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11. LISTS OF ABBREVIATION

BACoPE	Baba Amte Centre for People’s Empowerment

DEM	Digital Elevation Model
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
ISFM	Integrated Soil fertility management
KI	Key Informant
LULC	Land Use Land Cover
MoARD	Ministry of Agriculture and Rural Development
OWWDSE	Oromia Water Works Design and Supervision Enterprise
SDR	Sediment Delivery Ratio
SS	Sediment Storage
SWC	Soil Water Conservation
UTM	Universal Transverse Mercator
WB	World Bank
IWM	Integrated Watershed Management
WM	Watershed Management

12. EXECUTIVE SUMMARY

A watershed is defined as any surface area from which runoff resulting from rainfall is collected and drained through a common confluence point. Now a day, with the increasing population watershed degradation is a serious problem in developing countries like Ethiopia. Oromia Regional state is highly potential for agricultural production for the country.

Delo Mena is the potential Woreda in the Bale Zone but these Woreda are now become under vast threat of agricultural productivity reduction and the main cause of decline in productivity of land, low income of the people. To sustainable develop this high agricultural potential and labor available area; priority should be given to natural resources, especially soil and water conservation, based and economically feasible development projects. For that matter, investment on irrigation projects will increase crop production and reduce natural hazard risks. Therefore, construction of small-scale irrigation project is significantly important for the area.

Irba Girstu small scale irrigation project watershed is found in Delo Mena and Goba Woreda Bale Zone. Watershed degradation assessment study is carried out at the watershed level. The study has to assess Watershed characteristics related to land and soil degradation for watershed management project study. The study was based on overlay of soil geomorphology; climatic, present lands cover processed in Arc GIS 10.4.1 and analyze physical land resources, social implications and economic benefits.

The general objective of the Irba Girstu watershed management plan study is to identify, understand ecological and socio-economic problems in the watershed and prepare the watershed intervention plan that enable sustainable management and use of resource; there by establishing long-lasting irrigation water supply system while improving livelihood of the communities in the watershed through creating and sustaining improved agricultural production systems and land productivity.

The methodology employed includes collection of primary and secondary data at field level .The study approaches and procedures exercised during different stages of the study include pre-field work, field work and post field work activities.

Irba Girstu Small Scale Irrigation Project Watershed has an area of 68,370.19ha. The watershed has an altitudinal range from 1200 to 4100m.a.s.l. six types of soils have been identified in the watershed namely: Calcisols, Cambisols, Fluvisols, Leptosols Luvisols and Vertisols.

All types of slopes are present in the watershed. It has about 1222 mm/yr annual rainfall. The mean annual temperature ranges from 7.2 – 32.3^{0}c.

The total population of watershed is about 111,832 in number. The farming system comprises field crop and vegetable production and livestock rearing and tree growing. The major crop types cultivated in the watershed are teff, sorghum,wheat, barley and pea are major once. The dominant trees grown in the watershed include *Cordia Africana, Junipers and Eucalyptus spps, Gravilia Robusta*. Soil degradation is decline of organic matter and depletion of nutrient. The common type of erosion is water erosion exhibited with all forms of erosion such as sheet and rills, gully and stream bank erosion.

To assess soil erosion hazard for project area the revised universal soil loss equation (RUSLE) approach was followed. The soil loss map was developed on Arc GIS environment by using RUSLE parameters (rainfall erosivity, soil erodibility, slope length and gradient, land cover and land management practices*)* as an input to assess average annual soil loss rate of the area. Based on the analysis, the total amount of soil loss in the watershed is about 19.24 ton/ha/year in mountains/hilly areas to gently sloping areas and nil at flat and level areas where deposition takes place from 68,370.19 hectare with mean annual soil loss of 0.11tons/ha/yr or 7520.72 tons per year. The average annual rate of soil loss in Ethiopia is estimated to be 12 tons/hectare and it can be even higher on steep slopes with soil loss rates greater than 300 tons/hectare/year, where vegetation cover is scant. The result of study also falls within the ranges of the findings of FAO (1984). According to the estimate of FAO (1984), the annual soil loss of the highlands of Ethiopia ranges from 1248 – 23400 million ton per year from 78 million of hectare of pasture, ranges and cultivated fields throughout Ethiopia.

Based on erosion hazard assessment, agro-ecological zone and land capability classes different physical, biological and Agronomic Practices has been recommended such as soil bund, stone bund, area closure, crop rotation, Agro-forestry, check-dam, bench terrace, tree plantations, etc. In line with this, implantation cot for the recommended conservation practices also been estimated as per standard, and the overall cost found to be **22,640,658.60** Birr. Land capability classification for soil conservation requirement was also done for the whole watershed. Accordingly, some of the land use classes are wrongly assigned with respect to soil conservation requirement class. Therefore, suitable and adjusted options were recommended.

13. 1. INTRODUCTION

1.1 BACKGROUND

A watershed is any surface area from which runoff resulting from rainfall is collected and drained through a common confluence point (Tripathi and Singh, 2001). The term is synonymous with a drainage basin or catchment area. Hydrologically, watershed could be defined as an area from which the runoff drains through a particular point in the drainage system. A watershed is made up of the natural resources in a basin, especially water, soil, and vegetative factors. At the socioeconomic level a watershed includes people, their farming system (including livestock) and interactions with land resources, coping strategies, social and economic activities and cultural aspects (MoARD, 2005). Based on BACoPE (2007) Watersheds is the undulating land area of any region forms several such units, each of which is called watersheds. Waters within each of these units drains to a common point. So the hills, valleys, forests and fields that encircle the falling rain and guide it into streams and then rivers, all form the enclosure that is a watershed.

Watershed management implies the sensible use of all resources (i.e. land, vegetations and water of the watershed) to achieve maximum production with minimum hazard to the natural resources and for the well being of people and environment (Seleshi *et al.*, 2009). The task of watershed management includes the treatment of land by using the most suitable biological and engineering measures in such a manner that the management work must be economical and socially acceptable. The various factors affecting the task of watershed management are: watershed characteristics (shape and size, topography, relief, and soils); climatic characteristics (precipitation, and amount and intensity of rainfall); watershed operation; land use patterns (vegetative cover, density, and state i.e. type and equality); social status of inhabitants; and water resources and their capabilities. The major control measures adopted for watershed management works are the vegetative measures or agronomical practices (strip cropping, pasture farming, fertilizing the crop land, grass land farming etc.), and the engineering measures or structural practices (gully control, diversions, water ponds, reservoirs, drainage works, flood protection, ground water recharging structures, terracing, bunding etc.).

Watershed management is an integrated use or management of land, vegetation, and water in a geographically discrete drainage area for the benefit of its residents, with the objective of protecting or conserving the hydrologic services that the watershed provides and of reducing or avoiding negative downstream or groundwater impacts (World Bank, 2014). A watershed provides an ideal unit for managing lands because the hydrologic cycle within a watershed drives many of the physical, biological, and environmental processes in the catchment. Thus, the watershed integrates all of the interconnected physical, biological, and chemical environmental processes (both intended and unintended) that result from (and in spite of) all of the activities occurring in the watershed (Pamela *et al.*, 2015). A watershed is an area of land that drains rain water or snow into one location such as a stream, lake or wetland. These water bodies supply drinking water, water for irrigation and industry and also used for recreation and helps in the development of habitat. Watershed management means the process of creating and implementing plans, programs and projects to sustain and enhance watershed functions that affect the environment, vegetation, animal and human communities within a watershed boundary. Watershed management includes managing of natural resources, land use pattern and human activities (Jaysukh *et al.*, 2015).

Effective watershed management can prevent community water shortages; improve water quality, check flooding and erosion. Watershed management also helps to improve the ground water conditions. Watershed management is used for optimum use of the available water resources in the catchment area (Jaysukh *et al.*, 2015). In recent time watershed health has been affected due to human intervention and unplanned development causing rapid erosion, siltation and pollution. Therefore, it is required to protect the natural environment of watershed and carry out development in the area in planned way. For this systematic watershed management study is to be carried out irrespective size of the catchment area.

The watershed management study is generally accepted and vital groundwork to endow sustainable irrigation development activities. Watershed Management is an iterative process of integrated decision-making regarding uses and modifications of land and water within a watershed. This process provides a chance for stakeholders to balance diverse goals and uses for environmental resources, and to consider how their cumulative actions may affect long-term sustainability of their resources.

The purpose of this integrated watershed based study is to restore the productivity of the degraded land found within the watershed and protect irrigation site from siltation and flood attack, through considering the population density, agricultural practices, topographic futures, drainage density and other parameters. Similarly, the remarkable stress due to burning of natural vegetation cover for charcoal, fuel wood and conversion to agricultural land, and over grazing of the pastures, their carrying capacity, shall be contest.

Thus, Watershed management study related to agricultural activities is very crucial to plan, execution of soil and water conservation practices, and other socio-economic interventions. This study will consequently control the soil loss, reduce the run-off, sediment deposit to the down the catchment and improve the livelihood of the community and thus will provide more time of concentration for run-off water to infiltrate into soil, which will finally contribute to ground water and enhance the sustainability of the river. It is, therefore, essential to have a watershed as a basis for planning and implementation of various soil and water conservation programs.

As a part of this study, Digital Elevation Model (DEM), satellite imagery, previous studies and metrological data for the watershed were procured. Based on the ground truth studies, the land use and land cover map of the watershed were prepared. The pressure on some of pasturelands for meeting fodder requirements of the livestock in the area was assessed. As a next step, using the topographical and physiographical data as available with various secondary sources and the land use map vulnerable to soil erosion were identified: Watershed management measures for arable & non-arable lands were suggested. The cost required for the implantation of the watershed management plan along with institutions responsible for the implementation was identified.

A package of Physical, Agronomic and biological soil conservation measures were recommended as per land capability class resulting in integrated soil & water conservation development plan. Moreover, Rainfall erosivity, topography, Agro-climate, Farming system and others Socio-economic circumstances were considered as criteria. Similarly, Past and present experiences in receptivity of framers to the introduced engineering soil and water conservation measures were considered. These all findings were used for planning of many different forms of watershed management study for sustainable irrigation development projects.

A study conducted on Irba Girstu Watershed suggests that the vegetation cover is relatively under dense vegetation cover and the majority of the slope gradient is gently sloping and sloping; and hence the soil erosion is majorly characterized by slight degree of erosion. The majority of land covers characterize by dense mixed high forest and afro alpine and sub-afro alpine vegetation followed by predominantly cultivated land, settlement and exposed soil surface with scattered shrub land cover. The challenge observed was low awareness of the community in natural resource conservation i.e., currently they converting vegetation cover to agricultural land. Demographically, there is moderate population pressure where by many areas of land are available for cultivation. The exploitation of natural resources is being induced with the need to open new land for cultivation and cutting of trees for sale. In many places, the depth of soil is good enough to support agricultural activities with soil fertility management.

Land degradation in the watershed is associated with vegetation clearance and improperly laid out of drainage channels in the cultivated lands. The number of livestock is found to be incompatible with carrying capacity of existing grazing lands particularly in the upper catchment. It has been observed that there is high rate of over grazing on both grazing lands and cultivated lands during dry periods. In line with this, soil and water conservation practices observed within the watershed command area was very limited.

1.2 Irba Girstu Small Scale Irrigation Project

Irba Girstu Small-Scale Irrigarion Project is found in Dello Mena Woreda of Bale Zones of Oromia Regional State. Different soil and water conservation intervention were applied but they did not meet their original purpose that is to reduce siltation from the watershed to a minimum level, increase the base flow of the streams and increase land productivity on the watershed area. Even if some of the activities indicated that there is good start for biological measures, physical measures were not well supported by biological measures and cultural practices of the farmers were poor. Thus, new marginal lands were brought to cultivation due to high population pressure. Land management that helps to improve soil fertility was minimal. The steep slope of cultural ditches and some crops aggravated soil erosion hazard. The other causes that contributed for improper implementation were, less attention given to soil conservation activities and technical failures. Due to less sense of ownership, the farmers themselves for different reasons/purposes destroyed the structures and forests on the watersheds. Some of the listed causes were shortage of fuel and construction wood, free grazing, shortage of cultivated lands, lack of awareness towards watershed treatment. Though the previous activities gave awareness to the local people as to how soil conservation measures reduce siltation, increase base flow of the streams and increase crop productivity, the expected result is far beyond the expectations. Hence, it calls for strong measures and recommendations that will be practically applicable that includes technical and social aspects of the area. To make the measure appropriate, strong discussions with the concerned bodies at each level are of paramount importance for erosion control and soil productivity improvement.

1.1.3 OBJECTIVE

1.1.3.1 General Objective

The general objective of the Irba Girstu watershed management plan study is to identify, understand ecological and socio-economic problems in the watershed and prepare the watershed intervention plan that enable sustainable management and use of resource; there by establishing long lasting irrigation water supply system while improving livelihood of the communities in the watershed through creating and sustaining improved agricultural production systems and land productivity.

1.1.3.2 Specific Objectives

- Recognition of watersheds as a proper unit for wise utilization and development of all land resources.
- To identify the biophysical and socio-economic problems of the watershed for different land uses
- To increase the productivity of the land through the practice of soil and water conservation measure.
- Utilization of natural resources for improving agriculture and socio-economic condition of the local inhabitants.
- To enhance the irrigable potential of the river water flow discharge for irrigation.

1.1.4 SCOPE OF THE STUDY

Watershed degradation assessment carried out at Irba Girstu watershed in order to investigate past and current Watershed management of the area. The study has to assess land characteristics related to land degradation and soil erosion assessment in watershed management study. The study was based on overlay of soil geomorphology; climatic, present lands use processed in Arc.GIS 10.4.1 environments and analyze physical land resources, social implications and economic benefits. The watershed study has investigated the land use, soil and vegetation types, and current erosion and Socio-economic status. Erosion hazard assessments were made through site investigation in addition to **RUSLE** soil erosion analysis. Overall status of the watershed and existing activities within the Watershed were assessed. The following points define the scope of the study:

- Proposing the structures that provide appropriate integrated watershed management options that reduce downstream effects due to sedimentation;
- Recommend different conservation measures based on local conditions so as to prevent the removal of the fertile topsoil;
- Prepare soil and water conservations structure design and layout,
- Preventing fragmentation of the land due to formation of gullies;
- Analyze and map erosion hazards in the watershed;
- Assess current activities for soil and water conservation in terms of coverage and effectiveness,
- Determine important hydrological parameters
- Land capability classification
- Estimating the cost required to implement the proposed watershed management plan

14. 2. METHODS AND MATERIALS

2.1 METHODS

The methodology employed includes collection of primary and secondary data at field level. The primary data were collected by field observation using reconnaissance survey, Key Informants (KI), Focus Group Discussion (FGD), Landsat Image and Topo Maps whereas secondary data was collected from published and unpublished material and reports. The study approaches and procedures exercised during different stages of the study includes pre-field work, field work, and post field work activities. The following are the details of the methodology pursued.

2.1.1 Pre Field

2.1.1.1 Base Map Preparation

During pre-field work the main activities were concentrated on base map preparation. To make the land resources survey activity simple and economical the Digital Elevation Model data (DEM) of the project area was extracted and land use/land cover was developed by using FAO and OWWDSE (2016) study shape file. In addition to the Land use/land cover base map, the watershed boundary, drainage line, networks, longest flow path and slope of the watershed was extracted from 30.7m DEM data by using Arc Hydro extension in the ArcGIS environment.

Guideline Preparation

The preparation of watershed management project guide line.

- Preparation of check lists and questionnaires for:
- ✓ Personal information to test the attitude and awareness of the residents.
- ✓ Interviewing KI such as Woreda experts and development agents and FGD with local comminutes.
- ✓ Field data collection format prepared for biophysical survey.

2.1.2 At Field

At field the following activities were undertaking; during field study the primary and secondary data of Irba Girstu watershed was collected.

2.1.2.1 Primary Data Collection

The study was conducted mainly by primary data collection. Field observation of the watershed through transects walk to investigate biophysical data, land form, land cover, types and forms of soil erosion, soil depth and stoniness, conservation practices and socio-economic activities in the a Irba Girstu Watershed.

- Field investigation on the topography, biophysical features, type, forms and extent of soil erosion.
- Qualitative description of the land use land cover the forms of soil erosion and conservation practice were also made.

2.1.2.2 Secondary Data Collection

The secondary data were collected from development agents and Woreda experts by using readily made questionnaires and by making discussion with the concerned experts.

2.1.3 Post Field

2.1.3.1 Data Analysis and Interpretation

The data collected at field were compiled and analyzed. Finally, Different maps were produced by digitizing using Arc GIS computer software and report writing was fully done at the office level. Moreover, climate, soil, land use/land cover, slope, farming practice and other factors were analyzed to determine soil erosion and Watershed degradation assessment.

2.2 MATERIALS

In conducting this study different materials are used at field and office**.** These include:

- Computer facility with GIS and Remote sensing programs;
- Field data collection format prepared for the study;
- GPS with Alkaline battery;
- Digital data like administrative maps, satellite imagery, FAO digital soil map, FAO digital Land cover map and ASTER_DEM data.
- Software: Arc GIS, Arc Hydro and Arc Swat

15. 3. GEOGRAPHIC AND NATURAL FEATURES

3.1 Location

Irba Girstu Diversion Irrigation project watershed has an area of 68,370.19ha (683.70Km^2) is located in Oromia National Regional State of Bale Zone at Delo Mena Woreda. Delo Mena Woreda is 555km far from Addis Abeba to south and 65km from capital city of Bale Zone which is Robe. Delo Mena woreda shares boundry with Medda Walabu Woreda at south, Harena Bulke at east, Goba Woreda at north and Barbare at west. The Irba Girstu Watershed is geographically located between UTM coordinates of 588013 to 595990 meters east 703488 to 760482 meters north and with an altitudinal, range is from 1,200 to 4,100m.a.s.l. (Figure 1).

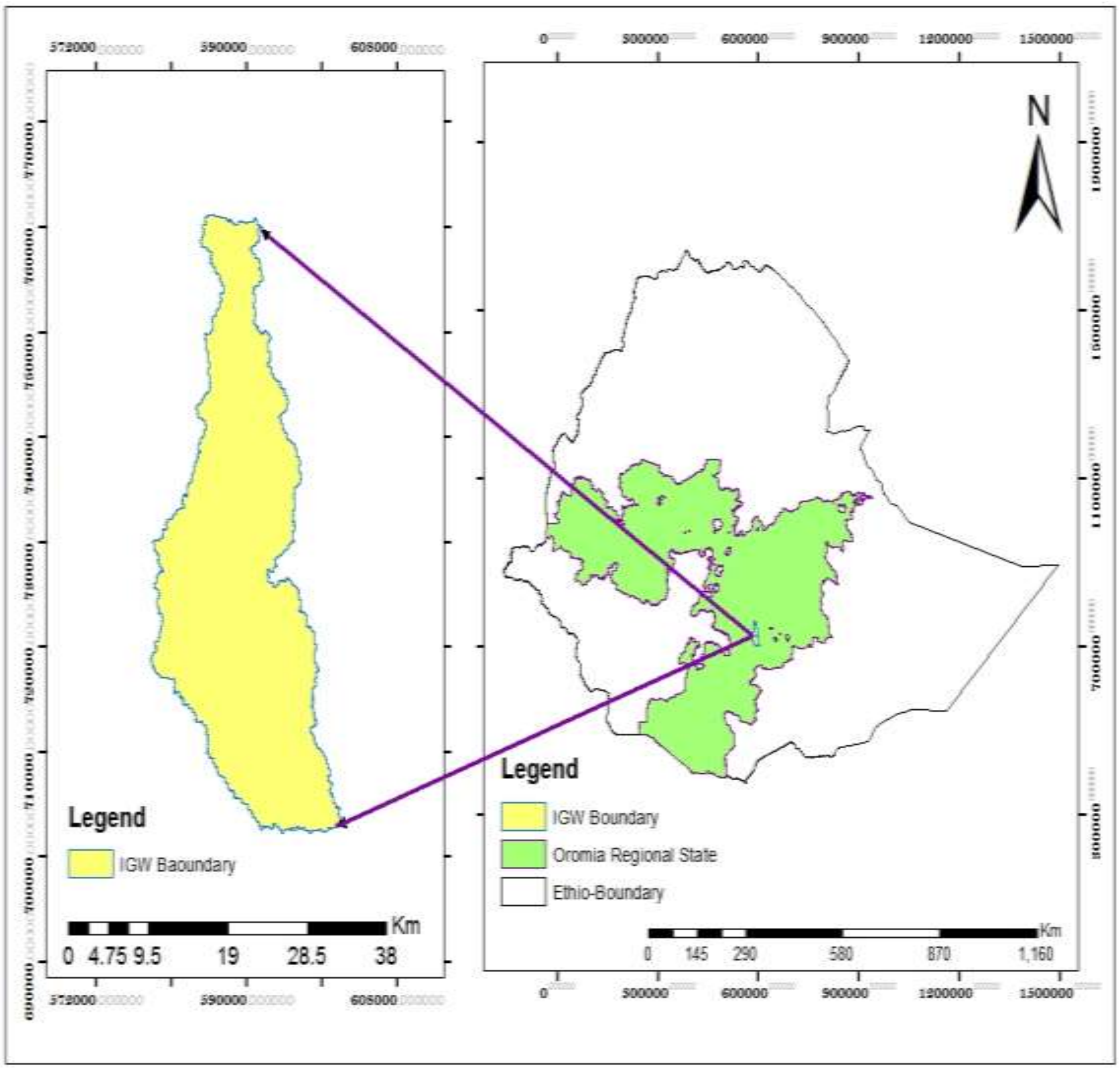

Figure 1: Location Map of Irba Girstu Watershed

3.2.1 Geology and Soil

Based on geological evidence, the dominant parent material in the central plateau is basalt; the soil of the catchment is the result of the weathering process of this basalt. As there is strong relation between landform and soil characteristics, samples to characterize soil type should be taken as per the major landform types within the watershed. Because of similarity in landforms, the soil characteristics are almost similar for most of the mapping units. a) Soil color: soil color is useful indicator of drainage. The dominant color for this watershed is black brown. b) Soil texture: soil texture is mainly concerned with size and shape of mineral particles. Soil erosion depends much on the infiltration rate of the soil. The infiltration rate again depends on soil texture. Hence, the decision for selecting graded or level physical soil conservation structures on cultivated lands mainly dependent on soil texture. For example, for clayey soil graded structures are recommended because of less infiltration rate. The dominant texture identified in this watershed is clay. C) Soil depth: It refers the depth of the soil above a layer of hard rocks, stones or other materials, which hinder root penetration. In this watershed soil class is very shallow soil depth. Two types of soils have been identified in the watershed namely: Cambisols and Vertisols. The dominant soil types are shown in the following map.

