AMHARA NATIONAL REGIONAL STATE
WATER IRRIGATION AND ENERGY DEVELOPMENT BUREAU
(BOWIED)

FEASIBILITY STUDY AND DETAIL DESIGN OF AWAJO SMALL SCALE IRRIGATION PROJECT

Volume I: WATERSHED FINAL REPORT

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AMHARA DESIGN & SUPERVISION WORKS ENTERPRISE
(ADSWE)

AMHARA NATIONAL REGIONAL STATE
BUREAU OF WATER, IRRIGATION AND ENERGY (BOWIE)

Feasibility Study and Detail Design

Of

Awajo small - Scale Irrigation Project

Volume I: Watershed Management Study

Final Report October, 2018

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FEASIBILITY STUDY & DETAIL DESIGN REPORT STRUCTURE

- **Volume I: Watershed Management**
- Volume II: Engineering Geology
- Volume III: Irrigation Agronomy
- Volume IV: Engineering Design
- Volume V: Socio Economy
- Volume VI: Environmental Impact Assessment

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EXCUTIVE SUMMARY

The study of Awajo Small Scale Irrigation Project study was conducted in North Shewa Zone, Tarma Ber Woreda. The project site is located in Adoke kebele, at Awajo small stream/River. Awajo Watershed is located between 1093130 to 1101760 meters north and 576300 to 581140 meters East in UTM coordinates with altitude ranges of 2509 up to 3113 meters above sea level.
The watershed extends to two Woredas, Tarma Ber and Mojana Wodera limited within 2247.67 hectares of North Shewa Zone. The watershed is labeled by the name of river Awajo and headwork, and studied with the objectives to characterize the existing conditions and future utilization and conservation of natural resources of the watershed which is the hydrologic unit or supply of the river. The method followed for this study was collection of primary and secondary data at field and office level. The study approaches and procedures followed different stages of study included pre-field work, fieldwork, and post fieldwork activities.

Soil erosion is defined as the physical degradation of the landscape over time. Water erosion has adverse economic and environmental impacts. The process is initiated when soil particles are detached from its original configuration by erosive forces such as rainfall. A method was developed in this research which combines the Universal Soil Loss Equation (USLE) with the computer capabilities of GIS. The USLE calculates long-term average annual soil loss by multiplying six erosion factors, rainfall erosivity, soil erodibility, slope length and gradient, land cover and land management practices, which describe the watershed characteristics such as climate, soil types, topography, land cover and land management. The GIS is used to calculate the slope steepness and slope length factors, and to store the USLE factors as individual digital layers and multiplied together to create a soil erosion potential map. This combination provides a way to assess soil erosion potential of the area with existing data sources. Based on the analysis, the total amount of soil loss in the watershed was about 16856.41 ton per year; an average of 32 ton/ ha/yr.

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ABBREVATIONS AND ACRONYMS

ADSWE	Amhara Design And Supervision Works Enterprise
AEZ	Agro-Ecological Zone
AGP	Agricultural Growth Program
ANRS	Amhara National Regional State
BoWRD	ANRS Water Resource Development Bureau
FAO	Farm Africa Organization
GIS	Geo-Information System
HH	House Hold
NGOS	Non Governmental Organizations
PWDP	Participatory Watershed Development Planning
RUSLE	Revised Universal Soil Loss Equation
SDR	Sediment Delivery Ratio
SOM	Soil Organic Matter
SWC	Soil and Water Conservation
USLE	Universal Soil Loss Equation
UTM	Universal Transverse Mercator
WRIA	Water Resource Inventory Area
WSD	Watershed Development

1. INTRODUCTION

1.1. General Background

The concept of land degradation is inseparable from that of sustainability. A sustainable land use is one that is able to continue without degrading the land it is using; the sustainability of a particular land use depends both on the properties of the resource and the way it is managed. Poor soil and water management is one of the main responsible causes for sever land and soil degradation, which again affect the successful development of a nation.

Now a day, with the increasing population and land degradation, most high potential areas are under immense threat of agricultural productivity reduction. Awajo Watershed where diversion irrigation project was intended was one of those areas considered as high agricultural potential areas in the Woreda. But, due to the ever increasing population and land degradation, productivity has reduced. Land degradation is assumed to be the main cause of decline in productivity of land, low income of the people. Natural resource depletion by sever soil erosion and environmental mishaps eroded the confidence of farmers living in the high rainfall and productive regions.

To sustainably develop this high market access, high agricultural potential and high labor available area, priority should be given to natural resources, especially soil and water based and economically feasible development projects. Irrigation projects must be integrated with watershed development strategy. The protection, improvement and rehabilitation of watersheds are of critical importance in the achievement of overall water development goals. Recognizing this, our country is turning increasing attention and resources to the field of watershed management. The natural resources on the watershed have to be properly utilized and conserved. This study particularly deals with the existing natural resources inside the watershed and future intervention needs to sustainably develop the watershed resources and safeguarding infrastructures.

1.2. Objective Of The Study

1.2.1. General Objectives

The general objective of the Awajo Watershed Management Study was to identify and understand ecological and socio-economic problems in the watershed so as to identify and prepare the watershed intervention plan that enable sustainable management and use of resource; thereby establishing long-lasting irrigation water supply system while improving livelihood of the communities in the watershed through creating and sustaining improved agricultural production systems and land productivity.

1.2.2. Specific Objectives of the Study

The specific objectives of the study are:

- Recognition of watersheds as a proper unit for wise utilization and development of all land resources.
- Rehabilitate the highly degraded environment and hence increase the productivity of the land within the study area through the practice of conservation measure in a way it can bring improved food and economic security.
- Utilization of natural local resources for improving agriculture and allied occupation so as to improve socio-economic condition of the local residents.
- Retardation of sediment load flow towards the weir.
- Retardation of flood, in volume and speed, flow towards the weir.
- Enhancing the irrigable potential of the river by improving ground water discharge.

1.3. Scope of the Study

The watershed management study of this project was intended watershed management to degradation, utilization and conservation of natural resources. The natural features of the watershed, topography, soil type, climate and socioeconomic conditions, demography and farming system were studied as criteria to analyze the forms, causes and effects of soil erosion of the watershed. Conservation experiences and the benefit of soil and water conservation were studied. Problems were identified in the field of SWC and development measures are recommended with management and planning techniques.

Water erosion was considered to be the most important cause of soil loss in the watershed. The Revised Universal Soil Loss equation is the best indicator of land degradation. All the parameters used in RUSLE: R, K, LS, C and P were calculated for each land mapping units. These parameters generated from rainfall, soil, digital elevation model, land cover and use, and slope maps respectively of the watershed were overlay and the amount of soil loss was so estimated and mapped. Finally, soil erosion result and its land use and management plan, on watershed base, were produced. Soil and water conservation measures were recommended for sustainable utilization of natural resources.

1.4. Limitation of the Study

The major limitation of this project was the difficulty to identify whether the data (like human and animal population, land users and other socio-economic) were inside or outside of the watershed boundary; thereby these data were collected on Woreda and kebele levels.

Secondary data collection was not satisfactory process, because it was difficult to get documented data of different seasons at offices of Woreda and kebele levels. Only data of current year or recent years were available, data series in the recent past years were not obtained enable us to review the socio economic trend analysis of the watershed.

2.METHODS AND MATERIALS

2.1 Methods

2.1.1 Data Collection

During pre-field work the main activities were concentrated on base map preparation. To set the methodology, previous studies and thematic maps, shape file, Digital Elevation Data (DEM) and satellite images of the project area were collected. Watershed boundaries, drainage lines and their networks, slope of watershed were extracted from 90 DEM data by using Arc Hydro extension in the Arc GIS environment**.**

After office works, the study was conducted mainly by field observation with the aid of GPS and map with computer software's to investigate biophysical data of the watershed. These data include land use, land form, soil depth, soil color, stoniness, water logging, drainage pattern, climate and conservation practices. Discussion with different levels of organizations, which was the basic part of the study, accomplished with Woreda and kebele agricultural officers, Development Agents and key informants using semi-structured questionnaires. Discussions were also held with the focus groups of the local farmers at the project site which include all groups of the community. During data collection, the following activities were undertaking.

- The primary data were collected in the field by using checklists of biophysical land resources survey. The survey team was a composition of different experts. This gave an advantage for discussion, new idea generation and /or as well as support to each other. The primary data also were collected from households, development agents by using readily made questionnaires and by making discussion with the concerned experts.
- The secondary data were collected from households, development agents and Woreda agricultural and rural development officers by using readily made questionnaires and by making discussion with the concerned experts.

2.1.2. Data Analysis

The data collected through questionnaires was organized and analyzed into different forms in line with the nature of issue supported by theoretical and empirical evidence from literatures. In analyzing the data, both qualitative and quantitative methods were applied.

2.1.2.1. Soil Erosion

The extent of erosion, specific degradation, and sediment yield from watersheds are related to a complex interaction between topography, geology, climate, soil, vegetation, land use, and man-made world to predict long-term rates of inter rill and rill erosion from field or farm units subject to different management practices.

RUSLE, modified from the USLE (Wischmeier and Smith, 1978), was designed to compute the average annual erosion of the watershed. In RUSLE, there are six factors: soil erodibility K, slope length L, steepness S, cover management C, and support practice P: derived from the surface characteristics and rainfall erosivity R, which reflects the raindrop effect and the runoff rate, derived from the rainfall.

The basic forms of the RUSLE equation has remained the same, but modifications in several of the factors have changed. Both USLE and RUSLE compute the average annual erosion expected on the field and are shown in equation:

A=RKLSCP

Where: A = Annual soil loss in tons per hectare per year

R = Rainfall Erosivity Factor

K = Soil Erodibility Factor

L = Slope Length Factor

S = Slope Steepness Factor

C = Cover Factor

P = Land Management Factor

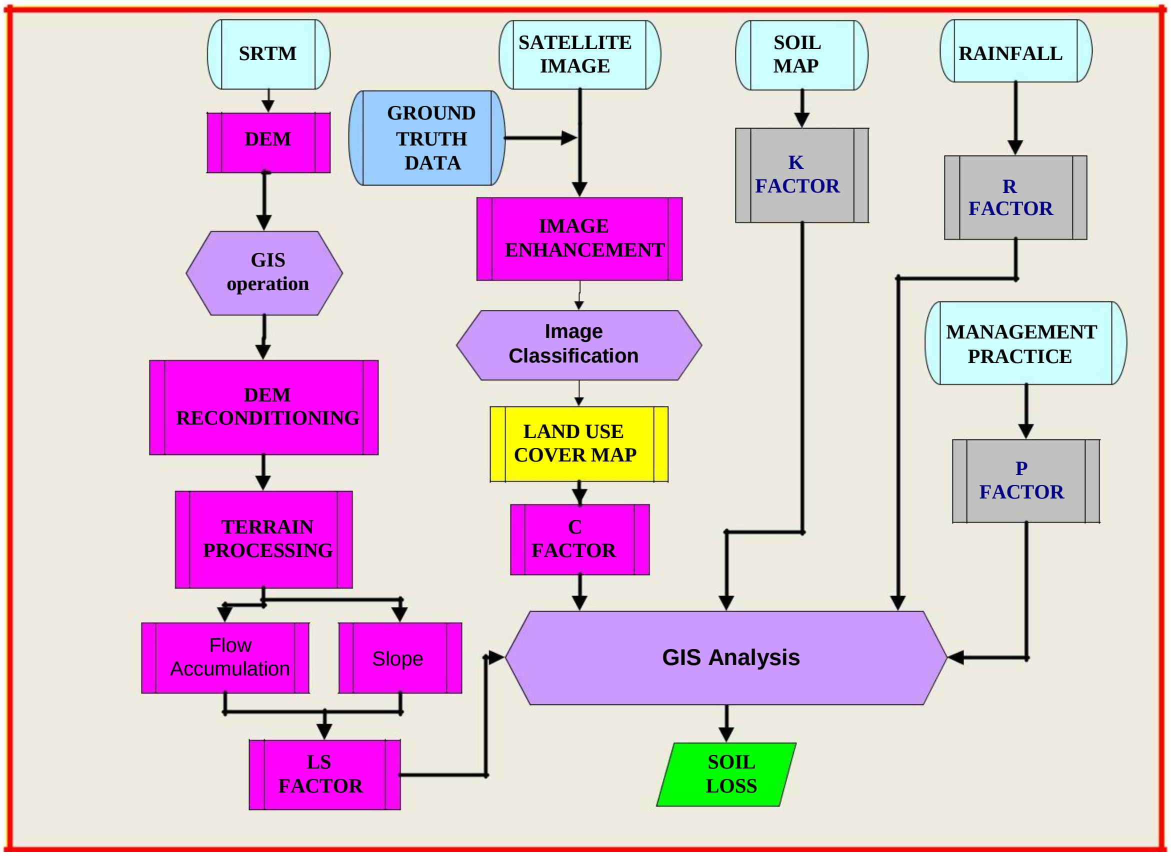

Figure 1: Procedures of RUSLE Implementation in GIS

2.1.2.1.1. Rainfall Erosivity (R)

It shows the energy of the rain to cause soil erosion. Rainfall erosivity would be calculated and mapped by using rainfall data found in and around the project area. The erosivity factor would be calculated by using annual rainfall of the area, adopted equations in Ethiopian condition by professor Hurni, 1983. However, rainfall kinetic energy and intensity data are not available in 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 + 0.562P

Where R= Rainfall Erosivity Factor (MJ·mm·ha^{-1}·yr^{-1})

P= Mean annual rainfall (mm)

The annual average precipitation was used to construct the spatially distributed rainfall map from which the corresponding average value of rainfall erosivity factor, R, was evaluated.

2.1.2.1.2. Soil Erodibility (K)

Soil erodibility represents the susceptibility of soil or surface material to erosion, transportability of the sediment, and the amount and rate of runoff given a particular rainfall input, as measured under a standard condition. Soil erodibility values reflect the rate of soil loss per rainfall-runoff erosivity index. Soil erodibility factors are best obtained from direct measurements on natural runoff plots.

Influencing factors of soil erodibility are soil characteristics such as permeability, infiltration, water holding capacity, distribution of particles, aggregate stability, tendency towards dispersion and absorption, transportability, structure, and humus content. The soil erodibility would be calculated for each mapping unit of generated geomorphology and soil map of the project area.

2.1.2.1.3. Slope Length and Steepness Factor (LS)

The effect of topography on soil erosion is accounted for by the LS factor in RUSLE, which combines the effects of a slope length factor, L and steepness factor S. In general, as slope length increases, total soil erosion and soil erosion per unit area increase due to the progressive accumulation of runoff in the down slope direction. Similarly as the slope steepness and slope grid layer increases, the velocity and erosivity of runoff increases in the down slope direction.

The slope length and slope steepness can be used in a single index, which expresses the ratio of soil loss as defined by (Wischemeier and Smith 1978).

$$\mathbf{LS = (\mathit{X}/22.13)^{m} (0.065 + 0.045\,\mathit{S} + 0.0065\,\mathit{S}^{2})}$$

Where X = slope length (m), S = slope gradient (%) and the value of m varies from 0.2 - 0.5 depending of the slope (Wischemeier and Smith 1978). Some references use m = 0.5.

Slope length X = over land flow length

Over land flow length = Lo=1/2D

D= Drainage Density

2.1.2.1.4. Land Cover (C)

The cover management factor represents the effects of vegetation, management, and erosion control practices on soil loss. As with other RUSLE factors, the C value is a ratio comparing the existing surface conditions at a site to the standard conditions of the unit plot. The land cover factor was 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 was synchronized with the adopted C value in Ethiopian condition.

Table 1: Land Cover Factor

No	***Land Cover/Use Class***	***Source***	***C Value***
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	0.1
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

2.1.2.1.5. Land Management Practice (P)

The management/land use practice will be estimated from land use maps and data from biophysical survey. The land management factor (P) in RUSLE is defined as the ratio of soil loss with a specific management practice to the corresponding soil loss with straight row upslope and down slope tillage. The P factor accounts for control practices that reduce the erosion potential of the runoff by their influence on drainage patterns, runoff concentration, runoff velocity, and hydraulic forces exerted by runoff on soil. The supporting mechanical practices include the effects of contouring, strip cropping, or terracing.

Table 2: P Values by Wischemeier and Smith, 1978

Land Use Type	***Slope %***	***P-Factor***
Agricultural land	0-5	0.1
	5-10	0.12
	10-20	0.14
	20-30	0.19
	30-50	0.25
	50-100	0.33
Other land use	All	1

2.1.2.2. Sediment Yield

The sediment delivery ratio (SDR) denotes the ratio of the sediment yield at a given stream cross section to the gross erosion from the watershed upstream from the measuring point (Julien, 1998). There is no precise procedure to estimate SDR, although the USDA has published a hand book in which the SDR is related to drainage area (USDA SCS, 1972). SDR can be affected by a number of factors including sediment source, texture, nearness to the main stream, channel density, watershed area, slope, length, land use/land cover, and rainfall-runoff factors. A watershed with steep slopes has a higher sediment delivery ratio than a watershed with flat and wide valleys. In order to estimate sediment delivery ratios, the size of the area of interest should also be defined. As shown in the following equations, the larger the size of the area, the lower the sediment delivery ratio because large areas have more chances to trap soil particles.

Considering that only some of the eroded soils are routed to the watershed outlet, knowing the ratio between the watershed sediment yield at the watershed outlet and soil erosion over the watershed, which is called sediment delivery ratio (SDR), is important for the decision makers. The RUSLE calculates soil loss forced by rainfall but doesn’t take the SDR into account. To generate the sediment yield at the outlet, empirical equations were carried out.

$$SDR = A^{-0.2}$$

Where SDR denotes the sediment delivery ratio and A- area of the watershed. The SDR physically means the ratio of the sediment routed to the outlet over the watershed, both overland and channel.

2.2. Materials

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

Equipments: GPS and Camera
Software: Arc GIS, Arc Hydro, Arc SWAT and others.
Data Models: DEM, Geomorphology/Soil and Land Cover Images

3.GEOGRAPHIC AND NATURAL FEATURES

3.1 Location

Awajo River watershed originates or starts in Tarma Ber Woreda and intersects Mojana Woreda Woreda along its route to the head work site, Awajo. The watershed, Awajo, is labeled by the name of the main river of the watershed and the order of the head work in the river.

Geographically the Watershed is located between 1093130 to 1101760 meters North and 576300 to 581140 meters East in UTM coordinates with an altitude ranges of 2509 up to 3113 meters above sea level.

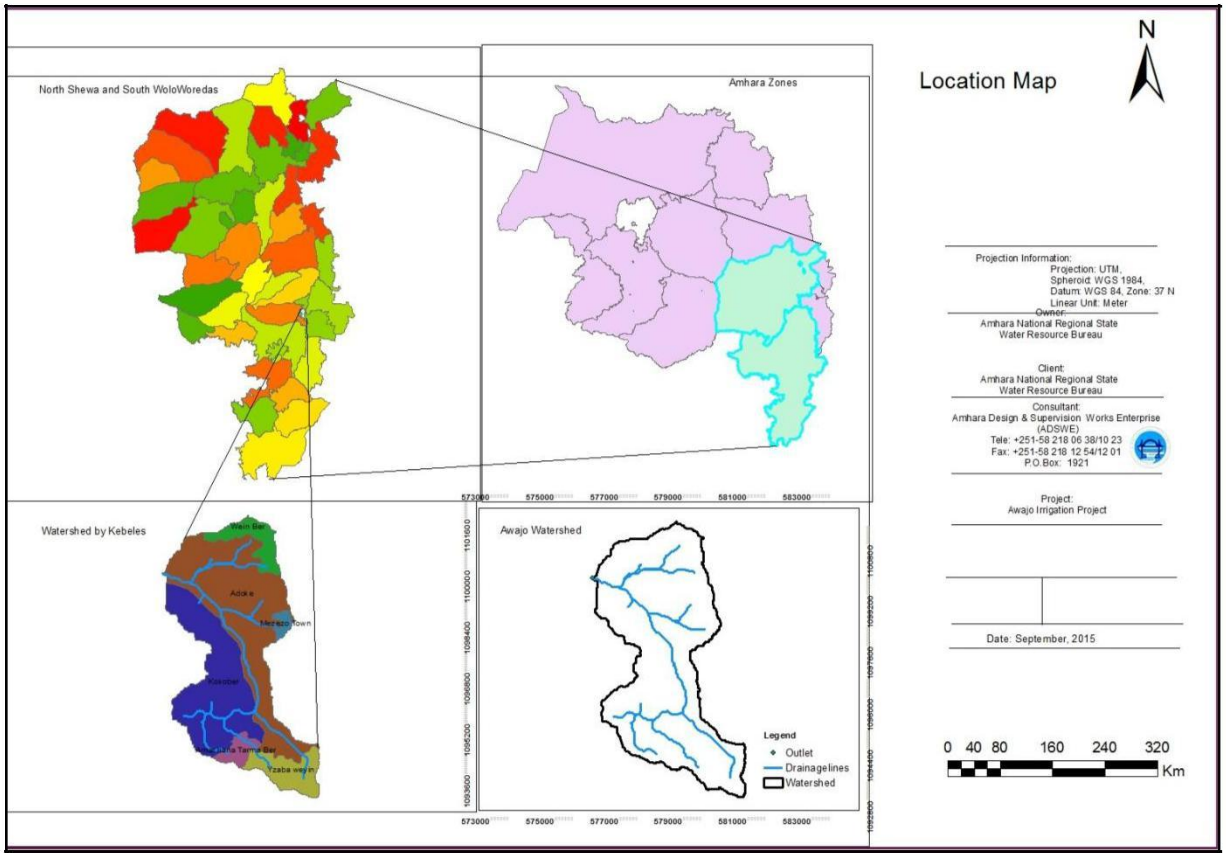

Figure 2: Location Map of Awajo Watershed

The drainage unit has historically been an important watershed area as it is among the earliest sources of water to its environs. It lay within a key agricultural area and has seen significant expansion in agricultural activity over the years. The watershed extends to two Woreda, Mojana wadera and Tarmaber which is limited within 525 hectares.

