

OROMIA REGIONAL STATE
Oromiya Irrigation Development Authority

Final Watershed Feasibility Report of Wataba SSIP

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1. INTRODUCTION

1.1. BACKGROUND

Productive land and adequate water availability is crucial for sustainable development and increased food production those countries base their livelihood on agriculture. The availability of this vital resource is not guaranteed for large sections of the world's population. Over 40% of the extra food required to meet the growing food demands by 2025 will have to come from intensified rain fed farming in sub-Saharan Africa region. In contrast almost quarter of Sub-Saharan Africa (SSA) population lives in water-stressed areas. (World Bank, 2005; UNDP, 2006). Ethiopia is relatively well endowed with water resources, having an estimated annual surface runoff close to 122 billion m³. Only 10-20% of the country's surface water resources access to the population (MOARD, 2008). Offering adequate water to the users, in the right quantities, at the right places and at the right time, by applying environmentally sound techniques and procedures is required for effective management of water resource.

The extent of fertile land available for agriculture is decreasing due to land degradation. Land degradation is caused by deforestation and inappropriate use and management of the natural resources, (soil and water). It leads to both non sustainable agricultural production and increased risks of catastrophic flooding, sedimentation, landslides, (Pla, 2000). Rapid population growth, existing agricultural production system; cultivation on steep slopes, clearing of vegetation and overgrazing, low inherent land productivity, lack of capital, inadequate support services and poverty” are the main factors that accelerate soil erosion (Mekuria 2005, cited in: WECD, 1987). Accordingly, proper management of on-site effect of soil erosion reduces the risks and negative impacts of downstream water resources due to water erosion. Tackling the on-site effects of soil

erosion requires an understanding of the rates of erosion processes as well as identification of the major controlling factors that aggravate or reverse the processes.

So this particular study will distinguish the potential causes and the associated reasons behind the respective causes and prepare Watershed management plan. Integrated watershed management plan is the process of evaluating, planning, restoring, and organizing land and other resource use within a watershed to provide desired goods and services while maintaining a sustainable ecosystem. This process provides a chance for agencies and stakeholders to balance diverse goals and uses for environmental resources, and to consider how their cumulative actions may affect long-term sustainability of these resources.

1.2.OBJECTIVES

The specific objectives of the project include:

- To propose appropriate interventions to reduce soil erosion on the upstream so that the sediment deposition on the downstream will be controlled.
- To undertake integrated watershed development activities in the sub-watershed and formulate an implementable project designs which will contribute to the livelihood improvement in the watershed.
- To propose different activities to improve vegetation cover and increase availability of various tree resources in the watershed areas by promoting plantation of tree species to enhance appropriate conservation.
- Assess the root causes of land degradation in the watersheds and identify proper conservation techniques that contribute to reduce soil erosion and improve infiltration rate to enhance the ground water recharge.
- Assess the previous activities on soil and water conservation and identify the gaps and incorporate to the project components for implementation.

The watershed study is part of the overall irrigation project feasibility study therefore, this prepared for watershed management plan of the Wataba watershed.

1.3. JUSTIFICATION

A sound watershed management plan will provide the frame for harmonizing economic development and natural resources conservation. It will also integrate socio-economic and cultural realities, institutional structures and the biological aspects into upland protection and conservation in order to attain sustainable development.

A watershed management plan provides actions to protect a watershed or prevent damage to it; mitigate the effects of land use to an acceptable level; restore degraded environments; optimize the availability of water resources

In this regards, this particular watershed management plan will be based on a complete inventory of the Watershed bio-physical and human resources. The objectives of the plan will not be limited to prevention of watershed degradation but also attaining increased production from the land on a sustained basis and a general improvement of the standard of living for the people living in the Watersheds must be an integral part.

Moreover, the watershed management plan will be a comprehensive development of a watershed so as to make productive use of all its natural resources and protect them from further degradation. This includes land improvements, rehabilitation and other technical works as well as the human considerations.

2. Methodology and Approaches

2.1. Methods

2.1.1. Data collection methods

Various data collection approaches & methods have been used for the watershed management study; to enable looking at different levels in the system features and resources of the watershed in relation to its dynamics in diversity, coverage and constraints. Those details used during the field data collection process are provided as follows:

2.1.1.1. Field observations

Field observations were conducted across the entire and adjacent watersheds encroaching. The tools used in the data collection were direct observation & measurement, ground-checking with in-hand secondary data and conducting interviews with the local farmers. Through transect walk, data have been collected on land use/land cover types, soils vegetation types, topographic features, soil erosion and land degradation problems, types of SWC and farming practices.

2.1.1.2. Public consultations

Frequent public discussions were conducted with the target community members in Watershed area those communities concerned with the proposed irrigation project as well as associated with conservation of the upstream decisive catchments. Many community members participated representing different social groups such as community leaders, officials, elders, women and youths. These community discussions helped us to understand perception of the local people on land degradation situation and their willingness on watershed management interventions and also to identify the watershed problems and solutions on the bases of community views and priorities.

2.1.1.3. Discussions and secondary data collection with Woreda sectors

In the meantime, of the field works, brief discussions were conducted with the Shrika Woreda with concerning sectors about major problems of the watershed and their causes, adopted interventions and strategies, sustainability of the implemented SWC measures and practices, land use proclamations and possible options & potentials for future development and management of

the watershed resources. These discussions have helped for cross-checking the issues raised by the community and fill the data gaps through secondary data.

In general, the interviews and group discussions were conducted based on the following points

- ✚ Historical profile of the land cover types; before three decade years;
- ✚ Categories of land use and farming system of the watershed;
- ✚ Crop production, productivity trends and related reasons;
- ✚ Measures practiced to improve land productivity;
- ✚ Existence of fallowing & tree planting practice;
- ✚ Alternative household energy sources;
- ✚ Understanding on the existence of land experiences with soil erosion;
- ✚ Traditional and institutional practice of soil conservation.

2.2. Materials

To undertake this study, the main materials involved was: -

- ✚ Administrative boundaries Maps (Regional, Zonal, Woreda and Kebele);
- ✚ Topographic map with the scales 1:50,000;
- ✚ Contour maps at 10 meters' intervals;
- ✚ Land use and land cover based on Land Sat ETM of 2016;
- ✚ Soils, population and climatic data (rainfall, temperature, etc); and

The socio-economic data was collected from Woreda Finance and economy development Socio-Economic and Geo- Spatial Data Analysis and Dissemination Core process (WoFED). The watershed boundary, which followed the natural hydrological system, and the drainage systems of the sub-watershed were generated from DEM at the spatial resolution 30m.

DEM Data was also used to generate contour map at 30m interval, altitude ranges, slope gradients, slope length, relief types, analytical hill shading, etc. In all respects, such information products had added values to further substantiate for soil erosion hazard assessment in the study area.

The land use and land cover map layers were generated from the Land sat of 2016. The classification involved both supervised and unsupervised methods. The representative study areas were selected based on the pixels demonstrating regular patterns. The study samples were used for the classification of Land sat data. While the actual coordinate data collected using the GPS receiver to classify the data.

The soil data, which mainly consisted of dominant soils, textures, depth and management constraints, were collected from secondary information and verified through intensive field survey.

The climatic data were collected from the available secondary sources of the National Meteorological Service Agency and the Ministry of Agriculture and Natural Resource Development.

2.3. Review of Policies and Strategies

Soil Conservation Research Project (SCRP)

This is the major undertaking, which started in 1981 under the Ministry of Agriculture in association with the University of Bern, Switzerland and United Nations University, Tokyo. The project had six regional research units covering different climatic zones in the Ethiopian highlands. The SCRCP had made an important contribution to scientific understanding of the erosion processes in Ethiopia. Its work includes:

- Design and studies with test plots
- Measurements of climatic data, runoff, sediment loss and land use data within catchments.
- Investigation into the rate of soil formation
- Land cover mapping with satellite images and ground survey
- Agro-ecological land use planning
- Soil studies and mappings

Various SWC measures have also been tested; all project works and results are available, in several series of research progress reports.

Related Research Findings

Some of the research findings in relation to soil loss rates and severity of soil erosion have been summarized as follows:

- At National level, estimated an average soil loss of 42 t/ha/year cultivated fields
- The maximum of 300-400 t/ha/year in highly erodible and intensively cereal-cultivated fields
- Estimated average erosion rates on currently unproductive crop land and cropland planted on annual crops are 70 t/ha/year and 42 t/ha/year respectively, while its averages 8 t/ha/year on land planted to perennial crops and 5 t/ha/year or less for all other land cover types
- Result obtained from test plots at AnditTid SCRIP site indicated that soil loss under traditional soil management techniques averaged 152 t/ha/year, /SNNPRS/
- At Anjeni (in Amhara Regional State) on experimental plot with different slopes and conservation practices, soil loss rates varied from 53 t/ha/year to 161 t/ha/year. In the same site soil loss is reduced by 32% with graded bunds, 54 % with graded Fanya-Juu and 66% with grass strip.

The net losses were estimated at 2 % only; the rest being deposited at the lower edges of the fields in grassland in the forest. However; on bare soils plot, erosion rates were as high as 293 tones/ha/yr. Comparison study between treated and untreated catchments of Gununo, evaluating soil loss using modified RUSLE showed that 67% the soil loss comes from untreated catchments with nearly the same proportions of rills reported from untreated catchments, indicating the strong correlations between soil loss and rills developed.

Ethiopian Highlands Reclamation Study

The Ethiopian Highland Reclamation Study (EHRS, 1984) intended to analyze and explain the processes and types of degradation in the highlands, identify the areas and peoples most critically affected, estimate the rates and costs of degradation in different locations and evaluate present measures to combat and /or avoid degradation. The EHRS assessment study concluded that some 1.900 million tons of soil were annually eroded from highlands, equivalent to an average net soil

loss of 100 tons/ha and an annual loss of 8 mm in soil depth. Those soil losses estimated by EHRS were found to be overestimated compared with other studies. However, this study has little importance for the present study.

2.4. Review of Policies, Strategies and Guidelines Related Natural Resources Conservation

2.4.1 Rural Land Administration and Land Use Proclamation (2005)

In the past years, there were no rules and regulations how land is being used, managed and administered. Very steep slopes, which could lead to severe erosion/land degradation, have been cultivated for crops without any soil conservation measures. Therefore, it has become necessary to sustainably conserve and develop natural resources and pass over to the coming generation through the development and implementation of a sustainable rural land use planning based on the different agro ecological zones of the country, the proclamation no.456/2005 had been declared by the Federal Government. The proclamation gives the right to hold and use rural land registration and holding certificate, transfer of rural land right, obligation of rural land users. Furthermore, the proclamation takes into account the land use planning and proper use of sloppy, gully and wetlands. Here, part of the proclamation that restricts the rural land use i.e. **“the land use planning and proper use of sloppy, gully and wetlands”** which is relevant to the watershed management are considered and summarized below.

- A guiding land use master plan which takes into account soil type, land form, weather conditions, plant cover, and socio-economic conditions and which is based on watershed approach, shall be developed by the competent authority and implemented.
- Equitable water use system between upper and lower watershed communities
- In any type of rural land where SWC works have been undertaken a system of free grazing shall be prohibited and a system of cut and carry feeding shall be introduced step by step.
- The management of rural lands the slope of which is less than 30% shall follow the strategy of soil conservation and water harvesting.
- Development of annual crops on rural lands that have slopes between 31-60 percent may be allowed only through making bench terraces.

- Rural land, the slope of which is more than 60 percent shall not be used for farming and free grazing; they shall be used for development of trees, perennial plants and forage production development of trees.
- Rural lands of any slope which is highly degraded shall be closed from human and animal interference for a given period of time to let it recover, and shall be put to use when ascertained that it has recovered. Unless the degradation is caused by the negligence of the peasant farmers, semi pastoralist and pastoralist the users shall be given compensation or other alternatives for the interim period.
- Rural lands that have gullies shall be made to rehabilitate by private and neighbouring holders and, as appropriate by works the local community, using biological and physical works.
- Rural lands that have gullies and are located on hilly areas shall be rehabilitated and developed communicably and as appropriate by private individuals
- The biodiversity in rural wetland shall be conserved and utilized as necessary, in accordance with a suitable land use strategy.

The Proclamation also gives provisions on the responsibility of the Federal Ministry of Agriculture and Rural Development and the Regional States. It is believed that, the existence of this proclamation and making use of it would offer strong support in the proper use and management of the natural resources in a sustainable manner in near future. It will also contribute in implementation of the current proposed watershed management projects and plans in the study area in more sustainable manner. It also serves as a base in proposing the mitigation measures for the study area.

2.4.2 CBPWM- Guideline Main Principle of Watershed Development

Watershed development can be defined as the rational and socially acceptable utilization of all the natural resources for optimum production to full fill the present need with minimal degradation of natural resources such as land, water, and environment.

In the Ethiopian context, according to Community Based Participatory watershed development Guideline 2005, by the Ministry of Agriculture and Rural Development the principles, which will be taken into account, are as follows:

a) Participatory: Watershed communities need to be involved in all stages of planning,

implementation and management of watershed development activities. It is a continuous process and not a one-time exercise. Different participatory techniques ", was used based upon existing and innovative experience.

b) Gender Sensitive: Women are the most affected by environmental hardships; for example, they need to walk long hours to fetch increasingly scarce water, firewood and animal dung in addition to attending livestock, to name a few. Their involvement in watershed development planning, implementation and management is the key to ensure that they equally benefit from the various measures.

c) Building upon Local Experience, Strength and other works: Local knowledge is essential to improve existing technologies, to adapt new ones and to manage natural resources and other measures once they are introduced and established. Best practices should be identified and disseminated.

d) Realistic, Integrated, Productive and Manageable: Watershed development planning should be realistic, based upon local capacity, locally available resources and other forms of government and partners support. Integrated conservation and development of the natural resources base is the guiding principle for watershed development together with the optimum use of social resources. To the extent possible watershed development activities should provide tangible and quick benefits to households. This is possible if measures are designed to accommodate both production and conservation requirements. Some measures, however, need some time before the full benefits can be achieved. In this case, combination of measures with short and longer-term benefits is essential. This can be achieved if quality criteria and integration aspects of the interventions are met.

e) Watershed Logic and Potential Respected: Adoption of ridge to valley approach, of manageable size, and focused on interactions between land uses and their capability. Simple land use and features descriptions would help to find suitable range of technical options to optimize existing land use or changing it for the better in respect of both biophysical and social requirements. Due emphasis will be placed on production enhancement activities by optimizing productivity per unit area, per unit time, and per unit of water for both land owners and landless families. In this regard, the role of quality physical structures, vegetative cover and biological measures will be emphasized. Reclamation and rehabilitation of degraded and marginal lands,

including gullies, through alternative and productive land-use systems will be promoted as a main activity in most areas. In semi-arid and arid areas, great attention will be provided for water harvesting in situ and off site.

f) The Need for Flexibility at Different Levels: Flexibility is a key criteria required in PWDP to fit in local conditions. Flexibility is needed during the selection of community watersheds, their size (slightly smaller or larger than the ranges indicated) and clustering and during the steps of the procedures. Similarly, flexibility is essential when considering the choice and design of measures within the agreed criteria of quality and integration.

g) Cost-sharing and Empowerment/Ownership Building: Cost sharing by stakeholders contributes to the sustainability of a project for establishing the responsibility of various stakeholders in the management of the resources. Various forms of local contributions are possible based upon social networks and group formation mechanisms.

h) Complementary to Food security and Rural Development Mainstream (including HIV / AIDs. Health and Education and Others):

To the extent possible, watershed development planning will incorporate additional elements related to basic services and social infrastructure. These activities will all benefit from participatory watershed development framework. The principles and approaches have been taken into account in this study.

2.4.3 National Conservation Strategy

The national policy on natural resource and the environmental sector, has an objective to promote improved soil conservation practices that enhance and maintain land productivity for sustainable development of agriculture, and in general, biomass and biodiversity. The policy provides the guiding principles and strategies. Some of the strategies proposed, related with soil conservation are summarized below:

- Build up on use of indigenous soil management system to develop and promote improved technologies, the use of farmyard, green manure, compost, biological nitrogen fixation etc.
- Develop forestry on the farm, around the homestead, on eroding and/or eroded hill sides,

- Through a program of farmer's participatory research determine for specific agro ecological zones the relative effectiveness and economic advantages of physical and biological soil conservation systems, which are the most suitable for soil and water conservation
- Enhance and strengthen the holistic approach to research, extension and training of farmers, extension workers and researchers.

This national conservation strategy shall be considered in the preparation of the watershed management project preparation.

2.4.4 Rural Development Policy and Strategies

The objective of the rural development strategy of the Federal Democratic Republic of Ethiopia (EDRE) and the regions focus on:

- ✓ Maximum and best use of the land resources, labour and capital to produce enough of the essential items
- ✓ Increasing food and agricultural production, and
- ✓ Generating job opportunities for the rural population

Along these objectives, the rural development program would specifically focus on increasing the productivity of crop and livestock sub-sectors. It specifically focuses towards attaining sufficient quantities of food to meet the food requirement of the people and expanding off-farm employment opportunities by which the rural society could get additional entitlement to food.

