

**Department of Natural Resources Management
College of Agriculture and Natural Resources
Wolkite University**



**Standard Base Evaluation of Qualities of Soil and Water Conservation Structures in
Gutam Watershed, Gurage Zone, Ethiopia.**

A Senior Research Project

**In Partial Fulfillment of the Requirements for the Bachelor of Science degree in Natural
Resource Management (NaRM 3163)**

By: Eijg Assemamaw, Mentiwab Chanie, Temesgen Abey

Advisor: Nigatu G-medhin

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Abstract

This research is entitled Standard Base Evaluation of Qualities of Soil and Water Conservation Structures in Gutam Watershed, Gurage Zone, Ethiopia. The study included biophysical field surveys and household level survey. SWC structures were widely practiced such as level of soil bund terrace on cultivated lands and brush wood check dam on eroded and small gully areas in the watershed. A total of 20 level of soil bund terraces and 20 brush wood check dam that lie in three randomly selected transect lines on farm lands and small gully areas, respectively were investigated. Width of check dam and gully, height of check dam and gully (length for brush wood check dam) and canal, and base width, and canal depth, length of soil bund, leg width and distance between two consecutive soil bunds were measured against the standard values provided by MoARD. A total of 20 Household heads were interviewed through open-ended questionnaires to assess the community based watershed management practices and their associated attributes in Gutam watershed. Evaluation of SWC measures indicated that the quality of structures practiced in cultivated area was in good position compared to SWC structures implemented on eroded and small gully areas. Level of soil bund structures that were implemented on cultivated lands showed very significant differences in the height of soil excavated and top width is 10%. The existing level of soil bund structures meet 25%, 10%, 95% 10%, 50% and 35% with the recommended standard in the canal width, height of soil excavated from bund canal, length of soil bund, top width of soil bund, and base width of soil bund and depth of canal respectively. The qualities of brush wood check dam constructed on gully area were almost the same as the recommended standard. From the study it was possible to conclude that, since SWC conserved cultivated lands differentiated across the years of constructed structures (stabilized with differ tree), the measures had better hold the soil in- situ and improved inter-terrace soil physical and biological properties. This suggests that by applying soil conservation measures upstream, the erosion rate and the amount of silt entering streams has been reduced. Improving land productivity through SWC in the upstream areas is the means to cut the huge costs of silt cleaning in dams and irrigation canals of the downstream areas.

Key words: SWC, land degradation, SWC sustainability, community participation

List of Acronyms

CBA	Cost Benefit Analysis
CP	Conservation Practice
CWAO	Cheha Woreda Agricultural Office
ESWC	Evaluation of Soil and Water conservation
FAO	Food and Agricultural Organization of the United Nation
GFZESO	Grana Farema Zegba Extension Services Office
IUCN	International Union for Conservation of Nature
m	Meter
MCA	Multiple Criteria Analyses
MoARD	Ministry of Agriculture and Rural Development
SCRP	Soil Conservation Research Program of Ethiopian
SNNPR	Southern Nation Nationality and People Region
SPSS	Statistical Package for Social Science
SWC	Soil and Water Conservation
SWCM	Soil and Water Conservation Management
UNCCD	United Nations Convention to Combat Desertification
USAID	United State Agency for International Development
WCED	World Commission on Environment and Development

Chapter One

1. INTRODUCTION

1.1 Background of the study

Across Sub Saharan Africa, 75 percent of the population depends on subsistence farming at the end of the last century (Sanchez, 2007 and Nziguheba, 2010). In this region, soil erosion and nutrient depletion are major forms of land degradation, which considered as the main problems retarding the growth of agricultural productivity (Grepperud, 1995). In Sub Saharan Africa nearly 40% of soils are nutrient deficient capital reserves (Grepperud, 1995).

Moreover, soil erosion leads to the breakdown of soil aggregates and clods into their primary particles of clay, silt and sand. Through this process, the carbon that is held within the clays and the soil organic content is released into the atmosphere as CO₂ (Morgan, 2005). Lal (1995) has estimated that global soil erosion releases 1.14 Pg C annually to the atmosphere. Soil erosion has also greater impact on crop production. Den Biggelaar et al (2004) claims that the highest relative yield loss in Africa on Alfisols, Vertisols and Ultisols is estimated at 0.56. 0.56 And 0.60% yr⁻¹, respectively. According to Hurni (1993), in Ethiopia, the mean annual average of soil loss from natural and undisturbed land is 1-1.5tha⁻¹. The loss of soil from cultivated land is much greater and ranges between 8-42tha⁻¹. Therefore, based on the Morgan (2005) findings, it is now clear that huge amount of soil nutrient is being deteriorated from single hectare of agricultural land in Ethiopia.

The prevention of soil erosion and nutrient depletion relies on selecting appropriate strategies for soil conservation (Morgan, 2005). In Ethiopia both traditional and modern conservation practices have been adopted at varying levels (Nigatu, 2013). Abay (2011) disclosed that soil and water conservation measures practiced in Gutam have adapted well to the local conditions and protected the soil from being eroded. In line with this, study in central highlands of Ethiopia the Cat ion Exchange Capacity (CEC) of the soils was lowered by (30.1) in non-terraced farm plots and higher (38.2) in farm plots with terraced practices (Abay Chala *et al*, 2016). However, the SWC in Ethiopia covered very few areas and most of them, except those in Konso, have limitations in layout and construction quality (Nyssen et al. 2007; Watson and Currey 2009). No prior study has been conducted on standard based evaluation of qualities of soil and water

conservation structures in Guraghe Zonal Study. Thus, standard based evaluation of qualities of built structures in Gutam Watershed in Cheha District will be conducted based on Ethiopian Ministry of Agriculture and FAO's technical specifications and standards.

1.2. Statement of the problem

It is apparent that Ethiopian farmers have been practicing various soil and water conservation practices for centuries through their tradition. Modern soil and water conservation practices have also been practiced by farmers through close assistance and consultation of agricultural office extension service agents and NGOs in different part of the country with varying level and scale of management. The massive mobilization of farmers by government in construction of soil and water conservation schemes has been started since 2011. Although positive impacts been observed in various conservation sites, failure or destruction of built conservation schemes have also been observed in many other conservation areas. Therefore, this study is aimed in evaluating the effectiveness of selected government mobilized soil and water conservation structures in built structures in Gutam Watershed in Cheha District, Guraghe Zonal State.

1.3 Objective of The Study

1.3.1 General objective

- To evaluate the qualities of selected government mobilized physical soil and water conservation Structures in Gutam watershed in Cheha District.

1.3.2 Specific objectives

- To evaluate soil and water conservation practice (level soil bund and brushwood check dam) in the study area
- To assess factors affecting standardized construction of (length of soil bund) among farmers in Gutam watershed.

1.4 Research Questions

1. To what extent does standards of Ministry of Agriculture and Rural Development in constructing soil bund are applied by farmers in Gutam Watershed?
2. To what extent does standards of Ministry of Agriculture and Rural Development in constructing brushwood check dam are applied by farmers in Gutam Watershed?
3. What are factors determining appropriate construction of soil and water conservation structures?

1.5 Significance of the study

Any research work must have its own significance in solving societal and governmental problems. Like all other studies, this study is expected to provide base line information regarding qualities of soil and water conservation works for other researchers who are interest to conducted related works. Failure success stories in construction of conservation will provide important researched ideas for the policy makers in the sector of agriculture. Furthermore, this research work will provide scientific recommendations regarding standardized construction of soil and water conservation structures and thus Wolkite University can provide capacity building trainings for farmers and agricultural agents through its community service program.

1.6 Scope of the study

The researches were conducted in Gutam Watershed in Cheha Woreda. Only built structures categorized in two age categories would be used for this study. The study would be delimited only to evaluation of government mobilized conservation works in the watershed.

1.7 Limitation the of study

In this study, there were a lot of limitations that were faced us, such as: -

- Shortage of finance and time
- Shortage of different related reference book
- Lack of accessibility of internet website
- Shortage of transportation service
- Lack of organized secondary data due to the absence of documentation and organized data base system in the study area

Chapter Two

2. Literature Review

2.1 Land Degradation in Ethiopia

Land degradation can be related to both natural and human induced processes. According to the United Nations Convention to Combat Desertification (UNCCD), land degradation is defined as a natural process or a human activity that causes the land to be unable to provide intended services for an extended time (FAO, 2014). On the other hand, according to Hurni, (1993) the unhindered degradation of soil can completely ruin its productive capacity for human purposes and may be further reduced until steps are taken to stop further degradation and restore productivity.

In Ethiopia land degradation in the form of soil erosion and declining fertility is serious challenge to agricultural productivity and economic growth (Lemenih, 2006). The speed and extent of soil degradation depend on different factors, such as soils, relief, climate and farming systems (intensity of use).

The main causes for land degradation are complex and attributed to a combination of biophysical, social, economic and political factors. There are different views on the causes of land degradation: many indicate that population pressure to be the main cause for deforestation, overgrazing and expansion of cultivation into marginal lands.

