem, the site couldn't be utilized according its potential.

Based on this, training for capacity building in relation to family planning should be given to the local people so as to reduce the increment of the population. Some basic alternatives like solar and electricity, work opportunity and other income generating activities need to be introduced to decrease the fuel consumption thereby conserving the natural resources like vegetation, soil and water. Some knowledge about maintenance and construction of small ponds need to be occurred within the community by giving regular training in order to use the run off for irrigation purpose in their local area.

6. Socio economic aspect of the watershed

In the watershed there are more than ten Tabias which are found in Enderta wereda. The active human power in the tareget Tabia is male 1173 female 1140 and total 2313.

Most of the people in the watershed are used small scale farming. The crops grown are barely, wheat, bean, and Teff. The land holding size of the Tabias ranges from 0.25 – 1ha but the average land holding is 0.55ha. Average family size is 4.3

Most of the population of Enderta wereda is followers of both orthodox Christianity and speaking mono language. But there are also Catholics and Muslims in both Wereda.

Adoption of soil and water conservation practices is perceived and valued as positive by all the farmers regardless of wealth differences. The local people have good awareness and great willingness to conserve their natural resources

Their past conservation efforts is based on community participatory approach. They use from bottom to top approach of communication and planning system of in watershed management.

They have got practically positive impacts on production of crops, spring discharge increment, and vegetation cover improvement in their surroundings.

Mass mobilization undertaken for more than three decades in soil and water conservation practices has minimized flooding and thus soil erosion or degradation both in the farmlands and off-farm conservation, although it was less in on-farm conservation compared to the off-farm conservation. Results of the study also indicated that perception of farmers towards benefits of conservation attempts in changing and hence important contribution towards livelihoods has been recorded. However, the benefits are not yet adequate. Free grazing and conflicts over communal grazing lands were the major problems, causing the destruction of the physical and biological conservation

works. Thus, the local leaders should give accreditation to informal institutions, in order to empower the local community and minimize the conflicts among the society in relation to communal natural resource management.

The water sector is one of the most vulnerable sectors to climate variability and change. Drought and flood are the most important climate change hazards for the sector. Drought affects the availability of safe water making it difficult for sustainable provision of water provision of water services due to dried/reduced yield of water points as well as making it difficult development of new sources as the ground water will get deeper in to the ground increasing dry wells to be abandoned after drilling. A decline in water availability during dry periods has resulted in changing priorities of water use. Women and girls are the most vulnerable to the impacts of climate change. Women and girls need to invest more time in collecting water from distant sources making time more constrained to income generating activities and to attend schools.

7. Infrastructures

The Misrar Teli watershed is accessible up to the site. It has 2km dry weather starting from Romanat up to the site. There are five-development agents in The Mahbere Genet Tabia who are responsible to lead the agricultural development works done in this area. There is one governmental nursery site within the catchment that can include one foreman and two technicians near this site.

8. Existing soil and water conservation aspect of the watershed

Describing the existing condition of soil and water conservation aspect on this watershed area is basic information so as to identify the common problems and constraints that disturbs the ecological condition of the area, and proposing the suitable protective measures that reduces loss of water and soil besides to raising the protecting condition of the area.

In this area, evaluation of the bio physical and socio economical condition of upstream part of the diversion was done focusing at the assessment of problems, potentials and improvement ways. Such study is very important to reduce the sediment transportation and improve ecological condition of the area.

The watershed of the diversion site that is found at unprotected condition with dominantly free gazing land and rock outcrops has greatly influenced the structure to be constructed. Sediments with some boulders have been transported from the bare lands. This will silt up the structure area and reduces the life span of the diversion to provide water for irrigation purpose.

In the existing situation of the watershed, there are some soil and water conservation measures that can reduce the sediment transportation and reduce the degradation of the natural resources. These are mainly stone bunds, hillside terrace, gabion check dams and tree plantation and area closures.

Therefore an efficient and effective utilization of the existing water resource is very important by proposing good soil and water conservation measures that improve the irrigational status of the site.

In the steep terrain hillside terrace was proposed to reduce the soil erosion thereby transportation of sediment. On the sloping and gentle sloping terrains the stone bunds, with some grass plantation was proposed. In the gullies and river side tree plantation and stone check dams was recommended to reduce soil erosion, Sediment transportation and minimize the destruction of the structures of the diversion scheme.

8.1 Extent of soil erosion

The Misrar Teli watershed has vein shaped drainage pattern. Some gully (drainage) that was not treated with conservation measures produces much sands, cobles, gravels and boulders. Some of the watershed of the site is found in unprotected condition. Especially, the lower, some middle part and steep peripheries of the catchment with less conservation measures, and the degraded steep terrains with unstable gullies and river banks are the main areas for sediment generation and transportation. However, some part of the watershed has got some soil and water conservation measures and good vegetation cover like area closures found on moderately steep terrains. These conservation measures reduce soil erosion and sediment transportation toward the reservoir area.

Specifically, the part of the main river and the steep limestone and weathered basaltic area are easily erodible areas. These areas are the main source of the sediment generation and transportation. So such areas are required the appropriate soil and water conservation measures to reduce the destruction of the diversion scheme.

9. Soil and water conservation based development strategies

The efficient utilization of this potential for irrigation purpose is restricted due to destructive role of the surrounding area and poor management of the land resource.

The degraded and unprotected surrounding area is causing to have much more sediment transportation and loss of runoff that could have been used for irrigation during rainy season.

On the severely eroded riverbanks, where much more sediment is generated and transported to the diversion site, stone and gabion check dams is the key remedy to resist the undercutting of the riversides. For further strength, multipurpose trees and grass species near the river and gully side is needed.