3.2.2 Irba Girstu Watershed Major Soil Descriptions

Soils are key parameters in watershed management. The soils significant characteristics that influence the process within watershed are soil permeability, soil erodability and compositions of nutrients that help vegetative growth. These characteristics are influenced mainly by soil properties such as soil texture, structure, depth, organic matter content, soil fertility, soil reaction, soil colour and stoniness. These properties of soils are highly important parameters in watershed development planning. The decisions taken during the planning process have to, reflect a basic soil conditions within Irba Girstu Watershed. According to OWWDSE, 2016 on integrated land use planning study at scale of 1:10,000 under Guji-Bale project, five major soils have been identified for Irba Girstu watershed i.e. Calcisols, Cambisols, Fluvisols, Leptosols Luvisols and Vertisols (Figure 2 and Table 1).

3.2.2.1 Calcisols

Calcisols accommodates soils with substantial accumulation of secondary carbonate. Calcisols are widely spread in arid and semi arid environment, associated with highly calcareous parent materials. The Calcisols of the study area are the most widely distributed soil type and classified as Umbric Fluvisols (Dystric), Mollic Fluvisols (Eutric) and Mollic Fluvisols (calcic).The surface textures of the Calcisols are fine and medium textured of clay, clay loam and sandy clay loam and the effective depth is shallow, moderately deep and very deep. The soils are brown to black in colour, generally well to moderately drained, sub angular soil structure, derived from mainly alluvium parent material. They also have less permeable, a favorable structure and high water holding capacity. They are found dominantly on flat topography. The soils cover an area of **51.52ha** or **0.08%** of the Watershed (Table 1).

3.2.2.2 Cambisols

Cambisols represent soils in which soil formation is characterized by a certain development of structure, or by colour indicating moderately pronounced alteration and development. They occur wherever conditions are not favorable for other soil processes than weathering to take place. Cambisols are derived from a wide range of parent materials. The soils are generally well drained, moderately deep to deep, and medium textured of clay loam, sandy clay loam and sandy loam soils found dominantly on nearly level to sloping topography. Cambisols in the Watershed are classified as Chromic, Haplic, Calcaric, Eutric, Dystric and Humic Cambisols. The soils cover an area of **3,098.5**ha or **4.53**% of the Watershed (Table 1).

3.2.2.3 Fluvisols

Fluvisols accommodate genetically young, azonal soils in alluvial deposits. The name Fluvisols may be misleading in the sense that these soils are not confined only to river sediments, they also occurs in the lacustrine and marines deposits (WRB, 2006). The Fluvisols of the Watershed area are the most widely distributed soil type and classified as Umbric Fluvisols (Dystric), Mollic Fluvisols (Eutric) and Mollic Fluvisols (Eutric). The surface textures of the Fluvisols are fine and medium textured of clay, loam and sandy clay loam and the effective depth is moderately deep and very deep. The soils are brown to black in colour, generally moderately drained, sub angular soil structure, derived from mainly alluvium parent material. They also have less permeable, a favorable structure and high water holding capacity. They are found dominantly on flat topography. They are significantly found in the Watershed and classified as Haplic, Eutric and Humic Fluvisols. The soils cover an area of **286.15**ha or **0.42**% of the Watershed (Table 1).

3.2.2.4 Leptosols

Leptosols are very shallow soils limited in depth by continuous hard rock. They are commonly occurring on steep slopes. The Leptosols are developed on relatively young surfaces origin. Moreover, since they occur on steep slopes, they are exposed to a high degree of erosion, which is responsible for a further decrease in depth. They are the third dominant soil and found significantly throughout the Sub basin. Leptosols of the Sub basin cover an area of **14,599.89**ha or **21.35**% of the Watershed (Table 1).

3.2.2.5 Luvisols

Luvisols are soils having an agric horizon, which has a base saturation of 50% or more at least in the lower parts of the B-horizon. These soils are derived from different parent material. They are found in areas where climatic conditions permit clay movement. They are common on flat and gently sloping topography. Luvisols are also found on rolling and strongly sloping topography, but limited in extent. They are generally well drained, deep to very deep, and fine to medium textured Clay to sandy clay loam soils. Luvisols are widely distributed in the Watershed and are classified as Haplic, Chromic, and Vertic Luvisols. These soils cover an area of **50,091.06**ha or **73.26**% of the Watershed (Table 1).

3.2.2.6 Vertisols

Vertisols are churning, heavy clay soils with high proportion of swelling clays. This soil forms deep wide cracks from the surface to dawn wards when dry out which happen in most years (WRB, 2006). Alternative swelling and shrinking of expanding clay results in deep cracks in the dry seasons and formation of slicken sides and wedge shaped structural elements in the subsurface soil. Gilgai micro relief is peculiar to Vertisols although not commonly encountered. Depression and level to undulating areas mainly in tropical, subtropical, semiarid to sub humid and humid climates with alternation of distinct wet and dry seasons are common environmental area for development of Vertisols. The soils are brown to black in colour, generally moderately to poorly drained, angular blocky to prismatic soil structure, moderately deep to very deep, clay textured, derived from mainly alluvium parent material. They also have less permeable, a favorable structure and high water holding capacity. They are found dominantly on flat topography. They are significantly found in the Watershed and classified as Haplic, glayic and Humic Vertisols. The soils cover an area of **243.07**ha or **0.36**% of the Watershed (Table 1).

Table 1: Major Soils of Irba Girstu Watershed

S/N	Major Soils	Area (ha)	Coverage (%)
1	Calcisols	51.52	0.08
2	Cambisols	3098.5	4.53
3	Fluvisols	286.15	0.42
4	Leptosols	14599.89	21.35
5	Luvisols	50091.06	73.26
6	Vertisols	243.07	0.36
Total		**68,370.19**	

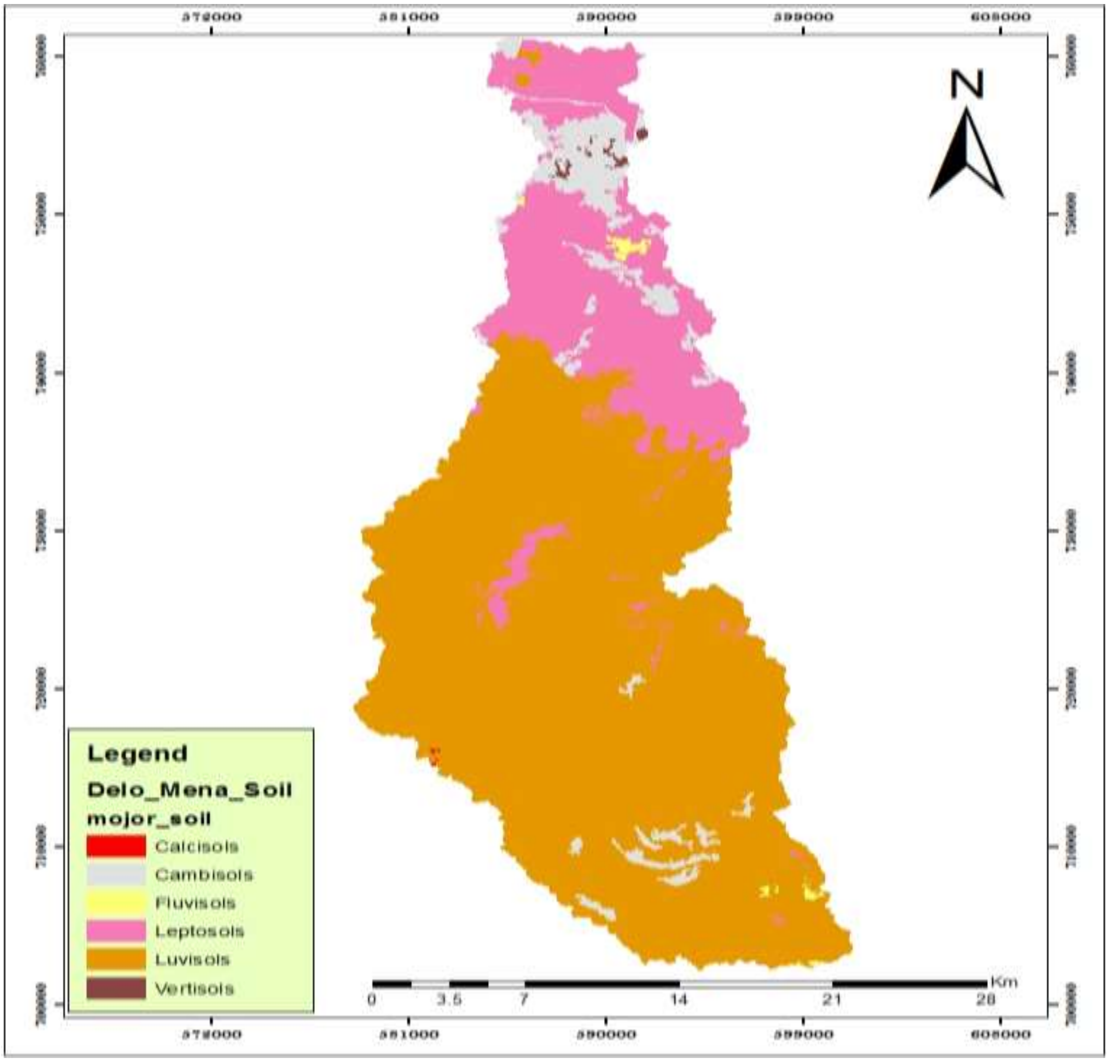

Figure 2: Soil Map of Irba Girstu Watershed

3.3 Drainage Pattern

The Irba Girstu River drains from north-west to southeast to low land area of Genale Sub-basin. The outlet was taken on Irba Girstu river and produced the intended watershed command area considering where the critical watershed significantly influence the irrigation site. The main river that characterizes this watershed is Irba Guda and Yadot in Souther part of the Watershed. The Drainage Pattern has something to do with erosion hazard and sediment yield. As it can be seen in the drainage map the drainage pattern is dendrite.

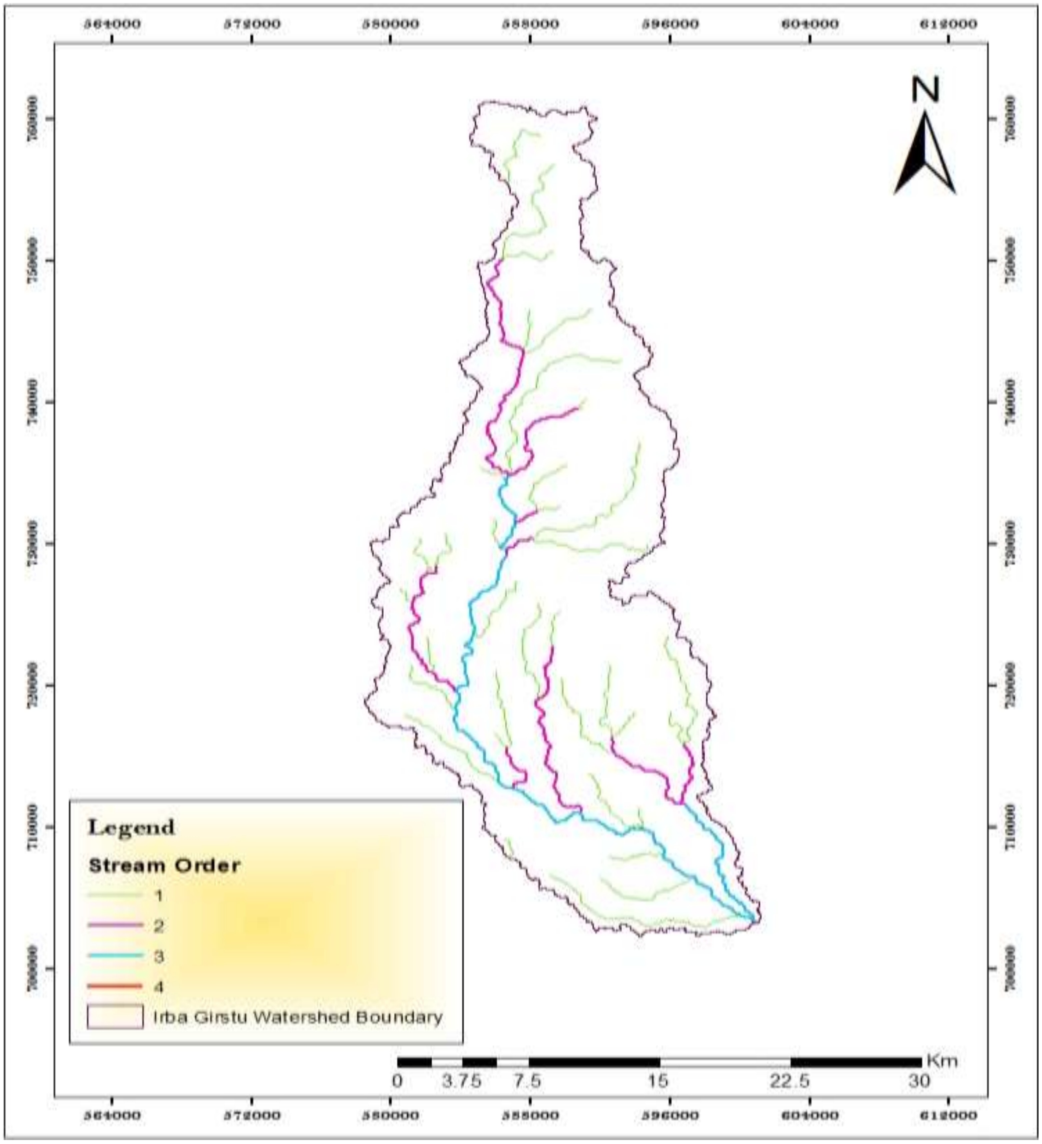

Figure 3: Drainage pattern

The order of the streams in this watershed is 4th and the most important drainage parameters are also indicated in table below.

Table 2: Drainage Parameters of Irba Girstu Watershed

S/N	Stream Order	No of Streams	Length in Km
1	1st	39	183.65
2	2nd	19	75.64
3	3rd	16	59.18
4	4th	1	0.22
Total		75	318.68

3.4 Topography

The Irba Girstu Watershed is found within 1,200 to 4,100 meters above sea level altitudinal range. The watershed has marked topographic variation. The dominant slope class are Gently sloping(0 – 3%) and Sloping (8 - 15%) which covers 31.44 and 31.33% respectively followed by Moderately steep (15 - 30%) which is 24.47% of the total area as depicted in Table 3.

Table 3: Irba Girstu Watershed Slope Class

Description	**Slope Class**	**Area (ha)**	**Coverage (%)**
Flat or almost flat	0 - 3	2851.56	4.17
Gently sloping	3 - 8	21495.84	31.44
Sloping	8 - 15	21423.33	31.33
Moderately steep	15 - 30	16731.20	24.47
Steep	30 - 50	3134.61	4.58
Very Steep	>50	2733.65	4.00
Total		**68,370.19**	**100.00**

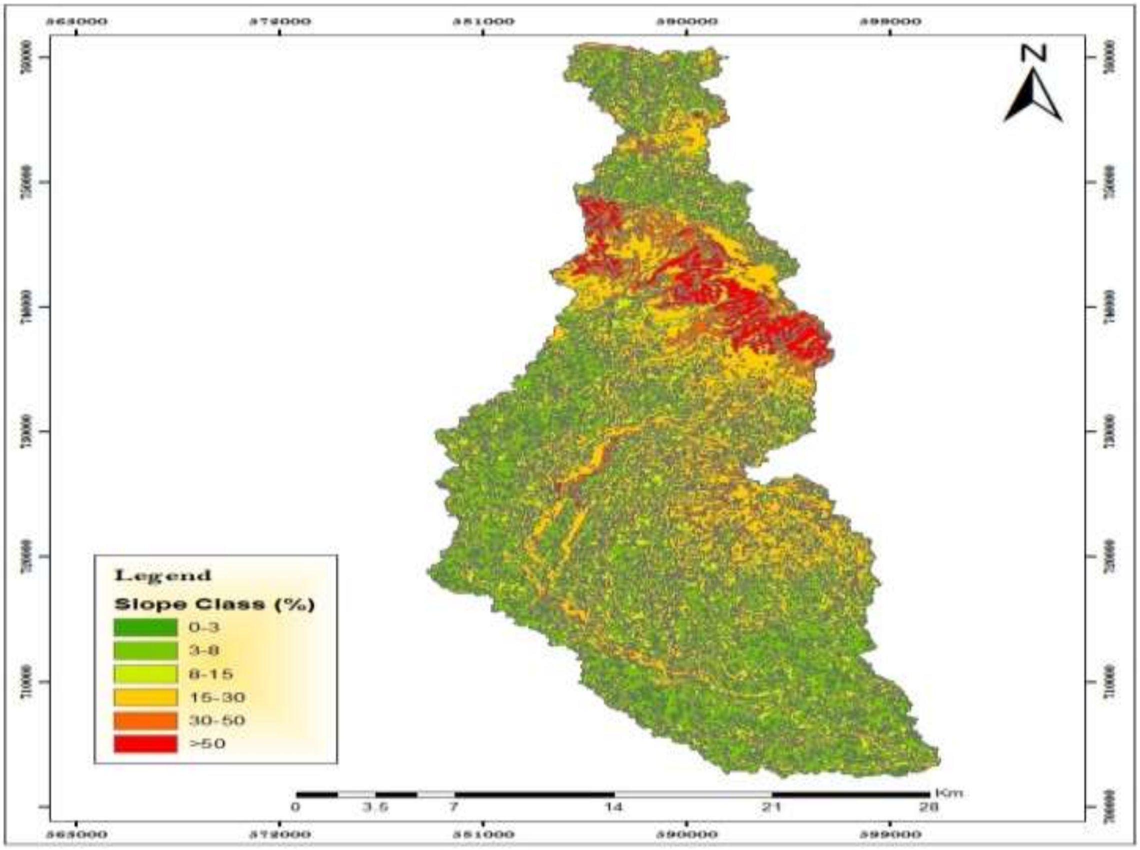

Figure 4: Slope Map of Irba Girstu Watershed

3.5 Watershed Geomorphology

The watershed is the basic unit of all hydrologic analysis and designs. Usually a watershed is defined for a given drainage point. This point is usually the location at which the analysis is being made and is referred to as the watershed "outlet". Watershed geomorphology refers to the physical characteristics of the watershed. Certain physical properties of watersheds significantly affect the characteristics of the rate and volume of runoff, and sediment yield from the watershed have much to do with shape, size, slope and other parameters of the landscape. These suggest that there should be some important relations between basin form and hydrologic performance. If the basin and hydrologic characteristics are to be related, the basin form must also be represented by quantitative descriptors. These parameters can be measured from maps or aerial photos. The following are brief descriptions on important watershed forms and relief parameters: **Area of the watershed** (A) is also known as the drainage area and it is the most important watershed characteristic for the hydrologic analysis. It reflects the volume of the water that can be generated from a rainfall. Thus the drainage area is required as input to models rain gage from simple linear prediction equations to complex computer models. Once the watershed has been delineated, its area can be determined, either by approximate map methods or by GIS.

Length of watershed/Axial length (L_b): Conceptually this is the distance traveled by the surface drainage and sometimes more appropriately labeled as hydrologic length. This length is usually used in computing a time parameter, which is a measure of the travel time of water through a watershed. The watershed length is therefore measured along the principal flow path from the watershed outlet to the basin boundary. Since the channel does not extend up to the basin boundary, it is necessary to extend a line from the end of the channel to the basin boundary. The measurement follows a path where the greatest volume of water would generally travel. **Basin length**, L_b, is the longest dimension of a basin parallel to its principal drainage channel and Basin width can be measured in a direction approximately perpendicular to the length measurement. The relation between mainstream length and drainage-basin area for small watershed is given below; where L_b is in km and A in km^2. $L_b = 1.312\ A^{0.568}$

Slope of watershed: Watershed slope affects the momentum of runoff. Watershed slope reflects the rate of change of elevation with respect to distance along the principal flow path. It is usually calculated as the elevation difference between the end points of the main flow path divided by the length. The elevation difference may not necessarily be the maximum elevation difference within the watershed since the point of highest elevation may occur along a side boundary of the watershed rather at the end of the principal flow path. If there is significant variation in the slope along the main flow path, it may be preferable to consider several sub watersheds and estimate the slope of each. Basin slope has a profound effect on the velocity of overland flow, watershed erosion potential, and local wind systems. Basin slope S is defined as $S = h/L$, where h = fall in meters, and L = horizontal distance (length) over which the fall occurs.

Shape of watershed/Basin shape is not usually used directly in hydrologic design methods; however, parameters that reflect basin shape are used occasionally and have a conceptual basis. Watersheds have an infinite variety of shapes, and the shape supposedly reflects the way that runoff will “bunch up” at the outlet. A circular watershed would result in runoff from various parts of the watershed reaching the outlet at the same time. An elliptical watershed having the outlet at one end of the major axis and having the same area as the circular watershed would cause the runoff to be spread out over time, thus producing a smaller flood peak than that of the circular watershed. A number of watershed parameters have been developed to reflect basin shape. Form factor, shape factor, circularity ratio, elongation ratio, and compactness coefficient are the typical parameters; important in defining the shape of a watershed/basin; and are discussed as below.

Shape factor (B) The shape of the basin affects the stream flow hydrograph and peak flow rates. If the shape of the watershed is almost elongated type which indicates the runoff response is somewhat high, and show high peak flow. The drainage area divided by the square of the main channel length i.e. L^2/A; where value > 1.

Form Factor: The area of the basin divided by the square of axial length of the basin I.e. A/L^2; where value < 1.

f <1 means less runoff with respect to square where, f = 1

Elongation Ratio: The ratio of the diameter of a circle of the same area as the basin to maximum basin length i.e. $E_r = 1.128A^{0.5}/L$; where value < 1. Elongation ratio shows us how much the watershed is elongated. The E value is with the range less or equal to one. Less value indicates more elongation, which in turn shows less peak flow.

Circularity Ratio: The ratio of basin area to the area of a circle having the same perimeter as the basin i.e. $Cr = 12.57\ A/P_r^2$; where value < 1. Expresses how much the watershed resembles a circle.

Compaction Coefficient: The perimeter of the basin divided by circumference of equivalent circular area i.e. $C_c = 0.2821P_r/A^{0.5}$.

