BAHIR DAR UNIVERSITY

COLLEGE OF AGRICUTLURE AND ENVIRONMENTAL SCIENCES

GRADUATE PROGRAM

EFFECTS OF SOIL AND WATER CONSERVATION PRACTICE ON BIO-PHYSICAL ATTRIBUTES, LIVESTOCK FEED RESOURCES AVAILABILITY AND PEOPLE'S LIVELIHOOD CONDITION OF DEBRE-MEWI WATERSHED, NORTH WEST ETHIOPIA

M.Sc Thesis

BY

Sisay Damtie

February, 2017

Bahr Dar, Ethiopia

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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE (M.Sc.) "IN LAND RESOURCE MANAGEMENT"

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THESIS APPROVAL SHEET

As member of the Board of Examiners of the Master of Sciences (M.Sc.) thesis open defence examination, we have read and evaluated this thesis prepared by Mr Sisay Damtie entitled "Effects of Soil and Water Conservation Measures on Bio-Physical Attributes, Livestock Feed Resources Availability and People's Livelihood Condition of Debre-Mewi Watershed, North West Ethiopia". We hereby certify that, the thesis is accepted for fulfilling the requirements for the award of the degree of Master of Sciences (M.Sc.) in Land Resource Management.

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DECLARATION

This is to certify that this thesis entitled "Effects of Soil and Water Conservation Practices on Bio-Physical Attributes, Livestock Feed Resources Availability and People's Livelihood Condition of Debre-Mewi Watershed, North West Ethiopia" submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in "Land Resource Management" to the Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University by Mr. Sisay Damtie (ID. No. BDU 0602090) is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of our knowledge and belief.

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Signature & date_____________________

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ABBREVIATIONS

ANRS	Amhara National Regional State
BoA	Bureau of Agriculture
CSA	Central Statistical Authority
Das	Development agents
DMW	Debre-Mewi Watershed
EFAP	Ethiopia Forestry Action Programme
ETB	Ethiopian Birr
FFW	Food for Work
FAO	Food and Agricultural Organization
GIS	Geographical Information System
HHs	House Holds
M.a.s.l.	Meter above sea level
PAs	Peasant Association
SPSS	Statistical Package for Social Sciences
SWC	Soil and water conservation
SWCP	Soil and water conservation practices
TLU	Tropical Livestock Unit
WFP	World Food Program
WOCAT	World Overview of Conservation Approaches and Technologies

Effects of Soil and Water Conservation Practice on Bio-Physical Attributes, Livestock Feed Resources Availability and People's Livelihood Condition of Debre-Mewi Watershed, North West Ethiopia

By

Sisay Damtie

Major advisor: Getachew Fisseha (PhD)

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ABSTRACT

Soil and water conservation practice (SWCP) have been widely implemented in many parts of Ethiopia since 1983. As a number of researchers agree, most of the physical structures are strengthened by biological measures and also huge amount of land had been closed from direct interference of human and animals to treat degraded and gully areas. The aim of this study was to analyze the effects of SWCP on biophysical attributes, livestock feed availability and community livelihood improvement at Debre-Mewi Watershed (DMW) in comparison with the nearby untreated Sholit watershed which are located in West Gojjam Zone, Ethiopia. Semi-structured interview was applied for these two watersheds to collect all required data for the study. To strengthen the data which were collected using questionnaire and to get additional data focus group discussion including watershed committee was conducted in each watershed. Transect walk were also applied in each watershed to observe current biophysical situation of the area. GIS technique was also used to analyze land use type of DMW. The result shows that SWCP has high contribution to improve biophysical feature (forest coverage, bushes and shrubs increased; and rock out crops were totally eliminated) as compared to the previous studies of the area in DMW. Comparison was made between DMW (treated) and Sholit (untreated) watersheds, and in terms of income, households in DMW were found to be better off by 882.91 ETB per annum than Sholit households even though the differences is not statistically significant. The mean feed resource harvested for livestock from SWC structures found to be 1.55 quintal in DMW where as in Sholit watershed it was found to be 0.21 quintal per annum per household. The result also indicated that feed resource harvested from SWCP, tropical livestock unit and land holding size are statistically significant for peoples' livelihood with 3.2, 0.5 and 0.8% significance level respectively.

Keywords: Biophysical, Livelihood, Livestock feed, Soil and water conservation practice.

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CHAPTER 1: INTRODUCTION

1.1 Background and Justification

The population of the world is dependent on land resource for food and other necessities. More than 97% of the total food for the world's population is derived from land, the remaining being from the aquatic systems (Pimentel, 1993). Hence, land and water resources are the basis for humans to generate income and produce consumable goods and services (Wallace, 2007). Nevertheless, their availability is limited in space and time due to erosion, and this influences livelihoods, especially of the rural poor who directly depend on them (Antoci *et al.*, 2009). Soil erosion is one of the biggest global environmental problems resulting in both on-site and off-site effects. It has been accelerated in most parts of the world, especially in developing countries, due to different socio-economic and demographic factors and limited resources (Eswaran *et al.*, 2001). According to Eswaran *et al.* (2001) the global annual loss of soil due to natural and anthropogenic factors constitutes 75 billion tons per year. This soil erosion will remain a very important global issue for the 21st century because of its adverse impact on agronomic productivity, the environment, and its effect on food security and the quality of life. Problems associated with the accelerated erosion persisted for more than a million geologic years in almost all parts of the globe (*Adediji et al., 2010*), however, soil erosion by water is commonly recognized as one of main reasons of land degradation in worldwide has dramatic effect on the world economy especially for developing countries like Ethiopia which their economy is depend on agriculture (Beskow *et al.*, 2009).

Agriculture is the backbone of Ethiopian economy which is highly dependent on natural resources (Akililu Amsalu and Graaff, 2007). But agricultural production is low due to soil erosion and it results in high level of poverty in the country (Mitiku Haile *et.al*., 2002). Especially soil erosion by water and its associated effects are recognized to be severe threats to the national economy and mainly occur in the highland areas of the country (Gizachew Ayalew and Yihenew G. Selassie, 2015). According to Mengistu M. (2003) about 371,000 km² of lands of the country is over 2000 m above sea level. However, highland areas are considered as areas situated 1,500 m above sea level (Mwendera *et al.*, 1997) and considering this, Ethiopian highland region accounts 43% the total land mass of the country or 537,000 square kilometers (Hurni, 1988). This highland

region is inhabited by the vast majority of the Ethiopian human and livestock populations (Wagayehu Bekele, 2003) and responsible for 95% of cultivated land and it accounts for 90% of national economy (Hawando, 1997) although it is under continuous threat from soil erosion. According to Wagayehu Bekele (2003) soil erosion is considered to be among the major factors responsible for the recurrent malnutrition and famine problems in the country as it reduces yield and income and poses a threat to household food security (Shively, 1999).

Soil erosion and nutrient depletion are two particularly common sources of declining agricultural productivity. Empirical studies have linked low and declining crop yield to the existence of soil erosion (Troeh *et al*., 1991). Crop yield decline partly as essential organic matter and plant nutrients are lost. Eroded soils also suffer from moisture deficiency. Subsoil does not contain as much organic matter as topsoil and has smaller particle sizes, and is thus less permeable to water and less capable of storing moisture (Pagiola, 1994). Thus, immediate consequence of soil erosion is reduced crop yield followed by economic decline and social stress. The integrated process of soil degradation and increased poverty has been referred to as the "downhill spiral of un sustainability" leading to the "poverty trap" (Moges Abebe and Holden, 2006), especially in Ethiopian highlands where the livelihoods of the people predominantly based on mixed-crop-livestock farming (Haileslassie A. *et al.,* 2005).

Livelihood of the vast majority of Ethiopian highland population depends directly or indirectly on mixed-crop-livestock farming. Such dependence obviously leads to increased vulnerability of the economy to problems related to soil erosion (Wegayehu Bekele, 2003). There are several estimates about economic impacts of soil erosion in the country. For instance Hagmann (2006) indicated that erosion reduces Ethiopian’s food production by 1-2 % per annum and it cost on average 2.2% of land productivity annually. These figures imply that the economic impact of erosion is significant in the country. Erosion and the decline in humus content of soils reduce infiltration capacity of soils and soil moisture storage capacity. Consequently, decline in infiltration and moisture storage capacity of soils reduces the capacity of crops to withstand droughts (Louis, 2012). Many studies in Ethiopia attributed the widespread poverty, structural food insecurity and recurring famine partly to the environmental degradation problem in general and soil erosion in particular (Mihrete Getnet, 2014). Hence, Soil and water Conservation is critical

to human well-being. Their prudent use and management are more important now than ever before to meet the high demands for food production and satisfy the needs of an increasing world population (Humberto and Rattan, 2008).

Soil and Water Conservation Practices (SWCP) in highland areas of Ethiopia can foster the production of various kinds of ecosystem services that have both upstream and downstream benefits (Woubet Alemu *et.al.*, 2013). Theoretically, physical soil and water conservation structures have the potential to reduce soil loss by decreasing overland flow of water and increase yield by reducing moisture stress on plant growth through retention of rainwater that would otherwise be lost to runoff (Wagayehu Bekele, 2003). According to Mulugeta Demelash and Karl (2010), appropriate soil and water conservation practice can significantly improve soil chemical and physical properties: soil organic matter, total Nitrogen (N), available phosphorous (P), bulk density, infiltration rate and soil texture. Therefore, implementing SWC practices that maintain or restore the capacity of soil to retain water along with nutrients and organic matter that can dramatically reduce agricultural water demand, reduce vulnerability to drought and flooding, and also increase soil carbon storage, as well as productivity. In addition, by reducing runoff, it reduces the need for chemical fertilizer inputs and it improves water quality downstream (CSA, 2007). The findings of Troeh *et al*. (2004) also indicates that SWCP has significant contributions for the production of livestock feed, crop production improvement and other necessities for livelihood improvement.