Table 3: Administrative Units in the Watershed

Region	Zone	Woreda	Rural Kebeles	Area hectare	Percent Hectare
Amhara	North Shewa	Mojana Wadera	Amashana Tarma Ber	71.89	3.20
		Tarma Ber	Mezezo Town	32.62	1.45
			Wein Ber	144.67	6.44
			Kosober	754.06	33.55
			Adoke	1043.78	46.44
			Yzaba weyin	200.65	8.93
			Total Area	2247.67	100

3.2. Topography

The rate and volume of runoff, and sediment yield from the watershed have much to do with slope and other parameters of the landscape. The rugged terrain and steep slopes accelerate land degradation. The rugged and steep land has influenced not only lowered infiltration of rainwater but also the water holding capacity of soils. They also have negative impacts on the efficiency of soil and water conservation measures particularly that of physical SWC measures. This is attributable to small cross sectional area of the channel of the structures, which otherwise need deep excavations. Thus the structures get filled with sediment within one shower of rainfall.

3.2.1. Slope

The Watershed has marked topographic variation. Six types of slope classes are present. The dominant slope class is moderately steep (15-30%) which covers 33.24% of the total area followed Sloping (8-15%) which is 23.53%. Steep (30-50%), gently sloping (3-8%), very Steep (>50%) and flat or almost flat (0-3%) accounts 22.43%, 12.31%, 6.72% and 1.78%, respectively. Table 4 shows the slope classes and proportion of the watershed.

Table 4: Slope Class and Coverage

No.	Slope		***Area Coverage***	
	Description	***Class (%)***	***Hectare (ha)***	***Proportion (%)***
	Flat or almost flat	0-3%	39.99	1.78
	Gently sloping	3-8%	276.62	12.31
	Sloping	8-15%	528.79	23.53
	Moderately steep	15-30%	747.03	33.24
	Steep	30-50%	504.11	22.43
	Very Steep	>50%	151.13	6.72
	Total		2247.67	100

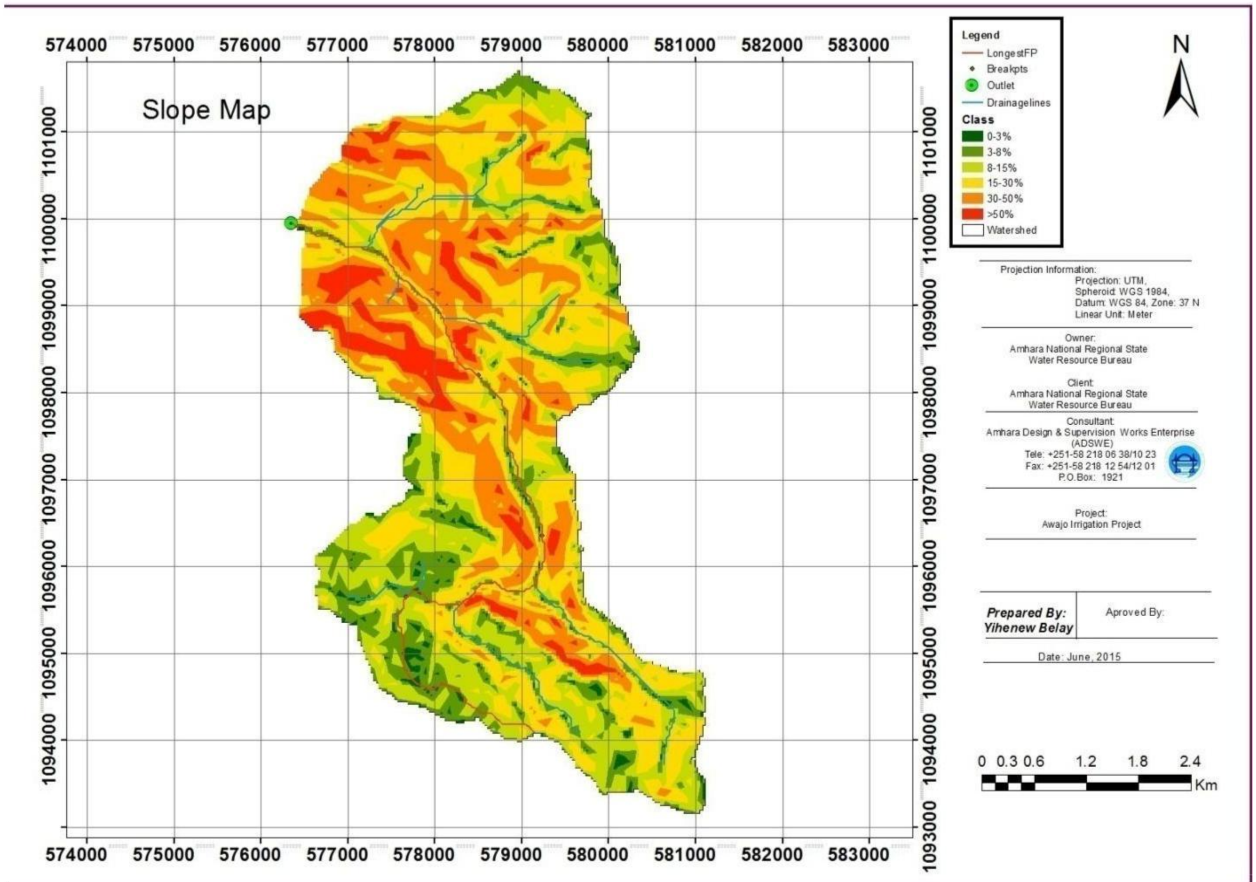

Figure 3: Slope Map of Awajo Watershed

3.2.2. Contour

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. 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 micro- 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 of the watershed indicate that steeper slopes occur in those locations relative to areas that have less closely spaced contours; whereas sparse contour lines indicate plains.

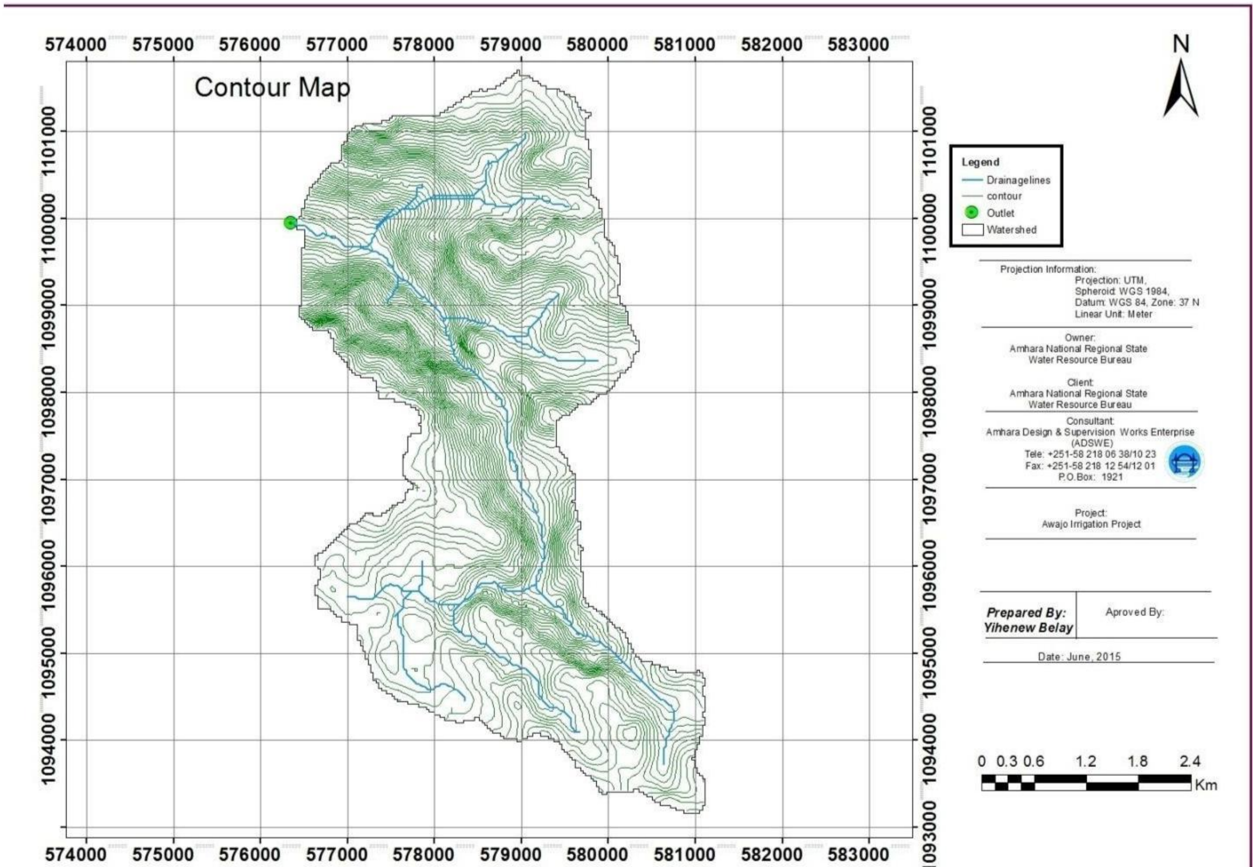

Figure 4: Contour Map of Awajo Watershed

2.2.3. Elevation

The elevation of the project area ranges from 2509 up to 3113 meters above sea level. The watershed lay within one elevation class, 2300 -3200 meters, based on which the watershed is set in Middle lands and highlands (Weina Dega and Dega) traditional agro-climatic/ecology zones. The difference in altitude and therefore of climate conditions have provided the scene for a wide variety of cropping patterns in agriculture. The watershed consists of one altitude classes; but two traditional agro-climatic zones, as there is difference in altitude that can govern a wide variety of mode of agriculture.

3.2.3. Drainage

The drainage pattern has something to do with erosion hazard and sediment yield. The main river of the watershed intersects two Woreda along its route. The drainage pattern of the watershed is ordered by this main river, to which all other drainage lines are tributaries. The tributaries of the main river are long; joining to the main river channel in much kilometers travel rise from different parts of the watershed and significantly affect the flood characteristics of the watershed. The drainage pattern of Awajo watershed is dendrite with total streams length of 7.66 km and longest flow of 10.47 km.

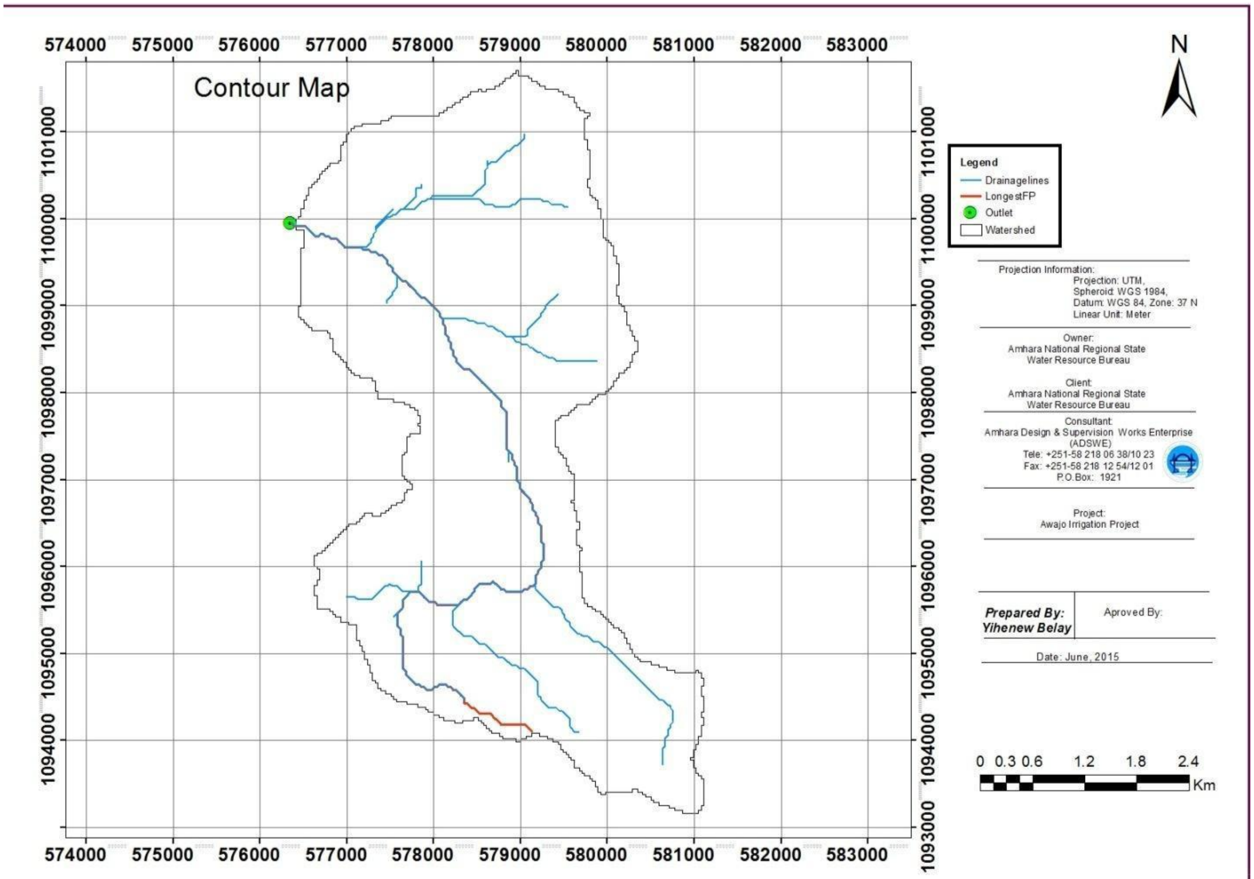

Figure 5: Drainage Map of the Watershed

3.2.4. Soil

There is strong relation between landform and soil characteristics. The watershed has various land form. As per the variety of landforms within the watershed, the soil characteristics are different for most of the mapping units. There are four different soil types, Eutric Cambisols, Eutric Regosols, Lithosols and Vertic Cambisols. The depth of soil in the watershed is very shallow in hills and mountains to deep in plain areas.

Table 5: Soil Type and Coverage

No	***Soil Type***	***Area Coverage***	
		Hectare (ha)	***Percent (%)***
1	Eutric Camisole	59.85	2.66
2	Eutric Regosols	608.95	27.09
3	Lithosols	471.06	20.96
4	Vertic Cambisols	1107.8	49.29
Total		2247.66	**100**

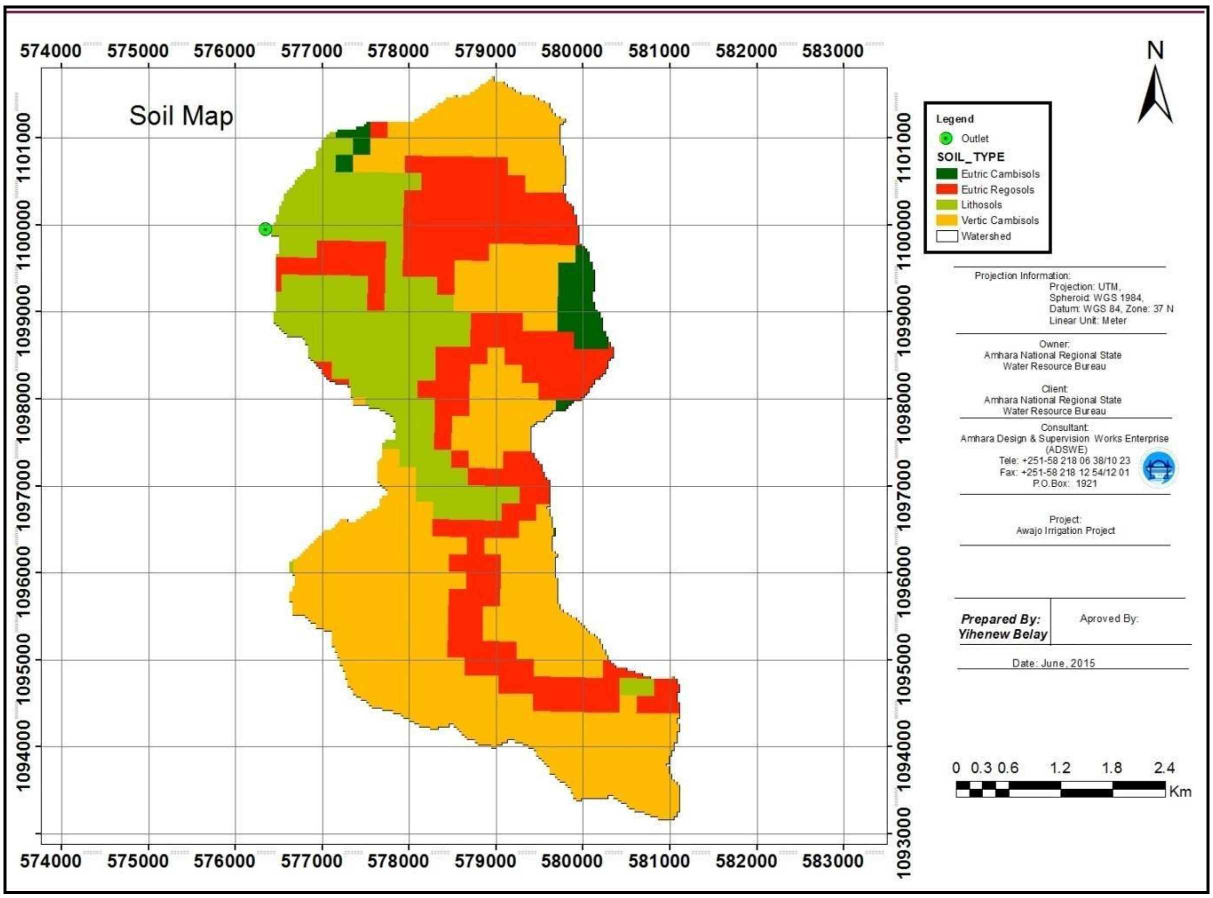

Figure 6 Soil Type Map of the Watershed

3.2.5. Climate

The interaction of human activity on the distribution of vegetation through land management practices and seemingly beginning of rainfall events can make land more vulnerable

These vulnerabilities become more acute when the prospect of climate change is introduced. Rainfall and temperature are the prime factors in determining the climate therefore the distribution of vegetation types. There is a strong correlation between climate and biomass.

3.2.5.1. Temperature and Rainfall

3.2.5.1.1. Temperature

Important climatic variables such temperature and rainfall were observed at Amhara Region climate map source. The watershed comprises two temperature ranges, cold and tepid zones.

Table 6: Thermal Type and Coverage

No	Temperature Class- ^{o}c	Temperature Code	Traditional classification	Area ha	Area Percent
1	10.0-12.5	Cold	Wirch	673.82	29.979
2	12.5-15.0	Cool	Dega	1554.83	69.175
3	15.0-17.5	Cool	Dega	19.01	0.846
Total				2247.66	**100**

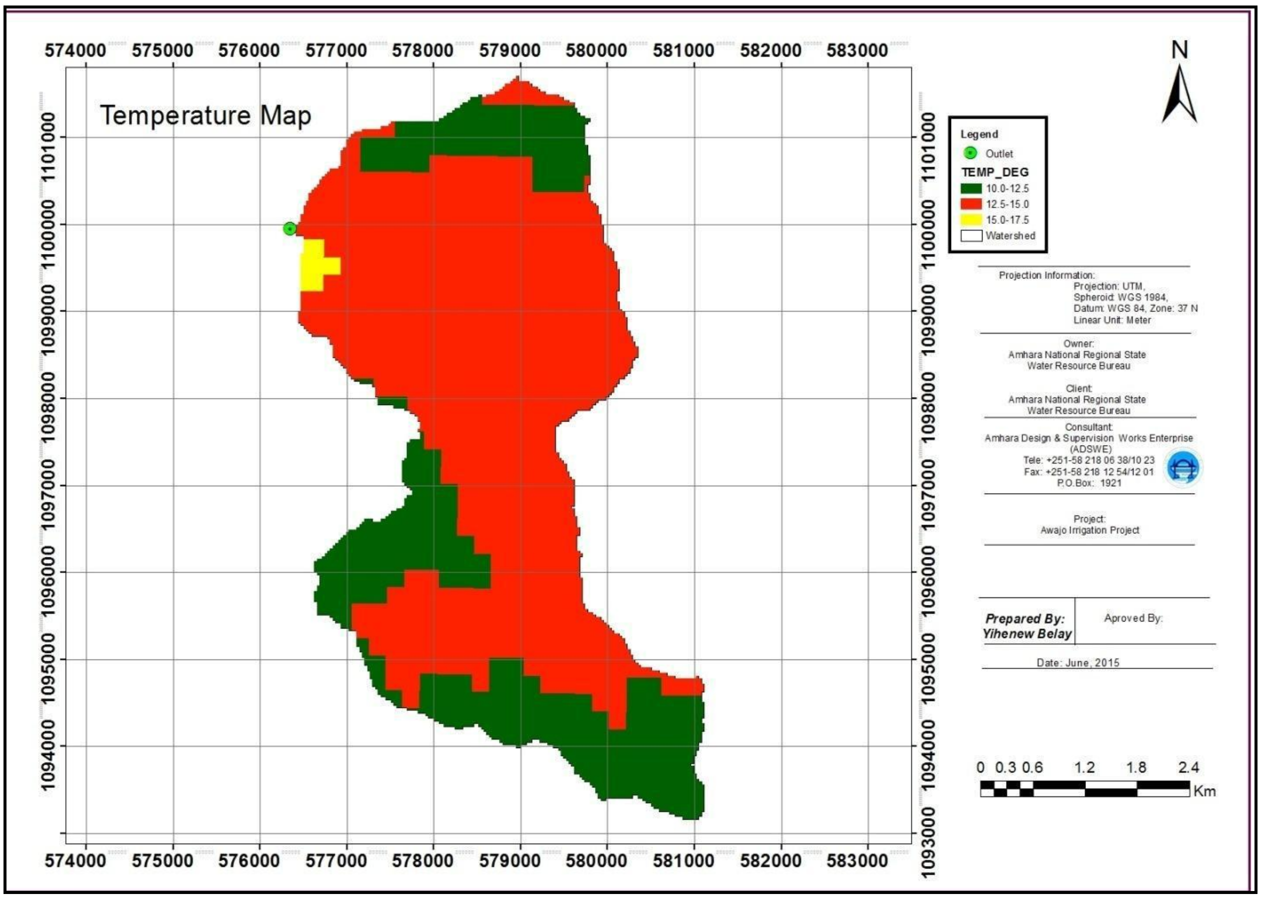

Figure 7: Temperature Map

3.2.8.2. Rainfall

The extremes of either too much or too little rainfall can produce soil erosion that can lead to land degradation. However, soil scientists consider rainfall the most important erosion factor among the many factors that cause soil erosion. Rainfall can erode soil by the force of raindrops, surface and subsurface runoff, and river flooding. The velocity of rain hitting the soil surface produces a large amount of kinetic energy, which can dislodge soil particles. The watershed comprises two rainfall zones with minimum rainfall of 1200 mm and maximum 1800 mm.

