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**WATERSHED MANAGEMENT ADOPTION AND SOCIO-ECOLOGICAL-LIVELIHOOD  
IMPLICATIONS IN THE UPPER GIBE BASIN, SOUTH WEST HIGHLAND OF ETHIOPIA**

**PhD Dissertation**

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**Watershed Management Adoption and Socio-Ecological-Livelihood  
Implications in the Upper Gibe Basin, South West Highland of Ethiopia**

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## **Declaration**

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As dissertation Research advisor, I hereby certify that I have read and evaluated this dissertation prepared, under my guidance, by Fekadu Mengistu Ashami entitled “Watershed Management Adoption and Socio-Ecological-Livelihood Implications in the upper Gibe basin, Southwest Highland of Ethiopia”. I recommended that it be submitted as fulfilling the dissertation requirements for Degree of Doctor of Philosophy in Environment and Development.

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I Fekadu Mengistu Ashami, declare that this dissertation manuscript entitled “Watershed Management Adoption and Socio-Ecological-Livelihood Implications in the upper Gibe basin, Southwest Highland of Ethiopia” is my own original work with the guidance and close direction of my supervisor, Dr. Engdawork Assefa. It has never been presented for degree in any other universities or institutions and that all the sources of materials used for the dissertation have been duly acknowledged. It has been submitted in partial fulfillment of the requirements for Degree of Doctor of Philosophy (PhD) in Environment and Development at Addis Ababa University.

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## Abstract

Watershed degradation is the greatest challenge in the highlands of Ethiopia, promoting interests in the intervention of watershed based management approach to avert land degradation and to enhance people's livelihoods. Given this strategy, a wide range of watershed management programs have been implemented in different parts of Ethiopia for several years to solve the problems. However, the effects of watershed management program have not been well examined and documented. To this end, the objective of this study was to explore the state of watershed management program and people's psycho-social conditions, participation and adoption of the watershed management practices and to investigate the effects of the management program on socio-ecological and livelihood in Rebu watershed of the upper Gibe basin, southwest Ethiopia. To address these, a total of 304 sample households (145 program participants and 159 non-participant households) were randomly selected from three program participant and three counterfactual sub-watersheds across various topographic settings. Household survey, key informant interviews, focus group discussions and personal transect observations were employed to collect data. A wide range of data analysis tools employed such as descriptive statistics, logistic regression, multivariate and ordered probit model and propensity score matching method. Results of state-of-the-art indicated that although, watershed development program has become the primary objective of the policy and development plans of the country and there are strong efforts in the implementation, the emphasis still stresses on the attainment of economic growth rather than environmental concern. Top-down approach of planning the watershed development is still dominating. Empirical results of study indicated that local communities were well aware of the problems of watershed degradation and outcome of mitigation measures despite its variation in different topographic settings and for watershed program participants. Exposed stone, gullies and rills and tree root exposure were major indicators of soil erosion, while crop yield decline and soil cultivability decline were for diminishing soil quality. Cultivation of steeper slopes, deforestation and poor land management practices were perceived by farmers as the major causes of watershed degradation. The ecological benefits were perceived higher in the upper topographic areas, while the socio economic benefits were in the middle and lower areas. The overall community participation index value of 43.4 % showed moderate levels of participation. Soil bund, grass strip cultivation with soil bund and compost were the major watershed management practices adopted. Estimates of the propensity score matching indicated that the existence of a positive additional significant livelihood assets value of 24.8 % for program participants compared to non-participants suggesting the need of up scaling the program in to the areas not covered. There is also a positive association between important components of watershed management-perception, participation, adoption and livelihoods. Various physical, socio economic and institutional factors affects the perception, community participation, adoption of watershed management. Hence, policy makers and planners need to recognize heterogeneity in households' socio economic and topographic specific characteristics in watershed management. It also suggested more participatory and integrated approach need to be encouraged to upscale and sustaining of watershed management.

Keywords: watershed management program; perception; participation; adoption; livelihood impacts; Rebu watershed, upper Gibe basin, southwest Ethiopia

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## Acronyms and Abbreviations

**ADLI:** Agricultural Development Led Industrialization

**ATT:** Average Treatment Effect on the Treated

**DFID:** Department for International Development

**DPSIR:** Driving-Pressure-State-Impacts-Responses

**FAO:** Food and Agriculture Organization

**GIZ:** Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH

**GTP:** Growth and Transformation Plan

**ha:** hectare

**m. a.s.l.:** meter above sea level

**MERET:** Managing Environmental Resources to Enable Transition to more sustainable livelihoods

**Mg:** Mega gram

**MVP:** Multivariate Probit

**NGOs:** Non Governmental Organizations

**NN:** Nearest Neighbor

**PASDEP:** Plan for Accelerated Sustainable Development to Eradicate Poverty

**PPS:** Probability Proportional to Size

**PSM:** Propensity Score Matching

**SD:** Standard Deviation

**SLM:** Sustainable Land Management

**SLMP:** Sustainable Land Management Program

**SPSS:** Statistical Package for the Social Sciences

**SSA:** sub-Saharan Africa

**SWC:** Soil and Water Conservation

**TLU:** Tropical Livestock Unit

**WFP:** World Food Program

**WOCAT:** World Overview of Conservation Approaches and Technologies

## **PART I: INTRODUCTION AND STATE –OF- THE ART**

**Chapter 1:** Introduction

**Chapter 2:** Development, Current Practices and Future Prospects of Watershed Management Program in Ethiopia: State- of – the Art

## Chapter 1: Introduction

### 1.1. *Setting the scene*

A watershed can be defined as any surface area from which runoff resulting from rainfall is collected and drained through a common outlet (Kumar & Sharma, 2013). The term is synonymous with a drainage basin or catchment area (Desta, Carucci, Wendem-Ageñehu, & Abebe, 2005). It is a hydrologic unit that has been described and used both as a bio-physical unit and as a socio-economic unit for planning and implementing resource management activities (Addisu, Goshu, G.Selassie, & Tefera, 2013). The bio-physical unit in a watershed includes its water, soil, and vegetation. While, the socioeconomic unit includes people, their farming system (including livestock) and interactions with land resources, coping strategies, social and economic activities and cultural aspects (Desta et al., 2005). Therefore, this study follows the definition that, as well as being a useful unit for physical analyses; watershed can also be a suitable socio-economic unit for management planning and implementation of watershed resources. The management of watershed implies a process of organizing or wise use of land and other resources used in the watershed to provide the desired goal without adversely affecting environmental resources (FAO, 1986). It appears to have moved from a focus on physical water and soil conservation to the integration of social, economic, and environmental development (Perez & Tschinkel, 2003).

