



CLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES

DEPARTMENT OF BIOLOGY

**The Contributions of Watershed Management for Woody Plant
Diversity and Other Ecosystem Services in Hidabu District, North
Shewa, Ethiopia**

A thesis submitted to school of graduate studies of Addis Ababa University in partial fulfillment of the requirement for the degree of Master of Science in Biology

By

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ADDIS ABABA UNIVERSITY
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As members of the Board of Examiners of the MSc Thesis Open Defense Examination, we certify that we have read and evaluated the Thesis prepared by Birhanu Mengistu entitled as *“Contributions of Watershed Management for Woody Plant species Diversity and other Ecosystem Services in Hidabu Abote District, North Shewa, Oromia”*, and examined the candidate. We recommend that the thesis be accepted as fulfilling the thesis requirement for the degree of Master of Science in Biology.

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CERTIFICATION

This is to certify that the research work presented in this thesis entitled “*The Contributions of Watershed Management for Woody Plant Diversity and Other Ecosystem Services in Hidabu District, North Shewa, Ethiopia*” which is being submitted to Addis Ababa University, Addis Ababa for the award of MSc in Biology by Mr. Birhanu Mengistu has been carried out by his under my guidance and that the work is original and dependable.

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LIST OF ACRONYMS AND ABBREVIATIONS

a.s.l – above sea level

EHRS – Ethiopian Highlands Reclamation Study

FAO – Food and Agricultural Organization

FDRE – Federal Democratic Republic of Ethiopia

FFW – Food For work

GEF – Global Environmental Facility

GTZ – German Technical Cooperation

HADAO – Hidabu Abote District Agriculture Office

IFPRI – International Food policy Research Institute

IWM – Integrated Watershed Management

MoARD – Ministry of Agriculture and Rural Development

MoWR – Ministry of Water Resource

NGO – Non-Governmental Organization

°C – degree centigrade

SCRP – Soil Conservation Research Project

SLM – Sustainable Land Management

SPSS – Statistical Package for Social Science

SSA – Sub - Saharan Africa

SWC – Soil and Water Conservation

UN – United Nation

UNEP – United Nation Environmental Program

USA – United State of America

WSM – Watershed Management

WSMPs - Watershed Management Practices

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ABSTRACT

Watershed management practice has been taken as a main strategy to rehabilitate the degraded land, for biodiversity conservation and improving agricultural productivity of land in Ethiopia. However, its contribution to woody plant Species diversity and other ecosystem services rarely evaluated. This study aimed at assessing to the contribution of WSM for woody plant species diversity and other ecosystem services and to assess factors that affect the adoption of SWCPs in Hidabu Abote District, North Shewa, Oromia. The study was conducted based on comparative analysis between Sire-Morose (treated) and Yaya-Dakabora (untreated) micro-watersheds which are assumed to be in similar agroecology. A total of 40 sample quadrats of each 20m x 20m (400 m²), size that were laid systematically along transects lines were used for vegetation data collection. In addition 1m x 1m (1m²) sub plots were laid within the main quadrates to sample herbaceous plants. To document perception of local communities, a semi structured questionnaire was developed and data were collected from 123 respondents. To analyze data both descriptive and inferential statics were used. The results indicated that due to watershed management practices the availability of water, income per household from crop production by 28.4%, livestock productivity enhanced and employment opportunities increased in the study area. It also reduced runoff, soil loss, land degradations and improved biodiversity conservation. Comparative assessment result of the vegetation revealed that the overall mean species diversity, evenness and richness were higher in Sire-Morese than in Yaya- dakabora indicating the positive impact of watershed intervention on local biodiversity. In general, watershed management practices had positive biophysical, socio-economical, environmental and ecological impacts. Therefore, strengthening watershed management practices for woody plant species diversity and enhancing ecosystem services was recommended as a result of this study.

Keywords: Siremorese, Yaya-Dakabora, Diversity, Slope, treated, Untreated, woody plants

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the Study

Inadequate natural resources management on watersheds is a major problem of water and land degradation and rural poverty in the world today (Kenneth et al., 1994). Micro-watersheds are essential to existence of biodiversity and play a great role in the livelihoods of humans. Additionally an important portion of a society's economic acquired and overall survival is gained through the ecosystem services and goods provided by watersheds (Anne, 2016).

Besides to this in developing countries both governmental and non-government organizations (NGOs) development agencies should implement WSM projects for at least 25 years with the plan of reducing poverty and increasing agricultural productivity on hillsides in rural areas. In the previous seven years, biodiversity conservation organizations have build up some WSM projects as a method to intensify productivity and reduce farmer encroachment on neighboring forestland areas with high biological diversity (Carlos and Henry, 2003)

As cited in Sharma et al., (2005) the severe food shortages in 1973, and the most memorable famine and disasters the followed the 1984 drought affected 8.7 million people and leading to about one million deaths, and the 2006 catastrophic flood in Dire Dawa can be the crucial examples. Due to these effects, the Government of Ethiopia and non- governmental organizations have initiated, SWC and watershed development since 1970's and 1980's, respectively (Lakew Desta *et al.*, 2005). Watershed, especially in the developing world has increasingly been managed and developed to conserve natural resources, increase agricultural productivity and thus enhance food security and alleviate poverty. Hence, land and water management in a watershed context is also becoming a central adaptive strategy in Ethiopia. The fundamental of the agricultural economy is rainfed agriculture and effective watershed management is a precondition to reducing the effects of droughts and floods that increase the vulnerability of the poor to food shortage and exacerbated land degradation (FDRE, 2001).

Sustainable development and increased food production in agricultural based developing countries requires availability of sufficient water and fertile land. Water especially affects greatly the prosperity of people and their development potential and health. The availability of this vital resource is not guaranteed for large sections of the world's population (Tesfaye Habtamu, 2011). The mass of developing nations, the quantity and quality of natural resources are reducing aftereffect in more heavy floods and droughts. Effective integrated watershed management can reduce these effects and play a major role for existence of biodiversity and regeneration of fragmented land (Fikru Assefa, 2009). Watershed management is necessary to keep all the biophysical elements of a watershed functional or producing the vital ecosystem services. In most African countries, including Ethiopia, destroying of trees and other vegetation has resulted in the loss of ecosystem services more especially the production of clean fresh water (Michael *et al.*, 2014)

Because of its topography, insufficient road infrastructure in drought prone areas, geographical location and heavy dependence on rain-fed agriculture, low adaptive capacity in combination with weak institutions, high growth rate of population, under-development of water resources, low economic development level, Ethiopia is one of the most vulnerable countries to the adverse effects of land degradation (Meaza Hadush, 2015). Land degradation and soil erosion coupled with erratic rainfall and extreme droughts remain the main challenges of Ethiopian smallholder agriculture (Tatek, 2015).

In Ethiopia, under process of subsistence agriculture, in both sparsely populated low land, and densely populated high land regions of the country, survival is solely linked to exploitation of land (Musher Ali and Kedru Suru, 2012). Soil erosion and its damage leading to soil loss was a main problem which have been realized and acknowledged, especially since the devastating famine in Ethiopia in the 1970s (Yinager Dessie *et al.*, 2011).

The scale and magnitude of anthropogenic induced land degradation is increasing in the highlands of Ethiopia (Megersa SL, 2018). Even though watershed development is a priority of the current government of Ethiopia, the advantages derived from the development effort are restricted and there exists frequent destruction of rehabilitated areas through free grazing and farming practices. To improve sustainability and the benefits derived from the natural resources management different projects and programs are under implementation in the highlands of Ethiopia (Aytnew Endashaw, 2015).

However, there are limited data on the environmental and socio-economic contributions of watershed managements in the study area. Therefore, this study aimed at filling existing gap in data with the overall objective of documenting the role of watershed management for biodiversity and rehabilitation of degraded land in Hidabu Abote District.

1.2. Statement of the Problem

Land degradation and destruction of forests due to natural and human activity is an ordinary environmental challenge in Ethiopia. This resulted in low productivity and causes loss of local biodiversity, loss of vegetation cover, and threatening livelihoods of farmers in the country. As cited in Yericho Berhanu and Belay Simane, (2015) in adequate preserving the quality of environment, poor management of watershed and absence of natural resource conservation has greatly damaged the sustainable development of the country. This is comparable with the present study. To solve these problems the government and non-governments (NGOs) have been implementing watershed management for existence of biodiversity and rehabilitation of degraded land. However, its effects have not been evaluated and no document which describe the comparison between treated and non-treated villages of study area. Therefore, studies was focused on to evaluate the role that watershed management play for biodiversity and rehabilitation of degraded land, a change on the livelihood of community, to compare treated and untreated Micro-watersheds in terms of, species composition, soil and water conservation, and finally to will give a recommendation based on the assessment of watershed management contribution in Hidabu Abote Wereda.

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of this study is to assess the contribution of WSM for woody plant species diversity and other ecosystem services in Hidabu Abote District.

1.3.2. Specific Objectives

The specific objectives of this research were:

- To investigate the species composition of plants under the selected watershed management compared to the land use with no management practices.
- To assess the values of WSM for rehabilitation of degraded land in study area.

- To evaluate the values of watershed management in the livelihoods of household in the research area.

1.4. Significance of the Study

The importance of this study was to assess the role of WSM for woody plant species diversity and rehabilitation of degraded land in the study area. The study would generate information and provide awareness for community to understand about biological and mechanical rehabilitation of degraded land practices and adoption of those practices and help the governmental and non-governmental organizations, and local level organizations to create and develop effective sustainable watershed management practices and techniques. The study findings would have significant contribution to learn and think more about how to better design and implement the watershed management program in line with the local condition and can help biodiversity conservation institution, experts and development agents to formulate strategies, investment programs and projects that would bring positive synergies to restore land productivity. The significance of the finding would not be restricted to the place under study, but also other sites which have the same Socio-economic, institutional and natural resource background with that of the study area. Finally, the study would be used for academic purpose as a source of reference materials.

1.5. Scope of the Study

The study was carried out in Hidabu Abote District, North Shoa Zone of the Oromia regional state. The study was delimited to assessment of the role of WSM for woody plant diversity and rehabilitation of degraded land in improving natural resource recovery as well as technological adoption. Specifically the study covered Yaya-Dakabora and Sire Morose micro watershed in HA District. These micro-watersheds have been implemented under fund of GTZ, SLM and HA District Agriculture office. The sample micro-watersheds were selected from micro-watersheds implemented during 2004 E.C. All investigations worked in line with WSM contributions in improving local households' access to water resource, natural resource recovery, participation and technological adoption in the context of the local communities.

1.6. Limitation of the Study

This study has some limitation and faced some constraints. As the researcher tried to contact some stake holders found in district to ask information to write this paper the following limitation was occurred. An availability of sample households in the house to perform interviews with them. It was very difficult to obtain the relevant information from the district office as there is no good filing system for unknown case, they are not found in Bureau. Additionally, because of budget, lack of material, for the problem occurred (Covid-19 virus) in our world including Africa and Ethiopia it was too difficult to got detail information from the respondents and burden of work, it was impossible to cover more than two micro-watersheds of the study area. Therefore, functioning of watershed associations and users groups and soil fertility test of watershed area was issues that need further research.

CHAPTER TWO

2. REVIEW OF RELATED LITERATURES

2.1. Definition of Watershed

As a starting point, it is appropriate to set some basic definitions of watershed. Based on different understanding of these concepts, different scholars have given diverse definitions of watershed which are varying in their detail. Alemayehu Dechasa (2012), define watershed as the drainage basin or catchment area of a stream or river. This shows that, whole upstream topography with a defined drainage channel, which is the source of the lower stream.

According to Lakew Desta, (2005) watershed is defined as surface of land from which runoff resulting from rainfall is collected and drained through a common confluence point. The term is synonymous with a drainage basin or catchment area. As defined by John Wesley Powell cited in (Michael et al., 2014), a watershed is: "that surface of the earth, surrounded by distribution and circulation of water within which all organisms are inextricably joined by their common water course and whereas, human settled, simple sense requirement that they become part of a community." FAO (2007) defines a watershed as the geographical area drained by a watercourse. Similarly watershed is the surface area bordered by rise in elevation of land, where water is gathered and drained into a water body such a marshland, watercourse or lake. The concept is also used, to refer to a river basin, catchment area or drainage basin (Isaac, 2009). A watershed is a dividing line on the landscape that drains all precipitation received within a catchment area into a particular river or receiving body of water (David, 2012).

2.2. Concept of Watershed Management and its Components

Watershed management is an activity of formulating, creating and implementing programs; in addition it is a landscape strategy which aims to apply natural resource handling methods in order to improve livelihoods and rise beneficial conservation, continuous use, and leading of natural resources (Nick and Tassew Woldehanna, 2012). Additionally, Watershed management implies guiding and coordinating how to use land and water resources in a watershed. Management should provide desired environmental services and goods without

adversely affecting resources upstream or downstream (Kenneth *et al.*, 1994). As scholars stated (Salah *et al.*, 2008) WSM is the organized use of vegetation, water and land for its residents to keep and conserve the hydrologic services that they gain from the watershed and decrease or avoid the impact of downstream or ground water. Similarly WSM means improving the socio-economic and biophysical situation of a catchment area or a watershed, for instance, by supplying drinking water, building contour bunds, check-dams, field bunds (raised edges), building health care facilities, etc.(Solomon *et al.*, 2013).

According to FAO (2007) WSM is an activity aimed at ensuring a continuous use of watershed recovery. These resources are dealt with through an organized ecosystem approach centered on the understanding of the overall interactions between physical and biological factors. Inequalities among communities in terms of their socio-economic status and their access to water and other resources and services as a consequence of their geographical location are best addressed at the watershed level. (Calling, 2004), stated watershed management consists of the following components namely:

Water management: Where rainfall is unreliable and inadequate, water shortage severely limits crop production. Water characteristics like storage (ground water storage, surface storage, and root zone storage), water use (drinking water, evaporation, and transpiration irrigation), inflows (precipitation, ground water inflow and surface water inflow) and outflows (surface water outflow, ground water out flow) are the principal factors to be taken care of in continuous management of water. The wide interventions for water management are: Rainwater collecting, ground water recharge, maintenance of water balance, preventing water pollution, economic use of water. Rainwater collecting forms are the major constituent of water management.

Land management: Treatment that is done on land feature like depth and texture, moisture and infiltration rate, slope, terrain, and formation and soil capability are the major elements of land management activities in a watershed. The broad category of land management interventions are structural measures, vegetative measures, production measures, and protection measures which are inter-dependent to each other.

Biomass management: The advantages of biomass management are: ecopreservation, biomass regeneration, forest management and conservation, plant protection and social forestry, increased productivity of animals, economy and source of work connected with

activities, sanitation and health programmes, eco-friendly life style of people, better living standards for people and formation of a learning community.

2.3. History of Watershed Management

The history of WSM was dating back to 5000 years old, since during farming was started. Human beings uses watershed to obtain necessary things to fulfill their needs, and they have been manipulating water and slopes in order to benefit cultivation, prevent over flow of water and other disastrous. In a very long past time, the irrigation system in China on the banks of Yellow River and in the Fertile crescent around the three major Near East rivers (Nile, Euphrates and Tigris); urban water supply system in Greeks and Romans; and hillside terracing and plantation on slopes in Mediterranean region landscapes were the forerunners of current or recent watershed management (Gadisa Chimdesa, 2016).

The idea of WSM has globally gained significance following the United Nations Conference on Environment and Development in 1992 in Rio de Janeiro (also known as the Earth Summit) (Forch and Schutt, 2004). Modern WSM was firstly emerged in 20th century that focused on hydraulic engineering and forestry interventions. However, experience has shows this technical measures alone are not enough to address watershed problems. These days, world-wide environmental, socio-economic and political changes are challenging some of the foundations on which watershed management has been based for the last two decade years. Thus WSM is passing through experiments for a period of time in which “old” and “new” practices co-exist and mix (Teketel Abuto, 2009).

2.4. Integrated Watershed Management (IWM)

According to Scholars Integrated watershed management(IWM) is defined as a way of planning, coordinating, leading, controlling, and supervising the performance of process to manage watershed resources in order to increase the products and services for residents of the watersheds and decrease wastage of natural resources. Achieving maximum benefits for stakeholders while keeping damage to a minimum needs suitable plan of an organization that will manage these tasks. It must be supported by specific laws and regulations of the central government to be able to handle the complex process and it must maximize community participation (Ghafouri *et al.*, 2012). IWM is a mechanism of conservation, development and favorable utilization of the available natural resources in a watershed on a sustained basis. It

is a progress with a multidisciplinary approach with people in the watershed as chief functionaries (decision makers and main actors) in the process. Integrated watershed management is essentially the concept of integrated water resources management applied at the watershed scale. Since it is the only approach capable of balancing growing demand for a limited resource with a sustainable resource base (Mehmet and Şermin, 2011).