In the lower part, there are some tributaries that generate sediment with some boulders that can silt up the inlet of the diversion scheme. Therefore before the treatment of these tributaries the upper steep hillsides need to be treated by physical and biological soil and water conservation such as hillside terrace (stone bunds) supported with tree plantation on the steep grazing land, grass stripes and soil bund on the cultivated land. This will reduce the formation of the gully and accumulation of the sediments at the downstream. After such treatment, using stone check dams with tree and grass plantation at the edge of the drainage, further expansion of the tributaries (gullies) will be reduced.

Such an effective, an appropriate and integrated watershed management will return it to its natural condition, reduce the speed of runoff, sediment transportation and generation thereby decrease the silting up of the structures and prolong the life time of the diversion.

The development strategy for this particular study area is prepared mainly depending on the system of land classification for the better use of land and appropriate application of the soil conservation measures on which the necessary information are collected to determine soil conservation

requirement classes which are mainly related by the physical land resources as agro climatic zone, landscape and soil properties. Moreover the past conservation efforts and availability of materials were also taking in to consideration.

9.1 Catchment and Command area

Based on the IFAD criteria the treatment will be done specifically near the structures, around and within the command areas due to the limitation of the budget; but for the future through different strategies with donors and massive mobilization the watershed will be treated so as to sustain the structures of the wear and reduce erosion of command area. So the treatment of the upstream and downstream is followed with the four times command area and 2/3rd is for the upper catchment and 1/3rd is for the command area and the nearby surroundings.

9.1.1 Catchment area

In the 322.68km2 catchment area of this scheme, there are some unprotected land use types that are exposed to gully and rill erosion. This causes to deplete the existing natural resource like soil, water and vegetation. In addition to this, some sediment with some boulders has been transported from such landscape to the reservoir through the natural drainage. As a result of this, the structure will be destructed and reduce its efficiency to harvest the determined amount of water to the command land. Based on this, some possible solution has been devised on the target land use types. Currently only the area around the diversion scheme is considered for treatment. The rest of the large areas will be done when its own budget is released for over all watershed development works

Cultivated land

The cultivated lands that are found around the proposed diversion scheme using the above mentioned methods with a total area of 133ha are not well treated with soil and water conservation measures although there are some

traditional conservation measures that didn't follow the contour lines and correct spacing between the bunds.

Based on this, some physical, biological and agronomic measures were proposed to reduce the erosion of the cultivated land and minimize sediment transportation. The nearby cultivated lands have gentle and sloping features, good soil depth, clay and clay loam soil texture, no water logging problem, slight soil erosion and <15% stoniness. Based on the land capability classification, the soil and water conservation class will be fall on IIIE. This land unit has a dominant slope of 8%.The land use needs some stone bunds, contour farming system and grass strips with integrated agronomical development activities.

Physical measure

The spacing and the type of measures proposed were done based on different field experience and research findings, various empirical formula as well as interpolations adopted to our topography that does not bring difficulty for different agricultural practice.

Stone bund

The area of the land to be treated with stone bunds that affect the diversion structure is 133ha. The total length of stone bund to be constructed using the horizontal interval of 12.50m is 106,400m.

Biological measure

In such land use type some grasses and multipurpose trees on the bund need to be planted to strengthen the stone bund, reduce the depletion of soil through run off and to provide with food and forage to the local farmer.

Grass stripes also needed after the construction of the stone bunds on the undulating plane and gentle sloping of cultivated land to minimize the soil erosion.

In this case, the interference of livestock and human being should be avoided during the early stage of the seedling, and planting activity need to be done at the beginning of the rainy season. The most appropriate tree species for such treatment are Acacia salingna, Acacia etbaica, Parkinsonia aculeate, citrus species, Mango, Prosopis chilensis, Sesbania sesban, and local bamboo species and local grass, shrubs and trees.

Agronomic measures

Contour farming

Contour farming is a cultural measure in soil conservation where farming operations are conducted a long contour lines or across the slope.

Expected out come

Every furrow acts as a miniature reservoir to hold the excess runoff and gives increasing time and opportunity to the soil to absorb as much as water as possible for shortage and supply back to the crops. In heavy rainfall, it reduces the velocity of runoff and erosion process. Prevention of soil erosion and increasing supply of moisture to the plant are thus the ready results of the above method, which is reflected in increasing crop production.

Crop rotation

Crop rotation is a practice of growing different crops one after another on the same piece of land.

Requirement

Regarding erosion control the rotation period should be short. a rotation in three years is recommended in this area.

Expected out come

Crop rotation helps to reduce the depletion of soil nutrients and a decline in crop yields in addition to fertility restoration and soil and water conservation. crop rotation is a popular traditional practice of controlling disease, pests, and

weed infestation. this is due the fact that different crops are not equally susceptible to certain kind of pests or diseases.

Fertilization and maturing

Fertilization refers to application of chemical fertilizer while maturing is the application of green manure of farmyard manure. Green manure is a plant material (leaves and tender branches) collected and prepared to be incorporated in to the soil green or, is a crop or forage plants ploughed in while the crop are still green.

Requirement and consideration

The fertility status of the soil should be known by testing the soil and required quantity of inorganic fertilizer should be applied at proper time.

Introduction of selective high yielding varieties

High yield varieties are improved seeds, which gives more yield as compare to the local varieties. In addition to supplying high yields, they also function in controlling erosion because of their early maturity; they will cover the soil from impact of raindrops.

Introduction of selective conserving crops

Selective conserving crops help to successfully reduce erosion and to get harvest on sustainable basis on eroded soils. As to the specific crops to be proposed, research out puts is needed.