The watershed, as a socio-ecological entity, plays very important role in providing food, social and economic security, as well as important life support services fuelling peoples' livelihoods (Wani & Garg, 2011). However, the loss or continual decline in the capability of a watershed resources (soil, water and vegetation) to provide ecosystem services, presents a major threat to food security, economic well being and the livelihoods of many people across the globe (Lal, Safriël, & Boer, 2012; Mekonnen, Keesstra, Baartman, & Ritsema, 2015). Estimates indicate that up to 25 percent of the Earth's land area may be severely degraded (FAO, 2011) and that, despite global efforts to halt land degradation, the area affected continues to increase (Bai, Dent, Olsson, & Schaepman, 2008). The problem is severe in developing countries and requiring urgent attention (Wani, Sreedevi, Singh, Pathak, & Rego, 2002; Darghouth, Ward, Gambarelli, Styger, & Roux, 2008). Sub-Saharan Africa is particularly vulnerable to the threats of natural resource degradation mainly because of its consequences for subsistence agriculture from which about 75

percent of the population derive their livelihoods (Erkossa, Wudneh, Desalegn, & Taye, 2015; Tully, Sullivan, Weil, & Sanchez, 2015).

Ethiopia is one of the sub-Saharan African countries experiencing watershed resource degradation-loss or persistent decline in the potential productive capability of watershed resources (Darghouth, Ward, Gambarelli, Styger, & Roux, 2008; Lal et al., 2012; Mekonnen, Keesstra, Baartman, & Ritsema, 2015). Land, water, forest and biodiversity are being degraded at an alarming rate and It is becoming a major constraint to the future growth and development of agriculture where the majority of rural livelihoods is dependent, particularly in the highland areas of the country (Holden & Shiferaw, 2004; Haileslassie, Priess, Veldkamp, Teketay, & Lesschen, 2005; Haile, Herweg, & Stillhardt, 2006; Amsalu & de Graaff, 2007). Agriculture, the main promising resource sector of the economy (Matouš, Todo, & Mojo, 2013), is associated with accelerated watershed degradation like soil erosion, soil fertility decline, reduced infiltration, drying up of rivers, increased flooding frequency and rapid silting up of reservoirs (Nyssen, Poesen, Moeyersons, Haile, & Deckers, 2008; Tilahun et al., 2013; Tamene, Adimassu, Aynekulu, & Yaekob, 2017).

Although, watershed degradation extent and severity vary significantly across various locations of Ethiopia, existing evidences provide sufficient evidences for the severity of the problem. About 1.5 million tons of topsoil are lost from highland areas each year due to erosion (Tamene & Vlek, 2008). Similarly, estimate on soil nutrient depletion from the Ethiopian highland areas has indicated a rate of 122, 13 and 82 kg ha<sup>1</sup> year<sup>1</sup> of nitrogen, phosphorus and potassium, respectively; out of which 70 percent, 80 percent and 63 percent respectively of the nutrient outflows are contributed by watershed degradation through soil erosion (Haileslassie et al., 2005). The severity of the problem is associated mainly with land mismanagement such as the past and present intensive agricultural activities, deforestation and overgrazing, and hilly topography, torrential rainfall and driven by underlying forces such as population growth, weak implementation of policies, national and international market demand, and poverty (Hurni et al., 2015; Asmame & Abegaz, 2017; Mekuriaw, Heinimann, Zeleke, & Hurni, 2018).

The degradation of the watershed affects the land from which the soil is washed, damages the area downstream by floods and sediments and is detrimental to the economy (Haile et al., 2006). Soil erosion resulting in relocation of the top soil which is rich in organic matter, nutrients, soil

microorganisms (Shiferaw & Holden, 1998; Shiferaw & Holden, 1998; Hengsdijk et al., 2005); loss of soil fertility or productivity that leads to the degradation of the quality of cropping and grazing land (Teklewold, Kassie, & Shiferaw, 2013); yield may become so poor that the land has to be taken out of cultivation (Shiferaw & Holden, 1999; Tilahun et al., 2013); decreasing soil depth, and therefore decreasing rooting depth and water storage capacity (Nyssen et al., 2010; Meshesha, et al., 2012). The on-site effects of watershed degradation in Ethiopia, measured in lost agricultural production is estimated to cost 2 to 6.75 per-cent of Agricultural GDP per annum (Schmidt & Tadesse, 2012). Under business as usual scenario, Sonneveld & Keyzer (2003) predicted that the agricultural production potential of the land would be reduced by 30 percent due to soil erosion by the year 2030. Notable off-site effects of soil erosion also include flooding, sedimentation (Temesgen et al., 2012); damage to infrastructure (such as roads, water supply systems), and siltation of downstream natural and artificial water bodies and the ecosystems they sustain (e.g., lakes, hydroelectric power-generating reservoirs) (Lai 2001; Pender & Gebremedhin 2007; Hurni et al. 2015).

In response to these challenges, a large scale of efforts have been made to implement watershed management practices in Ethiopia with the support gained from various international organizations to mitigate watershed degradation and to enhance sustainable development of ecological balance and improvement in livelihood of households (Teshome et al., 2016; Gebregziabher et al., 2016; Gessesse et al., 2016). Despite the increasing efforts made and the growing policy interest, adoption of those watershed management practices by smallholder farmers has generally been limited (Shiferaw, Okello, & Reddy, 2009). Moreover, regardless of all those efforts, the natural resource base is deteriorating from time to time and becomes major causes for declining agricultural productivity, livelihoods insecurity and vulnerability (Darghouth et al., 2008; Mekonnen et al., 2015).