Scholars like Chisholm and Tassew (2012) stated that IWSM requires protection and regeneration of Micro-watersheds in a method that maximize production and generating both long-term and short-term incentives for community living in the watershed place. Watershed management fits squarely with sustainable development principles, combining gains in the environmental (conservation of natural resources), economic (gains from sustainable agriculture, forestry, healthy ecosystems and related products) and social spheres (strengthened social capital, reduced migration, enhanced nutritional status, increases in women's income and reductions in their workloads).

A watershed resource such as vegetation, soil, and water are highly interactive and implies their problems are interrelated. Therefore, vegetation, soil and water cannot be managed for sustained availability in separation from each other. Any effort of managing the natural herbage cover is futile unless the expansion of cultivation in to areas with natural vegetation is stopped. This requires sustained or even improved productivity of cultivated fields, for instance through sufficient SWC. Hence viewing the whole of a watershed as means of treating simultaneously all forms of land uses in the unit is essential (Alemayehu Dechasa, 2012).

2.5. Watershed Management practices in Ethiopia

Ethiopia has a long lived history of watershed management. Its system has changed from top-down infrastructure solutions to community-based attitude. Now a time it has a participatory policy and legal framework that facilitate decentralized inclusive development, institutional arrangements that encourage and allow public agencies at all stages to work together, and an approach to natural resources that reflects local legislation and tenure practices (Gebrehaweria Gebregziabher, 2012). In Ethiopia, in 1980s WSM has focused on SWC measures. During this time, the achievements of early watershed projects were marked as the source of main watershed initiatives in Ethiopia (Tsfaye Habtamu, 2011).

Arege Bazezew and Abebe Worku (2018), show that majority of WSM skills in Ethiopia concentrated on the construction of physical structures. The water and soil protection practices contain biological measures, mechanical measures, and institutional arrangements. The primarily category refers to particular management practices that make use of agronomic practice and biological materials rather than physical structures. Mechanical skills, similarly, refer to skills that need physical structures, often with a barrier function. Institutional arrangements refers to land tenure arrangements, forms of labor exchanging, and so forth that may also contribute to maintenance of fertility (Mazzuucato and Niemeijer, 2000).

Evidence recommends that Ethiopia has not succeeded the full potential of its surface and groundwater resources. Watershed management programs took lessons from the last several decades in order to use the new opportunities to reduce farmers' on rain-fed dependency, use low-productivity subsistence and land fragmentation. It replaces with massive use of water and increase the participation of local people in watershed management. The problem is not only to find solutions but also making agreements on the solutions regard inclusive and equitable that lead the country towards put a goal which rural agriculture is the basis of economic growth (Gebrehaweria Gebregziabher, 2012).

2.6. Community Participation in Watershed Management

Community-based watershed management have a great value in helping the government to achieve its aim of making agriculture the driving pressure of economic development in one country (Gebrehaweria Gebregziabher, 2012). In many developing countries, the emphasis of watershed management work is on the welfare of the men and women. Human resource development and participation of the whole community in watershed management is very essential in multi direction. The main cause has been that any watershed management work could not fruitful without giving priority to consideration of the activities contributed from people's; this means that watershed development has been problematic when applied without local people participation (Ted, 2009). Similarly, MoARD (2012) describes that the key for success watershed management will be the total participation of community, and their negotiation in the selection and integration of different technologies within the natural boundaries of a watershed cite for most favorable use of water and land resources. This includes land improvements, restoration, and other technical works as well as betterment of people. Water can be developed and managed if a watershed is taken as a planning unit.

Community activities depend on the watershed for their livelihood and survival, and in turn are responsible for the proper or improper use of the resource. Therefore, community participation is critical for the success of participatory watershed management as it aims to create a self-supporting system essential for sustainability.

As Dube and Swatuk, (2002), stated direct involvement of target community with the state, and transforming the common experience of conflict into co-operation can help to reverse environmental deterioration. Besides, Pretty and Ward (2001) indicated both Governments and NGOs have recognized that protection of Micro-watersheds cannot be achieved without the interest based participation of local people. Therefore, successful watershed development could achieve through the total local community participation (Alemayehu Dechasa, 2012). It is not only enough farmers' participation during planning phase of watershed development to regenerate land and water resources but also farmers participation is necessary during the implementation of both SWC practices like terracing, bunding by FFW. Since, they are near to the truth problems, and therefore they are aware of issues that experts may loss, and their objectives are more practical for development of economy (Stocking, 1996). Furthermore, their activity in conservation work is also considered useful in improving the adoption of the recommended technology (Ashby et al., 1996).

2.7. Land Degradation in Ethiopia

Land degradation is widespread in Ethiopia. It has been attributed to the traditional pastoral livestock grazing, but also results from the encroachment of agriculture and the adoption of crop monoculture. Land degradation further results from the excessive use of tree resources, which are rising overexploited to support livelihoods by sailing wood fuel and charcoal as a source of income and for other benefits (Michael *et al.*, 2014). Birtukan Dufera, (2016) defined land degradation as a process that lowers the productivity of the land due to inedible use of land and other external forces. It reduces the quality and quantity of natural land resources, due to un wise use of the land by human beings. It encompasses the vegetation and deterioration of natural landscapes, soil degradation and includes the adverse effects of erosion, urbanization, overgrazing, excessive tillage, sediment deposition, road construction, over clearing, extractive industries, decrease of plant communities, disposal of industrial wastes and the effects of noxious plants and animals. By implication, the term “land degradation”, and “soil degradation”, become almost synonymous concepts, and actually

goes wider than that includes the degradation of water and vegetation (Alemayehu Dechasa, 2012)

Land degradation has become common challenge in many developing countries including Ethiopia. In Ethiopia the major uses of lands are agricultural and pastoral and, hence, ultimately dependent on soil productivity. Land degradation causes loss of local biodiversity, declines ecosystem services and crop productivity followed by economic reduction and social stress. The increased poverty and integrated process of land degradation has been referred to as the “downhill spiral of unsustainability” lead to the “poverty trap” (Kjell, *et al*, 2002).

In East African high lands very fast soil loss is a serious threat to continuous agricultural production. Soil erosion in these places results in loss of soil fertility, less crop products, food shortage and off-site effects such as siltation of water ways and damage to different structures (Megersa SL, 2018). Soil fertility is declining in most Sub-Saharan Africa countries (Marc Corbeels, *et al*, 2000).

The Ethiopia land mass is generally categorized in to the high land (above 1500m.a.s.l.) and the low land(below 1500m.a.s.l). The high lands comprise about 44% of the whole land mass and accounts for 95%of cropped land. Serious erosion is estimated to have affected 25% of high land area. According to some estimates in the mid-1980s it was estimated that 4% of the high lands had been so, seriously eroded that they could not be economically productive. From, an estimated 90% soil is deposited down slope, and the remaining sediment transported to Egypt leaving Ethiopia (Teklu, 2014).

Land degradation is the retreating of biodiversity and ecosystem functioning that negatively affects the provisioning of ecosystem services and eventually impedes poverty eradication and sustainable development (UN General Assembly, 2012). It involves both vegetation and soil degradation. Vegetation degradation is the reduction in the number of species and the vegetation composition, where as soil degradation refers to negative changes in the physical, chemical and biological properties of the soil (Omar A. *et al.*, 2013). Land degradation is also “reduction in land productivity that affects the integrity of an ecosystem through erosion, salinization, loss of soil fertility and the like” (UNEP & GEF, 2004).

The assessments of Global degraded land percentage trend indicated increment from 15% in 1991 to 24% in 2008: with more than 20% of the whole all cultivated lands, 30% of natural

forests, and 25% of grasslands undergoing some degree of degradation (IFPRI, 2012; Bai ZG *et al.*, 2018). Most areas of the country are suffering to land degradation. For example, the same way deforestation, population increment, severe soil loss, low vegetative cover and unbalanced crop and livestock production are major driver of land degradations with additional factors like soil types, topography and agro-ecological parameters in Ethiopia (Temesgen Gashaw *et al.*, 2014).

Another impact of land degradation is biodiversity loss. Biodiversity loss is a reduction in genetic, species and ecosystem diversity. Biodiversity conservation and woody plant species are under the problem of ways of using land in protected areas (Wegene Getachew and Feleke Woldeyes, 2015). The current land use changes severely reduce biodiversity and provisioning of water for food security (Schulz *et al.*, 2016). According to (Liniger *et al.*, 2017) driver of biodiversity loss and degradation of ecosystem is change of natural and semi-natural land use systems in to agricultural land, settlements and transportation systems that threatens agro biodiversity likes crops diversity as well as wild species diversity on farming lands and at the same time contributed to degradation of these agro-ecosystems. In our country, where the agricultural sector accounts for more than 50% of gross domestic product and employs over 80% of the population, land degradation in the form of soil erosion and declining fertility is a serious challenge, (Berhanu Gebremedhin and Scottm, 2003). The degradation of agricultural land causes a serious risk to current and potential food production in the highlands of Ethiopia (Azene, 2001). Average soil loss rates 21 to 42 tons per hectare per year on cultivated lands (Tesfaye Habtamu, 2012).

This is to say that under process of subsistence agriculture, in both densely populated high lands and sparsely populated low land areas of the country, survival is solely linked to exploitation of land (Musher Ali and Kedru Suru, 2012). Soil erosion and its damage leading to soil loss have been realized and acknowledged, especially since the devastating famine in Ethiopia in the 1970s (Yinager Dessie *et al.*, 2011). As Lakew Desta *et al.* (2005) indicates degraded lands in Ethiopia constitute large regions of the country. Some areas are much more degraded than others. Unfortunately, the “degradation trend” of the latter is also very fast, with the accelerated erosion rates being recorded in the high potential places for cultivation. This indicates a need to prevent and conserve watersheds across the country. Degradation occurs on all lands, cultivated, grazing, and others. As conservation research project (SCRIP) estimated, from the highlands about 1.5 billion tons of soil reduced by erosion annually.

According to the Ethiopian Highlands Reclamation Study (EHRS), soil degradation is estimated to cost the country 1.9 billion US\$ between 1985 and 2010. These call for external interventions based on the local socio-economic and technical potentials if the country is to continue as a nation (Megersa SL.2018). The EHRS quotes the 1981 statement of the USA National Soil Erosion/Soil Productivity Research Planning Committee that "erosion reduces productivity first and foremost through loss of plant-available soil water capacity," which is seen to reflect a growing consensus in the scientific literature (Jan and David, 2005).

2.8. Expected Benefit of Watershed Management Roles

2.8.1. Environmental Benefits

Applying watershed management in degrade environment improves the vegetation cover of the hillside and sloppy areas by minimizing accelerated-runoff and growing of different plant species. Better planned, politically helped, and seriously practiced natural resource management activities can support to minimize or eliminate some of the challenges. In the highland of northern part of Ethiopia Tigray Region 522,600 haectare of land have been regenerate by applying Various SWC measures (Nyssen et al., 2006). According to Birtukan Dufera, (2016) stone bund have positive impact on the soil and water conservation, soil fertility management, land management, crop production and reduce soil erosion and its side effect or negative impact was increase rodents such as rat, reduce the farm land size this decrease the crop production.

Yenealem Kassa *et al.* (2013) demonstrated the impact of integrated SWC has a significant role in raising the quality and quantity of crop productivity in eastern part of Ethiopia in West Harerghe Zone, Ethiopia. Watershed management interventions needs the regenerate of damaged surface of land to rehabilitate flows of natural resources in turn lead to well developed management of the Micro-watersheds in some countries like Korea (Alemayehu Dechasa, 2012).

2.8.2. Economical Benefit

The basic goal of WSM in rain-fed systems is to make better livelihood security and to minimize rural poverty, while protecting or enhancing the continuity of the environment and the agricultural resource base. Through this purpose watershed management significant

reduce runoff, loss of soil and improve ground water level, household income, vegetation cover and increase productivity of land in treated watershed as compared to the untreated watershed (Wani *et al.*, 2006). Watershed development can result in improving the life of the community directly or indirectly. The life of community is dependent on the availability of natural resources. Community participation based and continues watershed development can bring quality of life to any local people in providing various important ecosystem service (Bank-Netherlands, 2001).

The Economical benefit of WSM can be seen in the way that the economy of peoples as well as, economy of individual improved. At community level we can see access of the community to natural resources that exist in the watershed because of the intervention. At household level individual farmers can have direct involvement during the implementation of the physical and biological activities, for daily wage in the form of cash/FFW. The maximum interest of very fast population growth with the disparity of rain fall distribution will bring an improvement on food security achievement if and only if there is good watershed management implemented effectively. Sustainable watershed development can enable a country to bring good standard lifestyle of community, enable a country to increase income by using water resource for multipurpose (MoWR, 2001). Likewise, Yoganad and Gebremedhin , (2006) indicates majority of the watershed projects were developed for the advantage of increasing income obtained from farm, enhancing agricultural productivity, soil and water conservation, generating rural employment, decreasing risk by diversifying crops in rain fed areas.

2.8.3. Social Benefits

Through the community participation of watershed in different stages and the formation of watershed committees, user groups and new or strengthened institutions of activities they can have a chance to strengthen social bondage in collaborating among them. According to DFID (2008) to create social advantage for such intervention social capital can have a chance to create mutual expectation and reciprocity lower the costs of working together, that means it has a direct influence upon other type of capitals. Besides to this, through the straight involvement during the intervention of watershed development, communities can have possibilities, like, directly involve the community members in developing a vision for the future of the watershed, give knowledge to citizens on the wise use of natural resource in

sustainable manner, give chances to raise association between communities for mutual benefit.

2.9. Biodiversity Conservation and Woody Plant Species

Biodiversity describes the comprehensive overall term for the degree of nature's variety or variation within the natural system; both in abundance and frequency. Totally, it describes, the variety of all forms of life on earth. The different plants, animals and microorganisms contain different genes and ecosystems (Mutia, 2009). According to Tadesse Kidane-Mariam (2003) the most serious environmental problems in one country is earth devastation; that leads to destruction of biodiversity. Among various benefits of biodiversity species, some are, aesthetics benefit, economic benefit, and cultural benefit. If biodiversity is not protected wisely, natural resources, which have a great significance in the life duration of human being will become disappeared (Tirhas Mebrhatu, 2009).

Woody vegetation species have a great role in providing socio-economic and ecological benefits that sustain livelihoods of communities and the national economy (Neelo *et al.*, 2013). Measures of species diversity play a critical role for ecosystem existence (Magurran, 2004) since species diversity are an important parameter of a plant community, one of the major criteria for conservation of natural resource and connected to ecosystem dynamics and environmental quality (Kalema, 2010).

Ethiopia is known by its great natural and cultural diversity form with its topography and latitudinal position and existence various flora and fauna (Dinkissa Beche, 2011). According to Lemma Tiki and Menfes Tadesse, (2015) environmental conservation is an essential and timing issue to solve less productivity of land in Ethiopia. They showed that to improve ecological components it is very important to organize different SWC practices in to the region closure to encourage reform of land degradation, because it is one of the major critical challenge facing human beings in farming production for sustainable progress in Ethiopia. So strategies should be design and apply to rehabilitation of degraded areas quickly before the conditions become worst. To search the serious land degradation problems in Ethiopia, enclosure practices can play important role in rehabilitating degraded lands (Getachew Mulugeta, 2014).

The aim of biodiversity conservation have been partly achieved and could be further strengthened in the future include: protected areas, species protection and saved technologies for recovery measures for threatened species, ex-situ and in-situ conservation of genetic diversity (e.g. gene banks), ecosystem restoration, payments and markets for biodiversity and ecosystem benefits (e.g. for ecotourism or carbon sequestration). Incorporating considerations of biodiversity conservation into management practices in sectors such as agriculture, forestry, and fisheries, collects of benefits by local communities to persuade them the necessity of biodiversity conservation, develop multilateral environmental negotiations such as: environmental negotiations with other international economic and social institutions, public awareness, communication, and education (MEA, 2005).

Tirhas Mebrhatu, (2009) reveals that the strategies play a great role to conserve biodiversity are in-situ conservation, increasing afforestation, ex-situ conservation using gene banks, botanical gardens, arboreta, planted forests and agro forestry systems. Other strategies include integrated land use and conservation, monitoring utilization and generating information on the status of overexploited species, raising public awareness especially at community level and harmonization of laws related to land use.

2.9.1. Plant Community Types

The species compositions of the communities better express their relationships to one another and environment than any other characteristics. Plant community types can be defined as the collection of plant species growing together in a particular location that show a definite association or affinity with each other (Kent and Cooker, 1992). Plant community can be understood as combination of plants that are dependent on their environment, influence one another, and modify their environment (Mueller-Dombois and Ellenberg, 1974). As they stated, the floristic composition of vegetation includes all species occurring within a plant community. However, most plant communities consist of many different species which are not particular to discover all species within a community. Hence, it is common to use the dominant species in naming plant communities (Kent and Cooker, 1992). Information on plant population structure analysis helps to respect the healthy regeneration of the tree species under utilization. It indicates the history of forest disturbances to that species and environment and hence used to forecast the further trend of the population of that particular species (Peters, 1996).