Soil erosion varies with soil types (edibility) and erosive factors like slope of the land (length and steepness), rainfall characteristics (volume, intensity and duration), soil cover and land management (Prasannakumar *et al*, 2012). Among the soil types, Luvisols and Nitosols were found to be most vulnerable to water erosion, while Vertisols and Phaeozems were less vulnerable (Herweg *et al*, 2000). The impact of soil erosion is complex leading to reduction in soil depth and moisture storage capacity together with soil-nutrient losses, and ultimately results in reduced agricultural production and productivity (Vancampenhout *et al*, 2006). Soil erosion is a threat not only to agriculture but also to the economy, as the country's economy depends on agriculture.

2.2 The Concept of Sustainability

A recognized definition of sustainability is that of the World Commission on Environment and Development (WCED). The Commission defined sustainable development, as “development that meets the needs of the present without compromising the ability of the future generations to meet their own needs (Tuner 1993 in USAID, 2001)”. Sustainable development is to increase peoples’ standard of living and in particular, the well-being of the least advantaged people in societies, while at the same time avoiding uncompensated future costs. Thus, any sustainable strategy of the future should have to confront the question of how a vastly greater number of people can gain at least a basic livelihood in a manner, which can be sustained (Chambers and Can way, 1992 in Turner, 1993). Therefore, to ensure the sustainability of the renewable resources, sustainable conservation techniques and practices should be adopted. In addition, communities should be aware of the necessities and effectiveness of their active participation in their own development so as to ensure continuity of effective and efficient SWCM.

Not only should the natural resource be sustainable but also conservation practice (CP) should be effective and sustainable (Masresha, 2014). CP should have continuity and longevity. Sustainability, which involves here continuity, sees participation as fundamental to developing a self-sustaining momentum of development in a particular area (Oakley, 1992) The factors that give it longevity includes organization, empowerment, homogeneity, tangible social and economic benefit, threat to survival, policy support, positive experience with past collective actions, etc. (Awortwi, 1999).

2.3 Concept of sustainable watershed management

The Ethiopian government has for a long time recognized the serious implications of continuing soil erosion to mitigate environmental degradation and as a result large national programs will implement in the 1970s and 1980s. However the efforts of these initiatives will see to be inadequate in managing the rapid rate of demographic growth within the country, widespread and increasing land degradation, and high risks of low rainfall and drought. Since 1980, the government has supported rural land rehabilitation, these aimed to implement natural resource conservation and development programs in Ethiopia through watershed development (MoARD, 2005).

Watershed management implies the wise use of natural resources like land, water and biomass in a watershed to obtain optimum production with minimum disturbance to the environment. In the past, the concept of watershed management focused mainly on the management of these resources in medium or large river valleys, designed to slow down rapid runoff and excessive soil erosion, and to slow the rate of siltation of reservoirs and limit the occurrence of potentially damaging flash flooding in river courses (Paul, 1999). At present, the overall objectives of watershed development and management programs take the watershed as the hydrological unit, and aim to adopt suitable measures for soil and water conservation, provide adequate water for agriculture and domestic use, and improve the livelihoods of the inhabitants.

Management of watersheds can be made possible by using a variety of technologies such as vegetation conservation like grass contours, alternative tillage techniques and physical structures like terraces, stone bunds, gabion box etc. But the essence is to achieve sustainable development that can replicate by the inhabitant of the watershed after the project left (Masresha, 2014).

In Ethiopia Watershed management is merely considered as a practice of soil and water conservation. The success stories of early watershed projects will mark as the basis of major watershed initiatives in Ethiopia (Masresha, 2014). But only technological approaches will be adopted from those early successful projects and the lessons related to institutional arrangements will neglect. The newly implement projects neither involve nor took effort to organize people to solve the problem collectively (Paul, 1999).

2.4 Soil and Water Conservation practices in Ethiopia

The importance of soil conservation is largely neglected in Ethiopia prior to 1974. The problem attracted the attention of policy makers and international donors only after the disastrous drought and famine of 1974. An effort to halt the problem of soil erosion started after the Ethiopian government initiated massive soil conservation programs following the 1975 land reform. A large number of conservation and afforestation projects will undertake by food-for-work (FFW) programs (Hengsdijk *et al*, 2005). This massive campaign in soil conservation under FFW did not bring a wide dissemination and adoption of the practices by farmers (Hurni, 1993). This is because farmers constructed SWC practices during the campaign, but they had no interest to

implement or expand these without food for work (Shiferaw *et al*, 1999). Most of the conservation measures will remove after the government changed in 1991 (Shiferaw *et al*, 1999).

Between 1995 and 2009, soil conservation activities have been undertaken as part of the agricultural extension package of the present government through mass mobilization with a top-down approach and without incentives for the time farmers spent on SWC activities (Shimeles, 2012). The approach is to construct conservation measures at individual level but not at watershed level. Emphases are given to the quantity of measures rather than the quality of measures. SWC is mainly limited to physical measures. Dis-adoption and non-adoption of SWC measures will common phenomena in this period. This indicates that the extension system did not bring about behavioral changes among farmers probably because the focus are on changing the farmland rather than farmers' behavior (Akalu Teshome,*et al* 2014).

Since 2010, the government of Ethiopia has embarked again on a massive SWC campaign. The current approach is also mass mobilization, but then at watershed level. And there is an attempt to make such SWC program more participatory. In each watershed area, agricultural offices along with local administrators organize a 15-day farmers' workshop to create awareness about the problems of soil erosion and its causes. During the workshop, farmers prioritize their major natural resource problems, causes, and possible solutions. Then, they reach consensus about the natural resource problems that require collective action. Farmers participate in SWC activities in nearby sub-watershed areas (Shimeles, 2012).

2.5 Soil Conservation Measures

Soil erosion is prevented by several agronomic and biological properties. Crop rotations, agro-forestry and soil synthetic conditioners, reduced tillage, riparian buffers, cover crops, vegetative filter strips, residue, canopy cover management and no-till are important among these. There are differences among these biological practices in relation to their mechanisms of erosion control. Biological measures such as buffers or thin films (e.g., conditioners), conditioner application in direct contact with the soil surface, crop residues using manure protect the soil from erosion (Safdar *et al* 2017).

2.5.1. Agricultural conservation measures

1) Crop management; Soil fertility is improved and wind and water reduce soil erosion by good crop management practices. Keep soil covered is fundamental principle of conservation agriculture. Soil protection from erosion by leaving crop residues on soil surface after harvesting is also helpful approach. 2) Crop selection; if the gap is too long between harvesting one crop and sowing of the next crop than the additional cover crops may be required. The stability of the conservation agriculture system is increased by cover crops and erosion impacts are reducing by the improvement of soil properties and this biodiversity in the agro-ecosystem are promoted for their capacity. The more effective crops in soil erosion are perennials than annual crops. The most effective are sugar cane, fodder grasses, sweet potatoes and tea (Safdar,*et al* 2017).

3) Early planting; the protection of the ground against raindrop impact is ensured by the crop shoots from the ground within one or two weeks after the onset of the rains. 4) Crop rotation; the practice of growing a series of dissimilar types of crops in the same space in sequential seasons is crop sequencing or crop rotation for benefits such as such as avoiding pathogen and pest buildup that occurs when one species is continuously cropped. Soil nutrient depletion is avoided by the crop rotations that balance the nutrient demand of various crops (Blanco,*et al* 2009). 5) Inter-cropping; the impact of raindrops is reduced with the soil cover by the fast-growing legumes such as cowpeas and beans early in the season before a canopy is developed by cotton or maize to shield the soil. 6) Strip cropping; this is the practice of growing different crops in alternate strips in the same field. It helps minimizing wind and water erosion. Crop rotation and minimum tillage in addition to contour strip cropping has proven to be best method to conserve soil and water (Safdar,*et al* 2017).

2.5.2 Physical soil conservation measures

Physical soil conservation structures are permanent features made of Earth, stones or masonry, designed to protect the soil from uncontrolled runoff and erosion and retain water where needed (Akalu Teshome, 2014).

2.5.2.1 Cut-off drains

Cut-off drains are made across a slope for intercepting the surface runoff and carrying it safely to an outlet such as a canal or stream. Their main purpose is the protection of cultivated land, compounds, and roads from uncontrolled runoff, and to divert water from gully heads (Amsalu A, 2008).

2.5.2.2 Retention ditches

These are made along the contours to capture and retain incoming runoff water and hold it until it seeps into the ground (Nyangena, 2008). They are alternate to cut-off drains when there is no channel to discharge the water nearby. Sometimes these are for water harvesting in semiarid areas (Akalu Teshome, 2014).

2.5.2.3 Infiltration ditches

The structure used to harvest water from roads or other sources of runoff is infiltration ditches. They comprise dug along the contour, upslope from a crop field and a ditch of 0.7-1.5m deep. Water is blocked at the other end when it is diverted from the roadside into ditch and seep into soil after it is being trapped (Besha, 2004).

2.5.2.4 Water-retaining pits

Water-retaining pits allow runoff water to seep into soil after by trapping the water.