1.2. Statement of the Problem

By recognizing problem of land degradation, the government of Ethiopia has made several SWCPs. Level soil bunds (LSB), stone bunds (SB), Fanya Juu bund, different kinds of check dams, biological soil and water conservation measures have been widely implemented in many parts of Ethiopia including the study area, Debre-Mewi Watershed (DMW) with governmental and none governmental support from 1983 to 2006. Most of the physical structures strengthened by biological measures and also huge amount of land had been closed from direct interference of human and animals. Due to this, vegetation cover had been improved. There are studies that indicate activities mentioned decreased rate of soil erosion, increased soil fertility and improve crop production and productivity (Teklu Erkossa and Gezahegn Ayele, 2003). But, there are no enough studies that show

the effect of SWCP on biophysical attributes of the watershed, livestock feed availability and livelihood improvement. Thus, this research is expected to verify whether SWCP improve biophysical attributes of a watershed, and if it can help to increase livestock feed availability and improve livelihood of the community.

1.3. Objectives

1.3.1. General objective

To assess the effects of soil and water conservation practice (SWCP) on biophysical attributes, livestock feed resource availability and people's livelihood conditions in DMW.

1.3.2. Specific objectives

- To assess the effect of SWCP on biophysical attributes of the watershed.
- To assess livestock feed availability as a result of SWCP.
- To analyze the effect of SWCP on the peoples' livelihood condition in the watershed.

1.4. Research Questions

- ✓ What are the effects SWCP on the biophysical attributes of the watershed?
- ✓ Do SWCP improve livestock feed availability in the study area?
- ✓ What are the effects of SWCP on livelihood conditions of the people in DMW?
- ✓ Is there a difference between DMW (treated) and Sholit watershed (untreated) with respect to biophysical attributes, feed resource availability and livelihood conditions of the people?

CHAPTER 2: LITRATURE REVIEW

2.1. Soil and Water Conservation Practice (SWCP)

2.1.1. History of SWCP

Soil erosion from unsustainable land use practices in Ethiopia is not a new phenomenon. It is as old as the history of agriculture itself (Daba, 2003). High rainfall variability characterized by a quasi-periodic fluctuation, and consequently drought situations, has occurred throughout human history in the country (Haile, 1988). However, it is only very recently, in the past three decades that the Ethiopian government recognized the impact of soil erosion after the devastating famine in 1970s (Shiferaw Bekele and Holden, 1998). Although Ethiopia was one of the food exporter country in the world until late 1950s, cumulative effect of continuous soil erosion, ever-increasing population pressure, and inappropriate development policies change the situation and the country became food aid dependent since the devastating famine in 1970^{th} (Aredo, 1990). To address this problem, considerable efforts have been made since that time to rehabilitate degraded environments and stop further degradation by the government (Herweg and Ludi, 2003). By this action, huge areas were covered with terraces, and millions of trees were planted with the support of international organizations (Tadesse, 2001).

The Ethiopian government first recognized the severity of the soil degradation problem following the 1973/74 famines in Wollo. The 1973/74 droughts drew also the attention of external donors to land degradation and soon conservation become a priority (Berhanu Gebremedhin and Swinton, 2003). According to (Berhanu Gebremedhin and Swinton, 2003), after the early 1970s, national efforts to conserve lands become intensified. These interventions largely relied on mobilization of farm households and food for work (FFW) projects to conserve degraded lands through the construction of soil bunds, stone terraces and afforestation with financial aid from World Food Program (WFP) which reached about US$50 million per year in 1987. Aside from the introduced soil and water conservation measures, peasants have been aware of problems related to soil erosion and developed different indigenous soil and water conservation practices that sustained

agriculture for centuries. For example different conservation practices in the Northern Highlands (Hoben, 1996); well-developed terracing systems of Konso in southern Ethiopia (FAO, 1990); ditches in Northern Shewa in the Central Highlands and different techniques in the Eastern Highlands (Asrat Kebede *et al*., 1996). The attention given by Ethiopian government to the expansion of conservation activities since the early 1970s is an indication of increasing awareness about problem.

The Ethiopia government initiated a massive program of SWC and rehabilitation in most degraded highland areas of the country with heavy external financial support and manpower resources under the FFW programme following the 1975 land reform and establishment of the kebele administration, which were instrumental in mobilizing labour and assignment of local responsibilities. This involved over 30 million peasant workdays per year (Hurni *et al*., 2007). Between 1975 and 1989 terraces were built on 980,000 ha of cropland; 280,000 ha of hillside terraces were built, 310,000 ha of highly denuded land were revalidated (Hans *et al*., 1996). This was further expanded with the involvement of mainly the World Food Program (WFP) since the early 1980s, which provided incentives for conservation activities. On croplands, structural measures, mainly soil and stone bunds were built uniformly across regions with FFW incentives in food deficit areas of the highlands of Ethiopia. Conservation activities were mainly undertaken in a campaign often without the involvement of the land users. Peasants were not allowed to remove the structures once it built but maintenance was often carried out through FFW incentives (Shiferaw Bekele and Holden, 1998). However, this massive campaign of soil conservation and afforestation, does not seem to have succeeded either in triggering widespread voluntary adoption of the practices by farmers in a sustainable manner or in solving problems related to soil erosion. In the wake of the announcement of an economic policy change in March 1990, and the subsequent change in government in May 1991, farmers removed most of the conservation structures built on their plots and cut down the trees planted under the project (Shiferaw Bekele & Holden, 1998). The soil erosion problem persists and increased mass poverty in rural areas. Although there are localized indigenous conservation practices, they did not match the severity and intensity of the soil erosion problem in the country (Hoben, 1996). According to (Hoben, 1996), the development and widespread use of all sorts of conservation practices have been curtailed due to disincentives created by the political, institutional, and economic environments in the country. By considering this, full participatory SWCP was started. This has occurred

through different stages that professionals gathering data, analyzing it, preparing plans and then asking the local community if they agree, before requesting mobilization of local resources (notably labour) to implement these plans (Mitiku Haile *et al.*, 2006). It is possible to say that this way of implementation shows some changes in the country as a whole and specifically in Amhara Region.

(ANRS) has intensively launched the natural resource development work through public mobilization since 2010. This strengthened SWCP in the region and forces political leaders taken it as a priority agenda. As a result SWC campaigns are underway every year throughout the region (ANRS BoA, 2013). Debre-Mewi watershed is one of the site in the region where SWC practices is implemented. The practice was not that much in the large scale before 2010 but since this time expertise put their effort in the area to open the eyes of the community and it shows good progress in rehabilitation of degraded lands by SWC measures (Getachew Engdayehu, 2013).

2.1.2. Importance of soil and water conservation

Researches indicated that large proportion of soil erosion (almost half of soil losses) occurs from the cultivated fields that cover only 13% of the country and on average 42 tons of soil is being washed out from a hectare of cultivated fields (Hurni *et al.*, 2007). The same study also indicated that highest average soil loss occurred on lands which was once under cultivation and currently unproductive and with less vegetation cover that estimated that every year in highlands of Ethiopian that loses about 1.9 to 3.5 billion tones of topsoil (EFAP, 1993). This large amount of soil loss made the country to be described as one of the most serious erosion areas in Africa and in the world (Hurni *et al.*, 2007). Excessive soil loss with other factors led to reduced average crop yield per unit area. Because, erosion removes the most productive portion of the soil, that is, the chemically active part such as organic matter and clay fractions. It also causes a deterioration of soil structure, moisture holding capacity through lowering soil depth, increasing bulk density, soil crusting, and reducing water infiltration (Woubet Alemu *et al*., 2013). Hence, Soil and water conservation practices (SWCP) especially in upland areas is important as it can foster the production of various kinds of ecosystem services that have both upstream and downstream benefits.

Physical soil and water conservation structures have great potential to reduce soil loss by decreasing overland flow of water and increase yield by reducing moisture stress on plant growth through retention of rainwater that would otherwise be lost to runoff (Wagayehu Bekele, 2003). By reducing runoff and the need for chemical fertilizer inputs, downstream water quality improves (CSA, 2007). It also helps to restore the capacity of soil to retain water along with nutrients and organic matter; farmers can dramatically reduce agricultural water demand, reduce vulnerability to climate extremes of drought and flooding, and also increase soil carbon storage, as well as productivity (Aylward, 2004). According to (Mulugeta Demelash and Karl, 2010) appropriate SWCP can significantly improve soil chemical and physical properties: soil organic matter, total nitrogen (N), available phosphorous (P), bulk density, infiltration rate and soil texture.

2.1.3. Types of soil and water conservation practice

Soil and Water Conservation Practices (SWCP) are defined by WOCAT as activities at a local level which maintain or enhance the productive capacity of the land in areas affected by, or prone to, degradation (WOCAT, 2007). According to WOCAT, SWCP classified as agronomic, vegetative, structural and /or management measures that prevent and control land degradation and enhance productivity in the field (WOCAT, 2007). Looking at land degradation caused by human activities, the SWC technologies can be found everywhere in the world and can be described as good practices in agriculture. Further WOCAT distinguishes three stages of intervention: prevention, mitigation or rehabilitation. The stage of intervention determines the treatment of the degraded land and also, which technology or conservation measures should be used. Prevention implies a treatment or an application of a technology that maintains natural resources and their environmental and productive function on land that may be prone to degradation (WOCAT, 2007). Mitigation means that the land is already degraded this on-going degradation has to be stopped, because the impacts of this stage are already noticeable in the short term. The last stage of intervention, rehabilitation, is required when the land is already degraded to such an extent that the original use is no longer possible and the land has become practically unproductive. In this case long-term and more costly investments are needed to have any impact" (WOCAT, 2007). Furthermore, WOCAT defines three conservation measures as follow:

Agronomic measure: such as conservation agriculture, manuring/composting, mixed cropping, mulching, etc

- Are usually associated with annual crops
- Are repeated routinely each season or in a rotational sequence
- Are of short duration and not permanent
- Are often not zoned
- Do not lead to changes in slope profile
- Are normally independent of slop

Structural measures: such as terraces (Banks, bunds and other structures)

- Often lead to a change in slope profile
- Are of long duration or permanent
- Are carried out primarily to control runoff, wind velocity and erosion
- Often require substantial inputs of labor or money when first installed
- Can be aligned at a certain gradient

Vegetative measure: such as grass strips, hedge barriers, windbreaks, or agro forestry etc.