Miscellaneous

During the assessment made on the gullies and main river, it is observed that some of the tributary gullies and main river that come from the mountains have a very steep slope and exposed rock outcrops. When these drainages reach the plain and gentle slope of cultivated land and grazing land, they create very deep gullies and generate much more sediments.

Therefore to reduce the destructive role of the flood transported materials and to minimize soil erosion and gully expansion, stone check dams or gabion

check dams and gully side plantation are recommended. These gullies to be treated are shown in the development map of the watershed.

Physical measure

Stone check dams

The construction of check dam proposed here is on tributary gullies draining to the main river course. Due to the fact that most of the main river course is covered with rock out crops and loosely arranged cobles of river and gully sides, in selected areas where the main source of sediments, stone check dams are designed to trap the sediments.

There are many large gullies that are main source of sediment. But for the moment due to budget constraint in the region only two near bye gullies are taken for current treatment programme. They drain from steep topography and are found at unstable condition. They are not treated with soil and water conservation measures. For the reclamation of the gullies a 1meter height of stone check dams is recommended. The spacing for each check dams are determined using rule of Thumbs, i.e.

$$S = \frac{1.7H}{G}$$

where, H = Height of check dam

G = Slope in decimal

S = spacing

An apron, twice the height of check dam, which is 3 meter long, is needed to protect the scouring effect of the water which causes sliding of the structure on the downstream of the Check dams. A notch or spill way having a length of 2/3 rd of the length of the check dam has to be constructed at the middle to allow the water and to flow safely through the center part of the apron. A foundation of up to 0.5 m is needed to stabilize the check dams against overturning and sliding.

Table 4: Description of the condition of the gullies

Name of gullies	Aerial distance from the site (m)	Average slope (%)	Average width (m)	Length (m)	Depth of gully(m)
Gully-1 (upstream)	246	12	8	2607	2
Gully-2 (upstream)	1286	8	5	849	1.5
Gully-3 (downstream)	1346	10	6	1084	1.6

Note: The distance from the diversion site given for each gullies is the aerial distance and the construction for 1m height of check dam has a key of 0.50m in both sides of the gullies. They should be also constructed with well-arranged stones in order to have good stability.

Table 5: The quantity of the stone check dams for each gully

Name	Height (m)	slope(dec.)	Spacing(m)	No of check dam	Length (m)	total Pd
G1	1	0.12	14.17	184.02	1472	2944
G2	1	0.08	21.25	39.95	200	400
G3	1	0.1	17.00	63.76	383	765

Note: These gullies are found around the diversion scheme and downstream of the diversion within the command area that is given priority for treatment. So the total length of the check dam is 2055m and Pd is 4110.

The norm is 0.5m/pd or 0.5m^3/pd of stone check dam. The total cost gabion mesh for the **2055**m^3, using the dimension of 2mx1mx1m and its cost per mesh 512Birr, is 526,080 Birr. Adding the tie wire, 0.5kg/1m^3/10 birr the total cost will be **546,580 birr.**

Biological measure

An integration of the check dams with biological soil and water conservation method is found important for effective prevention of gully expansion. However these gullies are enriched with natural vegetation near the gully sides. So these plants need to be well protected to reduce the gully expansion. Some multipurpose trees need to be integrated with this existing vegetation. For detail amount of tree plantation, see development plan of the watershed

In this case, the interference of livestock and human being should be avoided during the early stage of the seedling, and planting activity need to be done at the beginning of the rainy season. The most appropriate tree species for such treatment are Acacia salingna, Acacia etbaica, Parkinsonia aculeate, citrus species, mango, Prosopis chilensis, Sesbania sesban, and local bamboo species and local grass, shrubs and trees.

9.1.2 Command area

The lower area of the watershed is formed mainly from the alluvial deposit that is transported from the upper catchment area. In this case, the command area is situated in such landscape. This area is largely placed in gentle sloping (3 - 8%) topography. It has less vegetation cover with moderate soil erosion. In spite of this, some physical, biological and agronomic measures are important to reduce the disturbance of the natural resources. The gully also needs to be treated to protect from under cutting of the command land by gully erosion. So the length of the gully bank to be treated by using one rows of tree plantation on one side.

In between the boundary of the cultivated land with 52 ha, (DERET) grass stripe and 1meter spacing of multipurpose trees need to be applied.

In this case, the interference of livestock and human being should be avoided during the early stage of the seedling, and planting activity need to be done at the beginning of the rainy season. The most appropriate tree species for such treatment are Acacia salingna, Acacia etbaica, Parkinsonia aculeate, citrus species, Mango, Prosopis chilensis, Sesbania sesban, and local bamboo species and local grass, shrubs and trees.

Grazing land

It is situated in diversified topographic features commonly moderately steep and steep terrains. Most of such area are degraded and bare land due to the

presence of past over grazing and sever deforestation for many years. There are only some scattered tree and shrub species.

The grazing lands that are found around the proposed command area using the above mentioned methods with a total area of 17ha are not well treated with soil and water conservation measures although there are some traditional conservation measures that didn't follow the contour lines and correct spacing between the bunds.

Based on this, some physical, biological and agronomic measures were proposed to reduce the erosion of the command area and minimize sediment transportation. The nearby grazing lands have moderately steep, shallow soil depth, loam soil texture, no water logging problem, moderate soil erosion and >90% stoniness. Based on the land capability classification, the soil and water conservation class will be fall on VIE. This land unit has a dominant slope of 20%.The land use needs some hillside terrace bunds, contour farming system and grass strips with integrated agronomical development activities.