Texture ratio (T): it expresses the ratio of number of streams per length of basin perimeter. It can be given as N/P_r

Stream order (Os): is the measure of the amount of branching with in a watershed. A Midium-un branched tributary is the first order stream. When these two 1st order streams join, they create 2nd order tributary. The 3rd order is occurred when two second order stream join and so on. With the help of stream orders, drainage pattern of the basin can easily be distinguished. Drainage pattern in turn indicates the flow pattern and geological formation of the area. Dendrite drainage pattern, for instance, shows there were no folding and faulting processes.

Drainage density (D): it is the ratio of the total length of streams within a watershed to the area of the watershed. Thus drainage density has the units of the reciprocal of length. A watershed with a high drainage density is characterized by quick response. Drainage density varies inversely as the length of overland flow and indicates the drainage efficiency of the basin. A high value indicates a well-developed network and torrential runoff causing intense floods while a low value indicates moderate runoff and high permeability of the terrain. In many situations, it is also of interest to consider channel cross-sections. Cross-sections can take on a wide variety of shapes and sizes. Cross-sections information is needed to determine the extent of flooding during high flows. High values of drainage density are expected from easily eroded soils, relatively impermeable, steep slopes and scantly vegetation covered watersheds. A high value of the drainage density would indicate a relatively high density of streams and thus a rapid storm response. A value typically ranges from 1.5 to 6 mi/mi^2. It is given by D = total stream length/drainage area.

Length of over land flow (Lo): Length of over land flow expresses how far a drop of rain travels until it joins the concentrated channel flow. It can be expressed by L = 1/2D, Where, L = Over land flow length (m), D = Drainage density.

Channel slope: The channel slope is determined as the elevation difference between the endpoints of the main channel divided by the channel length. The length of the channel affects the velocity of flows and hydrograph shapes. Commonly, only the main stream is considered in describing the channel slope of the watershed.

Bifurcation ratio (R_b): Expresses the ratio of primary stream to that of secondary or secondary to that of tertiary and so on. It is given by $R_b = N_w/N_w+1$, Where N_w = number of streams in the watershed order.

The watershed characteristics are analyzed and presented in the following table.

Table 4: Catchment Morphology of Irba Girstu Watershed

S/N	*Parameters*	*Symbols*	*Unit*	*Formula*	*Result*
1	Area	A	km2	Measured	683.70
2	Perimeter	P_b	Km	Measured	239.64
3	Axial length	L_b	Km	1.312*A^0.568	47.55
4	Basin width	W	Km	A/L_b	14.38
5	Total no. of streams	N	No	Measured	75
6	Total stream length	L	Km	Measured	318.68
7	Main stream length	L_m	Km	Measured	82.32
8	Stream density	S_d	no/km2	N/A	0.11
9	Main stream slope	S	%	Measured	
10	Stream order	O_s	No	Measured	4
11	Drainage density	D	km/km2	L/A	0.46
12	Over land flow length	L_o	Km	1/2D	0.23
13	Shape factor	B	unit less	L_b^2/A, B>1	3.31
14	Form factor	R_f	unit less	A/L_b^2, F<1	0.30
15	Perimeter of circle having same A	P_c	km	3.545A^0.5	49.23
16	Gravelius's shape index	K_G		Pr/2√πA	2.59
17	Elongation Ratio	E		1.128 √A / L_b , E < 1.0	0.62
18	Circularity Ratio	R_C		12.57 A / Pr^2	0.15
19	Compactness Coefficient	C_C		0.2821 Pr /√A , Cc ≥1.0	2.58
20	Texture ratio	T	unit less	N/P_b	0.31
21	Diameter of circle having same area	D_c	km	1.128A^0.5	27.77

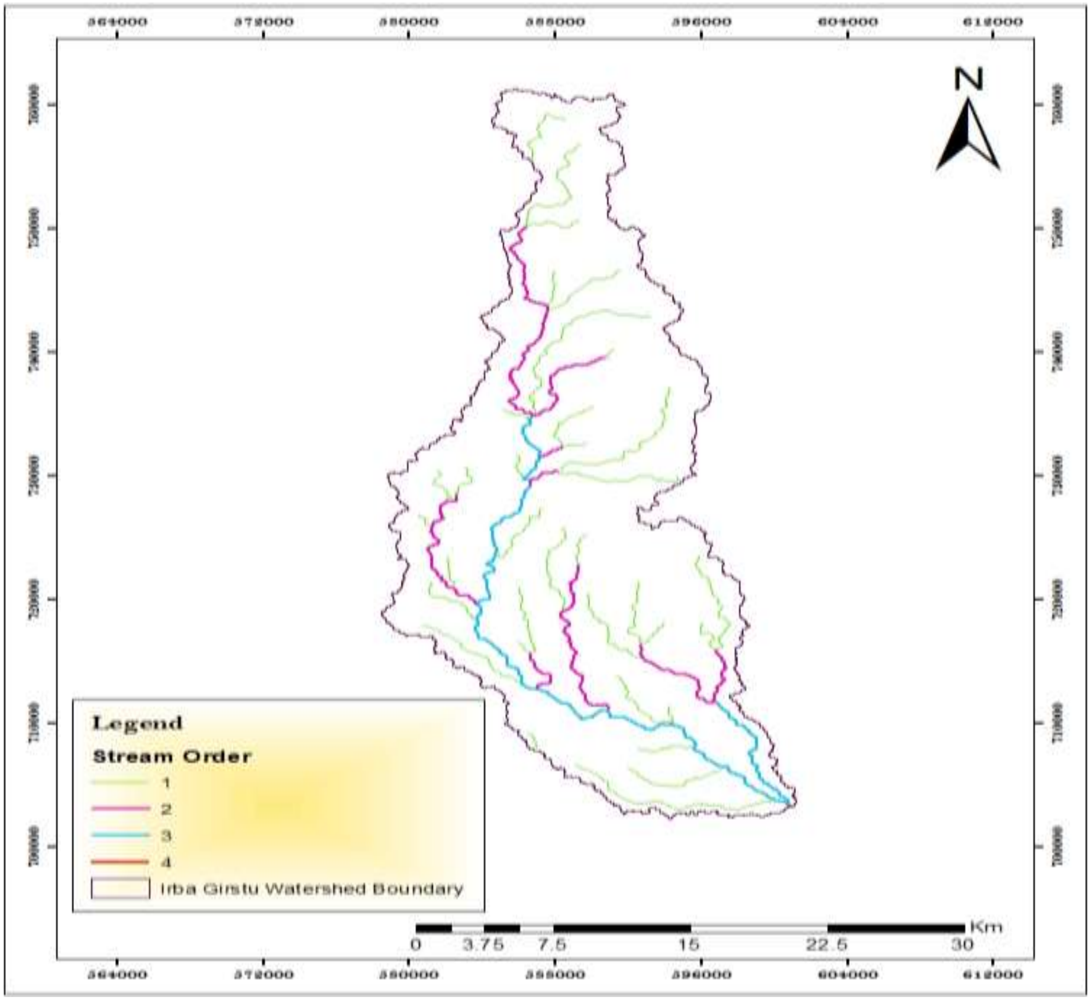

Figure 5: Stream Order

Table 5: Stream order of Irba Girstu Watershed

S/N	Stream Order	No of Streams	Length in Km
1	1st	39	183.65
2	2nd	19	75.64
3	3rd	16	59.18
4	4th	1	0.22
Total		75	318.68

3.6 Agro Climate

The watershed is situated from elevation 1200 to 4100 m.a.s.l. It has about 450 to 600 mm/yr annual rainfall. In addition, trees like *Cordia Africana*, *Junipers Procera* are common trees in the area and crops like teff, maize, sorghum, wheat, barley and chek pea are major once. The majority of the soil color is black brown, reddish brown and red soil. According to the above characteristics the watershed falls in arid and semi-arid lowland (ASALs) agro climatic condition. The climatic condition of these woreda is arid and semi- arid which cover 71.2% and 28.8% respectively.

3.6 Land Use Land Cover

Land cover refers to physical features on the surface of the Earth-vegetation, water, the built-up land. Whereas, land use specifically refers to the human (economic) utility of what is on the Earth's surface (Younos and Parece, 2015). The watershed land use history and present situation are discussed with KI and FGD especially elderly farmers. From LULC data analysis, the majority of the Watershed area is covered with Dense Mixed High forest and Afro alpine and sub-afro alpine vegetation which accounting 64.17 and 14.29% of the total area followed by Predominantly Cultivated Land accounts 9.09% of the total area as described in Table 6.

Table 6: Land use and Land cover of Irba Girstu Watershed

S/N	LULC Class	Area (ha)	Coverage (%)
1	Afro alpine and sub-afro alpine vegetation	9772.67	14.29
2	Bushed Shrub Grassland	44.5427	0.07
3	Predominantly Cultivated land	6213.94	9.09
4	Moderately Cultivated land	2629.57	3.85
5	Dense Bushland	343.422	0.50
6	Dense Mixed High forest	43870.5	64.17
7	Disturbed High Forest	1187.7	1.74
8	Open Bushland	1118.94	1.64
9	Open Forest	1268.65	1.86
10	Open Shrubland	1273.84	1.86
11	Settlement	646.42	0.95
Total		**68,370.19**	**100.00**

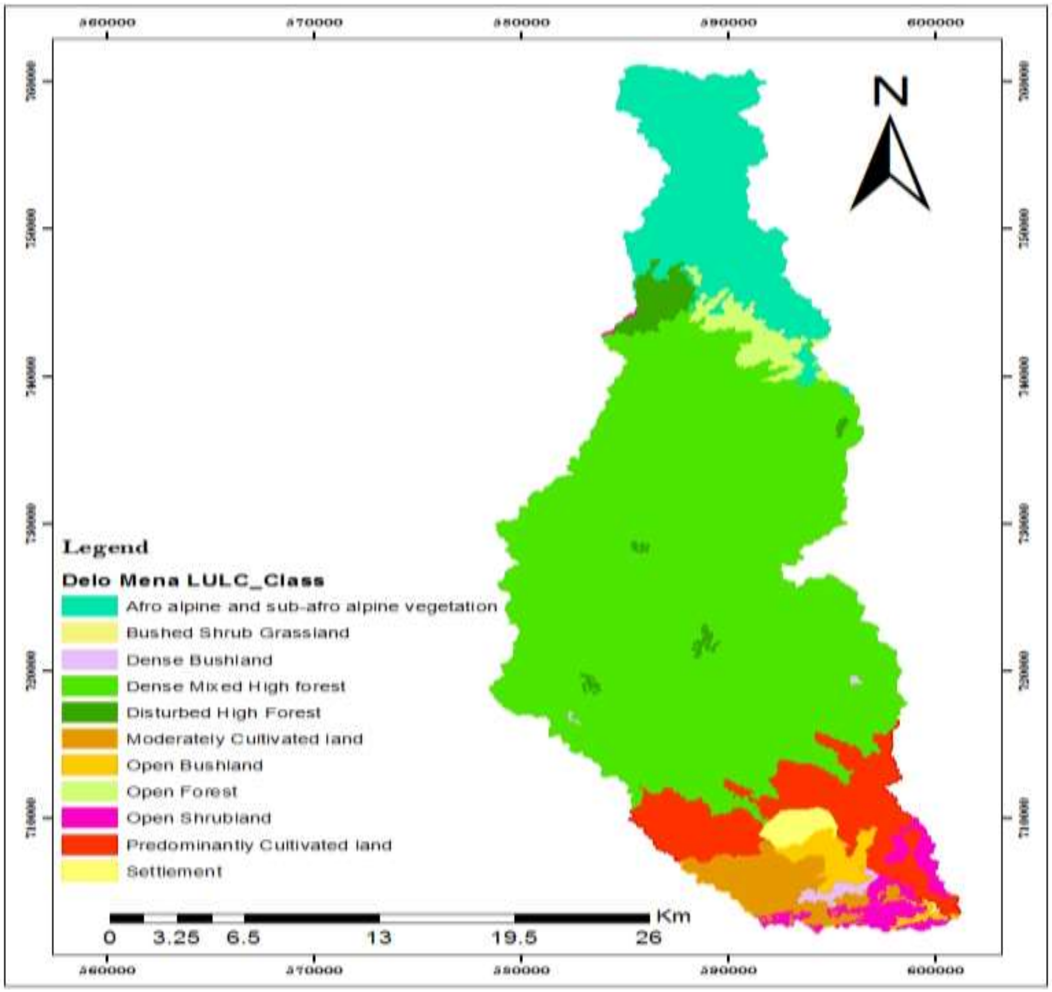

Figure 6: LULC Map of Irba Girstu Watershed

3.6.1 Past Land Use History

As some elderly farmers explain, population density is by far lower than the present, hill sides and stream banks were covered with naturally grown trees and grasses. The production of the cultivated land and the occupation of each household were enough to support family's food need. But as the population grows, these all things deteriorated. Population growth is attributed to expansion of cultivated lands and use of trees for firewood. The farmers said that expansion of the cultivation do exist till now. The expansion is mostly on grazing, bush lands and hilly areas of the watershed.

3.6.2 Present Land Use Condition

The farming system in the watershed is mixed with dominantly oxen plough cereal crop production and livestock rearing, which is centuries old system. Accordingly, the major land use types in the watershed include cultivated, grazing, very spares and patches of shrub/bushes, plantations, settlement and miscellaneous lands. The distribution of land use type is very fragmented and patches that are virtually difficult to show on map of small scales

3.6.3 Future Land Use Trend

The most part of this watershed has relatively steep slope with shallow soil depth and endanger the remaining soil remnants on cultivated and grazing lands. This is due to total removal of top soil by accelerated erosion on steep lands. However, by implementing some protection and developmental measures the existing sever conditions can be changed to hopeful one. If there is no appropriate measure to curtail the situation, the total watershed will be changed to unproductive area.

16. 4. PROBLEM IDENTIFICATION

Most developing countries of the world are threatened by global and local environmental changes. The worst effect lies on mismanagement natural resources for survival and have very few resources to offset the negative effect of environmental change. People are exposed to many problems directly or indirectly related to environment due to their mismanagement. Watershed problems in Ethiopia are characterized by land degradation, deforestation, over grazing and inappropriate farming practice. Field observations at Irba Girstu watershed, FGD with elder and KI interviews indicated that physical and biological degradations are the common phenomena of watershed and offer challenge to the development and resource base. The identified problems in the watershed discussed in the following section.

4.1 Watershed Degradation

Watershed degradation is the loss of value over time, including the productive potential of land and water, accompanied by marked changes in the hydrological behavior of a river system resulting in inferior quality, quantity and timing of water flow. Watershed degradation results from the interaction of physiographic features, climate and poor land use (indiscriminate deforestation, inappropriate cultivation, disturbance of soils and slopes by mining, the movement/trampling of animals, road construction, and badly controlled diversion, storage, transportation and use of water). Watershed degradation, in turn, leads to accelerated ecological degeneration, reduced economic opportunities and increased social problems (FAO, 1999). Based on field observation and discussion with focus group participant and key informants, the major factors that pose watershed degradation in Irba Girstu Watershed are deforestation, forest degradation, overgrazing, stream bank cultivation and mismanagement of agricultural land and steep land cultivation. This factor resulted in decline land productivity, quantity and quality of water, flash flood occurrence, landslide, drought and loss of biodiversity in the watershed.

4.1.1 Land and Soil Degradation

Land Degradation is any form of deterioration of the natural potential of land that affects ecosystems integrity, either in terms of reducing its sustainable ecological sustainability or in terms of reducing its biological richness and maintenance of its resilience”(FAO, 2017). Land degradation defined as the loss of utility or potential utility or the reduction, loss or change of features or organisms which cannot be replaced (Taffa, 2011). Continued deterioration of land may lead to a permanent decrease of its biological potential and a deterioration of living conditions for inhabitants. The causes of these processes are invariably a combination of natural phenomena amid man's actions such as the destruction of vegetative cover, overgrazing and inappropriate agricultural practices that are not in harmony with the ecological environment. It is man's actions, often because of increasing population pressure, that extend and accelerate the processes of degradation. Water erosion includes sheet, rill, gully erosion and mass movements; and chemical degradation to the leaching and removal of nutrients and the buildup of toxicities other than those due to excess salts. Physical degradation includes those processes such as poor cultivation practices, which adversely affect soil physical properties such as infiltration rate, structural stability, root penetrability, and permeability. Some of these processes, which result in the exposure of the soil surface to rainfall, are closely related to sheet and rill erosion. Biological degradation refers to processes, which accelerate humus mineralization rates, and largely reflects the moisture/temperature regimes of the environment and land use practices.

Soil degradation is the decline in any or all of the characteristics which make soil suitable for producing food. Soil degradation occurs through the deterioration of the physical, chemical and biological properties of soil that results in soil compaction, salinisation, acidification, and soil loss from wind and water erosion. Soil degradation is a critical and growing global problem, with implications for a number of key policy areas, including food security, climate change, flood risk management, drought tolerance, drinking water quality, agricultural resilience in the face of new crop diseases, biodiversity and future genetic resources (Young *et al.*, 2015). Soil degradation is potentially reversible through planned ecosystem restoration and by introducing agricultural systems and practices that regenerate soil by building fertility and increasing biological activity and SOC. It is essential that soil health should be given a central position in decisions made to combat climate change and that it is recognized as a vital resource for the future of humanity (Young *et al.*, 2015).

4.1.2 Erosion Hazard Assessment

4.1.2.1 Soil Erosion

Soil erosion is the removal of soil particles (including plant nutrients and organic matter) from the place where it belongs by water or wind (Taffa, 2011). It is a natural process and generally aggravated by human intervention, and exceeds the rate of soil regeneration (Gonenç *et al.*, 2015); it is the most widely recognized and most common form of land degradation and, therefore, a major cause of falling productivity (Stocking and Murnaghan, 2001). Soil erosion affects the earth and its inhabitants directly and indirectly. Topography, rainfall, wind, lack of vegetation covers, soil properties, and land use/range land mismanagement practices are the immediate causes of soil erosion. There are also underlying causes, such as population pressure, poverty, land tenure problem, lack of appropriate production and conservation technologies, various government policies or lack of them aggravate land degradation which enhanced soil erosion, decline land product and productivity, food insecurity and drought. Soil erosion also encourages non point sources pollution which affects water quantity and quality.

The major form of land degradation in Irba Girstu watershed is soil erosion by water. The common type of erosion is water erosion exhibited with all forms of erosion such as sheet and rills, gully and stream bank on very steep slope areas. The soil erosion in the watershed is slight which is due to primarily by human activities that progressively ever grown. The long aged agricultural activities resulted in progressive depletion on resources through deforestation, overgrazing and over cultivation and hence sever soil erosion and land degradation.

Today, these resources, including water resources, are exceedingly depleted resulting in environmental, socio-economic and ecological losses. The resources depletion has created to progressively lowered land productivity to the rural people. The disastrous soil degradation in this watershed is caused by sheet and rill erosion. Most part of the cultivated land is subject to sheet and rill erosion, especially the hazard is more on cultivated lands. The cause of sheet and rill erosion is complex and inter linked with one another. The identified key factors aggravating this problem are:

- Expansion of cultivated land to steep slopes, stream sides or ecologically sensitive lands,
- Inadequate land covers during erosive periods
- Over population of livestock and
- Lack of sufficient conservation measures.

4.1.2.1.1 Sheet Erosion

Sheet Erosions is the removal of thin layer of soil and it is unnoticed because of the total amount of soil removed in any storm usually small. However, it has series determinately effect on soil fertility and productivity since it removes lighter soil particles and soluble nutrients. Sheet erosions the dominant form of erosion occurring in all parts of the Watershed. It is the most widely destructive erosion process. However, it is obvious that sheet erosion is more series where the surface cover is little.

4.1.2.1.2 Rill Erosion

Rill erosion is the next noticeable form of erosion. In all areas where sheet erosion occurs, we can observe the symptoms of rill erosion. The symptom of rill erosion is the occurrence of rills or small channels on different land units. Rill erosion occurs in all parts of the basin and considered as the second destructive form of erosion. The intensity of rills varies with in the basin; rills are observed frequently in areas of having relatively high slopes and frequent rain.

4.1.2.1.3 Gully Erosion

Similar to sheet and rill erosion, gully erosion[1] is a threat in Irba Girstu Watershed. With continues encroaching of gullies mostly towards cultivated and grazing land; gully erosion is also a problem in the watershed. Unlike the promising beginning on conserving cultivated lands, gullies has been ignored a serious problem. Because of this neglection, the gullies are regularly expanding. Cultivated and grazing lands are expanded up to the edge of the gully and even on gully sides. Livestock are trampling around and inside gullies. Most of the gullies in the watershed can be grouped to medium sized and deep gullies observed at the cultivated land due to poor land management.

[1] Gully Erosion is an advanced stage of rill erosion much as rill erosion is an advanced stage of sheet erosion. A channel or miniature valley cut by concentrated runoff but through which water commonly flows only during and immediately after heavy rains.

Figure 7: Gully Erosion at Irba Girstu Watershed (Field Survey 2019)

4.1.2.1.4 Stream Bank Erosion

Stream bank erosion is a form of water erosion and occurred due to excess amount of flood, which comes from the high land area of the catchment. The side of the river becomes expanded, and the cultivated land near to riverbank becomes further risk. Most of the time stream bank erosion is not understand by the people about its effect but this form of erosion expanded and devastates high amounts potential areas, irrigation structures, weirs and canals. The area affected by stream bank erosion may be understand by people are small as compared to other forms of water erosion and treatment is not usually made because this land is considered as marginal land. At this area big stone boulders are coming towards the downstream and affect the direction of flow water to the downstream.

4.1.3 **Erosion Rate and Estimated Soil Loss**

Erosion is the removal of soil particles from the large soil mass and transportation or dislocation of soil particles in to downstream area by running water. The revised universal soil loss equation (RUSLE) for Ethiopian condition was used to compute the total average annual soil loss from sheet and rill erosion within the watershed for it considers different catchment characteristics. Of course, the major weakness of this equation is that it could not estimate gully, stream bank and channel erosions. For ease of computation, the five parameters of the RUSLE are estimated for each of the mapping units. Thus, the total sum of average soil loss from all mapping unit within the watershed may estimate the total soil loss of Irba Girstu Diversion watershed. The revised universal soil loss equation is given as A= R*K*LS*C*P

Where: A = Average annual soil loss (ton/ha/yr); R = Rainfall erosivity, K = Soil erodibility;

LS = Slope length factor and gradient; C = Cover factor; P = Management factor

All the layers of R, K, LS, C and P with 30.7 x 30.7m output cell size were generated in GIS and were crossed to obtain the product, which gives annual soil loss (A) for the sub basin. Each parameter of RUSLE was assessed in the following sections.