- Involved the use of perennial grasses, shrubs, or trees
- Are of long duration
- Often lead to a change in slope profile
- Are often aligned along the contour or against the wind
- Are often spaced according to slop

2.2. Effect of SWCP on Biophysical Attributes

2.2.1. Reduction in soil erosion and slope gradient

Land covered by plant biomass, living or dead, are more resistant to wind and water soil erosion and experience relatively little erosion because rain drop and wind energy are dissipated by the biomass layer and the topsoil is held together by the biomass (Pimentel *et al.*, 2005).

2.2.2. Work load

SWCP reduces runoff water and improves ground water capacity. So, it makes easier access to water and had particularly reduced women’s workload and therefore increased “quality” of life. More time was used for family care and domestic work by saving time in activities such as fetching water, security and carrying heavy loads (Ismo, 2006). According to (Wagayehu Bekele, 2003) economic benefits of SWCP for the household came as water for all year round agricultural production and time used for water related activities, *e.g.* fetching water and laundry, at homes. Several crops were harvested and more time was left for domestic work due to easier access to water resources.

2.3. Livestock Feed Availability

Most of the world's livestock, particularly ruminants in pastoral and extensive mixed systems in many developing countries, suffer from permanent or seasonal nutritional stress (Bruinsma, 2003). Poor nutrition is one of the major production constraints in smallholder systems, particularly in Ethiopia. Many researches have been carried out to improve the quality and availability of feed resources, including work on sown forages, forage conservation, the use of multi-purpose trees, fibrous crop residues and strategic supplementation. There are also prospects for using novel feeds from various sources to provide alternative sources of protein and energy, such as plantation crops and various industrial (including ethanol) by-products. The potential of such feeds is largely unknown. Given the prevalence of mixed crop–livestock systems in many parts of the world, closer integration of crops and livestock in such systems can give rise to increased productivity and increased soil fertility (Mcintire *et al*., 2005). In such systems, smallholders use crops for multiple purposes (food and feed, for example), and crop breeding programmes are now well established that are targeting required quality as well as grain yield in crops such as maize, sorghum, millet and groundnut.

Rehabilitating degraded land by SWCP can addressing livestock nutritional constraints. Gully treatment with different rehabilitation measures results generating of different livestock feed specious. Forage plants such as Elephant grass and *Sesbania sesban* were planted as stabilizers of conservation structures reduced soil losses, improved the

availability of organic inputs for soil improvement, and offered animal feed and consequent increase in cash income (Tilahun Amede, 2003). These forage plants are fast growing and the farmers harvested frequently and fed their cattle. The farmers who have these forages at their homestead could not suffer from the shortage of feed as those who had not planted. The plant species also greatly contributed to the stabilization of the soil conservation structure. *Sesbania sesban*, legume plant species, besides being used as bund stabilizers and feed, it was chopped and incorporated in to the soil for improvement of soil fertility (Tilahun Amede, 2003).

SWCP increases crop production by improving soil chemical and physical properties (Mulugeta Demelash and Karl, 2010) and crop residues uses for animal feed, and it helps full filling the nutritional need of livestock as it is the most part to get the economic benefit obtained for the livestock (Dubale, 2001). The nutritional needs of farm animals with respect to energy, protein, minerals and vitamins have long been known, and these have been refined in recent decades (Mcintire *et al*., 2005).

2.4. Effects of SWCP on Peoples Livelihood Improvement

Soil erosion has decreased in many parts of the developed countries by means of good agricultural practices and SWC methods. As a result, these countries produce more food today than 50 years ago. In fact, many of the world‟s developed counties increased their food per capita in the last fifty years (Roetter and Keullen, 2008). SWC can improve soil organic matter, total N, available phosphorous (P), bulk density, infiltration rate and soil texture cost (Mulugeta Demelash and Karl, 2010), and this is very important to increase land productivity which is one livelihood determining main factor . Straw, from cereal field crops is also used as construction, fuel and fencing materials (Dubale P., 2001). That is why, in many cases crop residues are in high demand in some local market for different uses. Economic impact has been mainly achieved through increased crop production. An increase in crops has two-fold effect. First, it helps to secure food for the household and, secondly, to create a surplus which can be sold (Wagayehu Bekele, 2003). According to Wagayehu Bekele (2003), increased cropping gave food for the families and there was no need to buy food grain from the market. Surplus was sold in the market and income was used for family expenses such as education, clothing, sugar, tea, salt, and improved housing. Later, more organized cash crop production plantations were started.

CHAPTER 3: MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location

Both DM and Sholit watersheds were situated within Yilmana Densa and Bahirdar Zuria Woredas in West Gojjam Administration zone of Amhara Regional State (Figure 3.1.). DM watershed is geographically located between 11°20'10'' to 11°21'58" N and 37°24'07" to 37°25'55' E whereas Sholit watershed is located in between 11°22'20'' to 11°22'28" N and 37°24'15" to 37°24' 16'' E which is located in the East direction of DMW. Both of the watersheds are far from the capital city of Ethiopia, Addis Ababa and the capital city of Amhara Regional State Bahir Dar by about 500 and 30 km respectively.

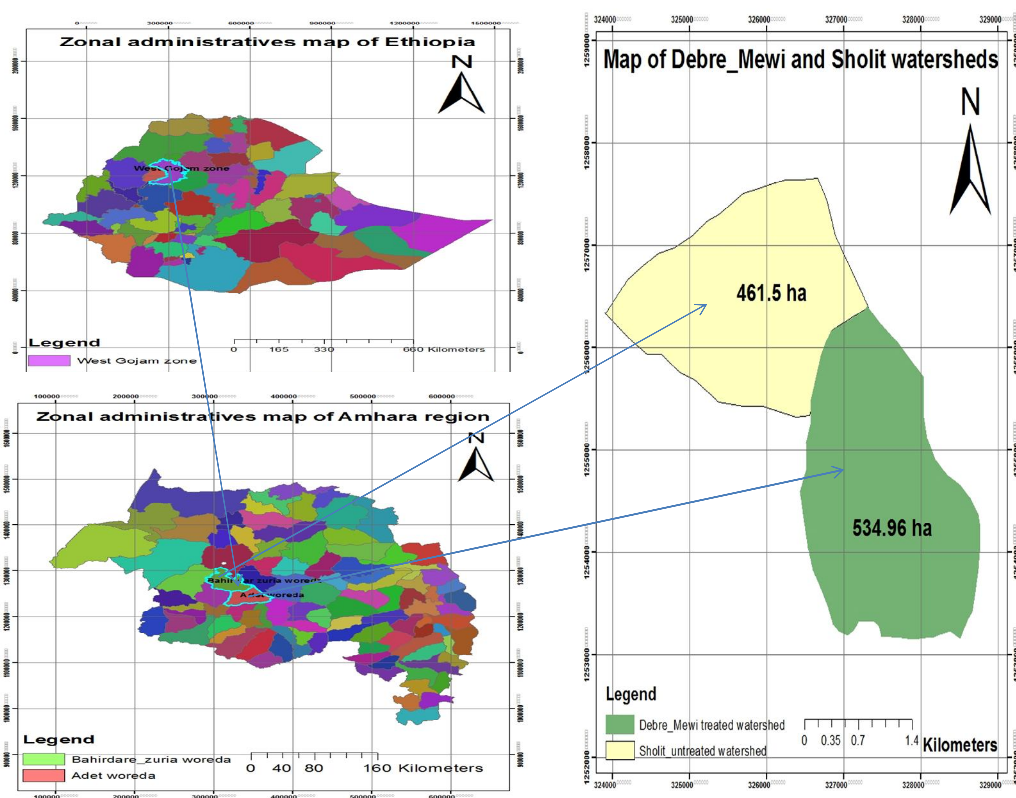

Figure 3. 1. Location map of the study area (researcher, 2016)

3.1.2. Climate

There is a meteorological station at Adet town, which is the nearest to the study area. Based on the 20 years rainfall data analysis of this station, both of the watersheds are characterized by single maximum rainfall pattern with peaks in July and August and receives on average annual precipitation of 1221.3 mm. About 80 - 90% of the rainfall falls in the main rainy season (“Kiremt”), which starts in June and extends in August/September. In both watersheds, rainfall has a unimodal annual distribution. It is in this season that the major agricultural activities, such as ploughing, sowing and weeding are performed. The dry months are between November and March (known as *bega*) when less than 6.06 % of the total annual rainfall occurs. In both watersheds the mean annual minimum and maximum temperatures are 16.24 and 20.25 ^{O}C respectively. The elevation ranges between 2200 -2366 m.a.s.l. Thus, both of the watersheds are under the category of Moist Woina dega agro ecology zone (BMBO, 2015).

3.1.3. Topography

The slope gradient of DMW ranges from 5 to 45% whereas the slope gradient of Sholit watershed ranges 0 to 30 %. The eastern and north eastern view of the DMW along the main road to its outlet is nearly gentle followed by steep, moderately steep and gently sloping. In the north western side, it is almost the same scene with the earlier (Getachew Engdayeh, 2013).