Physical measure

The area of the land to be treated with hillside terrace that affect the command area is 17ha with a dominant slope of 20%. The total length of stone bund to be constructed using the horizontal interval of 12.50m is 38857m

Biological measure

In such land use type some grasses and multipurpose trees on the bund need to be planted to strengthen the stone bund, reduce the depletion of soil through run off and to provide with food and forage to the local farmer. Furthermore in the very steep landscape area closure is recommended to revegetate the deforested natural vegetation.

In this case, the interference of livestock and human being should be avoided during the early stage of the seedling, and planting activity need to be done at the beginning of the rainy season. The most appropriate tree species for such

treatment are Acacia salingna, Acacia etbaica, Parkinsonia aculeate, Prosopis chilensis, Sesbania sesban, and local bamboo species and local grass, shrubs and trees.

Agronomic measures

Contour farming

Contour farming is a cultural measure in soil conservation where farming operations are conducted a long contour lines or across the slope.

Expected out come

Every furrow acts as a miniature reservoir to hold the excess runoff and gives increasing time and opportunity to the soil to absorb as much as water as possible for shortage and supply back to the crops. In heavy rainfall, it reduces the velocity of runoff and erosion process. Prevention of soil erosion and increasing supply of moisture to the plant are thus the ready results of the above method, which is reflected in increasing crop production.

Crop rotation

Crop rotation is a practice of growing different crops one after another on the same piece of land.

Requirement

Regarding erosion control the rotation period should be short. a rotation in three years is recommended in this area.

Expected out come

Crop rotation helps to reduce the depletion of soil nutrients and a decline in crop yields in addition to fertility restoration and soil and water conservation. crop rotation is a popular traditional practice of controlling disease, pests, and weed infestation. This is due the fact that different crops are not equally susceptible to certain kind of pests or diseases.

Fertilization and maturing

Fertilization refers to application of chemical fertilizer while maturing is the application of green manure of farmyard manure. Green manure is a plant material (leaves and tender branches) collected and prepared to be incorporated in to the soil green or, is a crop or forage plants ploughed in while the crop are still green.

Requirement and consideration

The fertility status of the soil should be known by testing the soil and required quantity of inorganic fertilizer should be applied at proper time.

Introduction of selective high yielding varieties

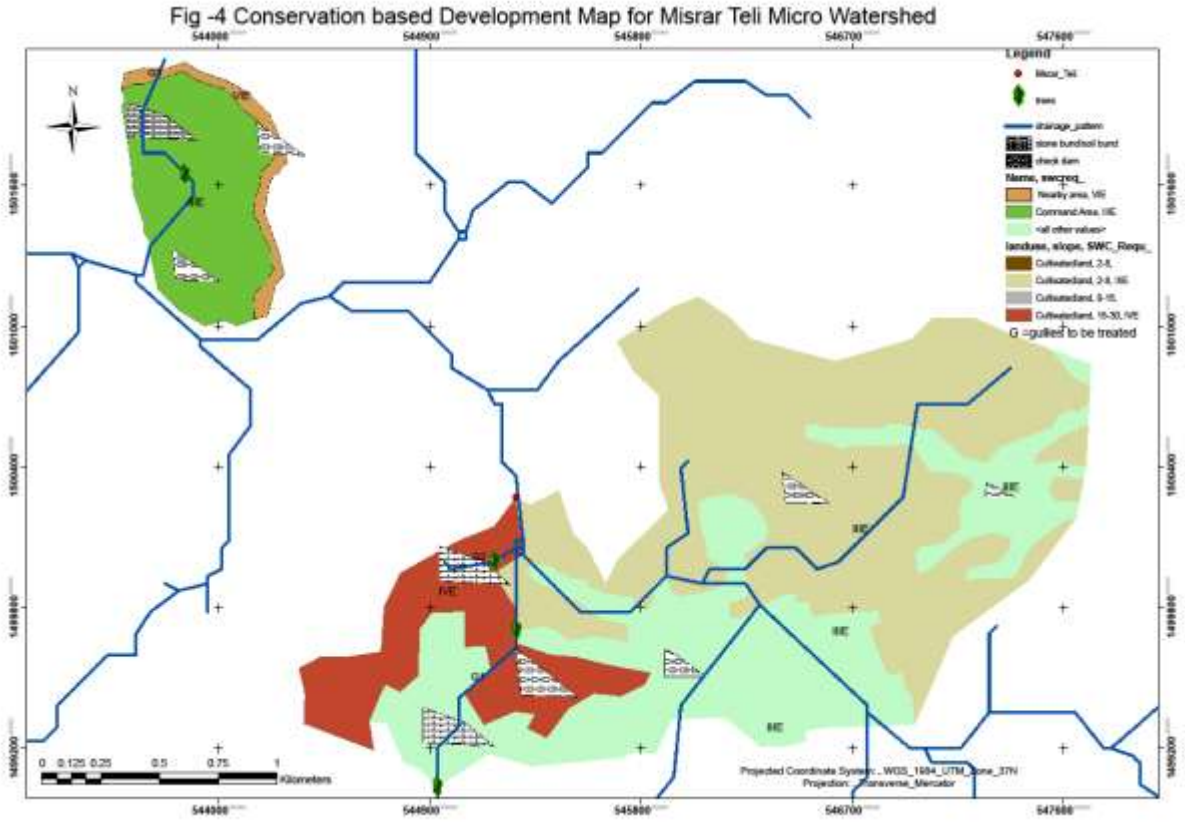
High yield varieties are improved seeds, which gives more yield as compare to the local varieties. In addition to supplying high yields, they also function in controlling erosion because of their early maturity; they will cover the soil from impact of raindrops.