The runoff normally occurs into a series of pits which are dug into ground (Megersa, 2018). Banks around the pits are made by the soil from the pit. Excessive water carry from one pit to next by furrows. The amount of runoff determines the size of pit and its typical size is 2 m square and 1 m deep (Bewket, 2007).

2.5.2.5 Broad beds and furrows

The runoff water is diverted into field furrows (30 cm wide and 30 cm deep) in a broad bed and furrow system. The lower end of field furrows is blocked. The water backs up into the head furrow after the filling of one furrow and flows into the next field furrow. Crops are grown on the broad bed furrows of about 170 cm wide between the fields (Nyssen *et al*, 2007).

2.5.2.6 Fanyajuu terraces,

An improved SWC structures, are made by digging a trench and throwing the soil uphill to form an embankment and over time creates sloping bench-like terraces. (Ayele,*et al* 2004)

2.6 Multiple Criteria Analyses for SWC Evaluation

Most SWC investment activities are evaluate using a CBA, which assumes that complex soil and water objectives can be convert into one basic objective of “maximizing profit.” However, the objective function consists of a single choice criterion, yet within SWC investments, there are usually several objectives or goals (Prato, 2000). Therefore, a discrete MCA has been developing as a decision-making tool when different objectives have to be fulfilled (Akalu Teshome,*et al*

2014). MCA is a decision-making tool applied to choice problems in the face of a number of different alternatives and conflicting criteria (Hajkowicz, et al 2001). (CIFOR, 1999) defined MCA as a decision-making tool developed for complex multi-criteria problems that include qualitative and/or quantitative aspects of the problem in the decision-making process. MCA is an evaluation method, based on sustainable development economic theory, that ranks or scores the performance of decision options against multiple criteria (Hajkowicz, et al 2001), ensuring the final results have clear meaning in terms of sustainability (Boggia A. et al, 2011).

For evaluation of SWC investments, CBA only compares one “with” case with one “without case” (or “before” and “after” case), resulting in all effects being valued in monetary values, and focused mostly on the efficiency criterion. MCA has the disadvantage that it does not allow for an easy comparison of streams of costs and benefits over time, and relies on subjective weightings attached to several criteria by the stakeholder’s concern. An appropriate solution to evaluate SWC is the use of CBA results as one of the criteria (efficiency) in the MCA evaluation of SWC measures (Akalu Teshome, et al 2014). Therefore, MCA appears to be one of the more appropriate tools to evaluate SWC practices.

Chapter Three

3. Material and Methods

3.1 Description of the study area

3.1.1 Location

Gutam watershed is found in Geranafarma zega kebele, in south part in guraga Zone, in SNNPR State, Cheha Woreda. It is 35km far from wolkite town, 175 km away from Addis Ababa. According to population and house censuses of 2007 the total population of the kebele is 3500 of these 1900 of them are male and 1500 of them are females those having 2155 households among this 275 of them are females 1880 of them are male households. (CWAO 2019).

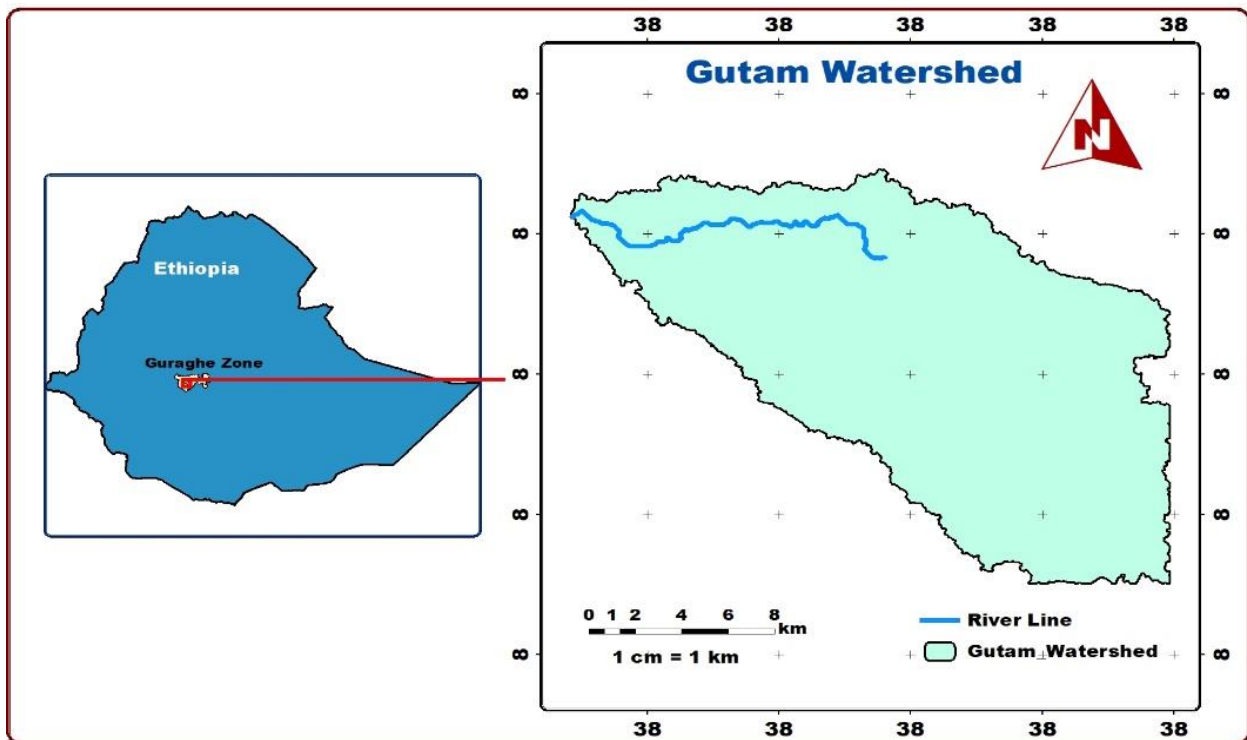


Figure 1: Map of Gutam watershed.

3.1.2 Climate

The watershed enjoys mild temperature condition and characterized by Wayinadega agro climatic zone. The lowest and the highest annual average temperate are 18⁰C and 27⁰C respectively. The rain fall of those areas is unimodal ranging from May-October but they vary in depending on the climatic conditions. The average annual rainfall of Gutam watershed is 1000mm (CWAO, 2019).

3.1.3 Population

The study area would be conducted in Gutam watershed, in Gerana Farema Zegeba kebele in cheha Woreda. The total population of this area is 3500 of which 1900 are male and 1500 are females. The total households of watershed are 100 of which women households are 40 and men households are 60. According to the data from CWAO population of statistics one household or family have an average of 4 members (CWAO 2019).

3.1.4 Topography

The topographic condition of Grana Farema Zegeba kebele is characterized by undulated, hilly 25% and gentle or flat 75% area. The topographic area of the study area is more dominate gentle slope topographic area (CWAO 2019).

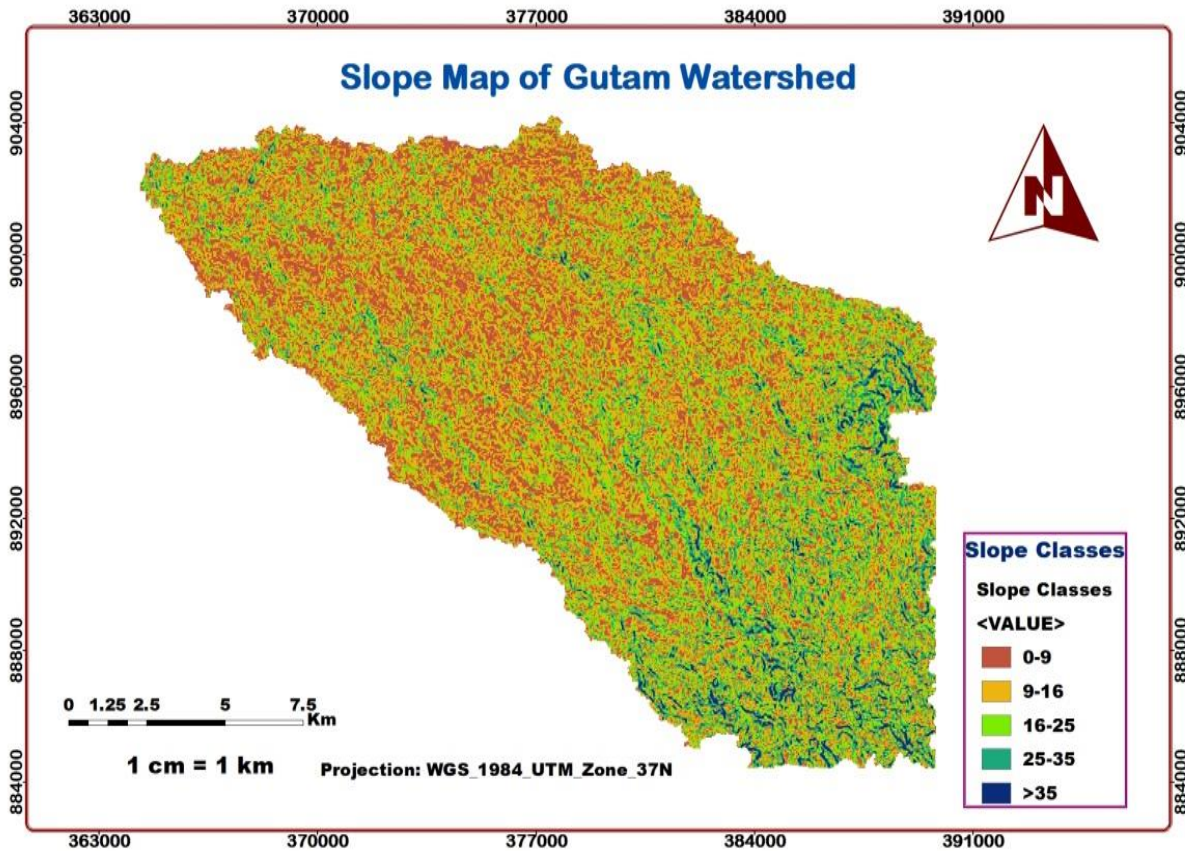


Figure 2: Slope map of Gutam watershed

3.1.5 Soil types

In Cheha woreda Gutam watershed are different types of soil. These are; Red, Black and brown. Of these, the first types of soils covering the largest part of the watershed. Red soils are young