3.1.4. Soil

According to Addisalem Assefa (2009), as cited by Getachew Fisseha *et al*. (2011) laboratory analysis result of soil samples indicated that the soils of the study area are Eutric Vertisols (33.28%; 181.0 ha), Eutric Luvisols (24.83%; 135.0 ha), Pellic Vertisols (19.55%; 106.32 ha), Eutric Cambisols (8.29%; 45.1 ha), Eutric Fluvisols (7.43%; 40.4 ha) and Eutric Aquic Vertisols (6.62%; 36.0 ha). The Vertisols, Luvisols and Fluvisols are found in gently undulating lands, while the other soil types occupy the higher altitudes.

3.1.3. Farming system

In both watersheds, agriculture is rain-fed, with a subsistence farming system. Land and livestock are therefore the most important livelihood assets. Teff (*Eragrostis teff*), finger millet, maize (*Zea mays*) and Wheat (*Triticum vulgare*) are the major crops cultivated in both watersheds.

3.2. Sampling Methods and Data Collection

3.2.1. Type and sources of data

For this study quantitative and qualitative data were collected from primary and secondary sources. Primary data which were collected from sample households include information on: age, sex, family size, educational level and land holding size, types of livestock, livestock number per household, type and area coverage of SWCP, types and livestock feed harvested from different SWCPs and area closure, total household income from farm production (crop income), income from animal product, forage production and other benefits from created assets in the watershed. Secondary data about population, age structure, farming systems, infrastructure situation, crop production trend, annual rainfall and min and max temperature, etc. were collected from different sources.

3.2.2. Method of data collection

Data were collected through GIS techniques, transect walk, semi-structured interviews, direct field observation and focus group discussion. A structured questionnaire was used to collect the primary data. Development agents (Das) were recruited and trained on the techniques of data collection, including how they should approach farmers, conduct the interview, and convince the respondent to give relevant information on sensitive economic and social issues. After they were made aware of the objective of the study and content of the questionnaire, pre-test had been conducted under the supervision of the researcher. Some adjustments were made to the questionnaire and the data were collected under continuous supervision of the researcher. The survey was conducted on May 2016.

3.2.3. Determination of sample size and sampling technique

The total house hold heads (HHs) residing in DM and Sholit watersheds were 205 male, 38 female and 151 male, 35 female respectively, The formal interview was conducted with 50 HHs from DMW, 38 from Sholit watershed that were selected proportionally. The number of HH heads that were selected for interview was selected by using Yemane formula (Yemane, 1967).

$$no = \frac{z^2 pq}{d^2} \qquad \qquad n = \frac{no}{1+(\frac{no-1}{N})}$$

Where,

no is desired sample size when the population is greater than10,000

n is number of sample size when the population is less than10,000

p is 0.1 (proportion of the population to be included in the sample i.e. 10%)

z is 95 % confidence limit i.e. 1.96

q is 1-0.1 (i.e. 0.9)

d is margin of error or degree of accuracy desired (0.05)

N is total number of population

Based on the above sample size determination method, the number of total sample HHs that were selected for interview are 88. The sample households (HHs) were randomly selected from a list of total HHs from each watershed. If the selected household not available after repeated visits, alternative farmer living that village was interviewed.

3.3. Method of Data Analysis

Both descriptive and econometric analysis was use for this research. The descriptive statistics such as minimum, maximum, mean, percentage, standard deviation. T-test and chi square test were also employed to compare treated (DM) and untreated (Sholit) watersheds with respect to different explanatory variables were used. Econometric analysis, called multiple linear regression model was employed to estimate the SWCP on people’s livelihood condition in DMW.

3.3.1 .Variable specification and hypothesis

Dependent variable

In this study peoples' livelihood condition (PLC) which is measured in terms of income has been taken as a continuous dependant variable. To analyse peoples' livelihood condition in terms of income, total income of each sample household from crop production, livestock production, petty trade, weaving, selling of charcoal and fuel wood, food for work, tailoring, labour sale and other income sources were calculated in monetary values.

Independent variables

In addition to SWCP, different variables are expected to affect household livelihood condition in the study area. The major variables affecting farmers' livelihood condition are:

1. Area of soil and water conservation structures (ASWC): This variable is a continuous variable that measures the area of soil and water conservation structures in hectare that a household implemented in his/her land. Large area of SWC structures of farmers are expected to increase productivity of land by reducing soil and water degradation problems. Therefore, it is hypothesized that farmers with large area of SWC structures are more likely to be better in livelihood condition.

2. Feed resources harvested from SWC structures (FRH): Livestock feed is one of the major inputs to improve livestock production and productivity. The livestock feed resource that has been collected from different soil and water conservation structures was measured in quintals. Availability of these feeds expected to increase income of the household from sales of livestock and livestock products as well as sales of the feed itself. This implies that better availability of livestock feeds affects the livelihood condition of the household positively. In addition to the above variables the following variables has been identified to have an influence in the income of the household (Gebre Tekie, 2013)

3. Age of household head (AGE): this is a continuous explanatory variable designating age of the house hold head. The livelihood condition of the household expected to be

positively related to age. As the age of the household head increases, the person is expected to acquire more experience and endowed with more assets. Thus, it is hypothesized that older age of the household head is positively associated to the livelihood condition of the household.

4. Sex of the household head (SEX): dummy variable (1 if the household head is male and 0 otherwise). Sex of a household head could have an influence in a household's livelihood condition. As explained in the literatures, female-headed households can be in difficult condition than male headed households to gain access to valuable resource. Moreover, with regard to farming experience males are better than the female farmers in the study area. Therefore, it is hypothesized that male-headed households are better in livelihood condition than female-headed households

5. Family size (FAS): households with large number of economically dependent family members will be expected to face high dependency burden. The existence of large number of children under age of 15 and old age of 60 and above in the family expected to affect the livelihood condition of the household. That means, the working age population (i.e., 15-60 years) supports not only themselves, but also additional dependent persons in the family. Thus, it is hypothesized that the family with relatively large number of dependent family members (high dependency ratio) negatively affects the livelihood condition of the household in the study area.

6. Educational level of the household heads (EDU): Educational attainment by the household expected to enhance production by promoting awareness of the possible advantages of modernizing agriculture by means of technological inputs; enable them to read instructions on fertilizer applications and diversification of household incomes which, in turn, expected to have a positive influence on household livelihood condition. Educational level will have binary values as 1, households who can read and write and 0, households who cannot read and/or write.

7. Total livestock owned (TLU): Livestock are source of income for farming households. Households who have better possession of livestock are expected to be better in livelihood condition. This is so because livestock contribute to the household meat, milk and egg for direct consumption and draft power, manure and income from sales of

livestock. Therefore, it is expected that livestock holding have a positive implication on livelihood condition and the total number of livestock holding of the household will be measured in tropical livestock unit which is adopted by Genene Tsegaye (2006).

8. Land Holding Size (LHS): refers to the size of the land in hectare (owned, shared and rented) that allocated for annual and perennial crops, vegetable and for homestead farming activities and for grazing purpose. During data collection the actual size of land that the respondent households have recorded in hectares or on the bases of their local land area measurement like 'kada' (1/4 of a hectare). Larger size of land implies more production and availability of food grains. Hence, size of the land has significant impact in determining livelihood condition of the household at the study area. Therefore households with large size of land are expected to be better in livelihood condition.

9. Oxen (OX): In most part of Ethiopia rural households use oxen to plough their farm land to produce crops. The number of oxen in the households is very determinant to plough their farm land. Hence larger number of oxen expected to have significant impact in determining livelihood condition of the household at the study area. Therefore households with large number of oxen are expected to be better in livelihood condition.

3.3.2. Model specification for analysis of livelihood condition

Livelihood condition of the household is often determined by SWCP and with other socio-economic and demographic factors. The effect of such factors was determined using regression analysis to specify and validate empirical data that were collected. It was also used to verify hypothesis regarding the effects of different explanatory variables on livelihood condition of rural household and to draw inferences that could guide research and policy decisions. Thus, to describe the effect of SWCP together with other socioeconomic variables on livelihood condition of the household, multiple regression model was employed for this study. The functional form of the relationship between dependent variable, livelihood condition (on the left side) and explanatory variables (on the right side) was illustrated as follows.

Livelihood condition (PLC) = f{ASWC, FRH, AGE, SEX, FAS, EDU, TLU, LHS, OX}

The following linear multiple regression model was used for this study to estimate the effect of the independent variables on livelihood condition of household.

$$PLC = \alpha + \beta_1 ASWC + \beta_2 FRH + \beta_3 AGE + \beta_4 SEX - \beta_5 FAS + \beta_6 EDU + \beta_7 TLU + \beta_8 LHS + \beta_9 OX + e_i$$

Where, ASWC = Area of Soil and Water conservation structures of the household in hectare, FRH **=** Feed resources harvested from SWC structures in ton**,** AGE = Age of the household head, SEX = a dummy variables for gender of the household head (1 if Male and 0 otherwise), FAS = Family size of the household, EDU = Level of education of household head, TLU = Tropical Livestock Unit, LHS = Land holding Size of the household in hectare**,** OX **=** Number of oxen the household has e_i = Random term /disturbance term which represents all other factors that were have effect on household's livelihood condition.

The data were subjected to linear regression model, using the ordinary least squares method (OLS). The hypothesis of no significant difference in the effect of the independent variables on household livelihood condition was tested at five level of significance with (n-k) degree of freedom, (where; n = number of observation (n=88), and K = number of parameters (K =9).

The null hypothesis has been tested by comparing the coefficients of the explanatory variables with its corresponding standard error. The null-hypothesis was accepted if half of the coefficient of each explanatory variable is greater than its corresponding value of standard error. When the existence of null-hypothesis accepted for an explanatory variable, this was showed that there is no relationship between the explanatory variable and the dependent variable. Otherwise, the alternative hypothesis gets accepted by rejecting the null-hypothesis. In this case there is a relationship between the explanatory and dependent variables or the explanatory variables have significant effect on livelihood of the household.