Introduction of selective conserving crops

Selective conserving crops help to successfully reduce erosion and to get harvest on sustainable basis on eroded soils. As to the specific crops to be proposed, research out puts is needed.

For the specific description and budgeting of the overall conservation measures to be applied on this watershed area are described in the next cost chapter. The norm of the conservation measures proposed in this watershed area is described in annex 1.

Figure 5 Conservation based Development map for Misrar Teli micro waterhed



10. Cost for the Micro watershed development activities

In the development of the micro watershed of the scheme, different soil and water conservation activities have been planned for the sustainability of the irrigation project.

For the implementation of soil and water conservation measures in the micro watershed 41,525.85Pd is needed. So using the work norm for one pd 15 birr, the total labor cost needed to implement the conservation measures is 622,887.75 birr. As it is mentioned above in detail for the gabion check dam, the total cost is 546,580 birr. For the details see the following table.

A. Soil and water conservation measures cost

Different soil and water conservation measures have been proposed for the sustainability of the project site at micro watershed level. Each land uses and drainages were proposed to get appropriate soil and water conservation measures. The required Pd and corresponding cost also specified in the following table.

Table 6: Conservation based development plan for Misrar Teli micro watershed

S/N	Target to be Treated	Recommended activities	Unit	Total Plan	Work norm	Total pd	Total cost (Birr)	Activity timelines by years			Estimated cost -C by years C * 1000		
								1	2	3	1	2	3
1	Cultivated land	Stone bund	km	106.4	250pd/km	26600	399000	43	43	21	160	160	80
2	Cultivated land	Grass stripes	km	40	16pd/km	640	9600	16	16	8	4	4	2
3	Grazing land	Hillsideterrace	km	38.857	250pd/km	9714.286	145714.286	15.543	15.543	7.77143	58.286	58.286	29.143
4	Gullies	Gabion check dam	m^3	2055	$0.5m^3$/pd	4110	61650	822	822	411	25	25	12
5	Gully side	Plantation				0	0	0	0	0	0	0	0
		4.1 Pitting	No.	4540	1pd/15pits	303	4540	1816.0	1816.0	908.0	1.82	1.82	0.91
		4.2 Seedling production	No.	4540	15pd/1000 seedlings	68	1022	1816.0	1816.0	908.0	0.41	0.41	0.20
		4.3 Seedling plantation	No.	4540	1pd/50 seedlings	91	1362	1816.0	1816.0	908.0	0.54	0.54	0.27
		Total pd for plantation				0	0	0	0	0	0	0	0
						0	0	0	0	0	0	0	0
	Total					41525.85	622887.786	6344.1	6344.1	3172.05	249.16	249.16	124.58

B. Training cost

Training need to be given for the technical upgrading and skill enhancement for the local people found in the micro watershed area in relation to soil and water conservation so as to minimize the erosion hazard and increase land use productivity.

Table 7 Training cost for Misrar Teli Micro watershed

A.Training Materials						
S/N	Types of materials	Unit	Quantity	Unit cost in birr	Total cost	Remark
1	Stationary	No.	60	20	1200	Pen 6 birr and writing pad 14 birr, (20birr/person)
2	Scotch	No.	10	35	350	
3	White board	No.	3	1400	4200	
4	Flip chart	No.	6	120	720	
5	White board marker	pack	6	110	660	
6	Flip chart marker	pack	6	130	780	
7	Tape meter (50m)	No.	5	120	600	
8	Plastic Rope (200m)	Roll	4	100	400	
9	Preparation of domenstartion area (field practice)	No.	10	100 birr/ one domenstration	1000	labour payment to prepare practical field for physical and biological measures
10	Digging hoe	No.	10	100	1000	
11	spade	No.	10	80	800	
12	line leveling	No.	10	30	300	
13	poles	pair	5	120	600	
	Total cost				**12610**	

b.Trainees and trainer							
S/N	Trainees and trainer	Unit	Quantity	Average perdium per person in birr	Days/year	Total cost	Remark
1	**Trainees**						
a	Tabia Development agents	No.	5	120	10	6000	SWC, Livestock, crop, irrigation, agricultural devlopment admi
b	Formans	No.	10	120	10	12000	Both for nursury and SWC formans
c	Technicials	No.	5	120	10	6000	Both for nursury and SWC technician
d	Tabia adminstration	No.	4	120	10	4800	
e	local farmers	No.	20	120	10	24000	Selected local farmers who have good understanding in conse
2	**Trainer**						
a	Wereda/regional Agricultural and irrigation expert	No.	2	200	10	4000	Crop sceince and irigation expert
b	Wereda/regional soil and water conservation expert	No.	2	200	10	4000	Forester and soil and water conservation expert
c	Wereda/regional livestock mangement expert	No.	1	200	10	2000	
	Total		49			**62800**	

C. Monitoring and Evaluation cost

Monitoring and evaluation is a system of following up and judgment of the value and benefit of the intervention made in the project. It starts from the study and design up to the accomplishment and outcome of the project development. So in this programme different assessment, measurements and controlling activities will be made based on the project scheduling packages.