Various literatures conducted in different parts of Ethiopia came-up with different factors that explain the low level of success of conservation initiatives- ranging from the poor performance of the technologies themselves to policy and institutional deficiencies at different levels (Desta et al., 2005; German, et al., 2006; Raes et al., 2007; Teklewold, Kassie, & Shiferaw, 2013; Haregeweyn et al., 2015; Kerse, 2018). The interventions were basically emphasizing only on

physical planning, over looked local perception, lack of adequate stakeholders' participation, and little attentions given to livelihoods.

Hence, in an effort to address these problems, the basic paradigm and approach to watershed conservation has evolved over time (Amsalu & de Graaff, 2007; Gessesse et al., 2016). In recent years, the Ethiopian government with the support of Non-Governmental Organizations has changed its land management policy to more holistic watershed management approach-comprehensive approach that have based community and its livelihoods as center piece of interventions using community-based participatory watershed development as its main guiding principle (Desta et al., 2005; MoARD, 2005; Evans, Giordano, & Clayton, 2012; Haregeweyn et al., 2015; Gessesse, et al., 2016; Teshome, et al., 2016; Gebregziabher, et al., 2016; Gessesse, et al., 2016). The overall objective of this approach is to improve the livelihood of community/households in rural Ethiopia through comprehensive and integrated natural resource development. Given this strategy, different watershed management programs have been implemented throughout the country by the Federal Government, Regional Governments and Non-Governmental Organizations.

Despite the fact that policies and strategies are important in achieving economic development, sustained growth in the agriculture sector relies on how watershed resource is managed by farmers. Efforts are needed to understand the behavior of households' perception, participation, adoption decisions and livelihood characteristics towards sustaining watershed management practices so as to achieve their sustained development in environment and livelihoods. Understanding of households' psycho-social or perception, participation and watershed technology adoption behaviors would lead to more conscious perception of the complex link between agricultural practices, environmental impacts and livelihood effects. It may contribute to improve the effectiveness and sustainability of watershed management conservation measures. Furthermore, an understanding of the farmers' livelihood is also important to be aware of the livelihood condition of households undertaking watershed management program; enables to build the strong base to households whether offered watershed management practices are worthwhile undertaking or not and for the up scaling planning of watershed management intervention strategies towards enhancements for socio-ecological and livelihoods of households.

Against this backdrop, this study was carried out in upper Gibe basin, Southwest Shewa Zone of Oromia Regional State, Ethiopia.

### *1.2. Statement of the problem*

With the given very high population growth rate and continued degradation of natural resources, the possibilities to augment agricultural production through area expansion are very limited in Ethiopia. This makes clear that the greatest opportunity for increasing agricultural productivity likely to come from improved watershed management practices and efficient application of improved agricultural inputs (Sonneveld, 2002). In pursuit of this, the country has been in continuous struggle to increase agricultural production and ameliorate livelihoods through sustainable use of natural resources for several years (Shiferaw et al., 2009). Nevertheless, conservation of land and water resources for sustainable intensification of agriculture has remained one of the most challenging policy issues. Despite these efforts, increasing degradation of watershed gradually deprives the key productive resources and impacting the sustainability of agricultural productivity and livelihood security in the country (Haregeweyn et al., 2015; Gessesse et al., 2016).

These problems are particularly severe in the highland areas of Oromia region where, the natural resources are under extreme stress to support the overall increasing population. The conservation efforts made could not preserve the watershed resource of the region. Resource degradation combined with the ever-increasing population and climate variability continues to be one of the root causes of low productivity and livelihoods insecurity in the region (WARDO, 2013). Upper Gibe basin, the study area, is one of the mountainous, steep and highly fragile lands of the region where extensive land degradation affected the productivity of majority of the rural people (WARDO, 2013).

The watershed management program in developing countries including Ethiopia over many years generally have been trying to combine the goals of resource management and poverty alleviation, but have unfortunately not achieved a great deal in this regard (Perez & Tschinkel, 2003). Although various literatures raised different factors so far, the major constraining problems with past watershed management efforts are largely rooted in a lack of understanding of the important interface between watershed resource conservation and livelihoods, and the

factors that motivate farmers to invest in watershed management measures over the long run sustainability of the program ( Achouri, 2003; Bewket, 2003 ; Bruneau, 2005; Desta et al., 2005; Zeleke, Kassie, Pender, & Yesuf, 2006; Haregeweyn et al., 2015). Farmers' view of the environment is often ignored by both experts and policy makers, top-down management approaches of watershed interventions that focuses on natural resources conservation, lack of considering productive livelihood options, lack of inclusiveness and participation, the absence of long-term management mechanism and lack of consideration of the dilemma that the farmers face between survival and environmental exploitation in planning and implementing watershed management practices (Sonneveld & Keyzer, 2003). This is an indication on how the promotion of widespread systematic use of watershed management practices requires a more holistic approach, taking into account how sustainable watershed management measures and livelihood strategies.

In recognition of these challenges, aiming at reducing widespread watershed degradation and enhancing livelihood opportunities of households through sustainable use of the watershed natural resource base, the regional government of Oromia has undertaken a massive investment in watershed management since the late 1990, and it was featured among the most important investment areas to boost agriculture production. The regional development strategy of conservation-based Agricultural Development Led Industrialization through its successive development plans highlighted sustainable watershed management as a key pillar to maintain economic growth in the region. For example, the Plan for Accelerated and Sustainable Development to End Poverty - PASDEP (2006–2010) outlined an investment strategy that included a series of watershed management activities with the goal of accelerating agriculture production to foster sustainable development. Similarly, the Growth and Transformation plan - GTP (GTP I, 2010–2015; GTP II, 2016–2020) maintained its focus on agricultural productivity, research and natural resources management by prioritizing investments in watershed conservation infrastructure (MoFED, 2010). It outlined the importance of promoting agro-ecology based sustainable land management to combat land degradation. In addition, the Strategic Investment Framework for Sustainable Land Management (ESIF, 2009-2023) was created to improve rural livelihoods by scaling up sustainable land management practices with the objective to restore, sustain, and enhance the productivity of land resources (MoARD, 2010).