$SE\ \beta_i = \beta_i/2$

Where:

$SE\ \beta_i$ = Standard error of i^{th} β_i

β_i = Parameter estimate of β_i

If SE $\beta_i > \beta_i$ /2 accept the null hypothesis, no relationship between the independent variable to that of the dependent variable considered in the model and If SE$\beta_i < \beta_i$ /2 reject the null hypothesis and accept the alternative hypothesis which means there is relationship between the independent variable to that of the dependent variable considered in the model).

Application software such as excel spread sheet and SPSS version 20 were employed for this analysis. Along with the regression analysis, in this study, descriptive statistics, such as mean, standard deviation, percentage, t-test and chi-square test were employed to analyze the data. Finally, data were presented in the form of figure and tabulation.

CHAPTER 4: RESULTS AND DISCUSSION

4.1. Socio Economic Conditions of the Study Area

4.1.1. Sex of household head

Out of a total of 88 randomly taken respondents, 86 % were male-headed and 14 % were female-headed households. Male-headed households account 88 % in DMW and 84 % in sholit watershed. Likewise, female-headed household accounts 12 % in DMW and 16 % in Sholit watershed. The Chi-square test indicated that the systematic relationship between watershed type and sex of household head is insignificant (Table 4.1.).

Table 4.1. Distribution of sample households by sex

Sex	DMW (N = 50)	Sholit watershed (N = 38)	Total sample (N = 88)	$\chi2$-value
	Percent	Percent	Percent	
Female	12	16	14	
Male	88	84	86	0.608
Total	100	100	100	

Source: Own computation result, 2016

4.1.2. Age of the household head

The mean age of the sample household heads was 46.3 years with the standard deviation of 13.167. Accordingly, the mean age of the treated (DMW) was 47.86 years and 44.24 years for untreated watershed (Sholit) with the mean difference of 3.623**.** The statistical analysis showed that there is no statistically significant difference between treated and untreated watersheds in terms of sample households' age (Table 4.2.). The maximum and minimum age of the total sample households found to be 78 and 24 years respectively (Table 4.3).

4.1.3. Family size

The mean family size of the sample household heads was 5.26 which varied between 2 and 11 persons with standard deviation of 1.657 (Table 4.3). The average family size for both DMW and Sholit watershed sample households found to be the same which is 5.26 persons. The result showed that there is no statistically significant difference between treated and untreated watersheds in terms of family size (Table 4.2.).

4.1.4. Land holding size

The average landholding of the total sample household heads was 1.67 ha. with standard deviation of 0.86. The mean land holding size for treated watershed and untreated watershed sample households was found to be 1.68 and 1.65 ha. per household with SD of 0.62 and 1.1 ha. respectively with mean difference of 0.04 ha. The difference is found to be statistically significant at the significance level of 5% (Table 4.2.).

4.1.5. Livestock holding

Livestock as part of mixed farming system is paramount important to a household livelihood. Livestock plays an important role in the farming system of the area. Cattle, sheep and goat, equine and chicken are kept by farmers for income source, draft power and food (milk, meat, egg). The total average livestock holding for sample households was 4.78 TLU with standard deviation of 2.69 (Table 4.3). The average livestock holding for DM and Sholit watersheds sample households in Tropical Livestock Unit was found to be 5.17 and 4.26 with SD of 2.69 and 2.66 respectively and with mean difference of 0.90 TLU. The result showed that there is no statistically significant difference between DMW and Sholit watershed sample households in terms of livestock holding (Table 4.2.).

Table 4.2. Distribution of age, family size, land and livestock holding of sample households

Variables	Total sample (N = 88)		DMW (N=50)		Sholit (N =38)		Mean difference	t – value	sig
	Mean	STD	Mean	STD	Mean	STD	Mean		
AGE	46.30	13.167	47.86	13.608	44.24	12.441	3.623	1.283	.213
FAS	5.26	1.657	5.26	1.601	5.26	1.750	-.003	-.009	.733
LHS	1.6719	.86110	1.6875	.62589	1.6513	1.10632	.03618	.194	.007
TLU	4.7759	2.68636	5.1662	2.66967	4.2624	2.65579	.90383	1.577	.714

Where, AGE = Age of the household head, FAS = Family size of the household, LHS = Land holding Size of the household in hectare**,** TLU = Tropical Livestock Unit and N = number of sample size.

Source: Own computation result, 2016

Table 4.3. Maximum, minimum and mean of continuous variables

	N	Minimum	Maximum	Mean	Std. Deviation
Age of the household head	88	24.00	78.00	46.30	13.17
Family size	88	2.00	10.00	5.26	1.66
Land holding size of the household	88	0.25	5.00	1.67	0.86
Number of oxen per household	88	0.00	3.00	1.35	0.80
Tropical livestock unit	88	0.00	14.91	4.78	2.69
Area of soil and water conservation	88	0.00	2.00	0.45	0.50
Feed resource harvested from ASWC	88	0.00	6.00	0.97	1.17
Peoples' livelihood condition	88	2300.00	27000.00	11793.9432	4845.255

Where, N = number of sample size.

Source: Own computation result, 2016

4.1.6. Oxen holding

Table 4.4. Distribution of ox holding of sample households

Number of ox	DMW (N = 50)	Sholit (N = 38)	Total sample (N = 88)	χ2-value
	Percent	Percent	Percent	
0	6	29	16	
1	52	18	37	14.16
2	38	47	42	
3	4	6	5	

Where, N = number of sample size.
Source: Own computation result, 2016

Oxen are the most important means of land cultivation and basic farm assets. Households who own more oxen have better chance for better livelihood. Moreover, oxen possession can enable good performance of crop production through improving household access to land. Among the sample households about 16%, 37%, 42% and 5% have zero ox, one ox, two oxen and three oxen respectively. The result revealed that 29% of sample households in Sholit watershed and 6% of sample households in DMW had no ox. As we can see in the above (table 4.4.) there is a significant difference between the two watersheds with respect to the number of oxen owned. The difference is statistically significance at 5% level (Table 4.4.).

4.1.7. Education

Table 4.5. Distribution of education level of the sample household head

Variable		DMW (N = 50)	Sholit watershed (N = 38)	Total sample (N = 88)	χ2-value
		Percent	Percent	Percent	
Education level of the household head	Illiterate	60	39	51	10.66
	read and write	14	42	26	
	primary school	26	16	22	
	grade9_12	0	3	1	
Total		100	100	100	

Where, N = number of sample size.

Source: Own computation result, 2016

Educational attainment by the household expected to enhance production by promoting awareness of the possible advantages of modernizing agriculture by means of technological inputs; enable them to read instructions on fertilizer applications and diversification of household incomes which, in turn, expected to have a positive influence on household livelihood condition. From the survey made at study area, which is shown in (Table 4.5.), 51 % of the sample household heads were illiterate of which about 60 % was from DMW and 39 % were from Sholit watershed. The educational level of the household head found to be statically significant at 1 percent significance level. Thus there is a significance difference between DMW and Sholit watershed households with regard to education level.

4.2. Effect of SWCP on Biophysical Attributes

4.2.1. Soil erosion reduction

Result from field observation shows that almost all farm lands at DMW are treated with physical as well as biological soil and water conservation structures (Figure 4.1.). Not only this but also all grazing lands are closed from free grazing. In addition all gullies in the watershed are treated with different check dams, biological measures and protected. During field observation transect walk any sign of rill erosion was not observed.

Figure 4.1. Treated farm land, protected grazing land and treated gully from tope to down respectively (researcher, 2016)

According to results in the group discussion, soil erosion is reducing gradually from year to year related to developed conservation structures. It helps to protect the removal of fertile top soil in the farm land because rain water percolate down rather than run off as a form of flood. This is because conservation structures break water speed and help to have time to percolate rather than run off. As a result soil is protected while water is conserved as a form of ground water. This is important not only for soil and water conservation practices rather it also very important for conflict resolution.

Traditionally the local community used to make drains to discharged excessive water from their farm land. Especially in the sloppy area most of rain water follows down to the slope rather than percolate to the ground. Hence, the water is high in volume and fast moving which can easily remove the top soil that is fertile. Even it removes crops, and cuts a land

and form gully. Due to this, no one wants to accept flow of water from his or her neighbour and it causes conflict when the upper one let the water to the down flow. The conflict is very sever even sometimes goes up to human death. However, SWCP helps as a conflict resolution tool in addition to its importance for conserving water and soil. Most of rain water percolates down so that the amount of runoff water critically reduces. Not only this, but also the conservation structures systematically arrange how the excessive water can flow downwards without affecting any one. Due to this, currently there is no conflict in DMW community related to excessive water flow.

To the contrary at Sholit watershed, rill erosion and huge gullies were frequently observed. Grazing lands are highly degraded due to free and over grazing (Figure 4.2.).

Figure 4.2. Unprotected grazing land and untreated gully at Sholit watershed (researcher, 2016).

Results from the group discussion also indicated severity of the problem that farm lands are highly affected by erosion in Sholit watershed. It removes fertile top soil in the farm land. Farm lands and grazing areas are affected by rill and gully erosions. In the wait

season there are high run off water which form a flood. This flood cuts a land and form gully even in the farm land. So, ran off water management is a challenge in the area and it frequently causes for conflict.