Table 8: Monitoring and evaluation cost for Misrar Teli Micro watershed

S/N	Types	Unit	Quantity	Unit cost in birr	Days/year	Total cost
1	**Supervision and controlling activities**					
a	Assessment by professions	No.	4	250	60	60000
b	Technicians and selected local farmers	No.	20	120	60	144000
2	**Materials for data collection and measurement**					
a	Stationary	No.	24	20	_	480
b	A4 papers	pack	6	150		900
c	A3 papers	pack	5	350		1750
d	Sampling eqipments	No.	10	80	_	800
e	Digging materials	No.	10	100	_	1000
f	Beam balance (pedulos)	No.	3	800	_	2400
3	**Labour**	No.	15	100	_	1500
	Total					**212830**

D. Nursery upgrading cost

An efficient tree nursery site requires a range of materials and equipment that will help to complete jobs efficiently and within a structured time frame. The equipment or materials that are chosen will depend on the size of the operation and the amount of money available. So for the implementation of specific soil and water conservation micro watershed a ful1 and organized nursery site is very necessary. In this site there is a governmental tree nursery site that needs some materials and equipments for upgrading it.

Table 9: Nursery upgrading cost for Misrar Teli Micro watershed

	Nursery Upgrading cost					
S/N	Types	Unit	Quantity	unit cost in birr	Total cost	Remark
1	Nursury tools					
a	shovels	No.	4	80	320	
b	watering cans	No.	3	75	225	
c	Fencing nursury site	m	700	85	59500	
d	soil seives	No.	2	400	800	
e	Pruning saw	No.	5	150	750	
f	wheelbarrow	No.	3	300	900	
2	Office for the forman and technicals	No.	1	25,000	25000	
3	Maintenance Feeder road to nursury	Km	2	100	100000	500 Pd/km, 100birr/pd
					187495	

E. Material requirement for soil and water conservation implementation

The active human power is male 1173, female 1140 and total 2313

The total working labor required to carry out the conservation activities in the diversion scheme is 41526Pd. This minus the working labor for seedling production is 41458Pd. The average working day per month is 18. By

assuming there are 6 working months in a year, there will be 108 working days. Therefore, the labor power required per day is 384. One working group consists of 20people. This gives a total of 19 groups.

Table 9: Equipment /material/ requirement

S/N	Types of tools	Unit	Quantity Per group	Total Quantity	Unit price In Birr	Total price In Birr
1	Hammer	No.	1	19	120	2303.21
2	Shovel	No.	6	115	40	4606.42
3	Pick axe	No.	8	154	60	9212.83
4	Craw bar	No.	1	19	150	2879.01
5	Measuring tape	No.	1	19	50	959.67
6	Line level	No.	2	38	30	1151.60
7	Pole (2m long)	No.	2	38	20	767.74
8	String	Roll	0.5	10	50	479.84
	Total					**22360.32**

F. Maintenance cost

For the sustainability of the project maintenance activities need to be incorporated in the irrigation development especially in the soil and water conservation activities of the micro watershed.

Table 10 Maintenance cost for Misrar Teli Micro watershed

S/N	Types of maintenace	Unit	Quantity	Unit cost in birr	Total cost	Remark
1	Selected Soil and water conservation measure	pd	2076.29	15/pd	31144.4	Total cost = 5% of the labour cost
2	Soil and water conservation Tools					
a	Pick axe	No.	154	80	12320	
b	spades	No.	115	80	9200	
c	hammer	No.	19	80	1520	
3	Stores for equiment and tools	No.	1	20000	20000	
4	White board	No.	3	100	300	
					74484.4	

Table 11 Summary cost for Misrar Teli Micro watershed development plan

S/N	Types	Total cost
1	Training	75410
2	Monitoring and evaluation	212830
3	Nursury	187495
4	Labour SWC	622888
5	Gabion check dam	546580
6	Materials for swc activities	22360
7	Maintenance	74484
	Total	**1,742,047.00**
	Contigence (5%)	**87,102.35**
	Grand total	**1,829,149.35**

11. Operational calendar

The soil and water conservation measures proposed in this sub watershed that believed to relieve the existing soil erosion problem need to be done based on the prepared calendar. This will make the traditional spate irrigation system efficient in addition to conserving the surrounding area.

All tree planting activities should be done at the beginning of the rainy season. Beating up, which refers to the replacement of the dying, suppressed and missing seedlings to have good density and distribution is also an important activity after planting tree seedlings.

The construction of check dams has to be started before the beginning of the rainy season. It is also important to start before the beginning of the rainy season. Summary of the main types of activities and operational calendar is given on the next page.

Table 12 Operational calendar for watershed development activities for three years

Type of activity	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar	Apr.	May	Jun.	Years
Preparation of the necessary goods													1st
Seedling production													1st
Pit preparation													1st
Seedling planting													2nd,3rd
Beating up													2nd,3rd
Check dam construction													1st
Hillside terrace													1st
Stone bund													1st
Grass stripes													1st
Maintenance													2nd,3rd
Guarding													1st 2nd 3rd

12. Conclusion and recommendation

Some of the target areas are found in disturbed ecological condition. The poor local capacity for water diversion and the destructive effect of the surrounding area cause to loss much more water and fail in attaining the maximum crop production through irrigational activities.

The protection measures employed in such catchment area is very low. As a result of this the sediment transportation with some boulders has been occurred. This will disturb the function of diversion and decrease the life span of the structure by silting up the inlet and reducing the amount of water to be harvested. As a result of this, the recommended cultivated land for irrigation purpose cannot get enough water from the diversion. This will cause reduction of the annual crop production that the local farmer can obtain from the given plot of land.

Based on this, training for capacity building in relation to family planning should be given to the local people so as to reduce the increment of the population and deforestation activities. Some basic alternatives like solar and electricity, work opportunity and other income generating activities need to be introduced to decrease the fuel consumption thereby conserving the natural resources like vegetation, soil and water conservation. Some knowledge about maintenance and construction of small ponds need to be occurred with in the community by giving regular training in order to use the run off for irrigation purpose in their local area.