The policy has the broader goal of benefiting people through pro poor growth while relieving dependence on external aid. These objectives describe four main issues. These are:

- Assuring rapid economic development, ensuring that the rural poor benefit from the development effort
- Reducing the country's dependency on external aid and developing a free market economy.

2.4.5 Food Security Strategy (2002)

The food security and the Food security program outlined by the federal Government of Ethiopia underline the importance of sustainable use and management of the natural resource base. As described in the documents, this component aims at optimum use of land protecting the natural

resources base to enhance sustainable food security. It mainly focuses on: initiating soil conservation measures in areas where soil degradation is extremely high, improving forest management systems, insuring availability of fuel wood, serving as source of construction material and animal feed etc., initiating soil surveys and studies to increase the proper use of land, expanding and strengthening reforestation program on hill sides and eroded steep slopes, creating public awareness of natural resources management and intensifying planting of multipurpose tree species(fuel, fodder, soil conservation etc.)

The food security program also has the following main components, namely: agriculture, (crop, livestock) small scale irrigation, infrastructures/rural roads sustainable use of natural resource base; market and credit services, clean water supply and capacity building.

3. General Description of the Watershed Area

3.1. Location

The project site is found in Oromia Region State, Arsi Zone and Shirka Woreda administrations. Water source proposed for Wataba small scale irrigation project is Wataba River. Bounds of Wataba watershed from 540158.656m to 566906.903m E, and 839604.296m to 852284.256m N UTM coordinates. Its area coverage about 19,480ha with an altitude of 2160 to 3764 masl. The watershed covers thirteen kebeles of Shirka Woreda. The head work site for irrigation is located with GPS reading: co-ordinate points are E*565405 and N*847967 with 1702m elevation.

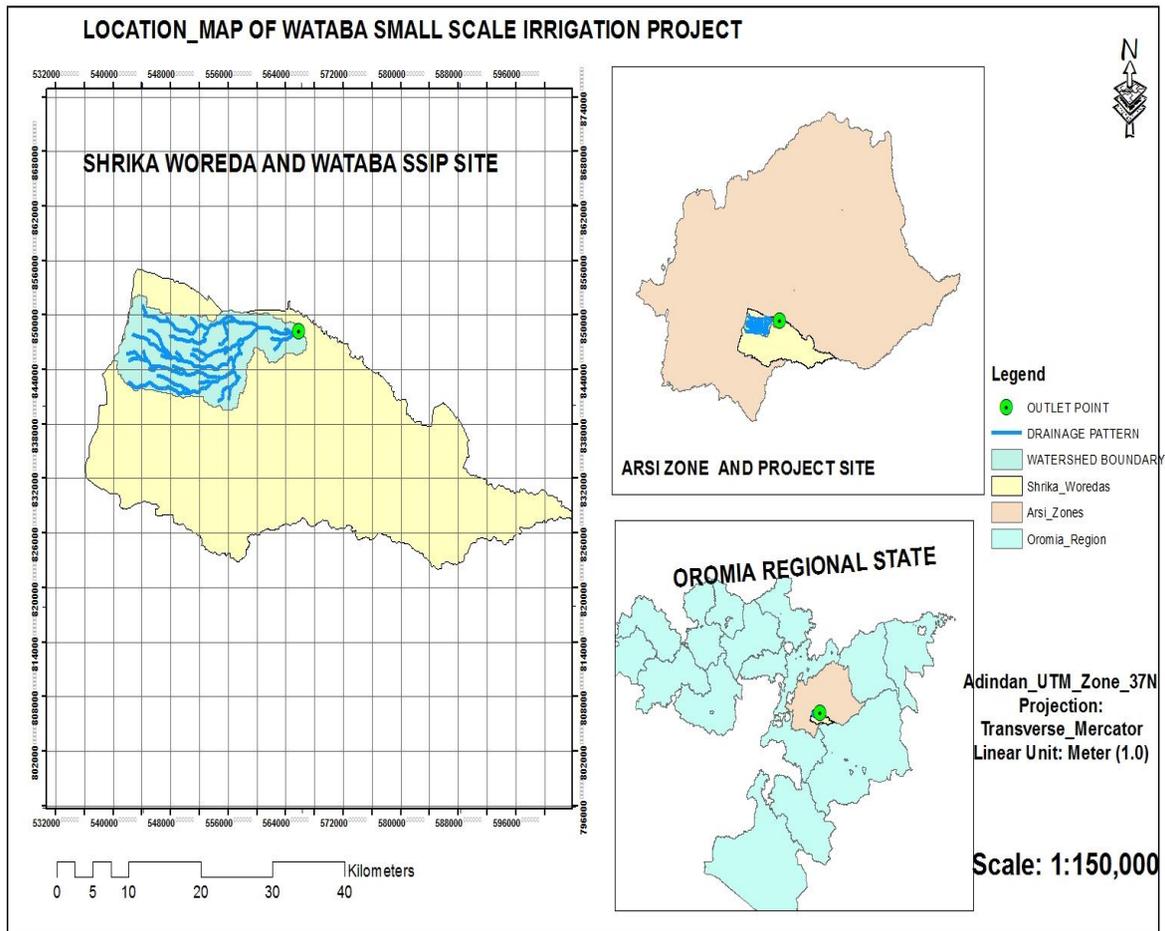


Figure 1. LOCATION MAP OF WATABA PROJECT

3.2. Topography of Wataba Watershed

The Wataba watershed is a medium to high relief hills and severely dissected side slopes and plateau with different types of land scape. The terrain shapes include, concave, convex, ridge, and slopy hillside relief form. The topography of the watershed is rolling and rugged on the north east, and southwest of the watershed. Generally, the elevation increased from West to East and its range from 2425m to 2689m. The upper and the ragged part of the watershed is dominated by concave and convex slope shapes whereas on the lower part of watershed linear slope shape dominating.

3.3. Contour of Wataba Watershed

Contours contain information about the relief, shape and the form of the land and the relative distribution in space of the components of the landscape of the watershed. An impression of the topography is obtained from the contours printed on this kind of map.

The elevations of landmarks and reference points, such as hilltops and mountains peaks, are also printed on topographic maps. Following contour lines, it is possible to delineate watersheds within the watershed on a contour map and enables the gradient or slope between two points to be measured. Closely spaced contours on the contour map, upper part of the watershed, indicate that steeper slopes occur in those locations relative to areas that have less closely spaced contours; whereas sparse contour lines, lower part of the watershed.

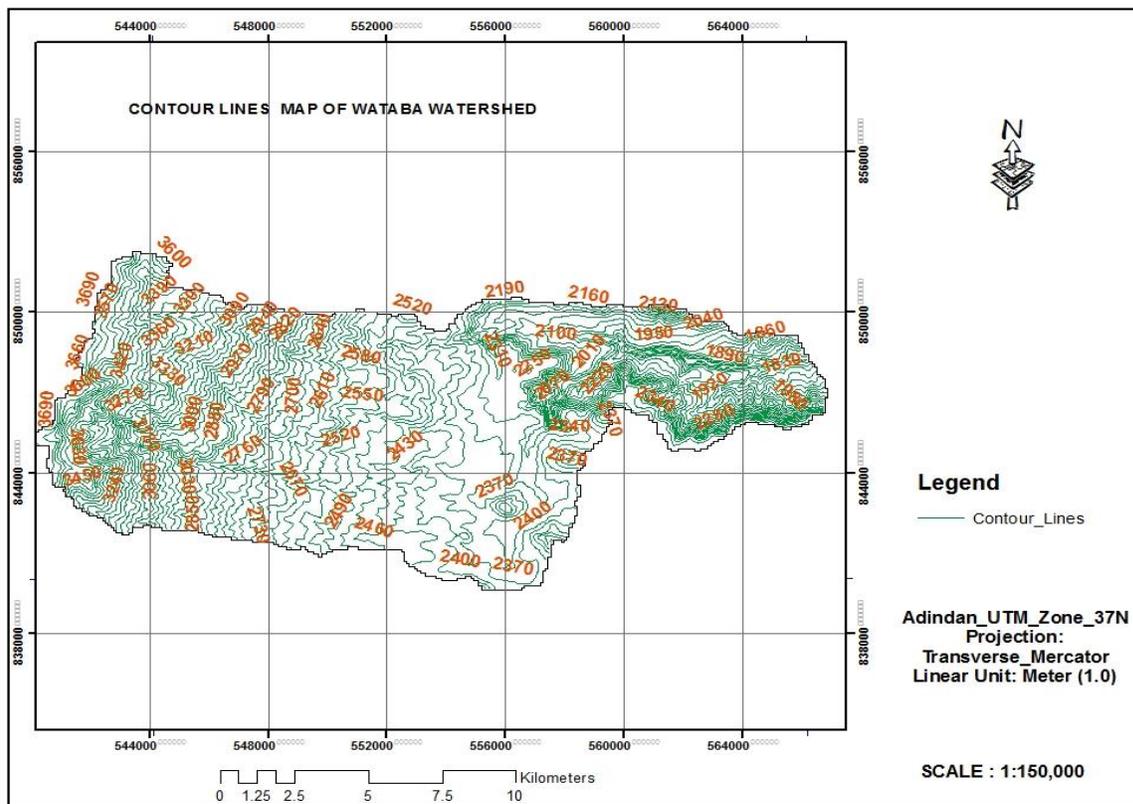
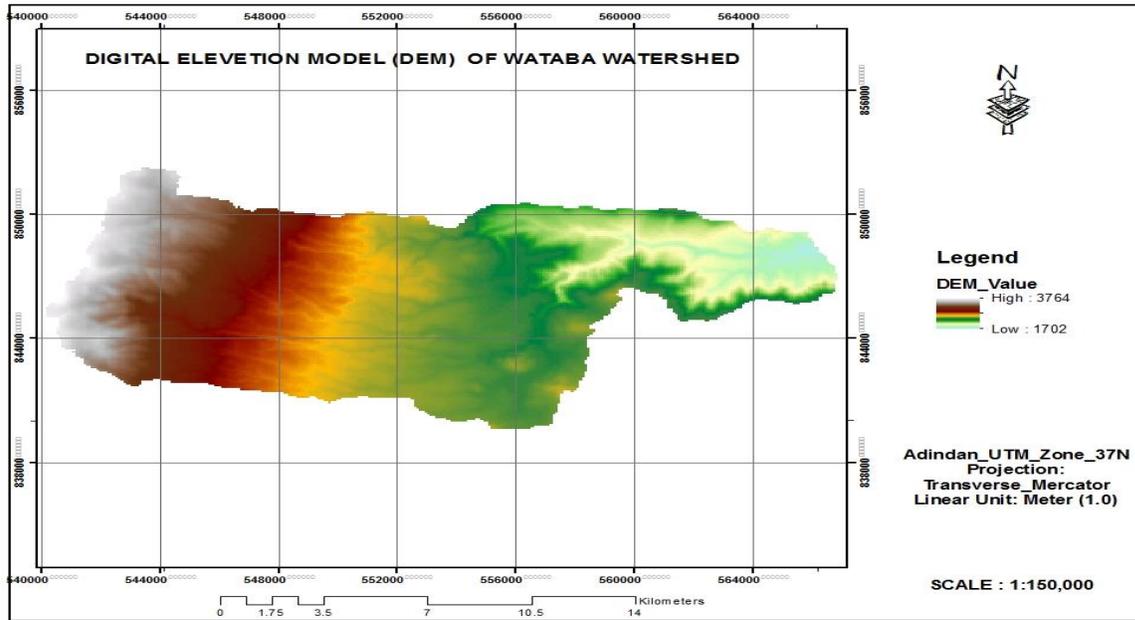


Figure 2. Contour map of Wataba Micro Watershed



3.4. Drainage Pattern and stream networks of watershed

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. Its Dendrites characteristic, show there were no folding and faulting processes. As a result, the drainage pattern will help us to know the erosion hazard and sediment yield of the watershed. The watershed has a regular dendrites shape with its narrow width at the upper stream and wider at the downstream. Its cover about 19480 hectares' area; The drainage pattern is also shown in the map below: -

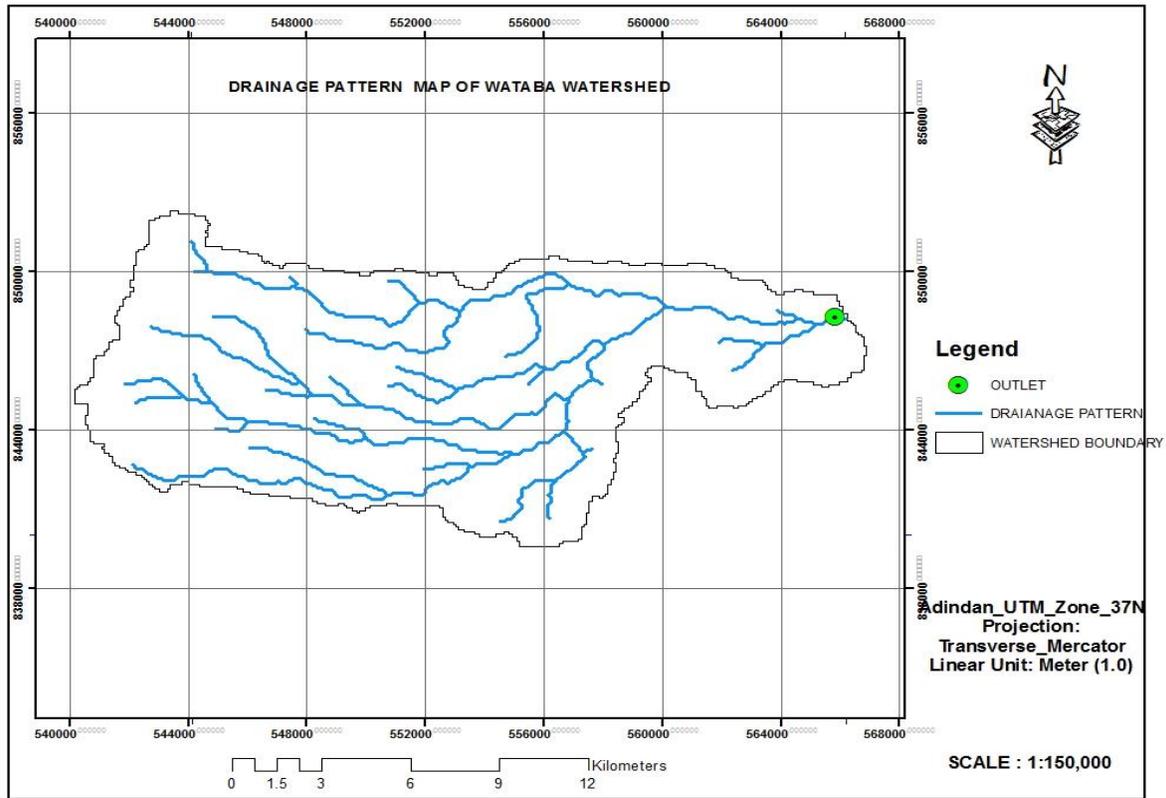


Figure 3. Map of the drainage pattern of Wataba Watershed

3.5. Slope

Based on the national guideline of Community Based Watershed Development, slope computation had also been made with six classes. The Guideline suggests the use of such classification for soil and water conservation and other land management recommendations. In most cases, slopes over 8.0 percent are generally recommended for relevant conservation interventions according to the landscape and physical human activities. According to slope classes of watersheds (Table 1.) could be designated for various natural resources management programs under the existing conditions of the watershed.