Towards this end, watershed management intervention program is being executed in South West Shewa Zone, upper Gibe basin of Oromia National Regional State by the government and different NGOs, since the 1997/8 (WARD0, 2013). The program implemented various watershed management activities. Of these, the most common conservation measures were physical and biological soil and water conservation measures, agro-forestry activities and soil fertility management activities. Moreover, in realizing the need for value adding and natural resources management based income generating activities at household level, the program linking natural resource management technologies with the application of high-yielding and disease tolerance crop variety and improved fruit tree promotion( wheat, potato and apple); livestock development activities such as introduction of forage species (grasses, legumes and trees); establishment of community nursery; fuel saving stoves; poultry, livestock fattening and rearing activities and introduction of improved beehives were supported through different community based institutions.

Though many efforts have been exerted in realizing the program in many areas of the study watershed, Rebu watershed in the upper Gibe basin, Southwest Shewa Zone, Oromia Regional State, Ethiopia for a long, there is hardly any attempt to address the interface between watershed management intervention program and households' socio-ecological-livelihood implications through highlighting sustainable livelihoods approach. Studies on farmers' perception of watershed degradation, community participation in different stages of watershed management, farmers' adoption decision and intensity of adoption of watershed management technologies and the nexus between perception, participation, livelihoods and adoption in watershed management are not found.

Although, watershed degradation problems and management adoption is an increasingly discussed phenomenon in the scientific literature as evidence of its presence and impacts continues to grow in Ethiopia (Bekele & Drage, 2003; Bewket, 2007; Bewket & Teferi, 2009; Demelash & Stahr, 2010; Kassie, et al., 2015; Haregeweyn et al., 2015), local perception of watershed degradation problems and preferences about how to deal with it are still largely overlooked, lack of concerted focus on sustainability issues-level of community participation from their early diagnostic phases of planning, implementation and monitoring (Amsalu & de Graaff, 2006; Haregeweyn et al., 2017), lack of understanding households' multiple technology

adoption behaviors, lack of attempt to examine socio-ecological-livelihoods effects of watershed management program through highlighting sustainable livelihoods approach. Moreover, there is hardly any attempt to examine such principal components of watershed management such as, perception, participation, adoption and socio-ecological-livelihood implications in different topographic settings-upper, middle and lower catchments. Therefore, considering farmers' understanding of watershed management adoption and socio-ecological- livelihoods implication remains a critical input in the design, planning, and implementation of successful watershed management strategies that are adequate for local realities, be they social, cultural, or environmental (Marin, 2010; Schwilch et al., 2012; Patt & Weber, 2014), and furthermore, it may well determine their behavior toward mitigation and adaptation actions (Stern, 2000; Vignola et al., 2010).

In line with the above statements, this study has attempted to address the following objectives and key research questions.

### *1.3. Objectives of the study*

The overall objective of this study was to explore the performance of watershed management program on households' socio-ecological-livelihoods in Rebu watershed of the upper Gibe basin, southwest Ethiopia.

The specific objectives to be perused under this study include:

1. to assess the development, current practices and future prospects of watershed management practices: stat-of-art the watershed
2. to investigate how farmers perceive watershed degradation -soil erosion and soil fertility decline- severity, causes and indicators and to explore the determinants: Implication to sustainable watershed management program
3. to examine status and factors affecting the community participation at different stages- planning, implementation and monitoring of watershed management practices
4. to analysis farmers' adoption decision and intensity of adoption of watershed management practices
5. to explore the socio-ecological benefits of watershed management intervention in Rebu watershed of upper Gibe basin, Ethiopia: Farmers' perspectives

6. to assess the enhancement of livelihood assets of households through watershed management intervention program
7. to examine the nexus of farmers' perception, participation, livelihoods and their implication for sustaining watershed management program

#### *1.4. Research questions*

1. How are the development, current practices and future prospects of the watershed management practices in Ethiopia?
2. How are the local people's perceptions about watershed degradation indicated through the severity of soil erosion and soil fertility decline and its implication to watershed management practices?
3. What are the status and factors affecting community participation in different stages of watershed management program?
4. How do farmers' adoption decision and intensity adoption of the watershed management practices looks like?
5. How farmers do perceived the socio-ecological benefits of watershed management practices?
6. What is the effect of watershed management program on livelihood assets of households?
7. How was the interaction of the perception, community participation, adoption decisions and livelihoods for sustaining use and the up scaling planning of watershed management practices?

#### *1.5. Analytical framework of the study*

Conservation and management of land and water resources for sustainable agricultural production and livelihood improvement in many developing regions, representing the intersection of hot-spots of widespread poverty and fragile ecosystems (Shiferaw & Bantilan, 2004) has remained one of the most challenging policy issues for a long time. This is because, the increasing degradation of agro ecosystems gradually deprives key productive resources and

affects communities whose livelihoods heavily rely on utilization of these resources. Such degradation of land and water resources gradually diminishes the capacity of individual farmers and communities to undertake critical investments needed to reverse the situation.

Watershed management intervention programs have occupied a central role in solutions to watershed degradation problems and enhancing livelihoods (Haregeweyn et al., 2015). More recently, as rapidly growing populations in Africa have become a concern, watershed approach conservation practices are seen as the means through which to obtain the necessary increase in agricultural production and improvements in peoples' livelihoods without degrading the land resources (Mazzucato & Niemeijer, 2000). Ethiopia is one of the sun-Saharan African countries where watershed degradation is the greatest challenge, particularly in the highlands (Haregeweyn et al., 2015; Gebregziabher et al., 2016). Pressures of agricultural activities resulted in serious changes of environment, including high soil loss, water resource pollution, soil fertility depletion, loss of vegetation cover as well as biodiversity, which in turn affect the ecosystem services and livelihoods of smallholders. Natural resource degradation, particularly watershed resources degradations in the form of soil erosion and soil fertility decline are a huge challenge for any years in Rebu watershed-study area which is part of southwest highlands of the upper Gibe basin. The extensive land degradation affected productivity of the majority of the rural people who live in the mountainous, steep and highly fragile lands (WARDO, 2013). This is associated to mainly land mismanagement and poor farming on the hilly and higher slopes by human population and overgrazing by livestock population pressure.