N.B you can see in the Annex table 6 and 7 the mean rain fall data of Debresina and Saladingay station of Tarmaber and Mojana wodera woreda

3.2.5.2. Agro Climatic Zonation

In agro climatic zone classification, rainfall, temperature and altitude are the most common criteria. These values set the watershed under dega, the majority of the watershed, and small part of weina dega agroecology zones as shown the table below.

Table 7: Agroecology and coverage

No	Agroecology	Temperature code	Area Hectare	Area Percent
1	Dega	Cold	2228.65	99.15
2	Woyine Dega	Tepid	19.01	0.85
Total	**2**	**2**	2247.66	100

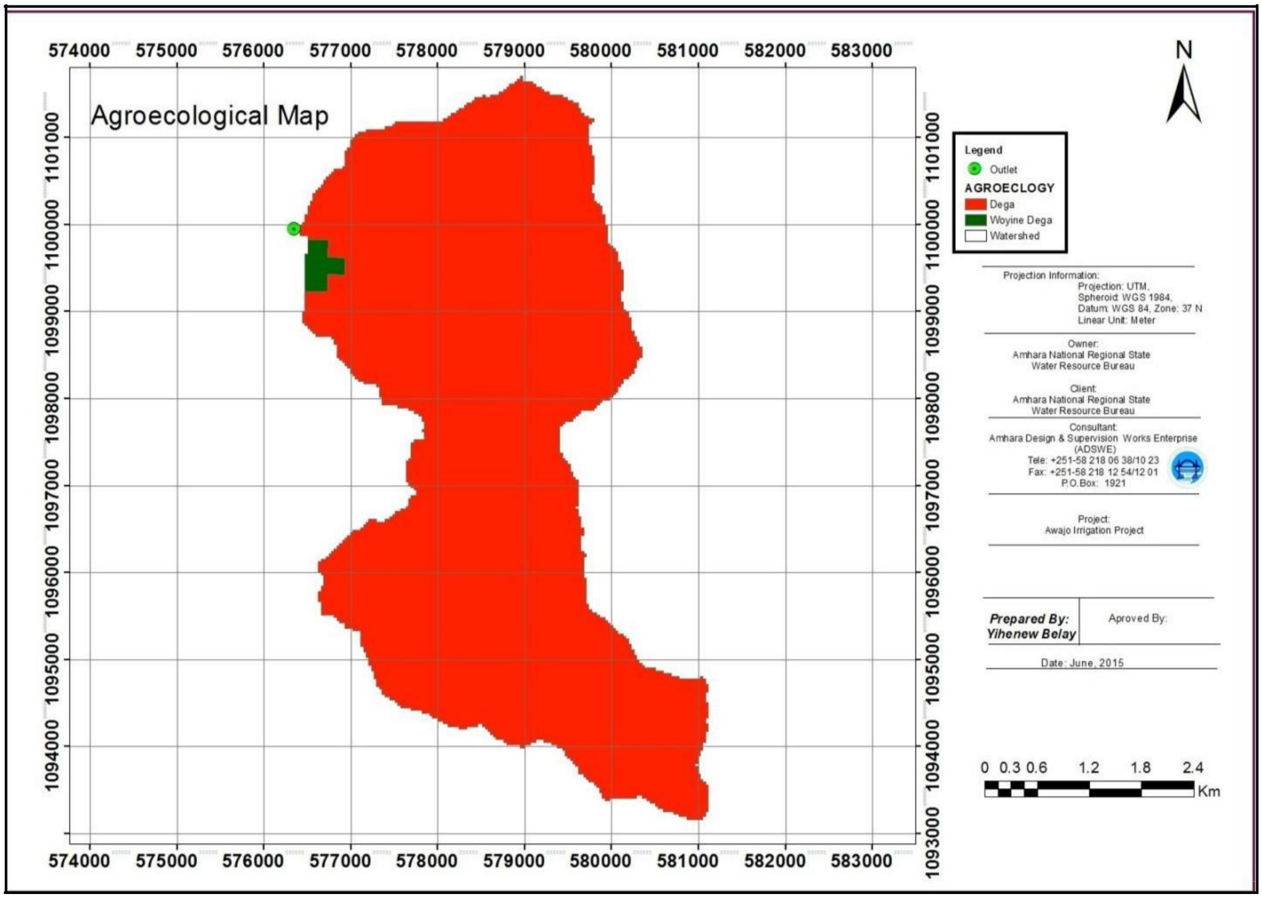

Figure 8: Agro ecology Map

4.SOCIO-ECONOMIC CONDITIONS

4.1 Demography

The total population of two rural kebeles intersecting the watershed estimated to be about 10543 of which 5740 male and 4804 female. The population of the watershed includes those reside outside the watershed because the population was considered on kebele level but population of kebeles out of Tarma Ber woreda that intersect the watershed was not included because of data in availability.

Table 8: Population Size and Distribution

Zone	**Woreda**	Population & Households	Population			Households		
North Shewa	Tarma Ber	Kebeles	Male	Females	Total	Male	Females	Total
		Abergina	1571	1471	3042	494	121	615
		Adebabay Tsion	4169	3333	7502	1059	127	1186
		Total	5740	4804	10544	1553	248	1801

Source: Woreda Agriculture office

N.B Population data is collected based on Keble level

The general nature of the settlement pattern is rural and traditional, which is clustered into groups called “Got” are rather sparsely scattered throughout the area. Average working days for rural communities were about 20 days per month. The houses were moderately scattered on flat plateau over the watershed. Similar to housing condition of rural Amhara, wood and mud were the major materials commonly used for the construction of house in the watershed. Almost all the housing units in the area had the same type of walls and the majority of them have roof of Eucalyptus trusses with corrugated iron sheet roofing.

4.2. Farming System

The farming system in the watershed comprised field crop production, livestock rearing and tree growing. Agriculture was the main economic base of the community in the watershed. Both crop production and livestock rearing, mixed agriculture, was carried out with almost equal emphasis. The results of household survey show that crop products were the major source of income followed by livestock.

4.2.1. Crop Production

Crop production was the leading economic activity in all part of the project area. The major crop types cultivated in the watershed were cereal crops and vegetables. The production system for almost all crop types was traditional with oxen plowing and packed animal transportation.

Farming operation and agricultural crop production process was carried out throughout a year. Land plowing was done by traditional farm implement and oxen power, which cuts soil in shallow depth and very small width. **the major types of crops growing in the Awajo watershed are:**

- ✓ **Wheat**
- ✓ **Barley**
- ✓ **Teff**
- ✓ **Bean**
- ✓ **Lentil and Chick Pea Etc**

4.3.Existing Cropping Pattern

The rainfed agriculture is mainly based on summer (Kiremt) rainfall. In the project area rainfed cropping season starts commonly from the month of June to November/December. During this time of span some crops are grown despite the fact that there is moisture stress or rain shortage frequently towards the end of the rain season. The cultivated land coverage by different crops (cropping pattern) varies from year to year especially depending on climatic factors (typically due to early or late start of the kiremt rainfall). Furthermore, farmers' preferences, soil conditions, market price situations and feed habit of the society also determine the cropping pattern. Wheat, barley, faba bean and teff are the major crops grown, in the project area, during rainy season. Tomato, pepper, onion, garlic, and maize are grown in the dry season and are used, most of the time, for market purpose as cash incomes.

At kebele level, where the project area is found, wheat is the leading crop in area coverage having a share of 26.9% and followed by teff, chick pea, faba bean, barely, lentil, filed pea, respectively (Table 10).)

Table : Existing cropping pattern and production (rainfed) of Wedera kebele, 2015

S/N	Crop type	Cropped Area (ha)	Cropped Area (%)	Productivity (qt/ha)	Production (qt)
	Meher				
1	Teff	210	19.4	10	4200
2	Faba bean	112	10.3	19	2128
5	Filed pea	50	4.6	13	650
6	Lentil	100	9.2	16	1600
7	Chick pea	180	16.6	28	5040
8	Vetch	15	1.3	11	165
9	barely	101	9.3	24	2424
10	Wheat	310	28.7	36	11160
Total		1078	100		27367

Source: Wedera Kebele Agricultural Development Office

4.3.1. Productivity

According to the results of the discussion with agricultural extension agents and farmers, the productivity of crops was decreasing year after year at alarming rate. The higher yield was associated with fertilizer application and improved seeds. Agricultural inputs such as fertilizers and improved seeds were distributed in the previous years but due to high cost and shortage of the supply, restricted the use.

4.2.1.2. Cropping Calendar

Cropping Calendar was also identified through discussion with the community members and extension workers. Farming operation and agricultural crop production process was carried out throughout a year. The crop calendars, especially plowing frequency, sowing, and weeding should be performed through scientific specifications. However, farmers perform these and other cropping practices traditionally.

4.3.2.2. Livestock Production

The livestock species and population has both negative and positive effects on the project in many ways. Livestock husbandry was also an integral part of crop production and contributes to the household economy including part of food. Even if crop production was the first economic activity, almost all production procedures were manipulated by the support of livestock labor.

Livestock in the farming system also contributed draught power, dung fuel, manure for soil conditioning, food, cash income and transport. Economically livestock and livestock products constitute significant part on the farmers' life. They are the only insurance at the time of crop failure.

4.3.2.2.1. Livestock Species

All livestock species are found or reared in the watershed. Cattle rearing are compulsory as agriculturalists for draught animal farming and secondary for meat and milk production. Commonly shoats, equines and poultry and bee colonies are also reared in the watershed for different purposes. Equine are also common as back transport as cattle for draught farming.

4.3.2.2.2 Livestock Management

The livestock management which includes herding, housing, feeding and breeding was traditional. Unlike the size of livestock, the productivity was very low. There were many feed sources as crop residues and grasses produced from straw and grazing land respectively were easily available, but there was feed deficit due to limitation in management.

There was incidence of livestock diseases, seasonal and regular diseases that reduce population and productivity. Veterinary services were not satisfactory in proximity; skilled manpower and material supply to control and treat livestock disease in most kebeles.

4.3.2.3. Forest Production and Wild Life

Forest Production

There were vegetative covers, especially dominated by shrub lands. Economically and ecologically important indigenous trees are almost disappeared because of the use of tree resources for different socio-economic and socio-cultural needs at the rate of beyond its regenerative capacity. The main needs and uses of tree resources include firewood, construction, and charcoal production. the most common tees are found in the watershed Equliptes,Oliya african,Acciea,Bisana,Shola and mostly bushes and shurubs area common but less coverege of forest

4.4.2 Wild Life

Some wild life found in the are

Mammals: red fox, monkey, , and others.

Hyena, Monkey, Ape, Fox, jart and others.

Birds: Kiltim Sebari, Chilfit, Tinb ansa, Duke, kok and others.

4.3. Infrastructure

As the watershed found away from the Woreda capital, Tarma Ber town, it is poor in facilities in all aspects. Almost all part of the watershed had no any communication services like road except part of the upper catchment and no telephone or mobile telecom services and has no electricity in the area. The watershed and the command area have no any type of road except steep foot paths that connect gravel roads.

5.LAND USE /LAND COVER

5.1 Past Land Use History

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

5.2. Present Land Use/Cover

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

5.2.1. Cultivated Land

Cultivated lands are found on all types of slope classes all over the watershed. The soil depths of the cultivated lands are decreasing due to long year cultivation without remedial measures. For a very long period of time the area is subjected to continuous cultivation of almost similar crops, especially food grain are the major crops both in production and area coverage. Cultivated land located in almost all slope classes of the watershed, covering 88.85% of the watershed area.

5.2.2. Grazing Lands

Grazing land covered 3.26% of the watershed area. This land use type was more or less located in all types of slope class; however it was mostly found moderately steep and steep slopes though patches of grazing lands were available on flatter and steeper slopes. This was because of the non suitability for cultivation due to poor soil depth and fertility. Most part of the grazing land was found grazed without any shifting or controlled system. Only few farmers harvested the grass by cut and carry system to feed their cattle and for sale from these protected grass lands.

5.2.3. Forest Areas

There was no forest area except shrub and bush lands composed of different species of indigenous trees but its coverage is very large which is the dominant cover of the watershed. The shrubs and bush lands exist in covers 7.88% of the watershed area. Economically and ecologically important indigenous trees are almost disappearing because of the use of tree resources for different socio-economic and socio-cultural needs at the rate of beyond its regenerative capacity.

5.2.4. Settlements

Rural settlements in the watershed were scattered, that it could not be delineated as one village. It was even noted that there is one house in the farm lands which can't be considered as a village. Individual houses are even being constructed on farm lands and grazing areas without plan.

Table 9: Land Cover Type and Coverage

No	Major Land Cover	Area hectare	Area percent
1	Cultivation	1997.14	88.85
2	Grassland	73.32	3.26
3	Shrub land	177.2	7.88
	Total	2247.66	**100**

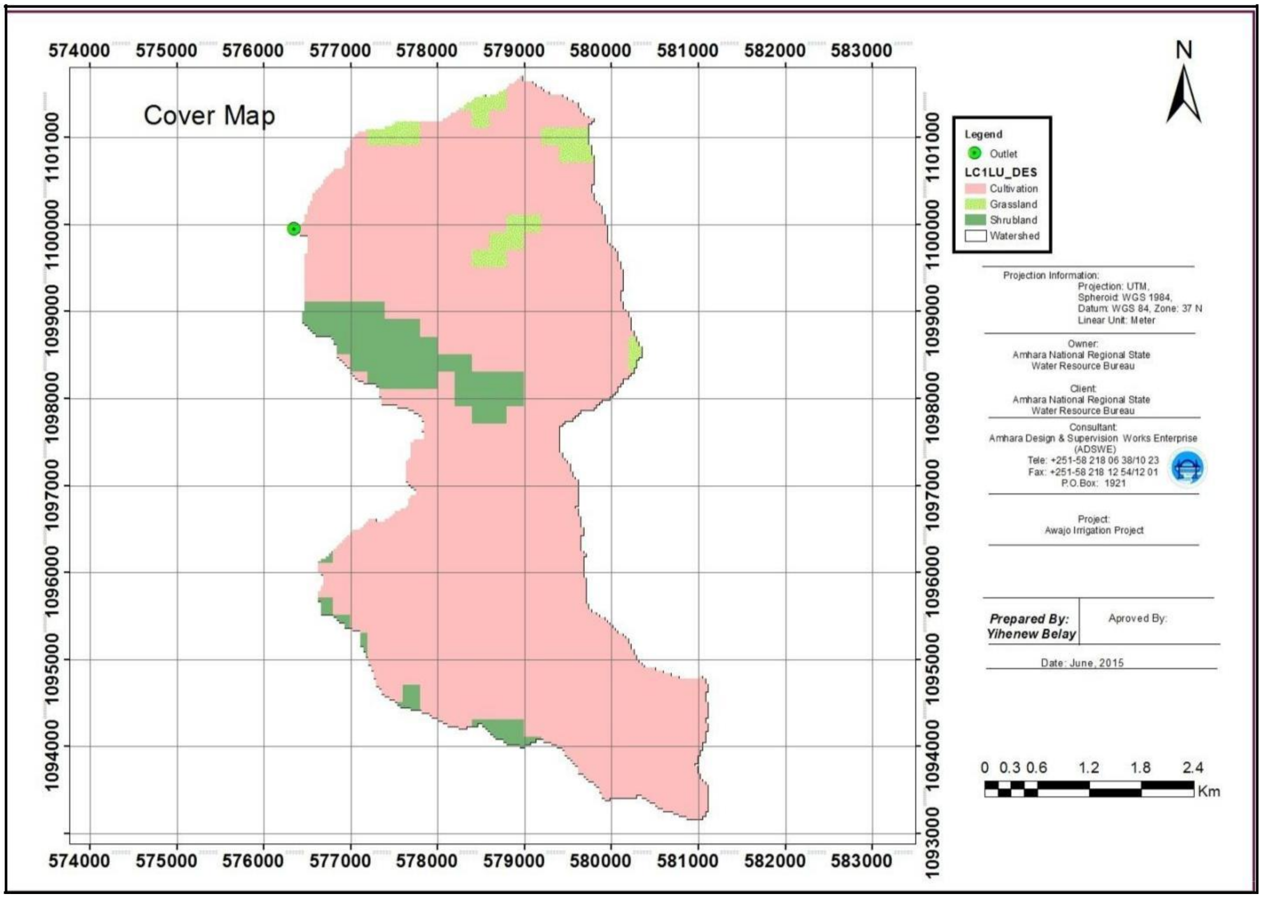

Figure 9: Land Use/Cover Map of the Watershed

6. LAND DEGRADATION

Land degradation is not a new phenomenon in the watershed. The disastrous soil degradation, which is the main types of land degradation, in the watershed is caused by water, cause of biological degradation. Soil erosion caused by water agents was a common phenomena becoming a major constraint to agricultural development in all parts of the watershed. Soil degradation is described by decline of organic matter, depletion of nutrient, salinization and drying up of rivers and lakes. Crop production reports have shown crop yield is increasing but it was achieved with more fertilizer application. Livestock production is decreasing in number and type. The production of calves and animal products is decreasing.

6.1. Extent and Rate of Degradation

Assessment of land degradation is not an easy task, and a wide range of methods are used, including expert judgment, remote sensing and modeling. Because of different definitions and terminology, there also exists a large variation in the available statistics on the extent and rate of land degradation. Further, most statistics refer to the risks of degradation or desertification, based on climatic factors and land use, rather than to the current state of the land. The degradation rate of the watershed was said to be alarming rate as the changes observed within the last years, as elders and resource persons described; population density was by far lower than the present, hill sides and stream banks were covered with naturally grown trees and grasses. The production of the grazing, cultivated and forest land, and the occupation of each house hold was enough to support family’s food need. But as the population grew, these all things deteriorated. Population growth is attributed to expansion of cultivating and use of trees for fire wood.

6.2. Soil Erosion

The watershed of Awajo demonstrates severe soil degradation problems. The problem has been long aged and deep rooted, as the watershed is one of the aged agricultural areas. The major form of land degradation in the watershed is soil erosion by water. The common type of erosion is water erosion exhibited with all forms of erosion such as sheet and rills, gully, river bank erosion and land sliding on very steep slope areas. The soil erosion in the watershed, amounting over 16856.41tons of soil loss every year, is not due to natural causes but primarily to human activities that progressively ever grown since centuries. The long aged agricultural activities

resulted in progressive depletion on resources through deforestation, overgrazing and over cultivation of steep areas and hence sever soil erosion and land degradation. Presently, these resources, including water resources, are exceedingly depleted resulting in environmental, socio-economic and ecological losses. The resources depletion has created to progressively lowered land productivity to the rural people.

6.2.1. Forms of Erosion

6.2.1.1. Sheet Erosion

The disastrous soil degradation in this watershed is caused by sheet and rill erosion. Most part of the cultivated land is subject to sheet and rill erosion, especially the hazard is more on cultivated lands. The cause of sheet and rill erosion is complex and inter linked with one another. The key factors aggravating this problem are:

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

The problems arise mainly from population growth and poverty, which caused arable land expansion, intensive land use, deforestation and over exploitation of the land for short term benefit (nutrient depletion).

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

6.2.1.2. Rill Erosion

Rill erosion is the next noticeable form of erosion; in all areas where sheet erosion occurs we can observe the symptoms of which exists where sheet erosion occurs. The symptom of rill erosion is the occurrence of rills or small channels. Rill erosion occurs in all parts of the watershed and is considered as the second destructive form of erosion. The intensity of rills varies within the watershed with respect to slope and rainfall. Areas bordering the high lands are subjected to frequent rill erosion.

6.2.1.3. Gully Erosion

Alike sheet and rill erosion, gully erosion is a threat. With continues encroaching of gullies mostly towards cultivated land; gully erosion is also a problem in the watershed. Unlike the promising beginning on conserving cultivated lands, gullies have been ignored a serious problem. Because of this neglect ion the gullies are regularly expanding. Cultivated lands are expanded up to the edge of the gully and even on gully sides. Livestock are trampling around and inside gullies. Gullies of different size in Length, width and depth were observed in the watershed.

4.2.1.4. Stream Bank Erosion

It was also a threat on productive lands adjoining rivers. The source of Awajo found in the highland areas. This river possess long flow path having concentrated run off cause loss productive mass of soil in its banks. At some parts of the river, it was not affected by as such severe stream bank erosion as compared to other forms of water erosion but treatment is usually made because stream bank erosion may be critical at some unstable banks.

6.2.2. Erosion and Sediment Yield Estimation

6.2.2.1. Estimation of Soil Loss

The assessment of erosion hazard can be considered as a special form of land resource evaluation to identify those areas of land where the maximum sustained productivity from a given land is threatened by excessive soil loss. In performing this analysis, each thematic map of soil loss parameter, which is the same grid cell size and coordination, were used. The modified universal soil loss equation (USLE) for Ethiopian condition was used to compute the total average annual soil loss from sheet and rill erosion within the watershed. All the parameter of USLE was shown spatially throughout the watershed.

The modified universal soil loss equation is given as: A= RKLSCP

Where:

A = Average annual soil loss (ton/ha)

R = Rainfall erosivity

K = Soil erodibility

S = Slope length factor

C = Cover factor

P = Management factor

6.2.2.1.1. Rainfall Erosivity Factor (R)

The erosivity factor was calculated on the bases of mean annual rainfall data of the watershed 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:

$R=-8.12 + 0.562P$

Where: R= Rainfall erosivity factor ($MJ \cdot mm \cdot ha^{-1} \cdot yr^{-1}$)

P= Mean annual rainfall (mm)

The watershed area had set under rainfall class of 1500-1800 mm rainfall value with average rainfall of 1650 of the class, and then erosivity value of 919.18 MJ.mm/ (ha.h).