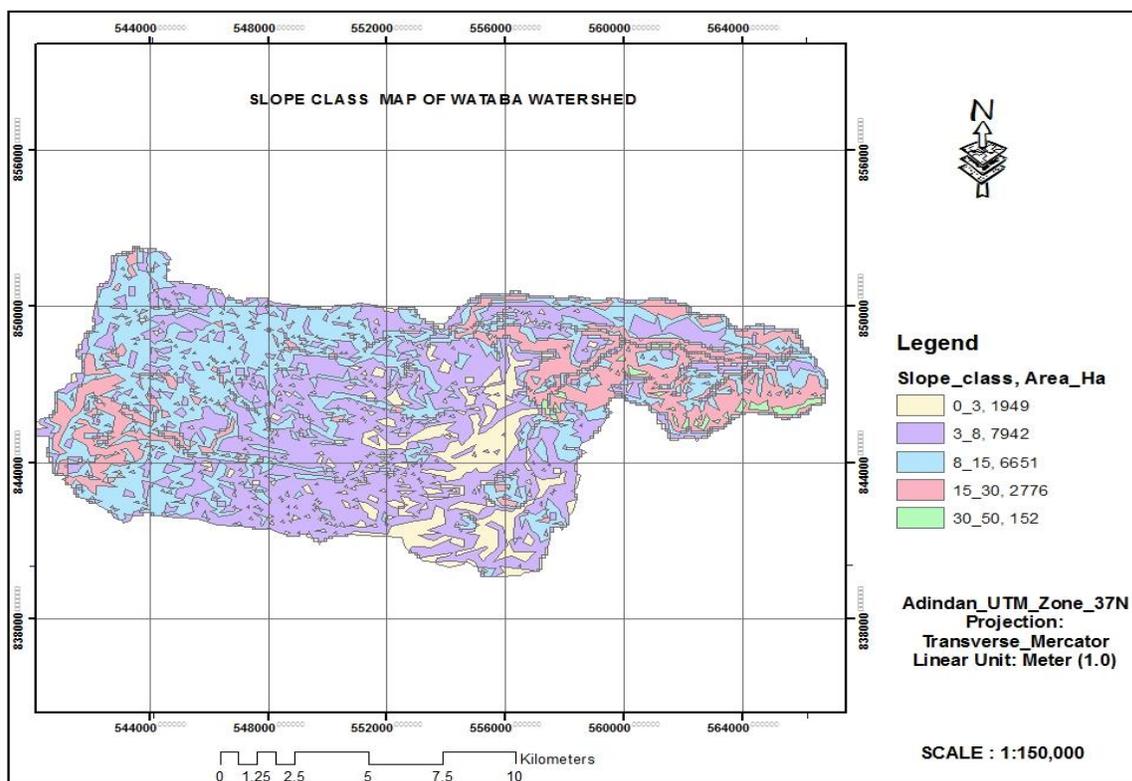


Figure 4. Slope classes and their distribution in Wataba Watershed

Table 1. Slope classes and their distribution in Wataba Watershed

S.No	Slope Gradient (%)	Slope Class	Area (Ha)	% percent
1	0 to 3	Flat or almost flat	1949	10.01
2	3 to 8	Gently sloping	7942	40.79
3	8 to 15	Sloping	6651	34.16
4	15 to 30	Moderately steep	2776	14.26
5	>30	Steep	152	0.78
Total			19480	100

Source: Computed in GIS, 2017.

3.6. Climate

3.6.1. Rainfall Distribution

The amount, duration and intensity of rain fall have a great effect over life on earth. Rainfall distribution is moderate and bimodal rainfall pattern where the two season merging together. The mean annual rainfall of the project area (as measured at meteorological station for the period of used for soil loss analysis are four stations such as Gobessa, Bedessa, Ticho and Bokoji Farm. This is the closest meteorological station to the project area, which is located at nearer areal distance from the project area.

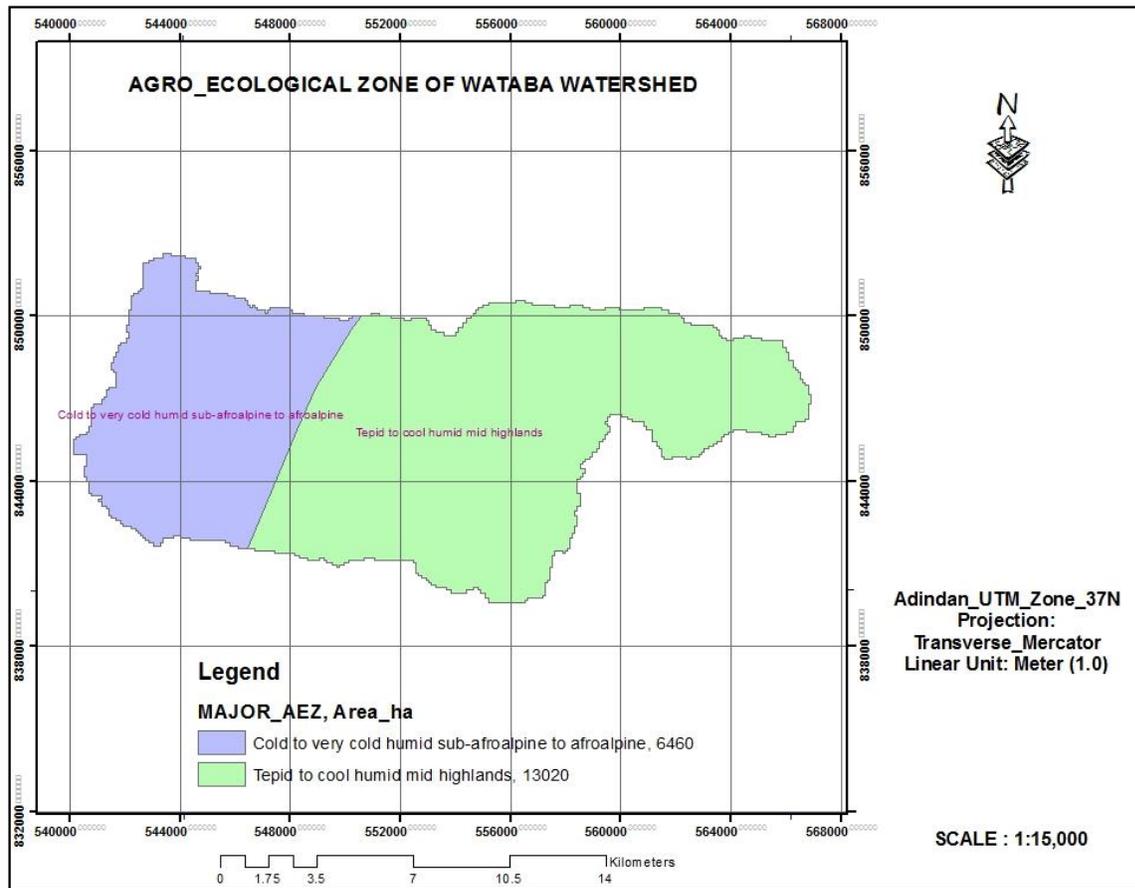
The monthly rainfall distribution is measured at station is a sort of bimodal where the main rainy season extends over the period of mid-June to mid-October with its peak in September. The area also experiences small peak during the period of March to May.

3.6.2. Thermal Zones

Temperature during growing period, which refers to the amount of temperature available for plant growth and development during the growing period, usually defined by the mean daily temperature during the growing period (Berhanu, 1999). Accordingly, the data of WoFED and WoANRD, the minimum and maximum temperature ranging between 20⁰c and 25.0⁰c respectively.

3.6.3. Traditional Agro ecological Zone of the Woreda

The Traditional Agro ecological zone of the project study Woreda fall 58% about the area of 13020ha within the Dega, and 42% about the of 6460a under classified Weyna Dega. Project proposed site and Watershed total included in almost 100% in Weyna Dega parts. According to the Ethiopian growing season classification, the watershed is characterized by its longest length of growing period (LGP), which is above 180_210days.



3.7. Soils

Formation of soil and its types can be varying from one geographical conditions to others. For example, mountainous and hill-side terrain, due to natural weathering of rock beneath the soil and formation of soil at the surface by decaying organic and inorganic materials caused by natural process on the upper stream, whereas the accumulation silt to the lower basin is due to deposition of sediment by surface runoff, and the sediment deposition in downstream substantially larger quantities than the formation of soil in situ. Some research finding indicates that globally the time required to form soil in situ/ upstream estimates vary widely, from less than 2 years to 750 years to form 1cm (Bouletal, 1973), with most estimates lying in the range of 100-400 years or between 0.8-3 tons/ha/year. However, it is agreed that the soil forms at much faster under farming. While the Bennett (1938) study indicated that tillage operation probably increase the rate of top soil renewal to mount 11 tons/ha/year.

Based on Ethiopian highlands reclamation study (EHRS, 1986), the formation of soil in the highlands of Ethiopia estimated to be 2-22 tons/ha/year. According the research finding, the formation of soil is very slow process, it takes between 200-1000 years to structure 2.5cm (1 inch) of top soil in crop land conditions, and even longer and on pasture and forest land conditions (Hudson,1981,OTA 1982, Lal 1984, Elwell, 1985).

Together with climate and terrain, soil conditions determine what agricultural production possibilities exist in a given area from a biophysical perspective. Soil erosion also depends greatly on the infiltration rate of soil. The infiltration rate again depends on the soil texture, structure, Rhumus and moisture content, soil depth and surface roughness. Recommendations regarding soil conservation structures used for rehabilitation of degraded lands are based on the aforementioned soil properties. Although the level of field verification of the soil associations is not intensive.

According to FAO/UNESCO soils classification, Major Soil type are Orthic luvisols Pellic vertisols, Eutric cambisols, Chromic luvisols, Eutric nitisols and Leptosols has been identified in the watershed.

Table 2. Soil type in Wataba Watershed

S.No	Soil type	Area _ha	Coverage _ %	Erodablity(K) value
1	Eutric cambisols	2880	15	0.15
2	Pellicvertisols	5389	28	0.2
3	Orthicluvisols	6518	33	0.15
4	Chromicluvisols	2677	14	0.15
5	Eutric nitisols	1504	8	0.15
6	Leptosols	512	3	0.1
Total		19480	100.00	

Source: GIS Computed data

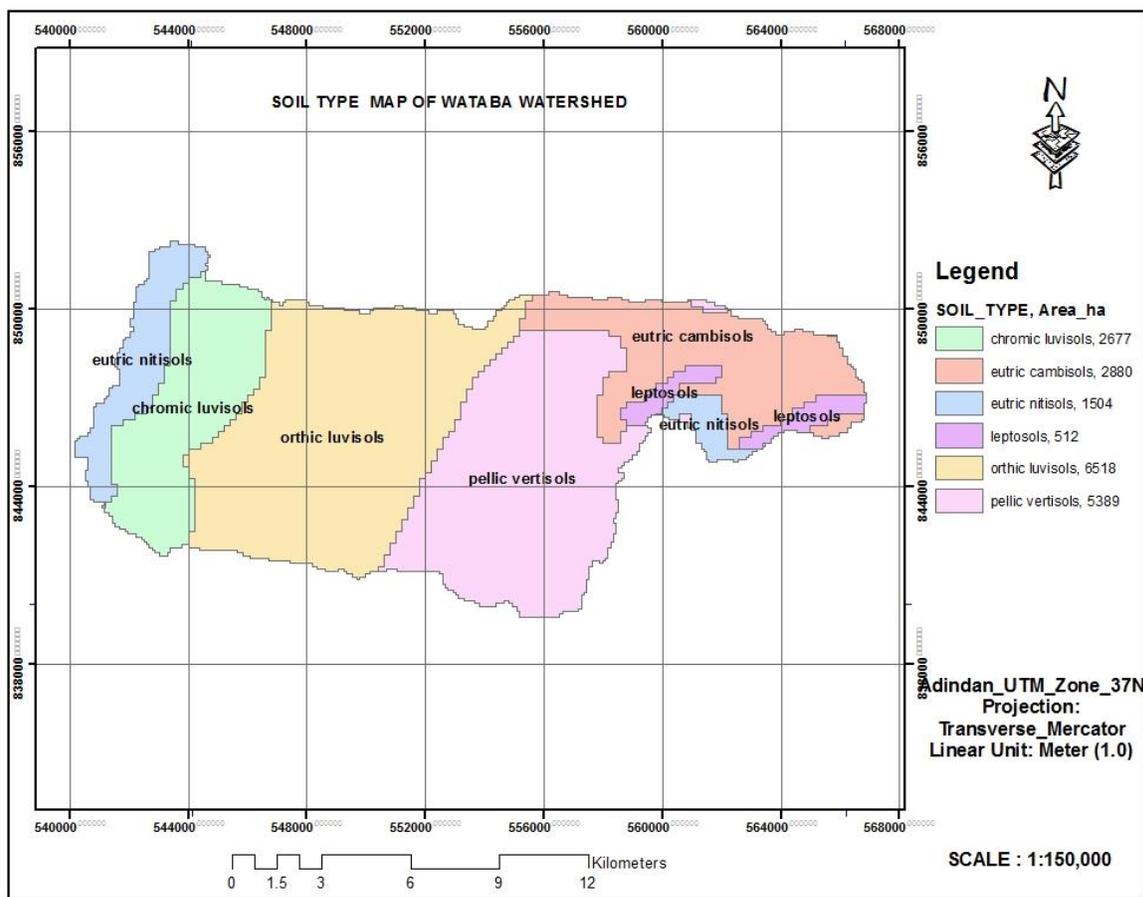


Figure 5. Soil type Map of Watershed

During the study, we observed that watershed has good vegetation coverage starting from the upper stream part to outlet area which is the main contributor for irrigation project sustainability of soil erosion point of view. Even though, the soil erosion was not acute problem in the watershed, the relief and slope characteristics with farming activities which directly related to expansion of cultivated land on hillsides in the upper stream, requires special attention of soil conservation measures. Therefore, to alleviate occurrence of soil erosion hazards and runoff problems proper biophysical soil conservation measures and implementation practices must be applicable.

3.8. Vegetation

Good vegetation cover has a positive effect on protection of soil from water and wind erosion. It also facilitates to infiltrate rain water to the ground, regulates evaporation rate from the ground surface and

also used as a mulch. Vegetation cover within the watershed area is diversified and faithfully reflects its climatic conditions and related altitudes. According to data obtained from Woreda agricultural office and field observation point of view the watershed with having very limited amounts of native tree species found such as: - *Cordia africana* (Wanza), *Juniperus procera* (Tid), *Ficus* Species(Shola), *Arundinaria alpine* (Kerkeha), *Podocarpus*, (*Zigiba*), *Croton macrostachyus*(Bissana), *Eucalyptus* spp.(Baher-zafe), *Prunes africanus* (Tikur- enchet) and etc

The major land use/cover descriptions of the watershed area are discussed as follows: -

- i. **Cultivated Land:** is defined as land used for the production of adapted crops (Lipton, 1995). It includes all arable land plus land under permanent crops (FAO, 1995a).
- ii. **Forest Land:** Land with tree crown cover (or equivalent stocking level) of more than 10 percent and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m at maturity in situ. May consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or of open forest formations with a continuous vegetation cover in which tree crown cover exceeds 10 percent. The percentage of dense cover varies with different approaches; however, generally, more than 60-70 percent of a defined area is covered by a certain vegetation layer (according to Eiten, 1968; adopted in the land cover classification, FAO, 1997a).
- iii. **Grazing/Open Grass Land:** Moreover, the land available for grazing animals; specifically, may refer to the land area for the animals of a particular stock owner or community herd (Reynolds, 1997). On the other hand, the grass land cover is defined as plant communities in which grasses are dominant, shrubs are rare and trees absent (Skerman&Riveros, 1990).

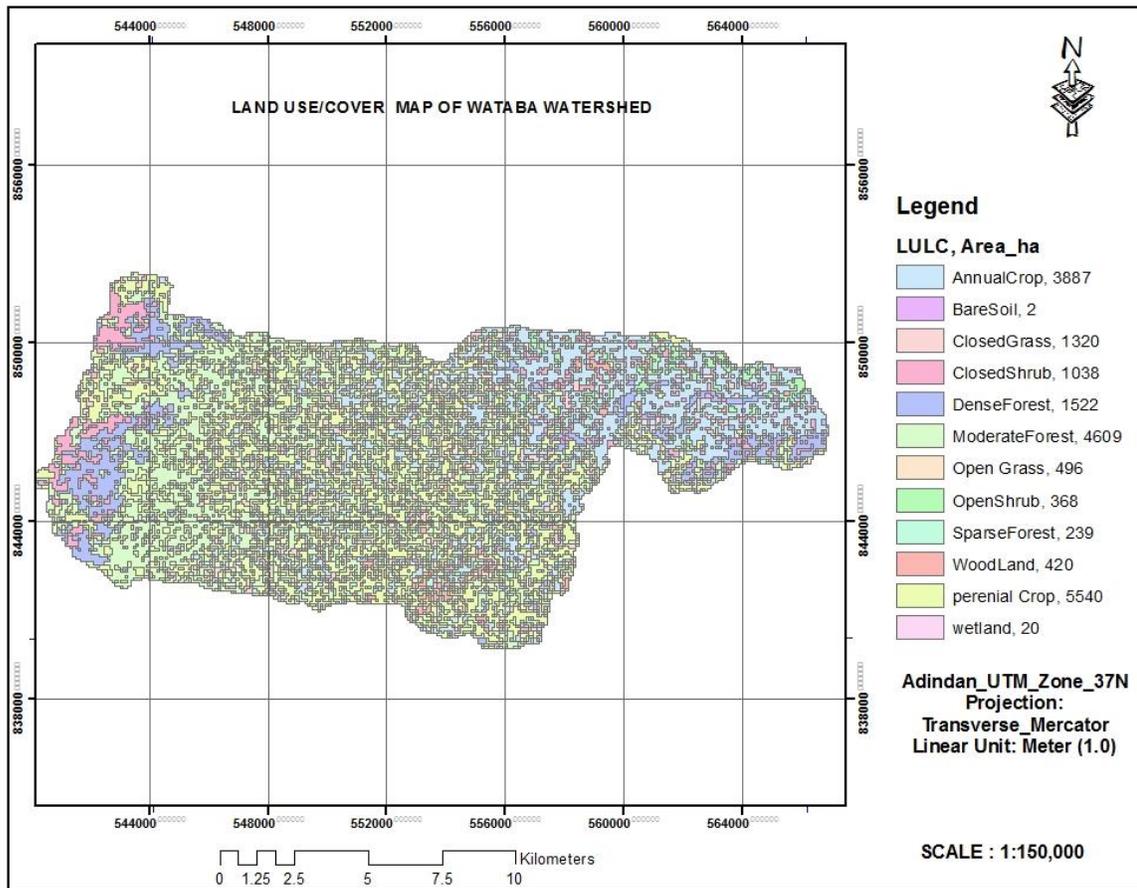


Figure:6.Land Use/Cover Map of watershed

Table 3. Land use/cover of Watershed

S.no	Types of land cover	Area	Coverage %
1	Moderate Forest	4609	23.68
2	Annual Crop	3887	19.97
3	Closed Grass	1320	6.78
4	perennial Crop	5540	28.47
5	Closed Shrub	1038	5.33
6	Dense Forest	1522	7.82
7	Sparse Forest	239	1.23
8	Open Shrub	368	1.89
9	Open Grass	496	2.55
10	Wood Land	420	2.16
11	Bare Soil	2	0.01
12	wetland	20	0.10
Total		19480	100

Source: GIS Computed data

4. Assessment of Soil Erosion and Conservation Activities

4.1. Assessment of Soil Erosion in the Watershed

4.1.1. Soil Erosion Rate Assessment

Erosion is defined as the removal of soil particles from the large soil mass and transportation or dislocation of soil particles in to downstream area by running water. Sheet and rill erosions are the most prominent features to almost all cultivated lands of highland watersheds in general and this watershed in particular. Though erosion is a subtle process, the hazard is clearly seen on cultivated lands. Major attention of this watershed study has also considered this fact to enable the intervention mechanisms effective in protection of the watershed natural resources before the resources are severely exposed.