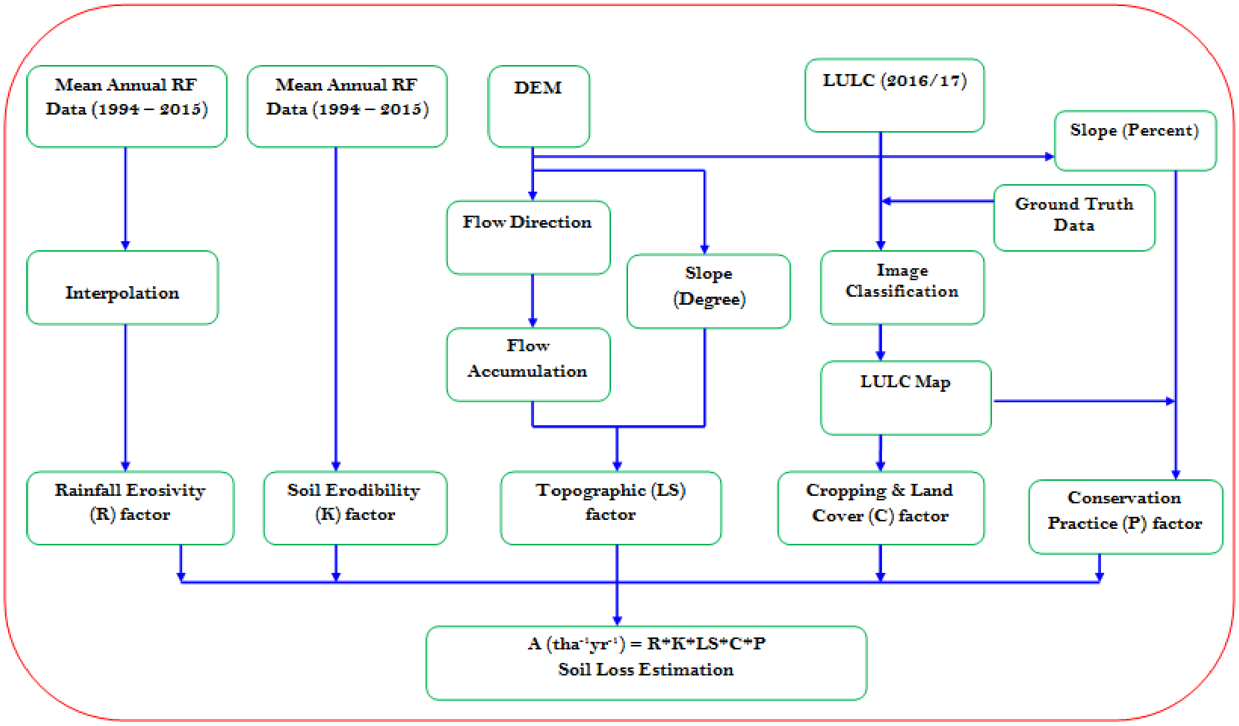

Figure 8: Soil Loss Analysis Framework

4.1.3.1 Rainfall Erosivity Factor (R)

Rainfall erosivity depends on amount, intensity and distributions of rainfall. The soil loss is closely related to rainfall partly through the detaching power of raindrop striking the soil surface and partly through the contribution of rain to runoff (Morgan, 1985). Though there are a number of ways of analyzing the rainfall erosivity depending on the local conditions of the place (country), the values of R factor for this study was estimated according to the equation adopted by (Hurni, 1985) for Ethiopian conditions.

$$R = -8.12 + 0.562 \times P$$

Where, R = Rainfall erosivity; P = mean annual rainfall (mm/yr).

To compute R factor, mean annual rainfall of 21 years were collected from four metrological stations such as Goba and Delo Mena which were neighboring stations. After calculating average 21 years of rainfall for each station, the R factor was computed using the above formula and converted in to raster surface using IDW (Inverse Distance weighted) interpolation methods in ArcGIS software (Figure 9).

4.1.3.2 Soil Erodability Factor (K)

Soil Erodability Factor (K) is defined as mean annual rainfall soil loss per unit of R for a standard condition of bare soil, recently tilled up-and-down with slope with no conservation practices and on a slope of 5˚ and 22 m length (Morgan, 1994). Main determinants of soil erodability are soil structural stability and the soils ability to absorb rain-fall. These properties in turn depends on a number of characteristics of the soil, such as texture, structure, organic matter content, soil depth and other physical and chemical properties of the topsoil. The value of K was given by (Hurni, 1985) based on soil colors in RUSLE for Ethiopian condition by adapting different sources and researches (Table 7).

Table 7: Soil Types with Their Corresponding K Values

S/N	Major Soils	Area (Ha)	Color	K - factors
1	*Calcisols*	51.52	Red	0.25
2	*Cambisols*	3098.5	Dark reddish brown	0.20
3	*Luvisols*	286.15	Brown/reddish brown	0.15
4	*Fluvisols*	14599.89	Reddish brown	0.20
5	*Leptosols*	50091.06	Brown to yellowish brown	0.15
6	*Vertisols*	243.07	Dark grayish brown	0.13
Total		**68,370.19**		

For the analysis of K factor, FAO standard classification of soil type was obtained from pervious study of OWWDSE. According to FAO soil classification five major soil types namely, Cambisols, Leptosols, Luvisols Nitosols and Vertisols were identified in the study area. After changing the vector format in to grid, the grid dataset was reclassified based on K-values adopted by (Hurni, 1985) (Table 7 and Figure 9).

4.1.3.3 Topographic Factor (LS Factor)

The slope length and slope steepness factors are commonly combined in a single index as LS and referred to as the topographic factor. Slope length is defined as the distance from the point of origin of overland flow to the point where either the slope gradient decreases enough that deposition begins or the runoff water enters a well-defined channel that may be part of a drainage network. Slope steepness has been considered as one of the most model parameters in RUSLE analysis due to the fact that the steeper the slope of a field, the more it is pushed down hill, the faster the water runs and the greater will be the amount of soil loss from erosion by water. Soil erosion by water also increases as the slope length increases due to the greater accumulation of runoff. The modified equation for computing the topographic factor (LS factor) in GIS environment is employed by the formula recommended by (Griffin *et al.*, 1988; Tadesse and Abebe, 2014).

LS = Power [(Flow Accumulation) x Pixel size/22.1,0.6]power[sin (slope) x 0.01745/0.09,1.3]

Where flow accumulation is the number of cells contributing to flow in to a given cell and derived from the DEM after conducting **fill**, **flow direction** and **flow accumulation** processes in ArcGIS. Cell size is the size of the cells being used in the grid based representation of the landscape. Finally, the LS factor map was derived using the above formula in ArcGIS spatial analysis raster calculator function (Figure 9).

4.1.3.4 Cover Management Factor (C)

The cover management factor represents the ratio of soil loss under a given cover to that of the base soil (Morgan, 1994). Land cover has a profound impact on erosion and deposition. Surface cover, such as vegetation or plant residue may intercept and reduce raindrop erosivity, increase infiltration, slow down runoff and reduce transporting capacity of water flow. The land use/land cover map was used for the estimation of C-value. The raster land use/land cover map was converted to a vector format and a corresponding C-value was assigned to each land use classes based on cover values proposed by Hurni (1985) (Table 8). Finally, using reclassification and vector to raster conversion the land use/ land cover map was converted to C factor map (Figure 9).

Table 8: Land covers class and corresponding C – factors

S/N	Land Use Class	Area(ha)	*C - factor*
1	Afro alpine and sub-afro alpine vegetation	9772.67	0.01
2	Bushed Shrub Grassland	44.5427	0.01
3	Predominantly Cultivated land	6213.94	0.15
4	Moderately Cultivated land	2629.57	0.15
5	Dense Bushland	343.422	0.01
6	Dense Mixed High forest	43870.5	0.001
7	Disturbed High Forest	1187.7	0.01
8	Open Bushland	1118.94	0.01
9	Open Forest	1268.65	0.1
10	Open Shrubland	1273.84	0.014
11	Settlement	646.42	0.09
Total		**68,370.19**	

4.1.3.5 Conservation Practice Factor (P Factor)

Conservation practice and land management directly affects the overall soil erosion problem and solutions on a farm. In RUSLE, P factor is the ratio of soil loss with a specific conservation practice to the corresponding loss with up and down slope cultivation, which has a value of one. The P-value ranges from 0 - 1 depending on the soil management activities employed in the specific plot of land. These management activities are highly depends on the slope of the area. P-factor is calculated for agricultural land only and for all other land use is assumed as 1, because there is no any control practice measures (Wischmeier and Smith, 1978). After assessing the conservation practice and their respective values, P - factor map was developed in ArcGIS using land use/land cover in line with Slope map of the study area (Figure 10).

Table 9**:** P - Values for the different slope classes of agricultural land

Land use	**Slope (%)**	***P - Value***
Agricultural land	0 - 3	0.1
	3 - 8	0.12
	8 - 15	0.14
	15 - 30	0.17
	30 - 50	0.25
	>50	0.33
Others land use	All	1.00

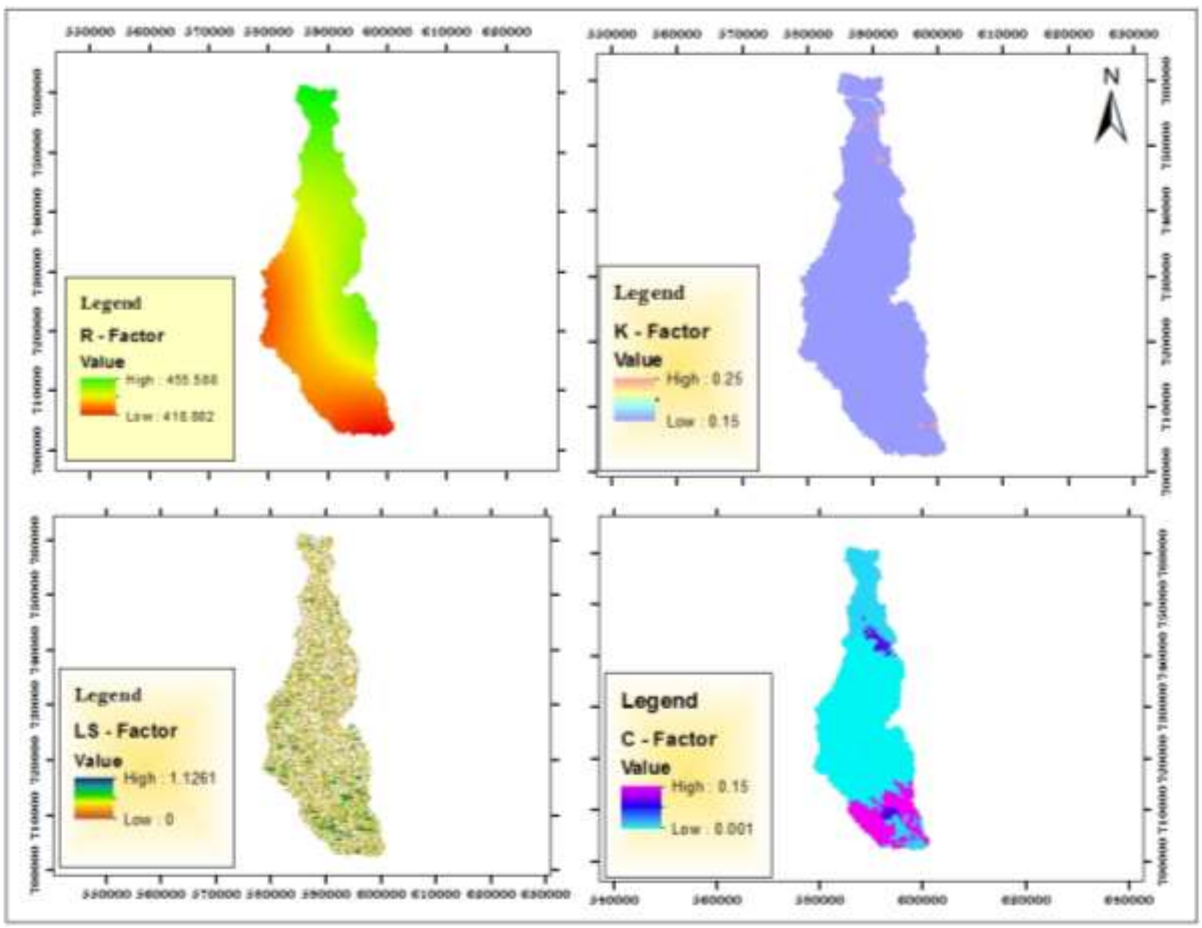

Figure 9: Map of Soil Loss Factors

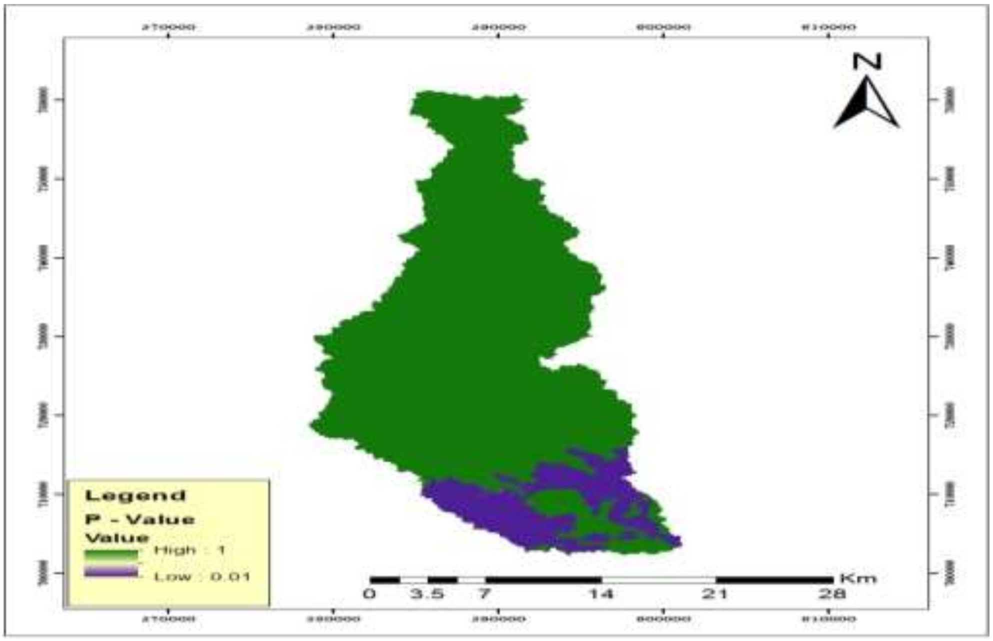

Figure 10: Map of P - Value

4.1.3.6 Estimated Soil Loss

The spatial distributions of amount of soil loss in the study area are ranges nearly slight in whole the watershed. In some parts of north western, south and southwestern are moderately distributed in the catchments (Figure 11). The total annual soil loss from the area is 19.24t/ha/yr, which make a total loss of 1,315,442.46 ton per year from 68370.19 ha of land. The mean annual soil loss is 0.11t/ha/yr, which make a total loss of 7,520.72ton per year from 68,370.19 ha of land. Since, the whole watersheds were dominated by gently sloping (3 - 8%) accounts 31.44% followed by sloping (8-15%) accounts 31.33% of the total area. In addition to its terrain features, poor land management and land over cultivation, deforestation and forest degradation, , over grazing and absence soil cover during the first periods of raindrops as well as water flows are also the major driving force for the recording of soil loss in whole the watershed.

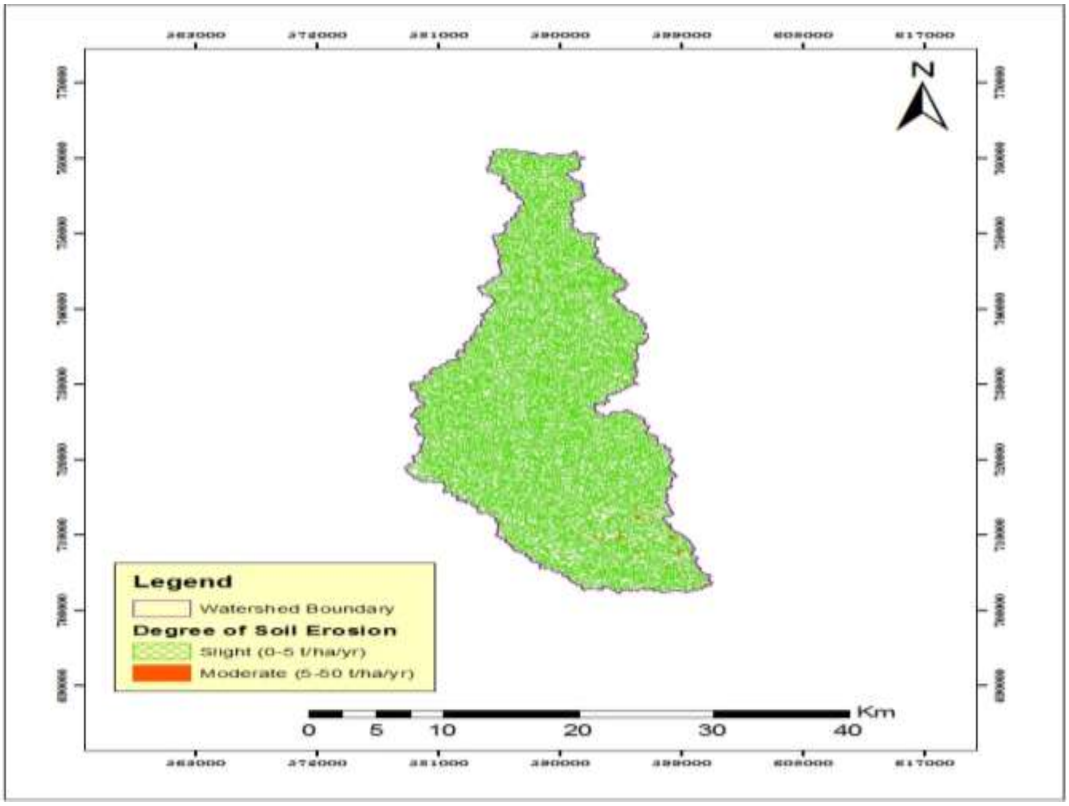

Figure 11: Map of Soil Loss

Table 10: Annual soil loss analysis in Irba Girstu Watershed

	Degree of Soil Loss Cover		
A	Area (ha)	Area (%)	Soil Erosion Rate
	60745.1	88.85	Slight (0-5 t/ha/yr)
	7625.08	11.15	Moderate (5-50 t/ha/yr)
Total	68,370.19	100.00	
	Annual Soil Loss		
	Area (ha)	ton/ha/yr	ton/yr
B	68,370.19	19.24	1,315,442.46
	Mean Annual Soil Loss		
	Area (ha)	ton/ha/yr	ton/yr
C	68,370.19	0.11	7520.72

4.1.4 Estimated Sediment Yield in the Watershed Outlet

The sediment delivery ratio (SDR) denotes the ratio of the sediment yield at a given stream cross-section to the gross erosion from the watershed upstream from the measuring point (Julien, 1998). To generate the sediment yield at the outlet (lowest Position of the watershed), empirical equations were carried out.

$$SDR = A^{-0.2} \text{ equation (1)}$$

Where, SDR denotes the sediment delivery ratio and area of the watershed. The SDR physically means the ratio of the sediment routed to the outlet over the watershed, both overland and channel. Sediment yield is commonly estimated by the following empirical formula:

$$Sy=E*(1/A^{0.2}) \text{ equation (2)}$$

Where, Sy= Sediment yield (ton) at the watershed out let; E = total erosion (ton); A = watershed area (ha)

Sediment Yield tells us how our top soils are being eroded by running water. Sediment yields are moderate at the lower position (Micro-Dam) of the watershed. The transporting ability of the runoff to move all the eroded sediments is insufficient. As a result, deposition occurs in reservoirs, depressions, at the toe of the hills where changes slope. Thus, the amount of erosion in the watershed is generally more than the amount of sediment leaving the watershed at the outlet point. Similar to that of erosion estimates, sediment yield is also calculated using empirical equation. The most common method for estimating sediment yield is sediment delivery ratio ($1/A^{0.2}$), which is developed from reservoir survey, or measurement of suspended and bed loads at the gauging station and compared with that of erosion in the watershed.

$$Sy=E*(1/A^{0.2})$$

Where, Sy= Sediment yield (ton) at the watershed lowest level,

E = total erosion (ton), A = Watershed area (ha),

Sy =19.24*(1/68370.19$^{0.2}$) and Sy = 2.067 tons per year

As shown in Table 10 and Figure 10, Based on the analysis, the mean and total annual soil loss potential of the study watershed was 0.11tons/ha/yr and 19.24t/ha/yr respectively.

4.1.5 Improper Land Cultivation System

The major cause for Watershed degradation is land structural deterioration of the watershed. The field observation result and discussion with focus group participant and KI interviews indicated that long-term excessive tillage and extensive agricultural land expansion to steep and marginal lands without any remedial measures results in depletion of soil nutrients and organic matter that in turn enhances crusting, aggressive runoff, accelerated erosion and ultimately low productivity. The removal of vegetation cover played a great role in the process of enhancing accelerated erosion. This was not a terminating single event, rather, a century process. As a result of this process, the topsoil depth is reduced to a minimum uncultivable value are the most important factors in high runoff yield that results in more accelerated erosion by water in Irba Girstu Watershed.

4.1.6 Deforestation and Forest Degradation

Deforestation is the conversion of forest to another land use or the long-term reduction of tree canopy cover below the 10% threshold. Deforestation can result from deliberate removal of forest cover for agriculture or urban development, or it can be an unintentional consequence of uncontrolled grazing (which can prevent the natural regeneration of young trees). The combined effect of grazing and fires can be a major cause of deforestation in dry areas. Deforestation implies the long-term (>10 years) or permanent loss of forest cover. Forest degradation is a process leading to a 'temporary or permanent deterioration in the density or structure of vegetation cover or its species composition'. It is a change in forest attributes that leads to a lower productive capacity caused by an increase in disturbances (FAO, 2007; 2016).