4.2.2. Land use land cover change

Table 4. 6. Land use/cover type and area covered by the respective land use type in the DMW watershed in 2016 (researcher, 2016)

Land use and cover type	2016	
	Area (ha)	%
Natural forest	2.7	0.5
Shrub and bush land	16.5	3.1
Grazing land	38.8	7.7
Cultivated and settlement	425.1	79.6
Eucalyptus plantation	33	6.2
Rock out crop	0	0
Treated gully and rehabilitated degraded land	18.4	3.3

In DMW majority of land, which accounts 79.6%, used for cultivated and settlement purposes. Research conducted by Addisalem Assefa (2009) and Getachew Fisseha *et al.* (2011) also indicated that cultivated land counts 80.7 % in 2009 and 81.51% in 2008 in their studies respectively. This study showed that the coverage of Eucalyptus plantation accounts 6.2% but in studies of Addisalem Assefa (2009) and Getachew Fisseha *et al.* (2011), it counts 0.7 and 1.28% in 2009 and 2008 respectively. This implies that currently farmers considered Eucalyptus tree as a cash crop and planted in the cultivated and grazing areas. This result also observed in field observation and mentioned in focused group discussions. As indicated in table 4.6, 7.7% of the watershed area is used as a grazing area. These two land use system are the one which can cause for land degradation. The result shows 3.3% of the watershed area either treated gully or rehabilitated degraded land. In Getachew Fisseha *et al*. (2011) study's that analyzed land use land cover change of DMW with three periods of interval (1957, 1982 and 2008), rock out crop was detected which accounts 3.3% in 2008 which is not seen 1957 and 1982 but it couldn’t observe in this study (Figure 4.3.). This indicates the presence of high erosion in between 1982 and 2008 that degraded the land and could change it to rock out crop. On the other hand the disappearance of this rock out crop in 2016 indicates the effect of SWCP on physical

feature of the area. According to Getachew Fisseha *et al*. (2011), Shrub and bush lands accounts 6.1%, 6.0% and 2.4% in the watershed in 1957, 1982 and 2008 respectively but in this study (2016) it accounted 3.1 %. This shows shrub and bush covered lands was highly shrank from 1982 to 2008 but it showed improvement in current study and it is the effect of SWCP on biological feature of the area. So, SWCP has highly contributed for improvement of biophysical feature of the area.

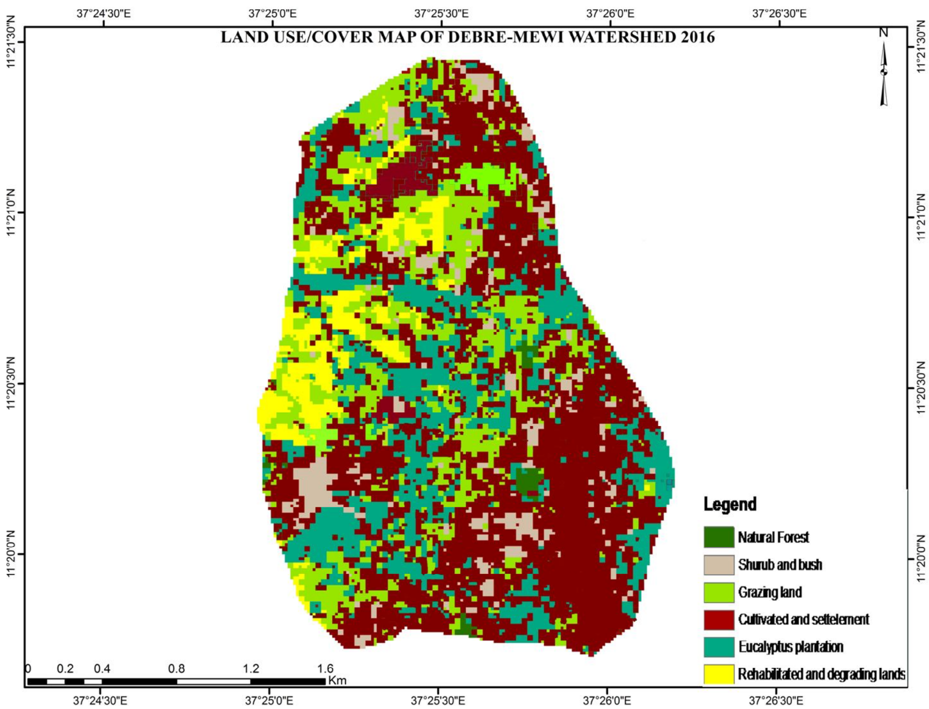

Figure 4. 3. Land use/Cover map of DMW in 2016 (researcher, 2016)

4.2.3. Water resource availability

According to farmers from group discussion, it was impossible to get ground water in less than 10 m deep in DMW but by now ground water can be accessible within 8 m depth, even it is possible to get ground water nearby each village (Figure 4.4.) but in Sholit watershed, ground water potential is reduced. There are a number of indicators raised in the group discussion about ground water potential reduction, which includes reduction of water volume in the stream and distance increment to access ground water through a hand dug well. There are two streams called Assabla and Bollo in Sholit watershed. Their water volume is highly decreasing through time and their flow become limited in time. As a result, it could not give service for the community as before. Other alternative source of

water in the area is ground water although the potential have been reducing. Previously ground water in the area could be accessed in about 13 m ground distance but currently it is a must to dig up to 16 m in the same place. Not only this but also this water is not accessible anywhere rather it is in a very specific area which is mostly far apart from villages. This put a burden on women work load.

Figure 4.4. Stream, communal hand dug well and private shallow well from top to down (researcher, 2016)

4.2.4. SWCP and women work load

Culturally woman supposed to do all house based activities including fetching water, firewood collection and others. According to the group discussion soil and water conservation affects women's work load both positively and negatively. The discussion at DMW indicates that SWCP reduces women's work load as they get water nearby and firewood from biological conservation practices although, SWCP creates additional workload related to livestock management. As cattle feed at home, women are supposed to

look after them, feed and drink them. However, the all over impact of SWCP in woman workload reduction is highly important (fig. 4.5.).

Figure 4.5. Fire wood and feeding collection from SWC structures (researcher, 2016)

4.3. Effects of SWCP on Livestock Feed Resource

4.3.1. Area of SWC structures

Different types of soil and water conservation measures were introduced to the study area. Graded soil bund, graded fanyajuu, stone bund and stone faced soil bund are most commonly practiced SWC measures on farm land in DMW (Figure 4.5.). Different gully treatment structures like lose stone check dam, brush wood check dam, gabion check dam, soil filled sack check dam, arch weir check dam has been also implemented. On hilly and communal grazing lands area closure, trenches, hillside terrace has been implemented.

Figure 4.5. Treated farm lands with physical and biological methods (researcher, 2016)

Farmers were asked to estimate the area of their land covered by different SWC structures. The result revealed that, sample household's mean area of land covered by different soil and water conservation measures found to be 0.45 ha. with standard deviation of 0.498. Majority of sample households in DMW are practicing soil and water conservation measures. On average each sample household have 0.45 ha. of land covered with different soil and water conservation structures with standard deviation of 0.498 ha. in DMW watershed and 0.11ha. of land in Sholit watershed with standard deviation of 0.23. The mean difference between the two watersheds in terms of area coverage of different soil and water conservations found to be 0.61 ha. The t- test shows significant difference between the two watersheds in terms of area coverage of different soil water conservation measures and the result is statically significant at one percent significance level. This result is fully coinciding with the result from focus group discussion and field observation.

Figure 4.6. Part of focus group discussion in DMW and Sholit watersheds from right to left (researcher, 2016).

According to farmers during the focus group discussion (Figure 4.6), DMW is well treated watershed in which soil and water conservation practices (SWCP) was started in 2001 E.C on degraded communal lands by fencing the area to protect it from human interaction and constructed terraces inside as needed. However, organized SWCP work have been in place since 2004 E.C. Currently soil and water loss in the watershed decreased significantly as almost all area in the watershed is treated. It could be proven during field observation that almost all gullies are treated; both physical and biological conservation structures were employed in farm lands of DMW. Soil and water conservation practice is also important for conflict resolution in addition to soil and water conservation according to group discussion result with DMW community. On the other hand SWCP is a new technology for Sholit watershed communities (Figure 4.7.). It is in initial stage and not yet organised. Hence, conservation structures are not common yet in the watershed. Even though, there are some physical structures observed in farm lands during field observation, it is not supported by biological measures and not controlled from free grazing. Gully treatment is not totally observed in Sholit watershed.

Figure 4.7. Picture in the left, untreated gully at Sholit watershed; picture in the right treated gully at DMW compile (researcher, 2016)

4.3.2. SWC practice and livestock feed resources

Livestock feed is one of the major inputs to improve livestock production and productivity. The major livestock feed resources include grazing, crop residues and collected grasses. Availability of these feeds varies across different months of the year. During the rainy season, grazing pasture and collected grasses are the two most important feed resources in the area. However, crop residues are the main livestock feed sources in the dry season of the year. Surplus feed is obtained following the cessation of the heavy

rainy season whereas moderate feed supply is available during the months of June, July, August and December. Despite the periodic availability of surplus pasture at the end of the main rainy season, feed resource harvesting from different soil and water conservation structures is a common practice in DMW to overcome the problem of feed deficit.

Farmers were asked to estimate the amount of feed resource harvested per year in quintal on different SWC structures. As it shown in table 4.7, on average sample households harvested 0.97 quintal of feed resource per year on different soil and water conservation structures with standard deviation of 1.17 quintal in the study area. The average feed resource harvested in DM and Sholit watersheds sample households was found to be 1.55 and 0.21 quintal per year with SD of 1.16 and 0.62 respectively and with mean difference of 1.34 quintal. The statistical analysis revealed that there is a significance difference between the two watersheds in relation to feed resource derived from different SWC structures. The difference is found to be statistically significant at 1% significance level. This implies that soil and water conservations structures have a significant effect on livestock feed resource availability in DMW.

Results from the group discussion also showed that community in DMW practices modern ways of cattle production. They almost stop free grazing and feed their cattle at home using cut and carry system. Communal and gully areas in the watershed is protected while all conservation structures are strengthened with forage plants. Hence, they could get forage throughout the year (Fig. 4.9.).