Cultivated lands especially on the higher slopes suffer more than other land units. This can be observed by yield reduction. The quality of soil on higher slopes is more deteriorated and the color is lighter than the flat plains. Land unprotected by vegetation and cultivated steep slopes are susceptible to sheet and rill erosion.

Universal soil loss equation considers the five parameters as an input and gives an annual average soil loss of the area. The equation uses rainfall erosivity, soil erodibility, slope length and gradient, soil cover, and land management practices. This mathematical equation can be represented on physical based models in the ArcGIS environment. Each variable could be overlaid to make the overall spatial analysis.

The mathematical equation of the RUSLE is given by the formula:

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

Where:

A = Annual soil loss in tons/ha over a period selected for R;

R = Rainfall-Runoff erosivity factor in MJ. mm/(ha.hr);

K = Soil credibility factor in (t/h/MJ.mm);

LS = Topographic factor (L = S lope length and S = Slope gradient factor);

C = Land cover and management factor; and

P = Treatment/conservation practice factor

4.1.1.1. Rainfall Erosivity Factor (R)

The soil loss is closely related to rainfall partly through the detachment power of raindrop striking the soil surface and partly through the contribution of rain to runoff (Morgan, 1994). This applies particularly to erosion by overland flow and rills for which intensity is generally considered the most important rainfall characteristics. The most suitable expression of the erosivity of rainfall is an index based on kinetic energy of the rain.

There are different ways of analyzing the R factor. For instance,

$R = 9.28 * P - 8838$. Mean annual erosivity (KE > 25) where P is mean annual Precipitation [Morgan (1974) cited in Morgan (1994)]

$R = 0.276 * P * I30$. Mean annual EI30, where P is mean annual precipitation [Foster et.al (1981) cited in Morgan (1994)]

$R = 0.5 * P$ (in US unit) and $R = 0.5 * P * 1.73$ (in Metric unit). [Roose (1975) cited in Morgan (1994)]

The first equation appears to work well for Peninsular Malaysia, whereas the application for other countries is less satisfactory. Especially with the annual rainfall below 900mm, the equation yields estimates of erosivity, which are obviously meaningless (Morgan, 1994). The second equation needs the value of I30 for calculating erosivity factor, which is difficult in our context.

However, rainfall kinetic energy and intensity data are not available most cases. Therefore, the erosivity factor R was calculated according to the equation given by Hurni (1985), derived from a spatial regression analysis (Hellden, 1987) for Ethiopian conditions based on the easily available mean annual rainfall (P).

It is given by a regression equation:

$$R = -8.12 + 0.562 * P$$

$$R=726$$

Where: R= Rainfall erosivity factor, and P= 1291 mean annual rainfall in mm

Rainfall Erosivity (R) for our watershed is computed through long year rainfall data analysis of the nearby Bokoji farm, Bedessa, Gobessa and Ticho national meteorology station; which is nearer distant of watershed center.

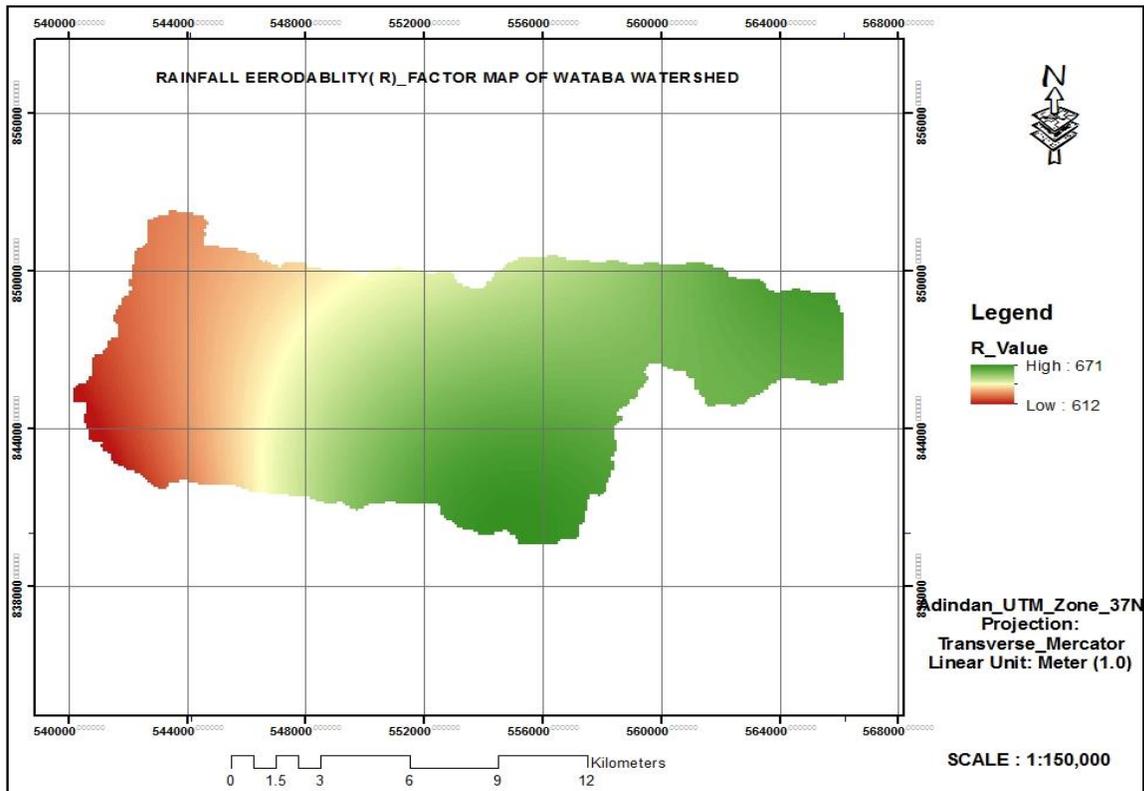


Figure:7.Erosivity(R) Factor Map

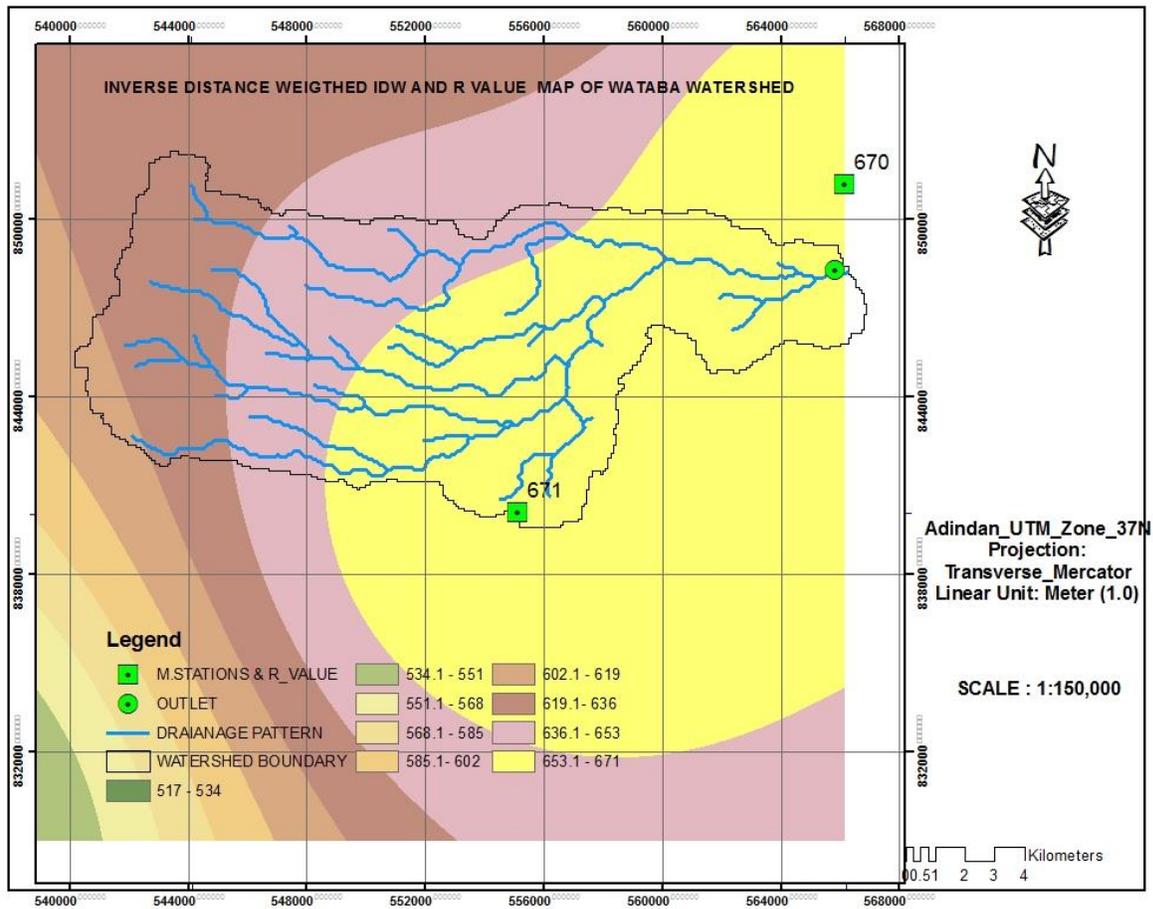


Figure 8. Inverse distance weighted (IDW) map of Wataba watershed

4.1.1.2. Soil Erodibility (K)

The Soil Erodibility factor characterizes more or less the soil sensitivity towards erosion force (Wischmeier and Mannering, 1969, Blume, 1992); or it 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 50 and 22 m length (Morgan, 1994). The value of K ranges from 0 to 1. The LUPRD, supported by FAO, 1984 adopts and estimates the Erodibility value of different soil types. Therefore, the Erodibility value of the study area was adopted from FAO study as tabulated below.

Table:4. Erodibility Value of soil units adopted in Ethiopian Condition

S/No	FAO soil unit	K- value	S/No	FAO soil unit	K- value
1	Orthic acrisol	0.15	16	EutricCambisol	0.15
2	Dystric Nitosol	0.15	17	DystricCambisol	0.15
3	Dystric Fluvisol	0.1	18	HumicCambisol	0.1
4	Eutric Gleysol	0.15	19	GleyicCambisol	0.15
5	CalcaricGleysol	0.1	20	CalcaricCambisol	0.15
6	DystricGleysol	0.15	21	Chromic Cambisol	0.15
7	HumicPlanosol	0.15	22	EutricNitosol	0.15
8	SolodicPlanosol	0.2	23	CalcaricFluvisol	0.1
9	Ochric Andosol	0.15	24	HumicNitosol	0.1
10	Molic Andosol	0.1	25	LuvicXerosol	0.2
11	Humic Andosol	0.1	26	EutricFluvisol	0.15
12	Vertic Andosol	0.15	27	FerricAcrisol	0.15
13	PellicVertisol	0.2	28	HumicAcrisol	0.1
14	Chromic Vertisol	0.2	29	PlinthicAcrisol	0.2
15	Orthic solonchak	0.15	30	Gleyic Acrisol	0.15
16	Orthic Luvisols	0.15	17	Chromic Luvisols	0.15

[Source: FAO 1989. Reconnaissance of Physical Land Evaluation in Ethiopia]

The soil class of this watershed are Orthic luvisols as discussed earlier. Therefore, according to FAO soil class, its erodibility value 0.15 were taken to estimate total annual soil loss of the project area. In the figure 6 below show that soil erodibility factor map of Watershed.

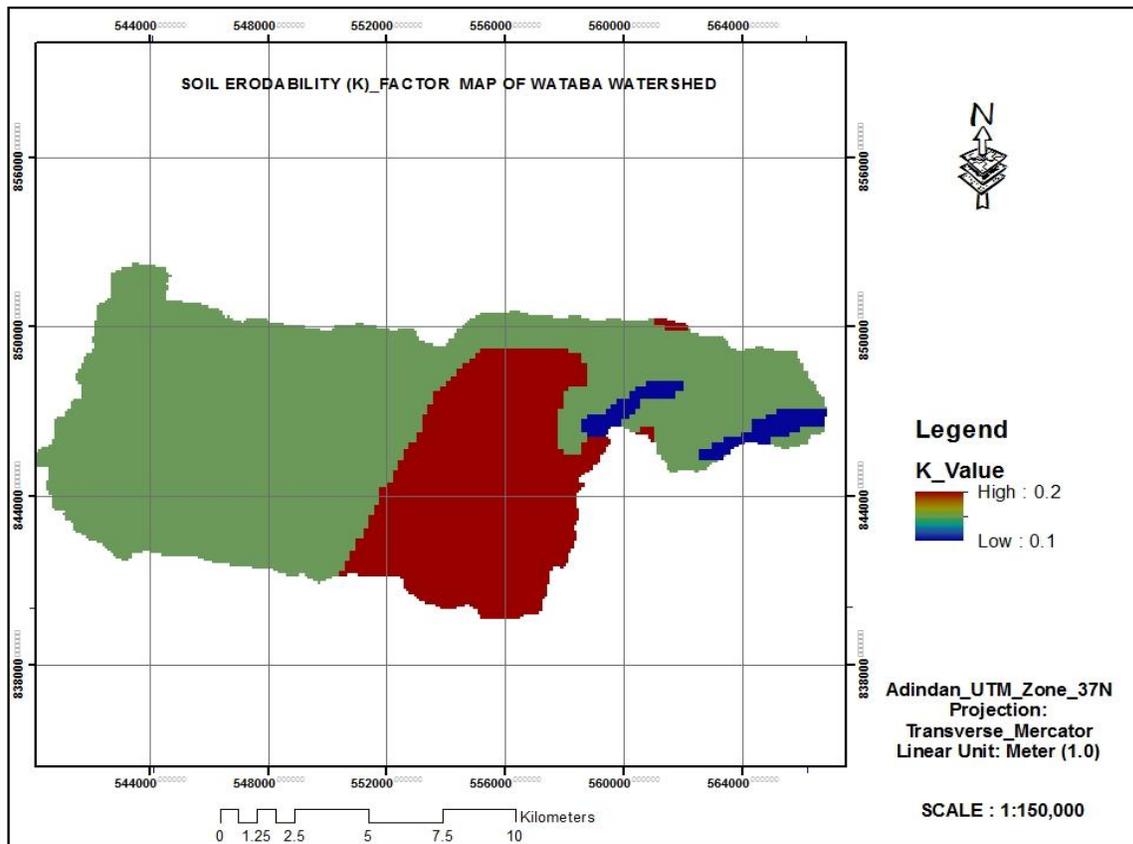


Figure 9. Erodability Factor Map of Watershed

4.1.1.3. Slope Length and Gradient Factor (LS)

The **LS** characterizes the effect of topography on erosion in USLE. By using DEM with finer resolution, it is possible to calculate both slope length ‘L’ and slope gradient ‘S’ rather than having to use as has been the case in the past, resulting in far greater accuracy than in previous assessments (Wischmeier and Smith, 1978). The slope length and gradient factors are estimated from DEM data in the ArcGIS environment. The technique described here for computing LS requires a flow accumulation grid layer and slope grid layer. The flow accumulation can be computed from the hydrological corrected DEM using Global Map per v15.0. Flow accumulation grid represents number of grid cells that are contributing for the downward flow. The cell size of the DEM represents the length of the cell.

$$L_S = \phi * ([Flow.Acc] X [cell size]) / 22.13, 0.6 X \phi * ((\sin [slope]) X 0.01745) / 0.09, 1.3$$

Where:

Cell size- represents the field slope length, and 22.13 is the length of the research field plot where the equation was derived.