According to FGD and KI interview the major drivers of deforestation and forest degradation in Irba Girstu Watershed were forest clearance for smallholder agriculture; illegal wood extraction (firewood, charcoal and lumber); forest fires; poverty and heavy dependence on exploitation of natural resources; rapid population growth; unstable and inefficient tenure and property right arrangements; and limited institutional capacity to manage forests. Further excess removal of forests/vegetation is contributing to Watershed degradation which resulting in rain fall-fluctuations, long dray season, drought, and shortage of fodder and food insecurity. Since harvested trees are not replaced adequately by tree planting in the catchments, soils are exposed to high intensive rainfall. The major sources of energy for the rural households in the watershed include mainly firewood. Most households get firewood from open forest and scrublands around homesteads and along roads and footpaths. These all negatively affect the availability of water and fodder in terms of quantity and quality. Deforestation and forest degradation is one of the serious problems in the watershed. Therefore; it should be addressed in this watershed management plan.

4.1.7 Overgrazing

Livestock production has been an integral part of farming systems for hundreds of years in many regions of Africa, particularly in Ethiopia. Overgrazing" is the removal of tissue from a living plant, to the extent that the tissue removed exceeds the ability of the plant to replace it, within a growing season (Schwennesen, Undated). Overgrazing occurs when plants are exposed to intensive grazing for extended periods of time, or without sufficient recovery periods. It can be caused by either livestock in poorly managed agricultural applications. It can also be caused by immobile, travel restricted populations of native or non-native wild animals. It reduces the usefulness, productivity, and biodiversity of the land and is one cause of desertification and erosion.

4.1.8 Population Pressure

Population growth (2.8%) is one of the underlying causes for deforestation in highlands. Increasing population pressure leads to increased demand for farm land and forest resource for fuel and home construction. In the country, about 74% houses in rural area and 72% houses in urban area constructed using forest resource. The ever increasing population is a driving force for increased deforestation, surface run-off, non-point sources pollutions and loss of biodiversity and decline land productivity and water availability.

4.1.9 Poor Infrastructure

The most crucial factor for poor watershed management is the lack of infrastructure (road, agricultural inputs etc) and market to facilitate agricultural activities and create job opportunity for livelihood in rural areas. Although the present government is giving special attention to rural roads and link it to regional markets but will take time. At present poor facilities of farm produce movement to market places discouraging farmers from improved cultivation practices.

4.1.10 Poverty

Poverty and exploitation of natural resources are interdependent. On one hand the degraded resources (eroded and deforested lands and loss of biodiversity) has adversely impacted the agricultural production and made the farmers poverty ridden. On the other hand poverty is the cause for natural resource degradation because the poor people in rural areas rely more on natural resource for their survival and livelihoods.

4.1.11 Lack of Market Access

Lack of market access can limit the shift to new crops and livestock types. Farmers who cannot market their produce have no reason to produce more than they can consume themselves. If markets exist but the price is low, they will also have few incentives to boost production.

4.1.12 Lack of Awareness

The low level of awareness of the society about the linkage between watershed and economic development is coupled with poor participation of farmers in the planning and management activities of watersheds. Farmers independently cultivated on steep slopes with poor agronomic practices based on their traditional knowledge for their livelihood. Unawareness of government policies of soil and water conservation has immensely contributed for land degradation.

4.1.13 Lack of Technical Support and Monitoring SWC Works

The most critical factor leading to unfruitful results in watershed development was lack of technical support and monitoring works of soil and water conservations. According to field observation, FGD and KI reports indicated that, the works of watershed development only for satisfying the political ambitions. No one technically support real works on the ground and periodically monitoring against to planned works.

4.1.14 Lack of Inputs in Affordable Price

Even if farmers know about climate-smart techniques and want to use them, they may be hampered by a lack of suitable inputs. Conservation agriculture, for example, uses certain types of equipment that may not be easily available. Advantageous crop and livestock breeds may also be hard to obtain. Examples include seed and planting materials of cover crops and legumes; seedlings of suitable tree species; traditional or adapted breeds of livestock; and seed of crop varieties bred to tolerate salinity, flooding and drought.

4.1.15 Lack of Suitable Finance

Rural finance is an important tool for farmers, who can benefit from several financial service sources including savings, remittances, leasing and insurance. However, financial services are poorly developed especially in many rural areas. What is more, financial products are not tailored to the needs of farmers, and banks tend to see farmers as high-risk clients due to their high dependence on unpredictable factors, such as the changing climate, and limited assets. Conventional insurance products do not suit smallholders' needs because the cost of servicing them in remote areas could be very high, including to assess damages. Such services add to premium loading, making insurance packages unaffordable. Moreover, reinsurance is difficult, as international reinsurance companies demand long-term risk data that is not often available in most developing countries – nor in some parts of developed countries.

17. 5. LAND EVALUATION AND ADJUSTMENT

Land varies in its characteristics from place to place. This variation affects its use as for each type of land, there are uses that are more or less physically and economically appropriate as regards productivity and return on invested capital. Land evaluation is the process of evaluating the response of the land when it is used for specific purposes (FAO, 2007). This process allows rational land use planning to be undertaken through the identification, for each type of land, of uses that are adequate and environmentally and economically sustainable for the natural and human resources. In this manner, it can be an important tool for land use both for individual users, for groups or for society as a whole. It should be adequate for local conditions and should consider economic aspects involved in each type of use so that it is applicable in the majority of situations concerning the availability of natural resources. Therefore, variability of land resources and farming system would mean variable problems and constraints in spatial distributed within the watershed. Variations in soil type, depth, slope and the like factors have a strong influence on agricultural land use practices. It is therefore, necessary to classify similar areas within the watershed based up on physical land resources and socio-economic characteristics.

5.1 Land Capability Classification

Land capability classification is a technique to determine the most suitable land use for any area of land. It has a particular purpose of recording all agricultural uses and conservation measures which allow the most intensive agricultural use of the land without risk of soil erosion. There is no one land capability classification but many for in every country or geographical region there are different factors which should be allowed for soils, climate, social customs, land tenure, and economic conditions vary from place to place. All of these factors may affect the choice of the best land use. Since capability classification attempts to relate the use of land to the attendant risk of erosion, all the factors and characteristics which influence the risk of erosion must be assessed and considered (Taffa, 2011). It is therefore, necessary to classify similar areas within the watershed based up on physical land resources and socio-economic characteristics. One of the most widely used systems of land classification is that of the Soil Conservation Service (SCS) of the U.S. Department of Agriculture (USDA). It commonly referred as land capability classification.

5.1.1 Irba Girstu Watershed Land Capability Class

Land capability assessment utilized soil information obtained from field survey to classify the land based on capability concepts of maximum limitations. In this regard, land capability maps were prepared based on the capability assessment criteria and used to determine the conservation needs; understand the basic characteristics of the soils and climate used as a background document for the preparation of soil and water conservation plan in the study area. In general, the capability class maps produced for the study area indicated in Figure 12 and Table 11.

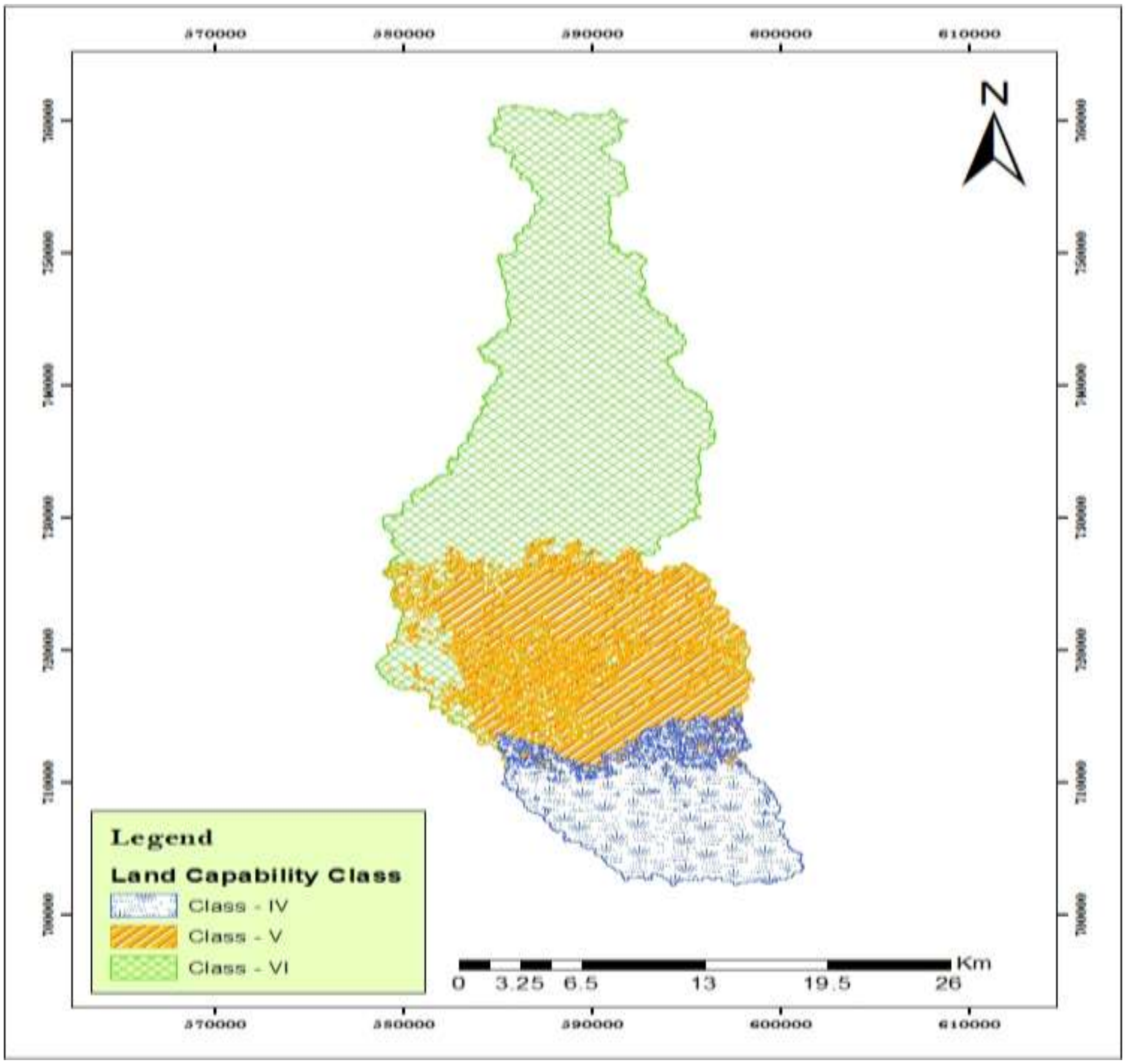

Figure 12: Land Capability Class Map

Table 11: Land Capability class and area proportional of the watershed

No	**Capability Class**	**Area (ha)**	**%**
1	Class - IV	11,868.14	17.36
2	Class - V	17,250.94	25.23
3	Class - VI	39,251.11	57.41
Total		**68,370.19**	**100.00**

5.1.1.1 Land Capability Class IV

This land unit class is high to moderately high levels of productivity under improved pasture species and crops, but there are very severe limitations on the choice of crops. In addition, very careful management is required. This class covers **11,868.14** hectares, which is **17.36%** of the land area of the watershed.

5.1.1.2 Land Capability Class V

This land is unsuitable for cropping, although some areas on easier slopes may be cultivated for pasture establishment or renewal and occasional fodder crops may be possible. The land may have slight to moderate limitations for pastoral use. The effects of limitations on the grazing potential may be reduced by applying appropriate soil conservation measures and land management practices. This class covers about **17,250.94** hectares, which is **25.23%** of the study area.

5.1.1.3 Land Capability Class VI

This land unit class may have either a single very severe limitation or a combination of several severe limitations. Have extreme limitations that restrict their use other than grazing, forestry and wildlife. These limitations make this class of land unsuitable to be cleared for grazing and steeper areas should be left under a vegetative cover, because of the potential erosion hazard and low productivity. Conservation measures including re-vegetation or retention of existing vegetation cover should be adopted. This land usually remains under native pasture or other natural vegetation cover. This class covers about **39,251.11**hectares, which is **57.41%** of the study area.

5.1.2 Land Use Adjustment

Land use changes are recommended based on land capability classification. Lands are classified as suitable for crop production, grazing and forestry activities based up on land capability classification. From the assessment those lands under class IV are assigned for cultivation and those under VII are assigned are suitable for afforestation.

5.1.3 Area Closure

Land capability classes also didn`t force the lands to be closed. However, degraded grazing and bush lands, and the gully banks need to be closed for rehabilitation purposes. Gullies should be temporary closed for at least for two years or so until the vegetation cover regenerate naturally.

18. 6. WATERSHED DEVELOPMENT PLAN

Watershed development interventions are key to improve the livelihood of people in the watershed at development through restored and enhanced land productivity, support rehabilitation of degraded land and development of natural resources, providing opportunities for income generating and contribute to small-scale infrastructure development. This will help to intensify the land productivity with no jeopardy on existing natural resources. As well watershed development interventions could save water reservoirs such as dams, irrigation schemes by reducing silt transporting runoff water. A multiple of development interventions are proposed for such cases, and recommendations are made based on the specific site conditions. The development interventions for the adjacent Schemes watersheds of Irba Girstu include: soil and water conservation, a forestation and forest management, crop production intensification and diversification; livestock development and management; income diversification; infrastructure development; alternative rural energy technology; and capacity building. These measures are discussed below:

6.1 Sustainable Watershed Development

The word "sustainability" is important in development assistance. It refers to the "ability" of something to be "sustained" (carried on) after outside support is withdrawn. For the community that builds a water supply, the repairing, cleaning and using the pump after it is constructed, is the desire. For an external donor, it is the continuation of the project or its outputs after the donor withdraws. For the mobilizer, it is the continuation of the community strengthening social process after he/she moves on. For environmentalists and ecologists, sustainability requires that an activity can be sustained (e.g. biologically) by the physical environment, that non-renewable resources are not used up. Sustainable Watershed Development safeguards natural resources and associated ecosystems for future generations**.** It is an integrated and coordinated approach to development planning is needed, and such planning should be capable of reconciling the needs of development and environment, and maximizing social, economic and environmental benefits (FAO, 2017).

Watershed development sustainability basically depends on successful management of resources satisfying human needs while maintaining and/or enhancing the quality of the environment and conserving natural resources. Sustainability on the other hand cannot be defined only from an ecological perspective point of view. Economical, social, political, cultural and institutional aspects should also be included. This implies that sustainable watershed development should be looked into from different scenarios or point of views as stated below:

Ecologically sound: which means that the quality of natural resources is maintained and the vitality of the entire agro-ecosystem is enhanced. The upper limit of the productivity of the ecosystem (carrying capacity) should not be exceeded to avoid degradation.

Economically viable: meaning that households can produce enough for self-sufficiency, generate income and gain sufficient returns to warrant labor and costs involved.

Socially just: which means that resources and power are distributed in such a way that the basic needs of all members of society are met and their rights to land, adequate capital, and technical assistance and market opportunities are assured. That all people have equal opportunities to participate in decision-making. Special attention should be given to involve landless and marginalized people specially women in decision-making and natural resources management.

Many conventional resource management programs failed to produce substantial improvement in land management or to satisfy the priority objectives of resource users. Understanding problems associated with the past and existing approaches, we need to strictly go to an approach of planning which insures sustainable management of resources and better satisfaction of resource users. The failure in the past is partly associated with approaches employed. Widely used development approaches were either aimed to address symptoms of the problems, sectoral by nature, top-down or a combination of these. Major failures with the past approaches may include:

- Lack of clear and consistent policy for sustainable development
- Failure to address the legitimate goals of target communities and to involve them in planning process,
- Failure to address all issues relevant to the problem,
- Failure to integrate all the necessary disciplines and activities (physical, social and economic issues),
- Undue emphasis on technical solutions,
- Institutional problems,
- Inadequate or ineffective regulations of land use,
- Lack of well integrated incentives, or inappropriate incentives,
- Lack of funds, and

- Lack of information, tools or training to make informed decisions.

The solutions for these problems can be listed as follows

- Improvement and strengthening of planning, management, monitoring and evaluation systems
- Strengthening of institutions and coordinating mechanisms
- Creation of mechanisms to facilitate the active involvement and participation of communities and people at local level

Development to be sustainable, strengthening the participatory rural organizations is cardinal which otherwise long-term oriented activities will be short-lived and dried-up as external support phases out from the areas.

By examining all uses of land in an integrated manner, it makes it possible to minimize conflicts, to make the most efficient trade-offs and to link social and economic development with environmental protection and enhancement, thus helping to achieve the objectives of sustainable development. The essence of the integrated approach finds expression in the coordination of the sectoral planning and management activities concerned with the various aspects of watershed development. Integrated consideration facilitates appropriate choices and trade-offs, thus maximizing sustainable development.

6.2 Rationales of Watershed Approach

Integrated watershed Management (IWM) is "the fitting together" of all the elements needed to appropriately manage a watershed. Some of these include conservation farming, forest management; pasture improvement, water resource development. These days, IWM plans also include interventions that address the livelihood constraints of target communities including improvement of social services (e.g. schools, health institutions and infrastructures). It is not only concerned with agricultural lands at present under cultivation, but also with forest, rangelands, degraded/abandoned areas and other soico-economic problems of the area.

Moreover, what happens upstream affects areas downstream. For instance, deforestation and erosion in the hills can silt rivers and cause flooding downstream. And the amount of water percolating into the soil high in a valley determines the flow of springs and rivers lower down. That makes it useful to study watersheds as whole and implement conservation practices over a whole area rather than piecemeal.

The major advantages that we obtain from using the watershed approach include the following:

- ❖ Orderly and systematic resource use and management i.e. it avoids scattered works and watershed follows a certain normal procedure
- ❖ Concentrations of efforts: This improves accountability and follow-ups as it makes supervision easy.
- ❖ Optimal use of resources: This is easily achieved through concentration of resources coupled with priority sites and activities being undertaken.

Enhance community participation in resource management. This is achieved mainly through participatory planning and implementation. Moreover it gives more chance to establish and strengthen sustainable village institutions such as

- ✓ Users group
- ✓ Self help group
- ✓ Women saving and credit group
- ✓ Village watershed committee

Watershed management projects involve actions that are aimed at "**production with protection**" e.g., protecting the natural resource on a sustainable basis, while producing goods and services needed by people. The basic idea of a project involves:

1. A definable set of inputs such as land, materials, and people.
2. A definable set of outputs.
3. A definable set of activities or processes, which transform the inputs in to the out puts.

The development of a watershed management plan needs to integrate the biophysical, social, and economic factors to insure that the project will be:

1. **Technically sound** i.e., the practices that are being recommended will achieve the physical and biological out comes that are desired,
2. **Accepted socially** i.e, watershed inhabitants and agencies involved see the projects as desirable
3. **Economically feasible**, both from the stand point of society as a whole, and from the stand point of individuals and agencies involved, and
4. **Environmentally sound**, i.e. there are no unwanted impacts on the environment, such as reduction in biological diversity, destruction of downstream aquatic systems and other changes that may come about indirectly because of project implementation.

At the project level, planners and implementers need to consider at least three key elements to avoid non-sustainable development. These are:

Continuity refers to sustaining the positive project ideas and technologies after project termination. Causes of non-sustainability in this case might include inadequate local participation, too much imported technology, materials, and personnel and draw down of local resources or productive capacity.

Diffusion refers to the spread of positive project ideas and technologies outside the project boundaries.

Externalities refer to the positive and negative effects of actions in a given location (**spatial Externalities**) and positive and negative effects of actions at a given time on life in some future period of time (**temporal Externalities**).

In watershed project, spatial and temporal Externalities relate to the upstream-downstream relationships what is done with the land and water upstream can affect those who live down stream. What happens upstream affects areas downstream. For instance, deforestation and erosion in the hills can silt rivers and cause flooding downstream. And the amount of water percolating into the soil high in a valley determines the flow of springs and rivers lower down. That makes it useful to study watersheds as whole and implement conservation practices over the whole area rather than piecemeal.

6.3 Some Basic Planning Principles

6.3.1 Set Appropriate Goals and Targets to Meet Objectives

A project goal such as “helping people to achieve a better life “however admirable, is not explicit. How does one decide when such a goal has been achieved? A more useful operational goal might be, “increasing cash incomes of project participants by ten percent within two years.

6.3.2 Use an Iterative Process to Identify and Assess Alternatives

The types of alternative to be considered include: which type of erosion control measures to consider, what species to plant, what structures are appropriate, etc.

6.3.3 ALWAYS APPLY THE WITH AND WITHOUT PRINCIPLE

One of the basic principles of planning is to develop and compare alternative scenarios of what is likely to happen with the project and without the project.

6.4 Problems of Uncertainties

All planning must recognize and cope with the problems of uncertainty. A number of uncertainties may be faced in the planning process.

a. **Climatic uncertainties**: Rainfall patterns, intensity and duration cannot be exactly be predicated. One should not develop watershed management plans based on average conditions.
b. **Technical uncertainties**: Reliable information about the effect of certain interventions may not be available for the different situations at present.
c. **Socio-economic uncertainties:** If there are uncertainties regarding the technical relationships used in planning, there is even more uncertainty regarding Socio economic variables. Data on the status of human welfare needed for planning, such as income, wealth, and levels of education, can be difficult to obtain for specific local areas. Estimates of the status of future human welfare are far more uncertain.
d. **Political uncertainties**: Creates economic and social instabilities that create uncertainties regarding the future direction of natural resource and other policies. They also create uncertainties regarding future law and regulations relating to the land tenure and other resource right of local people

All these and other uncertainties should be recognized and dealt with in the planning process.

6.4.1 Strategies for Coping with Uncertainties

The problem for planning is that change brings unexpected, unforeseeable results. Ecosystems are not static, but are continually changing. Although at times this change may be slow and gradual, at other times the change may be dramatic and swift (www.fao.org/3/W3641E/W3641E10.htm). Lundgren (1983) has suggested the following strategies to cope with such uncertainties

- ✓ **Increase understanding**

It deals with an unknown and uncertainly future is to increase our understanding of the present world strategies for doing this include:

- ✓ Postpone the decision to get more information

- ✓ Conduct sensitivity analysis; by systematically exploring how changes in assumptions affect results, we can better appreciate how uncertainty affects our results. Critical points that are sensitive to our assumptions and estimates should be identified.
- ✓ Imaging alternative futures.
- ✓ Increase flexibility[2]

6.5 Soil and Water Conservation Development Plan

For sound watershed management different interventions were proposed that will solve the stated problems when it is implemented properly. The development plan was designed by considering social, economical, technical and ecological aspects of the area. Based on this, the watershed management plan covers physical, bio-physical and biological conservation measures.