2.10. Land Rehabilitation Practices

To sort out the problems of deforestation and land degradation, the government has extensively carried out a number of rehabilitation programs supported by the World Food Program's and Food-For-Work system to protect further soil erosion and other factors of environmental destruction. Soil and water conservation activities, are the two main strategies to control land degradation and keep natural vegetation (Tagel Gebrehiwot and veen, 2014). Land rehabilitation is process of reforming and changing the land in some degree of its former feature, after it has been damaged by human and natural disasters (Mesfin Desalegn, 2010; Addise Ermias, 2014). They pointed out that land rehabilitation indicates the structural and biological reversing of degraded lands. According to Desta Damena, (2009) land rehabilitation practices refer to the conservation of environment (plants, animals, soil water air, etc) which is performed by the local community to regenerate degraded lands. Rehabilitation is also a practice designed to search out the cause of land degradation like erosion, deforestation, urbanation, backward farming, overgrazing, pollution, etc to improve ecosystem goods and services (UNEP, 2010).

The protection and restoration of degraded lands can be important to improve the functioning of the ecosystem through raising the diversity of species and their interactions. According to Aradottir *et al.* (2000) confirmed that reclamation of degraded land can promote continues development and create ecosystem health by decline soil erosion and grow biological productivity, water and soil quality. Some successful watershed managements decrease was reduced run off, soil erosion and associated downstream siltation, spread vegetation coverage, increased soil thickness, promote ground water table, made productive area and green environment lead to develop crop production and productivity (Temesgen, 2015). Deforestation, vegetation destruction and soil erosion are the cause of environmental degradation affects on periodic crop failure even in a normal rainfall conditions. In order to reverse the problems of deforestation and land degradation, strategies have been promoted to control land degradation and save the natural vegetation (Tagel Gebrehiwot and Veen, 2014).

Seasonal floods, increased down-stream crop production through SWC interventions, enhanced stored carbon; enhanced biodiversity, and social cohesion by improving livelihoods (Tongul and Hobson, 2013). The successful natural resource conservation measures for rehabilitating degraded land following watershed management approach in Ethiopia and

studies showed that the improvement in watershed management benefits peoples found at different stages (Lakew Desta *et al.*, 2005).

In most of the surveyed micro-watersheds, even though improper land use affected soil productivity on individually owned lands, common use lands were universally severely degraded and will demand intensive investment to restore. To solve these challenges, the government attempted to mobilize communities by using preferred conservation structures. Well establishment of tree/shrub considered as excellent land management lessons which can motivate the public to participate in such labor-intensive tasks (Kebede Wolka, 2015).

CHAPTER THREE

3. METHODOLOGY

3.1. Description of the Study Area

3.1.1. Location

The present investigation was conducted at Hidabu Abote District in North Shewa Zone of the Oromia Regional State. Geographical location of the District is between 9° 47' and 10° 11' North latitude and 38° 27' and 38° 43' East longitudes. It is found at 147 km north of Addis Ababa and 42 km from zone capital town Fitcha (Figure 1). Hidabu Abote is bordered on the south by Degem District, on the west by Kuyu and Wara Jarso District, on the North by Jamma river which isolates it from Dera District and on the East again by Degem District. Total area of the District it covers is 486 km² and inhabited by 104442 people with crude density of 215 persons per sq. km of which 15551 are farmer (HADA0, 2017).

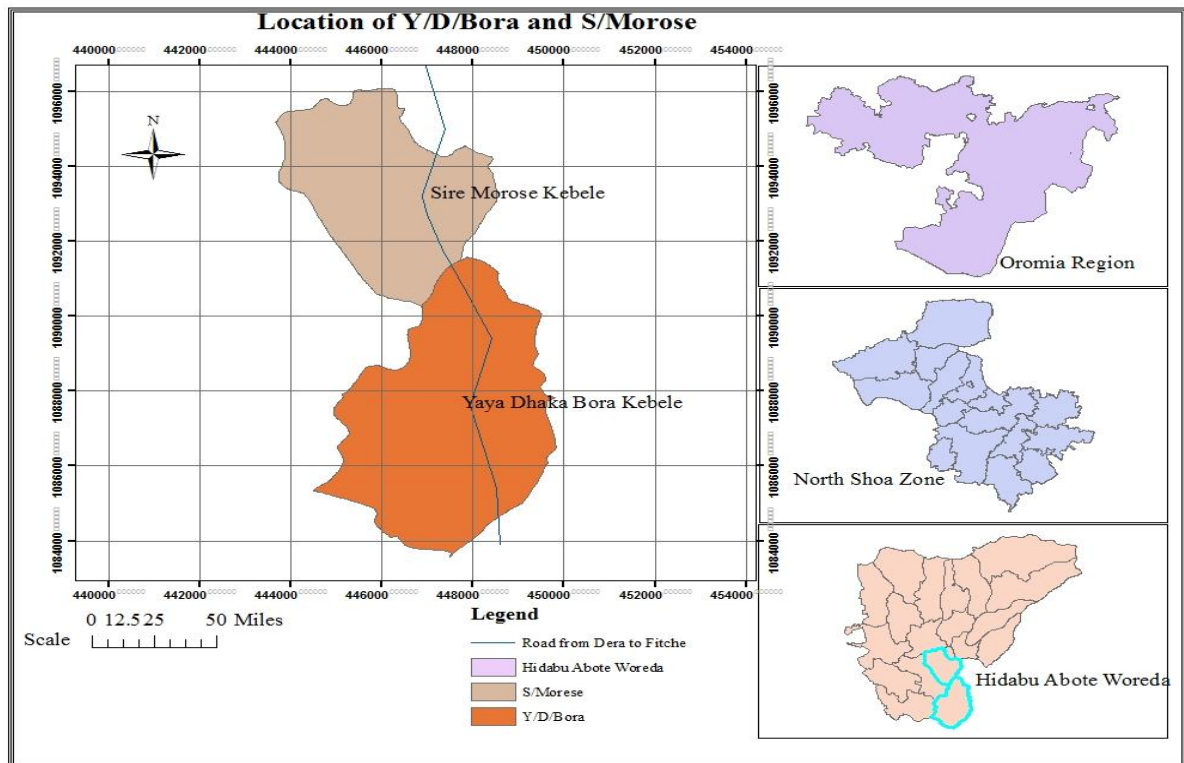


Figure1: Map of the study area in Hidabu Abote District, North Shewa Zone of the Oromia Regional State.

3.1.2. Topography

The study area is located in the Nile basin incorporating various land forms such as mountains, valleys, hills and plains that are within altitudinal range of 1160-3000m a.s.l. It encompasses Dhaka Bora Mountain which is 3000 m a.s.l. The biggest river in the District includes Jamma, Aleltu Guda and Wonchit River .Consequently the elevation difference in the study area is about 2000m that demonstrate the existence of variegated agro climatic zones. This also creates the opportunity to have a varied flora and fauna. However, the ruggedness of the topography has a negative impact on the cost incurred for the development undertaking infrastructure, mechanized farming and leads to land fragmentation (HADAO, 2017).

3.1.3. Description of the micro-watersheds

The implemented SWC measures in Sire-Morose for nine years were eye barrow, counter farming, terracing, stone bund, soil bund, stone and soil faced, micro basin, ditches, deep trench hill side terrace, half moon, gabion, check dams and gully cutting and in Yaya-Dakabora tillage, counter farming, check dam by wood, soil and stone bunds are practices. In both Micro-watersheds the most widely and intensively mechanical soil and water conservations were stone and soil bunds. The reasons this measures used by local community were more practiced was due to its effectiveness for decreasing soil erosion and for its best alternative mechanical SWC practices as a primary for protecting degraded land.

In Sire-Morose the biological SWC practiced measures were vegetative fencing, agroforestry, fallowing, compost making, and crop rotation, grass strips along the counters, mulching, and area closure and tree plantation at cropping land, grazing land and in forest areas. Where as in Yaya-Dakabora mulching, crop rotation, traditional agroforestry practices and grass strips along the counters were undertaken as a biological soil and water conservation practices. From biological SWC practices crop rotation was widely practiced in both micro-watersheds.

3.1.4. Climate

The district of study area is categorized in to three climatic zones. These are Dega (6%), Woina Dega (50%) and kola (44%) agro climatic conditions. District is characterized by bimodal rainfall cycle mainly summer and spring. Summer season ends for five months (June-October), while spring seasons ends for three months (March-May).The number of rain days were differ from area to area and this number slightly decreases as one goes down to the low lands. The district average annual temperature is ranging between 13^oc and 23^oc and rainfall which range from 900-1185mm (WVE, GIS Unit.2008; Atlas of Hidabu Abote District, Addis Ababa Ethiopia).

3.1.5. Vegetation and Type of Soil

The district has different types of plant species such as *Acacia tortilis*, *Acockanthera schimperi*, *Cordia macrostachyus*, *Dodonea angustifolia*, *Eucalyptus camaldulnesis*, *Eucalyptus globules*, *Carissa spinarum*, *Juniperus procera*, *Maesa lanceolata Forssk* , *Ximenia americana*, *Cordia africana*, *Olea africana*, *Hygenia abyssinica* and etc. There are also different species of wild animals like Warthog, Bushbuck, Mongoose, Hyena, Monkeys, Fox, Baboon, etc. In the district, agricultural activities have been practiced for a long period of time and population pressure was the major threat to vegetation cover of the area. There are three major soil types of study area are vertisol, clay and sandy soil (HADAO, 2017). There is a distinct difference between soils found at the up slope and valley bottom of the two Micro-watersheds. Black soil is dominating the valley bottom while red soil is prevalent in the up slope areas. Soil fertility is highly diminishing from time to time because of inappropriate farming, grazing and limited conservation practices in Yaya-Dakabora micro-watershed as compared to Sire-Morose (HADAO, 2017).

3.1.6. Socio Economic Characteristics

3.1.6.1. Crop production

Farming system in study area are mixed which comprises both crop and livestock production. The major economic activity of the community live in the study area was crop production. The major crops grown in the study areas are mainly annual crops including; teff (*Eragrostis tef*), sorghum (*Sorghum bicolor*), barley (*Hordeum vulgare*), wheat (*Triticum vulgare*), beans

(*Vicia faba*), maize (*Zea mays*) and the major vegetable crops are potato (*Solanum tuberosum*), onion (*Allium cepa*), garlic (*Allium sativum*), carrot(*Daucus carota var. sativa*), tomato (*Solanum lycopersicum*), cabbage (*Brassica oleracea*) and sugar cane are also grown in the area to some limited extents (HADA0, 2017).

3.1.6.2. Livestock production

Livestock production is a category of the agricultural practices, which are being carried out by the community as livelihood economic sources, since a number of years ago in the research area. The major livestock types in the research are includes cattle (dominant), sheep, goat, horse, mule, donkey and poultry. Livestock for smallholder farmer is a main component of agriculture which plays important role in the livelihoods of households. Beekeeping used widely by study area farmers as one of the most necessary agricultural activities, because this business does not need much land, timber and other non-timber forest products are also another income source of community in the study area (HADA0, 2017).

3.1.7. Land use and Land Cover of Study Area

Land use types in the research area include 947.3 (58.9%) of farmland, 307 (19%) of residential, 59.9 (3.7%) of grazing/pasture lands, 282(17.6%) of forest land, 10 (0.6%) of shrub/bush land and others land degradation features. (HADA0, 2017)

3.2. Research Design

To succeed the planned objectives of the study comparative survey methods were used. Both qualitative and quantitative information were collected to describe the nature of the problem under study in its current status. Sample farmer households who lived in the study area were determined by using the formula discovered by Cochran (1977). The methods of sample selection for Micro-watersheds, farmer households and vegetation data included purposive, random and systematic sampling techniques, respectively.

3.3. Sampling Techniques and Sample Size

3.3.1. Vegetation Sampling Design

Systematic sampling design was used to gather vegetation data from the research area. To gather data for vegetation suitable transect lines and sampling quadrates were made depend on the total area of the research site. Ten transect lines five for each watershed (four plots from each transect lines) were laid along the transect lines having 100 m intervals between each transect lines. Data was gathered from a total of 40 sampling plots size of 20 m x 20 m (400 m²) from the 1.6 ha of lands (20 plots from each micro-watershed). The interval between sample plots was 50 m drop in altitude. All woody species rooted within the main quadrates were documented using local names and their Diameter at Breast Height (DBH) was measured at 1.3 m above ground using diameter tape. Height of woody species was estimated. To gather data on saplings and seedlings five subplots of 1m x 1m (1m²) size located at the centre and four corners of the main quadrates were used. The first transect line was aligned randomly at one side of the watershed around the edge of the watershed followed by the remaining transects laid out. To avoid edge effects, the first transect was laid at 20 m inside the two micro-watersheds. Meter tape was used to establish the transect line and quadrates, and four corners were marked by using long tree stick. All plant woody plant species categories were identified, counted and the plots recorded by their local and /or scientific names with the help of local knowledgeable persons, forestry experts, and nomenclature following the published Volumes of Flora of Ethiopia and Eritrea (Hedbergs *et al.*, 2009). Based on the standard procedures developed by Lu *et al.* (2010) for height and Jiangshan *et al.* (2009) for DBH individuals were categorized into three size groups. Individuals with a height >2 m and DBH >2.5 cm were recorded as mature plant/tree, individuals height 1-2 m and DBH <2.5 cm were recorded as saplings and individuals with a height < 1 m were taken as seedlings and only their number was counted.

3.3.2. Household Survey Sampling

Purposive samplings followed by random sampling technique were used to compare perceptions on the role of watershed management for biodiversity and rehabilitation of degraded land. In order to select sample micro-watersheds, discussions were held with the officials at the district level. Accordingly Sire-Morose from treated and Yaya-Dakabora from

untreated, micro-watersheds were purposively selected by considering their location, agro-ecology and socio-economic similarity without having similar intervention for comparison. The two micro-watersheds have the same topographic character, soil type and temperature, altitude and rainfall, because they were located in one watershed and have common outlet. The independent variables such as house hold size, age, educational status, marital status, farm land size and distance to the market were expected to influence farmer's practices not to adopt or to adopt the selected SWC practices. Total sample sizes of 123 households were selected by using simple random sampling technique from the two Micro-watersheds (Table 1). Using the probability proportional of sampling size technique, the sample sizes from both Micro-watersheds were calculated. The required sample size was determined by using a simplified formula provided by Cochran (1977), as follows.

$$n = \frac{pq Z^2 pqNZ}{Nd^2 + Z^2 pq}$$

Where, n= sample size

N= total population of households in both sites

Z= confidence interval (1.96)

d= margin of error

p= proportion of population (0.5)

q= 1- p

d= 0.05 and q= 0.5 assumption

Table 1: Distribution of sample households by the two micro-watersheds

Micro-watersheds	Total number of HH	% Proportionate	Sample size of HH
Sire-Morose	273	56	69
Yaya-Dakabora	210	44	54
Total	483	100	123

In addition, a total of 10 key informants were selected from both micro-watersheds and four FGDs were held which had 8-10 persons for each watershed. Discussions were held by comparing both micro-watersheds about the present and past watershed management practices, land degradation, woody species cover and community participation in the two Micro-watersheds.

3.3.3. Data Collection

Both primary data and secondary data sources were used to get reliable and effective result. In this research, farmers were the major primary data sources. The primary data were gathered from prepared questionnaire, observation, focus group discussion, key informant interviews with selected model farmers and development agents and various levels of concerned government organizations. To get detail information these prepared FGD and questionnaire were translated into the mother tongue of the target population “Afaan Oromo”. Secondary source of information were gathered from unpublished as well as published sources, district agricultural official records, journals, project reports, research papers, books and other electronic media (internet).

Questionnaire: Was a tool for data gathering and recording the written responses from the individuals of sampled households, by creating face to face contact with the respondents and open ended and closed ended questionnaires were developed on the basis of the study objectives.

Focus Group Discussions (FGDs): FGDs were conducted in order to acquire qualitative data collections which were designed to extract insight about the attitudes, events and perceptions which were difficult to acquire other than this method of data collection. Four FGDs were held from each watershed which contains eight to ten members of participants. The discussion agenda was made ready which involves both semi-structured as well as open ended questions. The composition of the two micro-watersheds focus group members included both male and female households, district experts, local Da, youth and elders. The focus groups discussed on the experiences, problems, perception, participation towards SWC and impacts of watershed management on land rehabilitation and recommended for the possible solutions in the future action. Field notes taken for this discussion were reviewed after each discussion.

Field observation: In order to increase some responses with evidences, the researcher employed field observation. The observation checklist was prepared in accordance with the stated objectives of the study in order to strengthen the reliability and validity of the data gathered. In the meantime, observation of the actual community participation, perception of community on maintenance of implemented mechanical and biological structure, and the change observed because of the management intervention and land degradation problems

were considered and the observation give emphasis to SWC measures on private plot, homestead plantation and water harvesting structures.

3.3.4. Data Analysis

3.3.4.1. Vegetation data analysis

Both inferential and descriptive statistics were used for data analysis.