It is therefore the degraded catchment has to be well protected by using suitable soil and water conservation measures before the diversion is constructed. One nursery site need to be established so as to provide the proposed tees and shrub species to be planted in the watershed. This will lead to harvest the run off with less sediment and prolongs the life span of the spate scheme. Furthermore, one responsible watershed management expert need to be assigned to follow up the activities of the proposed conservation measures during construction period.

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Annex 1: The revised and final set of work norms

No	Activity	Unit	Revised Norms
ACTIVITIES FOR WHICH WORK NORMS ARE REVISED & CHANGED			
1	Soil Bund	PD/Km	**150 PD/km**
2	**Stone Bund**	PD/Km	**250PD/km**
3	**Fanya-juu**	PD/Km	**200PD/km**
4	**Planting on Bund**	PD/Km	**16D/km**
5	**Hillside Terracing**	PD/Km	**250PD/km**
6	**Cut-off Drain Construction**	**M^3/PD**	**0.70M3/PD**
7	**Grassed Waterway Construction**	**M^3/PD**	**1.0M3/PD**
8	**Bench Terrance Construction**	**PD/Km**	**500PD/Km**
9	**Stone Check-dam Construction**	**M^3/PD**	**0.5 M3/PD**
10	**Stone Check-dam Maintenance**	**M^3/PD**	**1M3/PD**
11	**Seedling Production**	**PD/1000 Seedling**	**15PD/1000**
12	**Pitting**	**PD/Micro-basins**	**1PD/15pits**
13	**Micro-Basin Construction**	**PD/ Micro-basins**	**1PD/Kg**
14	**Seed Collection(*)**	**PD/Kg**	**1PD/50Plants**
15	Seedling planting	**PD/Pits**	**4PD/ha/year**
16	Site Guarding	**PD/Ha./Year**	**0.4m3/PD**
17	**Small Farm Dam Construction**	**M^3/PD**	**0.5m3/PD**
18	**Pond Construction**	**M^3/PD**	**3000PD/Km**
19	**Farm Road Construction**	**PD/Km**	**500PD/Weir**
20	**Road Maintenance/Construction on<5% slop**	**PD/Km**	**700PD/ha/year**
MEASURES FOR WHICH WORK NORMIS NOTUET REVISED OR CHANGED			
21	Spring Development	**No**	**1700PD/spring**
22	Stream Diversion Weir	**No**	**3000PD/weir**
23	**Grass & Legume Seed production (mult.Center)**	**No**	**700PD/ha/year**
MEASURE EXCLUDED FRPOFEW (NO NORMS APPLICABLE)			
24	Bund maintenance	**-**	**Self-help**
25	Other structures/assets maintenance	**-**	**Self-help**

Annex 2: Information needed for land classification

Physical features

Slope	**(L)**	**Soll Depth**	**(D)**
0-3%	11	>50cm	D1
3-8%	12	100-150cm	D2
8-15%	13	50-100cm	D3
15-30%	14	25-50cm	D4
30-50%	15	<25cm	D5
>50%	16		
Past Erosion	**(E)**	**Texture**	**(T)**
None	E0	Sand	T1
Slight	E1	Sandy Loam	T2
Moderate	E2	Loam	T3
Severe	E3	Silt Loam	T4
Very Severe	E4	Clay Loam	T5
		SiltClay.Clay	T6
		Hevey Clay	T7
Water Logging	**(W)**	**Stonniness or Rockiness**	**(S)**
None	W0	<15%	S0
Intermittently Water Logged	W1	15-30%	S1
Regularly Water Logged	W2	30-50%	S2
Swaps	W3	30-90%	S3
Infiltration	**(I)**	50-90%	S4
Good	I 0	>90%	S5
Moderate	I 1		
Poor	I 2		

Annex 3: Land Classification Table

LIMITING FACTOR	Range of codes permitted in the column								
Slope (L)	1	2	3	4	1 - 4	5	6	1- 6	1- 6
Soil Depth (D)	1	1- 2	1 - 2	1 - 3	1 - 4	1 - 3	1 - 4	1 -3	1- 5
Past Erosion (E)	0	0	0 - 1	0 - 2	0 - 2		0 -3	0 -4	0- 4
Water Logging (W)	0	0	0 - 1	0 - 2	0 - 2		0 -2	0-2	0 -3
Infiltration (I)	0	0	0 - 1	0 - 2	0 - 2		0 -2	0 -2	0 -2
Topsoil Texture (T)	3- 5	3 - 6	3 - 7	2 - 7	2 - 7		2- 7	1- 7	1 -7
Surface Stoniness or rockiness (S)	0	0 - 1	0 - 2	0 - 2	0 - 3		0 -3	0-3	0 -4
Soil Conservation Requirement Class	I	II	III	IV	VI		VII	VIII	V
	Land Suitable for annual Crops				Land Suitable For Grazing or Perennial Crops		Land Suitable for forestry	Land None Suitable for Agric Culture	Swampy areas river beds