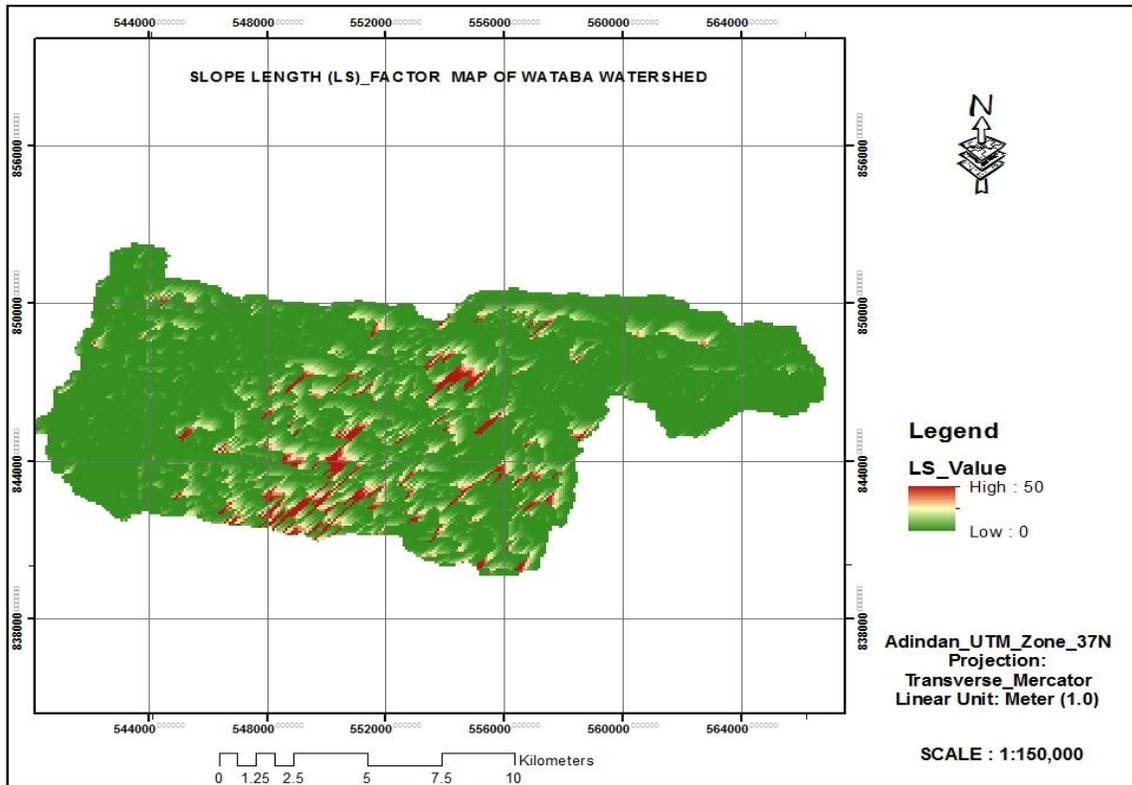


Figure 10. Slope length factor Map of watershed

4.1.1.4. Land Cover Factor (C)

The Land Cover/Land Use factor (C) represents the ratio of soil loss under a given land cover/land use to that of the base soil (Morgan, 1994). The land cover factor is also calculated for each mapping unit of a project area using the land use/cover map as an input. Each cover value of the project area would be synchronized with the adopted C value in Ethiopian condition.

Land use and land cover often used interchangeably, but the distinction between land use and land cover is an important one. Land use refers to the actual economic activity for which the land is used- food production, commercial forestry, and etc. Land cover refers to the cover of the surface of the earth. Examples of land cover classes include: water, snow, grassland, deciduous forest and bare soil without the reference how the cover is used. In many cases, land use and land

cover are directly related; for example, grass (land cover) may generally be used for livestock grazing (land use). Some classified maps include a mix of land cover and land use. However, the land cover factor used for this watershed analysis is the one adopted for our country’s conditions as tabulated below.

Table 5. Adopted land cover values applied to Watershed

No	Land Cover/Use class	Source	C- factor
1	Forest	Hurni, 1985	0.01
2	Shrub land	CGIP,1996	0.02
3	Grass Land	CGIP,1996	0.01
4	Dense grass	Hurni, 1985	0.01
5	Degraded grass	Hurni, 1985	0.05
6	Crop land/ wooded crop land	CGIP,1996	0.15
7	Crop land, Teff as a main crop	Hurni, 1985	0.25
8	Crop land, cereals, pulses	Hurni, 1985	0.15
9	Crop land: wheat, barely	CGIP,1996	0.15
10	Crop land: sorghum, maize	Hurni, 1985	0.10
11	Afro-alpine	BCEOM,1998	0.01
12	Open scrub land	CGIP,1996	0.06
13	Bush land	BCEOM,1998	0.1
14	Bare land	BCEOM,1998	0.6

The C value; of this watershed was assigned using the land cover map of the watershed and inferring the table of the C-values of the previous study. Most of the cultivated land in the lower part of the watershed was covered with cereals, wood crops etc. with moderate agronomic management. Generally considering all possible existing situations, the C-value of the catchment area as provided in the table 11 below.

Table 6. Land Cover (C) value of Watershed

S.no	Area		C_Value
	LULC	Ha	
1	Moderate Forest	4609	0.01
2	Annual Crop	3887	0.25
3	Closed Grass	1320	0.01
4	perennial Crop	5540	0.15
5	Closed Shrub	1038	0.02
6	Dense Forest	1522	0.01
7	Sparse Forest	239	0.01
8	Open Shrub	368	0.06
9	Open Grass	496	0.05
10	Wood Land	420	0.15
11	Bare Soil	2	1
12	Wetland	20	0.01
	Total	19480	

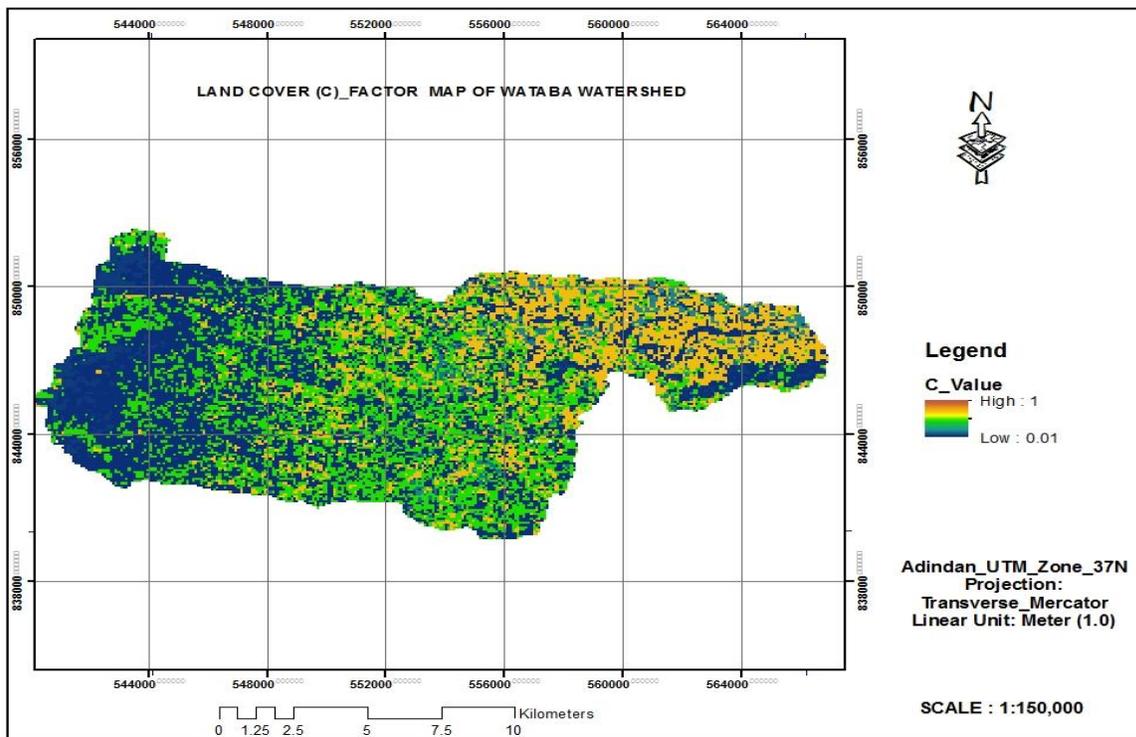


Figure 11. Land Use/Cover factor Map of watershed

4.1.1.5. land management practice (P)

The land management practice (P) value, is also one factor that governs the soil erosion rate. The P-value ranges from 0 to 1 depending on the soil management activities employed in the specific plot of land. These management activities are highly depending on the slope of the area. Wischmeier and Smith (1978) calculated the P-value by delineating the land in to two major land uses, agricultural land and other rural land use. Further, agricultural land sub-divided in to four and the later considered as unity bearing in mind that this upstream part of the watershed have the steepest slope and thus the slope percent to assign different P-value as provided in table 12 below.

Estimation of the P factor, for the study area, was carried out taking in account the local Conservation practices which was located during the field survey. In agricultural lands of the study area, particularly in the highland parts of the catchment, farmers plough their farmlands in all directions, i.e. both along the contour or perpendicular to the slope with ox drawn ploughs. They construct drainage ditches in crop fields along slopes to reduce run-off. The value of P factor was` assigned to cultivated lands based on the adopted P-value by Hurni (1985).

Table 7. P- Value Land management applied for Watershed

Land Cover	Slope	Factor
Dense Forest	3-8%	0.8
	8-15%	0.8
	15-30%	0.8
	30-50%	0.8
	>50%	0.8
Moderate Forest	0-3%	0.8
	3-8%	0.8
	8-15%	0.8
	15-30%	0.8
	30-50%	0.8
	>50%	0.8
Sparse Forest	0-3%	0.8
	3-8%	0.8
	8-15%	0.8
	15-30%	0.8
	30-50%	0.8
	>50%	0.8
perennial Crop	0-3%	0.9

	3-8%	0.9
	8-15%	0.9
	15-30%	0.9
	30-50%	0.9
	>50%	0.9
Grass land	0-3%	0.8
	3-8%	0.8
	8-15%	0.8
	15-30%	0.8
	30-50%	0.8
Woodland	>50%	0.8
	0-3%	0.8
	3-8%	0.8
	8-15%	0.8
	15-30%	0.8
	30-50%	0.8
	>50%	0.8

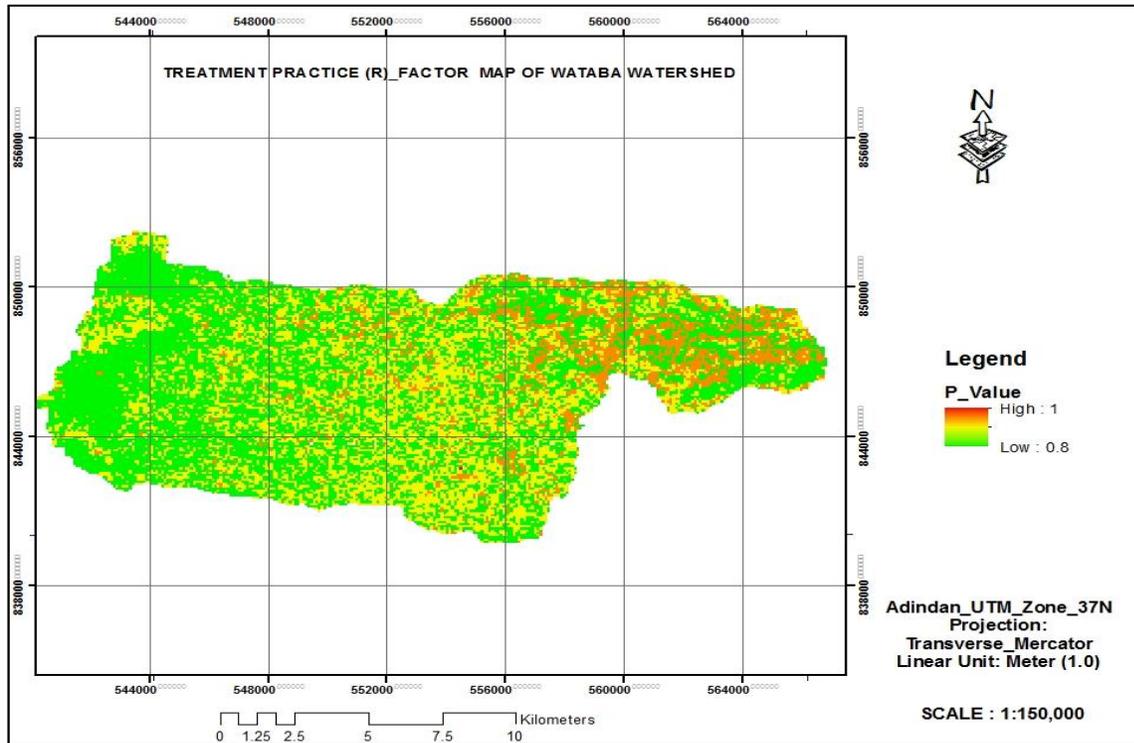


Figure 12. Land management [P]_ Factor map of Watershed

4.1.1.6. Annual Soil Loss Estimate of Watershed

Even if, erosion is a natural process, there is an option to minimize its effect but difficult to control. Therefore, it is advisable that the loss/erosion rate should not greater than the soil formation rate. Hence, it is important to set the allowable soil loss rate; it is the rate of soil removal in which its effect not affects plant growth and yield.

Soil loss tolerance refers to the maximum rate of soil loss can be tolerated without decline in economic productivity. However, the question of what level is tolerable depends on the situation of soil types and depth, its rate of formation, land use/cover, topography and so on. All the five parameters of soil loss assessment were computed using Arc GIS 10.3 geospatial database and Microsoft access database. Mean annual soil loss of Wataba watershed was computed by Raster calculator tool of Arc GIS. According to Rose (1994), annual soil loss tolerable limits in the tropical region estimated as 10t/ha/yr. Hurni (1986) estimated the soil loss tolerance level for the different agro ecological zones of Ethiopia to be the range 1-16t/ha/yr. According to both Hurni and Rose, the mean annual soil loss (10t/ha/yr) of the project study area falls in tolerable levels and almost 89% (18,482ha) of watershed. Therefore, there no sedimentation problem at all.

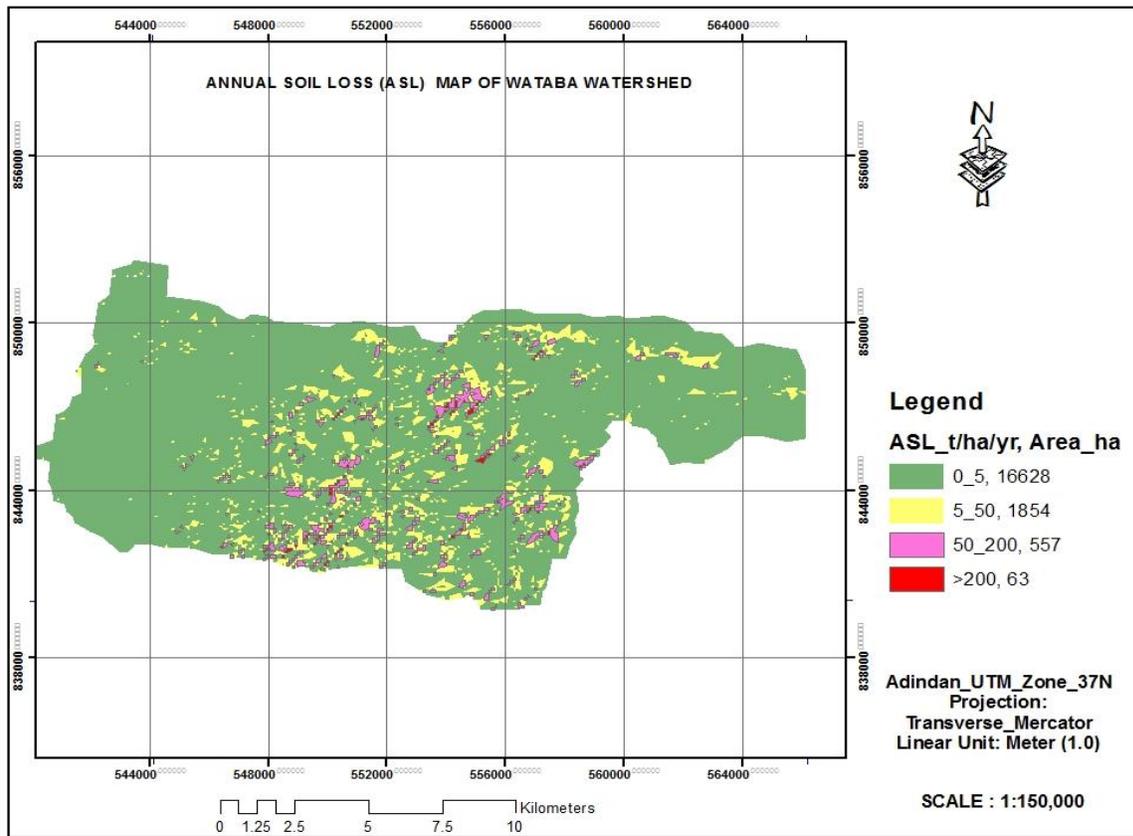


Figure 13. Annual Soil Loss Rate, extent & distribution map of Watershed
 According to this result GIS computed value, the minimum and maximum annual soil loss in the project are 0 and 886t/ha/yr. respectively. The greater watershed area from total catchment fall under tolerable soil loss area (8t/ha/yr) about 18,482%.