6.5.1 Physical Soil and Water Conservation Measures

Physical SWC measures are those soil and water conservation measures, which lead to change in land surface arrangement and profile. They are effective for retarding runoff velocity, and consequently store sediment that is carried by runoff and store or safely dispose excess runoff water. Various physical measures can be applied on different land uses particularly on cultivated and grazing lands. The following measures are proposed for the project area based on the Land Class Unit identified for different areas of cultivated lands. Physical measures are applicable in a broad range of agro-ecological zones and land uses. They should be integrated with:

- ✓ Bund stabilization using grasses, legume shrubs, trees, cash crops.
- ✓ Compost making.
- ✓ Control grazing-avoid animals to graze between bunds.

6.5.1.1 Soil Bunds

Soil bunds are earth banks thrown across the slope to act as a barrier to runoff, to form a water storage area on their upslope side and break up a slope into segments shorter in length than is required to generate overland flow. They are suitable on slopes between 3 to 15 percent on cultivated lands. Soil bunds are graded type for removing excess rainfall from the fields at safe

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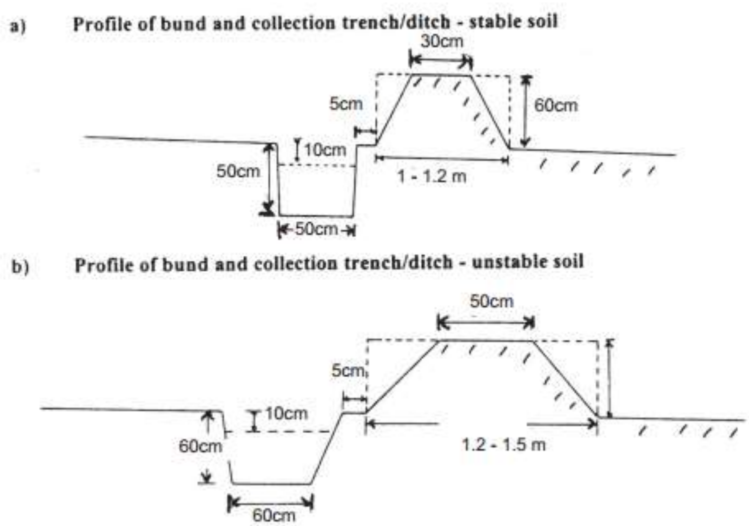
[2] *Increase flexibility: I*s way of coping with uncertainty is to increase management and organizational flexibility, so that it is easier to take advantage of unforeseen opportunities that arise, or respond quickly to unexpected situations. Strategies related to increased flexibility include: *Incrementalism and monitoring, Contingency planning, Diversification and Planned obsolescence.*

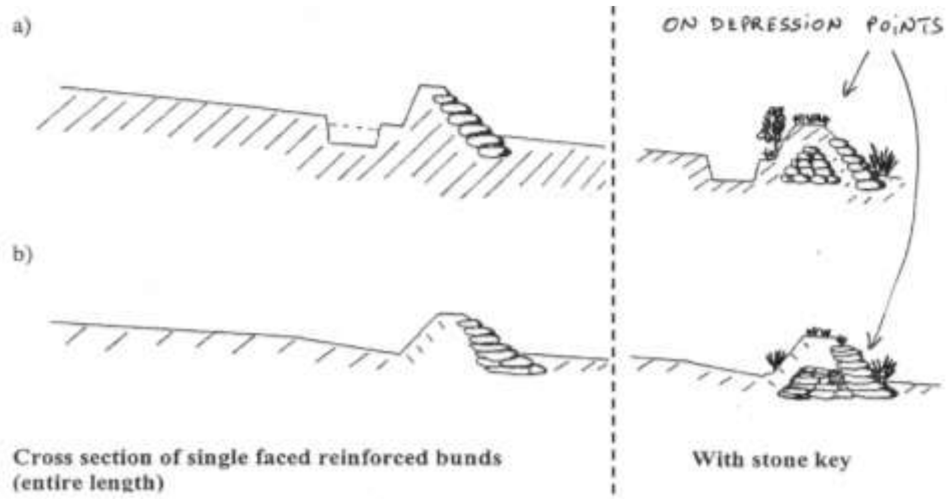
velocity. The project area receives medium rainfall and characterized by good vegetal cover, thus graded bunds at 1:250 is recommended. It is proposed to treat **523.57** ha with these measures, which need to be spaced at 15 to 20m and vertical interval being between 1 and 2m, depending on the actual field condition. Tied ridges at every 10m along the bunds are compulsory. The maximum length for graded bund should not exceed 500m in order to avoid risks of breakage and overtopping. The bunds could be stone-faced in areas with high stoniness area. Planting of grasses and other multi-purpose agro-forestry species should be integrated with such measures.



6.5.1.2 Stone Bund

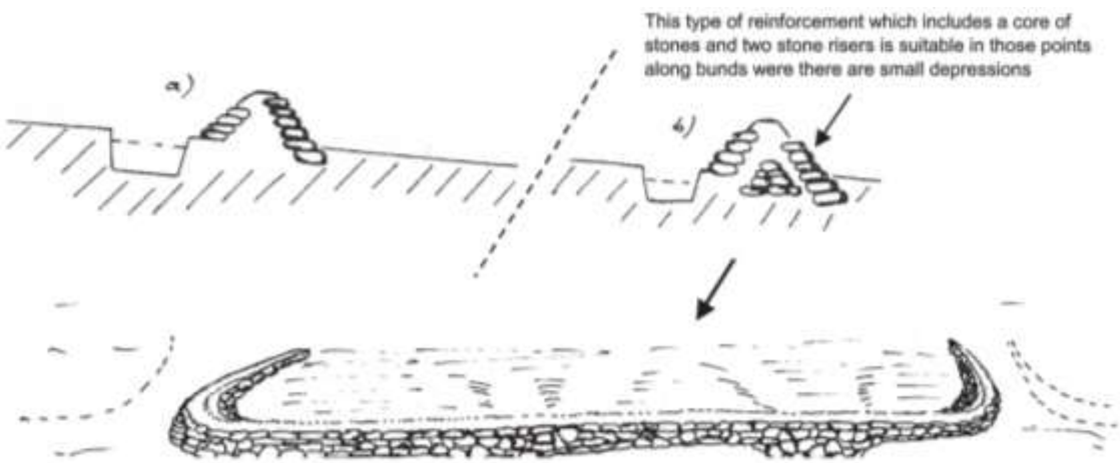
A stone bund is an embankment made of stone constructed along the contours (points of the same elevation) across sloping lands, without a collection channel or basin at its upper side. Soil, which is eroded between two bands, is deposited behind the bund. Stone bunds are either impermeable structure if their upstream side is sealed with soil or semi permeable if not. Whenever the bund has trapped enough sediment, the bund should be raised. In this way, a bench terrace will develop in the course of years. The main function of stone bund is to reduce the velocity of runoff and hence reduces the soil erosion process.

The stone bunds should have a bottom width of 1-1.5meter, a top width of 30-50cm and a height of 50-75cm. Care should be taken in the selection of stones, their placing and provision of a stable: foundation. A layer of soil should be placed on the top and upper side of the bund, which will reduce the flow of runoff through the bund and encourage the growth of grass. In areas where stones are, available stone bund is a good protection material. It is practiced in limited intense on watershed Mountains and hills and when combined with soil and grass strips are very successful.



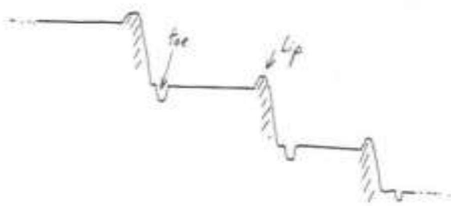
6.5.1.3 Stone Faced Soil Bunds

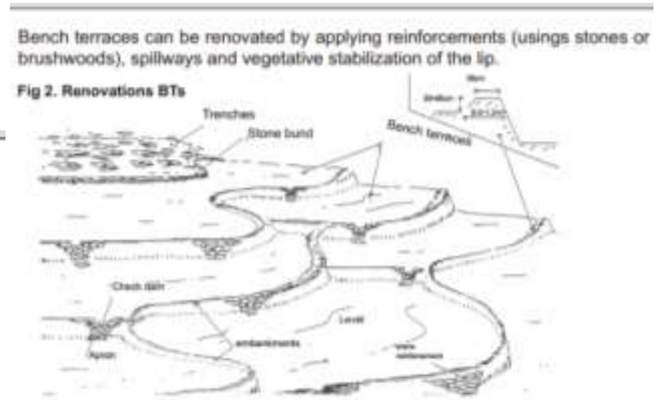
It is more suitable in drier areas and terrains with slight lateral slopes to strengthen soil bunds. The stone-faced preferred on lower side of bunds as more stable than double faced stone-faced. Stone-faced bunds largely applied both in traditional and new introduced systems. It is applicable in a broad range of land uses, particularly in cultivated lands with some level of stoniness.



6.5.1.4 Bench Terrace

Bench terrace is applied in areas of steep slope in which the terrace converts a steep slope into a series of steps, with nearly horizontal benches to reduce velocity of runoff, reduce soil erosion and decline in crop yields. It is applied generally on cultivated lands and unused steep hill sides of slopes of average 12 to 58% considering the various land use types (cereal, fruits, etc.).





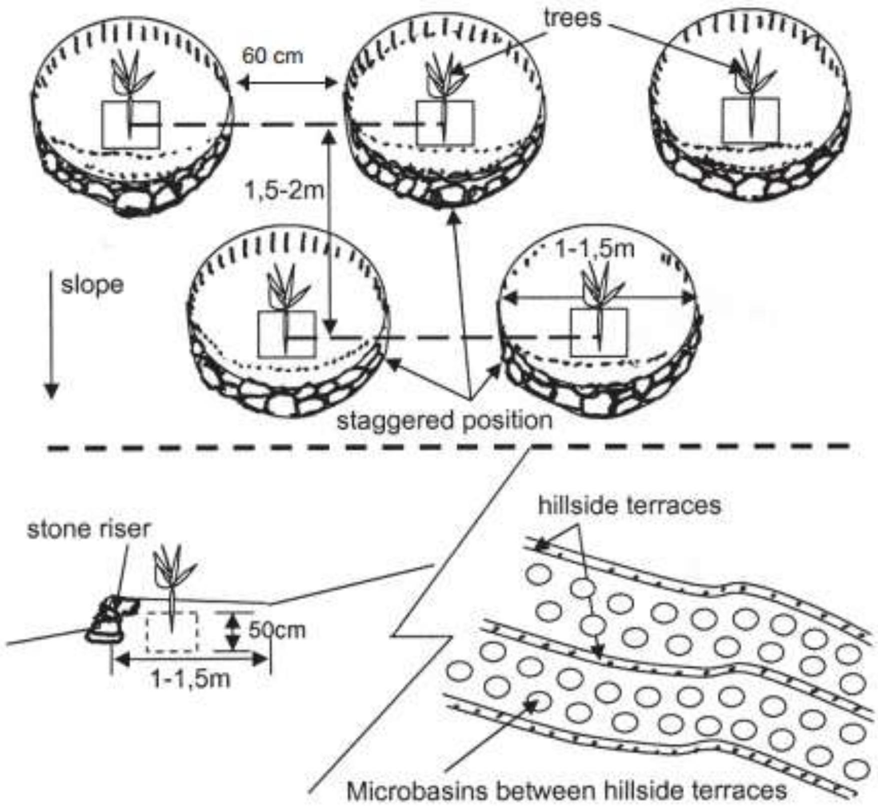
6.5.2 Agro-Forestry, Forage Development and Forestry

Agroforestry defined as a land-use system involving integrated production of trees and crops and/or livestock, characterized by the environment, plant species and their arrangement, management, and socio-economic functions. It includes homegardens, perennial crop based systems, farm woodlots, alley cropping, improved fallows, and rotational tree fallows (Atangana *et al.*, 2014). It is a collective name for land use systems and technologies, where woody perennials are deliberately grown on the same land management units as agricultural crops and/or animals, either in some form of spatial arrangement or on a temporal sequence (Chander *et al.*, 2014). Based on FAO (2017) agroforestry can provide many ecosystem services. It is a suitable tool for landscape restoration because it can enhance physical, chemical and biological soil characteristics, thereby increasing soil fertility, controlling erosion and improving water availability. Agroforestry systems that provide permanent tree cover which valuable for forest and landscape restoration options, especially in initiatives in which neither natural forest restoration nor full sun crops are viable. Agroforestry can enhance livelihoods in rural communities by providing a variety of food, fodder and tree products, which increase food and nutrition security, generate income and alleviate poverty. The restoration of degraded landscapes using agroforestry can increase the resilience of communities to shocks, including drought and food shortages, and help mitigate climate change.

The principle by which agro-forestry controls erosion is the same as biological measures except that the system allows the combined use of land for trees and crops or trees and livestock or both together on the same unit of land. Objectively, agro-forestry in watershed management program helps in obtaining maximum biomass production, conserving production base, improving soil conditions, promoting agro-based cottage industries and moderation of microclimate. The land-use system in the study area has all features of agro-forestry systems. Thus, interventions of agro-forestry system should focus on maintaining the existing situations and widen the scope by involving individual farmers on their own plots of land and around their home. The followings are some of the systems recommended in the project area.

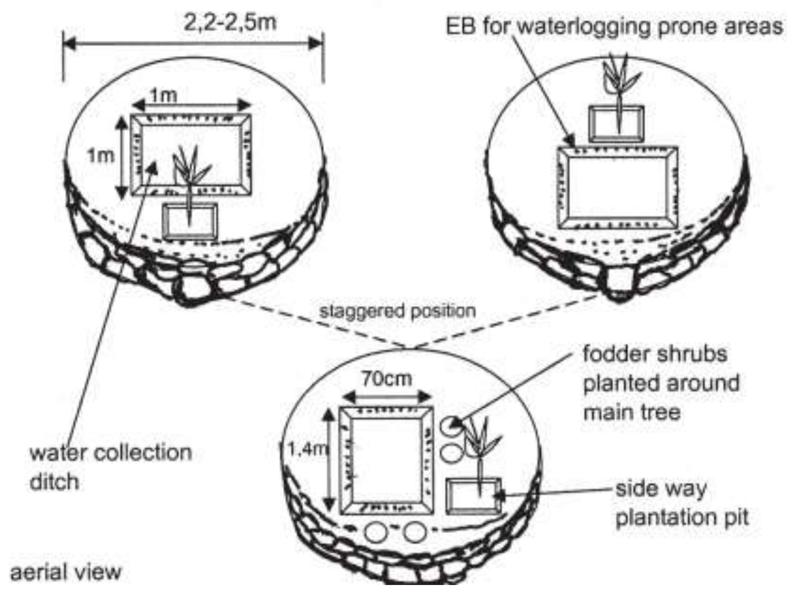
6.5.2.1 Micro Basins (MB)

It is commonly practiced in Ethiopia along farm boundaries using different local species. Although rarely used for communal and degraded areas, it can expand in such lands, as land use certification will encourage farmers to protect and develop such areas. It can be used also to fence group of cultivated plots. It is applicable in steep and degraded hillsides (max slope 50%) and for community closures. MBs need to be often combined with other measures such as hillside terraces, stone bunds, trenches, etc. can also be applied inside large gully areas for tree planting. MBs are small circular & stone faced (occasionally sodded) structures for tree planting which are suitable for medium to slightly low rainfall and stony areas with shallow soils. Based upon experience they are not very effective in low rainfall areas (where trenches, eyebrows, etc. are preferred).



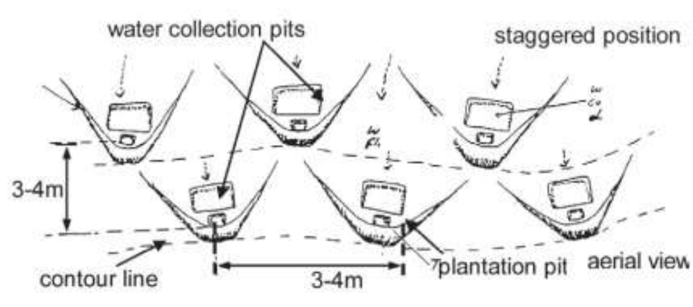
6.5.2.2 Eyebrow Basins (EB)

Eyebrow Basins is suitable in degraded areas, mostly in semi-arid and medium rainfall areas with shallow soils. It is commonly practiced in dry and moist weyna dega areas for the growth of trees and support to plantations in area closure. Applicable in steep and degraded hillsides for maximum slope of 100% if community closures, otherwise recommended for slopes above 50% for spot planting. Also it can be combined with other measures such as hillside terraces, stone bunds, and trenches based upon soil, slope and stoniness. It can also be applied inside large gully areas for tree planting. Good potential to improve degraded and steep hillsides - mostly for area closure and multipurpose tree and fodder tree plantations. It can also be planted with a mix of trees, shrubs and cash crops. Together with other measures EBs can significantly improve watershed rehabilitation, biomass production and recharging of water tables.



6.5.2.3 Herring Bones (HBS)

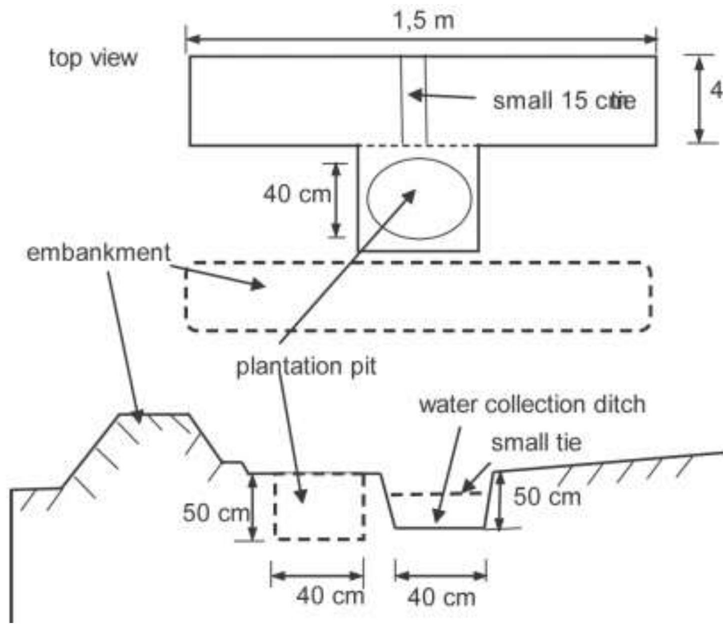
Herrin Bones are applicable in gentle slopes (<5%) on small plateaus, on degraded lands (widespread gullies) with portions of gentle slopes (lower sections of community closures, etc.) and homesteads. It can be often combined or mixed with other measures such as trenches soil and stone bunds, based upon soil, slopes and stoniness. HBs are small trapezoidal structures (called also A structures) for tree and other species planting. HBs are suitable for both dry and medium rainfall areas, and medium soil depth. Based upon experience HBs are most effective in medium/low rainfall areas (500-900 mm). It can be constructed only on slopes < 5% and soils > 50 cm depth.



6.5.2.4 Micro-Trenches (MTRS)

Micro-trench is suitable mostly in semi-arid and medium rainfall areas (600-900 mm). Introduced only recently in Ethiopia, MTRs has the potential to expand in many areas, including pastoral areas for improving grazing reserves. MTRs could be a better option than micro basins as they can collect and conserve more moisture. MTRs are more suitable than larger trenches in areas where rainfall is above 600-700 mm and for species that can be planted in denser spacing or higher density per hectare (particularly fodder shrubs).

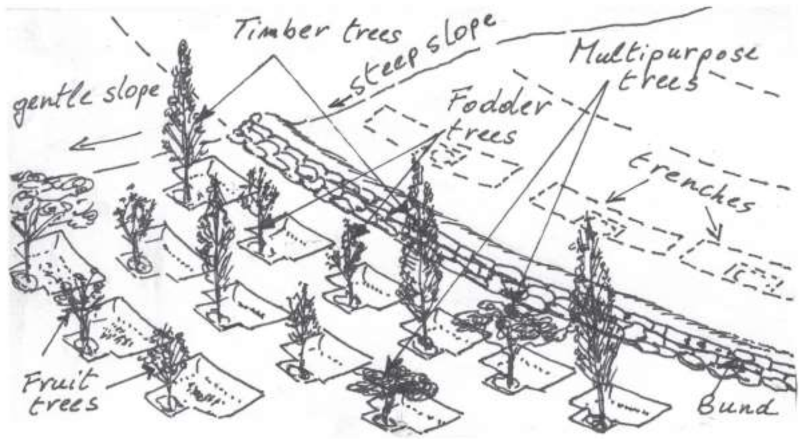
Applicable in a broad range of soils and slopes (<30%), on degraded lands (widespread gullies, etc), hillsides, and within homesteads for planting trees and fodder species along fences and backyards. It is often combined with other measures such as larger trenches, soil and stone bunds, and hillside terraces based upon soil and slope.



6.5.2.5 Improved Pits (IPS)

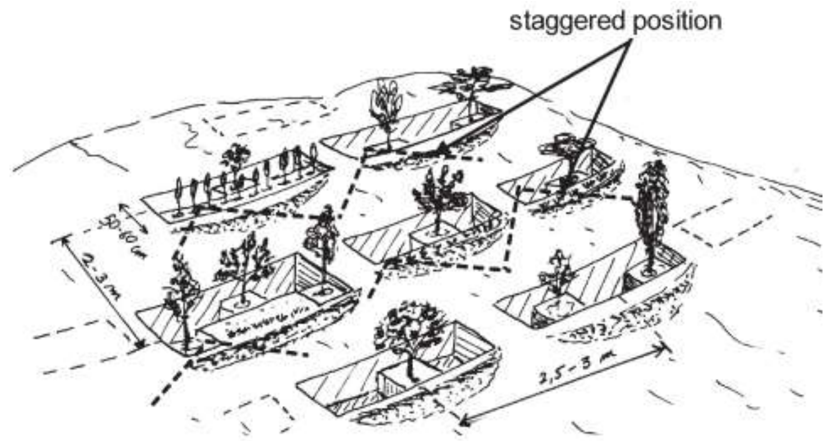
Improved Pits are applicable on slopes up to 8% maximum gradient and soils at least 50 cm depth on degraded lands with widespread gullies, hillsides, and within homesteads for planting trees and fodder species along fences and backyards.