soils developed in recent alluvial deposits and generally good for agriculture. However, recent information from Agricultural and rural development office reveals that the percentage coverage of the soil approaches the following (Black 25 %, Brown 15%, Red 67% and Others 3%). (CWAO, 2019).

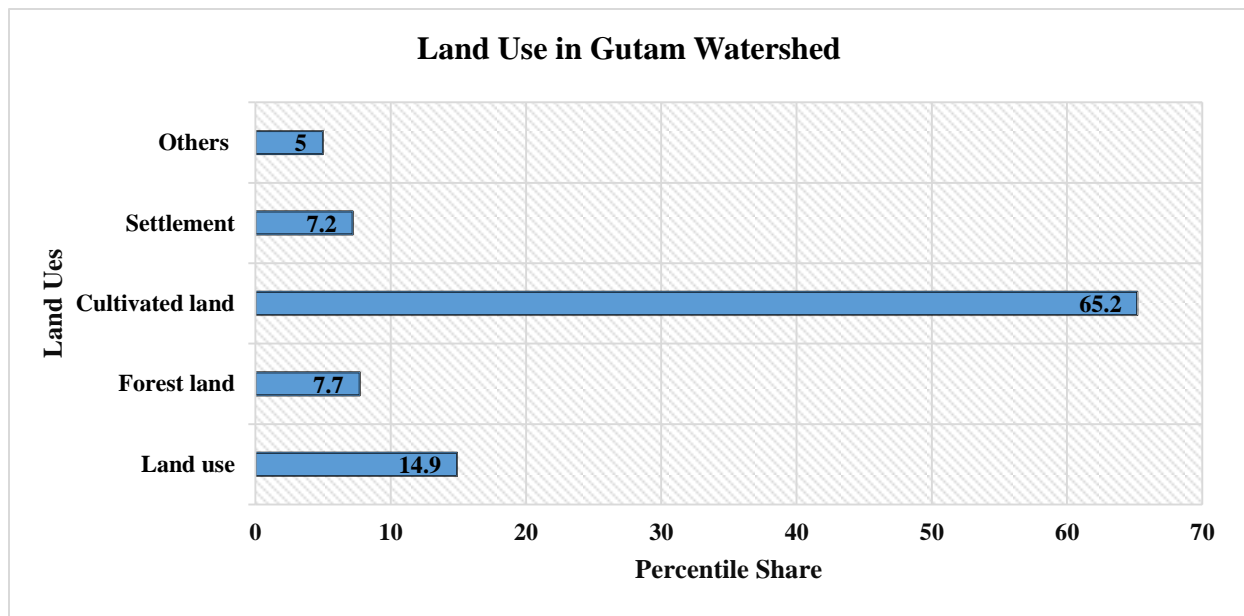
3.1.6 Vegetation

In Gutam watershed much of the natural vegetation has been destroyed and prolonged cultivation and human settlement. As the result much of the natural forest are found in some protect areas and along rivers. The dominant vegetation found presently in the area are Cordia Africana, Eucalyptus globulus, Acacia malanaxilon, Gesho, sesbania, acacia deurrence, washehen, chat and others (CWAO 2019).

3.1.7 Land use

In the study area, the land use system seems like the following

Figure 3: Land use system in the study area



(Source Cheha woreda agricultural office, 2019).

3.1.8 Farming system

The farming system of the community in the study area is mixed farming system in which both agricultural crop production and animal rearing are combined. They are few important crops

which produced in the study area are including wheat, maize, chat, enset, barely, millet, teff, and vegetables like (potato, carrot, cabbage), fruit like banana orange, mango, avocado etc.

From livelihood and income point of view there are various sources of livelihoods and income for local communities living in the Woreda. These include honey, crops (agricultural activities), chat Enset, livestock production, timber and other non-timber products. The importance of the different items keeps changing over time due to social and environmental factors. These products serve either house hold consumption or for cash income or both. For example, honey is exclusively for income and field crops and livestock are mainly for household consumption. Domestic fuel wood extraction is also another way of livelihood sources and income improvements in this area (Cheha woreda agricultural office, 2019).

3.2. Data collection Tools

The identification of important data collection tools useful in evaluating the standard of built conservation structure is important steps that were conducted before the outset of data collection. To study the qualities of built soil and water conservation structures, data collection checklist is prepared for the purpose of this study and it is tabulated in annex 1 & 2. The annex 1 in checklist would be filled by the measurements obtained by using instruments such as tap meter, clinometer (if possible), and 2m ranging pole, and 11m string, and water level. Besides, digital camera and standard questionnaires would be used as a tool of data collection for field observation, household survey, and focus group discussion. Structured and semi-structured questionnaires would be used to collected data provided through interviews. Moreover, secondary data would be collected and download from various websites serving as data sources.

3.2.1 Data Collection Procedures

Setup of appropriate data collection for scientific research is most important step for valid and precise analysis and conclusion of any research. Therefore, data collection methodology or procedures would be designed according to the objective of the study. Accordingly, designed of data collection procedures for effectiveness study are designed and presented in the next chapter and (annex 1). After precise closure of the catchments, either numerical or alphabetic tagging of constructed physical soil and water conservation structures would be applied. Thus, each and every physical soil and water conservation structures would have been numerically or

alphabetically tagged tabularized checklist. The checklist would be applied to record the field measurement units important for analysis and conclusion, the final result of the measurement represented in (annex 1).

3.3 Sampling Methods

The data were collected through questioner regarding ESWC practice and its sustainability from 100 household farmers. There are lack of resource and not voluntariness of farmers to give the data, so we were taken by using simple random sampling methods from the total household.

3.4 Sampling Techniques and Size

3.4.1 Sampling Technique

The sampling method applied for this study was multi stage sampling technique. We have purposive sampling was applied in selecting the watershed that has been applied for evaluation in this study. Thus, the watershed was selected purposively based on the recommendation of DA and experts of soil and water conservation in Cheha woreda. After selecting the watershed, once again we have applied purposive sampling to select the structure to be evaluated. The mostly or largely applied structure has been selected. Hence, soil bund and brushwood check dam has been selected for evaluation. Finally, all the samples are randomly taken in to consideration since the conserved part of watershed is not such a wide. Since the conserved structures are only concentrated to smaller land size, we have taken 20 samples from each conservation structures selected for evaluation.

3.5 Method of Data Analysis

After the data, was collected from sample respondents, the next step was data analysis. The collected data was organized, analyzed and interpreted by using SPSS 19 software and qualitative and quantitative data analysis methods like concept explanation, elaborations of respondent's answer which collect from the questioner and by quantitative data, descriptive statistics such as percentage, figure and table. The evaluation was based on Ethiopian ministry of agriculture standards which was set for agro ecology of Ethiopia. Comparative analysis of built and standardized document has been made to see whether the structures were built to appropriate standards. Hence, the evaluation was set to three major classes namely "Highly performed, Moderately Performed, and Poorly Performed". The classification was designed for the purpose of this research by researching team. A detail of this has been explained in chapter four. Standard

multiple regression was applied to see the power of predicting variables (Education, access to training, level of extension support) over the dependent variable (length of soil bund).

Chapter Four

4. Results and Discussion

4.1. Soil and water conservation practices in the study area

Different types of soil and water conservation measures were introduced to the study area. The introduction was aimed at conserving, developing and rehabilitating degraded agricultural lands and increasing food security through increased food production/ availability (MoARD, 2005). Based on the land use system in which the conservation measures were installed, soil and water conservation techniques introduced to the study area can be categorized into three: those on farm lands, degraded lands (mainly on hillsides) and measures to rehabilitate gullies. The practices were both physical and biological conservation measures. The physical measures brought were installed on farmlands, closure areas and grazing land. These include; soil bunds, Fanyajuu terraces, artificial waterway, trenches, and micro-basin and brush wood check-dams. However, the constructed SWC structures were planted verity species some part of area such as acacia saligna, local grass, acacia malanaxilon, acacia decurrens bamboo tree as biological measures.