4.1.2. Erosion Hazard & Severity of Soil Erosion

Mapping of erosion hazard risk is useful for rapidly identifying and pre-selecting areas that needs to be given priority in SWC works and/or for the watershed management planning. For purposes of prioritization this exercise out puts should be used combined with soil erosion assessment discussed in previous sections of this report. According to LUPRD study; FAO 1984, the soil loss of watershed is classified in to three main classes as provided in table 15 below.

Table 15: Soil Loss rate table of watershed

S.No	Soil loss class	Soil Loss (t/ha/yr)	Area (ha)	Coverage (%)
1	Very slight to Negligible	0-5	16628	84.0
2	Slight of Moderate	5-50	1854	9.7
3	Severe	50-200	757	3.9
4	Very Severe	>200	163	0.9
	Sum		19480	100.0

The erosion rates computed with the aid of this model are to be understood as a relative value (R.G. Schmidt, 1988) they can be used as a measure of the susceptibility of a given section of the landscape to soil erosion

None to Slight rates of soil erosion (0-10t/ha) is cover the almost Major area of watershed, as seen from the erosion rate distribution map as well as the table above. As already discussed in land use/cover parts earlier, these land plots are more Shrub land with wooded/forest lots and some of the agro-forestry dominated areas of particularly the upstream catchment. Therefore, the risk of erosion is probably safe otherwise management & protection of those existing resources has got the fundamental attention.

4.1.3. Sediment Yield Estimation

Most of time, in diversion projects sediment transport estimation may not be such much important. Even though, it tells us how our top soils are being eroded by running water. Due to lack of data, area factor is only considered to estimate sediment yield.

Taking density of mineral soil as 1.65 ton/m³

Total soil loss in tons/yr is equal to Catchment Area *(Soil loss [tons/ha/yr])

$$TSL = 19480ha \times 8 t/ha/yr = 155,840t/yr$$

$$\text{Estimated rate of erosion} = (155,840t/yr) / (1.65 t/m^3) = 94,448m^3/yr.$$

$$\text{Soil loss in depth} = (94,448m^3/yr)/(194,800,000 m^2) = 0.48mm/yr$$

By considering the area factor, the sediment yield can be calculated as follows:

$$\text{Area factor } (A_f) = \frac{1}{A^{0.2}}$$

Where:

A = area of watershed in hectare;

The area factor will be;

$$A_f = \frac{1}{A^{0.2}} = \frac{1}{(19480)^{0.2}} = 0.138$$

Therefore, the sediment yield can be calculated as;

$$\text{Sediment Yield} = [0.138 \times 94,448m^3/yr] = 13,128m^3/yr$$

5. Identification and Prioritization of Erosion & Land Degradation Problems in the Watershed

5.1. Identification of Soil Erosion & Land Degradation Problems

Watershed management as a common problem in Ethiopia, it is characterized by land degradation, deforestation, over grazing and inappropriate farming practice. According to the soil erosion rate/risk assessment results which are presented earlier, about 5% of this watershed requires immediate physical and biological SWC works strongly. However most of these endangered plots are within the downstream part of the watershed, it should be understood that a watershed is a natural entity of great interaction all in water balance, land mass movement and other natural environmental processes.

As observed with the watershed management field survey, land degradation and fertility losses in the catchment is mainly attributed to the following major factors:

- Removal of forest trees and bushes away from steep landscapes,
- Open grazing in steep slopes & pressure (burden) of grazing,
- Expansion of cultivation due to population pressure/density particularly in higher altitudes.

5.1.1. Removal of forest trees and Open grazing

The removal of forest cover due to all the cultivation, over-grazing & fire wood collection particularly in those undulating landscapes has got a leading role in the process of enhancing accelerated environmental degradation in the catchment. As a result, most of the hills and steep valleys of the drainage system are bare and heavily degraded. Rehabilitation works through area closure, certain physical & considerable efforts of biological SWC measures are strongly recommended.

5.1.2. Soil Erosion and Land Degradation

Moderate rate of soil erosion by water is identified on higher elevated part of the catchment approximated to 2% of the total watershed. In other hand, the risk of expansion of the current situation must also be more attention seeking. Currently, most of the soil erosion and land degradation problems in the watershed are related to:

- Much steeply valley dominant landscape of the catchment,
- Lack of responsibility from local administration & farmers with regard to the natural resource protection and land use on higher steep area in upstream of watershed.

5.2. Prioritization of Soil Erosion & Land Degradation in the Watershed

Merely due to their direct dependence on natural resources for survival with very few resources to counteract the negative impact of environmental change, local farmers are the first who would face challenges due to the land degradation. As a result, strong awareness creation plans are mandatory to improve their income level and alleviate poverty in a sustainable manner managing the local natural resource there. In line with such intervention, accessing them to rainfall-independent crop production through environment friendly small scale irrigation technology would have a vital role to strengthen their production economy.

Based on distribution and severity of degradation problems in the watershed, the first remedial solution is to conserve and protect those plots with undisturbed forest coverage which are nil and slightly prone; to bring sustainable development that considers both human welfare and environmental conditions.

6. Description for Hydrologic Conditions and Hydrologic Soil Groups

- ✚ **Land use:** Generally, the watershed divided basically into four land use / cover, which express the crops, grazing, forest & other lands. The land use / land cover is offered, in the first column of table below with a choice of two or three appropriate soil conservation practices, contouring, terracing & straight planting based on the existing watershed characteristics.
- ✚ **The Hydrologic conditions of the watershed/ catchments/:** can be graded good, fair, or poor based on the land use types for cultivated land; the hydrologic conditions reflect whether the rotation will encourage infiltration and promote a good tillage. Poor rotation is when we plant crops at the same field and growing continuously for many years. Good can reflect that growing within the catchments areas different types of crops in different years/ seasons. This will help for good water infiltration rate & better fertility enhancement of the soil. Fallowing also helps and more encourages regulating the vegetation cover and increment of soil fertility.
- ✚ **Grazing land:** - This can be categorized in the watershed areas based on alienist of repetition cover, for example the hydrologic condition is good when the grazing land is lightly grazed and more than 75% of the area with plant cover. For Fair hydrologic condition pasture land is moderately grazed, 50 to 75% of the area with plant cover. Heavily grazed land or no mulch with the area coverage less than 50% is Poor hydrologic soil group.
- ✚ **Farm/wood lots/:** Poor wood lots are heavily grazed or regularly burnt in manner that destroy litter, small trees and bush. Lots fair woods are grazed but not burned. Lots of wood may have some litter but usually not protected from gazing. Good woods lots are protected from grazing, so that litters and shrubs cover the soil.

7. Major Problems of the Watershed and related research findings on soil erosion.

Major problems of the area are summarized in to soil erosion and consequent land degradation, loss of vegetation cover, poor soil fertility, high population pressure and other socio economic problems. Soil erosion is generally more acute problem in the watershed area due to high rainfall intensity and soils erodible characteristics to the relatively depth and low structural stability.

Including the above mentioned problems, Rapid population growth, cultivation on steep slopes, clearing of vegetation and overgrazing are the main factors that accelerate soil erosion in watershed. Such unsustainable and exploitative land use practices due to an increasing demand for food and fodder by the growing human and livestock populations are responsible for accelerated soil erosion in many parts of the watershed area. Those practices reduce the protective plant cover, thereby exposing the soil surface to the destructive impact of high-intensity rainfall.

7.1. Identification of Soil Erosion & Land Degradation Problems

Watershed management as a common problem in Ethiopia, it is characterized by land degradation, deforestation, over grazing and inappropriate farming practice. According to the soil erosion rate/risk assessment results which are presented earlier, about 8% of this watershed requires immediate physical and biological SWC works strongly. However most of these endangered plots are within the downstream part of the watershed, it should be understood that a watershed is a natural entity of great interaction all in water balance, land mass movement and other natural environmental processes.

As observed with the watershed management field survey, land degradation and fertility losses in the catchment is mainly attributed to the following major factors:

- Removal of forest trees and bushes away from steep landscapes,
- Open grazing in steep slopes& pressure (burden) of grazing,
- Expansion of cultivation due to population pressure/density particularly in higher altitudes.

7.2. Prioritization of Soil Erosion & Land Degradation in the Watershed

Merely due to their direct dependence on natural resources for survival with very few resources to counteract the negative impact of environmental change, local farmers are the first who would face challenges due to the land degradation. As a result, strong awareness creation plans are mandatory to improve their income level and alleviate poverty in a sustainable manner managing the local natural resource there. In line with such intervention, accessing them to rainfall-independent crop production through environment friendly small scale irrigation technology would have a vital role to strengthen their production economy.

Based on distribution and severity of degradation problems in the watershed, the first remedial solution is to conserve and protect those plots with undisturbed forest coverage which are nil and slightly prone; to bring sustainable development that considers both human welfare and environmental conditions.

7.3. Some descriptions and relevant research findings on the soil erosion.

The highland part of the southern region is an ancient and clearly able to be seen uplifted of earth's surface, which may have virtual of their location, have constantly been associated by normal erosive forces and its soil formation. Erosion problems basically soil and water are the most serious limiting factors for agricultural productions and effective utilization of the resource bases, such as soil, water, and vegetation's for sustainable base for generations of generations.

Mountains topography of the river basin with steep and rugged landscape conditions, supplemented with fragile and delicate ecosystems needs wise agricultural practices and agro-ecologically sounded soil and water management measures and its implementation techniques.

Soil erosion by water usually occurs due to complex interactions of sub-processes of detachment and transport of soil materials by raindrops impacts and over land flow deposition. Mainly soil erosion consists of two principles of sequential events: - that is the detachment of soil particles from the soil mass and the entertainment/pursuit of the detachment particles (Young and Wireman, 1973).

Raindrops are the most important agents in detaching soil, because of their impact on the soil surface, while surface runoff is a principal agent in transporting detachment particles.

The process of soil erosion is determined by several factors including rainfall erosivity soil erodibility, land form and land management practices (Hudson, 1997). Among these, rainfall erosivity, soil erodibility and land form represent the inherent characteristics of the watershed. Erosivity is the potential capacity of rainfall to cause erosion and it depend on the intensity, duration and frequency of rainfall. Erosion by water and wind adversely affects soil quality and productivity by reducing infiltration, water holding capacity, nutrients, organic matter, soil biota and soil depth (OTA, 1982, El-swafty et.al, 1985).

Finding indicated that, annual soil loss of Ethiopian estimated to be around 1.5-3 million tons per year from main river basins, from this 50% occurs in crop lands, whereas soil loss can reach up to 296 tons/ ha/ year on steep slope catchment (FAO, 1986, SCRIP, 1987).

According to different studies, soil erosion problem occurs on cultivated land, in the regional level as well as on the study area in two relatively short and specific periods- April to June, with a peak rain fall in April, and July to September, with a peak rainfall in August. Due to less vegetation cover for the soil, because they are only on seed bed or early establishment stages of crop growth and consequently sever erosion take place on these months. (Belay, 1992)

Hurni (1986) also find that, the soil erosion problems highly pronounced in the months of March to May due to plowing at the sometime vegetation cover on those months usually very low and the lands are exposed for erosion.

The soil conservation research data also shows that the greatest erosion hazard on crop lands occur, when the soils are exposed prior to planting and early plant growth. Other accelerative factor's is intensive cultivation/ up and down plowing for cereal crops, mainly in Teff fields, the soil erosion severity becomes higher. Where as in well vegetated and grass cover lands are less eroded comparing the land cover with cereal crops.

Consequence of population pressure with fragmented land holding system, associated by expansion of agricultural lands through clearing of forest and bush lands contribute for vulnerability of soil erosion and forest deterioration of the project study areas. Similarity, the

project study area, characterized as mountainous topography, undulating to rolling landscape conditions coupled with traditional land use practices persists to hasten soil erosion and land degradation problems of the watershed.

Soil erosion is a cause of soil erosion loss and land degradation. Both water and wind erosion can contribute the considerable erosion problems in the watershed. In our project causes, rainfall is main factor for soil erosion. During the heavy rainfall seasons there is high probability of sever soil loss from mountainous and hillside terrains of the basin/ upstream/ and this accelerates to surface runoff which leads sediment depositions to the downstream which is proposed command area for irrigation.

The net loss was estimated at 2% only, the rest being deposited at the lower edges of the fields in grassland, in the forest, and along the valleys. However, on bare soils plot, erosion rate was as a high 293 t/ha/year.

Comparison study between treated and untreated catchments, indicating the strong correlation between soil loss and rills developed.

7.4. On Site Effects of Erosion

Due to shortage of agricultural land for cultivation, most of the population and their animals are insisted to live in the uplands of the basin. Also the agricultural activities are under taken within is geographical location. Despite to that the soil mechanical movement more activated on this circumstance.

Topographic conditions, continuous cultivation without rest and traditional agricultural practices with limited soil and water erosion measures, over grazing and landslides, these all enhanced to vulnerability of soil erosion and forest deterioration. From the upper streams it carries the fertile top soil with runoff water to the downstream of the catchment. During the heavy rain seasons it may carry boulders to the downstream proposed pump site for irrigation. There for recommended soil and water conservation measures should be applicable during the project implementation phases.

The conservation based agriculture itself needs sufficient land to manage in proper way and simultaneously it requires money and labor to run mainly physical, mechanical and biological conservation works as well as needs skilled man power to these things into practices.

7.5. Downstream Effects of Erosion

Even though, deposition of sediment has negative effects, it has positive effect and have a benefit to downstream in the containing of nutrient silts which helps to increase productivity in the soils. The negative effects are it accumulate excess sediments in the river, intensifying stream bank erosion and flooding, often leading irreversible loss of cultivated lands and settlement areas.

7.6. Over Grazing

Erosion does not appear in distinct forms, if over grazing is avoided and the grass cover is well maintained with ordinary grass management. With harsh grazing, the Variety of species in the vegetation is reduced, the soil will become thinner and lower, and its soil protection varnishes.

Over grazing leads to reduction of carrying capacity the canopies of vegetation, reduction of palatable plants with its nutritive value. Erosion on grazing land develops differently on normal cultivated land. Where the erosion features are obliterated by cultivation with heavier grazing, the varieties of the species in the vegetation reduced, the soil becomes shallow and fertility lower, and its protection effect minimized.

Although the share of responsibility on the part of other influences, such as fuel wood harvesting, suppress/ smother of natural fire cycle, wildlife degradation and conversation of range lands to crops land or human settlements, etc. has been emphasized in subsequent UNEP publications (WRI, 1994), over grazing has been considered the most important factors and it highly seen in the project area.

In the future to regulate overgrazing problems in the vicinity, rotational gazing/pad- docking /system development is very important. To regulate over grazing problems in the watershed areas, introducing to the farmers a good varieties of animals breeds by crossing with local once or use artificial inseminations for the best selected livestock species.

7.7. Deforestation

Deforestation has been one of the major factors contributing to land degradation through exposing of the soil for various form of erosion, such as sheet, rills, and gully and wind erosions. Forests, apart from their short term to long term positive effects on weather & climate conditions, it is the basic stabilizer not to remove soil by erosion, and regulate water potential in the ground surface as a foundation of streams, rivers and lakes.

Forest degradation does not simply mean the loss of vegetation cover, it can mean altered local or regional hydrology, altered climate and serious offsite impacts, such as: flood damage and depositions of sediment to the downstream and it causes ecosystem disturbance of the surrounding Environment.