Annex 4: Annual soil loss of the watershed

S/N	Land units	Area (Ha)	R (Erossivity)		K(erodibility)		Average Slop length (L)		Average Slope gradient		(C)Land cover		(P)Management factor		A (Soil loss)
			Ann.RF	R	soil color	K	Length(m)	L	Slope%	S	landuse type	C	mgt type	P	tons/year
1	Cultivatedland	8125	542.7	296.91	Black	0.15	7025	16.5	7	0.6	CP	0.150	PC	0.9	516121.12
2	Cultivatedland	11056	542.7	296.91	Black	0.15	9980	19.6	12	1.2	CP	0.150	PC	0.9	1611630.19
3	Cultivatedland	3929	542.7	296.91	Brown	0.2	4022	12.6	20	2.2	CP	0.150	PC	0.9	874277.46
4	Forestland	34	542.7	296.91	Brown	0.2	310	3.67	14	1.5	DF	0.001	SC.F	0.8	8.77
5	Forestland	2990	542.7	296.91	Brown	0.2	3430	11.7	16	1.7	DF	0.001	SC.F	0.8	2854.77
6	Forestland	795	542.7	296.91	Brown	0.2	1022	6.52	32	3.4	DF	0.001	SCEIG	0.5	523.17
7	Forestland	73	542.7	296.91	Brown	0.2	480	4.53	75	5.6	DF	0.001	SCEIG	0.5	54.48
8	Grazingland	49	542.7	296.91	Brown	0.2	315	3.7	9	0.9	DEG.G	0.050	SC.F	0.8	378.61
9	Grazingland	46	542.7	296.91	Brown	0.2	385	4.07	18	2.0	DEG.G	0.050	SC.F	0.8	872.04
10	Grazingland	89	542.7	296.91	Brown	0.2	793	5.77	36	3.6	DEG.G	0.050	SCEIG	0.5	2743.80
11	Homestead	2470	542.7	296.91	Black	0.15	2414	9.86	6	0.5	DEG.G	0.050	SCEIG	0.5	14107.52
12	Homestead	176	542.7	296.91	Black	0.15	790	5.76	4	0.3	DEG.G	0.050	SC.F	0.8	505.50
13	Homestead	1337	542.7	296.91	Brown	0.2	1855	8.69	10	1.0	DEG.G	0.050	SCEIG	0.5	17245.78
14	Homestead	175	542.7	296.91	Brown	0.2	688	5.39	12	1.2	DEG.G	0.050	SC.F	0.8	2776.56
15	Homestead	181	542.7	296.91	Brown	0.2	801	5.8	24	3.0	DEG.G	0.050	SCEIG	0.5	4672.62
16	Homestead	326	542.7	296.91	Brown	0.2	2001	9.01	28	3.2	DEG.G	0.050	SC.F	0.8	22330.50
17	Rock outcrops	417	542.7	296.91	Brown	0.2	1020	6.51	85	6.1	BLH	0.050	SCEIG	0.5	24391.95
	TOTAL	32268.00													3095494.82
												Tons per hectar per year			95.93

Note: Abbreviations used in the above table has been described below

Land cover

Dense forest (DF) Degraded grass (DEG.G) Bad land hard (BLH)

Dense grass (DG)

Fallow hard (FH) Sorghum, maize (SM) Ethiopia teff (TEFF)

Fallow ploughed (FP) Cereals, pulses (CP)

Management factors

Stripe cropping (SC) Applying mulch (AM)

Stone cover 80% (SCEIG) Plough on contour (PC) Stone cover 40% (SC.F)

Inter cropping (INC)

Annex -5 How to identify the texture of a soil

a) Definition

Soil texture is mainly concerned with the size and shape of the mineral particles of the soil. Particles are sand, silt and clay and they have the following diameters:

Sand : 0.05 - 2 mm (particles visible)
Silt : 0.002 - 0.05 mm (particles hardly visible)
clay : less than 0.002 mm (particles no visible)

Clayey soils have more than 50% clay particles.
Silty soils have more than 50% silt particles
Sandy soils have more than 50% sand particles.

Loams are soils with mixed particles of sand, silt and clay.

b) Significance of Soil Texture for Soil Conservation

Soil erosion depends much on the infiltration rate of a soil. The infiltration rate again depends on the soil texture. In a sandy soil, the infiltration rate is higher than in a silty soil. In a clayey soil, it may be initially high (for heavy black clay with cracking), but becomes low when the soil is moist to wet. Other factors influencing the infiltration rate are soil structure, humus content, soil moisture, soil depth and soil surface roughness.

In moist agroclimatic zones, the decision for selecting graded or level structures on cultivated land mainly depends on the soil texture found on the slope where conservation is planned. For clayey soil, graded structures are recommended, because the infiltration in the basins is too slow. For silty to sandy soil, level structures are recommended because the water retained in the basins will infiltrate more quickly.

c) How to Differentiate Between Clayey, Silty and Sandy soil

1. Take a small handful of fine earth from the slope,

2. Slowly add little amounts of water and mix it very well with the earth sample. Stop adding water as soon as the formed soil ball starts to stick to your hand.

3. The soil texture can be roughly estimated with your moist soil sample. Try to form the sample into the different shapes demonstrated on the next page. See how many of the pictures you can form with your soil. If you can not form it any further, stop at the previous picture and read the soil texture on the right side. This is the texture of your soil.

Now proceed to the next page and start forming your soil sample following the pictures from top down.

1. The soil remains loose and single grained and can only be heaped into a pyramid:

Sand (1)

2. The soil contains sufficient silt and clay to become somewhat cohesive and can be shaped into a ball that easily falls apart:

Loamy sand (2)

3. The soil can be rolled into a short thick cylinder

Silt loam (3)

4. the soil can be rolled into a cylinder of about 15 cm. length

Loam (4)

5. The soil can be bent into a U

Clay loam (5)

6. The soil can be bent into a circle that shows cracks

Light clay (6)

7. The soil can be bent into a circle without showing cracks

Heavy clay(7)

Note: Texture classes (1) to (4) are sandy to silty soils which have generally good infiltration.
Texture classes (5) to (7) are clayey soils which have generally poor infiltration.

Source: CFCDD (1986)