6.2.2.1.2. Soil Erodibility Factor (K)

Soil factors that influence erodibility by water are:

1. Those factors that affect infiltration rate, permeability, and total water retention capacity, and
2. Those factors that allow soil to resist dispersion, splashing, abrasion, and the transporting forces of rainfall and runoff.

The soil erodibility factor characterizes more or less the soil sensitivity towards erosion force. The value of K of all the soil types of the watershed are 0.1, 0.15 and 0.16. The soil of the watershed area was not surveyed as the command area but exported from Amhara Region Soil Map data and classified based on the FAO soil classification.

Table 10: Soil Type and Erodibility Coverage

No	*Soil Type*	*Erodibility(K Factor)*	*Area Coverage*	
			Hectare (ha)	*Percent (%)*
1	Dystric Histosols	0.1	86.40	16.45
2	Eutric Cambisols	0.15	386.76	73.66
3	Lithosols	0.16	51.93	9.89
Total			525.09	**100**

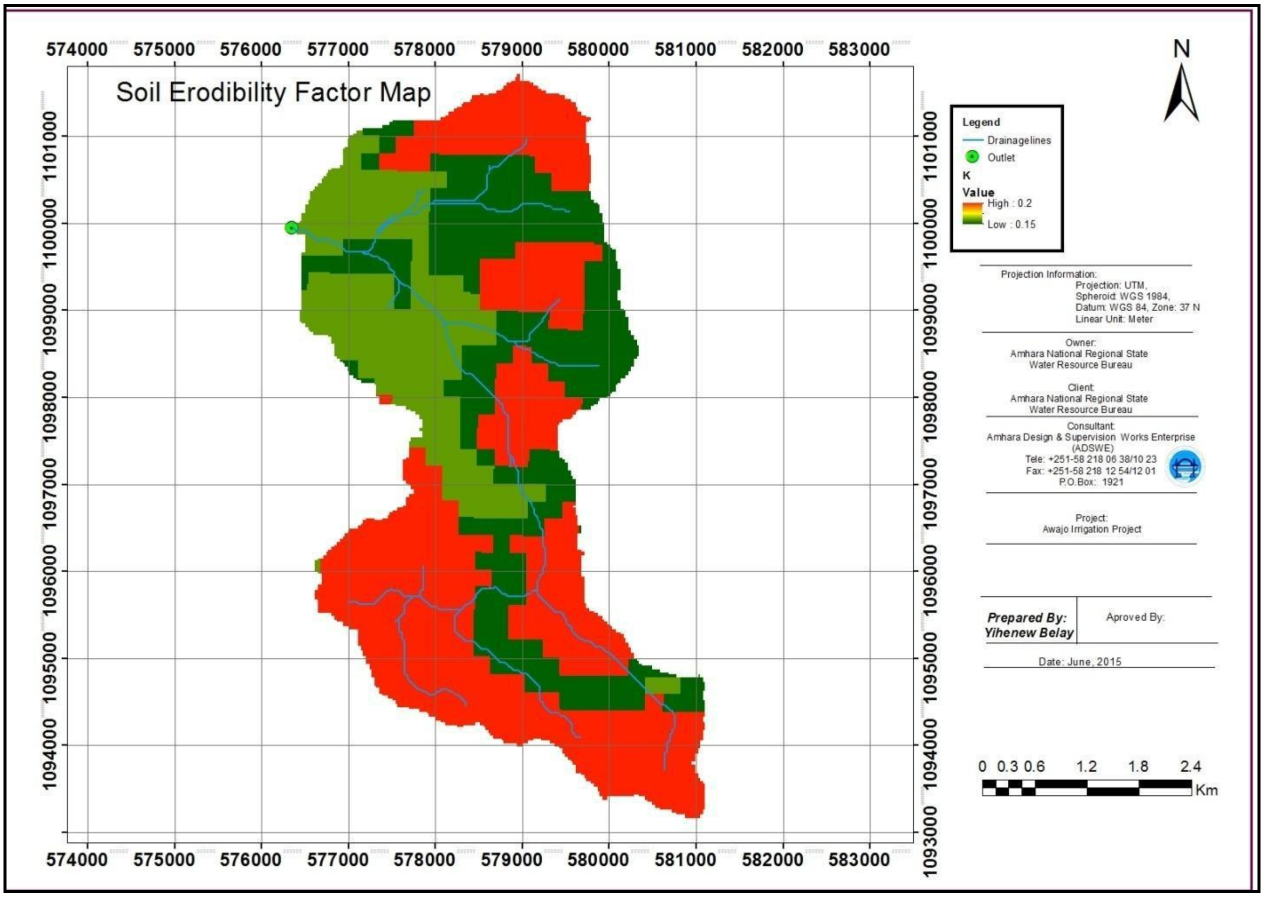

Figure 10: Erodibility Factor Map

4.2.2.1.3. Slope Length (L)

Studies have shown that erosion via water increases as the 0.5 power of the slope length ($L^{0.5}$). This results in about 1.3 times greater average soil loss per acre for every doubling of slope length. The slope length and gradient factors was estimated from Digital Elevation Model data in the GIS environment. The technique described here for computing L requires a flow accumulation grid layer. The flow accumulation also was computed from DEM (Digital Elevation Model). The cell size of the DEM represents the length of the cell. For this study, Slope length factor developed for Ethiopia was used. As a result the overland flow length 461m, the L factor was 3.8 used for soil loss calculation.

4.2.2.1.4. Steepness Factor (S)

As the slope steepness and slope grid layer increases, the velocity and erosivity of runoff increase in the down slope direction. The slope steepness factor estimated from Digital Elevation Model data in the GIS as slope grid layer. For this study, Slope steepness factor developed for Ethiopia condition was used. As a result, the slope steepness factor for each slope classes was used for soil loss calculation.

Table 11: Slope Steepness Factor(S)

Slope class	Area_ha	S_Value
0-5%	132.79	0.4
5_10%	350.57	1
10_15%	369.23	1.6
15-20%	279.43	2.2
20-30%	462.24	3
30_40%	322.58	3.8
40-50%	177.44	4.3
>60%	153.37	4.8

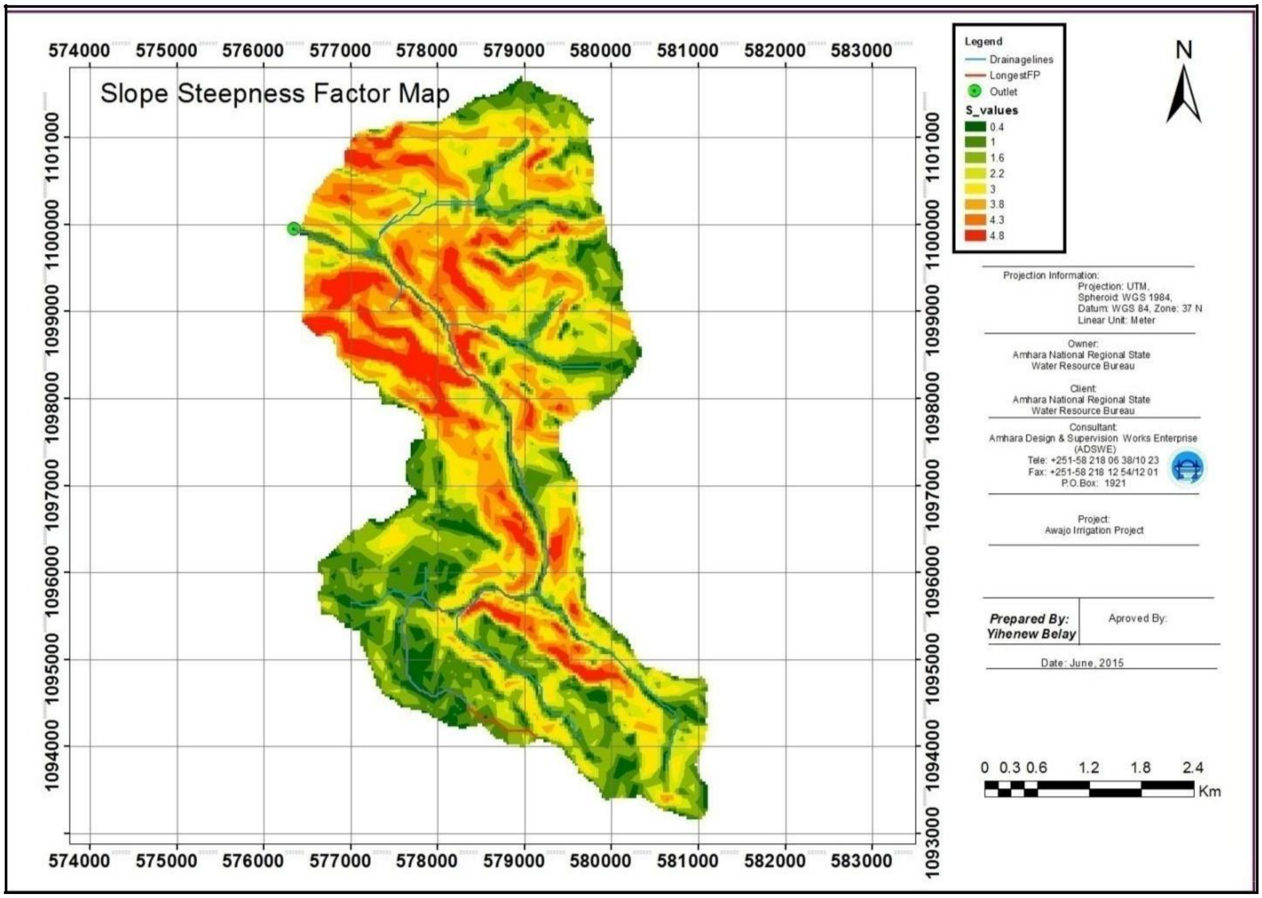

Figure 11: Derivation of Steepness Factor from Slope Map

6.2.2.1.5. Cover Factor (C)

The land cover factor was 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 was synchronized with the adopted C value in Ethiopian condition. The land cover/use map was taken from the Amhara region Land cover shape file prepared by finance.

Table 12 : Cover Management (C) Factor values of the study area

No	Land Cover Type	Cover Factor (C Value)	Area Coverage	
			Hectare	Percent
1	Cultivation	0.15	1997.14	88.85
2	Grassland	0.01	73.32	3.26
3	Shrub land	0.05	177.2	7.88
Total			2247.66	**100**

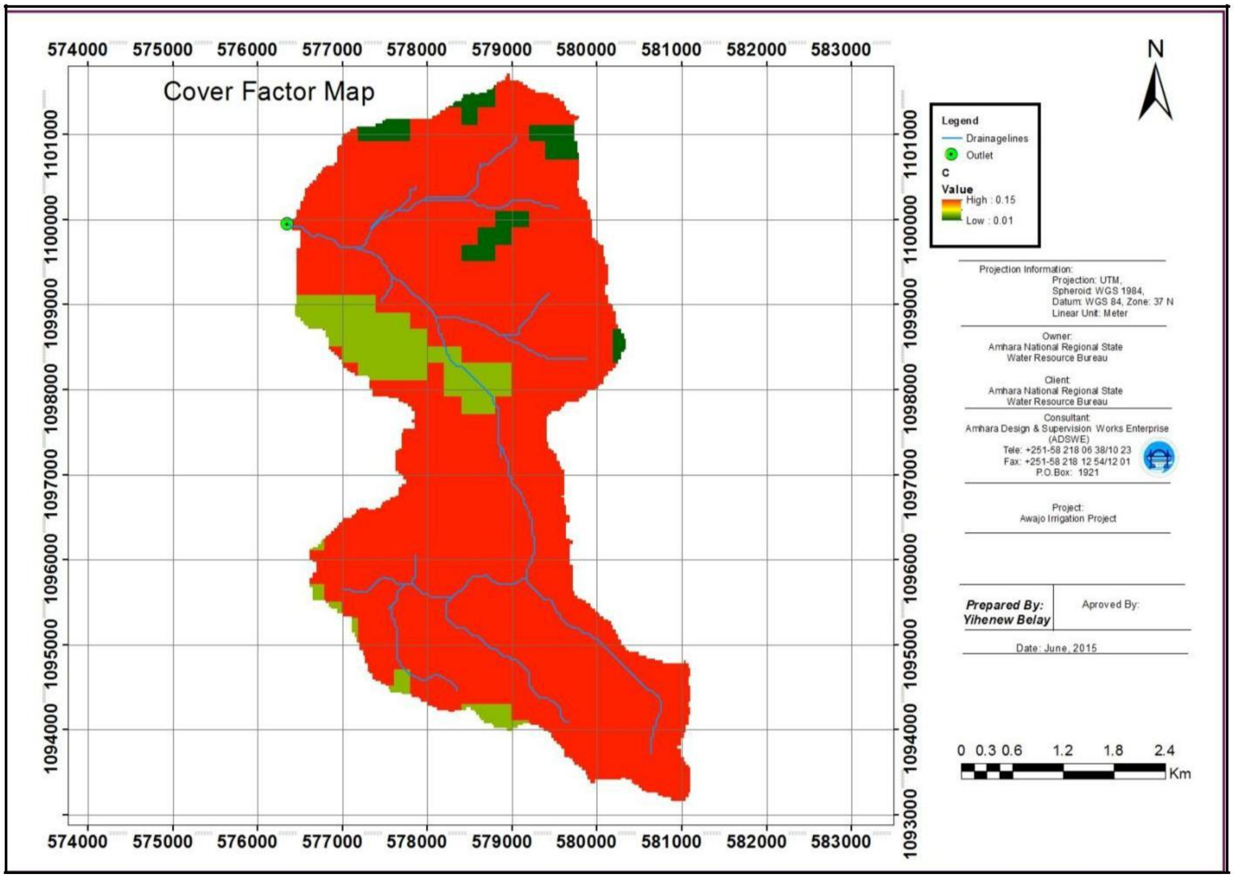

Figure 12: Derivation of Cover Factor from Cover Typ

6.2.2.1.6. Management Practice Factor (P)

The erosion management practice, P value, is also one factor that governs the soil erosion rate. The P-value ranges from 0.1-1 with mean value of 0.74 depending on the present land cover and slope condition of the watershed. To estimate the P-value by using Wischemeier and Smith, 1978 method, the land cover and slope map of the study area were supper imposed. The intersection of the two maps helps us to determine the P value spatially through GIS environment.

			Area Coverage	
Land Use Type	***Slope(%)***	***P-Factor***	***Hectare(ha)***	***Percent (%)***
	0-5	0.1	125.43	5.58
	5-10	0.12	317.78	14.14
Cultivated Land	10-20	0.14	613.09	27.28
	20-30	0.19	407.53	18.13
	30-50	0.25	439.53	19.56

	50-100	0.33	93.79	4.17
Other land use	All	1	250.51	11.15
Total			2247.66	**100**

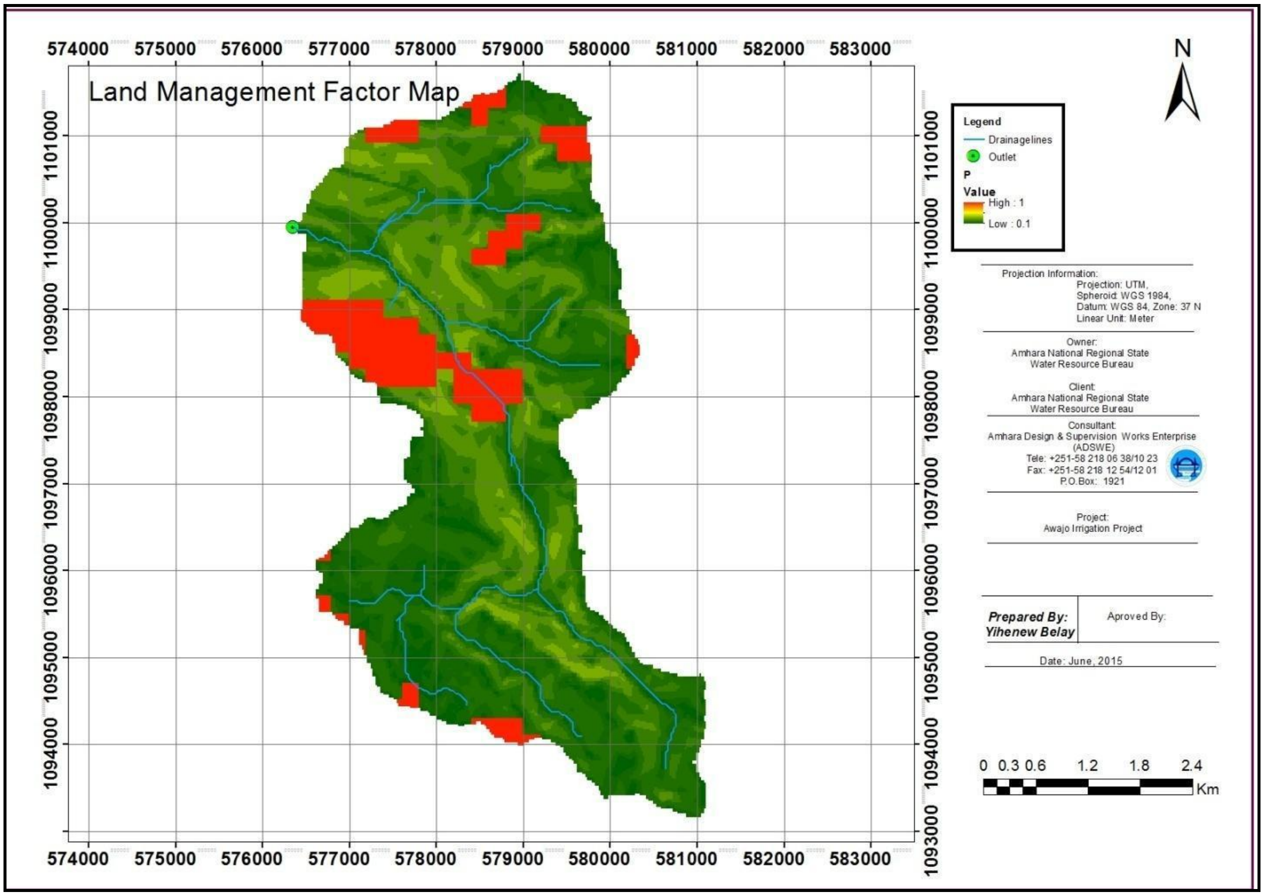

Figure 13: Derivative of Management Factor from Land Cover and Slope

6.2.2.3. Soil loss Amount (A)

All the five layers were superimposed and the parameters were multiplied according to the general RUSLE-formula. The values of the product give annual soil loss per hectare per year at pixel level. Based on the analysis, the total amount of soil loss in the watershed was about 16856.41 ton per year; an average of 32.1 ton per hectare per year.

Table 14: Soil Loss Summary of the Watershed

Soil Loss Rating			Area Coverage		Soil Loss	
Class	Ton/ha/yr	mm/yr*	Descriptions	Ha	Amount	Percent

Soil Loss Rating			Area Coverage		Soil Loss	
Class	Ton/ha/yr	mm/yr*	Descriptions	Ha	Amount	Percent
I	0-5	0-0.5	Non to slight	17.15	42.875	0.25
II	5-15	0.5-1	Non to slight	120.96	1209.6	7.18
III	15-30	1-2.5	Moderate	155.18	3491.55	20.71
IV	30-50	2.5-4	Moderate	100.55	4022	23.86
V	50-100	4-6.5	High	130.49	8090.38	48.00
Total				524.33	16856.41	100

*Specific Density of Soil=1.4 gm/cm^3

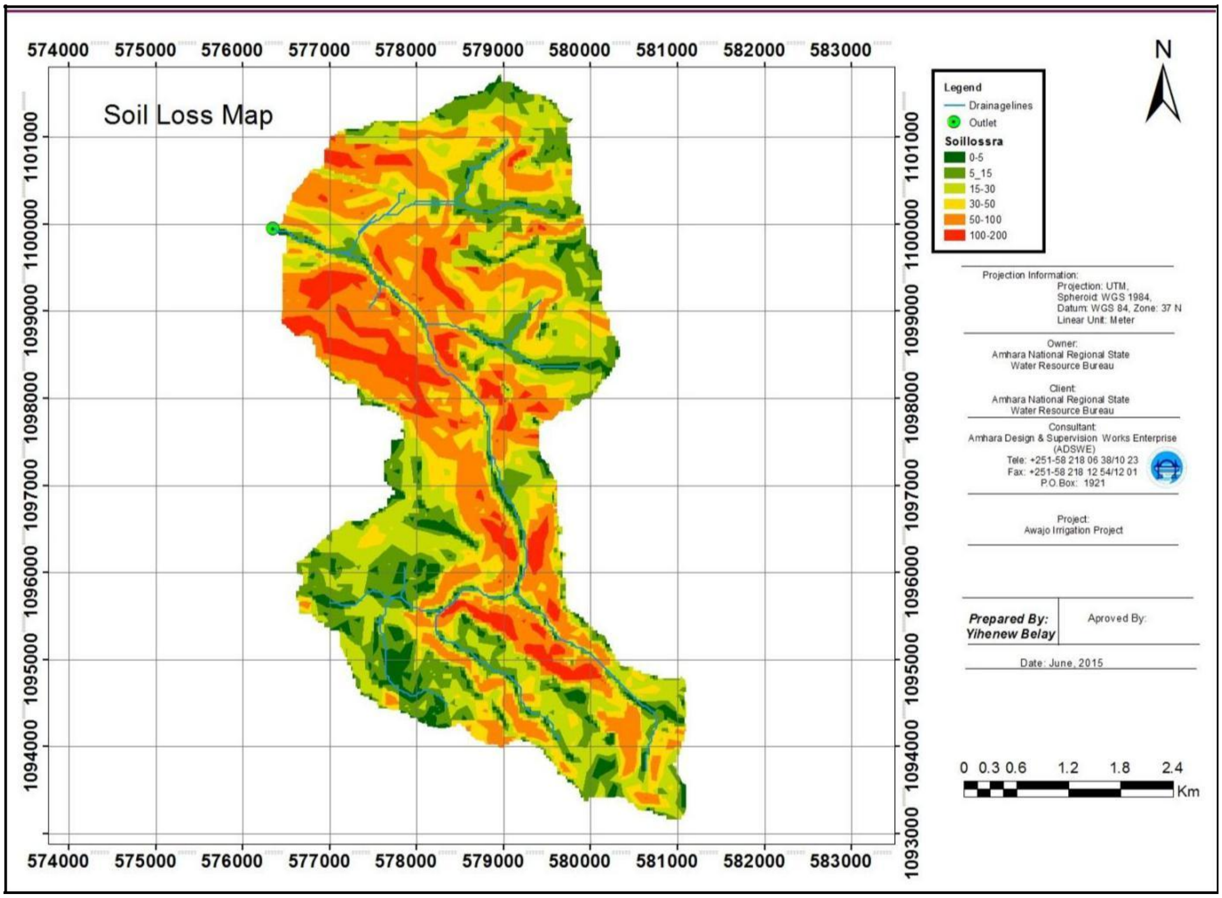

Figure 14 : Soil Loss Map of the Watershed

6.2.2.2. Sediment Yield

Even though sediment yield is not as such important for diversion projects, it tells us how our top soils are being eroded by running water. Similar to the soil losses, sediment yields are also very high at the out let of the watershed. The transporting ability of the runoff to move all the eroded sediments is insufficient. As a result deposition occurs in reservoirs, depressions, at the toe of the hills where slope changes. Thus the amount of erosion in the watershed is generally more than the amount of sediment leaving the watershed at the outlet point. Hence, the sediment yield cannot be estimated from erosion estimates within the watershed unless additional data are available. Similar to that of erosion estimates, sediment yield is also calculated using empirical equation. The most common method for estimating sediment yield is sediment delivery ratio ($1/A^{0.2}$), which is developed from reservoir survey, or measurement of suspended and bed loads at the gauging station and compared with that of erosion in the watershed.