Poor leaving standard, land shortage land for cultivation, fragmented land holding system, traditional way of farming system with low agricultural productivity were the main cause of land degradation and forest deterioration of the river basin.

The mountainous topography, undulating to rolling landscape conditions coupled with traditional land use practices persisted to accelerate soil erosion and land degradation problems of the Wataba watershed. Population pressure with fragmented land holding system, associated by expansion of agricultural lands through clearing of forest and bush lands contribute for vulnerability of soil erosion and forest deterioration of the upper watershed areas of the basin.

The research findings indicate that, our country is losing 200,000 hectares of forest every year as a result of fire and forest clearing. Due to extend dry seasons out breaks of forest occurred and therefore, special attention and mechanism should be under taken in order to protect it.

Some research findings Relation to soil loss rate and severity of soil erosion on land use type summarized as follows:

- ✚ At the National level, estimated an average soil loss of 42 t/ ha/year in cultivated lands
- ✚ The maximum of 300- 400 t/ha/year on highly erodible and intensively cereal cultivated fields
- ✚ Estimated average erosion on currently unproductive crop land and crop land planted cultivated and crop land planted on annual crops are 70 t/ha/ year and 42t/ha/year respectively, while it averages 8t/ha/year on land planted to perennial crops and 5t/ha/year or less for all other land cover types.

8. The Conservation Measures conducted in the watershed area.

The Woreda Agricultural and Natural Resource Development office under its Natural Resources Development, Conservation and Utilization key process owner carried out the following major soil and water conservation activities. Bio-physical Conservation Measures such as soil bund, 590 terrace 44, faanya-juu, 158.6, trench 245, check-dam and waterways 55.16, planting pits 1,79000 million have developed by community participation with government in Wataba watershed kebele and Woreda level in the year 2008/09 (WoANRD). Even if, there is greater effort of community and GO, the upper stream topographic feature is requiring the special different terracing structures, due to steepness factor. Therefore, during implementation of project, attention should be given on recommended watershed development intervention plans.

9. Watershed Development Strategy

Since watersheds are shaped by complex ecological relationships and diverse social systems that are continually responding to dynamic economic, social and cultural forces, watershed planning must first and foremost be an interdisciplinary process. It will require technical expertise in geology, hydrology, biology, ecology, engineering, environmental science, resource management, social science and rural development planning.

It must also strive to relate these processes to the human factor. It should address linkages between land use and water management, upland watershed issues and downstream concerns, public values and economic natural resource use, community well-being and sustainable watersheds, short term activities and long term sustainability issue.

Consideration of these issues requires participation not only by different agencies but also by farmers, businesses, environmental groups, and technical specialists from the profit and non-profit sectors, disadvantaged communities and the general public.

Having in mind all these factors, the anticipated integrated watershed management plan will consider the following bench mark issues:

1. Recognize and address multiple perspectives, issues, and objectives, including local, regional, and federal concerns of environmental, economic, and social nature.
2. Integrate and coordinate planning, management, monitoring, and community activities across agencies, and nongovernmental entities.
3. Provide for inclusive and participatory involvement by all agencies and all stakeholders to ensure meaningful input, including disadvantaged or hard to reach communities and stakeholders.
4. Use or provide at least a minimum level of assessment early in the process to provide a scientific foundation for moving forward.
5. Allow for a long-term, phased implementation strategy while managing for shorter term project delivery.

6. Develop a monitoring strategy for projects to provide scientifically valid information about effectiveness and to determine if overall plan is meeting stated objectives.
7. Establish a process for ongoing, informed decision-making through adaptive planning, management, and monitoring.

A watershed plan does not need to offer all the answers. Instead, it can lay out a long-term process towards finding answers and improving solutions and a long-term system of acquiring new information on key issues and trends to modify the management program. Moreover, watershed as a complex dynamic system will require time, information, and resources to manage. Hence, the study suggests to follow the program approach of watershed plan and management, in short term the study identified major programs that could give instant effect to the rehabilitation endeavor and that would pave the way to future sustainable management of the watershed.

In order to realize the planned programs, sustainable funding strategies will be explored by the leading offices, identifying additional sources, opportunities for leveraging resources, and long-term strategies for generating funds. A long-term perspective will also focus on conflict resolution and make the implementation less discouraging.

In order to ease implementation of the watershed development plan; the watershed need to be divided into smaller sub-watersheds. Each sub-watershed as a hydrological unit is connected, and any modification of the land use in watershed or sub-watershed will reflect on the water as well as sediment yield of the overall watershed. Accordingly, the Wataba watershed is classified in to micro-watershed/ sub-watershed, according to the Ethiopian Soil and Water Conservation Manual the minimum area to be treated as micro watershed is about 500 hectare of land, off course it depends on particular site condition.

10. The Development plan of Wataba watershed

Based on the finding of study the watershed management plan incorporated the following programs. General, it includes: Soil and Water Conservation program; Agro Forestry and Forestry Program; Livestock development Program and Capacity Development Program.

The aim of Wataba Watershed Management plan is to provide a support to sustainable natural resource management with designed small scale irrigation project. It takes in hand the issues of existing natural resources, impact sediments deposition on head work and canal structures and other related resources in the perspectives of sustained development and management. 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, schemes by reducing silt transporting runoff water. The Size of area to be treated ranges 250-500ha on which at micro watershed level based on the Moa, CBPWGL and but no limitation for the community to treat the land beyond this size. 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 soil and water conservation, a forestation and forest management, crop production intensification and diversification; livestock development; income diversification; infrastructure development; alternative rural energy technology; and capacity building. These measures are discussed below:

10.1. Soil and Water Conservation Development Plan

For sound watershed management different interventions are proposed that will solve the stated problems when it is implemented properly. The development plan is designed considering social,

economic, technical and ecological aspects of the area. Based on this, the watershed management plan covers physical, bio-physical and biological conservation measures.

10.2. 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. There are various physical soil and water conservation measures that can be applied on different land uses types, slopes, soil and etc. The soil erosion status of the area is classified as moderate to severe level. Both classes are hazardous and require strong measures of conservation, which is integrated in all agriculture activities because most physical soil conservation measures are applied in agricultural production areas. The main physical SWC measures recommended to be implemented in the Watershed are soil bunds, stone faced soil bunds, stone bunds, cut off drain, waterway, check dams. These 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.

Soil bunds: Applied generally on cultivated lands with slopes above 3 and below 15% slope. Soil bunds can also be applied on grazing lands with slopes at wider interval, and within slopping homestead areas combined with cash crops.

Cut off drain: After assessing existence of enough out let facility, cut-off drain is effective to avoid the excess runoff from cultivated lands. Before designing the cut off drain the peak runoff rate should be known.

- Suitable at a foot of a steep hillside under which cultivated fields are exposed.
- Constructed above gully head to divert run off from active gullies to treated/stable ones.

Micro-basins: Micro-basins are proposed to accommodate eroded soils and runoff water so as to create conducive microenvironment for any type of plantation activities. The shape of micro basins can be full or half moon type. For flat areas full moon type is recommended while half-moon is for steep slopes.

- Applicable in steep and degraded hillsides and for community closures.
- Need to be combined with hillside terraces, trenches and other measures.
- Constructed using sods, in areas without stones, and stabilized with plants.

Hillside Terraces: Hillside terraces are recommended on steep slopes community closures. Need to be combined with other measures, like micro basins, trenches, etc.

10.3. Biological Soil and Water Conservation Measures

Biological SWC is a conservation practice that prevents loss of soil and moisture, improve soil property and maintain/restore productivity and stability of the ecosystem through good farming system, good cover, recirculation of organic matter and nutrient and establishment of vegetative barrier. A number of biological SWC systems can be applicable for the study area solely or in combination with physical SWC measures based on the specific conditions. The proposed interventions Nursery establishment, Reforestation, closure of existing natural vegetation: Grass Strips, Compost Making and Utilization.

Grass strips: Grass strips are the most effective ones in arresting the sediment inflow. For this watershed there are different exotic and local grasses adapted in that area which therefore can be planted on soil and or stone-faced soil bunds. Grass strips can be done by direct sowing, planting the sods and by developing it from the un ploughed lands between the cultivated areas.

Green manuring, organic matter application, mulching and crop rotation: are considered as biological soil conservation measures. They are mainly concerned with keeping soil fertility and as a result develop good soil structure, which can resist erosion. Mulching and organic matter applications are much more effective than the other factors for they influence surface condition of the soil which in turn control infiltration rate.

Soil Fertility Management: The aim of soil management is to maintain the fertility and structure of the soil. Highly fertile soil result in high crop yields, good plant cover resulting in conditions, which minimize the erosive effects of raindrops and runoff. The central theme in here is that soil fertility must be seen as a key to soil and water conservation.

Soil fertility can be maintained through addition of organic matter; typically composting and manuring, to increase the resistance of erodible soil and increase agricultural production. The system includes practices such as leaving dead plant material at the surface of the soil, after the

crop is harvested, to keep moisture within the ground, and protect the soil from erosion. It also includes ploughing along contours to have plough furrows that slow down speed of surface runoff and increases soil-water infiltration.

Gully Control and Rehabilitation; The techniques of gully control and rehabilitation include, treating upslope lands, reclaiming the gully area, diverting runoff, close off, plantation and construction of different types of check dams across gullies to hold backwater and trap sediments. The type of check dams selected to treat and rehabilitate gullies depends on the gully features availability of construction materials, and slope gradient of the gullies. To this end, live brush wood check dams, stone check dam, and gabion check dam all integrated with plantations along the side of the gullies proposed for this watershed area.

Therefore, the measures for protection of riverbank are recommended. The intervention involves establishment of buffer zones on the sides of the riverbank and establish plantations of economically important vegetation of various types. This zone will act as a de-silting and sediment trapping zone and dispersing the concentrated run-off before entering into the rivers so that the runoff will have non-erosive effect. In this regard, establishment of buffer zone of 5-10 meters away from the edge of the riverbank by limiting cultivation and other agricultural operations beyond this zone is recommended. The buffer zone should be established with productive grass species that could be used for livestock feeding through cut and carry method; trees that can be used as fuel wood and construction materials and fruit trees that may be useful for generating income for communities who own the land adjoining the river bank. Thus, river bank protection measures are proposed on the right and left side of the proposed scheme River.

Promote Agro forestry and Fruit Production; The recommended agro forestry practices as part of the watershed development intervention are plantation of Federi- albida, Alley Cropping and Multi-Storey Gardening specifically at homesteads.

Access for credit services; The households in the watershed have a limited capacity to purchase farm inputs mainly fertilizer, buy improved livestock and accessing their fodder, and start any kind of business in the most part of the country and project area. However, if there is a strong credit facility, these households will have a chance to build their financial capacity. Thus for the

project to be successful, there must be a strong credit services in the watershed as seed money either in kind form or the ecological benefit from.

Homestead farming; Homestead farming has significant contribution in supporting the livelihoods of the households in the watershed. Traditionally, most farmers are applying manure to increase the yield of homestead farming. This is a good practice and needs to be strengthened.

Vegetable production; Vegetable production is one of the livelihood improvement activities at homestead level development. Treated the Upper part of the Scheme watershed will help for the community to produce vegetable due to the incremental moisture available. Shortage of irrigation water is the main reason that impedes the farmers in this particular activity. In this regard if integrated watershed development is practiced through the improvement of water resources mainly by improving the infiltration of rain water thereby increasing the volume of water which creates opportunity to undertake vegetable production which would be significantly improved and contributed a lot for the households.

Diversifying animal production and improve productivity; Micro watersheds in most area has big potential for cattle rearing, oxen and shoat fattening, poultry production, beekeeping, etc. Despite its potentials, the community is not benefiting out of it, because they are undertaking conventional method of animal production methods. Lack of practical training on the sector and skepticism in the side of the community are among the contributing factors for unproductive animal production. To alleviate the prevailing constraints and to improve productivity the following strategies.

❖ **Farmers should be advised to practice cut-and-carry system, instead of free grazing**

Most of the case watershed is situated in a sloppy area, therefore free grazing aggravates soil erosion and environmental degradation. To stop if not to reduce overgrazing and its negative consequences, the farmers in the watershed should be advised to use cut-and-carry system as well as should get awareness training regarding the benefits of cut-and-carry system.

Engage farmers in shoat fattening activities; Scheme for 5 shoats /user group/ scheme for a group member of 10 HH/scheme undertake fattening activities, basically in rainy season; Hence farmers should get in depth and practical training on fattening techniques

and management to run the activities year round using cut- and-carry as well as hay system.

- ❖ **Involve female farmers in poultry production;** Poultry production is another livelihood option mostly carried out by female farmers. In this connection in depth and practical training needs to be provided on poultry production and management for female farmers.
- ❖ **Involve farmers in Beekeeping;** Beekeeping is another livelihood opportunity which needs priority. Despite the availability of bee forage, beekeeping activities are not undertaken by the farmers. Therefore, the following points should get high emphasis so as to earn substantial benefits from apiculture.
 - ✓ In depth and practical training on apiculture should be provided to farmers
 - ✓ Farmers in the watershed should get repeated advise and extension service to use manual weeding rather than using agrochemicals, since there is abundant labor at household level
 - ✓ Provide improved beehives for 10HHs or youths/scheme and seed money for farmers to promote the sector.

Introduce fuel saving stove for energy source; The HHs in the micro watersheds are using biomass as energy source which triggers deforestation and exacerbate soil erosion. Therefore, promoting fuel saving stove is adverse effect contribute for mitigate deforestation, thereby to reduce sediment generation and delivery to the scheme. To this end, supplying the community with electric power is another alternative energy source to reduce deforestation and thereby reducing sediment delivery to the Irrigation Projects.

Therefore, appropriate proposed management plan includes: -

- Capacity building for all stakeholders benefited from watershed at different level.
- Tree plantation along hilly (upper stream) and road side.
- Grass planting along irrigation canal structural works.
- Implementation of rules and regulation of forest conservation as seated CBPWM-Guideline.

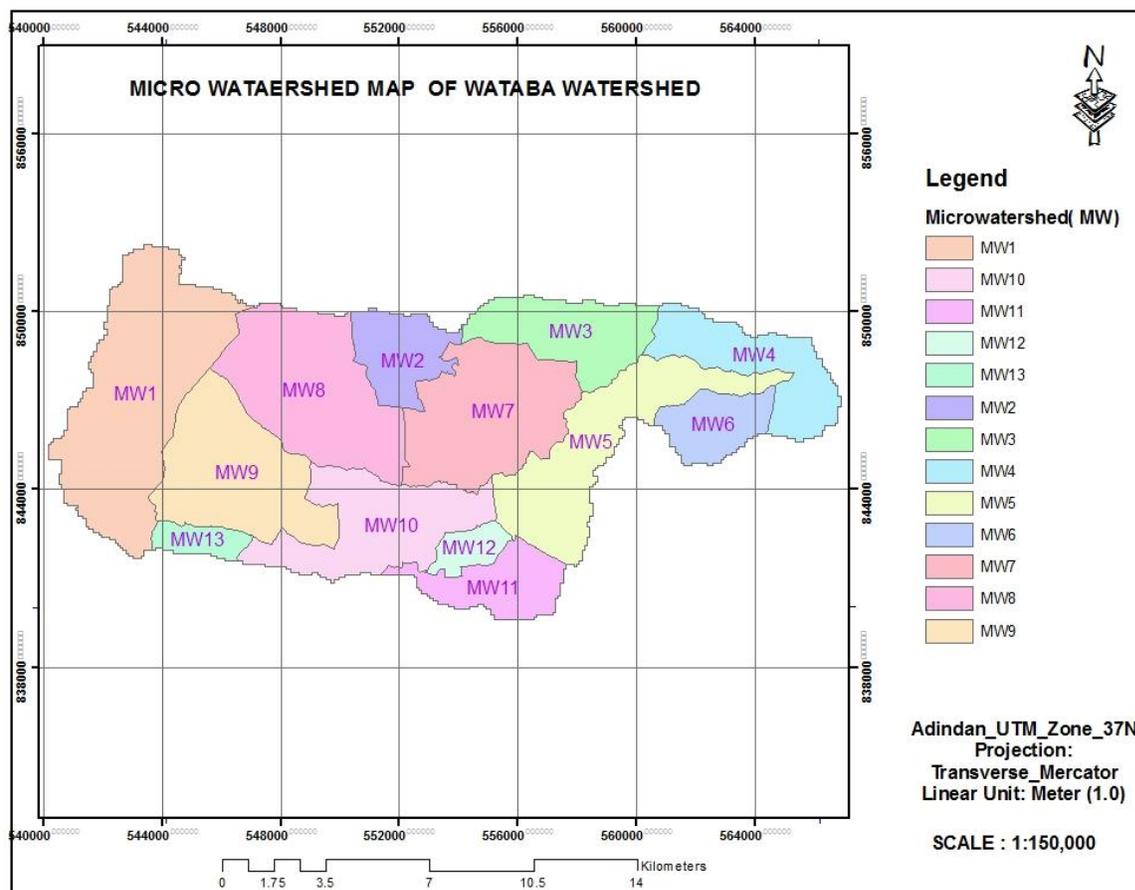


Figure 14. Development Plan Map of Micro Watershed of SSI Project
 Table 8. Development Plan of Wataba Micro Watershed of SSI Project

Micro Watershed (MW) code	Development Plans
MW1	Existing forest protection and development activities
MW2	Soil bunds construction, Fanjua Terracing, Bench terracing, Drainage system development and Agroforestry adaptation"
MW3	Soil bunds construction, crops rotation, Drainage system bench terracing, development, Mixed Cropping and Agroforestry adaptation, planting on bund Micro basin and water way constructing
MW4	Cut of drain construction, Soil bunds construction, Fanjua and Bench Terracing, Seedling production, Pitting, Grass strip and water way construction

MW5	Soil bunds construction, Drainage system bench terracing, development, Mixed Cropping and Agroforestry adaptation, planting on bund Micro basin and water way constructing
MW6	Cut of drain construction, Soil bunds construction, Fanjua and Bench Terracing, Seedling production, Pitting, Grass strip and water way construction
MW7	Soil bunds construction, crops rotation, Drainage system bench terracing, development, Mixed Cropping and Agroforestry adaptation, planting on bund Micro basin and water way Constructing.
MW8	Forest Development, Fanjua and Bench Terracing, Seedling production,
MW9	Soil bunds construction, crops rotation, Drainage system bench terracing, development, Mixed Cropping and Agroforestry adaptation, planting on bund Micro basin and water way Constructing
MW10	Cut of drain construction, Soil bunds construction, Fanjua and Bench Terracing, Seedling production, Pitting, Grass strip and water way construction
MW11	Soil bunds construction, crops rotation, Drainage system bench terracing, development, Mixed Cropping and Agroforestry adaptation, planting on bund Micro basin and water way constructing
MW12	Drainage system, development, and Agroforestry and Fruit tree developmet
MW13	Soil bunds construction, crops rotation, Drainage system bench terracing, development, Mixed Cropping and Agroforestry adaptation, planting on bund Micro basin and water way Constructing

11. Implementation Strategies

Strategy is a plan of action designed to achieve a particular goal. It is a plan chosen to bring about a desired future, such as achievement of a goal or solution to a problem. Furthermore, strategy is the art and science of planning and marshalling resources for their most efficient and effective use. (Wikipedia, The Free Encyclopedia).