In order to meet the demand of the growing population and reducing the negative impacts of agricultural development, wide ranges of watershed management programs have been designed and implemented in many parts of Ethiopia for decades to augment sustainable agricultural production and to enhance the livelihoods of the population (Desta et al., 2005; Evans, Giordano, & Clayton, 2012; Haregeweyn et al., 2015; Gebregziabher, et al., 2016; Gessesse, et al., 2016). The study area, south west highlands, upper Gibe basin is one of those areas where participatory watershed management program is being executed by the government and various non-governmental organizations since several years. However, there is scanty of information on the state of watershed management adoption and socio-ecological-livelihoods using sustainable livelihood framework.

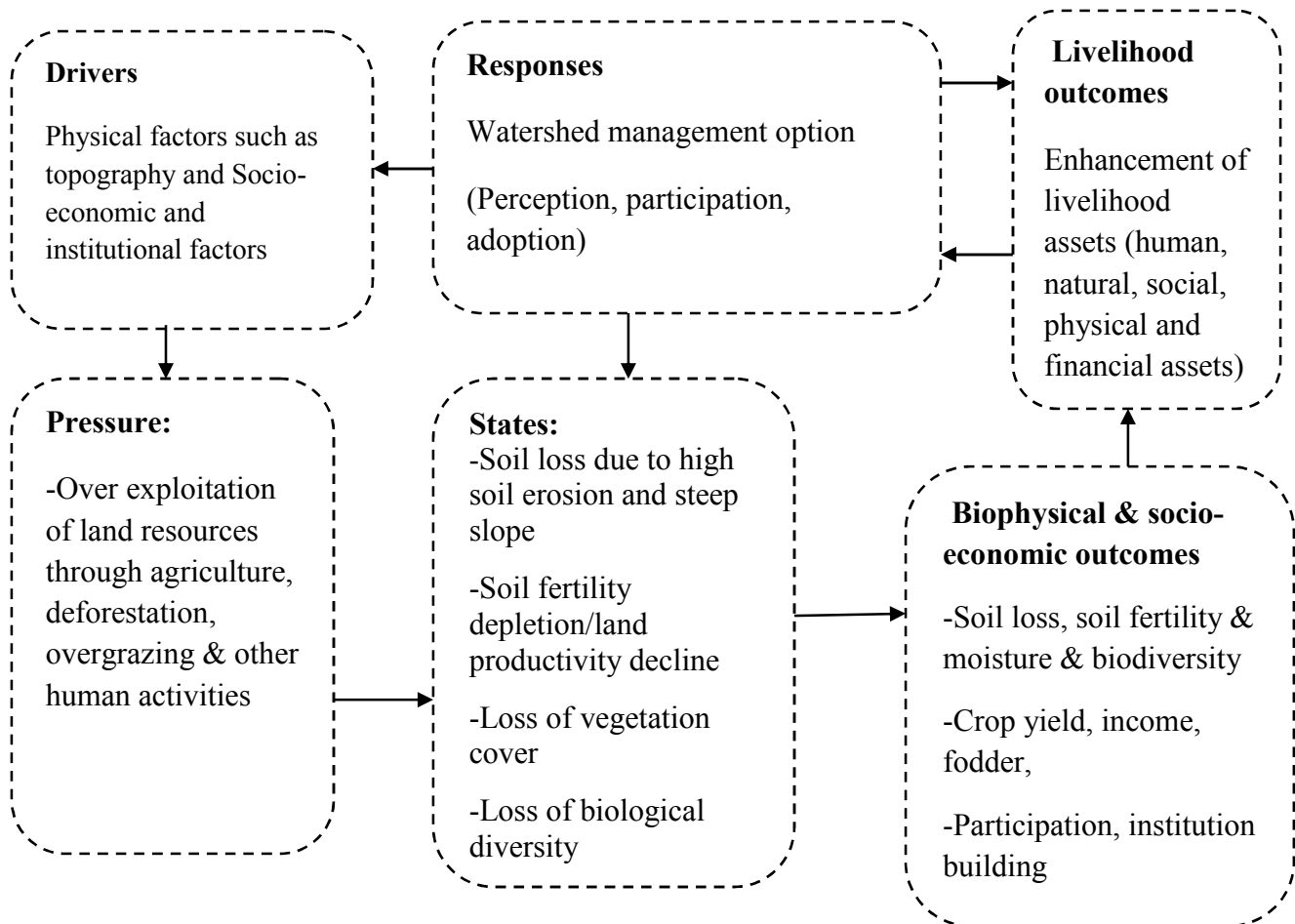
The use of watershed management program practices could be presented in the DPSIR- Driving force, Pressure, State, Impact and Response relationship framework along with sustainable livelihood framework (Chambers & Conway, 1991; OECD, 1993; Scoones ,1998; DFID, 1999; Krantz , 2001; Gobin et al., 2004; Borja et al., 2006; Martins et al., 2012). The conceptual framework (Figure 1.1.) therefore, places watershed management program in the context DPSIR relationship framework towards the achievements of socio-ecological-livelihood outcomes.

Driving forces for watershed conservation deteriorate ecosystem services including for example, the provision of food, fuel and forage. These disruptions have been associated with the direct biophysical and socio-economic factors and exacerbated by rapid population growth which would be resulted in not only decreasing land productivity but also aggravate ecological degradation and social problems (Teklewold, et al., 2013; Kerse, 2018). These comprise activities such as of agricultural intensification, rapid population growth, a shortage of land which is very hilly and excessive high rainfall along with soil erosion. These driving forces in this case produce different environmental pressures, including overexploitation of land resources, water, changes in land use and other human activities related to the development of agriculture, deforestation and overgrazing. Pressures are due to changes in the state of ecosystems or watershed natural resources in both the supply of ecosystem services and livelihoods of smallholders. This leads to watershed degradation that has both on- and off-site effects.

As a result of the perception of livelihood improvements of people, government and society perform different responses either individually or in collective action to control the state as well as promoting the impacts of the adoption of these actions (responses) that is watershed management strategies. Therefore, the impacts can be understood as changes in the quality and functioning of the watershed natural resources or ecosystem service delivery to the society. And also, depending on the social perception of livelihood improvements of people, government and society undertake different actions (watershed management strategy responses in this case) to control or maintain the effects of these responses to the state of the environment as well as to the drivers. Feedbacks between responses means that the ways in which the problem of watershed degradations are handled could affect driving forces, pressures and/or states. The responses could improve the socio-ecological and livelihoods of people as a solution to watershed degradation and sustained use of watershed management.