4.1.1. Soil and water conservation practices in the study area

Among the variety of SWC measures implemented on farmlands, graded soil bund, brush wood check dam were the common ones. Also, few *Fanya juu*, & artificial waterways. A total of 4 hectares of soil bund, >60m of brush wood check dam and 0.25 hectares of *fanyajuus* were constructed on farmlands in the watershed in 2010/011 (GFZESO, 2019). Here we have taken a photo of the watershed were soil bund and brushwood check dams are dominantly constructed.



Figure 4: Structure of level soil bund and brush wood check dam

4.1.1.1. Evaluation of Qualities of Soil Bund

For the purpose of this study, the evaluation standards applied for comparison are from Ethiopian ministry of agriculture and rural development (MoARD, 2005).

- i. **Depth of soil bund canal:** According to our survey, the depth of soil bund canal constructed in Gutam watershed was measured to be 43-51cm (Table 1). However, according to community based participatory watershed development manual prepared by Ethiopian ministry of agriculture and rural development (MOARD, 2005), the canal depth for appropriate level soil bund is 50 cm (table 1). In Gutam watershed 35% of constructed soil bunds meet the sated standard. Whereas, the remaining 65% of constructed level soil bunds does not meet the standard as sated here below.

Table 1: Depth soil bund canal structure in Gutam watershed

Depth canal (cm)	Frequency	Percent
43.00	1	5.0
45.00	2	10.0
46.00	2	10.0
47.00	1	5.0
48.00	3	15.0
49.00	3	15.0
50.00	7	35.0
51.00	1	5.0
Total	20	100.0

Source: Own field survey, 2019

- ii. **Base width:** the value of constructed soil bund we measured 0.90-1.5m (table 2). However, MoARD (2005) it recommended the bas width of soil bund is 1.00-1.2m. In Gutam watershed 50% of constructed base width of soil bunds meet the sated standard. Whereas, the remaining 50% of constructed base width of soil bunds does not meet the standard sated based by the ministry.

Table 2: Base width of soil bund structure in Gutam watershed

Base width	Frequency	Percent
.95	3	15.0
1.00	5	25.0
1.10	2	10.0
1.20	3	15.0
1.40	1	5.0
1.50	4	20.0
Total	20	100.0

Source: Own survey, 2019

- iii. **Top width:** the value of constructed the top width we measured 25-45cm (table 3). However, MoARD (2005) it recommended the top width of soil bund is 30cm. In Gutam watershed

10% of constructed top width of soil bunds meet the sated standard. Whereas, the remaining 90% of constructed top width of soil bunds does not meet the standard sated based by the ministry.

Table 3: Top width of soil bund structure

Top width in cm	Frequency	Percent
25.00	6	30.0
28.00	2	10.0
30.00	2	10.0
35.00	5	25.0
40.00	3	15.0
45.00	2	10.0
Total	20	100.0

Source: Own survey, 2019

- iv. **Length of soil bund:** According to our field survey the length of soil bund constructed in Gutema watershed we measured 30-65m (table 4). But the Ethiopian ministry of agriculture and rural development (MOARD, 2005), the length of soil bund is 30-60m. In Gutam watershed 95% of constructed length of soil bunds meet the sated standard. Whereas, the remaining 5% of constructed length of soil bunds does not meet the standard sated based by the ministry.

Table 4: Length of soil bund structure

Length in meter	Frequency	Percent
30.00	2	10.0
35.00	4	20.0
40.00	4	20.0
45.00	5	25.0
50.00	1	5.0
60.00	3	15.0
65.00	1	5.0
Total	20	100.0

Source: Own filed survey, 2019

- v. **Height of soil excavated from bund canal:** According to our field survey the soil bund constructed in Gutam watershed the height of soil excavated from bund canal we measured 0.30-0.62m (table 5). However, according to community based participatory watershed development manual prepared by Ethiopian ministry of agriculture and rural development (MOAR, 2005), the high of excavated soil canal is 60 cm. In Gutam watershed 10% of

constructed high of soil canal meet the sated standard. Whereas, the remaining 90% of constructed high of soil canal does not meet the standard sated based by the ministry.

Table 5: Height of excavated soil from bund canal structure in Gutam watershed

Height of Canal	Frequency	Percent
.30	3	15.0
.35	2	10.0
.40	2	10.0
.42	1	5.0
.43	2	10.0
.45	1	5.0
.46	2	10.0
.50	4	20.0
.60	2	10.0
.62	1	5.0
Total	20	100.0

Source: Own survey, 2019

- vi. **Canal width of soil bund:** According to our field survey the soil bunds constructed in Gutam watershed have canal width ranging from 39cm – 53 cm (table 6). However, according to community based participatory watershed development manual prepared by Ethiopian ministry of agriculture and rural development (MOAR, 2005), the canal width for appropriate level soil bund is 50 cm. In Gutam watershed 25% of constructed soil bunds meet the sated standard. Whereas, the remaining 75% of constructed level soil bunds does not meet the standard sated based by the ministry

Table 6: Canal width of soil bund structure in Gutam watershed

Canal width in centimeter	Frequency	Percent
39.00	2	10.0
40.00	4	20.0
42.00	2	10.0
43.00	2	10.0
45.00	1	5.0
48.00	1	5.0
49.00	1	5.0
50.00	5	25.0
51.00	1	5.0
53.00	1	5.0
Total	20	100.0

Source: Own survey, 2019

- vii. **Leg width:** The leg width value of constructed soil bund we measured 4cm-15cm (table 7). However, MoARD (2005) it recommended the leg width of soil bund is 5cm. In Gutam watershed 10% of constructed leg width of soil bunds meet the sated standard and 35% of

constructed leg width of soil bunds near to the standard. Whereas 55% was does not meet the standard sated based by the ministry.

Table 7: Leg width of level of soil bund

Leg width in centimeter	Frequency	Percent
.04	1	5.0
.05	2	10.0
.06	4	20.0
.07	4	20.0
.08	3	15.0
.09	1	5.0
.10	4	20.0
.15	1	5.0
Total	20	100.0

Sources Own fid survey, 2019

4.1.1.2. Correlation analysis between Slope and Distance between Bunds

According to our field measurement we measured the vertical interval was far from the seated by agricultural minister of rural development. We measure the slope in the field is 3-8.4% (annex 1). However, 98% we measured in the filed 3-8% then when in MoARD (2005) the slope is between 3-8% the vertical interval was recommended between 1-1.5m. But we measure the vertical interval less than one means that all vertical interval is less than one but the slope is 100% the some to the minister of agriculture but the vertical interval is not the same to minister of agriculture because minister of agriculture said that vertical interval is 1-1.2m but we measure less than 1m (annex 1).

Table 8: Effectiveness Evaluation Using Slope and Distance between Bunds

		Correlations	
		Distance between bunds	Slope between bunds
Distance between bunds	Pearson Correlation	1	0.163
	Sig. (2-tailed)		0.492
	N	20	20
Slope between bunds	Pearson Correlation	0.163	1
	Sig. (2-tailed)	0.492	
	N	20	20

Source: Own Survey, 2019

The relationship between slope and vertical interval between two consecutive soil bunds is expected to have inverse relationship where slope increases the distance between the consecutive

bunds decreases (Table 8). The correlation coefficient measured using SPSS shows weaker relationship between the variables (“r= 0.163 “n= 20 “p=<0.05). The rho (r) value of 0.163 implies that there is weaker positive relationship between the slope and the distance between consecutive bunds (table 8). However, actually we have expected the linear relationship between the two variables. This expectation is based on the fact that as slope increases the speed of runoff increase and thus it requires higher number of bunds with minimum vertical interval difference. Therefore, the slope and distance relationship between structures are poorly considered and are not meeting the required standard.

4.1.1.3. Correlation analysis between Slope and Length between Bunds

The relationship between slope and length of soil bund is expected to have inverse relationship where slope increases, the length of soil bunds decreases (Table 9). The correlation coefficient measured using SPSS shows weaker relationship between the variables (“r= 0.432 “n= 20 “p=<0.05). The rho (r) value of 0.432 indicates that there is moderate positive relationship between the slope and length of soil bund (Table 9). However, actually we have expected the inverse relationship between the two variables. Our expectation was based on the fact that, as slope increases the land will get more rugged and will have shorter slope length. Therefore, the slope and distance relationship between structures are poorly considered and are not meeting the required standard.