Sediment yield is commonly estimated by the following empirical formula:

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

Where, S_y= Sediment yield (ton) at the watershed out

let E = total erosion (ton)

A = Watershed area (ha)

$$S_y = 16856.41*(1/525.09^{0.2})$$

$$= 4816.35 \text{ tons per year}$$

6.2.3 Causes of Soil Erosion

The major cause for land structural deterioration of the project area is long-term excessive tillage without any remedial measures. Cultivation for a long period, which is common feature in the watershed results in depletion of soil nutrients and organic matter that in turn enhances crusting, aggressive runoff, accelerated erosion and ultimately low productivity. The removal of forest cover played a great role in the process of enhancing accelerated erosion. This was not a terminating single event, rather, a century process. As a result of this process, the topsoil depth is reduced to a minimum uncultivable value are the most important factors in high runoff yield that results in more accelerated erosion. The main causes of soil erosion in the watershed are the rapidly increasing human population, the limited area of fertile soils on flat lands, deforestation, and excessive livestock population.

6.2.3.1 Population and Land Degradation Processes

Awajo Watershed is among the most densely populated areas in North Shewa Zone. Land degradation in the watershed involves two interlocking, complex systems: the natural ecosystem and the human social system. Natural forces, through periodic stresses of extreme and persistent climatic events, and human use and abuse of sensitive and vulnerable dry land ecosystems often act in unison. Interactions between the two systems determine the success or failure of resource management programs. The problems arise mainly from population growth and poverty, which caused arable land expansion, intensive land use, deforestation and over exploitation of the land for short term benefit (nutrient depletion).

6.2.3.1.1 Deforestation and Overexploitation of Vegetation

Since harvested trees are not replaced adequately by tree planting, soils are exposed to high intensity of rainfall. The major sources of energy for the rural households in the watershed include mainly firewood. Most households get firewood from scrublands and private eucalyptus plantations around homesteads and along roads and foot paths. In using the vital energy needs, most wood producers in the watershed resorted to free gathered biomass fuels, including wood and riverside forest lands along rivers. The removal of vegetation cover due to expansion of farmland from bush lands was the other cause of destruction of the vegetation cover.

6.2.3.1.2 Improper Agricultural Management

Agriculture is the prime means of livelihood for the rural people and remain to be subsistence and traditional. A set of improper practices had to do with land extension, the main problem in watershed being the gradual extension of cultivated lands even to sloping areas. Both human and livestock population growth requires the extension of interference into new areas, and the subjection of these areas to the high levels of damage that follow initial interference. It requires the occupation of sites of lower resilience and higher sensitivity, for which existing management practices may be inadequate. Degradation then sets in, unless particular measures are taken to protect soil structure and maintain fertility. But such measures usually are absent; since this kind of practices takes place in situations where low cost solutions are sought because resources are lacking to invest in land protection.

6.2.3.1.3 Land Tenure

With regard to factors which foster or discourage land conservation efforts, it has been argued that only private ownership makes it worthwhile for peasants to care about the sustainability of their farming methods: "systems of land ownership as well as tenure and business arrangements which do not provide security to the farmer" are held to be "major obstacles to conservation" (FAO, 1983).

Much would have been made, in this respect, of the overuse of common property resources, a feature which was present in the societies of the watershed. Grazing lands, hills and mountains are communal lands in that individuals therefore had little incentive to make any long-term on-farm investments. Rapid population growth often is responsible for breakdowns in communal land management, failures in resource control and local tragedies of the commons.

6.2.3.1.4 Low Soil and Water Conservation Works

Watershed Approaches

Participatory conservation and watershed-based approaches have been successfully introduced and expanded in various regions in Ethiopia, particularly those having significant areas with complex, mountainous, and fragile ecosystems have developed national watershed programs or projects. Awajo watershed, unlike its suffering from geologic and climate variations, it was late in watershed treatment. The rural communities were traditional, which were the result of decades of experience and adaptation to climatic and environmental conditions. In the watershed, yearly much hectares of soil bund were constructed; however, these physical measures were constructed on area bases not on watershed bases.

The soil conservation programs were target-driven requiring procedures to be completed in scheduled time with the result the officials concerned could not integrate themselves with the community. The soil conservation works are not taken up on a watershed basis in the very high and high priority watershed identified towards implementation of soil and water conservation works. The beneficiary participation was confined to preparation of action plans and no stakeholder contribution was envisaged resulting in lack of involvement

SWC Development Works

There is no defined land use system followed in the watershed as well in the zone. For the last many years this had led over exploitation of the natural resources. It is an area where the government and the public should agree to adopt a policy if further degradation is to be avoided.

Soil conservation trend of the watershed is not encouraging as per the landscape of the area. Some donors had taken the initiatives and formulated projects to undertake different activities in some areas of many kebeles in addition to the government regular program. Despites all these, still the efforts were underway to understand and tackle the issues of soil conservation and land management in the watershed, in the zone as well.

The area coverage of soil and water conservation works were better during construction time, even the activity mainly targets on physical soil conservation measures, by now they hardly serve the purpose; the effectiveness was lower. The activities refers only physical soil conservation technologies particularly bunds that have less importance to soil fertility except conserving soil erosion in terms of physical soil movement and proper maintenance is not undertaken by the farmers owning the plot. Soil and water conservation activities especially biological soil conservation and agroforestry packages in the watershed has little success unless some measures are considered.

Controlled grazing, if practiced, works well where the ratio of land to people is high as Awajo watershed, so that the land could be left protected long enough. The problem with freed grazing is that increasing population damages soil and soil conservation structures.

Table 15: Soil and Water Conservation Achievement of Kebeles of the watershed found in Tarma Ber Woreda

SN	Measures	Unit	Achievements			
			2004	2005	2006	Total sustained
A	**Physical SWC Measures**					
1	Bund					
1.1	Stone Faced Soil Bund	Km	30	22		52
1.3	Hillside Terrace	Km	10			10
2	Flood Control					
2.1	Water Ways	Km/km3				1.5
3	Water Conservation					
3.1	Micro basin	No	900			900
3.2	Trench	No	1200			1200
B	**Biological SWC Measures**					
1	Plantation on bunds	Km	0.5	0.5		1
2	Grass strips	Ha	50			50

Source: Tarma Ber Woreda Agricultural Office (2006 EC)

6.3.3 Effect of Soil Erosion

6.3.3.1 Loss of Soil Mass

Soil erosion is by far the largest process causing land degradation, in the watershed. The mass of soil wasting from sheet, rill, gully, streams and slides is often assessed as the amount of soil material that has been removed from a landscape by water, since these physical changes are obvious and quantifiable. The total amount of physical soil loss in the watershed was that causes of land and soil degradation. Due to the poor soils, the process of restoring badly degraded areas will inevitably be difficult, slow and expensive.

6.3.3.2 Nutrient Loss

Degradation of the soil resource, on the other hand, has been reported alarming; soil productivity is declining at the rate of 2-3% per year (Hurni, 1993, cited in Dr Birru 2007) with soil erosion rate in most croplands usually being far beyond the rate of formation due to cultivation of steeply sloping lands without adequate SWC measures.

The capacity of the soil of the watershed to produce crop is greatly reduced. Soil from the top layer is the most concern because it contains more organic matter; rich in available plant nutrients. This soil is lost in sheet and rill erosion which are of great value in containing nutrients, like Nitrogen, Phosphorus and Potassium. The productivity of crop land is decreasing year after year at alarming rate. Land productivity is decreasing. The higher yield in production is associated with fertilizer application, improved seeds and farm expansions from other uses.

Loss of soil fertility is severely affected by soil erosion, use of dung and crop residues for household fuels and animal feeds and decline in fallow periods. Even though the farming system in the project area is mixed, crop–livestock, the culture is based on the nutrient take way from the soil that the nutrient return to the soil is very minimal.

6.3.3.3 Hydrological Degradation

Hydrological degradation that includes surface and subsurface water declines, seasonality of discharges of the rivers, variability of rainfall, etc. are important causes and consequences of the processes of land degradation and challenges the region for the sustainable water development works.

Awajo River, having has many drainage lines, for example is the main source of water of the area as being the main river in the watershed. However, apart from the main rivers and tributaries, there was hardly of high amount of perennial flow in areas; the severe occurrences of watershed degradation causes serious problem for many rural inhabitants had applied dry season irrigation, and obtain domestic use.

7.LAND EVALUATION AND ADJUSTMENT

7.1 Land Capability

The land is evaluated and classified into different land capability classes by considering seven limiting factors: slope, soil depth, soil texture, past erosion history, water logging, infiltration and surface stoniness.

The limiting factors for most cultivated, forest, grass and shrub and bush lands of the watershed are soil texture, soil depth and slope. The cultivated fields with slope 3-8% require conservation measure directed to proper drainage system. While cultivated lands on slopes 8-15% need additional physical conservation practices. Cultivated land on slopes 15-30% and 30-50% are previously subjected to very high erosion and now very degraded for cultivation, but with intensive structural measures and improved farming system they can be brought to productive land.

The land capability classification description:

Land suitable for annual crops I, II, III and IV

Land suitable for grazing or perennial crops VI

Land suitable for forestry VII

Land non suitable for agriculture VIII

Swampy areas, river beds V

Table 16: Land Capability Evaluation

Major-cover	Class	FID	Texture	Stonniness	Erosion	DrainAge	Depth_clas	Rockiness	CapabIlity	Limitation	Capa_Limit	Area_ha
Cultivation	0-3%	L1	T5	S3	E2	I2	D4	S2	VIII	T	VIIIT	26.47
	0-3%	L1	T6	S2	E1	I2	D4	S1	VIII	T	VIIIT	7.32
	0-3%	L1	T3	S2	E0	I0	D3	S1	VIII	TD	VIIITD	3.75
	3-8%	L2	T5	S3	E2	I2	D4	S2	VIII	TD	VIIITD	173.57
	3-8%	L2	T6	S2	E1	I2	D4	S1	VIII	T	VIIIT	57.89
	3-8%	L2	T3	S2	E0	I0	D3	S1	VI	TD	VITD	26.65
	8-15%	L3	T5	S3	E2	I2	D4	S2	VIII	TD	VIIITD	328.09
	8-15%	L3	T6	S2	E1	I2	D4	S1	VIII	T	VIIIT	108.87
	8-15%	L3	T3	S2	E0	I0	D3	S1	VI	LTD	VILTD	53.61
	15-30%	L4	T5	S3	E2	I2	D4	S2	VIII	T	VIIIT	441.33
	15-30%	L4	T6	S2	E1	I2	D4	S1	VIII	T	VIIIT	163.97
	15-30%	L4	T3	S2	E0	I0	D3	S1	IV	L	IVL	73.63
	30-50%	L5	T5	S3	E2	I2	D4	S2	VI	LT	VILT	313.8
	30-50%	L5	T6	S2	E1	I2	D4	S1	VI	T	VIT	95.56
	30-50%	L5	T3	S2	E0	I0	D3	S1	VI	L	VIL	28.84
	>50%	L6	T5	S3	E2	I2	D4	S2	VII	L	VIIL	76.8
	>50%	L6	T6	S2	E1	I2	D4	S1	VII	LT	VIILT	15.97
	>50%	L6	T3	S2	E0	I0	D3	S1	VII	L	VIIL	1.01
Grassland	0-3%	L1	T5	S3	E2	I2	D4	S2	VIII	T	VIIIT	0.48
	0-3%	L1	T6	S2	E1	I2	D4	S1	VIII	T	VIIIT	0.04
	0-3%	L1	T3	S2	E0	I0	D3	S1	VIII	TD	VIIITD	0.31
	3-8%	L2	T5	S3	E2	I2	D4	S2	VIII	T	VIIIT	7.16
	3-8%	L2	T6	S2	E1	I2	D4	S1	VIII	T	VIIIT	0.17
	3-8%	L2	T3	S2	E0	I0	D3	S1	VI	TD	VITD	2.17
	8-15%	L3	T5	S3	E2	I2	D4	S2	VIII	T	VIIIT	14.42
	8-15%	L3	T6	S2	E1	I2	D4	S1	VIII	T	VIIIT	0.18
	8-15%	L3	T3	S2	E0	I0	D3	S1	VI	LTD	VILTD	1.96
	15-30%	L4	T5	S3	E2	I2	D4	S2	VIII	T	VIIIT	23.64
	15-30%	L4	T6	S2	E1	I2	D4	S1	VIII	T	VIIIT	0.07
	15-30%	L4	T3	S2	E0	I0	D3	S1	IV	L	IVL	0.05
	30-50%	L5	T5	S3	E2	I2	D4	S2	VI	LT	VILT	15.22
	>50%	L6	T5	S3	E2	I2	D4	S2	VII	L	VIIL	7.45

Shrubland	0-3%	L1	T5	S3	E2	I2	D4	S2	VIII	T	VIIIT	1.62
	3-8%	L2	T5	S3	E2	I2	D4	S2	VIII	T	VIIIT	9
	8-15%	L3	T5	S3	E2	I2	D4	S2	VIII	T	VIIIT	21.66
	15-30%	L4	T5	S3	E2	I2	D4	S2	VIII	T	VIIIT	44.33

	30-50%	L5	T5	S3	E2	I2	D4	S2	VI	LT	VILT	50.69
	>50%	L6	T5	S3	E2	I2	D4	S2	VII	L	VIIL	49.89
												2247.64

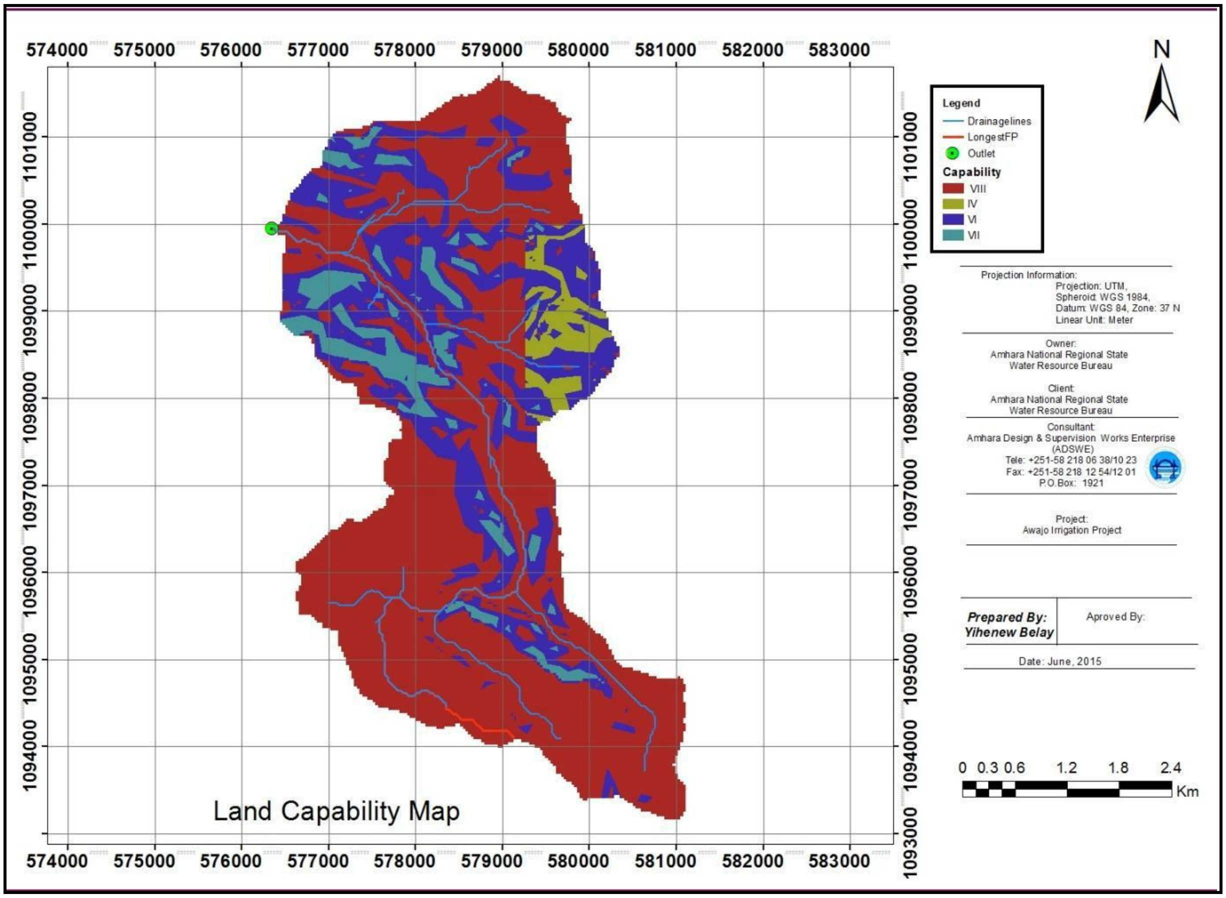

Figure 15: Land Capability Map of the Watershed

7.2. Land Use Adjustment

7.2.1. Land Use Change

Land use changes are recommended based on land capability classification and suitability. Of course, suitability class is done after chemical analysis. But lands are classified as suitable for crop production, grazing and forestry activities based up on land capability classification. Those lands under class III and IV are assigned for cultivation and V for grazing and perennial crops.

7.2.2. Closure

Land capability classes also didn't force the lands to be closed. However, degraded grazing and bush lands, and the gully banks need to be closed for rehabilitation purposes. Gullies should be temporary closed for at least for two years or so until the vegetation cover regenerate naturally.

8. PROBLEM IDENTIFICATION

Watershed problems in Ethiopia in general, in the Amhara Region in particular, are characterized by land degradation, deforestation, over grazing and inappropriate farming practice. Field observations at numerous points in the watershed indicated that physical and biological degradations are the common phenomena of this watershed.

For most of the part of watershed, land degradation and fertility losses are mainly attributed to the following major factors (root causes):

- ✓ Improper land utilization system.
- ✓ Soil erosion by water.
- ✓ Relatively higher animal population densities.

8.1 Improper Land Utilization System

The major cause for land structural deterioration of the watershed is believed to be long-term excessive tillage without any remedial measures. Cultivation for a long period, which is common feature for the northern part of the country, results in depletion of soil nutrients and organic matter that in turn enhances crusting, aggressive runoff, accelerated erosion and ultimately low productivity. Soils low in organic matter due to long-term cultivation and high in silt contents are usually most prone to crusting that often occurs after heavy erosive storms. The removal of forest cover played a great role in the process of enhancing accelerated erosion. This was not a terminating single event, rather, a century process. As a result of this process, the topsoil depth is reduced to a minimum uncultivable value are the most important factors in high runoff yield that results in more accelerated erosion.

8.2 Soil Erosion and Land Degradation

Soil erosion by water is high in this watershed .Even though erosion process is subtle one, it could be evaluated by its effect on cultivated lands and check dams. Uncontrolled erosion finally leads to land deterioration.

The major soil erosion and land degradation problems are related to:

- High population growth, which has led to shortage of and pressure on land for cultivation, which in turn has resulted in encroachment of cultivation to marginal lands (i.e. steep slopes, forestlands, grazing lands, etc.) without conservation measures.
- Over grazing and over stocking and continued lack of proper management of communal grazing lands and lack of attention to animal feed production by any concerned agencies.
- Lack of responsibility of the farmers with regard to land use.

8.3 Deforestation

Excess removal of forests is contributing to land degradation. Since harvested trees are not replaced adequately by tree planting in the region as well as in the watershed, soils are exposed to high intensity of rainfall the major sources of energy for the rural households in the watershed include mainly firewood The only sources of fuel wood therefore are some homestead plantations, crop residues and animal dung. The major sources of energy for the rural households in the watershed include mainly firewood and crop residues. Most households get firewood from scrublands and private plantations around homesteads and along roads and foot paths.

8.4 Decline of Soil Fertility

Loss of soil fertility is severely affected by soil erosion and land degradation, use of dung and crop residues for household fuels and animal feeds and decline in fallow periods. Even though the farming system in the project area is mixed crop–livestock, the culture is based on the nutrient take way from the soil that the nutrient return to the soil is very minimal. The chemical fertilizer use is also limited because of its unaffordable price to the watershed area poor farmers. The soil fertility problem in the watershed is therefore one of the serious problems, which should be addressed in this watershed management plan.