In the context of DPSIR application in the present study, the policy aspects of responses that is watershed management program was mainly analyzed. Based on this scheme, the framework shows that when profitable watershed resources management practices or technologies are available and capital and institutional constraints are not limiting, farm households may undertake different watershed management and conservation measures. This will improve the level of well-being and natural resource conditions, which will in turn enhance the socio-ecological conditions and stock of livelihood assets available for production, consumption and investment decisions in the subsequent periods. These also in turn affect the sustained use and up scaling planning of watershed management programs.

Figure 1.1, DPSIR conceptual frame-work to analysis watershed management and implications to the socio-ecological-livelihood outcomes of households



Sources: DPSIR Framework -Adapted and modified (Kellner, Risoli, & Metz, 2011)

## 1.6. Methodology

### 1.6.1. Setting of the Rebu watershed in Gibe basin

Rebu watershed, the study area, is located at the upper part of the Gibe basin in Oromia Regional State, Southwest Shewa Zone, Ethiopia. It extends from 8° 30'00" to 8° 35'0"N, and 38° 0'0" and 38°5'0"E (Figure 1.2) with an altitudinal range from 2100-2883 m.a.s.l. Gibe River is by far the largest tributary of the Omo River in Ethiopia and typically flowing south/southeast (WARDO 2013). The confluence of the large Gibe River with the smaller Wabe\_River forms the even larger Omo River. Consequently, the whole drainage basin is sometimes called Omo-Gibe River basin with the Gibe and the Omo draining the upper and lower reaches, respectively. The basin is one of the potential areas for development of hydropower and irrigation projects in the country.

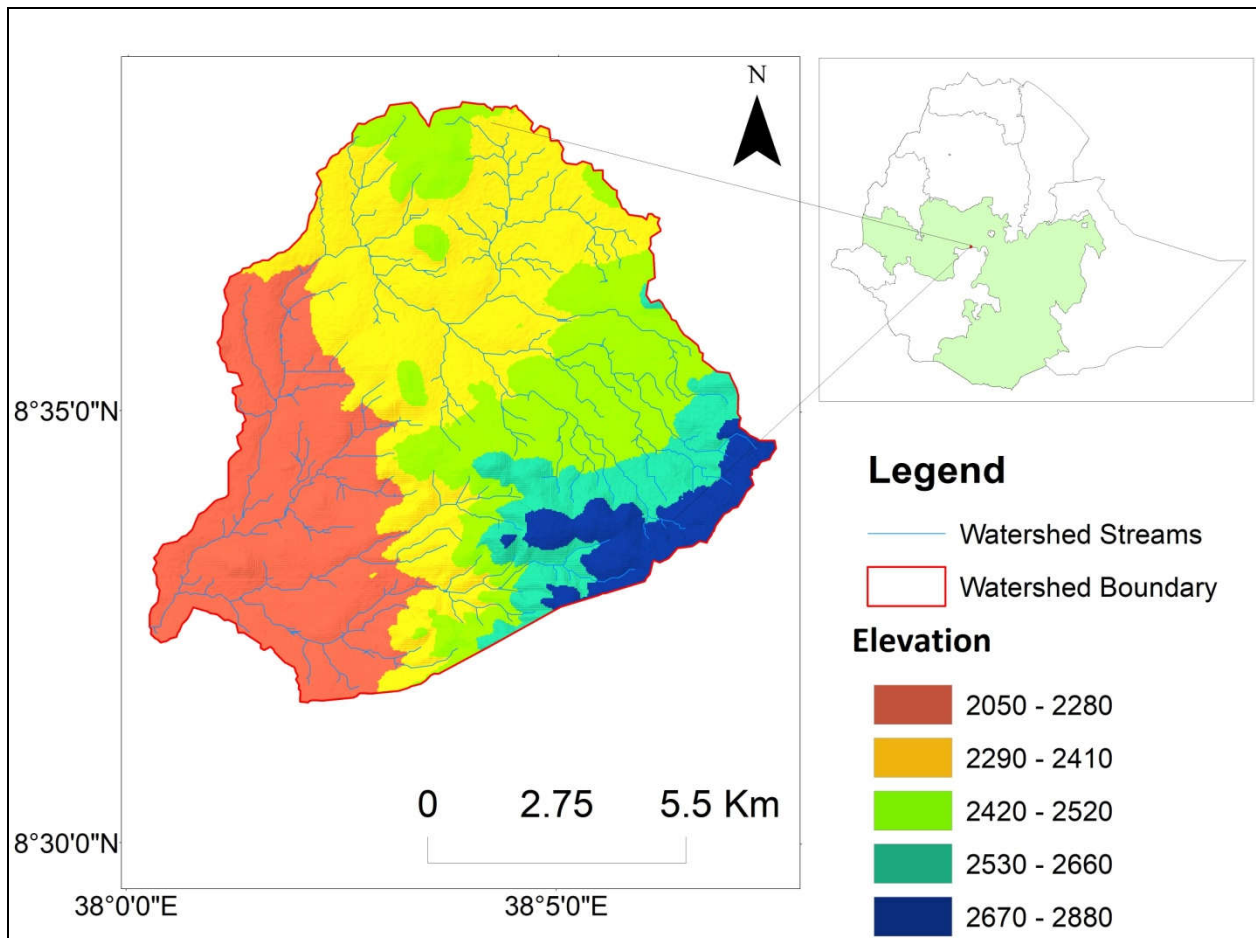
In terms of political administrative divisions the study area, Rebu watershed, falls in Oromia Regional State, Southwest Shewa Zone, Woliso district, Ethiopia. The district is one of the 11<sup>th</sup> districts found in Southwest Shewa Zone of Oromia Region. It is bounded with Wonchi district in the north, Saden Sodo in the south, Southern Nations and Nationalities in the west and Becho woreda in the east. Agro-ecologically the district is subdivided in to Dega (60%) and Woinadega (40%). The total area of the district is about 70, 222 ha and is subdivided in to 37 rural and 3 urban kebeles (WARDO, 2013). The total geographical area of the watershed covers 11,528ha (70 percent *Dega* /highland) and 30 percent *Woinadega* /mid land) representing 16.4% of the district area (WARDO 2013). The watershed comprises about 5, 197 households, with 3681(71 percent) male and 582\_(29 percent) female-headed, with an average family size of 5.7 (WARDO 2013).