Table 9: Effectiveness Evaluation Using Slope and Length of Soil Bunds

		Correlations	
		Slope Diff. Between Bunds	Length of Soil Bunds
Slope Difference Between Bunds	Pearson Correlation	1	.432
	Sig. (2-tailed)		.057
	N	20	20
Length of Soil Bunds	Pearson Correlation	.432	1
	Sig. (2-tailed)	.057	
	N	20	20

Source: Own Survey, 2019

4.1.1.4 Evaluation of Qualities of Brush Wood Check dam

According to FAO, Brush wood check dams made of posts and brush are placed across the gully. The main objective of brush wood check dams is to hold fine martial carried by flowing water in the gully. Small gully heads, no deeper than one meter can also be stabilized by brush wood

check dam. Brush wood check dam are temporary structures and should not be used to treat ongoing problems such as concentrated runoff from roads or cultivated fields. They can be employed in connection with land use changes such as reforestation or improved range management until vegetative and slope treatment measures became effective

i. Width of brush wood check dam and gully

The width of gully width the contracted of gully also equal or near to the width of gully. According to our field survey the gully small, so the brush wood check dam constructed in Gutam watershed have the width ranging from 1m –4.40m. However, according to community based participatory watershed development manual prepared by Ethiopian ministry of agriculture and rural development (MOAR, 2005), the check dam width is 2-3m. In Gutam watershed 55% of constructed of brush wood check dam meet the sated standard. Whereas, the remaining 45% of constructed does not meet the standard sated based by the ministry (annex 2).

ii. Branch thickness of the check dam:

The value of branch thickness for brush wood check dam in the small gully is in according to minister of agriculture is recommended the thickness is 6-10cm (table 10). we measured in the field is 50% full fill the standard from minister of agriculture but the other one is approaches to the recommended standard from the minister of agriculture, similarly according to FAO recommended the thickness of the post material is 6-12 then our measure and the recommended standard of FAO is the same as to minister of agriculture 50% is the same

Table 10: Branch thickness of the check dam

Thickness	Frequency	Percent	Valid Percent	Cumulative Percent
.01	1	5.0	5.0	5.0
.04	3	15.0	15.0	20.0
.04	1	5.0	5.0	25.0
.05	1	5.0	5.0	30.0
.05	3	15.0	15.0	45.0
.06	4	20.0	20.0	65.0
.07	3	15.0	15.0	80.0
.08	2	10.0	10.0	90.0
.09	1	5.0	5.0	95.0
.40	1	5.0	5.0	100.0
Total	20	100.0	100.0	

Source Own filed survey, 2019

iii. The height of post material for appalled the check dam:

The height of post material of brush wood check dam is depending on the height of gully. When the height of gully deep the height of post materials also increased but we measured in our filed measurement is 50cm-1.1m (annex 2). when the depth of the height gully is 1.2- 3.5 m then depend on the minister of agriculture when the height of the gully is increased perpendicularly increased the height of post material, so different height of gully we get different height of post material brush wood (annex 2).

iv. Length between the check dams:

According to the minister of agriculture and FAO when the length of b/n two brush wood check dam was differing from gully to gully. In our filed survey we measure in gutema watershed the length b/n two brush wood check dam is 2.1m-7.5m. The gully is including all types that has steep and gentle slope in when the length is short 2.1m-4m step slop of the gully but 4.3m-7.5m the gully is gentle slope because the length is high (annex 2).

4.1.1.5 Summarized the Performance Category of Installed Structures of level soil bund and brush wood check dam

For the purpose of this research we have categorized performance level of soil bund and brush check dam's construction in to three classes based on our predefinition. Soil bund performances were classified in to categories based on the parameters we have applied for our field survey. Accordingly, those structures constructed having 5-8 parameters at good levels are classified in to high performance classes. High performances were defined for structures (canal width 48-51cm), Top width (28cm-30cm), base width (0.95m-1.10m), length (30m-60m), height of excavated soil from bund canal (50cm-62cm), leg width (4cm-6cm), vertical interval (60-73cm), distance between two consecutive soil bund (5.60m-8m) (table 11). Moderate performances were defined for structures having (canal width (42-45cm, 53cm), Top Width (25cm-35cm), base width (1.20cm-1.40m), length of soil bund (65), height of excavated soil from bund canal (43cm-46cm), leg width (7cm-9cm), vertical interval (40cm-50cm), distances between two consecutive bund (8.20m-10m) Poor performances were defined for structures having (canal width <39-40, >53), Top width, base width (<25cm, 40cm-45cm), length of soil bund (<30m), height of excavated soil from bund canal (30cm-42cm), leg width (<4cm, 10cm-15cm), vertical interval (30cm-38cm) (table 11).

A. Soil Bund

Table 11: Performance category of installed structures of soil bund

Canal Width					
H		M		P*	
48-51cm	F=8, P=40%	42cm-45, 53cm	F=6p=30%	<39,39-40 >53cm	F=6p=30%
Top Width					
28cm-30cm	F=4 P=20%	25cm,35cm	F=11 P=55%	<25,40-45cm	F=2 P=25%
Base Width					
0.95m-1.10m	F=10 P =50%	1.20m,1.40m	F=4 P=30%	<0.95m,1.50m	F=4 P=20%
Length					
30m-60m	F=19 P =95%	65m	F=1 P=5%	<30m	-
Height					
50cm-62cm	F=7 P 35%	43cm-46cm	F=6 P=30%	30cm, 42cm	F=7, P=35%
Leg width					
4cm-6cm	F=7 P= 35%	7cm-9cm	F=8 P=40%	<4cm, 10cm-15cm	F= 5 P=25%
Vertical interval					
60cm-73cm	F=2 P=10%	40cm-50cm	F=6 P= 35%	30cm-38cm	F=14 P = 55%
Distance between two consecutive soil bund					
5.60m-8m	F=10 P= 55%	8.20m-10m	F= 6 P= 30%	10.5m-11m	F= 3 P=15%

**H= Highly Performed, M = Moderately Performed, P* = Poorly Performed, Fr= frequencies, p=percent

A. Brushwood Check dam

Table 12: Performances category of installed structure of brush wood check dam

Branch Thickness					
H		M		P*	
4cm-6cm	F=13 P =65%	7cm-9cm	F=6 P=30%	1cm	F=1 P=5%
Height of Post Material					
0.9m-1.1m	F=6 P =30%.	0.7m-0.85m	F=8 P=40%	0.5m 0.65m	F=4 P=30%
Width of Post Material					
2m-3.1m	F=12 P =60%	1.15m-1.5m,3.5m-4.0m	F=5 P=25%	1m-1.1m,4.4m	F= 3 p=15%

** H= highly performed, M= moderately performed, P* = poorly performed, Fr= frequencies, p= percent

Accordingly, those structures constructed having the parameters at good levels are classified in to high performance classes. High performances were defined for structures the branch thickness of the post materials (4cm-6cm), the height of post materials (0.9m-1.1m) and also width of check dam (2m-3.1m). Moderately performances were defined as branch thickens (0.7m-0.85m),width of check dam (1.15m -1.50m,3.5m-4.00m), poorly performed were defined as the branch thickens (1cm), height of post material (0.5m-0.65m), and width of check dam (1m-1.1m, 4.4m) (table 12).

4.2 Factors Affecting Construction of Soil and Water Conservation Structures

In this section the factors affecting farmer's ability in constructing standard based construction of soil and water conservation structures are identified based on standard multiple regression. The results are presented in a tabular form explaining factors affecting the construction of soil bund (soil bung length). Finally, models are specified.

4.2.1 Multivariate Analysis Result

4.2.2 Analysis of factors affecting construction of SWC structures (soil bund length)

A standard multiple regression was carried out to identify and assess the ability of independent variables (educational status, level of extension support, and access to training) in predicting construction of soil bund to the appropriate standard among the investigated households in Gutam watershed.

Primarily before undertaking linear regression, preliminary test of multicollinearity, normality, and homoscedacity has been carried out. This is done because presence of very strong interrelationship among the predicting variable has significant effect on the determination power of independent over dependent variable. Ideally the predicting variables should have strong relationship with dependent variable but not with predictors (Pallant, 2007). Predictors having correlation of 0.7 and above are not recommended and have been omitted from the SPSS analysis. To test out normality, Normality P-P plot was drawn using the SPSS software (see fig. 6). The result of the Normality P-P plot shows the point lying on straight diagonal line of points from bottom left to top right of the plot. This suggests that there is no major deviation from the normality.