The implementation strategies of a watershed management program serve as inducements to change people's behaviors and institutional arrangements that are relative to watershed systems. Generally, there are four factors that are required for the successful implementation of a watershed management plan (US EPA, 1996):

- a. Focus of the management strategy needs to be based on the geographic unit of the watershed, which often requires cooperation among multiple jurisdictions;
- b. The watershed management plans must apply sound management principles and this includes coordinated management activities;
- c. The activities should all include broad stakeholder involvement. By including stakeholders in the process from planning to implementation and formulating laws, programs should be understood and valued by the public at large; and
- d. There should be a clear schedule and implementation strategy.

12. Implementation time schedule

Implementation phase would become necessary to implement projects and activities according to the schedules set in the management plan. The major objective of this phase is, therefore, to create a solid ground for the whole system of Wataba irrigation based integrated Watershed programs.

This project has phased over a period time of three years. After phase out of the project time period the project will be handover to the community. During the implementation period the community share needs to be incorporated for the successful achievement and sustainability of the project.

13. MONITORING AND EVALUATION SYSTEM

13.1. Technical Monitoring

Unless soil and water conservation structures and erosion control measures are monitored and evaluated as per the design, their negative impacts outweigh their purposes of construction. All the physical structures should also be monitored in the construction time, before and after the onset of the rainy season so that it can be possible to avoid if there are some errors. For quick monitoring activities of bunds, the supervisor can use a small wooden cross bar so that do his work in time.

During time of construction, the following should be strictly monitored:

- Spacing between bunds and its length
- Check dams should be properly keyed across its base and up the abutments.
- Proper seeding selection in nursery
- Proper handling of seedlings

Activities needing monitoring after construction:

- To allow natural re-vegetation, livestock should not be allowed to trample around it.
- Periodic maintenance has to be done.
- Protection of the seedling.

13.2. Evaluation and Reporting system

A systematic evaluation and reporting system will be put into place for the watershed development. The inhabitants of the watershed, donors, and the relevant stakeholders of the district, zone and region will participate in the whole process of planning, implementation and evaluation of the project.

As a general direction, communities will be active participants of this project through their watershed committees. Each sub watershed will have its own watershed committee including females. The responsible organization will produce and submit periodic (monthly quarterly and annual) progress reports to the Regional Bureau. A joint team composed of all relevant stakeholders will conduct a mid-term and annual evaluation of this project.

13.3. Training and Capacity Building

Most soil and water conservation interventions were directly related to conserve soil. But soil without water is unproductive; such trainings should clearly show the advantages of SWC on water resources. The failures of physical measures are partly attributed to technical faults. Training farmers, DAs and Experts (supervisor) should be part and parcel of the project for it helps in the quality and quantity of the work. Quality works can also reduce maintenance costs. The training should focus on recommended soil and water conservation options and Integrated Water Resources Management (IWRM) and including experience sharing with similar projects. It is known that capacity building support is a critical component to achieve the desired results from watershed development programs and projects. These should include training of farmers and experts at each phase of implementation time required. In this line, for training achievement Woreda's ARDOs should facilitate the operational strategies for building the capacities of stakeholders at each level of hierarchy.

Main area of training and participants;

- Skill Improvement on Integrated SWC Practices: Selected experts of Zone and woreda experts are Women committee members were Involved In the Sub-watersheds' Programs.
- Training on the Preparation of Annual Action Plan; Woreda's experts and farmers;
- Concepts and Practices of Sub-Watersheds Management: Woreda, Kebeles and watersheds Management Teams/Committees;
- Agro-Forestry Concepts and Practices (Including Management of Selected Agro-Forestry Elements: Woreda experts and selected farming households;
- Establishment and Management of Tree Nurseries (Private and Government Demonstration Sites): Selected experts and farmers groups;
- Development and Management of Homestead Fuel Woodlots (Training): Selected household heads;
- Training on Integrated Feed Development and Management Techniques: Selected Woreda experts and watershed households;
- Training on composting and Improved Management of Organic Manures: Selected
- farmers.

14. Institutional Arrangements

Appropriate institutional arrangements should be made ranging from the region to the village level. At Zonal level, the existing Natural Resources Development, Protection and Utilization Core Process should give special emphasis to the watersheds programs and projects. Their follow-ups and monitoring and evaluation tasks will have to be purposefully planned and exercised. Under their mandates, the Zonal and Woreda should assign experts who will also be responsible for all processes of the watersheds programs.

At the Woreda level, the ANRDOs need to create a particular unit that will be managing the programs and projects of the watersheds in accordance with the implementation schedules. Created at each Woreda, such units should compose a mix of multidisciplinary professionals who may also have to be involved in the implementation of the watersheds plans regularly or intermittently as may be arranged by the ANRDOs management.

Regarding the grassroots level of responsibilities and tasks, the unit created at the Woreda ANRDOs should take the lead to reorganize and strengthen the watersheds' structures at the Kebele and village levels. In a special case, the existing watershed management committees in respective Kebele should be restructured and strengthened under the prime leadership of the Kebele managers, who at the same time, are accountable to the Kebele council. The composition of the Watershed Management Committee should accord the national Guideline of Community Based Participatory Watershed Development

The present grassroots structures uniformly created under the guidance of the Government well suit to strengthen and consolidate the structures and functionalities of the village Watershed Workgroups. The institution of Agriculture and Natural Resource Development (ANRD), among other things, should re-think the decisiveness of the Kebele and village watershed development structures as they serve as the points of entry, final nodes for practical translation of all particulars, domains of watershed restoration and sources of information for plan adjustments and modifications.

On the other side, the strategy of institutional arrangement should also embrace the cooperation and collaboration of the primary stakeholders. Strategically, the role of the ARD institution at all levels of hierarchy would remain vital in taking a lead to organize, create, develop and sustain collaborations for the common good of developments entrusted in them.

15. Conclusion and Recommendation

Soil erosion is identified as one of the growing land management problem resulting in both on-site and off-site effects. Soil erosion is generally a growing and more expanding problem in the watershed, where rainfall is more intense and soils are highly erodible due to the relatively erodible top soil and low structural stability.

In line with this, the watershed is under gradual clearing of the existing forest resources, which is directly affecting and exposing the soil resource of the watershed to erosion. Those practices reduce the protective plant cover, thereby exposing the soil surface to the destructive impact of high-intensity rainfall.

Considering the mounting problem of soil erosion and its impacts, it is necessary that appropriate management measures be undertaken. To achieve this, a sound knowledge of spatial variations in soil erosion is necessary. Because of the high cost of conservation and the competing production objectives such as population increase, infrastructure development, and land degradation, there is a need to target responses and resources to areas of high risk rather than spreading them equally across the landscape. Different land management program can then be implemented to deal with the various land degradation problems. These attempts must take into consideration the biophysical and socioeconomic conditions of the Watershed sites. Therefore, this study has placed the following key recommendations:

- ✚ Capacity building: Increasing attitude of the watershed community towards sustainable development/Integrated Watershed Management (IWM) through effective and consistent trainings. This includes skill trainings of Woreda agricultural experts & Kebele DA's in effective adoption of IWM, and
- ✚ Designing energy efficient home systems: supplying household cook stoves, infrastructure such as roads, developing social services, attainable credit conditions and technology.
- ✚ Because of accelerated land degradation, there must be sustainable soil conservation strategies in the area
- ✚ The vegetation cover of the land should be improved to reduce the removal of soil organic matter
- ✚ The water-holding capacity and nutrient availability of the soil should be increased by applying biological and agronomic conservation schemes to increase agricultural productivity and minimize biodiversity loss in the area
- ✚ The farmers should be included in all such schemes as active participants.

1. Integrated Watershed and Landscape Management Plan

Activities	physical plan				Financial Cost	
	Unit	Planned	Norm	Person /day	Unit price/ETB /	Total cost /ETB/
Hillside land treatment and management including woodlot est.	Ha					
Cut-off drains	m3	1500	1PD/0.7M3	2142	40	85,680.00
Hillside terracing	km	4.368	250PD/KM	1092	40	43,680.00
Trenches	no.	437	2PD/3Trenches	291	40	11,640.00
Planting seedlings on woodlot	no	49140	50P/PD	983	40	39,320.00
Gully rehabilitation with biophysical measures	ha					
Brush-wood check-dam constructed	M	75	3/PD	25	40	1000.00
Gully reshaping and leveling	M2	120	1M3/PD	120	40	4800.00
Gully treated with fruit tree	Ha	1.2	500PD/PP/R	600	40	30,000.00
Treatment of farmland (slop < 15%) with suitable bio-physical measures	HA					
soil bund construction	Km	10	150/KM	1500	40	60,000.00
Fana-Juu Terracing	Km	10	200/km	2000	40	80,000.00
cut of drain construction	m3	540	0.7M3/PD	772	40	30,880.00
Seedling production	No	150,000	15pd/1000	2250	40	90,000.00
Pitting	No	125000	15pd/1000	1875	40	75,000.00
Seedling planting	No	225000	50plants/pd	4500	40	180,000.0
Grass strip	Km	20	30PD/KM	600	40	24,000.00
water way construction	m3	240	180/0.75	320	40	12800.00
planting on bunds	Km	20	16pd/km	320	40	12,800.00
Treatment of farmland (slop > 15%) with suitable bio-physical measures	Ha					
Bench terrace	Km	0.01	500PD/KM	50	40	2000.00
cut of drain construction	M3	50	1PD/0.7	72	40	2880.00
water way construction	M3	100	1PD/0.75	134	40	5,360.00
planting on bunds	Km	0.03	50plants/pd	77	40	3,080.00
seedling planting	No	600	50plants/pd	12	40	600.00

2. Seed/Seedling Supply and Establishment of Community Nursery

Investment in Integrated Watershed and Landscape Management	physical plan		Financial Cost	
	Unit	planned	Unit price/ETB/	Total cost /ETB/
Promoting conservation agriculture on 5% of the farmlands	Ha	22		3,900.00
Crop residue management	Ha	5.5		
Green manuring	Ha	2.5		
Reduce/zero Tillage	Ha	1		
Inter cropping	Ha	13		
Promoting agro forestry and fruit on 2% of the farmlands	Ha	8		2,900.00
Area covered by allay cropping	Ha	3		
Area covered by fruit trees	Ha	5		
Promotion of improved forage production on private land	Ha			
Amount of forage seed distributed	Kg	25		12,500
Promotion of fuel saving technologies	No of HH	20	1191.70	23,834.00
Groups established on production of fuel saving technologies	No	20		
Fuel efficient stoves produced	No	4		
Biogas plant produced	No	1		
Scaling up of adoption of improved farm technologies (e.g. Ayebar, BBM, Trashing equipment, etc)	No of HH	60	3745.50	224,730.00
Female HHs provided with farm technology /Ayebar BBM, Threshing equipment/	No	20		
Male HHs provided with farm technology /Ayebar BBM, Threshing equipment/	No	40		
Establishment of community nurseries	No	1	50,000	0,000.00
Grand Total				1,133,384.00

Appendix 1. Biophysical SWC work activities Schedules for Wataba Watershed

No	Work Activities	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1.	Bench Terracing	█											
2.	Fana-juu Terracing	█											
3.	Soil bund Construction	█											
4.	Water ways Construction			█									
5.	Check dam Construction	█											
6.	Micro-basin Establishment			█									
7.	Re-vegetation						█						
8.	Cut and fill		█										
9.	Nursery Site Establishment									█			
10.	Seed Propagation	█											
11.	Pitting			█									
12.	Tree Planting						█						
13.	Maintenance of Physical SWC works	█											

16. APPENDEX 2. Mean Monthly Rainfall at Gobesa (mm)

Monthly Rainfall at Gobesa station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total RF
1984	0	3.5	31.5	21.5	166.2	76.5	145	102.3	154	2.2	10.5	38.3	751.3
1985	30.9	2.6	41.9	226.2	235.4	32.9	220	151.9	61.8	125	39.2	7.5	1175.6
1986	2.7	109	39.7	281.8	104.2	130.4	116	115.4	108	69.6	12.5	33.5	1122.5
1987	6.9	30.5	257.7	75.8	135	33.8	71.7	91.9	80.3	83.6	16.7	13.7	897.6
1988	7.7	48	26.1	183.7	35.8	52.7	88.3	169.1	96.5	191	0	0	898.5
1989	17.7	0	94.2	188	124.3	44.6	120	160.1	176	80.5	41	219	1264.8
1990	10.9	229	110.1	190.4	103.5	50.2	102	172.2	132	42.4	18	14.9	1175.6
1991	14.5	114	101.9	120.1	200.2	86.4	166	219.3	86.3	11	24.4	19.7	1163.1
1992	99.2	27	12.1	135.7	178	82.3	153	221.9	99.7	99.1	80.8	82.4	1271.6
1993	420	42.4	4.9	231.3	69.44	38.72	46.4	334.8	150	301	51.4	3.96	1694.9
1994	0	0	107.1	253.6	125.8	182.2	430	353.4	158	73.5	88.8	8.9	1781.3
1995	0.6	149	448	428.1	111.5	54.8	99.1	199.9	163	118	3.2	55.7	1830.6
1996	48.5	21.2	188	160.5	325.5	178.9	280	185.6	177	32.4	85.8	5.3	1687.8
1997	30.4	0.6	88.6	238.8	171.1	159.3	171	75.9	133	353	367	6.8	1795.3
1998	138	179	153.4	238.8	165.3	69.9	80.5	368.6	310	265	0	0	1967.3
1999	8.5	4.8	150.6	75.6	54	103.6	185	164.6	156	229	17.1	11.6	1160.6
2000	0	0	14.5	134	157.9	119.9	64	170.7	171	180	160	57	1228.2
2001	8.6	34.2	151	65.1	141.2	135	144	167.4	62.6	170	67.1	33.4	1179.6
2002	48.2	9.8	86.5	190	66.2	67.3	133	99.6	71.9	63.7	43.4	167	1046.6
2003	76	0	43.2	231.3	44.3	192.4	277	235.7	132	34.4	36.6	82.6	1385.2
2004	70.1	52	78.4	149.2	35.2	52	138	240.8	197	100	9.7	18.6	1141.2
2005	69.3	13.7	120.8	173.2	112.1	54.9	95.3	81.3	73.7	45.4	79.6	0	919.3
2006	3.4	33	88	41.1	146.9	96.4	153	325	189	64.1	14.1		1153.9
Mean	48.4	48	106	175.4	130.8	91.09	151	191.6	136	119	55.1	40	1291

Gobessa station

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