On average, Rebu watershed receives annual rainfall ranges from 1250-1350 mm with the main rainy season occurring from June to mid-September. The mean maximum and minimum temperature of the study area is 25°C and 8°C, respectively. The watershed is characterized by different land use types with cultivated land being dominant (50 percent); grazing land(4 percent); homesteads(10 percent); forest and bush(18 percent); degraded hillsides and gullies (16 percent) and others (2 percent) (WARDO, 2013).

Agriculture has been practiced in the watershed for a very long time and it is the main economic activity and source of livelihoods for the watershed population. The farming system is both crop

and livestock production which contributes a small-scale subsistence farming in the watershed. The dominant soil types in the area are vertisols soil and clay soil. The main crops cultivated in the study watershed, include, wheat (*Triticum aetivum*), barley (*Hordeumvulgare*), beans (*Phaseolus lunatus*), peas (*Pisum sativum*), teff (*Eragrostis tef*) and lentil (*Lensculinaris*). In addition, horticultural crops includes *Enset/kocho/warqe* (*Ensete Venter cosum*), *chat/jima* (*Catha edulis*), fruits, potato (*Solanum tuberosum*), as food and/or cash crops are cultivated. Livestock is closely integrated in the farming system. There are limited areas of traditional irrigation in small plots as part of the overall mixed crop-livestock farming system (WARDO, 2013).

Figure 1.2, Location of Rebu Watershed, South West, Ethiopia



### 1.6.2. Motivation for the selection of the watershed

Watershed deterioration through soil erosion and nutrient depletion by rainwater due to deforestation, farming on the hilly and higher slopes and livestock population pressure has contributed to both soil and pasture degradation in the watershed (WARD0, 2013). Any changes in natural resources as a result of severe watershed deterioration problems not only have greater impacts on agricultural productivity and the agriculture-dependent livelihoods but they also impact significantly on the down basin—a key area for the development of hydropower and irrigation projects. This necessitated the introduction of a watershed management program and many efforts have been undertaken for several years. There are various efforts in this regards for many years and have reported some positives effects. The study watershed is characterized by its specific watershed management program intervention experience, state of soil erosion, ability to capture biophysical and socioeconomic heterogeneity, and represent higher, medium and lower elevation watersheds within the highlands of the basin. However, there is no study conducted in the study area so far with regards to state of watershed management adoption and socio-ecological-livelihood implications across different topographic settings-upper, middle and lower. Therefore, the study is relevant to understanding the farmers' psychosocial, participation, and adoption behavior, and socio ecological-livelihood implications of conservation and management of watershed resources.

### 1.6.3. Research design

The research design is the detailed plan for an investigation (Creswell, 2003). In the present study, a mixed method research design was employed through which the primary quantitative data were collected via a semi-structured household survey, while the qualitative data were sourced through personal observations, focused group discussions and key informant interviews. The reason for the choice of this method is to describe the nature of the situation as it exists at the time of the survey. The use of mixed method study design in research is to ensure that the study is comprehensive in terms of breadth and depth (Johnson & Onwuegbuzie, 2004). The application of mixed method, both qualitative and quantitative methods, strengthens a given study as the findings of one method may be supported by the findings obtained by the other and particularly complex social phenomena have various dimensions and linkages in which they are

best understood via a range of diverse methods (Creswell, 2003) and to ensure that the study is comprehensive in both breadth and depth (Johnson & Onwuegbuzie, 2004).

#### 1.6.4. Sources of data

For the study purpose, both primary and secondary data were used. The primary data were collected from household heads, key informants who include community elders, chair person, extension groups, development agents, watershed management work experts and officials and the focus group discussants who encompass community leaders, elders, development agents, experts and non-government actors involved in the watershed management program. Personal transect walk observation was also employed.

The secondary data were sourced from reports of watershed management documents and other government' reports, relevant program documents related to watershed management program in the context of Ethiopia (such as watershed management evolution, practices, achievements and existing gaps for the development of sustainable watershed management practices) were made through reviewing documents to complement primary data. The primary and secondary data were collected in order to cover every aspect of the study.

#### 1.6.5. Sampling technique

This study used combinations of purposive sampling and random sampling techniques. At first level, the identification of the sub-watershed or villages was undertaken during a transect walk observation and in discussion with local elders and administrators, watershed management program experts and officials. Through the process, map developed by the program and district was also used. Based on this, the study watershed was classified in to upper, middle and lower reach of the farmers. Within this frame-work, three sub watersheds/ villages from the watershed management program\_(named after program participant households) such as *warabo* from the upper, *gurasenbate* from the middle and *kake* from the lower were selected based on specific criteria, such as for example, success rate of the activities which was evaluated based on time when the work started (when the program first started) and observable evidence related to the performance of the watershed management activities. On the other hand, concurrent comparison sub watershed /villages from areas of the national government's regular extension program and other public-based watershed management intervention practices (named after program non-

participant households ) such as *gunjo/halle/*, *mogora/gaja* and *roge* were chosen purposively based on their close similarity to the selected program watersheds in their social, infrastructural, agro-climatic, environmental settings and economic characteristics. Intotal, six sub watersheds / villages were selected for the study. The use of purposive sampling in this case lies in selecting information- rich-cases and to capture the differential processes and outcomes based on different disaggregated topographic settings as well as program participant and non-participant households.

Secondly, a list of household heads (the basic unit of the study) was obtained from rural kebele (smallest administrative unit) administration and the farmers’ training center (FTC) from each strata. Hence, the total number of household heads in the selected sub watershed or villages was 1261 out of which 1097 were male and 164 were female. Then, household heads were stratified in each village based on gender. Consequently, the total sample size was determined by a simplified formula given for finite population according to Yamane (1967). Probability proportional to size is used to draw sample households proportionally and to give equal chances in the selection process from each strata. Finally, the respondent household heads were selected by using the random sampling technique-lottery method. Hence, the total sample size, 304 household heads (145 of which were direct participants in the program, out of which 126 were male and 19 female and 159 program non-participants, out of which 138 were male and 21 female) were randomly selected (Table 1.1). The a simplified formula provided by Yamane (1967) was :

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the population size of six sub watersheds/ villages, and e is the level of precision assumed to be 5 percent.