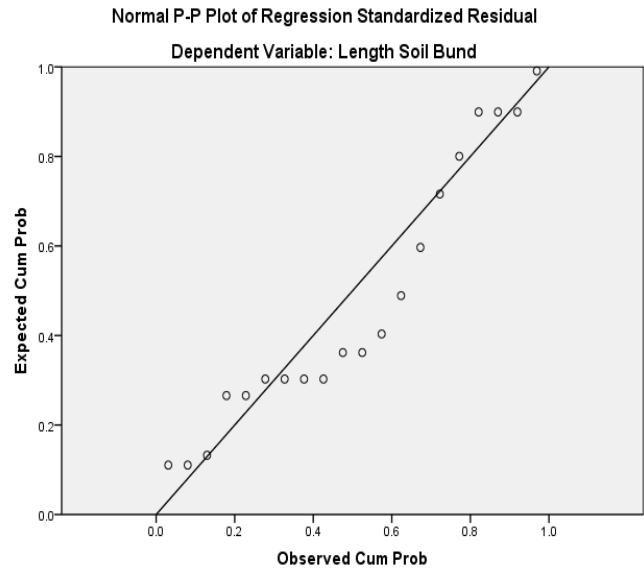
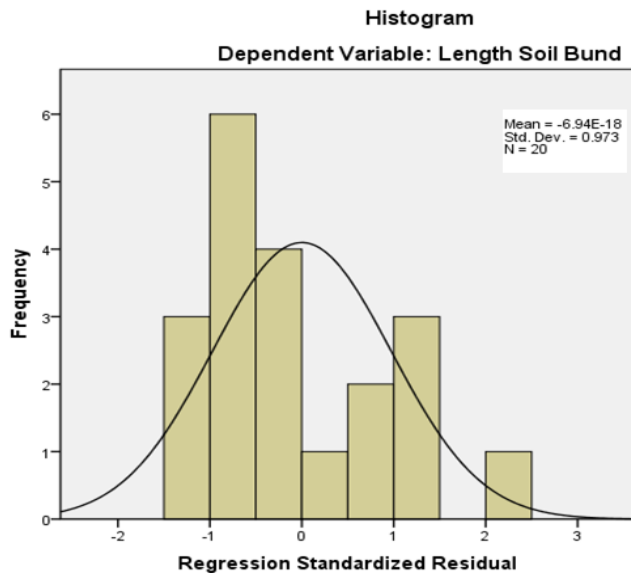


Fig 5: Normality and Linearity Plots

4.2.2.1. The Variables

Dependent Variable: standardized construction of soil bund (bund length)

Independent variables:

X_1 : Education Status

X_2 : Level of extension support

X_3 : Access to training

4.2.2.2 Rationale of selecting variables and theoretical expectations

As it is explained above three explanatory variables were selected for Standard regression analysis. The variables were thought to have significant effect in determining the dependent variable (length of soil bund) of the investigated farmers in Gutam Watershed. However, it should be noted that these by no means are the only variables, rather these are variables that researcher is able to consider with conditions we have currently. Other variables not considered in this study are recommended for other researchers in this field of science.

Educational Status (X_1): As farmers advance in education, adoption of standard based construction of soil and water conservation is more likely. Therefore, it is expected to positively affect the construction of soil bund.

Level of Extension Support (X_2): Frequent extension contact is important for better watershed management practices. Frequent extension contacts are expected to positively impact adoption of standard base soil bund construction.

Accesses to training (X_3): short training on SWC is very essential for better management of watershed. Ideally it is thought that farmers who took training will construct soil bund to its standard than those who didn't.

4.2.2.3 Regression Analysis Result

As it is defined above three explanatory (predictor) independent variables were selected which are thought to have significant impact on construction of standardized construction of bund length by farmers in the investigated watershed (Gutam). However, two variables (level of extension support X_2 and access to training X_3) were found statistically insignificant; therefore, the variables have weak or no effect on standard (length of soil bund) construction of SWC structure (soil bund). The remaining one variable (education) was found to have statistically significant effect on the dependent variable. The summary of the standard regression model is presented as follows.

Table 13: Model Summary

Model	R	R Square	Adjusted R Square	Std. E. Estimate	Change Statistics	
					R Square Change	Sig. F Change
1	.622 ^a	.387	.273	8.81591	.387	.045

a. Predictors: (Constant), Level of support from extension service officers, Educational Status of Respondents, Institutional support (training)

b. Dependent Variable: Length Soil Bund

R square tells you how much of the variance in the independent variable is explained by the model. According to our model result, 0.622 of R square was calculated explaining 62.2% of variance in construction of soil bund length to its standard has been explained by the model. R square is just the square result of R value implying the weight in which the dependent variable is expressed correctly by about 38.7 percent (table 13). The significant level of our model which explains the level our confidence to the model was statistically determined to be 0.045 which is approximately around 95%. Therefore, we are about 95% confident on our new model.

Table 14: Standard regression predicting the likelihood of Standardized soil bund construction

Model	USC		SC	t	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Constant)	60.888	18.434		3.303	.004					
X ₁	-3.898	1.413	.588	-2.758	.014	-.617	-.568	-.540	.842	1.188
X ₂	.169	1.674	.022	.101	.921	-.172	.025	.020	.822	1.217
X ₃	-2.609	6.341	-.092	-.411	.686	-.306	-.102	-.081	.758	1.319

Dependent Variable: Length Soil Bund, USC (*unstandardized coefficient*), SC (*standardized coefficient*), Tolerance T, VIF (*Variance Inflation Factor*)

Source: Computed from the survey data, 2019

The above Table presents the strength of variables in predicting dependent variable among the investigated households in the watershed.

Variables like educational status, level of extension support; access to training was considered for statistical regression analysis. Educational status of the dwellers of the watershed was found to have unique strong contribution in predicting appropriate length of soil bund. The remaining two variables were found statistically not significant (Table14). The issue of multicollinearity was examined since the value of Tolerance (T) is greater than 0.1 indicating all the three variables are not strongly correlated and their relation have no impact on the model. Furthermore, VIF (variance inflation factor) which is the inverse of tolerance (T) indicates as there is no problem of multicollinearity among independent variable since all the values under VIF are less than 10 (table 14).

More specifically, the coefficient of educational status implies, as the level of educational status enhances to another one more advanced level, the likelihood of constructing soil bund length to appropriate standard enhances by 3.89 times than it decreases. Similarly study by (Karami, 1997), shows that extension and educational factors positively determine the adoption of sustainable agriculture (table 14).

4.2.2.4 Model Presentation

Based on the results of the standard regression analysis, model has been drawn to show the relationship between the dependent and predicting variables. This model has ability to reflect the impact of independent variable on the dependent variable. Therefore, the extent of determining appropriate bund length in constructing level soil bund by farmers dwelling in the watershed influenced by a set of independent variables specified in the following model:

$$Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$$

Where Y, the dependent variable, is the length of soil bund constructed by farm households in the Gutam watershed, b_0 is the intercept, and $b_1, b_2 \dots b_n$ are the coefficients of the independent variables X_1-X_n (Raut *et al*, 2011). Therefore, the model developed through the above method is presented as follows:

$$Y = 60.88 + 3.898X_1$$

Chapter Five

5. Conclusion and Recommendation

5.1 Conclusion

The purpose of this study was to analyze the sustainability of SWC measures practiced in cultivated land and eroded or small gully area by evaluating the technical standard of constructed SWC technologies, assessing terracing in maintaining soil fertility and evaluating the communities' and government participation empowerment for Gutam watershed.

- ✚ Brush wood check dam implemented on the small gully in general were in good condition as compared to the standard.
- ✚ However, the widely constructed SWC structure, soil bund terrace on cultivated land, characterized by back height, top, leg and canal width, canal depth, and vertical interval between successive terraces were significantly lower than the technically recommended standard. This implies that the structure installed was weak and thus will have short life span and couldn't stop land degradation.
- ✚ The community members believed that SWC practices in the area transferred technical knowledge that enabled them to construct SWC structures and conserve their land on their own. The result of the survey indicated that the sustainability of SWC activities would be achieved by the active participation of all stakeholders mainly member of the community. The problem of fitness of the technologies to the farmers' requirements and the farming system circumstances is partly a reflection of a problem in the approach followed in the planning and implementation of the SWC measures.
- ✚ Educational status of the respondents was found to have significant impact on standardized construction of soil bund length. However, other variables like level of extension service support was found insignificant since the consultation service from them was almost once a year.

5.2 Recommendation

The following recommendations are important to be considered to enjoy more benefits by addressing the constraints of governmental body and farmer adoption for soil and water conservation practices.

- Local governments should work harder to implement appropriately existing land use regulation and directives
- Standardized soil and water conservation measures should be practiced in the study catchment with a full consensus and participation of the dwellers.
- The brush wood check dam almost better. However, the soil bund structure is week. So to give adequate awareness and training in the local community about soil bund structure.
- Improving popular participation sustainable soil and water conservation will be achieved through the participation of local people. So emphasis should be given to this.
- The existing monitoring and evaluation system is limited to the SWC intervention in which large-scale SWC activities emphasized more on the construction of physical structures. There should be consistent assessment with the farmers' participation on their own land focusing impact on land productivity and improvement in the community livelihood.
- The administrators of the specific watershed should work towards the enhancement of educational service provision since it was found quite significant in affecting the SWC practice.
- Level of extension support is weakest of its kind and thus better and frequent extension follow up mechanisms should be installed as a system.
- Further studies should be made to get more information about the quality of conservation structure status of the cultivated land and other related impacts on the dwellers on the study catchment.

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7. Appendixes

Annex 1: Result of soil and water conservation evaluation of soil bund parameter.