Figure 4.9. Treated DMW (researcher, 2016).

But communities in Sholit watershed practices free grazing and they get grasses in wet season only. During the field observation it was common to see cattle in grazing area while areas are over grazed in sholit watershed but it is hardly seen cattle in the field in DMW and all areas including farm lands are covered with grasses or forage plants (Figure 4.10.). This could highly affect the livestock production of the community. Focus group discussion in DMW community shows their livestock production is improved significantly when it is compared with the previous one before SWCP. They used to count the number of cattle they have but were not benefited as cattle were not productive because of lack of enough forage with nutritional value. But now they focus on products rather than numbers.

Figure 4.8. forage in a gully treated area, forage plants in conservation structure from left to right at DM and free grazing in the right at Sholit watershed (researcher, 2016)

4.4.Effects of SWCP on People's Livelihood Condition

Table 4. 7. Distribution of area of SWCP, feed resource harvested and livelihood conditions of sample households

Variables	Total sample N = 88		Sample household DMW N =50		Sample household Sholit N =38		Mean difference	t value	sig
	mean	STD	mean	STD	mean	STD	Mean		
ASWC	0.45313	0.498530	0.71550	0.489348	0.10789	0.227657	0.607605	7.746	.000
FRH	0.9716	1.16980	1.5500	1.16058	0.2105	0.62202	1.33947	6.952	.000
PLC	11793.94	4845.25	12175.20	4690.60	11292.29	5060.56	882.91	.845	.430

Where, ASWC = Area of Soil and Water conservation structures of the household in hectare, FRH **=** Feed resources harvested from SWC structures in qt**,** PLC = people's livelihood condition an**d** N = number of sample size.
Source: Own computation result, 2016

Soil and water conservation expected to have an effect in livelihood improvement by increasing in water availability which allows production of cash crops, improved soil and

water management leads to higher yield, integration of forage development with SWC structures would increase the benefit of the community from livestock. SWC also affects people's livelihood condition through conflict resolution, work load reduction especially for woman. An attempt has been made to assess the effect of SWCP on the people's livelihood condition which measured in terms of income by interviewing each and every one of the sample respondents in the two watersheds. Income data for the study watersheds has been collected from farm production (crop income), animal product, forage production and other benefits from created assets in the watershed. The monetary value has been derived based on the local market prices per unit of the grain equivalent.

The survey results show that sample house households in DMW and Sholit watershed had a mean income of 12175.20 ETB and 11292.29 ETB per year per household respectively with mean difference of 882.91 ETB while the mean annual income of the total sampled households was found to be 11793.94 ETB per annum per household. This means that households in DMW are better in terms of livelihood condition (Table 4.7.). The study conducted by Yenealem Kassa *et al.* in 2013 on the impact of integrated soil and water conservation program on crop production and income in West Harerghe Zone, Ethiopia using propensity score matching method, found that there is annual income difference between soil conservation participants and non-participants. But in this study, even though there is a mean income difference in the two watersheds the t-test indicates that the difference is not statistically significant (Table 4.7.).

According to farmers during focus group discussion, erosion was a critical problem in DMW. It removes the tope soil, which is fertile, and reduces the productivity of land year to year. After SWCP implementation the situation is changed. The conservation structure helps to reduce erosion. As a result most of rain water percolates down rather than runoff and it helps to conserve soil and water in the area. Reduction of soil loss due to SWCP contributes to manage soil fertility. That is why; crop productivity is increasing in time since SWCP was started in DMW. This result was also supported by Shimeles Damene (2013). He conducted a research on effectiveness of soil and water conservation measures for land restoration in Wello area, Ethiopia and he found that physical soil and water conservation structures help to maintain soil fertility and crop yield improvement. SWCP not only increase crop productivity but also helps to increase access of forage and resulting improvement of livestock production. Status of livestock production and crop

productivity are key factors which can determine livelihoods of a community. So, SWCP highly contributing for livelihood improvement in DMW. There was a research done by AgREN (Agricultural Research & Extension Network) in 2000 on the contribution of soil and water conservation to sustainable livelihoods in semi-arid areas of Sub-Saharan Africa and its finding showed that there are important contribution of SWCP on community livelihoods.

4.5. Farmers Livelihood Conditions and Influencing Variables

Table 4. 8. Output of multiple regression analysis factors affecting people's livelihood condition

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	2812.617	1379.576		2.039	0.048
Area of soil and water conservation	2206.645	904.213	0.230	2.440	0.019**
Feed resource harvested for livestock from SWC structures	1110.261	499.542	0.275	2.223	0.032**
Age of the household head	-12.873	18.078	-0.037	-0.712	0.481
Sex of the house hold head	-606.105	778.177	-0.042	-0.779	0.441
Family size	73.230	164.052	0.025	0.446	0.658
Education level of the house holed	420.876	294.611	0.078	1.429	0.161
Tropical livestock unit	446.935	149.683	0.254	2.986	0.005***
Land holding size of the house hold	2007.940	725.264	0.268	2.769	0.008***
Number of oxen per house hold	307.914	551.696	0.044	0.558	0.580

Dependent Variable: peoples' livelihood condition

Source: Own computation result, 2016

In this study livelihood condition of the household was determined by SWCP together with other socio-economic and demographic factors by measuring in terms of income.
A multiple linear regression model was employed to estimate the potential effect of SWCP and other socioeconomic variables on livelihood condition of the household.

Nine variables were hypothesized to have an effect on household's livelihood conditions and all variables were entered to the model. Out of the variables analyzed, the coefficients of four variables, namely area of soil and water conservation structures, feed resource harvested for livestock from SWCP, livestock holding and land holding size of the household found to be variables that have significant effect on livelihood conditions of the households in DMW. The remaining five variables, age, sex, family size, educational level and number of ox per household were found to have correct signs but insignificant effect on livelihood condition of the household in DMW (Table 4.8.).

The goodness to fit or coefficient of determination or the R-squared which is (0.905) shows that, 90.5% of the explanatory variables jointly explain the dependent variable (people's livelihood condition). The remaining 9.5% is not explained by the explanatory variables which are incorporated in the model.

4.5.1. Area of soil and water conservation structures

The area of land covered with different soil and water conservation structures had significant effect on the livelihood condition of the household at 5 % significance level in DMW. It is also positively correlated with livelihood condition of the household. The results of linear multiple regression model parametric estimates of area of soil and water conservation of the household showed that an increase in area of soil and water conservation in one hectare of land for the household increases their income by a factor of 0.23 being other explanatory variables which were included in the model constant. The possible explanation for this result is that households who implement different soil and water conservation structures on their land becomes in a better position in livelihood condition than households who didn't implement soil and water conservation structures on their land. Hence practicing soil and water conservation measures mitigate soil erosion caused by water and this will improve the livelihood status of households in the study area.

4.5.2. Feed resource harvested for livestock from different SWCP

The livestock feed resource collected from different soil and water conservation structures had a significant effect on livelihood condition of the household at 5% significance level. The result implies that better availability of livestock feeds affects the livelihood condition

of the household positively. The parametric estimates of linear multiple regression model showed that an increase livestock feed resource by one quintal increases the households income by a factor of 0.275 being other explanatory variables which were included in the model constant in DMW. The model result confirmed that practicing soil and water conservation measures had significant effect in livelihood condition by increasing livestock feed resource availability and the result is in agreement with prior expectation. Hence implementing soil and water conservation measures mitigate soil erosion caused by water and this will increase livestock feed availability and this in turn improves livelihood condition of the household in the study area. So we can conclude that investing SWCP have positive significant effect in terms of mitigating land degradation, increasing livestock feed availably and to improve household's livelihood condition in terms of income.

4.5.3. Total livestock owned

Livestock had a significant and positive effect on the household's livelihood condition in the study area. The positive sign of slope coefficient indicates that when livestock owned increase by one TLU, the household livelihood condition improves by a factor of 0.254. The possible explanation for this result is that as households have large number of livestock (ox, cow, heifer, calf, donkey, goat, sheep and chicken) they become in better position in livelihood condition than farmers who have few livestock.

4.5.4. Land holding size

The results of the linear multiple regression model show that land holding size of the household head was positively related to the livelihood condition of the household. The coefficient of this variable was statistically significant at less than 1 % probability level implying that as the size of land holding of the household increase by one hectare, the livelihood of that household will improve with a factor of 0.268 being other explanatory variables which were included in the model constant in DMW. Therefore, since land is the most important resource in rural area for crop production and animal rearing, as the size of land holding of the household increases, the livelihood condition of the household could be in a better position than households who have smaller land size.

CHAPTER 5: CONCLUSIONS AND RECOMMEDATIONS

5.1. Conclusions

The result of this study showed that soil and water conservations structures have a significant effect on livestock feed resource availability in DMW. This result has also been supported with focus group discussion and field observation results that soil and water conservation structure improves the availability of livestock feed resource and water resources. Therefore, it can be conclude that soil and water conservation activities has key role to enhance livestock feed resource as well as to improve livestock productivity of the DMW.

The survey results showed that sample households in DMW had a mean income of 12175.20 ETB where as a mean income of sample house households in Sholit watershed was found to be 11292.29 ETB per year which indicates that households in DMW are better in terms of livelihood condition. But even though there is a mean income difference in the two watersheds, the t-test indicates that the difference is not statistically significant. From this result we can conclude that to see the effect of SWCP in the two watersheds on people's livelihood condition, it needs longer period of time. However, in DMW watershed, the results of linear multiple regression model estimates revealed that the most statistically significant variables are area of soil and water conservation structures, feed resource harvested on soil and water structures, livestock holding and land holding size of the household. The result indicated that a unit change in the area of SWC activities, feed resource harvested from SWC structures, livestock holding and land holding size enhance the people’s livelihood condition by a factor of 0.23, 0.275, 0.254 and 0.268 respectively. But, age**,** sex, family size, educational level and number of ox were found to have insignificant effect on livelihood condition of the household in DMW.