9. WATERSHED DEVELOPMENT PLAN

Watershed development interventions are key to improve the livelihood of people in the watershed at development through restored and enhanced land productivity, support rehabilitation of degraded land and development of natural resources, providing opportunities for income generating and contribute to small-scale infrastructure development. This will help to intensify the land productivity with no jeopardy on existing natural resources. As well watershed development interventions could save water reservoirs such as dams, 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 MoANR CBPWGL. PASIDP II is mainly focuses at micro watershed level up to 300ha 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 adjacent Schemes watersheds of PASIDP II include: soil and water conservation, afforestation 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:

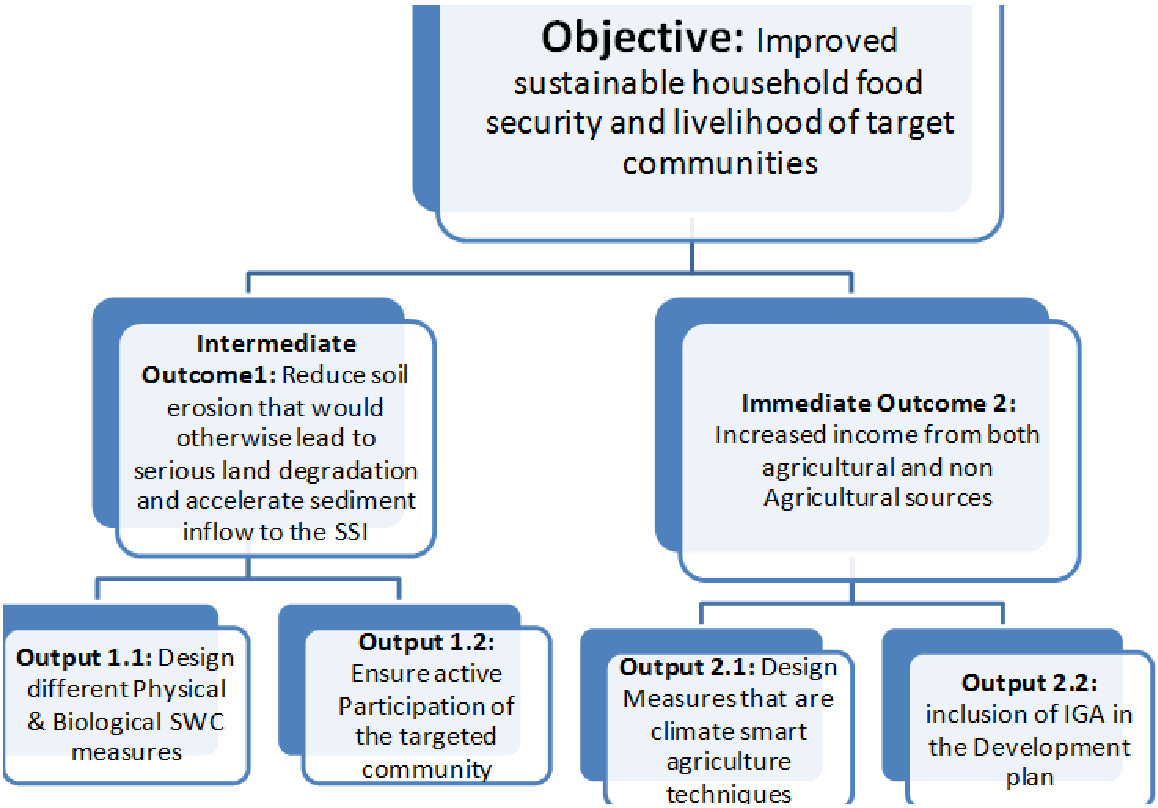

Figure: Target of PASIDP II project

9.1 Sustainable watershed development

The word "sustainability" is important in development assistance. It refers to the "ability" of something to be "sustained" (carried on) after outside support is withdrawn. For the community that builds a water supply, the repairing, cleaning and using the pump after it is constructed, is the desire. For an external donor, it is the continuation of the project or its outputs after the donor withdraws. For the mobilizer, it is the continuation of the community strengthening social process after he/she moves on. For environmentalists and ecologists, sustainability requires that an activity can be sustained (e.g. biologically) by the physical environment, that non-renewable resources are not used up.

Many people assume that development means quantitative growth, whereas its main characteristic is qualitative change. To develop is to grow, and to grow means more than to get bigger; it also means to become more complex and stronger. When a community develops, it gets stronger and more complex. It undergoes social changes changing the overall social system belonging to six dimensions: technological, economic, political, interactive, ideological and worldview. An economist may see development as only an increase in wealth or income (absolute or per capita); and an engineer may see development as a greater control over energy, or more sophisticated and powerful tools. To a mobilizer, however, those are only two of the six dimensions of a community that change. Development means social change in all six cultural dimensions: technological, economic, political, interactive, ideological and worldview.

A mobilizer does not develop a community and more than a flower grows taller by someone pulling it up. A community (as a social institution) develops itself. A mobilizer can only stimulate, encourage and guide members of the community. Some people assume that community development simply means getting richer — an increase in per capita wealth or income. It can be, but is more. It is social change, where a community becomes more complex, adding institutions, increasing its collective power, changing qualitatively in its organization. Development means growing in complexity and strength in all six dimensions.

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

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

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

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

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

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

The solutions for these problems can be listed as follows

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

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

The choice of appropriate technology is a factor in ensuring the sustainability of development activities. Farmers reject available technologies not because they are conservative or ignorant, but because they randomly weigh the changes in incomes and risk associated with these technologies under their natural and economic circumstances. Thus, any externally engineered technologies, is opt to fail if it did not take into account the local farmer's circumstances. Farmer's circumstances refer to factors that affect farmer's decisions with respect to adoption of either technologies. Farmers' circumstances focus both on farmer's current technology as well as his decision about changes in that technology.

The farmer's circumstances have direct influence on farmers' decisions on spectrum of technologies related to crop, livestock and soil and water management practices. This is referred as interactions of farming system. It involves the production and consumption decisions of a farm-household, including the choices of crop, livestock, soil and water management, off-farm enterprises and food consumption habits.

The cardinal point is that crop; livestock, soil and water management technologies result from the interactions of the farming system as a whole. Thus, in order to choose technological components it should primarily take into account farmers' circumstances. Conflicts between the introduced technologies with local circumstances of a farmer will lead to rejection of the introduced technology. For example, varieties may be rejected if they mature too late for the planting of next crop. Fertilizer recommendations aimed to maximize yield may be rejected if they are not consistent with either income increasing or risk avoiding objectives. Physical soil and water conservation works may be rejected if it competes for scarce land resources or fails to meet the income-increasing objectives of the poor farm household. To capsulate, the packages for new agricultural technologies should consider the farmers' overall interaction within the farming system. Otherwise they opt to fail.

Integrated approach to problem solving and understanding issues at a system level is also an issue to bring a sustainable development. For this a number of actions need to be taken but the easing of rigid disciplinary boundaries is of special importance among them. Agriculture needs to be treated not as an independent sector or industry but as a critical element in achieving broader social and economic goals. This emphasis allows particular production processes and resource management practices to be understood in their ecological as well as socio-economic and cultural contexts. By examining all uses of land in an integrated manner, it makes it possible to minimize conflicts, to make the most efficient trade-offs and to link social and economic development with environmental protection and enhancement, thus helping to achieve the objectives of sustainable development. The essence of the integrated approach finds expression in the coordination of the sectoral planning and management activities concerned with the various aspects of watershed development. Integrated consideration facilitates appropriate choices and trade-offs, thus maximizing sustainable development.

9.2 Rationales of Watershed approach

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

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

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

- Orderly and systematic resource use and management i.e. it avoids scattered works and watershed follows a certain normal procedure
- Concentrations of efforts: This improves accountability and follow-ups as it makes supervision easy.
- Optimal use of resources: This is easily achieved through concentration of resources coupled with priority sites and activities being undertaken.
- Enhance community participation in resource management. This is achieved mainly through participatory planning and implementation. Moreover it gives more chance to establish and strengthen sustainable village institutions such as
    - Users group
    - Self help group
    - Women thrift and credit group
    - Village watershed committee

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

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

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

1) **Technically sound** i.e., the practices that are being recommended will achieve the physical and biological out comes that are desired,

2) **Accepted socially**, i.e., watershed inhabitants and agencies involved see the project as desirable.

3) **Economically feasible**, both from the stand point of society as a whole, and from the stand point of individuals and agencies involved, and

4) **Environmentally sound**, i.e. there are no unwanted impacts on the environment, such as reduction in biological diversity, destruction of down stream aquatic systems and other changes that may come about indirectly because of project implementation.

At the project level, planners and implementers need to consider at least 3 key elements to avoid non-sustainable development. These are

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

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

3) **Externalities** refer to the positive and negative effects of actions in a given location (**spatial Externalities**) and positive and negative effects of actions at a given time on life in some future period of time (**temporal Externalities**). In watershed project, spatial and temporal Externalities relate to the upstream-downstream relationships what is done with the land and water upstream can affect those who live down stream.

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

9.3 Some Basic planning principles

A. Set Appropriate Goals and Targets to meet objectives

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

B. Use an iterative process to identify and Assess Alternatives.

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

C. Always Apply the with and without principle

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

1.1 Problems of Uncertainties

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

a) **Climatic uncertainties**: Rainfall patterns, intensity and duration cannot be exactly be predicated. One should not develop watershed management plans based on average conditions.

b) **Technical uncertainties**: Reliable information about the effect of certain interventions may not be available for the different situations at present.

c) **Socio-economic uncertainties** If there are uncertainties regarding the technical relationships used in planning, there is even more uncertainty regarding Socio economic variables. Data on the status of human welfare needed for planning, such as income, wealth, and levels of education, can be difficult to obtain for specific local areas. Estimates of the status of future human welfare are far more uncertain.

d) **Political uncertainties**: - Creates economic and social instabilities that create uncertainties regarding the future direction of natural resource and other policies. They also create uncertainties regarding future law and regulations relating to the land tenure and other resource right of local people

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

9.4 Strategies for coping with uncertainties

The problem for planning is that change brings unexpected, unforeseeable results. Ecosystems are not static, but are continually changing. Although at times this change may be slow and gradual, at other times the change may be dramatic and swift.

Lundgren (1983) has suggested the following strategies to cope with such uncertainties

9.5 Increase understanding

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

- ✓ Postpone the decision to get more information
- ✓ Conduct sensitivity analysis; by systematically exploring how changes in assumptions affect results, we can better appreciate how uncertainty affects our results. Critical points that are sensitive to our assumptions and estimates should be identified.
- ✓ Imaging alternative futures.

9.6 Increase flexibility

Another way of coping with uncertainty is to increase management and organization's flexibility

a) **Incrementalism and monitoring**: - these strategy plans for small incremental changes, allowing for constant monitoring and evaluation as you go along. One does not get locked in to planning for a long time period, but rather plans for a step at a time, and revision of plans as new information is available.

b) **Contingency planning**: - In our vehicles we carry a spare tire just in case our tire gets a puncture. Like this during planning we should have a room for contingency.

c) **Diversification: -** For example instead of planting one species of tree to met a particular anticipated need, plant a mixture of species to meet different needs if there is a possibility that future needs may change

9.6 Encourage Innovation

Peters and Waterman (1982) found that the most successful companies in the United States rely more on developing a team of innovative people with considerable autonomy for action, than on developing formal long-range plans. Companies used plans more as a loose framework for action than as a rigid agenda to be followed.

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

9.7.1 Physical Soil and Water Conservation Measures

Physical SWC measures are those soil and water conservation measures, which lead to change in land surface arrangement and profile. 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 command area 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 slops above 3 and below 15% slope. Soil bunds can also be applied on grazing lands with slops at wider interval, and within slopping homestead areas combined with cash crops.

Stone-faced soil bunds: These structures are recommended on cultivated lands with some levels of stoniness.

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.

9.7.2 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: Soils in the command area range from the very infertile, in steep slopes, to moderately fertile, in lower slopes. There is a close relationship between soils, and soil and water conservation**.** 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 ferrous that slowdown speed of surface runoff and increases soil-water infiltration.

Area Closure: Area closure is a protection system and saving mechanism of land against any external influences including erosion. Slopes above 40% are recommended to be closed from day to day human activities and livestock grazing to give a way for natural trees and grass vegetation regeneration.

Gully Control and Rehabilitation ;The techniques of gully control and rehabilitation include, treating upslope lands, reclaiming the gully area, diverting runoff (partially or wholly), 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 (depth, width, gradient, gully formation stage, slope), 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.

River Bank Protection; River bank erosion is one of the problems in most part of rivers and streams. Since PASIDP II is water sector project it works on the buffer area of the rivers on which the structure to be constructed. The buffer area of the river or streams should be protected with different conservation technologies. Moreover, in these areas cultivation is practiced close to the edges of the rivers. Such cultivation practices are made without any interventions that may protect the cut and slide of riverbank. In future, if the practices are allowed to continue unabated, there would be a danger of losing many cultivated lands and the proposed reservoir may get filled with sediment and consequently its effectiveness reduced.

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

Promote Agro forestry and Fruit Production ; The recommended agro forestry practices as part of the watershed development intervention are, Alley Cropping and Multi-Storey Gardening specifically at homesteads. Generally the PASIDP II program is mainly focus on food in secured and potential area for development. So these areas are more favorable for fruit production particularly in the homestead areas. So planting of fruit trees experience is available all over the region. Thus, this has to be strengthened through providing the necessary financial and technical support from PASDP II project.

Access for credit services; The households in the watershed have a limited capacity to purchase farm inputs mainly fertilizer, buy improved livestock's and accessing their fodder, and start any kind of business in the most part of the country 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, the c 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.

Farmers should be advised to practice cut-and-carry system, instead of free grazing ;Most of the case watershed is situated in a very 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;** Basically in rainy season; fattening is not done in dry season because of lack of forage to feed animals. 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. This is basically connected with the evil that the farmers in the watershed are using herbicides which kill bee, and the farmers don’t possess the required experience, skill and knowledge to carry out beekeeping activities. 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 are abundant labor at household level

Introduce fuel saving stove for energy source ; The HHs in the micro watersheds are using biomass as energy source which triggers deforestation and exacerbates soil erosion. Therefore, promoting fuel saving stove is adverse effect contribute for mitigate deforestation, thereby to reduce sediment generation and delivery to the scheme. The watershed is very close 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 dam.

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

9.7.3. Climate Smart Agro forestry

The establishment of an agro forestry system can enrich livelihood through many possible benefits (social, economic, environmental). Trees can either work as wind breaker, provider of shade or "nutrition pumps". The roots of most trees grow deeper into the soil than the roots of other crops. This means that they can recover nutrients and water from lower soil layers. Leguminous trees can even help to fix atmospheric nitrogen and can therefore enrich the soil with much-needed nitrogen. Especially with the ability to fixate carbon and nitrogen and the diversification of the farm production system, agro forestry qualifies for adapting to and to mitigate climate change.

- Biodiversity: more habitats for many species of plants, animals and other organisms
- GHG emissions: trees bind carbon in their biomass (above and below ground); decaying biomass contributes to carbon storage in the soil
- Improves air quality: trees work as wind-breaker and help to reduce soil erosion; this reduces dust and other particles in the air
- Soil fertility: decaying biomass protects soil surface through litter and more carbon is stored in the soil
- Water retention: trees slow the flow of water due to their above and below ground biomass

9.7.4. Livestock Management Interventions

The study on the livestock population and available grazing lands and also forage production showed that the existing grazing lands and fodder sources are not compatible with the total number of livestock population. To solving these problems and to enhance livestock efficiency and minimize overgrazing, different options that address improvement in feed and disease control is required.

The most practical option, which will be within the farmers practice and acceptance, is improvement of grazing lands and Fodder and pasture growing along food crops and on soil & water conservation schemes. Crops that can produce more crop residue and with high nutritive value are also recommended. The grazing lands have to be improved by sowing palatable grass seeds in grazing areas and creating controlled grazing systems to use the grazing within the lands carrying capacity. In addition, fodder production has to be increased year after year with improved veterinary services. This option requires keeping the livestock growth rate to not more than 5% annually.

The second option would be de-stocking the number of livestock and encouraging the farmers to raise only few and improved livestock with intensified management and at the same time devoting some parts of the cultivated lands to grazing lands is considered, given the acceptance of farmers.

Poultry production

In Ethiopia chickens are the most widespread and almost every rural family owns chickens, which provide a valuable source of family protein and income (Tadelle *et al.*, 2003). The total chicken population in the country is estimated to be 56.5 million with native chicken representing 96.9%, hybrid chicken 0.54% and exotic breeds 2.56% (CSA, 2014). The most dominant chicken types reared in Ethiopia are local ecotypes, which show a large variation in body position, comb type and productivity (Halima, 2007).

The major proportion of chicken production (98%) in Amhara National Regional State (ANRS) is a traditional sector, at small holder level, from which almost the whole annual meat and egg production is produced (ANRS BoARD, 2006).

According to the recent agricultural census study, the total chicken population of the region is estimated to be 14.44 million, accounting to 33.3% of the national chicken population, and kept for both eggs and meat production purposes.

One and the major suggested solution to increase the production and productivity of chicken is utilization of chicken production system which is modern, market oriented and compatible with the existing situation of the farming system. Therefore, by minimizing the production constraints through use of selected and productive poultry breed as well as improvement of the production system (feeds and feeding, housing, health, etc), it is possible to supply chicken products for the market demand over the household consumption.

Chicken production and consumption provide different functions for the producer as compared to the other livestock production. Among the different functions, the following are the main ones in the Awajo watershed

- ✓ Immediate source of cash income
- ✓ Provides meat and egg for household consumption
- ✓ Source of organic fertilizer of home yard
- ✓ Requires low initial capital investment, small land and low labor input
- ✓ Their product is acceptable by most of the community and the meat and eggs contain special proteins that allow children to grow strong and their brain to develop

Bee keeping

Beekeeping in Ethiopia is one of the traditional farming activities undertaken by small farmers for supplementary income. Related to this, honey is traditionally consumed with bread or used to prepare alcoholic beverage, Tej and Birz. Nowadays, it is believed that honey has a potential to alleviate poverty of small framers by supply honey to the markets for merchants and users. But the major challenges of the sector includes poor technical know-how on the part of bee-keepers on appropriate bee-hive management and harvesting techniques leading to poor quality and low yields, widespread use of traditional beehives.

9.7.5 Alternative Energy Development

Unless alternative energy sources are sought and complimented, the conventional sources of the present supply of fuel wood is not sustainable. Promotion of energy saving technologies such as closed stoves needs to be initiated and promoted. The use of kerosene as alternative energy source and the homestead tree plantation, forest development in area and wood lot plantations and road and farm boundary plantations should be encouraged. The use of crop residue and cow dung, which would have been used for increasing soil fertility, as energy should gradually be discouraged. In addition, awareness creation on the energy saving technologies and their production and distribution on credit or grant bases should be enhanced.

9.7.6 Income generating activities

A key concept of income generating activities is sustainable food security in the watershed. Income generation can help to overcome food insecurity when economic factors are a fundamental cause of food insecurity and when food is available in local markets but lack of money is the main difficulty faced by the vulnerable population.

Currently, on and off -farm income generating opportunities are limited or not widely practiced in the Shemamatbeya watershed and micro-watershed-I area that poverty becoming deep rooted in households. This is associated with limited knowledge and skills on entrepreneur, and inadequate financial capacity of the households and the local institutions. As the result of this, low-income community members mainly women and landless youngsters lead their livelihoods in selling of charcoal, fuel wood, stones, gravel, and cow dung.

Handicraft have been producing from various kinds of items such as wood, leather and metal; Pottery, which is the other type of handicraft in which decorative utensils are made from; Leather, which is value added products for which skins and hides are very common to make domestic artifacts such as clothes, household implements and tools and furniture. So handicraft have besupported by finance and traiing by projects and Woreda.

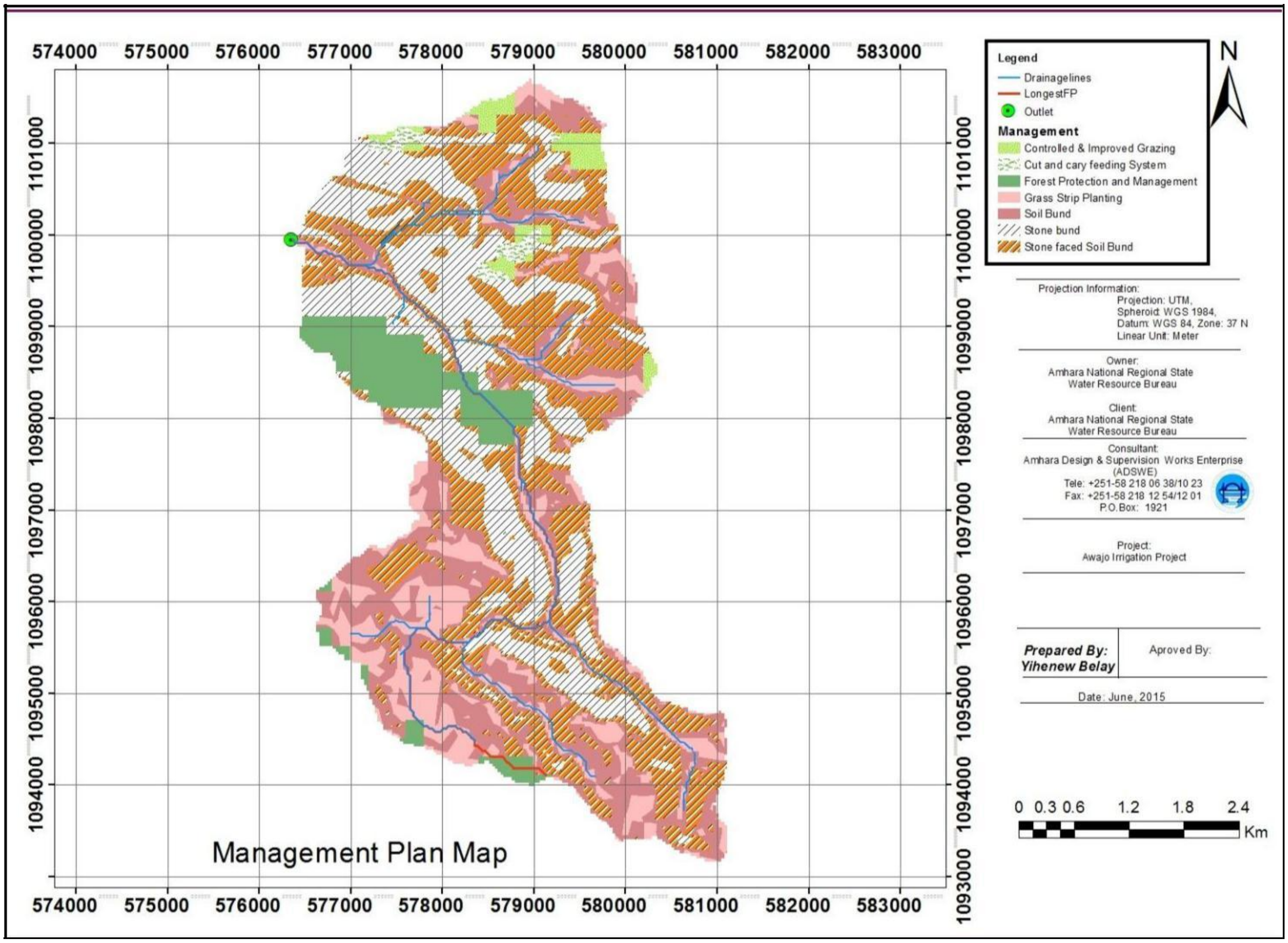

Figure 20: SWC Development Map of Awajo Watershed

9.7. 6 Implementation and Budgeting

The proposed watershed management interventions includes time schedule for the measures implementation with the sequence of activities; list of inputs required; strategic issues that should be considered for successful implementation and institutions that should be responsible for implementing the proposed development interventions based on the existing government structures. These all have been discussed by considering the existing situation of the country, regional and the local situations.