No_	Slop In %	HD (m)	H (cm)	TW (cm)	BaWD (m)	CW (cm)	CD (cm)	VI (cm)	LW (cm)	L (m)	Distance b/n two consecutive bund (m)
1	7.3	10	60	40	1.00	39	50	73	7	60	8.940
2	8	5	50	35	1.10	40	49	40	4	45	11.10
3	8.4	5	43	35	1.00	42	43	42	5	65	7.50
4	4.5	10	60	45	1.00	43	48	45	6	35	8.20
5	4	10	40	40	1.00	40	47	40	8	60	7.20
6	3.7	10	46	35	0.95	50	50	37	10	45	8.40
7	3.8	10	30	30	0.95	50	50	38	7	30	5.60
8	3.2	10	42	28	0.90	50	50	32	8	35	8.50
9	3	10	50	25	1.95	50	49	30	6	45	7.00
10	3.7	10	45	25	1.90	51	48	37	7	35	7.00
11	3.5	10	50	25	1.50	53	45	35	8	60	10.50
12	3.6	10	30	30	1.20	39	46	36	10	50	8.80
13	3.1	10	46	35	1.50	40	48	31	15	45	7.90
14	3.8	10	30	35	1.50	42	50	38	8	35	8.00
15	6	10	35	35	1.40	42	46	60	4	45	7.50
16	4.2	10	35	35	1.50	43	50	42	8	40	7.90
17	5	10	40	28	1.20	48	45	50	8	40	8
18	3.7	10	43	25	1.10	49	49	37	7	45	11
19	3.8	10	50	25	1.10	50	50	36	10	40	10
20	4.4	10	62	25	1.20	45	51	44	10	40	8
Mean	4.54	9.5	0.44	32.55	1.143	45.2	48.2	0.42	0.56	44	8.35
Std. D	1.41	2.119	0.966	6.8937	0.22	4.85	2.19	0.1008	0.27	10	1.39981

N.B m= meter cm= centimeter VI=Vertical Interval, L=Length of bund, LW = leg width, S=Slope, TW=Top Width, BaW=Base Width, D = Canal Depth, CW = Canal Width, H=height

of soil excavated from bund canal, S.D standard deviation = HD= horizontal distance of the bund.

Annex 2: Result of soil and water conservation evaluation of brush wood check dam parameter.

<i>No_</i>	<i>VPM (m)</i>	<i>BT (cm)</i>	<i>HG (m)</i>	<i>GW (m)</i>	<i>BW (m)</i>	<i>HD (cm)</i>	<i>L (m)</i>
<i>1</i>	<i>Eucalyptus globulus (1)</i>	<i>6</i>	<i>3.50</i>	<i>8.80</i>	<i>4.40</i>	<i>80</i>	<i>7</i>
<i>2</i>	<i>Acacia deccurences (1)</i>	<i>5</i>	<i>3.50</i>	<i>7.50</i>	<i>3.50</i>	<i>90</i>	<i>5</i>
<i>3</i>	<i>Atat (1.1)</i>	<i>7</i>	<i>2.10</i>	<i>7.10</i>	<i>3.10</i>	<i>100</i>	<i>4.70</i>
<i>4</i>	<i>Washehen (0.8)</i>	<i>6</i>	<i>2.20</i>	<i>6.00</i>	<i>3</i>	<i>100</i>	<i>4.50</i>
<i>5</i>	<i>Tefie (0.9)</i>	<i>9</i>	<i>2.10</i>	<i>5.00</i>	<i>2.80</i>	<i>110</i>	<i>4.80</i>
<i>6</i>	<i>Abeshtid (Juniprus procera)</i>	<i>7</i>	<i>1.80</i>	<i>5.50</i>	<i>2.50</i>	<i>100</i>	<i>3.30</i>
<i>7</i>	<i>Zegba (0.75)</i>	<i>8</i>	<i>1.65</i>	<i>2.50</i>	<i>3</i>	<i>80</i>	<i>4.70</i>
<i>8</i>	<i>Kiteketa (.8m)</i>	<i>5</i>	<i>1.6</i>	<i>1.95</i>	<i>4</i>	<i>90</i>	<i>4</i>
<i>9</i>	<i>Acacia deccurences (0.9)</i>	<i>8</i>	<i>1.45</i>	<i>1.90</i>	<i>2</i>	<i>85</i>	<i>5.10</i>
<i>10</i>	<i>Eucalyptus globulus90.9)</i>	<i>7</i>	<i>1.45</i>	<i>1.90</i>	<i>2</i>	<i>80</i>	<i>7</i>
<i>11</i>	<i>Tifie (1.5)</i>	<i>4</i>	<i>1.50</i>	<i>1.10</i>	<i>3</i>	<i>65</i>	<i>2.10</i>
<i>12</i>	<i>Kiteketa (1.4)</i>	<i>1</i>	<i>1.20</i>	<i>1.00</i>	<i>2</i>	<i>70</i>	<i>2.30</i>
<i>13</i>	<i>Acacia deccurences (1.4)</i>	<i>6</i>	<i>1.00</i>	<i>0.95</i>	<i>1.50</i>	<i>55</i>	<i>3.10</i>
<i>14</i>	<i>Acacia deccurences (1.4)</i>	<i>4</i>	<i>1.00</i>	<i>0.80</i>	<i>2.50</i>	<i>70</i>	<i>4</i>
<i>15</i>	<i>Atat (1.5)</i>	<i>4</i>	<i>1</i>	<i>0.75</i>	<i>2.60</i>	<i>60</i>	<i>4.30</i>
<i>16</i>	<i>Eucalyptus globulus (1.2)</i>	<i>4</i>	<i>2.40</i>	<i>2.10</i>	<i>1.15</i>	<i>80</i>	<i>7.5</i>
<i>17</i>	<i>Acacia deccurences 91.1)</i>	<i>5</i>	<i>2.50</i>	<i>2.50</i>	<i>1.20</i>	<i>60</i>	<i>7</i>
<i>18</i>	<i>Atat (0.8)</i>	<i>4</i>	<i>2.70</i>	<i>2.45</i>	<i>1.10</i>	<i>50</i>	<i>6</i>
<i>19</i>	<i>Washehen (1)</i>	<i>6</i>	<i>1.90</i>	<i>2.46</i>	<i>1.00</i>	<i>70</i>	<i>5.5</i>
<i>20</i>	<i>tefie (1)</i>	<i>4</i>	<i>2.40</i>	<i>2.80</i>	<i>1.40</i>	<i>65</i>	<i>4</i>
Mean		<i>0.0734</i>	<i>2.077</i>	<i>3.478</i>	<i>2.437</i>	<i>0.78</i>	<i>4.795</i>
Std. Dev		<i>0.07898</i>	<i>1.53</i>	<i>2.239</i>	<i>0.959</i>	<i>0.167</i>	<i>1.53</i>

N.B: m= meter cm= centimeter, *L=Length*, *VPM = vertical post martial* *HG = Height of Gully*, *Std. Dev = standard deviation*, *BT=Branch Thickness*, *HD= Height of check dam* *GW = Gully width*, *BW = width of brush wood check dam*.

Annex 3: Household based questionnaire;

This questionnaire is prepared with aim to research the outlook of farmers living within Gutam watershed about the conservation practices constructed. Therefore, we kindly request your cooperation in forwarding genuine ideas to further strengthen our research.

A. General Information

Date _____

1. Region: SNNPR
2. Zone: Gurage
3. Woreda/District: Cheha
4. Tabia/Keble: Grana farmazegeba
5. Village _____
6. Sex 1. M 2. F
7. Age _____
8. Level of education _____
10. Family size _____
11. Size of landholding (in hectares) 1. Own _____ 2. Rented _____ 3. Others _____
12. Household income status 1. Income in Birr or quintals _____ 2. Oxen _____ 3. Cows4. Goat _____ 5. Sheep _____
13. Is your annual agricultural income enough to satisfy your annual consumption? 1. Yes 2. No
14. If your answer is no, for how many months is it sufficient? _____
15. If your annual agricultural income is insufficient to satisfy your annual consumption, how do you satisfy the shortage (put according to their importance)? Through:
 1. Food aid
 2. Food for work
 3. Non-farm occupation
 4. Others_____

B. Community participation and government empowerment.

16. How do you rate the support of extension service officers?
- A. Excellent B. Very Good C. Good D. Poor
17. How often do you receive consultation service from extension service officers?
- A. Daily B. Twice a Week B. Weekly C. Once in a month
D. Once in 2-3 months E. >3 months
18. Have you ever received trainings on installation of soil water conservation structures?
- A. Yes B. No
19. If “Yes” on question number 18, who gave you training?
- A. From government body
B. Non-governmental organization
C. Nearby universities
D. Other _____
20. What conservation structures do you traditionally apply in your farmland?
1. _____ 2. _____ 3. _____

21. What supports have you received from government in supporting your conservation works?
- A. Material (physical materials like shovel etc.)
B. Training
C. Inputs (seedling etc.)
D. Others _____
22. What local organizations do you apply in constructing conservation structures?
- A. 1 to 5 B. Debo C. Other _____
23. Have you observed changes in erosion after introduction of conservation structures in your watershed?
- A. Yes B. No
24. If “Yes” on question number 23, is there any positive change in agricultural productivity?
- A. Yes B. No
25. If “Yes” on question number 24, how much quintals do you harvest per hectare before introduction of SWC?
- A. < 5 B. 5-10 C. 10-15 D. 15-20 E. >20
26. How much quintals per hectare do you harvest after introduction of SWC?

A. <5

B. 5-10

C. 10-15

D. 15-20

E. >20

27. Have you observed any change in plant cover?

A. Yes

B. False