The study showed that implementing soil and water conservations improves the availability of water, livestock feed resource; reduce conflict, and productivity of cultivated land in DMW watershed. It also reduces conflicts among communities and work

load of females' in the watershed. On the other hand, SWCP failed to gain the above benefits in Sholit watershed.

5.2. Recommendations

- Soil and water conservation should be given more attention and the watershed development practice of DMW communities should be scaled up and implemented in to other areas of the region to enhance livestock feed resource availability.
- Quality improves of livestock and improved forage development should be given attention to increase income from production of livestock.
- Agricultural intensification should be strongly improved to enhance productivity of household per hectare through new technologies such as use of small scale irrigation to produce more than once a year and other options to improve livelihood condition of the household.
- To minimize or avoid lack of awareness of the community and the public at large, government should design awareness creation programs about the problem of land degradation and the importance of soil and water conservation so as to promote SWC activities and in order to meet its intended positive effect on livelihood condition of the household.
- The government and concerned bodies should participate the communities starting from watershed planning process in order to have timely, effective and reasonable decision making in the planning and implementation processes of watershed development intervention activities.
- There should be commitment on the government to enforce the implementation of watershed by-laws that could better protect soil and water conservation structures and to ensure their sustainability.

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APPENDIX

Data collection on Effects of Soil and Water Conservation Practice on Livestock Feed Resources Availability and People's livelihood condition

Question code: ---

Woreda; ---

Kebele; ---

Got; ---

Date of interview ---

Part 1. Demographic characteristics

1. Name of interviewed house hold head ----------------------------------Sex-------age-------
2. For how long have you lived in this area?_______Years
3. Marital status: 1) Single 2) Married 3) Divorced 4) Widow
4. Religion … A, orthodox B, Muslim C, protestant D, others
5. Educational status of the household head?

A. Cannot read and write B. Can read and write C. Primary (Grade 1-8)

D. grade 9 - 12 E. diploma and above

6. Family size (house hold head) --------------------------------------

Part 2: Land characteristics

7. Landholding (in ha.) & land use pattern

Farm Size	Own	Rented	Total
landholding Size			
Crop land			
Fallow land			

Grazing land			
Others (specify			

8. How could you get access to the land you are cultivating currently? (If your answer is more than one you can choice)

A. Through renting B. Through share cropping

C. Inherited from the parents D. Allocated by the PA

9. How do you see the size of Cultivated land over time ?

A. No change

B. becoming scarce

C. Increasing over time

Part 3: Livestock Condition

10. Do you have your own animals? 1. Yes 2. No

If your answer for Q. No. 10 is yes, write number of your animals in the Table below?

No	Type of Animal	Breed type		Total
		Indigenous in No	Exogenous No	
1	Oxen			
2	Cow			
3	Bull			
4	Heifer			
5	Calf			
6	Sheep			
7	Goat			
8	Horse			

9	Mule			
10	Poultry			
11	Bee colony			

11. If you have exotic breed of Animal, can you use genetic improvement? 1) Yes 2) No

12. If your Answer in question ‘’11’’ is yes, what type of genetic improvement method you use?

1) Artificial insemination /AI/ 2) Bull selection 3) Both

13. Do you know the advantage of genetic improvement? 1) Yes 2) No

14. Is their Animal health clinic in your area? 1) Yes 2) No

15. Mention the major livestock disease in your area?

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16. What are the major constraints(shocking) of livestock production in your area ?

Part 4: SWC and Livestock feed production

17. What are the major types of physical and Biological SWC measures implemented on your farm land?

No	Types of physical SWC	Area in hector	Types of Biological SWC	Area in hector
1				
2				
3				
4				

5				
6				

18. Are you producing forage from each physical and Biological SWC measures constructed on your farm land?

1. Yes

2. No

19.If yes, describe type and amount of dry forage produced from each physical and Biological SWC measures?

Types of physical and biological SWC	Area in hector	Types of forage species produced from each physical and Biological SWC measures	Amount of dry forage produced from each physical and biological SWC measures in quintal

20. What are the major feed sources for your livestock before SWC measures?

Types of livestock feed	Mark ‘’X’’ Sign accordingly
Crop residue	
Hay	
Communal grazing	
Private grazing	
Concentrate	
Improved forage spp	

21. What are the major feed sources for your livestock After SWC measures?

Types of livestock feed	Mark ‘’X’’ Sign accordingly
Crop residue	
Hay	
Communal grazing	
Private grazing	
Concentrate	
Improved forage specious	

22. Do you face a shortage of feed for your Animals? 1) Yes 2) No

23. If your answer for question No ‘’ 22 ’’ is yes, in which season the problem is more sever?

1) Winter 2) Summer 3) Autumn 4) Spring

24. did you sale livestock feed for others?

A. yes B. No

25. If your answer is yes ,How much money you get per year ?(birr)

----

26. If you have lived here for a longer period of time, what do you say the change of livestock productivity after soil and water conservation measures taken ?

A. Increasing □ B. Decreasing□ C. No change □

27. IF your answer is increase what are the causes for this ?

----

28. Do you know forage development strategy? 1) Yes 2) No

29. If your answer in question ‘’24 ‘’ is yes, list that forage development strategy you practice?

----

30. Did you improve the nutritive value of feed? 1) Yes 2) No

31. If your answer in question ‘’26’’ is yes what type of method you practice?

1) Urea treatment 2) Silage making 3) Molasses block

32. Did you practice improved forage development? 1) Yes 2) No

33. If your answer in question ‘’28 ‘’ is yes, list types of strategy you use for forage development?

Part: 5 SWC and Crop production

34**.** What type of crops did you grow in the completed cropping seasons?

Types of crop	Mark “X ” accordingly
Maize	
Barley	
Wheat	
Teff	
Potato	
Finger millet	

35. Crop Residue and yield before SWC?

Types of crop	Crop yield in quintal Before SWC	Crop yield in quintal After SWC	Crop residue in quintal Before SWC	Crop residue in quintal after SWC
Maize				
Barley				
Wheat				
Teff				
Potato				
Finger millet				

36. If you have lived here for a longer period of time, what do you say about crop productivity in your area?

1. Increasing □ 2. Decreasing□ 3. No change □

37. If you say it has increased, please list the major factors that are considered as possible causes.

No	Possible reasons	Yes	No	Rank (1,2,3,4,)
1	Carry out SWC structures			
4	Applying manure			
5	Use of chemical fertilizers			
6	Improved seeds			
7	Others			

38. If you say it has decreased, what are the major factors that you assumed as possible causes?

No	Possible causes	Yes	No	Rank (1,2,3,4,)
1	Soil erosion			
2	Drought			
3	Soil fertility decline			
4	Unexpected rainfall during harvest season			
5	Pest, disease			
6	Others			

39. What measures do you think should be taken to improve crop production?

No	Activities	Yes	No
1	Carry out SWC structures		
3	Improved seeds		
4	Applying manure		
5	Use of chemical fertilizers		
6	Fallowing		
7	Others		

Part : 6 Livelihood condition

40. put your source of income (in order of importance).

No	Sources of income	Yes	No	Rank (1,2,3,4,)	The amount of income that you get from each source per Annual (birr)
1	Crop production				
2	Livestock				
3	Petty trade				
4	Weaving				
5	Selling of charcoal and fuel wood				
6	Food for work				
7	Tailoring				
8	Labour sale				
9	Others				
	Total				

Questions for focus group discussion

Related to reduction in soil erosion

Did the treatments/SWC undertaken in watersheds showed the sign of reduction in soil erosion?

How do you see/perceive/look the benefits of the SWCP?

How other activities like closed areas, planted trees, etc. can directly reduce soil erosion?

How much the community's' cooperative action was useful in the rehabilitation of degraded land in the watershed?

Do you think and noticed that SWCP contributes for the increment of surface and ground water? If yes, how are the degree and the level of change?

Related to change in land use

Is there is positive change noticed in land use in the watershed related to forest coverage?

Related to reduced work burden for women

Did the conservation activities play a role in reducing the work load of women (in fetching drinking water, collecting fuel wood, fodder.) after soil and water conservation activities introduced.

Conversion factors used to compute tropical livestock unit (TLU)

Animal category	TLU
Calf	0.25
Weaned calf	0.34
Heifer	0.75
Cow or ox	1
Horse	1.1
Donkey (adult)	0.7
donkey (young)	0.35
Camel	1.25
Sheep or goat (adult)	0.13
Sheep or goat (Young)	0.06
Chicken	0.013

source : adopted from Genene Tsegaye (2006).

AUTHOR'S BIOGRAPHY

The author was born in Farta Woreda South Gondar Administrative Zone of Amhara Natonal Regional State, and Ethiopia in September 21,1980. He attended his Elementary education in Atikena Elementary school and completed his secondary school education at

Azezo secondary school. After completing his primary and secondary school he joined wondo Genet College of Forestry in September 1995 and graduated with diploma by forestry in June 29,1996. Following his graduation he served as development agent from June 1997 to February 2000 in Dera Woreda at Kebele level. From March 2001 to may 2002 he served as supervisor and he became woreda expert from June 2003 to September 2007. From November 2007 to 2009 he served as Dera Woreda department of agriculture head. He joined Bahir Dar University in july 2006 to 2011 in B.Sc program and obtained B.Sc. degree in Disaster Risk Management and Sustainable Development in Summer program. Following his graduation, he served as head of department f agriculture and vice chief administrator of South Gondar zone from November 1, 2015 up to now. He joined Bahir Dar university in 2014 in College of Agriculture and Environmental sciences to specialize in Land Resource Management.