3.3.4.2. Diversity indices

Diversity indices test the degree of uncertainty that the diversity of observed particular species in a given habitat is high or low. They are used to conclude a lot of recorded data in one or sets of figures by mathematical expressions. From the various indices, Shannon-Wiener diversity index (H') is the most applicable index of diversity (Amanuel Ayanaw and Gemedo Dalle, 2018). It was used to compute for both species diversity and species evenness of the plant community types in the vegetation (Feyera Senbeta, 2010).

Species diversity: For comparison of species diversity in the two Micro-watersheds Shannon diversity index was employed. Diversity index was calculated according to Shannon-Wiener (1949) by using the formula:

$$H' = - \sum_{n=1}^S p_i \ln p_i$$

Where: H' = Shannon diversity of species

Σ = summation symbol

S = number of individuals of a given species

\ln = log base n (natural logarithm)

P_i = is the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of the total cover (n/N).

N = total number of individuals found (Shannon-Wiener, 1949).

Shannon's Equitability or Evenness (E) is calculated from the ratio of observed diversity to the maximum diversity by using the equation.

$E = \frac{H'}{H'_{\max}}$ or $\frac{H'}{\ln S}$ Where: $H'_{\max} = \ln S$, E = Equitability or evenness, assumes a value between 0 and 1, with 1 complete evenness (Kent and Cooker, 1992). $\ln S$ = The natural logarithm of the total number of species in each community, S= Number of species in each community (Shannon-Weiner, 1949).

Species Richness: particular measure of species richness is termed as Menhinick's index (D) (Menhinick, 1964). The species richness of the woody species was calculated as,

$$D = \frac{S}{\sqrt{N}}$$

Where: D= Species richness (Menhinick index).

S= number of species in the sample

N= total number of individuals in the sample

Similarity coefficient – the similarity of species types with regard to species composition was assessed by using Sorensen's coefficient and computed from the following formula as described by Grieg-Smith (1983).

$$Ss = \frac{2a}{2a + b + c}$$

Where: Ss = Sorensen's similarity coefficient

a = number of species found in two samples

b = number of species found in sample one (community one)

c = number of species found in sample two (community two), Kent and Coker (1992).

3.3.4.3. Analysis of the vegetation structure

In this study, the structural analyses of the woody plants were described by using the following components, such as, species density, frequency, height class distribution, Important Value Index (IVI), diameter at breast height (DBH) and basal area. In woody species structure data analysis, the growth stages such as seedlings, saplings and mature plants could be one of the elements of diversity that determine the rate of recovery after disturbance. Population structure of tree diameter at breast height (DBH) distribution has been used to infer past disturbances, regeneration patterns and succession trends in tree populations. To determine the population structure, individuals of each species encountered were grouped into seven DBH classes (i.e. 1. < 5, 2. 5-10, 3. 10-15, 4. 15-20, 5. 20-25, 6. 25-30 and 7. > 30 cm). The height classes also classified in to seven (i.e. 1.< 3, 2. 3-6, 3. 6-9, 4. 9-12, 5. 12-15, 6. 15-18, and 7. 18 m) following the method of Birtukan Dufera (2016). The vegetation data of the woody species were calculated and summarized in Microsoft Excel using the following formula.

$$\text{Density} = \frac{\text{Total number of individual of species in all plots}}{\text{Total number of plots studied}}$$

$$\text{Relative Density (RD)} = \frac{\text{Number of all individual of the species}}{\text{Total number of individual species}} \times 100$$

Frequency is defined as the number of plots in which particular species occurs in study area. It was determined by dividing the number of plots in which the species occurred by the total number of plots from which all the species sampled in the area under the study.

$$\text{Frequency of species (\%)} = \frac{\text{Number of plots in which the species occurred}}{\text{Total number of plots studied}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Sum frequency of all species}} \times 100$$

Basal Area (BA); the basal area of the woody species was calculated as; $BA = \pi d^2/4$

Where BA = Basal Area in m² per hectare.

d = diameter at breast height in meter.

$\pi = 3.14$

$$\text{Relative Dominance} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}} \times 100$$

Importance Value Index (IVI) of a species was calculated from the sum of Relative Dominance (RDO), Relative Density (RD) and Relative Frequency (RF) (Kent and Coker, 1992). $IVI = RDO + RD + RF$

3.3.4.4. Household survey data analysis

The collected data from both primary and secondary sources were analyzed, summarized and presented through quantitative and qualitative method. For quantitative data analysis both descriptive and inferential statistics were used. Descriptive statistics includes percentage, standard deviation, mean, frequency, maximum, minimum and cross-tabulation. Inferential statistical analysis (continuous data) was analyzed through one way ANOVA (Analysis of Variance) and t-test, while, categorical data was analyzed using chi-square (χ^2) test. Finally, all the gathered data were compiled and analyzed by using SPSS computer software version 20 and STATA version 11 software. Then the gathered data were analyzed, interpreted, and presented in tables.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1. Impact of Watershed Management Practices on Woody Plants

4.1.1. Contribution to Floristic Composition

From the two micro-watersheds a total of 42 woody plants belonging to 36 genera and 29 families were documented (Table 2). Accordingly, out of total number of woody species recorded in both micro-watersheds 42 species belonging to 29 families were exist in Sire-Morose and 25 species belonging to 20 families were exist in Yaya-Dakabora. From the total species, 25 species (60%) belonging to 20 families were common for the two micro-watersheds, while 17 species (40%) belonging to 9 families were found only in Sire-Morose.

Out of the whole recorded woody plant species from micro-watersheds the density of woody plant species were, 759, 475, 287 of tree, saplings and seedlings were counted and recorded in Sire-Morose, respectively. Where as in Yaya-Dakabora the density of woody plant species were 295, 101, 43 of tree, saplings and seedlings were counted and recorded respectively (Appendix table 2 and 3). As the collected data indicated composition of woody plant species proportion of trees, saplings and seedlings were higher and more diversified in Sire-Morose than Yaya-Dakabora (Appendix 1 and 2). From the analysis of data of species such as *Carissa spinarum*, *Eucalyptus globules*, *Albizia gummifera*, *Eucalyptus camaldulnesis*, *Croton macrostachyus* were the most dominant species in Sire-Morose. Whereas *Croton macrostachyus*, *Lippia adoensis*, *Albizia gummifera*, were the most dominant species in Yaya-Dakabora (Appendix table 1 and 2). Fabaceae was the most diverse family represented by 6 species and 3 genera (Table 2). On the other hand, about 72.4% families were represented by one genera and one species.

Table 2: Number of species in different plant families in the research area

Family	Genera	Species
Acanthaceae	1	1
Anacardiaceae	1	1
Apocyanaceae	1	1
Aquifoliaceae	1	1
Asteraceae	2	2
Boraginaceae	1	1
Celastraceae	1	2
Cupressaceae	1	1
Euphorbiaceae	1	1
Fabaceae	3	6
Icacinaceae	1	1
Loganiaceae	1	1
Malvaceae	1	1
Meliaceae	2	2
Meliantaceae	1	1
Moraceae	1	2
Myrsinaceae	2	2
Myrtaceae	2	3
Oleaceae	1	1
Phytolaccaceae	1	1
Podocarpaceae	1	1
Proteaceae	1	1
Rosaceae	2	2
Rutaceae	1	1
Salicaceae	1	1
Santalaceae	1	1
Sapindaceae	1	1
Verbenanaceae	1	1
Vitaceae	1	1
	29	36
		42

With regards to species number the most dominant families recorded in Sire-Morose were Fabaceae (6 species (14.3%) and followed by Myrtaceae (3 species (7.14%) (Appendix table 3). In Yaya-Dakabora the most dominant species were Fabaceae (3 species (12%) which was followed by Asteraceae and Myrtaceae with 2 species (8%) (Appendix table 4). The other remaining families of both micro-watersheds were represented with two and single species (Appendix table 3 and 4). In both micro-watersheds as the result showed that Fabaceae was the most diverse and dominant family in number of species. The current result was similar to the finding of (Wegene Getachew and Feleke Woldeyes, 2015) who reported that Fabaceae was the most governing family in Maze National Park and Gera Moist Montane forest even if they have slight variation of weathering conditions.

The effects of management that assisted the biological and mechanical SWC factors made difference in the composition of woody plant species in both micro-watersheds. Well developed management, practices and awareness of society for environmental conservation have a great value to create conducive environment with fast colonizing ability of species in disturbed areas by means of natural or artificial activities which was true in Sire-Morose watershed. On the other hand, because of environmental disturbances Yaya-Dakabora micro-watersheds consists of fewer compositions of woody species. This finding was in agreement with study in Hawassa Zuria district, Ethiopia that showed the fact sustainable soil and water conservation practices improved composition of woody species as compared to open grazing land without SWC practices (Lemma Tiki and Menfes Tadesse, 2015).

4.1.2. Similarity and Diversity of Woody Plant Species

4.1.2.1. Species diversity, evenness and richness

The values of Shannon diversity index (H') of plant species in Sire-Morose were much higher than that in Yaya-Dakabora. The higher mean diversity value being 3.482 was recorded in Sire-Morose which was greater than Yaya-Dakabora (2.901) (Table 3). The result indicated that the diversity of woody species in the Sire-Morose was higher than that of Yaya-Dakabora implying that watershed management contributed to rehabilitate the non-herbaceous plant species density and diversity. This was attributed to the management divergence between the two Micro-watersheds. The result was synonymous with the finding of (Gerbe-Mariam Yaebiyo, 2015), who indicated that in the treated watershed there was great woody plant species density and diversity than the untreated watershed and suggesting

that implementation of IWM contributes positively to the rehabilitation of woody plant species diversity and density. The relatively high diversity and evenness indices indicated that conserved woody plant species in Sire-Morose and their protection from human and livestock disturbances unlike Yaya-Dakabora which was open for human and livestock disturbance. The greater number of species evenness in Sire-Morose indicated that species were distributed more or less equally and the lower evenness of woody species in Yaya-Dakabora revealed that the watershed was dominated by fewer species and this could be attributed to excessive disturbance and selective cutting of some useful species by humans without replacing. It was found that dominance and evenness were inversely related, implying that Yaya-Dakabora was considered to be with less species diversity than Sire-Morose.

The diversity of woody species varied among the two micro-watersheds. The Sire-Morese micro-watershed was comparatively the most diverse with respect to woody species. Sire-Morese micro-watershed had the highest species richness, Shannon (H') and Species Evenness (E) indices than in Yaya-Dakabora (Table 3). This shows that managing of watershed has positive effect on the species richness. The above results were similar with the finding of (Mengistu Asmamaw, 2011), who showed that due to optimal environment and minimum disturbance, species diversity, species evenness and species richness in area enclosures were higher than that of open grazing lands.

Table 3: Comparisons of different diversity indices of woody species in both micro-watersheds

Micro-watersheds	Richness	Shannon Index(H')	Evenness (E)
Sire-Morese	42	3.482	0.774
Yaya-Dakabora	25	2.901	0.727

4.1.2.2. Similarity of woody plant species

The analysis of Sorensen's similarity coefficient (SSC) indicated that there were considerable similarity in woody plant species composition between Sire-Morose and Yaya-Dakabora. The SSC result gave a value between 0 and 1 showing that complete community overlap was equal to 1 and complete community difference was equal to 0. The Sorensen's similarity coefficients for the two Micro-watersheds were 0.75. This number showed that there were similarities of woody plant species between the two Micro-watersheds. The factors in the

research area such as, climatic conditions, geographical location, altitudinal range, and topographic features were play a great role for similarities of woody species composition between the two micro-watersheds. The differences in woody species composition between the two micro-watersheds were due to a well developed of watershed management activities in Sire-Morose which enriched in species composition than Yaya-Dakabora. It was suggested that rehabilitation of ecosystem by different environmental conservation mechanisms such as afforestation, reforestation and others in Sire-Morose can lead the area to be covered by different plant species. The study result agreed and similar with studies that concluded due to dissimilar in management, enclosed and open sites significantly differ in woody species composition (Mengistu Asmamaw, 2011).

4.1.3. Vegetation Structure

4.1.3.1. Density of woody plant species

The overall density of woody species in Sire-Morose was 1901.25 per hectare with the proportion of seedlings (18.9%), saplings (30.8%) and trees (49.7%). Whereas, in Yaya-Dakabora it was 548.75 per hectare, of this constituted seedlings (9.8%), saplings (23%) and trees (67.2%) (Table 3). The density of each woody species category in Sire-Morose was higher than in Yaya-Dakabora. The finding of this study was in negotiate with the report by Lemma and Menfes (2015) who indicated that area closures with SWC on degraded hill-slope increased density of woody species. Whereas, in Yaya-Dakabora watershed had poor management practices so far and was open for disturbances. This finding from Yaya-Dakabora was in agreement with the study by Alemayehu Dechasa, (2009) which reported that fact that, disturbance caused reduction in woody plants density and impaired the natural regeneration including development of seedlings.

Table 4: Comparison of woody plants density in Sire-Morose and Yaya-Dakabora micro-watershed in Hidabu Abote district.

P.no	Sire-Morose micro-watershed				Yaya-Dakabora micro-watershed			
	Trees/Shrubs	Saplings	Seedlings	Total	Trees/Shrubs	Saplings	Seedlings	Total
1	29	28	17	74	12	5	-	17
2	35	27	15	77	14	6	2	22
3	37	21	19	77	12	6	3	21
4	39	22	16	77	19	4	1	24
5	36	29	14	79	15	3	2	20
6	43	23	12	78	17	5	1	23
7	47	19	11	77	19	2	-	21
8	49	16	10	75	13	7	4	24
9	53	24	13	90	16	6	2	24
10	51	27	10	88	19	4	2	25
11	54	25	8	87	16	5	13	24
12	51	24	8	83	18	4	2	24
13	45	20	7	72	15	4	3	22
14	41	28	14	83	17	3	4	24
15	37	23	14	74	18	4	2	24
16	30	26	15	71	14	5	2	21
17	29	24	19	72	12	9	2	23
18	22	22	21	65	9	8	-	17
19	17	26	24	67	11	5	5	21
20	14	21	20	55	9	6	3	18
Total	759	475	287	1521	295	101	43	439

4.1.3.2. Frequency

The species were identified from a total number of plots which was from 20 plots for each watershed. It was found that *Carissa spinarum* is the most frequent species (90%) occurring in 18 plots sampled followed by *Croton macrostachyus* (85%) recorded in 17 plots in Sire-Morose (Table 4). The recorded data was indicated that *Carissa spinarum* and *Croton macrostachyus* were the most frequent species than the other woody species found in Sire-Morose by comparison. Because, *Carissa spinarum* adapted easily to different

environmental conditions, spiny nature, and can resist other disturbances, whereas *Croton macrostachyus* was fast growth and drought hardiness, the tree is grown as a hedge plant and is suitable for intercropping and the leaves are used as green manure and fodder. It is also useful for reforestation of shifting sand dunes, degraded land, stabilizes and enriches the soil and provides shade in plantations.

Belete Kebede, (2012) cited in Birtukan Dufera, (2016) also reported that *Carissa spinarum* was the most frequent species followed by *Croton macrostachyus*. Because of its spiny nature, *Carissa spinarum* is not harvested for firewood, building, not browsed to others woody species and *Croton macrostachyus* are grows fast and is unpalatable to both wild and domestic animals. In Yaya-Dakabora *Croton macrostachyus* was the most frequent species (80%) occurring in 16 plots sampled followed by *Rhocissus tridentata* (75%) recorded in 15 plots (Table 5). Because *Rhocissus tridentata* was fast growing species.

Table 5: Frequency of top ten and nine distribution of most frequently occurring species

Sire-Morose micro-watershed		
Name of species	No of quadrants	Frequency (%)
<i>Carissa spinarum L.</i>	18	90
<i>Croton macrostachyus Del.</i>	17	85
<i>Eucalyptus globules</i>	16	80
<i>Albizia gummifera (J.F. Gmel.)CA.Smith</i>	15	75
<i>Acacia abyssinica Hochst. Ex Benth.</i>		
<i>Calupurnea aurea (Ait)</i>	14	70
<i>Podocarpus flactus (Thunb.) R.B ex</i>	13	65
<i>Mirb.</i>	13	65
<i>Rhus natalensis Bent hex Krauss</i>	12	60
<i>Lippia adoensis Hochst.ex Walp.</i>	12	60
<i>Olea africana Mill.</i>	11	55

Yaya-Dakabora micro-watershed

Name of species	No of quadrants	Frequency (%)
<i>Croton macrostachyus Del.</i>	16	80
<i>Rhocissus tridentate</i>	15	75
<i>Lippia adoensis Hochst.ex Walp.</i>	14	70
<i>Albizia gummifera (J.F. Gmel.)CA.Smith</i>	14	70
<i>Vernonia</i>	13	65
<i>Rhus natalensis Bent hex Krauss</i>	11	55
<i>Acacia abyssinica Hochst. Ex Benth.</i>	11	55
<i>Eucalyptus camaldulnesis</i>	10	50
<i>Eucalyptus globules</i>	10	50

4.1.4. Importance Value Index

The greatest IVI indicates the degree of abundance and dominance of a given species in relation to the other species. The computation of IVI showed that *Eucalyptus globulus* (18.87), *Albizia gummifera* (18.41) and *Carissa spinarum* (18.35) were most important species in Sire-Morose (Appendix 4), whereas *Albizia gummifera* (18.58), *Croton macrostachyus* (18.48) and *Carissa spinarum* (18.04) were important species in Yaya-Dakabora watershed (Appendix 5). The remaining species had low IVI values compared to the most dominant species. The higher IVI value of the species is related to the higher basal area, abundance, density and frequency distribution of the species of the two micro-watersheds. The less IVI values of species need more conservation and management practices than other dominant species in both micro-watersheds and the dominant species in both micro-watersheds also need conservation and management since their IVI values were very small.