Table 17: Watershed Management Activity and Budget Plan

No	Activities	unit	Planned	work norm	PD	Total cost
A	**physical measure**					
1	Hillside terraces	km	43	330pd/km	14190	567600
2	Stone faced soil bund	km	275	250pd/km	68750	2750000
3	Soil bund	km	243	200pd/km	48600	1944000
4	Micro basin	no	99155	1pd/5mb	19831	793240
5	Eyebrow basin	no	35849	1pd/2ey	17925	716980
6	Trenches	no	6330	1pd/3mt	2110	84400
B	**Biological measures**					0
1	Grass strip	km	20	30pd/km	600	24000
2	Plantation	no	490560	50pd/km	9811	392448
3	area closure	ha	74	4pd/hac	296	11840
	Total				191628	7,676,956

PD: Person Day, ETB: Ethiopian Birr

Table 18: Basic Nursery Establishment

S/N	Type of hand tools and equipment	Unit	Quantity	Unit price	Total cost
A	Hand tools and equipment				7,640
1	Wheel barrow	No	2	500	1,000
2	Watering can	No	10	150	1,500
4	Spade	No	10	150	1,500
5	Rake	No	5	100	500
6	Crow bar	No	1	120	120
7	Hammer	No	1	120	120
8	Root pruning scissors	No	3	100	300
10	Sickle	No	4	30	120
12	Knife	No	2	25	50
13	Bow saw	No	1	250	250
14	Seedling try	No	10	100	1,000
15	Pickax	No	1	90	90
17	Hoe	No	4	85	340
18	Sand sieve	No	4	25	100
19	Meter (50m)	No	1	150	150
20	Weighing Balance	No	1	500	500
B	Polythene tube	Kg	200	60	12,000
C	Seed	Kg	20	250	5,000
D	Office and store				18,750
	Store	No	1	10,000	10,000
	Fencing	Lsum	1	7,000	7,000
	Table	No	1	500	500
	Chair	No	2	250	500
	Shelf	No	1	750	750
E	Labor	PD	2,400	40	96,000
	Total				139,390

Table 1: Investment in Integrated Watershed and Landscape Management

	Major activities	Unit	Annual	Unit Cost	Total Cost
1	**Capacity development in watershed management**				
1.1	Study Tours for Districts experts and DA	No	12	4,090.31	49,083.72
1.2	Study tours for community watershed team &farmers	No	6	2,571.22	15,427.32
1.3	Farmers extension and research groups	Group	2	51,160.00	102,320.00
1.4	Training on integrated watershed management	No	48	2611.00	125328.00
	sub total				**292,159.04**
2	**Inputs for intensification of watershed**				-
2.1	Hillside communal land treatment and management	Ha	43	3,354.00	144,222.00
2.3	Area Closure and participatory forest management	Ha	74	1,390.00	102,860.00
2.4	Gully rehabilitation with biophysical measures	Ha	3	20,587.00	61,761.00
2.5	Treatment of farmland (slop < 15%)	Ha	243	3,304.49	802,990.09
2.6	Treatment of farmland (slop > 15%)	Ha	275	7,931.76	2,181,234.46
2	Promoting conservation agriculture on farmlands	Ha	60	3,981.31	238,878.50
2.5	Promoting agro forestry and fruit on e farmlands	Ha	40	3,981.31	159,252.34
2.6	Promotion of improved forage production	Ha	40	3,981.31	159,252.34
2.7	Promotion of improved poultry and small ruminants	HH	120	5,000.00	600,000.00
2.8	Promotion of fuel saving technologies	HH	72	300.00	21,600.00
2.9	Scaling up of adoption of improved farm technologies	HH	24	2,000.00	48,000.00
2.1	Promote soil fertility management practices	Ha	50	2,000.00	100,000.00
2.1	community pond construction	No	1	150,000.00	150,000.00
2.1	house hold pond construction	No	45	9,000.00	405,000.00
2.1	spring development	No	1	400,000.00	400,000.00
	sub total				**5,575,050.73**
	Total				**5,867,209.77**

Table 2: Yearly Implementation Schedule

No	Measures	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Physical SWC Measures												
1.1	Graded Soill Bund	x	X	X	X	x							
1.2	Stone Faced Soil Bund	x	X	X	X	x							
1.3	Stone Faced Soil Bund	x	X	X	X	x							
1.4	Cut Of Drains	x	X	X	X	x							
1.5	Water Ways	x	X	X	X	x							
1.6	Seedling Production	x	x	x	X	x					x	x	x
1.7	Pitting	x	x	x	X	x							
1.8	Planting						x						

9.8 Costs-Benefit Estimation

9.8.1 Cost Estimation

A/ Implementation (labor) cost:

- ✓ The manpower cost to implement the proposed measures is calculated by taking the current approximate estimation of labor price to be 40birr/pd, 191628 pd * 40birr/pd= 7,676,956.00**Birr**

B/ Nursery Establishment and Upgrading cost

- ✓ To upgrade the nursery with basic tools and lab our will require about 139,390 ETB birr.

C/ Capacity Building Cost

- ✓ The anticipated cost for training and experience sharing shall be 292,159.04birr.

D /Inputs supply for watershed intensification

- ✓ For intensification of watersheds promoting (Beehives ,Poultry ,Shoat And Energy Saving Stoves) = 5,575,050.73ETB birr.

- ❖ **Sub total cost is 13,683,555.77**ETB birr.

E/ Contingency costs, Let keep 10% of the sum of total cost of implementation, nursery upgrading, training, and that of inputs , which is = 10%*(**13,683,555.77**) = 1,368,355.58ETB birr.

- ❖ **THE GRAND TOTAL PROJECT COST = 15,051,911.35 ETB birr.**

Table 21: Cost Summery

S/N	Cost Title	Total Cost (Birr)	Cost Share By	
			Project	Community

1	Implementation (Lab our Cost)	7,676,956.00	3,070,782.40	4,606,173.60
2	Capacity Building	292,159.04	470,494.08	
3	Input For Watershed Intensification	5,575,050.73	19,270,977.71	
4	Nursery Establishment	139,390.00	139,390.00	
	Sub total	**13,683,555.77**	**22,951,644.19**	
5	Contingency (10%)	1,368,355.58	1,368,355.58	
	Total cost	**15,051,911.35**	**24,319,999.77**	**4,606,173.60**

9.8. 2 Costs-Benefit Estimation

9.8.3. Cost Estimation

Labor Cost: Soil and water conservation costs are estimated based on the future land use plan, physical, bio physical and bio physical soil and water conservation measures. The labour cost to implement the proposed measures is calculated by taking the current labour cost, 40 birr per person day set at national level for natural resource development. Privately owned farms should

9.8.4. Benefit Estimation

The benefits of the project are expressed both quantitatively and quantitatively. Quantitative benefits are estimated for production increment due to bund construction, crop forage and forest product, and mass of soil conserved.

9.8.4.1. Crop Yield

The estimation of production increment is by considering 451 ha of cultivated land in which biophysical SWC structures are recommended. Wheat and Bean are rotational crops used for computation. Productivity of wheat and Bean is taken 15 Qt/ha and 12 Qt/ha respectively. The production increase due to conservation bund is taken 8.65 Qt/ha for Wheat and 2.55 Qt/ha for Bean.

9.8.4.2. Grass Yield

Grass production on bunds and well managed grazing lands will increase. This increment is assumed to be 20 ton per hectare. Out of which 10 ton dry matter (10000kg) is assumed to be additional forages from bunds and managed fields due to improvement produced in each year.

- **Fodder production**- about 6 kg fodders can be harvested per year from each tree so plantation/forests tree will increase fodder production significantly.

Wood yield benefits: - the project is also supposed to have area closure for different purposes such as timber, fuel wood, and farm implements.

-**High amount of water recharge and development**.

Watershed development helps to recharge or increase infiltration of water to the ground and increase ground water. The development also helps for safe disposal or conveyance of excess water from cultivated, grass and forestlands without creating damage on these lands.

-Wildlife habitat development:

By closing and rehabilitating the forests the ecosystem becomes favorable habitat for wild life to live in. so the community get an additional income from tourism or and by selling products that obtained from animals.

-Creating rehabilitated and sustained environment. The environment will rehabilitate through conservation and a forestation measures.

9.8.4.3. Benefit from Conserved Soil

From this watershed 16856.41 tons of soil is expected to be arrested in each year due to conservation measures applied in it.

Sediment protection benefits: -

From this watershed 16.86 tone/ha (within one hectare) of soil is expected to be conserved in each year due to proper conservation measurement.

-Sediment reduction: - It is obvious that Bunds trap considerable amount of sediment. As a result productivity of the soil increases

9.8.4..4. Qualitative Benefits

The current level of land degradation, soil erosion, water resource conservation and development will be minimized and agricultural production will improve in a sustainable manner; rehabilitation of degraded area which will be a potential source for grazing, browsing and a source of fuel and construction wood.

9.8.4.54 Social Benefit

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

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

10.WATERSHED MANAGEMENT AND PLANNING

10.1Implementation strategy

Preparation for Implementation

Different watershed teams will play a major role in maintaining a high level of participation during implementation. They will coordinate the efforts provided by the community and those of single individuals or target groups.

Institutional organization and terms of reference

General roles and responsibilities for participatory watershed development program (PWDP):

1. Regional, zonal (if applicable), Woreda experts and DAs are responsible to propose and arrange training for land users before and during implementation based on local conditions and specific needs. Therefore, training proposals should be developed and forwarded to Woreda level which will provide the technical support.

2. DAs and Woreda experts are responsible to follow-up trials and development of on-farm participatory technology for innovative measures to be tested in specific areas.

3. DAs and Woreda experts will play a major role in strengthening the communication between the various sector agencies operating in the area by involving their experts and using their resources whenever required; for instance, education and health experts, resources, NGOs and others.

4. DAs and land users will also discuss the possible modifications that may occur to the plan during implementation

10.2. Resource Identification and Mobilization

(1) Self-help contributions and empowerment:

Work parties and solidarity efforts:

The community has a key role to play in the contribution of labor and support to the implementation of the plan. There are a number of activities that are within the reach of the land users to design and implement. Various forms of participatory mobilization and solidarity schemes following existing forms of mutual support can be employed. The *edir* and similar traditional social networks are some examples. Traditional work parties with varying degrees of sophistication and purpose carry out specific activities in a specific period of time. Some of these arrangements are known as: *debo* (most parts of Amhara). The arrangements often involve significant number of people even from relatively distant places.

The other set of traditional work party usually involves a few close friends and/or relatives who come together to fence, split wood, help in transportation, and construct soil bunds, harvest grass, hoe, plant seedling, and the like, which are known as wonfel in Amhara areas. It generally entails immediate labor reciprocity. The basic principle that draws people together in such an arrangement is the presumption that working close together increases per capita labor efficiency and ensures better output quality.

From the above, we have some relevance to implementation and management of

Watershed plans:

- Identify farming system-specific menu of activities which can be undertaken using self-help resources that would enhance household physical assets.

- Identify households on whose holdings NRM activities can be undertaken following watershed logic, can facilitate their organization into a number of wonfel groups, and can ensure timely accomplishment of the activity. Link the self-help activity to any other form of available support in different areas (highly food-insecure, for example).

- Facilitate the accomplishment of agricultural/NRM tasks in/around the homestead of disabled people following the spirit of wonfel.

Group formation, community and social organization: Proper establishment and construction of quality measures help much on sustainability but they are only half the job. The other half is proper management of assets. Proper management is not only necessary to sustain and improve measures but also to initiate their replication and expansion. Development initiatives will not be sustained unless beneficiaries make some form of resource commitment to support those initiatives.

Watershed development and management should be thought as a contract where self-help and external support efforts translate into commitments to manage, protect and eventually improve assets once established are considered part of the agreement.

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

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

A long-lasting, collective responsibility for natural resources requires the construction of a common vision rooted in the values of farmers who live on the watershed and experts in the Woreda line agencies. This can lead to adoption of new social norms and a refusal to allow land degradation to continue. This is also linked to gradually building an increased capacity of the watershed communities and the broader watershed continuums to build enough resilience to sustain themselves and exit from external assistance.

(2) Linkage with existing forms of support (safety nets, food security, other projects). The assumption that households' self-contribution is sufficient to build sufficient assets on their land holdings without support need to be verified based on local conditions. Some assets can be built using only local labor force contribution; however, this may not be sufficient for integrated and multiple assets on a large scale. Mass of assets sufficient to trigger efficiency and multiple productivity enhancement functions can only be achieved through economies of scale and integration between activities.

10.3. Organizational Arrangement At Watershed/Community Level Community Labor-Based Contracts and Solidarity

Schemes based on the watershed plan prepared, the amount of labor requirements and type of materials are then estimated.

Building on the traditional work parties, the labor component could be thought as a labor based community watershed "contract". The resources provided or to be provided on a self help and/or other forms of assistance can be translated into person days. The total cumulative person days can then be taken up as a credit that the able-bodied target group should "repay" back to themselves or to the community in a participatory manner, or to specific groups.

(e.g. selected female-headed households and households headed by elders) they themselves prioritize during a given year in terms of assets building for watershed development. Explore the options on how to best implement the watershed "contract" with the community

and different target groups: This process can be all part of a simple but effective participatory planning exercise, with the precise objective to make best use of the "contract" the group sets for itself. The amount of labor days available can be used entirely for community works (one option) or split into a combination of different sets of activities. For example, a given number of the labor days can be dedicated to achieve community-based interventions while other days are set aside to build assets for needy individuals or to build their most productive lands/assets. Simple but highly powerful mechanisms such as the wonfel and similar working parties arrangements can be adapted to fulfill such contract and the preferred modality on how the target group will build such assets.

Most activities should be thought as a one-time event that cannot be re-constructed in the same land-use unit unless proven detrimental or resulting from major technical errors that justify their removal and/or replacement. In this regard, technical assistance is key and should be related to quality works and proper transfer of skills.

Decision-making and role of women and most vulnerable households

Watershed development should strive to ameliorate the position of women in general and female-headed households in particular. This point is related to the above deliberations, but seizes the opportunity to elaborate on the issue of using a combination of self-help and other forms of assistance interventions to support women-headed households and other labor-poor households. The case is also made for people unable to work to build significant assets but who are able to manage them; for example, the elderly, the partially disabled, and others. Many women and the categories of people named retain considerable potential to manage assets with dedication and care. In many parts of the country, the old men on the farm are often regarded as the best "farm keepers".

Linkages with land-use certification, The ongoing efforts on land-use certification in several regions is an excellent incentive to enable land users to value their land holding but also to encourage investments in degraded and marginal areas. The certification process should be closely linked with watershed development planning. The responsibilities of households in managing their land should be related to the management of the measures implemented in such landholdings following watershed development logic and interventions. Specific arrangements at Woreda and regional levels are needed to ensure that land certification is integrated with watershed development and avoid that interventions undertaken on private or communal areas are disconnected and of poor quality. For example, hillsides simply divided into plots and provided for land users on a private basis for planting and grass growth is not the best option for increasing productivity and to generate positive downstream effects. In this case, the area should first be treated with labor intensive moisture physical conservation measures (often beyond the contribution of single households), which then will make it much more productive and generate higher income for the users who share it. Furthermore, such treatment will also support the whole community if water-tables are raised significantly. Land-use certificates will then be more effective and highly valued. This is one example of many that should be taken into consideration.

10.4. Training And Experience Sharing

Building the capacity of local communities and extension workers is an important component in watershed management. Different people will have different roles and responsibilities in watershed projects implementation and there is a need to train people involved in the watershed development program/project at various levels-villagers, extension staff, and others.

Training can enhance knowledge, attitude (problem solving, behavior, and the like), skills (communication, technological, demonstrations, conceptual) and relationship (trust, respect, co-operation and team work)

How to assess training needs: The role that one is expected to play in watershed programs/ projects often determine training needs. We need to determine roles and responsibilities of the stakeholders (Woreda team, DAs, kebele, innovative farmers, and others). What are the activities that the stakeholder was involved with during the specified time frame and what are the skills/capacities required to effectively and efficiently undertake these activities?

Core aspects of training and experience-sharing: (1) Extension staffs need to be trained and encouraged to develop their own training modules as per the needs of the watershed community; (2) identification and use of trainers and resource persons both from within and outside the project area will strengthen the process of capacity building; (3) exposure visits, interactive sessions and networking among stakeholders can play a major role in the capacity building of the grass root level workers; (4) participatory training methodologies encourage innovation; (5) accountability must be in-built within the capacity-building process; (6) linkage with research institutions help in providing practical solutions to specific problems encountered.

11. MONITORING AND EVALUATION

For proper implementation of recommended physical and biological measures, monitoring and evaluation is basic instrument.

During time of construction the following should be strictly monitored:

Spacing between bunds and its length

Dimensions of channel cross-section

Check dams should be properly keyed across its base and up the abutments.

Spillway dimensions should be obeyed according to the design.

Proper seeding selection in nursery

Planting is recommended land unit.

Proper handling of seedlings

Activities needing monitoring after construction:

To allow natural re-vegetation, livestock should not be allowed to trample around the gullies.

Periodic maintenance has to be done.

Protection of the seedling.

Biting up is required.

At the time of implantation a coordinator is required to undertake the recommended measures and solve problems arising during implementation. The coordinator should have sufficient practical knowledge on soil and water conservation both physical and biological measures.

12.CONCLUSION AND RECOMMENDATION

12.1 Conclusion

The recent high agricultural potential regions of the country are now under immense threat. Most of them are depending on food aid to sustain throughout the year. Natural hazards specially hail storm, grazing and cultivated land shortage due to rise in population, decline in productivity of the land caused by mismanagement of the resource and their interwoven problems are reasons of the crisis. Soil erosion is also high in the region, which significantly has an impact on the production.

From the analysis results indicated above, Awajo watershed is moderately dissected, in to various land forms; from flat plain to very steep hills and mountains. High cultivation land demand and livestock density on the one hand and the need for less watershed burden on the other hand contradicts each other. These contradicting needs in this watershed make conservation activities more complex.

12.2. Recommendations

In solving these problems, long term benefits from natural resources based management has to be overlooked. Therefore, choice has to be made whether we shall exploit the resource and ameliorate famine today or prevent famine tomorrow with proper management practice.

Increasing awareness of the community through education and training is the basic factor to achieve successful development. Only it people appreciate the usefulness of the operations to be carried out, will they be inclined to take them up themselves. So we can give timely advice so that money, time effort and specially good will need not get lost. Together with local people, other ways can be looked to achieve the objectives in a manner which is better adapted to the environment.

A balance between population and environmental carrying capacity must be achieved by family planning and increasing agricultural productivity by intensification such as improved implements, supplying fertilizer, seed & pesticide, developing irrigation systems and creating reasonable credit supply condition.

In implementing soil and water conservation activities as per the development plan needs a strong follow up and good expertise. Because of less supervision, the works done had mostly fatal errors that led us wastage of scarce resources.

- To alleviate the above problems soil and water conservations should be held in the watershed based on the specification.
- Physical and biological conservation should be implemented in proper place and specification.
- Different concerned sectors/ stakeholders shall discuss and take their part in the watershed development work.
- Detail works for specification of conservation structures should be studied in detail.
- The farmers should be involved on planning and implementation period so that community based participatory watershed development procedures must be applied.
- Design measures that are climate smart agriculture techniques.
- To apply income generating activates
- Ensure active participation of target community
- In implementing soil and water conservation activities as per the development plan needs a strong follow up and good expertise. Because of less supervision, the works done had mostly fatal errors that led us wastage of scarce resources.