It can be combined or mixed with other measures such as trenches, soil and stone bunds, hillside terraces, etc, based upon soil and slope. IPs are square shaped water collection pits con structured along the contours with a plantation pit in front of the main water storage pit - main purpose similar as micro-trenches. IP support the growth of trees and fodder shrubs, and can be used for cash crops like coffee. They are effective in medium and low-medium rainfall areas (above 600-700 mm). IPs is a better option than normal pitting in degraded and moisture deficit areas. IPs is suitable for species that can be planted in denser spacing or higher density per hectare.



6.5.2.6 Water Collection Trenches

Water collection trenches are applicable in steep and degraded hillsides (max slope 100%) and for community closures. It can be combined with other measures such as hillside terraces, stone bunds, and trenches based upon soil, slope and stoniness. Also, it can be applied inside large gully areas for tree planting. It is highly suitable in many areas in the highlands to improve closures and plantations. Also relevant in pastoral areas to improve grazing reserves, aerial pasture, etc. Can easily be understood or adopted after demonstration. Trenches are large and deep pits constructed along the contours with the main purpose of collecting and storing rainfall water to support the growth of trees, shrubs, cash crops and grass or various combinations of those species in moisture stressed areas (350-900 mm rainfall). Trenches can have flexible design, to accommodate the requirements of different species. Therefore they can suit what the farmer want to grow. Trenches collect and store considerable amount of runoff water, thus vegetation grows faster and vigorous. Trenches protect cultivated fields located downstream from flood and erosion. Part of the water captured by the trenches reaches the underground aquifer. Therefore, water tables are recharged and supply springs and wells with good quality water and for a long period of time.



6.5.3 Integrated Soil Fertility Management (ISFM) and Biological Soil Conservation

Integrated Soil fertility management (ISFM) and biological soil conservation measures play a key role in supplementing and improving the performance of physical structures. They play an essential role in natural resources conservation directly and indirectly by influencing both the soil characteristics and the vegetative cover factors and enhances productivity per unit area (MoARD, 2005).

ISFM is a holistic approach in soil fertility management that embraces the full range of driving factors and consequences of soil degradation – biological, chemical, physical, social, economic, health, nutrition and political (Kihara *et al*., 2012). It is the best use of inherent soil nutrient stocks, locally available soil amendments i.e. crop residues, compost, animal manure, green manure and inorganic fertilizers to increase productivity while maintaining or enhancing the agricultural resource base (IFDC, 2003; TSBF, 2003). These practices necessarily include appropriate fertilizer and organic input management in combination with the utilization of improved germplasm. Improving agronomic efficiency entails more intensive farmer management in areas such as maintaining mineral nutrient balance, correcting soil acidity, and making effective use of limited organic resources (TSBF-CIAT, 2009). Further Integrated Soil Fertility Management is a set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs, and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at optimizing agronomic use efficiency of the applied nutrients and improving crop productivity (Thomas, 2012).

Soil erosion is mainly aggravated by poor cultural practices like overgrazing, over-cultivation, deforestation, cultivating along the slopes, continuous depletion of soil organic matter and soil organic residues or vegetation cover from the ground. Replacement of such management operations by sound land, crops and livestock management principles warrants conservation of resource base on sustainable basis. The first step in water erosion control is the control of splash (detachment of soil particles) resulting from the impact of raindrops followed by the conservation of transported soils through runoff water. Agronomic practices for soil conservation help in reducing the impact of raindrops through interception and thus reduce splash erosion. These practices also help in increasing infiltration rates and thereby reduce run-off and overland flow. Reduction in run-off and soil losses is achieved through land management practices, choice of crop, crop management practices and associated agronomic practices. Therefore, the best land management practices for ensuring proper watershed management may be defined as the most intensive and productive use of which the land is capable without causing degradation. If an appropriate agronomic conservation practice are adopt in the degraded watershed area, it can reduce soil loss too much less than its pre-treatment value. Agronomic measures also play vital role in increasing the soil resistance to erosion. This calls for increasing stability of soil aggregates through soil organic matter management. Organic matter makes the soil more elastic to absorb kinetic energy of raindrops without being broken. In addition, the soil aggregates that are rich in organic matter have more pores that enhance infiltration. Thus, agronomic/biological soil and water conservation measures utilize the role of land management practices and vegetation in helping to minimize soil erosion. On the other hand, the effectiveness of physical measures will depend on the integration of these measures as the ultimate goal of any soil and water conservation intervention is improvement of surface cover. Therefore, recommendation of agronomic measures is justifiable under the current conditions of the watershed and those measures identified are incognizance with the existing farming systems and potentials.

6.5.3.1 Mixed/Intercropping

It is a practice of growing more than one crop in the same field simultaneously. In this practice there is one main crop and one or two subsidiary crops. Generally, legume is used as one of the crops. This practice gives better cover on the land, good protection to soil from beating action of rain and protection from soil erosion, by binding the soil particles. Growing soybean, groundnut, cowpea etc. with maize etc. is a common example of this practice (Sharma and Singh, 2013).

Intercropping of food legumes with maize/sorghum is extensively practiced in the most densely populated areas (MoARD, 2005).

6.5.3.2 Crop Rotation

Crop rotation is the practice of growing a series of dissimilar types of crops in the same area in sequential seasons for various benefits such as to avoid the build-up of pathogens and pests that often occurs when one species is continuously cropped. Crop rotation also seeks to balance the fertility demands of various crops to avoid excessive depletion of soil nutrients. A traditional component of crop rotation is the replenishment of nitrogen through the use of green manure in sequence with cereals and other crops. Crop rotation can also improve soil structure and fertility by alternating deep-rooted and shallow-rooted plants (REMA, 2010). The improvement of plant cover and soil structure through sound crop rotations substantially influences the effect of runoff and levels of soil loss (MoARD, 2005).

6.5.3.3 Strip Cropping

Strip cropping is a cropping practice where strips of two or more crops are alternately established on the contour or, it is a system of establishing more than one crop in alternate strips following a contour pattern for the purpose of erosion control, crop diversification, and decrease the risks associated to the use of single crops only. This cropping system is designed as a defense mechanism against soil erosion in areas where the cropping system is dominated by row/sparsely growing crops that exposes the ground to erosive forces. For instance, crops like sorghum and maize are susceptible to erosion and need to be grown alternately with soil conserving crops (MoARD, 2005).

6.5.3.4 Mulching and Crop Residues Management

Mulch is any material, organic or mineral in nature, such as saw dust, straw, paddy husk groundnut shell, crop residues, leaves, loose soil etc. which is spread on the surface of the soil in order to protect the soil from the impact of rain drops, avoid surface crusting, reduce evaporation and thereby conserve soil moisture. Mulch also serves to moderate surface soil temperature. Mulch farming is a system of farming in which organic residues or other materials are neither ploughed into the soil nor mixed with it, but are left on the surface to serve as mulch. Mulch farming is not only useful for reducing soil and water loss but is also useful for maintaining high soil moisture in the field. Thus, mulching can be used in higher rainfall period/region for decreasing soil and water loss and in low rainfall period/region for increasing soil moisture. The natural sources of mulch are agricultural byproducts, for instance, straw, stubble, corn cobs, manures, wood chips. In agricultural practices it is best to "grow the mulch in place", that is to use residues in the same field where they grew earlier (Sharma and Singh, 2013).

Based on MoARD (2005) mulching/crop residue management is suitable mostly on plots around homesteads and with good soils. In open cultivated fields vertical mulching is preferred as it does not require many residues. Mulching is strongly recommended for tree planting using trenches and similar structures. This technology is not suitable in areas where both excess dryness or cold slow down the breakdown of residues. In dry areas crop residues can be easily decomposed by termites. In this case planted crops should be termite resistant during growth period. For further more mulching and Crop residue management have:

- ✓ Potentials for increasing moisture availability and infiltration are high. Mulching is an excellent fertility improvement measure, especially when combined with moisture conservation measures and compost applications.
- ✓ Mulching of plantation structures prior and/or after planting of trees/shrubs increases the growth of plants and induce high water conservation within the soil profile. Mulched closures become highly productive "vegetative sponges" with beneficial effects in water tables recharge and runoff control.
- ✓ Mulching is the covering of the soil with crop residues such as straws, maize/sorghum stalks or standing stubble. The cover protects the soil from raindrops, drastically reduces splash erosion and velocity of runoff. It then minimizes erosion, increases soil infiltration and permeability, prevents the formation of hard crusts and contribute to improve fertility.
- ✓ The second major advantage of mulching/crop residue maintenance is its potential for sustaining productivity.
- ✓ Mulching, in addition to its positive effects on soil structure also helps in reducing evaporation and maintaining soil moisture. The improved soil structure also will have an effect on moisture retention and consequently higher water budgets for the growing crop.

6.5.3.5 Integration Of Food/Feed Legumes Into Cereal Cropping Systems

Integration of food/feed legumes into the cereal cropping systems is defined as the growing of more than one crop in the same piece of land during one calendar year. Integration of cropping optimizes productivity by producing higher combined yields from the crops and greater economic returns from a given area of land than the same crop grown in monoculture. Better distribution pattern of labour demand. For example, land preparation is done only once for all crops and therefore the labour situation is less constrained. Control pests, diseases and weeds in the absence of biocides[3] and better to control of soil erosion.

a. Sequential cropping using food crops[4]

b. Sequential cropping using forage crops followed by food crops[5]

c. Intercropping/Mixed cropping[6]

6.5.3.6 Live Checkdams

Live check-dams are established by planting/seeding or plugging of cuttings in gully bottoms to replace or reinforce physical check-dams. It is a technique where fresh stems of plants (e.g. elephant grass, banana grass etc.) are bound together, horizontally planted and covered by soil. The use of other organic matter (e.g. straw, tree branches) may be used to economize on fresh planting material. The main objective of the establishment of live check-dams is to reduce the cost of establishing physical check-dams. Live check-dams can be applied by individual farmers and does not need the organization of a large group of people to undertake physical structures. Fresh vegetative material is placed in between two rows of reinforcing materials such as poplars and willows inserted in the soil as described above. Apply after the start of the rainy season.

6.5.4 Gully Erosion and Its Control Measures

Gully erosion is the most destructive and notorious process that contributes lion`s share to soil loss. Prevention of a gully formation is easier and more economical than treatment of gully. To

[3] Biocides: Chemical that kills microorganisms: a chemical designed to kill organisms, especially microorganisms

[4] Sequential cropping using food crops: Possible in areas where conditions for plant growth exist beyond the duration of one early maturing crop. Two short duration food crops can be fitted sequentially within a growing season.

[5] Sequential cropping using forage crops followed by food crops: Short duration forage and food crop can be fitted sequentially within the same year. Fast growing forage can be planted and harvested early to derive good quality feed.

[6] Intercropping/Mixed cropping: Intercropping is when two or more crops are grown in mixture as companion crops, in the same area of land at the same time.

prevent gully formation, their causes have to be investigated and those possible causes should be avoided. In most of the cases, the cost of restoring gully is by far greater than its agricultural value. But its control may be necessary because of its effect on dams, roads, irrigation works, fences, buildings, etc. in gully erosion control measure, three principles are followed (Taffa, 2011):

- ✓ Prevention of gully
- ✓ Shaping and filling of gully; and
- ✓ Treatment of gully

Small gullies can be shaped and filled with stones. Larger gullies are to be treated using different control measures. Treatment of a gully starts from the top of its watershed and proceeds downward up to the gully proper. Treatment in the watershed includes contour bunding, terracing, trenching, reafforestation and grazing land improvement. A diversion ditch should be constructed about 30 meters above the head of a gully to divert water from the gully head. Care should be taken in constructing and designing a diversion ditch because another gully may be created.

6.5.4.1 Stone Check Dams

It is suitable all over the country where stones can be easily collected. It commonly used to check gullies on highly eroded grazing and cultivated lands and hillsides. It is recommended in highly eroded gully areas in all land uses. It is not suitable for large gullies without catchment treatment and protection. A stone checkdam is a structure across the bottom of a gully or a small stream, which reduces the velocity of runoff and prevents the deepening and widening of the gully. Sediments accumulated behind a checkdam could be planted with crops or trees/shrubs grass and thus provide additional income to the farmer. Reduced erosion and accumulated soil sediments used for re-vegetation. Gullies could be reclaimed for production of trees (including fruits) and crops. Gullies control run-off and conserve moisture in the soil that give rise for springs at downstream sites.

6.5.4.2 Brushwood Check Dams (BW)

Brushwood Checkdams (BWs) are commonly used in parts of Ethiopia to stabilize small gullies. Traditional use of vegetative checks is common also in cultivated fields cut by small gullies because of strong showers. A technique can be easily adapted to many local conditions and integrated with others. In all land uses, it is affected by small gullies or as additional support to stone checkdams. It is suitable from dry-weyna dega to dega zones. In drier places, it needs to be combined with stone check dams. It is also recommended along farm boundaries affected by small gully. Brushwood checks can also be adapted to stabilize depression points along bunds. It can also reinforce bench terraces and SS bunds, roadsides affected by gully. Brushwood checkdams are vegetative measures constructed with vegetative materials, branches, poles/posts and twigs. Plant species which can easily grow vegetatively through shoot cuttings are ideal for this purpose. The objective of BWs is to retain sediments and slowdown runoff, and enhance the revegetation of gully areas. They are constructed either in single or double row. BWs are also ideal to stabilize conservation structures bunds, SS bunds, check dams, bench terraces, road sides, etc.

6.5.4.3 Gully Reshaping, Filling and Re-Vegetation

This measure is common on small gullies and combined with other watershed rehabilitation efforts this measure is highly suitable. The treatment of gullies has considered different dimensions cutting through various land uses, particularly on cultivated land. It is suitable in all agro climatic conditions. In dry areas, it needs to be always combined with physical measures.

Reshaping & Filling is an operation meant to decrease the gully erosion angle of incidence, create planting areas and encourage re-vegetation & stabilization, usually in small gullies or in other medium sized gullies from which most runoff has been diverted into a stable waterway or drainage line. When these gullies are shaped and smoothed, vegetation can be established over the levelled gullies. Some of these areas can be used for farming purposes.

Re-vegetation of a gully is the plantation of the re-shaped gully sides and bottom with multipurpose species, which it is to reduce runoff and control erosion and make the land productive. Gully re-vegetation implies reaching a dense vegetation cover over the entire gully surface, i.e. both sides and bottom by planting grasses, legumes and a variety of trees and shrubs. Reshaping & Filling system will be greatly enhanced by upper watershed rehabilitation aimed to replenish water tables and provide access to water within homesteads (hand dug wells). Integration of compost making, half-moon and eyebrows basins to support growth of trees and any other activity enhancing fertility is recommended.

6.5.4.4 Sediment Storage and Overflow Earth Dams (SS Dams)

Traditional structures similar to SS dams are common in several parts of drylands in Ethiopia. SS dams can be easily introduced in those areas, particularly where local structures are damaged by excess runoff. In other areas, start small scale and develop local interest by introducing high value crops and allocating SS dams to needy farmers - SS dams can become a "food insurance" site for food insecure households. Deep rooted perennials/annuals make use of the moisture and nutrient available in the accumulated soil behind SS dams.

It is recommended in highly eroded gully areas in all land uses. Not suitable for large gullies without catchment treatment and protection. Very high - for cash and staple crops, introduction of fruit trees in gullies, valuable trees, etc. Provide opportunities for income generation to small land holders and landless. Drought proof activity - even when rainfall is low SS dams collect sufficient moisture. Promote fertility management (compost, etc) and watershed protection, raise water table. SS dams are water harvesting and conservation systems that convert unproductive large and active gullies into productive areas (fertile cultivated or fodder producing areas, mixed plantations, and fruit tree orchards). SS dams are stone-faced earth dams constructed across medium/large size gullies to trap sediments, collect water and divert excess runoff. SS dams accommodate the runoff generated by the catchment located above the gully. The structures are often constructed in series along the gully. It is just like creating a land that does not exist. Contribute significantly to protect cultivated lands, arrest gully expansion and recharge water tables.

6.6 Development Plan

Watershed development interventions are a key to advance the livelihood development and secure biodiversity loss in the watershed through restored and enhanced land productivity. It support rehabilitation of degraded land and development of natural resources, providing opportunities for income generating and contribute to small-scale infrastructure development. This will help to intensify the land productivity with no jeopardy on existing natural resources. As well watershed development interventions could save water reservoirs such as dams; irrigation schemes by reducing silt transporting runoff water and recharge ground water. Besides, assessments of socio-economic conditions, soils and landforms, Soil erosion hazard, present land use and land cover details and problems. A multiple of development interventions are proposed based on the specific site conditions to reverse the existing adverse condition by considering the existing potentials and constraints as described in Figure 12.

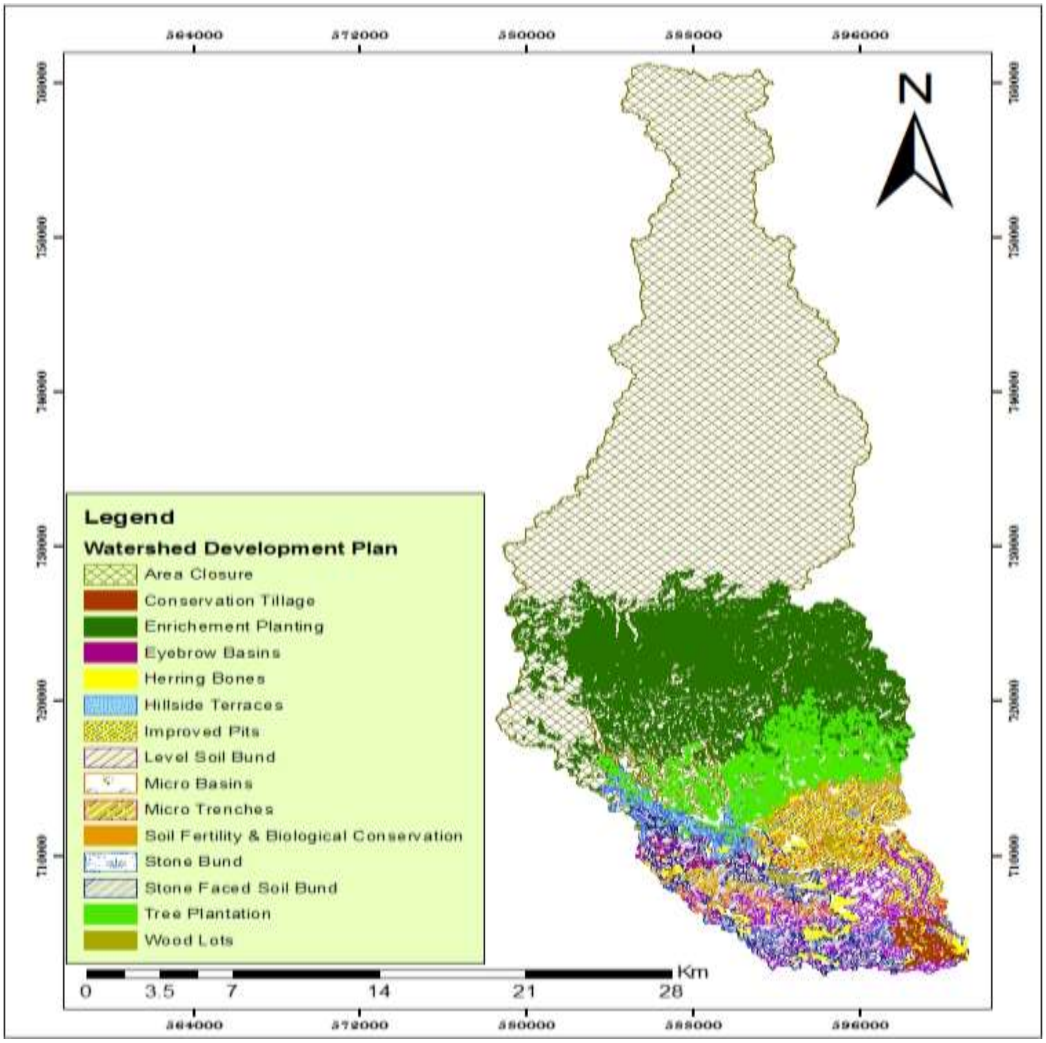


Figure 13: Watershed developmental Map

6.6.1 Estimation Watershed Developmental Costs

In soil and water conservation cost estimation, there are basic issues to be considered. There are soils and water conservation measures to be undertaken in each land unit under erosion risk and categorization of the land based slope steepness. Therefore, the area and slopes requiring conservation was estimated from erosion map; the slope map is also generated from digital elevation model (DEM). Then, unit rates are adopted from Community Based Participatory Watershed Development Guidelines (MoARD, 2005).

Table 12: Watershed developmental Cost Estimation

No	Proposed SWCMs	Length Per Unit Area Required	Unit	Norm	PD/ha	Rate/Person (Birr)	Rate/ha (Birr)	Area to be conserved (Ha)	Total Cost (Birr)
1	Area Closure		ha	4PD/ha	4	50	100	647.08	64,708
2	Soil bund	0.4	Km	150PD/Km	60	25	1,500	523.57	785,355
3	Stone bund	0.7	Km	250PD/Km	175	25	4,375	96	420,000
4	Stone faced soil bunds	0.6	Km	250PD/Km	150	25	3,750	471.66	1,768,725
5	Water way (stone paved)	120	M^3	1PD/0.75m^3	160	25	4,000	15	60,000
6	Improved Pit	600	No	1PD/5 Pits	120	25	3,000	390.64	1,171,920
7	Half-moon	0.4	Km	150PD/Km	60	25	1,500	220	330,000
8	Micro-basin construction	1000	No	1PD/5 MB	200	25	5,000	481.73	2,408,650
9	Micro-trenches	1200	No	1PD/3 MT	400	25	10,000	97	970,000
10	Eyebrow basins	500	No	1PD/2 EB	250	25	6,250	143.86	899,125
11	Hillside terracing	0.7	Km	250PD/Km	175	25	4,375	383.93	1,679,694
12	Stone Check dam	10,000	M^3	0.5 m^3/Pd	-	25	500,000	5	2,500,000
13	Cutoff drain construction	10,000	M^3	0.5 m^3/Pd	-	25	500,000	5	2,500,000
14	Hand dug well construction	10	No	40,000/HW	-	40,000	400,000	-	400,000
15	Small farm dam	10,000	M^3	0.4 m^3/PD	-	25	250,000	-	250,000

No	Proposed SWCMs	Length Per Unit Area Required	Unit	Norm	PD/ha	Rate/Person (Birr)	Rate/ha (Birr)	Area to be conserved (Ha)	Total Cost (Birr)
	construction								
16	Pond construction	10,000	M^3	0.5 m^3/ PD	-	25	500,000	-	500,000
17	Grassed waterway construction	8,000	M^3	1.0 m^3/ Pd	-	20	160,000	5	800,000
18	Pitting	5,404.40	Ha	1PD/150 Pits	180	-	400	5,404.40	2,161,760
19	Planting on bund	1	Km	16PD/Km	16	25	400	1500	600,000
20	Multi-storey gardening	-	Ha	4PD/Ha	4	25	100	750	75,000
21	River side protection and gully re-vegetation	25	Ha	500PD/Ha	500	-	2500	25	62,500
22	Seedling Production	2,000,000	No	-	-	-			
23	Seedling planting	1,900,000	No	-			0.25Cent /Seedling		475,000
	Total Cost (birr)								**20,882,437**

6.6.2 Developmental Inputs and their Estimation Costs

Developmental inputs are resources such as labor, hand tools and equipments, planting materials, etc., which are required for implementation of the activities. Table 9 below shows the list of inputs along with their quantity and time when these inputs are required. The period of time when these inputs are required should correspond with quantities of activities that require the inputs. The inputs identified as requirements for implementation of the proposed development interventions are those of labor, seedlings of trees and grasses, equipments for nursery and surveying activities and the like.