4.2. Socio-economic Characteristics of Household Sample

4.2.1. Demographic Characteristics

House hold size: House hold is a demographic concept defined by different Scholars, as all persons those live in the same shelter unit and have common eating arrangements. The result of survey showed that the majority of households (67%) and (74.1 %) have (> 6) family members and (12%) and (3.7 %) had smallest number of family members (1-3) in Sire-Morose and Yaya-Dakabora respectively and the rest percent contain moderate number of

family members. The mean family size of adopters and non-adopters with standard deviation were 2.8 (0.5) and 2.2 (0.7) in Sire-Morose and 2.9 (0.25) and 2.4 (0.6) in Yaya-Dakabora, respectively (Appendix Table 6). The family size mean between the two groups being statistically highly significant at ($p < 0.01$) in both micro-watersheds (Appendix Table 6). The findings of this study are similar with the results of Mesele Negash (2014) in Toni sub-watershed indicating that large families can give more adopter that help in maintaining and repairing damaged SWC structures in sustainable way.

Age distribution: Age distribution is an important indicator of the demographic studies. The findings of the result stated that the largest proportion of the survey population falls in the age 40-60 (about 72% and 69%) in Sire-Morose and Yaya-Dakabora respectively. The mean ages of adopters and non adopters with standard deviation were 43 (3.2) and 49 (6.7) years in Sire-Morose, and 42 (7.7) and 48 (7.3) years in Yaya-Dakabora respectively (Appendix Table 6). The result indicated that there, was statistically significant divergence between ages of two groups in both micro-watersheds at ($p < 0.01$) and related negatively with adoption of SWC. Farmers in this age group are assumed to have a good understanding about the contribution of watershed development for rehabilitation of degraded land, so that they usually more interested in participation of watershed management activities. The result of study was contradict with the finding of Birtukan Dufera (2016) who showed that age of individuals or respondents may not be important for SWC practices.

Marital status: Of the total heads of households or respondents surveyed 78% and 87% were married in Sire-Morose and Yaya-Dakabora respectively. The mean of marital status with standard deviation of the respondents were 2.1(0.3) for adopters and 2.4 (0.6) for non adopters in Sire-Morose and 2.1 (0.4) for adopters and 2.0 (0.4) for non adopters in Yaya-Dakabora (Appendix Table 6). The mean difference between the two categories was statistically significant in Sire-Morose at ($p < 0.05$) and insignificant in Yaya-Dakabora. This showed that the mean of marital status may not or might be influencing soil and water conservation practices in two Micro-watersheds.

Educational Status: As the result of study indicated that 70 percent and 57.4 percent of the respondents were uneducated (meaning no formal education) in Sire-Morose and Yaya-Dakabora, respectively. Large group of the respondents in the study watershed were illiterate (no formal education). The mean educational level of adopters and non-adopters with standard deviation were 0.8 (0.5) and 0.4 (0.2) in Sire-Morose, and 0.7 (0.4) and 0.5 (0.3) in

Yaya-Dakabora respectively (Appendix Table 6). The educational status among the two groups were statistically highly significant in Sire-Morose and significant in Yaya-Dakabora at ($p < 0.01$) and ($p < 0.05$) respectively. The study result showed that literate farmers are more participate in watershed development and environmental conservation in many directions than illiterate farmers. The current result is similar with the findings of result reported by Addisu Damtew (2011) which stated that the educational status increase the ways of using natural resources in sustainable manner and environmental conservation.

Farm land size: Farm size of the sample house hold was assessed and the result indicates that 68% and 72.2% respondents have owned less than one hectare in Sire-Morose and Yaya-Dakabora, respectively. This indicates that respondents in both Micro-watersheds had holding very small sized farm land. The mean of land holding within the standard deviation of the respondents were 1.8 (0.87) hectare for the adopters and 1.06 (0.24) hectare for non-adopters in Sire-Morose and 1.9(1) hectare for adopters and 1 (0.4) hectare for non-adopters in Yaya-Dakabora (Appendix Table 6). The mean difference land holding among adopters and non-adopters found to be statistically highly significant in both Micro-watersheds at ($p < 0.01$) (Appendix Table 6). The result implies that farmers those have owned large farm land had big interest to SWC practices than those who owned small farm land because; farmers have different category of land for different purpose at different topography of land slope. The study result was the same with reported findings of Mushir Ali (2012) revealed that farmers owned smaller farm land have less interest to participate in SWC practices.

Distance to the market: There is a maximum and minimum trip of journey that took the respondents from their house to the market based on the time to travel the distance. Therefore 75 and 280 minutes for Sire-Morose, and 80 and 220 minutes for Yaya-Dakabora. The required average time for respondents to travel to the market with standard deviation were 145 (40) minutes for adaptors and 115 (20) minutes for non-adopters in Sire-Morose and 151 (38) minutes for non-adopters and 113 (26) minutes for non-adopters in Yaya-Dakabora (Appendix table 6). The analysis of result showed that there were statistically highly significant mean differences both groups in the two Micro-watersheds at probability level ($p < 0.01$).

Gender of respondents: The population of sample respondents showed that in both Micro-watersheds, the greater bias is towards the male (Table 6). This implies that sex did not influence the activity of environmental conservation practices which is a base of

rehabilitation of degraded land. The result was in agreement with the finding of Aselefech Tadesse (2011) sex did not affect the adoption of environmental protection.

Table 6: Gender wise sample population of the household surveyed.

Sex category	Sire-Morose		Yaya-Dakabora	
	Number	%	Number	%
Male	54	78.3	44	81.5
Female	15	21.7	10	18.5
Total	69	100	54	100

Source household survey, 2019/20

4.2.2. Components of watershed management

Watershed management was an integral unit of resource management for common benefits for local community in both micro-watersheds. The majority of respondents (52.2%) in Sire-Morose said that, watershed management was the combination of biomass, land and water resources management, and majority of the respondents (53.7%) in Yaya-Dakabora did not understand and define watershed management is as well (Table 7). In Sire-Morose most of the respondents understood watershed management as integrated resource management as they had better awareness on management interventions of micro-watersheds. In Yaya-Dakabora IWM practices was not observed.

Table 7: Understanding the meaning of watershed management by respondents.

Variable	Sire-Morose		Yaya-Dakabora	
	Frequency	%	Frequency	%
Meaning of watershed management				
Biomass management	8	11.6	7	13
Land management	16	23.2	12	22.2
Water management	5	7.2	6	11.1
Combination of three	36	52.2	0	0
I do not know	4	5.8	29	53.7
Total	69	100	54	100

4.3. Rehabilitation of Degraded Land Practices in the Watershed

Key informants and focus group discussion indicated that before watershed management ecosystem disasters became a major problem in both micro-watersheds. The reason behind this problem was farmers were highly depending up on natural resources in a very traditional and unwise manner. Additionally, there were no organized and programme based conservation operations. By considering the problem of ecosystem disasters, due to land degradation, watershed management practices were undertaken in Sire-Morose. According to survey, the majority of farmers (66.7%) of the total respondents had perceptions about regeneration of fragmented land practices in Sire-Morose (87.2%) were adopters and (40%) were non-adopters indicated that change has been registered on regeneration of fragmented land practices through watershed management by physical and biological conservation activities (Table 8). Among the total respondent (51.9%) of the farmers had no concept about practices of rehabilitating fragmented land and 71.4% were adopters and (30.8%) were non-adopters in Yaya-Dakabora (Table 8).

Majority of farmers in Sire-Morose were adopter and in Yaya-Dakabora majority of farmers were non-adopters. The result from chi-square test indicated that there were statistically highly significant ($\chi^2=20.2$ and 9.01) differences between the two groups at ($p<0.01$) in Sire-Morose and Yaya-Dakabora respectively (Table 8). This showed that rehabilitation of degraded land and adoptability of soil and water conservation was direct and positive relationship. The result was similar to the finding result of Melese Erwaro, (2014) stated that ecosystem disaster due to land degradation can be rehabilitated by adoption of mechanical and biological SWC conservation practices.

According to respondent answered the combination of biological and mechanical SWC activities (53.6%) were the major regeneration of fragmented land activities in Sire-Morose and traditional SWC activities (68.5%) were the major ecosystem regeneration activities in Yaya-Dakabora (Table 8). WSM intervention integrated the regeneration of degraded land activities for common out puts which strengths the structure and continuity for a long period of time as compared to Yaya-Dakabora. Area closure is one of the factors that play a role for ecosystem regeneration practices in Sire-Morose which increased the reversing of woody species, fodder of livestock, soil fertility, habitat for wild animals and plants and totally ecological and economical benefit for the local community.

Table 8: Rehabilitation of degraded land practices by sample households

Sire-Morose							
Rehabilitation of degraded land practices	Adopters (39)		Non-adopters (30)		Total		X ² value
	Number	%	Number	%	Number	%	
Yes	34	87.2	12	40	46	66.7	20.2****
No	5	12.8	18	60	23	33.3	
Total	39	100	30	100	69	100	
Yaya-Dakabora							
Rehabilitation of degraded land practices	Adopters (28)		Non-adopters (26)		Total		X ² value
	Number	%	Number	%	Number	%	
Yes	20	71.4	8	30.8	28	51.9	22.2****
No	8	28.6	18	69.2	26	48.1	
Total	28	100	26	100	54	100	
Main Rehabilitation of degraded land systems	Sire-Morose			Yaya-Dakabora			
	Frequency		%	Frequency		%	
Improved biological SWC measures	8		11.6	6		11.1	
Improved mechanical SWC measures	20		29	11		20.4	
Integration of biological and mechanical SWC measures	37		53.6	0		0	
Traditional SWC measures	4		5.8	37		68.5	
Total	69		100	54		100	

Note: **** = Significant (P<0.01)

4.3.1. Soil Fertility Management Practices

According to sampled household survey, one of the serious problems that affected the agricultural land was soil fertility decline as expressed by large group of farmers in Sire-

Morose and most of farmers in Yaya-Dakabora (Table 9). According to the result of study, 43.5% of sample household in Sire-Morose and 83.3% in Yaya-Dakabora indicated soil fertility decline was considered as a problem (Table 9). Because of poor soil management practices intervention and lack of awareness of local community decline of soil fertility was high in Yaya-Dakabora compared to Sire-Morose. In both micro-watersheds farmers used fertilizer, manure, crop residues, crop rotation, fallowing and compost for soil fertility management, From the practices involved for soil fertility management crop rotation was the major as (30.4%) and (50%) respondents replied in Sire-Morose and Yaya-Dakabora Respectively followed by fertilizer application (Table 9). But due to shortage of lands some farmers did not use crop rotation.

The survey result of current study showed that sample households in both Micro-watersheds classified their soil fertility in to good, moderate and poor categories, and relatively majority of household respondents (47.8%) in Sire-Morose responded that soil fertility category as moderate (Table 9. On the other hand this indicated that WSM practices had brought soil fertility improvement which is a base for rehabilitation of degraded land and plays a great role in improving the income source of farmers in many directions. This finding is consistent with findings of Tesfaye Habtamu, (2011) that indicated WSM improve soil fertility status. In Yaya-Dakabora high percentage of respondents (64.8%) replied that soil fertility was poor due to lack of soil and water conservation measures (Table 9).

Table 9: Distribution of respondents by category of soil fertility decline and management

Indicators	Sire-Morose		Yaya-Dakabora	
	Frequency	%	Frequency	%
Perceive soil fertility decline				
Yes	30	43.5	45	83.3
No	39	56.5	9	16.7
Total	69	100	54	100
Management of soil fertility				
Crop rotation	21	30.4	27	50
Using manure	9	13	3	5.6
Apply fertilizer	17	24.6	17	31.5
Fallowing	4	5.8	5	9.3
Using compost	13	18.8	0	0
Apply crop residue	5	7.2	2	3.7
Total	69	100	54	100
Category of soil fertility				
Good	22	31.9	10	18.5
Moderate	33	47.8	9	16.7
Poor	14	20.3	35	64.8
Total	69	100	54	100

4.4. Impacts of Watershed Management

4.4.1. Impacts on households' income

WSM increased the benefit obtained from agriculture and income of households, while protecting the sustainability and ecological function of the environment. According to data obtained from Hidabu Abote District office, most farmers in both micro-watersheds practiced a subsistence mixed farming system which involves crop production and livestock production. The main income source of sample household respondents were livestock production, crop production, employed earning by salaries, natural resource use, vegetable production, safety net programme and from off-farm activities (Table 10). The majority source of incomes of households were from crop production (44.9%) and (53.7%) in Sire-

Morose and Yaya-Dakabora respectively which followed by animal production (Table 10). This showed that WSM had a positive impact on income sources.

According to focus group discussion and key informant in Sire-Morose explained WSMPs increased the employment chances for poor farmers by creating different work activities related to agriculture such as, afforestation, animal fating, bee keeping and small enterprises. The SWC practices like water storage mechanical structures and gully control structures were build on fields, which provided additional job chances to the small and marginal farmers. Additionally migration of farmers from rural to urban decreased due to the creation of additional employment chances. In general WSM was economical feasible and have positive impacts on crop production, create employment chance, decrease erosion and natural resource disasters, vegetation cover, decrease emigration, increase water resource demand, lay a base for growth of diversified crops, and decrease bare land place of the watershed. In untreated watershed Yaya-Dakabora all the mentioned change did not observed due to poor awareness and lack of management activities.

Table 10: Distribution of sample households in terms of income sources

Income source	Sire-Morose		Yaya-Dakabora	
	Frequency	%	Frequency	%
Natural resource	4	5.8	9	16.7
Crop production	31	44.9	29	53.7
Animal production	16	23.2	10	18.5
Vegetable production	14	20.3	5	9.3
Employed earning	2	2.9	0	0
Safety-net program	2	2.9	0	0
Off-farm activities	0	0	1	1.8
Total	69	100	54	100

The current survey result indicated that, the sample house hold incomes of some respondents were improved. According to the result (74%) and (29.6%) of sample household respondents' incomes were improved and (26%) and (70.4%) of sample household respondents were not improved in Sire-Morose and Yaya-Dakabora respectively (Table 11). A base for the improvement of majority percent of income in Sire-Morose was due to capacitating the WSM in habitants by introducing alternative technologies that provide multipurpose in many

direction like provision of improved crop seeds and vegetable varieties, introduction of irrigation schemes, improved farming styles and implementation of SWC measures, in addition which improve soil fertility and decrease removal of soil by erosion as compared to Yaya-Dakabora. The finding was agreement with the finding result of Tesfaye Habtamu, 2011) in Lenche Dima, Tsegur Dijjil watershed showed WSMPs improve the household income at different level.

Sample household respondents were replied different reasons that household incomes were not improved (Table 11). For both Micro-watersheds the main reasons included poor environmental conservation and unwise use of natural resources, poor quality of seed and fertilizer, shortage of water resource and problem of soil fertility were the main reasons that made the sample household were not improved. According to the survey result (62.5%) of respondents in Sire-Morose replied as soil fertility problems and (50%) of respondent in Yaya-Dakabora replied as lack of SWC measures (Table 11). But, in Yaya-Dakabora there were no technological intervention as compared to Sire-Morose.

Table 11: Factors affecting household incomes in both Micro-watersheds

Indicator	Sire-Morose		Yaya-Dakabora	
	Frequency	%	Frequency	%
Improved HH incomes				
Yes	53	76.8	14	25.9
No	16	23.2	40	74.1
Total	69	100	54	100
Reasons for not improved	Frequency	%	Frequency	%
Lack of SWC measures	2	12.5	20	50
Soil fertility problem	10	62.5	2	5
Poor quality of seed and fertilizer	4	25	4	10
Shortage of water	0	0	14	35
Total	16	100	40	100

4.4.2. Impacts on Crop Production

According to the survey, in both micro-watersheds crop production was the most important source of household incomes. The main crop production types in both micro-watersheds were cereals crops such as teff (*Eragrostis tef*), wheat (*Triticum vulgare*), barely (*Hordeum vulgare*) maize (*Zea mays*), beans (*Vicia faba*), peas (*Pisum sativum*), and vegetable such as potato (*Solanum tuberosum*), onion (*Allium cepa*), garlic (*Allium sativum*), carrot (*Daucus carota var. sativa*), tomato (*Solanum lycopersicum*) and cabbage (*oleraceavar capitata*). Due to similar agro-ecological zone the crops produced in both micro-watersheds were the same. The major crops grown in both micro-watersheds were teff followed by Wheat.