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14. APPENDICES

Table 1: FAO Soil Unit & Their Corresponding K Values

FAO soil unit	K- value	FAO soil unit	K- value
Eutric Fluvisol	0.15	Luvic Phaeozem	0.10
Calcaric Fluvisol	0.10	Gleyic Phyaeozem	0.10
Dystric Fluvisol	0.10	Eutric Cambisol	0.15
Eutric Gleysol	0.15	Dystric Cambisol	0.15
Calcaric Gleysol	0.10	Humic Cambisol	0.10
Dystric Gleysol	0.15	Gleyic Cambisol	0.15
Mollic Gleysol	0.10	Calcaric Cambisol	0.15
Humic Gleysol	0.10	Chromic Cambisol	0.15
Plinthic Gleysol	0.15	Vertic Cambisol	0.20
Eutric Regosol	0.15	Ferallic Cambisol	0.15
Calcaric Regosol	0.10	Orthic Luvisol	0.15
Dystric Regosol	0.15	Chromic Luvisol	0.15
Lithosol	0.10	Calcic Luvisol	0.15
Cambic Arinosol	0.10	Vertic Luvisol	0.20
Luvic Arinosol	0.10	Ferralic Luvisol	0.15
Feralic Arinosol	0.10	Albic Luvisol	0.20
Albic Arinosol	0.10	Plinthic Luvisol	0.20
Rendzina	0.10	Gleyic Luvisol	0.15
Ranker	0.10	Eutric planosol	0.20
Haplic Phaeozem	0.10	Dystric Planosol	0.20
Calcaric phaeozem	0.10	Mollic Planosol	0.15
Humic Planosol	0.15	Cacic Xerosol	0.20
Solodic Planosol	0.20	Gypsic Xerosol	0.20
Ochric Andosol	0.15	Luvic Xerosol	0.20
Molic Andosol	0.10	Orthic Acrisol	0.15

Humic Andosol	0.10	FerricAcrisol	0.15
Vertic Andosol	0.15	HumicAcrisol	0.10
Pellic Vertisol	0.20	Plinthic Acrisol	0.20
Chromic Vertisol	0.20	Gleyic Acrisol	0.15
Orthic solonchak	0.15	Eutric Nitosol	0.15
Molic solonchak	0.10	Dystric Nitosol	0.15
Takyric solonchak	0.20	Humic Nitosol	0.10
Gleyic solonchak	0.15	Orthic Ferralosol	0.15
Orthic solonetz	0.20	Xanthic Ferralosol	0.15
Mollic solonetz	0.15	Rhodic Ferralosol	0.15
Gleyic solonetz	0.20	Humic Ferralosol	0.10
Haplic yermosols	0.20	Acric Ferralosol	0.15
Calcic yermosols	0.20	Plinthic Ferralosol	0.15
Gypsic yermosols	0.20	Eutric Histosol	0.10
Luvic yermosols	0.20	Dystric Histosol	0.10
Takyric yermosols	0.20	Haplic Xerosol	0.20

Source: FAO 1989. Reconnaissance Physical Land Evaluation in Ethiopia

Table2: Land Cover Factor (C)

No	Land Cover	Cover Management Value	No	Land Cover	Cover Management Value
1	Water	0.00	15	Rivers or deep zones	0.027
2	Urban	0.01	16	Dense vegetation	0.002
3	Wet land	0.00	17	Medium forest	0.006
4	Forest	0.03	18	Grass	0.12
5	Paddy Field	0.06	17	Soil without vegetation	0
6	Crop land	0.37	18	City	0.85
7	Forest	0.001	19	Clouds	0
8	Savana	0.04	20	Grain corn	0.40
9	Mining Scrub land	0.25	21	Silage corn, beans and Canola	0.50
10	Swamp	0.28	22	Cereals	0.35
11	Bare Land	1	23	Seasonal horticultural crop	0.50
12	Brush	0.72	24	Fruit trees	0.10
14	Hay and pasture	0.02	26	Scrub Forest	0.041
15	Ravine Forest	0.041	27		

Table 3: Work Norms of the Soil and Water Conservation Practices

No.	Activity	Unit	Revised norms
Activities for which work norms are revised and changed			
1	Soil bund	PD/km	150PD/km
2	Stone bund	PD/km	250PD/km
3	Fanya-juu	PD/km	200PD/km
4	Planting on bund	PD/km	16PD/km
5	Hillside terracing	PD/k	250PD/km
6	Cut-off drain construction	M^3/PD	0.70 M^3/PD
7	Grassed waterway construction	M^3/PD	1.0 M^3/PD
8	Bench terrace construction	PD/km	500PD/km
9	Stone check-dam construction	M^3/PD	0.5 M^3/PD
10	Stone check-dam maintenance	M^3/PD	1 M^3/PD
11	Seedling production	PD/1000 seedling	15PD/1000
12	Pitting	PD/pits	1PD/15 Pits
13	Micro-basin construction	PD/micro-basins	1PD/5MB
14	Seed collection (*)	PD/kg	20PD/kg
15	Seedling planting	PD/Plants	1PD/50 plants
16	Site guarding	PD/Ha./year	4PD/ha/year
17	Small farm dam construction	M^3/PD	0.4 M^3/PD
18	Pond construction	M^3/PD	0.5M^3/PD
19	Farm road construction	PD/km	3000PD/km
20	Road maintenance/construction on <5% slope	PD/Km	500PD/km
Measures for which work norm is not yet revised or changed			
21	Spring development	No	1700 PD/spring
22	Stream diversion weir	No	3000 PD/weir
23	Grass and legume seed production (multiplication center)	*No*	700 PD/ha/year
Measure excluded from ffw (no norms applicable)			
24	Bund maintenance	-	Self-help
25	Other structures/assets maintenance	-	Self-help

(*) Seed collection has a different specific norm (60 PDs/kg) for Grevillea robusta seeds only (applicable under MERET project framework only).

Table 4: Summary of Work Norms

	Activities	Work norm (interim)
I.	**Soil and water conservation**	
1	Bunds stone spillway + apron	2 PD/1 spill way + apron
2	Bund stabilization (grasses and legumes)	30 PD/km
3	Hillside terrace + trench construction	330 PD/km
4	Waterway construction (stone paved)	1 PD/0,75 m³ earth/stone work
5	Waterway check and drop + apron structure (CDA)	1 PD/ 3 CDA
6	Brushwood checkdams construction	1 PD/3 linear meters
7	Stone faced/soil bunds construction	250 PD/km
8	Gully re-vegetation	500 PD/ha
9	Sediment storage dam (SS dam)	1 PD/0,75 m³ earth/stone work
10	SS dams spillway construction	1 PD/0.5 m³ spillway
11	Gully cut and fill/reshaping/leveling	1 PD/1 m³ earth work
12	Compost making (Pit: 4mL x 2mW x 1.5mD)	10 PD/pit
13	Compost making (heap: 4mL x 2mW x1.5mD)	1 PD/linear meter
14	Eyebrow basin construction (EB)	1 PD/2 EB
15	Trench construction	2 PD/3 trenches
16	Herring bone construction (HB)	1 PD/4 HB
17	Improved pits for dry areas	1 PD/5 Improved pits
18	Micro-trenches	1 PD/3 micro-trenches
19	Mulching of trenches / eyebrow basins / herring bones, and others.	1 PD/50 structures
20	Alley cropping	10 PD/km
21	Mulching of degraded land and long fallows	250 PD/ha
22	Zai pits	1 PD/50 pits
23	Grass strips	30 PD/km
24	Grassland improvement	20 PD/ha/year
II.	**Infrastructure**	
25	Road Construction (Type 2 – surfaced/paved)	4000 Pd/km
iii.	***Supplementary measures***	
26	Manuring of planting pits	1 PD/200 pits
27	Cow dung collection and distribution	6 PD/ 1 m³
28	Grass seeds collection (area closures, bunds, etc)	10 PD/kg
29	Gabion structure	1PD/0,25 m³ of gabion check
30	Vegetative fencing and stabilization	40 PD/km
31	Stone shaping (SS and rockfill dam walls, large gully checks)	1 PD/0.5 m³ shaped stones
32	Stone collection and transport	1 PD/0.5 m³ transp. to site

Table 5: Land capability classification table

LAND CLASSIFICATION TABLE

LIMITING FACTOR	RANGE OF CODES PERMITED IN THE COLUMN								
SLOPE (L)	1	2	3	4	1-4	5	6	1-6	1-6
SOIL DEPTH (D)	1	1-2	1-2	1-3	1-4	1-3	1-4	1-5	1-5
PAST EROSION (E)	0	0	0-1	0-2	0-2		0-3	0-4	0-4
WATERLOGGING (W)	0	0	0-1	0-2	0-2		0-2	0-2	0-3
INFILTRATION (I)	0	0	0-1	0-2	0-2		0-2	0-2	0-2
TOPSOIL TEXTURE (T)	3-5	3-6	3-7	2-7	2-7		2-7	1-7	1-7
SURFACE STONINESS OR ROCKINESS (S)	0	0-1	0-2	0-2	0-3		0-3	0-4	0-4
SOIL CONSERVATION REQUIREMENT CLASS	I	II	III	IV	VI		VII	VIII	V
	Land suitable for annual crops				Land suitable for grazing or perennial crops		Land suitable for forestry	Land non suitable for agri-culture	Swampy areas, river beds...

Table:6 Monthly Rain fall **Debresina (Tarmaber woreda)**

Year	jan	feb	mar	apr	may	jun	jul	Aug	sep	oct	nov	dec
1962	0.0	0.0	0.0	0.0	0.0	45.7	451.2	384.2	310.9	129.0	207.9	20.5
1963	11.5	12.2	38.8	436.1	137.8	69.8	405.2	473.0	130.2	0.0	221.2	124.5
1964	104.6	73.6	104.3	253.5	175.1	112.0	527.9	575.2	231.9	141.8	8.5	223.1
1965	77.4	18.0	134.7	568.1	7.3	34.9	372.1	716.2	186.6	430.7	516.1	5.2
1966	16.0	316.9	106.0	362.0	33.2	151.8	291.1	463.9	195.9	140.4	5.1	0.0
1967	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1968	7.3	166.7	98.2	416.7	70.4	232.5	458.6	427.2	170.9	44.9	38.7	26.0
1969	211.1	292.6	37.1	292.5	184.0	59.1	435.2	473.0	69.7	151.1	85.2	0.0
1970	34.7	217.8	401.8	58.5	53.9	9.4	414.8	463.4	149.9	24.9	0.0	66.2
1971	55.1	14.6	83.2	190.5	333.4	53.5	313.9	802.8	227.8	16.5	293.1	388.5
1972	12.5	323.1	328.8	559.0	226.4	201.3	288.1	352.1	252.9	92.9	2.1	0.0
1973	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1974	0.0	82.4	192.6	16.4	297.2	111.5	421.6	310.5	290.0	91.1	0.0	0.0
1975	77.2	168.0	162.0	127.9	88.9	118.3	404.2	445.3	262.3	19.5	0.0	43.0
1976	30.0	2.5	221.8	350.4	62.6	48.7	288.2	523.6	111.5	118.0	54.2	44.0
1977	175.9	67.4	193.7	72.5	28.2	48.2	312.8	329.3	106.3	360.9	93.0	0.0
1978	77.8	89.9	53.2	104.9	2.5	63.3	334.7	314.3	108.2	76.9	64.5	125.2

1979	136.0	155.5	192.5	63.7	296.6	135.4	225.4	357.8	168.4	167.1	0.0	8.3
1980	87.3	32.6	107.2	158.0	118.3	60.3	543.1	458.3	251.9	90.0	77.1	0.0
1981	0.0	37.4	154.6	313.3	34.2	2.0	545.2	564.8	136.8	60.8	0.0	3.4
1982	58.8	96.2	169.6	160.6	193.3	0.0	187.8	436.7	211.0	197.5	238.9	63.0
1983	68.3	51.6	72.9	184.3	344.4	0.0	0.0	370.2	21.1	34.7	0.0	11.2
1984	14.2	54.7	4.2	34.1	351.4	82.6	159.1	97.0	278.5	0.0	95.4	0.0
1985	34.4	0.0	25.1	119.6	144.8	3.2	425.5	701.5	162.7	41.0	0.0	0.0
1986	0.0	101.2	220.9	281.2	110.7	225.5	383.2	271.9	168.3	63.3	0.0	104.1
1987	0.0	29.5	274.3	154.7	437.6	0.0	27.7	429.5	144.6	84.7	0.0	151.8
1988	188.0	142.8	13.2	138.8	38.2	39.7	230.7	282.0	208.5	163.9	0.0	0.0
1989	41.1	101.5	296.1	400.5	13.8	75.5	281.3	390.2	218.2	186.7	0.0	327.4
1990	88.0	124.2	66.6	134.8	10.4	3.4	316.3	289.8	274.6	94.3	0.0	0.0
1991	10.4	78.3	192.4	0.0	49.8	50.2	155.2	252.9	159.0	0.0	30.9	80.3
1992	121.4	133.4	50.8	133.4	27.5	15.3	113.5	571.2	202.5	114.4	9.4	44.9
1993	189.6	40.8	1.2	351.3	397.8	0.0	210.7	144.2	121.8	119.3	87.4	31.4
1994	0.0	0.0	100.2	64.1	114.7	83.1	485.4	374.4	165.7	37.9	104.9	27.1
1995	0.0	13.6	119.0	349.4	120.8	212.2	675.0	468.5	213.8	0.0	130.6	12.2
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	76.3	0.0	0.0	132.5	41.5	200.0	268.0	727.2	187.4	717.8	999.9	58.8
1998	0.0	50.8	107.1	175.9	95.7	33.1	621.0	593.7	454.6	84.3	0.0	0.0
1999	60.3	0.0	127.1	49.3	24.4	139.2	508.3	723.7	226.4	271.7	10.2	0.0
2000	0.0	0.0	29.0	103.1	132.7	33.3	453.7	599.3	412.5	198.4	118.0	201.4
2001	5.5	73.2	319.3	20.8	26.8	36.3	472.5	437.2	116.8	0.0	11.8	54.5
2002	106.5	0.0	100.2	131.2	4.0	64.9	121.8	404.9	173.4	0.0	0.0	185.9
2003	0.0	74.5	127.3	256.7	43.7	128.1	369.2	346.4	227.2	9.4	39.4	99.5
2004	178.3	107.8	79.9	235.8	12.3	96.2	390.8	417.0	186.9	169.3	89.3	70.7
2005	101.6	10.6	221.6	183.2	208.1	83.4	451.6	427.1	184.9	24.2	97.7	0.0
2006	114.6	45.4	154.8	135.8	59.0	48.0	485.8	510.4	235.9	108.6	0.6	255.2
2007	46.5	56.7	82.2	96.5	81.4	133.6	514.6	640.2	155.4	48.7	50.9	0.0
2008	59.0	0.0	0.0	115.7	146.2	110.8	432.1	351.6	117.2	103.5	169.7	0.0
	2677.2	3458.0	5565.5	8487.3	5381.0	3455.3	15774.1	19693.6	8591.0	5030.1	3951.7	2857.3
											Mean	1807

Table:7 Monthly Total rainfall of Sela-dengaye(Mojana wodera woreda)

year	jan	feb	mar	Apr	may	jun	jul	aug	Sep	oct	nov	dec	
1996	19.5	0	58.6	26.7	139	130.3	362.8	333.2	381.3	5.5	54.6	0	
1997	11.3	0	28.6	31.5	10.8	124.7	295.3	246.5	331.3	129	151	0	
1998	29	12.3	29.7	53.2	22.7	11.7	419.1	376.3	481.7	21.1	21.1	0	
1999	12.7	0	27.6	10.3	7.3	71.3	435.9	385.8	514.2	79.9	89.5	0	
2000	0	0	0	33.2	44.4	16.8	453.8	379.4	514	44.6	103	14.7	

2001	0	22.3	115	8.7	32.5	0	533.6	273.5	342.8	6.8	6.8	0	
2002	21.5	5.2	39.3	0	22.7	14.1	311.6	368.5	472.6	14.3	14.3	12.3	
2003	0	0	0	0	0	52.3	336.9	288.8	468.1	3	14.8	0	
2004	15.2	9.3	85.4	51.4	0	108.4	357.6	448.1	598.9	30.2	86	0	
2005	28.6	17.7	18.3	50.2	94.5	87.3	0	0	0	0	0	0	
2006	32.1	11.3	42.1	34.3	11	83.1	546.1	341.3	129.9	50	0.8	81.7	
2007	22.4	15.8	57.3	92.9	20	69.5	423.1	487	123.3	5	35	0	
2008	17.1	0	0	8	76.2	121.5	463.1	413.8	89.8	16.3	28.1	0	
	209.4	**93.9**	**501.8**	**400.4**	**481.1**	**891.0**	**4938.9**	**4342.2**	**4447.9**	**405.2**	**604.5**	**108.7**	1340
	16.11	7.22	38.6	30.8	37.01	68.54	379.9	334	342.15	31.2	46.5	8.3615	1340

Table:8 Curve number of Awoja Watershed

AREA_m2	Cover	Lamd use	Area_km2	Soil group	CN	CN*A
42161.74	Grassland	Grassland; unstocked (woody plant)	0.04	B	69	2.91
8568477.99	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; unstocked (woody pl)	8.57	C	83	711
276864.68	Grassland	Grassland; unstocked (woody plant)	0.28	B	69	19.1
186930.23	Grassland	Grassland; unstocked (woody plant)	0.19	B	69	12.9
239999.95	Grassland	Grassland; unstocked (woody plant)	0.24	B	69	16.6
58.07	Shrubland	Shrubland; Open (20-50% woody cover)	0.00	C	77	0
54313.77	Shrubland	Shrubland; Dense (>50% woody cover)	0.05	C	77	4.18
1389693.31	Shrubland	Shrubland; Open (20-50% woody cover)	1.39	C	77	107
39999.99	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; lightly stocked	0.04	C	83	3.32
5429219.20	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; moderately stocked	5.43	C	83	451
5574.54	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; lightly stocked	0.01	C	83	0.46
43454.11	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; lightly stocked	0.04	C	83	3.61
79999.98	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; lightly stocked	0.08	C	83	6.64
1209787.50	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; lightly stocked	1.21	C	83	100
79999.98	Shrubland	Shrubland; Dense (>50% woody cover)	0.08	C	77	6.16
535082.75	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; lightly stocked	0.54	C	83	44.4
32628.02	Shrubland	Shrubland; Open (20-50% woody cover)	0.03	C	77	2.51
39999.99	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; unstocked (woody pl)	0.04	C	83	3.32
13745.69	Cultivation	Cultivated Land; Rainfed; Cereal Land	0.01	C	83	1.14

		Cover System; lightly stocked				
326957.42	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; unstocked (woody pl)	0.33	C	83	27.1
386260.15	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; lightly stocked	0.39	C	83	32.1
150798.88	Shrubland	Shrubland; Open (20-50% woody cover)	0.15	C	77	11.6
159999.97	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; lightly stocked	0.16	C	83	13.3
39999.99	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; unstocked (woody pl)	0.04	C	83	3.32
359999.93	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; unstocked (woody pl)	0.36	C	83	29.9
276144.38	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; lightly stocked	0.28	C	83	22.9
39999.99	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; lightly stocked	0.04	C	83	3.32
564101.06	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; lightly stocked	0.56	C	83	46.8
799999.85	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; moderately stocked	0.80	C	83	66.4
959539.64	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; lightly stocked	0.96	C	83	79.6
39999.99	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; moderately stocked	0.04	C	83	3.32
126740.14	Shrubland	Shrubland; Open (20-50% woody cover)	0.13	C	77	9.76
39999.99	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; unstocked (woody pl)	0.04	C	83	3.32
39999.99	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; unstocked (woody pl)	0.04	C	83	3.32
13267.10	Cultivation	Cultivated Land; Rainfed; Cereal Land Cover System; unstocked (woody pl)	0.01	C	83	1.1
22591800.00		Total	22.59			1854
		Weithed CN	82.05			
		Area_m2	22,591,800.00			
		Area_km2	22.59			

Table:9 Time of concentration of the awojo watershed

S/n	Distance b/n elevation _m	Elevation	Vertical dist_m	Horizontal dist_m	Slope (m/m)	slope*dist	Tc(Kirpich)minute segment
1		2500					Tc=0.0195*((L^0.77
2	625.165		20.00	625.17	0.03	20.00	
3		2520	0.00	0.00			
4	371.620		20.00	371.62	0.05	20.00	
5		2540	0.00	0.00			
6	459.411		20.00	459.41	0.04	20.00	
7		2560	0.00	0.00			

8	287.564		20.00	287.56	0.07	20.00	
9		2580	0.00	0.00			
10	271.847		20.00	271.85	0.07	20.00	
11		2600	0.00	0.00			
12	273.901		20.00	273.90	0.07	20.00	
13		2620	0.00	0.00			
14	296.093		20.00	296.09	0.07	20.00	
15		2640	0.00	0.00			
16	81.113		20.00	81.11	0.25	20.00	
17		2660	0.00	0.00			
18	165.771		20.00	165.77	0.12	20.00	
19		2680	0.00	0.00			
20	144.853		20.00	144.85	0.14	20.00	
21		2700	0.00	0.00			
22	91.334		20.00	91.33	0.22	20.00	
23		2720	0.00	0.00			
24	72.731		20.00	72.73	0.27	20.00	
25		2740	0.00	0.00			
26	84.548		20.00	84.55	0.24	20.00	
27		2760	0.00	0.00			
28	62.244		20.00	62.24	0.32	20.00	
29		2780	0.00	0.00			
30	737.561		20.00	737.56	0.03	20.00	
31		2800	0.00	0.00			
32	941.529		20.00	941.53	0.02	20.00	
33		2820	0.00	0.00			
34	873.532		20.00	873.53	0.02	20.00	
35		2840	0.00	0.00			
36	746.858		20.00	746.86	0.03	20.00	
37		2860	0.00	0.00			
38	313.516		20.00	313.52	0.06	20.00	
39		2880	0.00	0.00			
40	88.413		20.00	88.41	0.23	20.00	
41		2900	0.00	0.00			
42	176.564		20.00	176.56	0.11	20.00	
43		2920	0.00	0.00			
44	272.411		20.00	272.41	0.07	20.00	
45		2940	0.00	0.00			
46	199.706		20.00	199.71	0.10	20.00	
47		2960	0.00	0.00			
48	353.231		20.00	353.23	0.06	20.00	
49		2980	0.00	0.00			
50	601.968		20.00	601.97	0.03	20.00	
51		3000	0.00	0.00			
52	148.054		20.00	148.05	0.14	20.00	
53		3020	0.00	0.00			

54	582.407		20.00	582.41	0.03	20.00	
55		3040	0.00	0.00			
56	88.462		20.00	88.46	0.23	20.00	
57		3060	0.00	0.00			
58	276.507		20.00	276.51	0.07	20.00	
59		3080	0.00	0.00			
			580.00	9688.91		580.00	
				weighted slope(m/m/) =	0.06		
				Main stream length_m =	9,688.91		
				Main stream length_km =	9.69		
				L(m)	9,688.91		
				V(m)	580.00		
				S(m/m)	0.06		
				Tc(min)	67.65		
				Tc(hr)	**1.13**		