Table 13: Developmental Inputs and their costs

	Type of tools	Unit	Quantity	Unit Cost	Total Cost
A	Hand tools and equipment				**15945**
1	Clinometers	No	2	500	1,000
2	Water level	No	2	350	700
3	Compass	No	2	400	800
4	Measuring tape(50m)	No	2	150	300
5	Axe/Pickax	No	4	75	300
6	Hoe	No	4	75	300
7	Rake	No	6	100	600
8	Shovel	No	6	120	720
9	Spade	No	6	120	720
10	Bow saw	No	2	200	400
11	Sand and soil sieve	M	10	30	300
12	Watering can	No	8	110	880
13	Wheel barrow	No	4	500	2,000
14	Root pruning scissors	No	2	100	200
15	Hammer	No	2	120	240
16	Plastic rope	M	100	0.75	75
17	Sickle/Knife	No	4	80	320
18	Seedling try	No	50	100	5,000
19	Weighing Balance	No	1	450	450
20	Spray (nap sack)	No	1	400	400
21	Sharpening file	No	2	120	240
B	Polythene tube	Kg	75	110	**8,250**
C	Seed	Kg	100	250	**25,000**
D	Nursery Establishment	No	1	50,000	**50,000**

	Type of tools	Unit	Quantity	Unit Cost	Total Cost
E	Office and store				**22,500**
1	Store	No	1	9,000	9,000
2	Shade	No	1	5,000	5,000
3	Fencing	M	300	20	6,000
4	Table	No	2	500	1,000
5	Chair	No	4	250	1,000
6	Shelf	No	1	500	500
E	**Labour**[7]	PD	2,000	15	**360,000**
	Total				**151,695**

Table 14: Cost Summery of Irba Girstu Watershed Development

Descriptions	Total Cost (Birr)
Watershed Developmental Cost Estimation	**20,882,437**
Hand tools and equipment	**15,945**
Polythene tube	**8,250**
Seed	**25,000**
Nursery Establishment	**50,000**
Office and store	**22,500**
Labour	360,000
Training	189,200.00
Supervision	9,200.00
Total Cost	**21,562,532**
Contingency (5%)	1,078,126.60
Grand Total	**22,640,658.60**

[7] **Labour = 2000(Monthly Salary) x 15 Workers x 12 Months = 360,000**

19. 7. IMPLEMENTATION PLAN AND STRATEGIES

7.1 General Schedule

The plan of implementation of the proposed watershed management interventions discussed in this section includes time schedule for implementation of the measures for showing the sequence of activities; list of inputs required; strategic issues that should be considered for successful implementation and institutions that should be responsible for implementing the proposed development interventions without disregarding the existing government structures. These all have been considered by looking into the actual situation of the country in general, the community, and the Woredas in the watershed in particular.

7.1.1 Time Schedule and Phasing

Implementation of watershed management interventions requires sequencing of activities based on priority and prerequisites. Planning for the implementation, thus, should take into consideration sequencing and phasing of interventions. For example, it is not wise to plan implementation of tree planting before seedling production is carried out. Generally, physical measures should be constructed where necessary before plantations. In soil and water conservation for watershed management, the first year of the watershed management program is devoted to capacity building (where required) and development of physical measures and nursery establishment for seedlings production. In subsequent years, it will be possible to take-up construction of physical measures simultaneously with seedling production and establishment of plantations.

Plan of implementation of watershed management intervention should also take into consideration the farming calendar of the farmers. As such, it should not interfere with the normal agricultural operations. Therefore, selection of appropriate season from the viewpoint of technical aspects and farming systems should be one of the major considerations in planning implementations of interventions. The duration of implementation period will depend on the quantity of work involved to achieve each intervention, which indirectly depends on the size of areas to be treated, availability of inputs, etc.

With the basic points discussed earlier, the plan of implementation of proposed activities for Irba Girstu watershed has been prepared and presented in Table 15 below. Implementation of the proposed watershed development interventions has been planned to be carried-out in one phase, the phase has a period of five years. Thus, all the proposed measures would be in place at the end of five year.

Table 15: Implementation schedule by phase and years

No	Proposed SWCMs	Length Per Unit Area Required	Unit	Area to be conserved (Ha)	Phase - I			Phase - II	
					Year 1	Year 1	Year 1	Year 1	Year 1
1	**Capacity Building**								
1.1	Experts	No			30	30	30	30	30
1.2	Local Community	No			30,000	30,000	30,000	30,000	30,000
1.3	Different Stakeholders	No			500	500	500	500	500
2	**SWC Practices**								
2.1	Area Closure		ha	647.08	✓	✓	✓	✓	✓
2.2	Soil bund	0.4	Km	523.57	✓	✓	✓	✓	✓
2.3	Stone bund	0.7	Km	96	✓	✓	✓	✓	✓
2.4	Stone faced soil bunds	0.6	Km	471.66	✓	✓	✓	✓	✓
2.6	Water way (stone paved)	120	M^3	15	✓	✓	✓	✓	✓
2.7	Improved Pit	600	No	390.64	✓	✓	✓	✓	✓
2.8	Half-moon	0.4	Km	220	✓	✓	✓	✓	✓
2.9	Micro-basin construction	1000	No	481.73	✓	✓	✓	✓	✓
2.10	Micro-trenches	1200	No	97	✓	✓	✓	✓	✓
2.11	Eyebrow basins	500	No	143.86	✓	✓	✓	✓	✓
2.12	Hillside terracing	0.7	Km	383.93	✓	✓	✓	✓	✓
2.13	Stone Check dam	10,000	M^3	5	✓	✓	✓	✓	✓
2.14	Cutoff drain construction	10,000	M^3	5	✓	✓	✓	✓	✓
2.1	Hand dug well	10	No	-	✓	✓	✓	✓	✓

No	Proposed SWCMs	Length Per Unit Area Required	Unit	Area to be conserved (Ha)	Phase - I			Phase - II	
					Year 1	Year 1	Year 1	Year 1	Year 1
5	construction								
2.16	Small farm dam construction	10,000	M^3	-	✓	✓	✓	✓	✓
2.17	Pond construction	10,000	M^3	-	✓	✓	✓	✓	✓
2.18	Grassed waterway construction	8,000	M^3	5	✓	✓	✓	✓	✓
2.19	Pitting	5,404.40	Ha	5,404.40	✓	✓	✓	✓	✓
2.20	Planting on bund	1	Km	1500	✓	✓	✓	✓	✓
2.21	Multi-storey gardening	-	Ha	750	✓	✓	✓	✓	✓
2.22	River side protection and gully re-vegetation	25	Ha	25	✓	✓	✓	✓	✓
2.23	Seedling Production	2,000,000	No	2,000,000	✓	✓	✓	✓	✓
2.24	Seedling planting	1,900,000	No	1,900,000	✓	✓	✓	✓	✓

7.1.2 Implementation Strategies

The proposal and plan of watershed management interventions alone will not ensure the effectiveness of watershed management program. Effective implementations of the proposed interventions should be part of watershed management plan, for which setting the strategies that ensure effective implementation of the proposed development interventions is required. Consideration of the implementation strategies during the preparation of the project plan is useful to make all preparations prior to embarking onto the implementation. With this logic, the strategies for implementation of the development interventions have been indicated as follows:

7.1.2.1 Implementation Interventions Should Be Participatory

In real sense, there should be participation at all stages of watershed management planning, starting from problem identification throughout all processes up to resource mobilization and maintenance after implementation. Although an effort has been made to involve the community during field investigation of the problems, it is not up to expected level. Thus, implementing the proposed interventions, every land user and others should participate while deciding the exact position of the measures.

7.1.2.2 Watershed Logic to be Respected

This strategy requires technical consideration of the orientation of the watershed, in which implementation of development interventions should commence from ridge that is the highest part of the watershed to the valley. This will help to systematically treat the bigger watershed through treating the smaller ones.

7.1.2.3 Community Capacity Building

With the existing capacity of the farmers in planning and laying out physical measures and technical capacity of the development agents, it would be difficult to implement the interventions. Building the capacity of both the community at the grass root level and the development agents through training and exchange of experiences of other areas having very effective and successful watershed management program is very crucial.

7.1.2.4 Group Work and Local Experiences

The community in the watershed and surroundings has good experience of working together for development activities. Working together has both positive and negative sides. One of the negative sides is that only few honest people work and others are overshadowed with such people. However, this can be minimized if there is good group leadership to fully involve the community and obtain the required involvement. Moreover, group work encourages consensus of the community to common interests and development interventions. This group work should also be linked with the implementation of common interventions such as area closure. In this case, traditional self-help groups could play significant role.

7.1.2.5 Linkage with Regular Extension Service

Government efforts to promote soil and water conservation measures have been most successful where they have been linked to the general extension service in degraded areas. However, the regular extension system under proposed project area is too weak with regard to natural resources conservation. Thus, watershed management interventions have to be seen as part of productive farming and not as an optional, extra and as such, it should be considered as preventive measure before the situation become irreversible.

7.1.2.6 Rural Land Certification

The Federal and Regional governments should ensure land holding security for the farmers so that every farmer is able to develop the sense of belonging towards the proposed development interventions.

7.1.2.7 Recognition of the Role of Women

Women are the most affected part of society in the watershed and elsewhere in Ethiopia. They travel a long distance to fetch water, collect firewood, etc. Their role in watershed management is significant especially in homestead interventions and interventions that are directly linked with their day-to-day activities. Therefore, their role should be recognized in all aspects of the implementation and sincere efforts should be made to achieve their involvement.

7.1.2.8 Project Cost-Sharing

Cost sharing by stakeholders helps in developing sense of ownership towards the implemented interventions among the stakeholders and ensures sustainability of the development measures. In this regard, those interventions requiring labor need to be implemented by community organizations and investment on those measures and inputs, which cannot be managed by the community, should be made by other agencies.

7.1.2.9 Flexibility in Placing Proposed Measures

In watershed, management there is no hard and fast rule that is peculiar to specific areas. It requires flexibility in locating the proposed interventions into practice depending on the conditions at micro- level, physical features and social conditions.

7.1.2.10 Institutions

Implementation of the proposed development interventions should be made through existing government structure. However, the organizational arrangement of Woredas in respect of understanding proposed interventions and number of labor is inadequate of handle the implementation of the plan successfully. Woredas have few professionals' with little knowledge on watershed management.

The organizational structure of Agriculture and Rural Development offices of the Woredas shows that there is one expert for each of the following: soil and water conservation, Agro-forestry and Forestry and they are the only human resources to carry out the natural resources development program. This number will not be adequate to handle the proposed watershed management activities. More importantly is that the woreda experts do not have any training to either upgrade their knowledge or improve their skill, as is the case for degraded and so-called food in-secured woredas of the country, the Woredas have no adequate budget and logistics for the sector.

It has been learned during the discussions that the attention given to the sector is very low, the reason attributed is most probably the negligence and overlooking natural resource sector in the area by the government. However, it will not be logical to establish a separate institution for implementing the proposed interventions. It is advisable to improve the existing manpower by recruiting additional experts and strengthening the capacity of Woredas in terms of skill and equipments. Moreover, the different experts in the Woreda such as rural road, water resources, social workers etc. need to be organized as multidisciplinary team with those experts in the natural resources sector.

7.1.2.11 Resource Identification and Mobilization

Self-help contributions and empowerment:

The community has a key role to play in the contribution of labor and support to the implementation of the plan. Implementation and management of watershed plans:

- Identify farming system-specific menu of activities, which can be undertaken using self-help resources that would enhance household physical assets.
- Identify households on whose holdings NRM activities can be undertaken following watershed logic, can facilitate their organization into a number of groups, and can ensure

timely accomplishment of the activity. Link the self-help activity to any other form of available support in different areas.

- Work towards requiring group members to contribute in kind to the task being carried out within their capacity and agreement.
- Identify eligible households where other assets are to be built using external support. Determine the quantity of the transfer that the group is eligible for and effect the payment on schedule.
- Facilitate the accomplishment of agricultural/NRM tasks in/around the homestead of disabled people following the spirit.

Group formation, community and social organization: Proper establishment and construction of quality measures help much on sustainability but they are only half the job. The other half is proper management of assets. Proper management is not only necessary to sustain and improve measures but also to initiate their replication and expansion. Development initiatives will not be sustained unless beneficiaries make some form of resource commitment to support those initiatives. Watershed development and management should be thought as a contract where self-help and external support efforts translate into commitments to manage, protect and eventually improve assets once established are considered part of agreement.

Social organization built on traditional or new methods is also intended to promote initiatives and activities that enable improved social interactions between groups and people, highlight gender issues constructively as well as optimize sharing of benefits and enhance mutual mechanisms of solidarity.

Group formation for social organization and income generation initiatives is, on the other hand, meant strengthen local capacities required to sustain community-focused development, to improve the living conditions and income of rural households, the poor and disadvantaged in particular.

A long-lasting, collective responsibility for natural resources requires the construction of a common vision rooted in the values of farmers who live on the watershed and experts in the *woreda* line agencies. This can lead to adoption of new social norms and a refusal to allow land degradation to continue. This is also linked to gradually building an increased capacity of the watershed communities and the broader watershed continuums to build enough resilience to sustain them and exit from external assistance. The community watershed team will form the groups that will implement the plan, generate community income and manage community assets. It will decide on the number of group membership following local norms.

Large parts of Ethiopia have degraded and food-insecure areas. These require the implementation of multiple activities that pass the test of quality. Otherwise, the impact of a few activities would remain limited and not be able to catch up with the pace of overall problems. As problems of households are multiple and interrelated, the solutions should be multiple and integrated. Therefore, a broad network of watershed plans and activities, properly selected and designed based on people's problems, priorities allow the vulnerable areas, and to plan based on food gaps, number of vulnerable people and resources available.

7.1.2.12 Organizational Arrangement at Community Level

Community labor based contracts and solidarity schemes. Based on the watershed plan prepared, the amount of labor requirements and type of materials are then estimated. Building on the traditional work parties, the labor component could be thought as a **labor based community watershed "contract"**. The resources provided or to be provided on self-help and/or other forms of assistance can be translated into person days. The total cumulative person days can then be taken up as a credit that the able-bodied target group should "repay" back to themselves or to the community in a participatory manner, or to specific groups they themselves prioritize during a given year in terms of assets building for watershed development. Watershed development should strive to ameliorate the position of women in general and female-headed households in particular. The case is also made for people unable to work to build significant assets but who are able to manage. Many women and the categories of people named retain considerable potential to manage assets with dedication and care. On the other hand, the number of chronic, food-insecure women-headed households is considerable compared to the total number of food-insecure households. In addition, it is not likely to move into other areas for opportunities as men do. Women groups or the whole target group could be organized to this effect and assist those women in building their asset base. Women have a high sense of protection, saving and market-oriented attitudes that should be nurtured. They should be given support to increase their participation in watershed development and NR management, including productivity intensification measures at homestead level.

7.1.2.13 Linkages with Land-Use Certification

The ongoing efforts on land-use certification in several regions is an excellent incentive to enable land users to value their land holding but also to encourage investments in degraded and marginal areas. The certification process should be closely linked with watershed development planning. The responsibilities of households in managing their land should be related to the management of the measures implemented in such landholdings following watershed development logic and interventions. Specific arrangements at woreda and regional levels are needed to ensure that land certification is integrated with watershed development and avoid that interventions undertaken on private or communal areas are disconnected and of poor quality.

7.1.2.14 Training and Experience Sharing

Building the capacity of local communities and extension workers is an important component in watershed management. Different people will have different roles and responsibilities in watershed projects implementation and there is a need to train people involved in the watershed development program/project at various levels-villagers, CBOs, extension staff, and others. The purpose is to achieve sustainable village/community-based development with integrated watershed management serving as a tool. Training can enhance knowledge, attitude (problem solving, behavior, and the like), skills (communication, technological, demonstrations, conceptual) and relationship (trust, respect, co-operation and teamwork). How to assess training needs: The role that one is expected to play in watershed programs/ projects often determine training needs. We need to determine roles and responsibilities of the stakeholders (*woreda* team, DA, *kebele*, innovative farmers, and others). What are the activities that the stakeholder was involved with during the specified period and what are the skills/capacities required to effective and efficiently undertake these activities.

Core aspects of training and experience sharing:

(1) Extension staffs need to be trained and encouraged to develop their own training modules as per the needs of the watershed community;

(2) Identification and use of trainers and resource persons both from within and outside the project area will strengthen the process of capacity building;

(3) Exposure visits, interactive sessions and networking among stakeholders can play a major role in the capacity building of the grass root level workers;

(4) Participatory training methodologies encourage innovation;

(5) Accountability must be in-built within the capacity-building process;

(6) Linkage with research institutions help in providing practical solutions to specific problems encountered.

20. 7. EXPECTED BENEFITS ANALYSIS

7.1 Economic Benefits

The direct benefit to the beneficiaries would increase income through generation of additional income and off farm schemes including creation of employment opportunity. Besides the watershed management plan implementation is expected to improve the food self-sufficiency and security status.

The local inhabitants are required to benefit from the availability and supply of the food and household items to the market with affordable prices. The regional economy will benefit through indirect, multiplier and intangible benefits. These benefits would be reflected in the form of;

- Increased income and employment
- Stabilization or increase in crop or pasture yields. Stabilization of yield refers to those situations where conservation prevents a decline in yields that would occur if erosion is unchecked. Increased in yield can also come from improved nutrient supply through organic matter, compost additions, agro-forestry, etc.
- Improved livestock production from increased quantity and quality of fodder, for example from alley cropping or bund embankments.
- Improved supply of fuel wood and construction materials
- Increase life span irrigation schemes and Dum

7.2 Social Benefit

The benefits of watershed management interventions will also yield social benefits that can be measured in qualitative and quantitative bases. Some of these include:

- Improvement in water supply owing to increased infiltration of rainfall;
- Social respect to women, currently very poor households and jobless youth whose means of income generation is increased and social value is improved;
- Prevention of flooding from downstream socio-economic infrastructures ;
- Increased value of land etc
- Minimize erosion and simultaneously increase the productivity of the land and the income of the farmers;

7.3 Environmental Benefits

- Recharge ground water, increase water availability in quantity and quality, supply, water for domestic and irrigation, hydro-power;
- Minimize natural disasters such as flood, drought and landslides, etc.;
- Mitigate non- point sources pollutions and its impact off - site
- Mitigate climate change and create surrounding environment conduce for living things
- Mitigate loss of biodiversity and increase its availability in quantity and quality
- Increase land productivity and keep soil nutrients on – site

8. MONITORING AND EVALUATION

Monitoring and evaluation of performance of interventions implemented as watershed management program is an important tool to value the proper implementation and out puts and impacts thereafter. Therefore, it should be considered with serious attention. Through monitoring, raw data or information can be collected from the project area, which at later time may be used for evaluating the success and impact of a project. Moreover, monitoring is a management tool, which facilitates continued learning and provides quality information for evaluation, which is a process in which judgments on success and/or failures are made.

Monitoring and evaluation of the performance of the activities during implementation and afterwards should be participatory for ensuring effective watershed management program. For the current project, it is recommended to carry out continuous monitoring at various stages as the condition permits. Evaluation should be made at the end of every year or completion of the plan of work for the year. Moreover, the impacts of the interventions should be evaluated.

- ✓ The following indicators are suggested for monitoring and evaluation:
- ✓ Amount of activities achieved against the plan
- ✓ Maintenance and improvement in the land productivity
- ✓ Improvement in livestock feed supply either in terms of quantity or quality
- ✓ Decrease in soil erosion and reduction in sedimentation
- ✓ Change in the livelihood of the community through a longer period
- ✓ Increase in vegetation cover on forest and grazing lands and decrease in deforestation and forest degradation

- ✓ Increase availability of water in terms of quantity or quality
- ✓ Decrease non-point sources pollution

Change in awareness of the community towards the need for watershed management, and the number of farmers community who have adapted the interventions on their farm land where required.

9. CONCLUSION AND RECOMMENDATION

9.1 Conclusion

The recent high agricultural potential regions of the country were under food insecurity due to mismanagement of Natural Resources. Most of them are depending on food aid to sustain throughout the year. Natural hazards specially hail storm, grazing and cultivated land shortage due to rise in population, decline in productivity of the land caused by mismanagement of the resource. The current soil loss is very high about 473.58ton/ha/yr. It brings loss of land fertility because it dislocates essential minerals and minimizing the rooting depth of plants. It also may create problem for downstream-cultivated lands. As elders said, the Irba Girstu and Yadot River flow was decreasing from time to time. Deforestation and overgrazing is a common phenomenon for this watershed and population was increased from time to time. There for the land was becoming degraded. These shows there were urgent need to environmental protection through different soil and water conservation activities.

9.2 Recommendations

- To alleviate the above problems Soil and water conservations should be held in the watershed based on the specification.
- Physical and biological conservation should be implemented in proper place and specification.
- Different concerned sectors/ stakeholders shall discuss and take their part in the watershed development work.
- Detail Watershed Inventory will be conducted for specification of conservation structures should be studied in detail.
- The farmers should be involved on planning, implementation and monitoring period so that Community based Watershed development must be applied.
- In implementing soil and water conservation activities as per the development plan needs a strong follow up and technical support. Because of less follow up and technical support, the works done had mostly fatal errors that led us wastage of scarce resources.

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