Based on the assessment of local households, and as the cost was calculated based on current market prices the total income from crop production in Sire-Morose was 109100(64.2%) Birr per household per year and in Yaya-Dakabora it was 60750 (35.8%) Birr per household per year (Table 12). There were great differences between both Micro-watersheds which accounted as 48,350 (28.4%) Birr per household per year. Depending on income differences of households per year from crop production it was easy to say that WSM implementation raised crop production income in Sire-Morose as compared to Yaya-Dakabora. The current study result was supported by the finding of (Gerbe-Mariam Yaebiyo, 2015) revealed that watershed management has positive and significant impact on major crops due to increase in soil fertility in treated micro-watersheds as compared to untreated micro-watersheds. Even though in Yaya-Dakabora farmers grow a number of crops, but due to lack of SWC practices which in turn increased soil erosion problems they obtained very low crop yields, whereas the reverse is true in Sire-Morose. Because of WSM measures changed the attitude of community towards the construction of different stone and soil bunds which in turn decreased soil erosion and raised crop yields. This result was supported by the finding of Meaza Hadush, 2015) which depicted that crop production and SWC practices have positive relationship.

According to FGD and key informant in Sire-Morose the income obtained from crop production was increased, which was attributed to the adoption and introduction of WSM practices. From field visit and the same source of further information it has been informed that the conservation measures such as soil and stone bunds that have been implemented were brought as increased soil fertility, soil moisture, surface and ground water availability, decrease removal of soil by erosion, regenerate ecosystem and improved crop management

practices. But from the key informant and focal group discussion in Yaya-Dakabora crop production was decreasing from time to time, in turn which resulted in declined of household income, migration and shortage of food.

Table 12: Average crop production and income per household in Sire-Morose and YayaMuka

Types of crop	Sire-Morose		Yaya-Dakabora	
	Production (Qt/year)	Income per household/year (in birr)	Production (Qt/year)	Income per household/year (in birr)
Teff	8.5	38250	5	22500
Wheat	12	28800	7	16800
Vegetable	6	8400	3	4200
Barley	5	9000	3	5400
Beans and peans	4	16000	2	8000
Maize	3	3900	1.5	1950
Sorghum	2.5	4750	1	1900
Total	41	109100	22.5	60750

4.4.3. Impact on Livestock

Based on survey in both micro-watersheds livestock owned across all sample households is given in (Table 13). Livestock populations was a necessary portion of the farming system and sample farmers rear livestock for various purposes, including draught power, milk, meat, eggs, transport and other purposes or exchange for cash or other production assets. In both micro-watersheds sheep, cattle, goats, horse, donkey and poultry has been raised for both commercial purposes and source of food. Sampled household farmers livestock ownership is measured by the average amount of Tropical Livestock Unit (TLU). The total livestock number in Sire-Morose was 349.5 TLU and 465.31 TLU in Yaya-Dakabora for sampled households (Table 13). This surveyed result showed that intervention of WSM activities reduced number of livestock in Sire-Morose by 115.81 TLU from the number of livestock registered in Yaya-Dakabora. Especially the radical change was observed on sheep and goat numbers due to completely protected from grazing land which was under area closure. Because they decrease the seedling survival of plant species and fertility of top soil which cause land degradation problems and finally resulted in disasters of biodiversity.

The contributions of WSM were promoted less livestock holding that depends on the quality and productivity of the livestock. Similar the management also promoted the cut and carry practice of feeding system which discourages the livestock mobility and number. This is done to limit dependence of domesticated animals on grazing land and it produce suitable condition for environmental protection and rehabilitation of degraded land. From this idea it could be inferred that implementation of WSM technology play a role to hold less livestock so that the quality could be managed and productive value obtained from livestock was increased. The finding result was similar with the finding of Meaza Hadush (2015) stated that the number and size of livestock units per households were found to be higher in un treated watershed than in treated watershed due to closure to grazing areas as a result of social fencing adopted by hill resource management society.

It was possible, based on information gathered from key informants and FGD in Sire-Morose to conclude that WSM intervention reduced the number of livestock and contributes to livestock management by providing fodder. But as information gathered from FGD and key informants in Yaya-Dakabora indicated the number of livestock was high and did not balance with the carrying capacity of the area, so that it increase grazing land degradation. The result was in line with finding of Birtukan Dufera (2016) revealed that shortage of grazing land, shortage of food, and poor quality of grass were the most often mentioned indicators for the deterioration of grazing land. The general characteristics of livestock feed sources, grazing land condition and number of livestock triggered land degradation.

Table 13: Type and number of livestock production by sampled households

Livestock population	Sire-Morose			Yaya-Dakabora		
	Number of livestock	TLU*	Total TLU	Number of livestock	TLU*	Total TLU
Cattle	252	1	252	324	1	324
Calves	52	0.25	13	76	0.25	19
Sheep	251	0.13	32.6	287	0.13	37.3
Goat	125	0.13	16.3	245	0.13	31.9
Donkey	34	0.7	23.8	45	0.7	31.5
Horse	6	1.1	6.6	14	1.1	15.4
Poultry	524	0.01	5.2	621	0.01	6.21
Total	1244		349.5	1612		465.31

Note- Conversion factor used in to TLU was: cattle = 1, sheep and goats = 0.13, horse = 1.1, donkey = 0.7, poultry = 0.01 (adapted from) (Storck et al., 1991).

4.4.4. Impact on Ground Water Recharges and Water Availability

The important major impact of WSM intervention was improving surface and ground water availability. Increased water availability play a great role in improving local households' income, used for irrigation purpose and improve the quantity and quality of crop production. In order to evaluate the impact of WSM in improving local households,' accesses to water availability, local households' source of water availability were collected. Accordingly, in Sire-Morose (72.5%) of respondents got access to water and (27.5%) of respondents did not have access to water, whereas, in Yaya-Dakabora (14.8%) of respondents got access to water and (85.2%) of respondents did not have access to water (Table 14). As it was observed there were differences between both Micro-watersheds due to management intervention in Sire-Morose that rehabilitate degraded ecosystem and increased the availability of natural resource, in turn that increased the percolation of water, attract the rainfall and finally laid a base and contribute towards accumulation of ground water. The result was similar with the finding of Pathak *et al.* (2013) indicated as various in-situ and ex-situ soil and water conservation measure significantly increased ground and surface water.

According to information gathered from respondents in Sire-Morose (62.3%) of sampled households utilized water from hand dug well and (65%) of respondents in Yaya-Dakabora was utilized spring (Table 14). Based on the surveyed result it was easily to conclude that SWC practices in Sire-Morose improve the quantity and quality of ground and surface of water. Key informants and FGD in Sire-Morose demonstrated, SWC measures has a great contribution in allowing rainfall to infiltrate that otherwise wasted as surface runoff and thus enhanced and keep soil moisture content and in other case increased surface and ground water accessibility. But in Yaya-Dakabora FGD did not know the relationship between WSM and the availability of surface and ground water.

Watershed management had an effect in increasing and improving source of water demand which increase the demand for the use of irrigation purpose. As a surveyed result indicated in Sire-Morose (68.1%) of sampled household used water for irrigation purpose from natural regenerate and harvesting water during rainy season and in Yaya-Dakabora only (9.3%) of sampled household used water for irrigation purpose (Table 14). Availability of adequate water resource and technological access in addition to irrigation geared household's perception toward vegetation production in Sire-Morose as compared to Yaya-Dakabora.

This showed that intervention of WSM had positive impact on the use of water resources. In the same way, Tirez Negusse, (2013) SWC improve the ground water availability in the downstream of the catchment that increase accessibility of water in the catchment by 17.6% of the average annual rainfall of the catchment and the hand dug wells and farmers currently utilizing water for irrigation purpose.

In this study, the required minimum and maximum time ranges to fetch drinking water from lake, natural ponds and river were assessed in both Micro-watersheds. Accordingly, 8 and 25 minutes in Sire-Morose, and 35 and 60 minutes in Yaya-Dakabora respectively (Table 14). This showed that WSM measures and time required to fetch water was negatively interrelated with each other means that due to construction of hand dung well surrounding their home the time required in searching of water was minimum in Sire-Morose as compared to Yaya-Dakabora. The trip to fetch water is the most time consuming tasks that the farmer faced in Yaya-Dakabora. The result was similar with the finding of Sebhatu Seyoum, (2010), revealed that WSM intervention reduce the time consumed for fetch water in treated watershed as compared to untreated Micro-watersheds due to construction of hand well dug surrounding the their residence.

Table 14: Response of sample household for access, source and purpose of water availability

Variables	Sire-Morose		Yaya-Dakabora	
	Frequency	%	Frequency	%
Access to clean water				
Yes	49	71	10	18.5
No	20	29	44	81.5
Total	69	100	54	100
Major source of water	Frequency	%	Frequency	%
Spring/protected	19	27.5	36	66.7
Spring/unprotected	5	7.2	3	5.6
Hand well dug	42	60.9	2	3.7
River	3	4.3	13	24
Total	69	100	54	100
Purpose of water	Frequency	%	Frequency	%
Irrigation	50	72.5	4	7.4
Domestic use	19	27.5	50	92.6
Total	69	100	54	100
Time taken to fetch water	Minimum	Maximum	Minimum	Maximum
	8'	25'	35'	60'

4.5. Environmental Change Observed in Watershed

Watershed management measures have great value to reduce ecosystem disasters and conserve natural resources. As FGD and key informants explained in Sire-Morose, an intervention of WSM raised local community participation towards plantation of plant species, afforestation, and regenerate of degraded lands, decreased soil loss by erosion, improves vegetation cover in environment as compared to Yaya-Dakabora. On the other hand, when vegetation cover increased in environment bee keeping activities were expanded and livestock fodder production also increased.

According to perception of sample households on trends of rehabilitation of degraded land was manifested by stating their understanding as increasing, decreasing or no change. As indicated in Table 15, (73.9%) respondents in Sire-Morose responded that rehabilitation of ecosystem has been increased. In Yaya-Dakabora (77.8%) of respondents replied that, rehabilitation of degraded land reduced from time to time. WSM geared the community towards the implementation of land management activities and increased the awareness for community.

The effects of rehabilitation of degraded land works need a long period of time to be appreciable by the community and managed in sustainable manner. According to information gathered from sample households the most visible change observed by farmers were increased water source, decrease loss of soil and increase vegetation cover of lands in Sire-Morose, but in Yaya-Dakabora there was no observed change (Table 15). Accordingly, in Sire-Morose reduce soil erosion (76.8%) was the major changed observed because of WSM measures followed by vegetation cover of lands. The surveyed result similar with the finding of Fikir *et al.* (2009) that revealed the reduction of soil erosion, and increased soil moisture availability which could be explained by the increase in crops production are the major observed changes after the IWSM implemented.

The observed changes as a result of WSM intervention explained by focal group discussion were: decrease soil erosion, regeneration of natural resources, increase quality and quantity of water, increase vegetation cover of land, improved crop production and availability of fodder for livestock increase. As a result of WSM implementation the physical environment was green as compared to before management intervention and this indicates that WSM have great role for existence of biodiversity and rehabilitation of degraded land in sustainable way.

Table 15: Observed change due to rehabilitation measures in Sire-Morose Micro-watersheds

Indicators	Sire-Morose		Yaya-Dakabora	
	Frequency	%	Frequency	%
Ecosystem regeneration measures over time				
Increasing	51	73.9	0	0
Decreasing	11	15.9	42	77.8
No change	7	10.1	12	22.2
Total	69	100	54	100
Change observed	Frequency	%	Frequency	%
Decrease soil erosion	53	76.8	0	0
Vegetation cover of land increase	10	14.5	0	0
Water availability increased	6	8.7	0	0
No change at all	0	0	54	100
Total	69	100	54	100

4.6. Perception of Farmers on Land Degradation

4.6.1. Land Degradation Problems

As high percent of sample households mentioned, because of unwise use of land and continuous cultivation of marginal lands, land was degraded from time to time which was a main case for biodiversity loss. According to sample households' (69.6%) and (79.6%) explained that degradation of land is a main problem in Sire-Morose and Yaya-Dakabora respectively. Due to implementation of different SWC measures land degradation in Sire-Morose was decreased as compared to Yaya-Dakabora. According to the survey, in both Micro-watersheds there were land degradation problems. The result of chi-square test showed that there were statistically high significant ($\chi^2=18.8$ and $\chi^2=3.9$) between adopters and non-adopters at ($p<0.01$) in Sire-Morose and at ($p<0.05$) in Yaya-Dakabora respectively (Table 16). The finding of result showed that awareness of local community toward land degradation, using modern alternative technology measures rather than traditional once was increased the adoption of SWC measure practices.

Table 16: Response of sample households for land degradation problems

Land degradation problem	Sire-Morose				X ²	Yaya-Dakabora				X ²
	Adopters(39)		Non-adopters(30)			Adopters (28)		Non-adopters(26)		
	No	%	No	%		No	%	No	%	
Yes	36	92.3	13	43.3	18.8***	25	89.3	19	73.1	3.9**
No	3	7.7	17	56.7		3	10.7	7	26.9	
Total	39	100	30	100		28	100	26	100	

Note: ** = significant (P<0.05) and *** = significant (P<0.01)

4.6.2. Causes of Land Degradation in both Micro-watersheds

According to information gathered from respondents the source of land degradation in both Micro-watersheds were: deforestation, over grazing, population growth, and lack of adoption of SWC measures, inappropriate farming styles, loss of soil by erosion and ploughing marginal land. As respondents replied (42%) in Sire-Morose and (55.6%) in Yaya-Dakabora soil erosion followed by population growth were the major cause of land degradation (Table 17). Accordingly, (40.6%) and (81.5%) respondents stated that there were deforestation problems in Sire-Morose and Yaya-Dakabora respectively (Table 17). As assessment was made, Yaya-Dakabora watershed were more deforested than Sire-Morose, due to implementation of WSM measures in Sire-Morose not only decreased land degradation problems but also decreased the loss of biodiversity, ecosystem disasters and deforestation of forest by giving alternative source of fuels and source of income which decrease dependency on forest resources. On the other hand this implies that WSM practices play a major role for existence of biodiversity and rehabilitation of degraded land.

Some of the reasons for deforestation of forests, as sample household expressed were conversion to arable lands, using trees for fire wood, timber and charcoal, income source by selling a tree as a wood and construction purposes. As information gathered from respondents in Sire-Morose the major reason for deforestation were used for arable lands (40.6%) and in Yaya-Dakabora used forest products as a main source of income (53.7%) (Table 17). As FGD

during discussion mentioned high demand for farm land by farmers was a main reason for deforestation of forest.

Generally, the effect of deforestation was loss of biodiversity and degrades forest lands and finally might lead to change the biological and physic-chemical attributes of land soil and produce appropriate condition for loss of soil by erosion and lowering of soil quality as sample households replied in both Micro-watersheds. According to survey, in both Micro-watersheds loss of soil by water erosion was a major and common happened problem. As respondents replied (87%) of sample households in Sire-Morose and (90.7%) of respondents in Yaya-Dakabora implied that loss of soil by water erosion was the major and most common types of soil erosion problems. The study result supported by the finding of (Addise Ermias, 2014) who revealed that the most of soil erosion problem was caused by water agents.

Loss of biodiversity, decreases number of animals, shortage of land and declining of quantity and quality of crop productivity were the main consequences of land degradation problem expressed by sample households. The current result indicated that the most common consequences of land degradation problems were decreasing (43.5%) in Sire-Morose and (74.1%) in Yaya-Dakabora (Table 17). As a result of implemented biological and mechanical SWC measures such as: stone bunds, soil bunds, terracing, micro-basin, decreasing quantity and quality of crop productivity in Sire-Morose was decreased as compared to Yaya-Dakabora. The study result supported by the finding of Samuel Chala, (2013) who confirmed that most prevalent causes of land degradation is soil erosion and the final result of land degradation was declining quantity and quality of crop productivity. As focal group discussion stated most of the farmers living style were deteriorating from time to time due to problems of land degradation and most farmers were migrated to urban or other places for survival by leaving their land. According to FGD replied that even if the farmers got the place, their social life status was never returned to its previous condition.

As sample household indicated the degree of land degradation problem was categorized as severe, medium and low. As most of respondent stated the degradation of land in Sire-Morose was low (49.3%) and in Yaya-Dakabora it was high (70.4%) (Table 17). The result indicated that WSM measures reduce the degradation of land and increased the regeneration of land in turn increased rehabilitation of degraded land in Sire-Morose by re-forestation, establishing mechanical SWC structures integrated with planting of different moisture

absorbing plants which is decreasing loss of soil by erosion and in other case reduce land degradation problems.

Table 17: Summary of sample households' awareness on land degradation problems

Variables	Sire-Morose		Yaya-Dakabora	
	Frequency	%	Frequency	%
Cause of land degradation				
Soil erosion	31	44.9	31	57.4
Population growth	15	21.7	9	16.7
Inappropriate farming styles	7	10.1	2	3.7
Ploughing marginal land	5	7.2	1	1.9
Lack of adoption of SWC measures	5	7.2	2	3.7
Deforestation	4	5.8	6	11.1
Over grazing	2	2.9	3	5.6
Deforestation of forest	Frequency	%	Frequency	%
Yes	26	37.7	42	77.8
No	43	62.3	12	22.2
Reason for deforestation	Frequency	%	Frequency	%
Use for arable land	29	42	11	20.4
Use for fire wood	17	24.6	7	13
Use for construction purpose	14	20.3	6	11.1
Use as a source income	9	13	30	55.6
Types of soil erosion	Frequency	%	Frequency	%
Soil erosion by water	62	89.9	48	88.9
Soil erosion by wind	7	10.1	6	11.1
Consequence of land degradation	Frequency	%	Frequency	%
Decreasing of crop productivity	32	46.4	39	72.2
Decrease number of animals	18	26.1	4	7.4
Shortage of lands	13	18.8	6	11.1
Loss of biodiversity	6	8.7	5	9.3
Degree of land degradation	Frequency	%	Frequency	%
High	9	13	40	74.1
Medium	22	31.9	11	20.4
Low	38	55.1	3	5.6
Total	69	100	54	100

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Watershed management activities played an important role for existence of biodiversity in sustainable way and to enhance regeneration of degraded land and improve species composition of wood plant diversity. Most of woody plant species of Sire-Morose (treated) watershed have better distribution, good rehabilitation status and production in their individual than in the Yaya-Dakabora (untreated) micro-watershed. This result showed that watershed practices have encouraging effect on vegetation parameters such as on species diversity, evenness, density and richness.

The sampled household in both micro-watersheds perceived about the problems, causes and consequences of land degradation and agreed that deforestation, growth, overgrazing, ploughing marginal land, lack of adoption of SWC measures, inappropriate farming styles and loss of soil by erosion were the major causes for land degradation problems and consequences of land degradation were loss biodiversity, ecosystem disasters, shortage of land, decrease number of animals and decreasing crop productivity and the degree of land degradation was classified as high, medium and low in both micro-watersheds.

The major factor affect the adoptability of WSMPs are age, sex, marital status, educational status, size of farm land, slop of land, perception of land degradation problems and distance from home to markets. Farmers perceive the WSMPs rehabilitate degraded lands, improve crop productivity, natural resource recovery, animal productivity, access to water resource, improve household income and increase SWC measures and finally they perceive that WSM play a major role for existence of biodiversity and rehabilitation of degraded land.

The environmental changes observed due to WSMPs are increase rehabilitation of ecosystem by integration of biological and mechanical SWC activities and reduce loss of soil by erosion and keep the soil fertility. The problems of SWC measures are reduce farm land, source of rodents, difficult to turn oxen and labor intensive.

Generally, the findings indicated that, perception, participation and maintenance of implemented WSMPs by respondents were not appreciable in both micro-watersheds. But relatively the interventions of WSMP increase the perception and maintenance of SWC in Sire-Morose as compared to non intervention WSMPs in Yaya-Dakabora.

5.2. Recommendations

Based on the results of the study the following points are recommended.

- Forest resources development program, protection and use strategies need to be devised for reducing the disappearance of woody plant species.
- Intervention of WSM in untreated (Yaya-Dakabora) micro-watershed and rehabilitation of ecosystem through biological and mechanical SWC measures is better option to assist the regeneration of woody plant species.
- For successful implementation of SWC technology, any program needs to be designed and implemented through multi-sectoral type of community based organizations.
- Impacts of WSMPs should be evaluated and monitored through time.
- Factors affecting adoption of SWC measures should be address by concerned stakeholders and partners found at different levels.
- Creating awareness on the various uses of natural resources so as to utilize them wisely.
- There is a need for more thrust on community participation from local administration as well as development agents for the ongoing WSMPs in the district.
- The planning and management of watershed should be based on research works and therefore, more basic research should be continued.

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7. APENDICES

1: List of woody plant species identified in Sire-Morose and Yaya-Dakabora micro-watersheds

Scientific name	Family	Local name	Habit	Watershed (P = present; A = absent)	
				Sire-Morose	Yaya-Dakabora
<i>Acacia abyssinica</i> Hochst. Ex Benth.	Fabaceae	Laaftoo adii	T	P	P
<i>Acacia brevispica</i> Harms	Fabaceae	Harangama	Sh/C	P	A
<i>Acacia etabaica</i> Schweinf.	Fabaceae	Alanqabeessa	T	P	A
<i>Acacia persiciflora</i> Pax	Fabaceae	Garbii	T	P	P
<i>Acanthus eminens</i> C.B. Clark	Acanthaceae	Sokorruu	Sh	P	P
<i>Albizia gummifera</i> (J.F. Gmel.)CA.Smith	Fabaceae	Mukarbaa	T	P	P
<i>Apodytes dimidiata</i> E.Mey.ex Arn	Icacinaceae	Calalaqa	T	P	P
<i>Bersama abyssinica</i> Fresen.	Melanthaceae	Lolchiisaa	Sh/T	P	P
<i>Buddleja davidii</i> Franch.	Loganiaceae	Adaaddii	Sh	P	P
<i>Calupurnea aurea</i> (Ait) Benth.	Fabaceae	Ceekaa	T	P	P
<i>Carissa spinarum</i> L.	Apocyanaceae	Agamsa	Sh/T	P	P
<i>Cordia africana</i> Lam	Boraginaceae	Waddeessa	T	P	A
<i>Croton macrostachyus</i> Del.	Euphorbiaceae	Bakkanniisa	T	P	P
<i>Dodonea angustifolia</i> L.f.	Sapindaceae	Ittacha	Sh/T	P	P
<i>Ekebergia capensis</i> Sparrm	Meliaceae	Somboo	T	P	P
<i>Eucalyptus camaldulnesis</i> Dehnh.	Myrtaceae	Bargamoo gurracha	T	P	P

<i>Eucalyptus globulus</i> Labill.	Myrtaceae	Bargamoo diimaa	T	P	P
<i>Ficus sur</i> Forssk	Moraceae	Harbuu	T	P	P
<i>Ficus vasta</i> Forssk	Moraceae	Qilxuu	T	P	A
<i>Grevillea robust</i> A.Cunn. ex R. Br.	Proteaceae	Mukaqawwee	T	P	A
<i>Ilex mitis</i> (L.) Radlk.	Aquifoliaceae	Mi'eessaa	Sh/T	P	P
<i>Inula confertiflora</i> A. Rich.	Asteraceae	Haxaawwii	Sh	P	P
<i>Juniperus procera</i> L	Cupressaceae	Gaatiraa	T	P	A
<i>Lepidotrichilia</i> <i>volkensii</i> (Gurke.) Leory.	Meliaceae	Qumanyoo	Sh/T	P	A
<i>Lippia adoensis</i> Hochst.ex Walp.	Verbenanaceae	Kusaayee	Sh	P	P
<i>Maesa lanceolata</i> Forssk.	Myrsinaceae	Abayyii	Sh/T	P	A
<i>Maytenus gracilipes</i> (Welw. Ex Oliv.)Exell	Celastraceae	Qarxammee	Sh	P	P
<i>Maytenus</i> <i>sensgalensis</i> (Lam) Exell	Celastraceae	Kombolcha	Sh/T	P	A
<i>Myrsine africana</i> L	Myrsinaceae	Qacama	Sh/T	P	A
<i>Olea europaea</i> subsp. <i>cuspidata</i> (Wall. ex G. Don) Cif.	Oleaceae	Ejersa	T	P	P
<i>Osyris quadripartita</i> Decn.	Santalaceae	Waattoo	Sh	P	P
<i>Pavonia urens</i> Cav.	Malvaceae	Hincinnii	Sh/T	P	A
<i>Phytolacca</i> <i>dodecandra</i> L. Herit	Phytolaccaceae	Handoodee	C	P	A
<i>Podocarpus flactus</i> (Thunb.) R.B ex Mirb.	Podocarpaceae	Birbirsa	T	P	P
<i>Prunus africana</i> (Hook. f.) Kalkm	Rosaceae	Gurraa	Sh/T	P	A
<i>Rhus natalensis</i> Bent hex Krauss	Anacardiaceae	Xaaxessaa	Sh/T	P	P

<i>Rhoicissus tridentata</i> (L.f.) Wild & R.B.Drumm.	Vitaceae	Dhangaggoo	Sh	P	P
<i>Rubus steudneri</i> Schweinf.	Rosaceae	Goraa	T	P	A
<i>Salix mucronata</i> Thunb.	Salicaceae	Alaltuu	Sh	P	A
<i>Vepris dainelli</i> (Pichi-serm.) Kokwaro	Rutaceae	Hadheessaa	T	P	A
<i>Syzygium guineensis</i> (Wild). Dc	Myrtaceae	Baddeessaa	T	P	A
<i>Vernonia amygdalina</i> Del.	Asteraceae	Dheebicha	T	P	P
Total				42	25

Appendix 2. Density of woody species in Sire-Morose micro-watershed, Hidabu Abote, North Shewa, Oromia.

Scientific name	Seedlings	Saplings	Tree/shrub	Total
<i>Acacia abyssinica</i> Hochst. Ex Benth.	7	10	25	42
<i>Acacia brevispica</i> Harms			9	9
<i>Acacia etabaica</i> schweinf.			10	10
<i>Acacia persiciflora</i> Pax		8	16	24
<i>Acanthus eminens</i> C.B. Clark		15	14	29
<i>Albizia gummifera</i> (J.F. Gmel.)CA.Smith	18	33	45	96
<i>Apodytes dimidiata</i> E.Mey.ex Arn	10	15	23	48
<i>Bersama abyssinica</i> Fresen.	19	10	25	54
<i>Buddleja davidii</i> Franch.		15	27	42
<i>Calupurnea aurea</i> (Ait)		8	15	23
<i>Carissa spinarum</i> L.	22	36	52	110
<i>Rhocissus tridentate</i>		10		10
<i>Cordia Africana</i> Lam	13		9	22
<i>Croton macrostachyus</i> Del.	11	27	46	84
<i>Dodonea angustifolia</i> L.F	18	8	24	50
<i>Ekebergia capensis</i> Sparrm		12	15	27
<i>Eucalyptus camaldulnesis</i>	17	26	48	91
<i>Eucalyptus globules</i>	17	33	55	105
<i>Ficus sur</i> Forssk		6	4	10
<i>Ficus vasta</i> Forssk			4	4
<i>Grevillea robust</i> A.Cunn. ex R. Br.	20		30	50
<i>Ilex mitis</i> (L.) Radlk.		6	9	15
<i>Inula confertiflora</i> A. Rich.	14	18		32
<i>Juniperus procera</i> L	6	20	16	42
<i>Lepidotrichilia volkensii</i> (Gurke.) Leory.	7	6	10	23
<i>Lippia adoensis</i> Hochst.ex Walp.	20	22		42
<i>Maesa lanceolata</i> Forssk.	9	11	23	43
<i>Maytenus gracilipes</i> (Welw. Ex Oliv.)Exell	10	31		41
<i>Maytenus sensgalensis</i> (Lam) Exell	5	6	13	24
<i>Myrsine Africana</i> L		5	10	15
<i>Olea africana</i> Mill.	10	24	26	60
<i>Osyris quadripartite</i> Decn.	6	19	27	52
<i>Pavonia urens</i> Cav.		5	8	13

<i>Phytolacca dodecandra</i> L. Herit		4	8	12
<i>Podocarpus flactus</i> (Thunb.) R.B ex Mirb.	8	20	15	43
<i>Prunus africana</i> (Hook. f.) Kalkm			12	12
<i>Rhus natalensis</i> Bent hex Krauss			15	15
<i>Rubus steudneri</i> Schweinf.	15		27	42
<i>Salix mucronata</i> Thunb.			10	10
<i>Vepris dainelli</i> (Pichi-serm.) Kokwaro			14	14
<i>Syzygium guineensis</i> (Wild). Dc		4	8	12
<i>Vernonia</i>	5	2	12	19
Total	287	475	759	1521

Appendix 3: Density of woody plant species in Yaya-Dakabora micro-watershed, Hidabu Abote District, North Shew, Oromia.

Scientific name	Seedlings	Saplings	Tree/shrub	Total
<i>Acacia abyssinica</i> Hochst. Ex Benth.		4	23	27
<i>Acacia persiciflora</i> pax			7	7
<i>Acanthus eminens</i> C,B. Clark			12	12
<i>Albizia gummifera</i> (J.F. Gmel.)CA.Smith	10	9	22	41
<i>Apodytes dimidiata</i> E.Mey.ex Arn		9	13	22
<i>Bersama abyssinica</i> Fresen.			8	8
<i>Buddleja davidii</i> Franch.			5	5
<i>Calupurnea aurea</i> (Ait)			7	7
<i>Carissa spinarum</i> L.			19	19
<i>Rhocissus tridentate</i>	9	20		29
<i>Croton macrostachyus</i> Del.	9	18	36	63
<i>Dodonea angustifolia</i> L.F			8	8
<i>Ekebergia capensis</i> Sparrm			4	4
<i>Eucalyptus camaldulnesis</i>			18	18
<i>Eucalyptus globules</i>		6	18	24
<i>Ficus sur</i> Forssk			3	3
<i>Inula confertiflora</i> A. Rich.	5		7	12

<i>Ilex mitis</i> (L.) Radlk.			4	4
<i>Lippia adoensis</i> Hochst.ex Walp.	10	13	20	43
<i>Maytenus gracilipes</i> (Welw. Ex Oliv.)Exell			12	12
<i>Olea Africana</i> Mill.		2	4	6
<i>Osyris quadripartite</i> Decn.		8	12	20
<i>Podocarpus flactus</i> (Thunb.) R.B ex Mirb.		2	4	6
<i>Rhus natalensis</i> Bent hex Krauss			4	4
<i>Vernonia</i>		10	25	35
Total	43	101	295	439

Appendix 4. IVIs of tree species in the Sire-Morose micro-watershed

<i>Scientific name</i>	<i>RDO</i>	<i>RF</i>	<i>RD</i>	<i>IVI</i>
<i>Acacia abyssinica</i> Hochst. Ex Benth.	4.5	4.75	3.29	12.54
<i>Acacia brevispica</i> Harms	4	2.03	1.19	7.22
<i>Acacia etabaica</i> schweinf.	2.7	1.69	1.32	5.71
<i>Acacia persiciflora</i> Pax	3.7	2.37	2.11	8.18
<i>Acanthus eminens</i> C,B. Clark	2	2.37	1.84	6.21
<i>Albizia gummifera</i> (J.F. Gmel.)CA.Smith	7.4	5.08	5.93	18.41
<i>Apodytes dimidiata</i> E.Mey.ex Arn	3	2.71	3.03	8.74
<i>Bersama abyssinica</i> Fresen.	3	3.05	3.29	9.34
<i>Buddleja davidii</i> Franch.	2.5	2.71	3.56	8.77
<i>Calupurnea aurea</i> (Ait)	2	4.40	1.98	8.38
<i>Carissa spinarum</i> L.	5.4	6.10	6.85	18.35
<i>Cordia Africana</i> Lam	3	1.36	1.19	5.55
<i>Croton macrostachyus</i> Del.	2.7	5.76	6.06	14.52
<i>Dodonea angustifolia</i> L.F	1.4	3.05	3.16	8.05
<i>Ekebergia capensis</i> Sparrm	2	1.69	1.98	5.67
<i>Eucalyptus camaldulnesis</i>	5	3.39	6.32	14.71
<i>Eucalyptus globules</i>	6.2	5.42	7.25	18.87
<i>Ficus sur</i> Forssk	2.2	0.68	0.53	3.41
<i>Ficus vasta</i> Forssk	1.5	1.02	0.53	3.05
<i>Grevillea robust</i> A.Cunn. ex R. Br.	2.4	2.03	3.95	8.38
<i>Ilex mitis</i> (L.) Radlk.	1	1.02	1.19	3.21
<i>Juniperus procera</i> L	2.4	2.71	2.11	7.22
<i>Lepidotrichilia volkensii</i> (Gurke.) Leory.	1.4	1.36	1.32	4.08
<i>Maesa lanceolata</i> Forssk.	1.5	3.05	3.03	7.85
<i>Maytenus sensgalensis</i> (Lam) Exell	1.4	1.36	1.71	4.47
<i>Myrsine Africana</i> L	1	1.69	1.32	4.01
<i>Olea Africana</i> Mill.	3.5	3.73	3.43	10.66
<i>Osyris quadripartite</i> Decn.	2.2	3.05	3.56	8.81

<i>Pavonia urens</i> Cav.	2.3	0.68	1.05	4.03
<i>Phytolacca dodecandra</i> L. Herit	1.2	2.03	1.05	4.28
<i>Podocarpus flactus</i> (Thunb.) R.B ex Mirb.	4.2	4.41	1.98	10.59
<i>Prunus africana</i> (Hook. f.) Kalkm	1.3	1.36	1.58	4.24
<i>Rhus natalensis</i> Bent hex Krauss	1.2	4.07	1.98	7.25
<i>Rubus steudneri</i> Schweinf.	2	1.69	3.56	7.25
<i>Salix mucronata</i> Thunb.	1	1.36	1.32	3.68
<i>Vepris dainelli</i> (Pichi-serm.) Kokwaro	2.3	2.03	1.84	6.17
<i>Syzygium guineensis</i> (Wild). Dc	1.6	1.02	1.05	3.67
<i>Vernonia</i>	2.2	1.69	1.58	5.47
Total	100	100	100	300

RDO=Relative dominance, RF=relative frequency, RD=relative density, IVI=important value index.

Appendix 5. IVIs of tree species in the Yaya-Dakabora micro-watershed

Scientific name	RDO	RF	RD	IVI
<i>Acacia abyssinica</i> Hochst. Ex Benth.	4	7.48	7.79	19.27
<i>Acacia persiciflora</i> pax	3.9	3.72	2.37	9.99
<i>Acanthus eminens</i> C,B. Clark	4.8	4.40	4.07	13.27
<i>Albizia gummifera</i> (J.F. Gmel.)CA.Smith	5.6	7.52	5.46	18.58
<i>Apodytes dimidiata</i> E.Mey.ex Arn	6	4.08	5.41	15.49
<i>Bersama abyssinica</i> Fresen.	4	1.36	3.71	9.07
<i>Buddleja davidii</i> Franch.	4.7	1.36	3.69	10.75
<i>Calupurnea aurea</i> (Ait)	4.8	2.04	2.37	9.21
<i>Carissa spinarum</i> L.	4.8	6.80	6.44	18.04
<i>Croton macrostachyus</i> Del.	2.4	6.88	9.20	18.48
<i>Dodonea angustifolia</i> L.F	4	2.04	2.71	8.75
<i>Ekebergia capensis</i> Sparrm	4.3	2.36	2.36	9.02
<i>Eucalyptus camaldulnesis</i>	7.2	5.80	5.10	18.1
<i>Eucalyptus globules</i>	5.4	6.80	6.10	18.3
<i>Ficus sur</i> Forssk	2.4	3.36	2.01	7.77
<i>Inula confertiflora</i> A. Rich.	3.4	2.72	2.37	8.49
<i>Ilex mitis</i> (L.) Radlk.	3.2	2.04	1.36	6.6
<i>Lippia adoensis</i> Hochst.ex Walp.	2.9	9.52	4.78	17.2
<i>Maytenus gracilipes</i> (Welw. Ex Oliv.)Exell	3.6	3.40	4.07	11.07
<i>Olea Africana</i> Mill.	3.4	2.68	3.36	9.44
<i>Osyris quadripartite</i> Decn.	4	2.04	4.07	10.11
<i>Podocarpus flactus</i> (Thunb.) R.B ex Mirb.	5	1.36	1.36	7.72
<i>Rhus natalensis</i> Bent hex Krauss	3.8	3.36	1.36	8.52
<i>Vernonia</i>	2.4	6.84	8.47	17.71
Total	100	100	100	300

RDO=Relative dominance, RF=relative frequency, RD=relative density, IVI=important value index.

Appendix Table 6. Comparison of mean difference between adopter and non-adopter of soil and water conservation.

Variable	Sire Morese			Yaya Muka		
	Adopters (N=37)	Non-adopters (N= 32)	t-value	Adopters (N=29)	Non-adopters (N= 25)	t-value
	Mean \pm SD	Mean \pm SD		Mean \pm SD	Mean \pm SD	
House hold size	2.8 \pm 0.5	2.2 \pm 0.7	-4.07***	2.9 \pm 0.25	2.4 \pm 0.6	-3.74***
Age distribution	43 \pm 3.2	49 \pm 6.7	4.76***	42 \pm 7.7	48 \pm 7.3	2.93***
Marital status	2.1 \pm 0.3	2.4 \pm 0.6	2.58**	2.1 \pm 0.4	2 \pm 0.4	-0.54NS
Educational status	0.8 \pm 0.5	0.4 \pm 0.2	-3.95***	0.7 \pm 0.4	0.5 \pm 0.3	-2.36**
Farm land size	1.8 \pm 0.87	1.06 \pm 0.24	-4.66***	1.9 \pm 1	1 \pm 0.4	-3.45***
Distance to the market	145 40	115 20	-3.84***	151 38	113 26	-4.13***

Note: ** = significant at $p < 0.05$; *** = highly significant at $p < 0.01$, NS= non significant, SD= Standard Deviation

Appendix B. Household Survey Questionnaire

This questionnaire has been prepared to gather information on the role of watershed management for biodiversity and rehabilitation of degraded land in Sire-Morose and Yaya-Dakabora micro-watersheds, Oromia Region, North Shoa Zone, Ethiopia. The principal objective of this questionnaire was to assess the role of watershed management for biodiversity and rehabilitation of degraded land. Dear respondents, you are kindly requested to give answers freely and openly. Any information you give is be kept confidential. Thus, your cooperation is very necessary to achieve the desired objective of the study of this research.

Part .I. Background Information

Region _____ Zone _____ District _____ Kebele _____

Name of watershed: _____ Date of Interview (dd/mm/yy): _____

Part .II. Household Characteristics

Name of the head of Household (Respondent) _____

1. Sex: 1. Male 2. Female.
2. Age: 1. 20-40 2. 40-60 3. Greater than 60
3. Marital status: 1. Single 2. Married 3. Divorced 4. Widowed.
4. Family size: 1. Small (1-3) 2. Medium (4-6) 3. Large (greater than 6).
5. Educational Level: 1. Read and Write 2. Illiterate 3. Grade (1-4th) 4. Grade (5-8th),
5. Grade (9-12th) 6. Collage /University.
6. What is the farm size of your land?
1. Less than 1ha 2. 1-2ha 3.3-4 ha 4. Above 4ha
7. Distance from home to farm land _____ (in minutes)
8. Distance from home to District market _____ (in minutes)

Part.III. Watershed Management and Its Characteristics

1. What does mean watershed management for you?
 1. Water management 2. Land management 3. Biomass management
 4. Combination of three 5. I do not know 6. Other (specify) _____
2. How do you describe the slope of your land? 1. Flat 2. Gentle 3. Steep 4.Others_____
3. What is the color of the soil in your watershed? 1. Red 2. Black 3. Brown 4.Others_____
4. Which soil color was easily eroded? 1. Black 2. Red 3. Brown, Reason for your answer?
5. In which soil color you practice soil and water conservation more? Why? _____

Part. IV. Impact of Watershed Managements

4.1. Household Income

1. What are the main sources of income for your livelihoods?
 1. Natural resource 2. Crop production 3. Animal production 4. Employed
 5. Vegetable Production 6. Off- farm 7. Saftynet program 8. Others specify_____
2. Do you feel that your household income has improved for you? 1. Yes 2. No
3. If “No” to question number 2, what have been the main reasons that your household income has not improved?
 1. Lack of soil and water conservation practices 2. Poor quality inputs (e.g. seed, fertilizer, etc)
 3. Soil fertility problem 4. Lack of water. 5. Others specify_____

4.2. Crop Production

1. What types of crops you cultivated on your land?

No	Type of crops	Total production in Qt/year in Sire-Morose	Total production in Qt/year in Yaya-Dakabora
1	Teff		
2	Barely		
3	Sorghum		
4	Wheat		
5	Maize		
6	Noug		

7	Beans		
8	Peas		
9	Vegetable		
10	Others(specify)		

2. Which types of crop is dominant in your watershed_____

4.3. Livestock production

1. What are your main livestock possessions?

No	Types of Livestock	No of Livestock	
1	Cattle		
2	Sheep		
3	Goat		
4	Horse		
5	Donkey		
6	Poultry		
7	Others (specify)		

2. What are the major problems of you for rearing livestock?

1. Shortage of grazing land
2. Shortage of forage
3. Decrease in productivity
4. Shortage of water
5. Others specify_____

3. Identify the major sources of feed for your livestock?

1. Crop residues
2. Communal grazing land
3. Private grazing land
4. Hay
5. Modern different grass species
6. Others (specify)_____

4. What type of grazing land system do you used? 1. Cut and carry 2. Free grazing

3. Zero grazing
4. 2 and 3
5. Others specify_____

5. Do you think that the carrying capacity of the grazing area fits with the number of livestock? 1. Yes 2. No

6. Do you perceive that livestock number cause the degradation of grazing land? 1. Yes 2. No

7. Did watershed management intervention improve fodder for livestock? 1. Yes 2. No

8. How do you evaluate the productivity and income from livestock after intervention of watershed management practices? 1. High 2. Medium 3. Low

4.4. Groundwater Recharges and Water Availability

1. What is the major source of water for you?

1. Spring /unprotected 2. Spring protected 3. Hand dug well 4. River 5. Others _____

3. How much time do you take to fetch water? _____ (minutes)

2. Do you have access of clear water availability? 1. Yes 2. No, Reason for your answer?

4. For what purpose do you use the availability of water?

1. For domestic use 2. For irrigation 3. Others,

Part .V. Watershed Management Practices and SWC Measures

1. Do you adopter of either stone bunds or soil bunds or both on your own land holding?

1. Yes 2. No

2. If you are not adopter of any soil and water conservation measures why did not you practices?

1. Shortage of land, 2 Shortage of labour. 3. I did not believe in the use soil and Water conservation structures 4. There is no one who is to design for me, 5. I do not know 6. My land does not require these structures 7. Other specify _____

3 Where do you learn the soil and water conservation methods? 1. From parents 2. From neighbors 3. From extension agents 4. From NGOs 5. Others (specify if any) _____

4. List the biological soil and water conservation measures applied in your watershed?

5. List the mechanical soil and water conservation measures applied in your watershed?

6. Identify the mostly biological and mechanical soil and water conservation practices in your watershed? Why mostly practices?

7. What happen to your farm land if you did not take a protection measure? 1. Loose portion of farmland 2. Soil productivity is decrease 3. Crop yields are reduced 4. Others (specify)

8. Why you use the soil and water conservation technologies?

1. To increase the soil fertility 2. To reduce the soil erosion
3. To conserve the biodiversity 4. To increase productivity of land 5. Others specify ___

9. Have you ever participated in any of watershed management practices by Government or NGOs? 1. Yes 2. No

10. If yes to question number 9, what is the driving force that initiated you to participate?

1. By interest 2. By force 3. FFW 4. Cash for work 5. Others _____

11. How you evaluate its impact on crop production and soil fertility? 1. Increasing

2. Decreasing 3. No change observed

12. What are the side effects of using soil and water conservation structures?

1. Source of rodents, 2. Reduce farm land, 3. Difficult to turn oxen, 4. Labor intensive

5. I do not know 6. Others specify _____

13. Are you carrying out the maintenance of watershed management practices established in your surrounding? 1. Yes, 2. No

14. If No, what were the reasons for not maintained? _____

15. Among the mechanical soil and water conservation practices, which one is major source of rodents? 1. Stone-soil phased bund 2. Soil bund 3. Stone bund 4. Check dams 5. Others ___

16. Did you compare the positive impact with the side effects of SWC measures? 1. Yes 2.No

17. If so which one is greater and how can reduce the side effects of soil and water conservation measures?

18. What challenges do you experience that might hinder you to adopt soil and water conservation measures?

1. Land fragmentation 2. Budget/ financial constraints 4. Lack of technical support

5. Not return short term benefit 5. If any specify _____

Part.VI. Land Degradation, Loss of biodiversity Rehabilitation of degraded land and farmers perception.

1. Do you perceive that land degradation is a problem for loss of biodiversity in your area?

1. Yes 2. No

2. What are the main and root causes of land degradation problem in your area?

1. Deforestation 2. Over grazing 3. Population growth 4. Inappropriate farming techniques
5. Ploughing marginal land 6. Lack of adoption of soil conservation measures
6. Soil erosion 8. Others if any _____

3. Is there deforestation of forest in your watershed? 1. Yes 2.No

4. What are the reasons for deforestation of forests in your area? 1. Used for agricultural lands

2. Used for fire wood 3. Used for construction purpose

4. Used as source of income by selling its products 5. Others if any _____

5. List the consequence of deforestation in your watershed?

6. Do you conserve the forest from degradation? If how do communities in the watershed contribute to the protection of forest?

1. Participate in forest development program
2. Respect rules bylaws and regulation of local governments and the Community
3. Reduce pressure on forest by planting multipurpose trees
4. Participate in afforestation and reforestation programs
5. Others (specify) _____

7. What types of soil erosion occurred in your lands?

1. Soil erosion by wind 2. Soil erosion by water 3. Others (if any) _____

8. According to your thinking what are the consequences of land degradation in your watershed?

1. Decreasing livestock number 2. Loss of biodiversity, 3. Shortage of land, 4. Declining crop yields. 5. Others _____

9. How do you perceive the degree of loss of biodiversity in your watershed?

1. Low 2. Medium 3. High

10. Do you think that the lost biodiversity can be rehabilitated? 1. Yes 2.No

11. What are the main rehabilitation of degraded land practices in your watershed?

1. Improved biological soil and water conservation measures.

- 2. Improved mechanical soil and water conservation measures
- 3. Integration of mechanical and biological soil and water conservation measures
- 4. Traditional soil and water conservation measures

12. How do you see rehabilitation of degraded land practices over a time?

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

13. What type of changes you observed in your environment after the rehabilitation of degraded land activities?

- 1. Water availability increased 2. Vegetation cover increased 3. Reduce soil erosion
- 4. No changed observed 5. Others specify_____

Part VII. Soil Fertility Decline and Management Practices.

1. Do you perceive that the problem of soil fertility decline on your land? 1. Yes, 2. No

2. How do you manage the fertility of soil in your field?

- 1. By compost 2. Crop rotation 3. By using manure 4. Apply Fertilizer 5. Crop residue
- 6. Fallowing 7. Others _____

3. How you perceive the fertility status soil in your land? 1. Poor 2. Moderate 3. Good

Appendix C. Questionnaire for Key Informant Interview

1. What are the observed impacts of watershed management practices on the main sources of livelihoods?

- A. Livestock size and type_____
- B. Crop production_____
- C. Environmental and ecological _____
- D. Employment and Migration_____
- E. Ground and surface water resource availability_____
- F. Forest conservation_____
- G. Soil and water conservation _____

2. What is the degree of land degradation in the watershed today?

3. Is there a benefit local community gained from watershed management practices?

4. How you evaluate the current land rehabilitation practices in your watershed?

5. What are the mechanical and biological SWC practices on your watershed?
6. How fertility of the soil is managed in the watershed and evaluates the status of soil fertility?
7. What participation of local community in the watershed management practices look like?
8. What are challenges/side effects of watershed management practices?
9. How can reduce the side effects of watershed management practices?
10. How local community maintained the implemented watershed management practices?
11. How do you evaluate the economical, social, political and ecological feasibility of the watershed management's practices generally?
12. Is there land degradation and soil erosion problem in your watershed? If so what are the cause, indicator and consequence of the problem?

Appendix D. Focus Group Discussion

The questions used in focus group discussions are the following

Discussion topics	Questions
1. Watershed management practices	Is there intervention of watershed management practice in your area by any governmental or nongovernmental organizations?
	If so list the mechanical and biological watershed management practices in your area?
	What are the contributions of watershed management practices to rehabilitation of degraded land and woody species conservation?
	How community participates and adopts toward the watershed management practices?
	Do you maintain the implemented soil and water conservation structure? If so how? If not why?
2. Impacts of watershed managements	Impacts of watershed management practices on crop production, livestock number, household incomes, ground and surface water availability, and biodiversity conservation?
	Impacts on Environments due to watershed management intervention?
	Impact on rehabilitation of degraded land and soil fertility managements?
3. land degradation	Do you have environmental problems in your watershed? If so specify the Environmental problem in your watershed
	Are there land degradation problems in your watershed?
	List the cause and consequence of land degradation problems?

	Do you take any measure to reduce the land degradation problems?
4. Challenges and side effects of watershed management practices	List the side effects of watershed management practices?
	Solutions for such problems according to your opinion and other factor that hinder you towards the adoption of SWC?

Appendix E. Field observation checklists

Questions	Activity
1. Status and problems of land degradation	
2. Cause and consequences of land degradation	
3. Biological and mechanical soil and water conservation practices in the watershed	
4. Factors that influence the adoption of farmers towards SWC practices	
5. Rehabilitation of degraded land practices in the watershed	
6. Woody plant species and biodiversity conservation activities implemented in the watershed	
7. Impacts of watershed management practices on crop production, live production, ground and surface water availability.	
8. Maintenance of implemented soil and water conservation structures	