Table 1.1, Distribution of sample sub watershed/villages of the watersheds and number of household heads

Participation status		Sample sub watersheds/villages	Total HH		Total HH	Sample HH		Total sample HH
			M	F		M	F	
Participant	upper	<i>Warabo</i>	192	33	225	46	8	54
	middle	<i>Gura senbete</i>	213	28	241	51	7	58
	lower	<i>Kake</i>	119	16	135	29	4	33
		Sub total	524	77	601	126	19	145
Non-participant	upper	<i>Gunjo /Halle/</i>	165	31	196	40	8	48
	middle	<i>Gaja</i>	176	22	198	42	5	47
	lower	<i>Roge</i>	232	34	266	56	8	64
		Sub total	573	87	660	138	21	159
		Grand total	1097	164	1261	264	40	304

Moreover, to capture information which would be difficult to obtain through the use of other techniques such as questionnaire survey, key informant interviews were held with 20 different purposively selected informants (3 female and 17 male) from a wide range of areas such as experts at Ministry of Agriculture and Rural Development, Region, zone and district natural resources management and protection unit, kebele administrators, leaders of development teams, and village elders. The criteria for selection of participants include involvement, knowledge and experience regarding watershed management practices and community participation in watershed management program practices. Community elders, chair person, extension groups, development agents, watershed management work experts and officials were the key informants. The respondents were notified prior to the interview, a time and place was agreed upon, informed consent was obtained prior to conducting the interview, and the results of each interview were transcribed immediately.

Furthermore, to generate additional contextual in-depth qualitative data, focus group discussions were also undertaken in each of the six sub watersheds by using checklists. Two focus group discussions were undertaken in each six sub watershed. The number of participants in each group

ranged from 8-11 members who were purposively selected in discussion with watershed management program experts, kebele chairperson and development agents. Accordingly, fifty-three (47 male and 6 female) people with different age and social status participated in the discussions. Knowledgeable and influential people and those having adequate information about the past and present conditions of watershed development and management practices, natural resources and community participation were the criteria used for the selection. Community leaders, development agents, experts and community elders and non-government actors involved in the watershed management were among the focus group discussants.

#### 1.6.6. Data collection methods

The primary data used in the study came from a detailed open and closed ended household survey, key informant interviews, focus group discussions (FGDs) and personal transect walk observations. These primary data were supplemented with data from secondary sources gathered from reports and other documents.

##### Household survey

Data collection instruments and development were carried out through a reconnaissance survey, discussions with experts and officials as well as a desktop review. The survey questionnaire was originally prepared in English and for the ease of understanding by the enumerators and respondents it was translated into *Afaan Oromo*, which is the local language of the study area. Prior to the final administration, the household survey questionnaire was pre-tested with 18 randomly selected individuals (three from each sub watershed) who were not members of the sampled households to modify instruments to local conditions. This was done after explaining the purpose of the study and obtaining their consent to participate. Based on the responses obtained, essential amendments were made on pertinent issues such as ordering and wording of questions and coverage of the interview schedule. As a result those found important were incorporated in the final version of the interview schedule. Then, using the pre-tested semi-structured interview schedule, primary data were collected through personal interview technique from sampled household heads. In case where a selected household happened to be away from home for a longtime or was unwilling to be interviewed, a randomly selected substitute was included. Eight enumerators who are bachelor degree holders, have knowledge about the area,

and are well acquainted with the culture and language of the local communities were selected and trained (for three days) for data collection. The data was collected during April 2017 to June 2017 through personal interview technique from sampled household heads. Background information of the study watershed; socio-economic and demographic characteristics of the households; institutional aspects, problems of watershed natural resource degradations-soil erosion and soil fertility decline severity, causes and indicators, ecological and economic benefits of watershed management practices, community participation at different stages of watershed management practices, adoption decisions, and livelihood conditions were collected information.

### Key informant interviews

The interviews with key informants were also used to capture data from them on a one-on-one basis. This allowed the researcher to collect reliable and accurate data needed in order to achieve the objectives of the research. Information collected included the past and present condition of watershed resources, problems of watershed changes, development trends, current practices and future prospects of watershed management practices, institutional contexts and supports, extent of community participation in watershed management practices, challenges, livelihood changes and sustainability. The information was collected from April 2017 to June 2017. Interview durations varied from one respondent to another. Typically interviews lasted between 15 to 30 minutes, but some lasted as long as 45 minutes.

### Focus group discussions (FGDs)

To generate additional contextual data, focus group discussions were conducted by using checklists. The discussions held were aimed at documenting local knowledge regarding past and current conditions of natural resources, watershed deterioration problems, and levels of community participation at different stages-planning, implementations and monitoring of watershed management practices, challenges, livelihoods changes and sustainability. The information was collected in May to June 2017. Here the researcher was limited to facilitating the discussion using a checklist of topics to guide the sessions in an orderly way.

## Guided transect-walk observations

The researcher also used guided transect- field-walk observations method which allows for discussion among the participants during the walk which helps in clarifying issues that are not clear and familiar to him. The guided transect -walks observations across a given area were undertaken with the development agents and elders who were familiar and knowledgeable about environmental conditions and farming activities, and who were willing to accompany the researcher for the walk during which they had an opportunity to emphasise and support their responses with evidence on the existing environmental conditions. During the transect-field-walk observations, the researcher asked questions and paid attention to the explanations given by the participants, observed environmental conditions and made notes in the field note book. The gathered information was used in complementing the data from interviews, focus group discussions. As part of the process, a transect-walk observation was made in the selected area to observe various features of watershed degradation characteristics and indicators, agricultural practices and the activities of the watershed management measures which included the type of watershed management practices and their condition, vegetation cover, grass cover, availability of permanent water sources. Field observation was conducted throughout the whole process of the research.

### 1.6.7. Method of data analysis

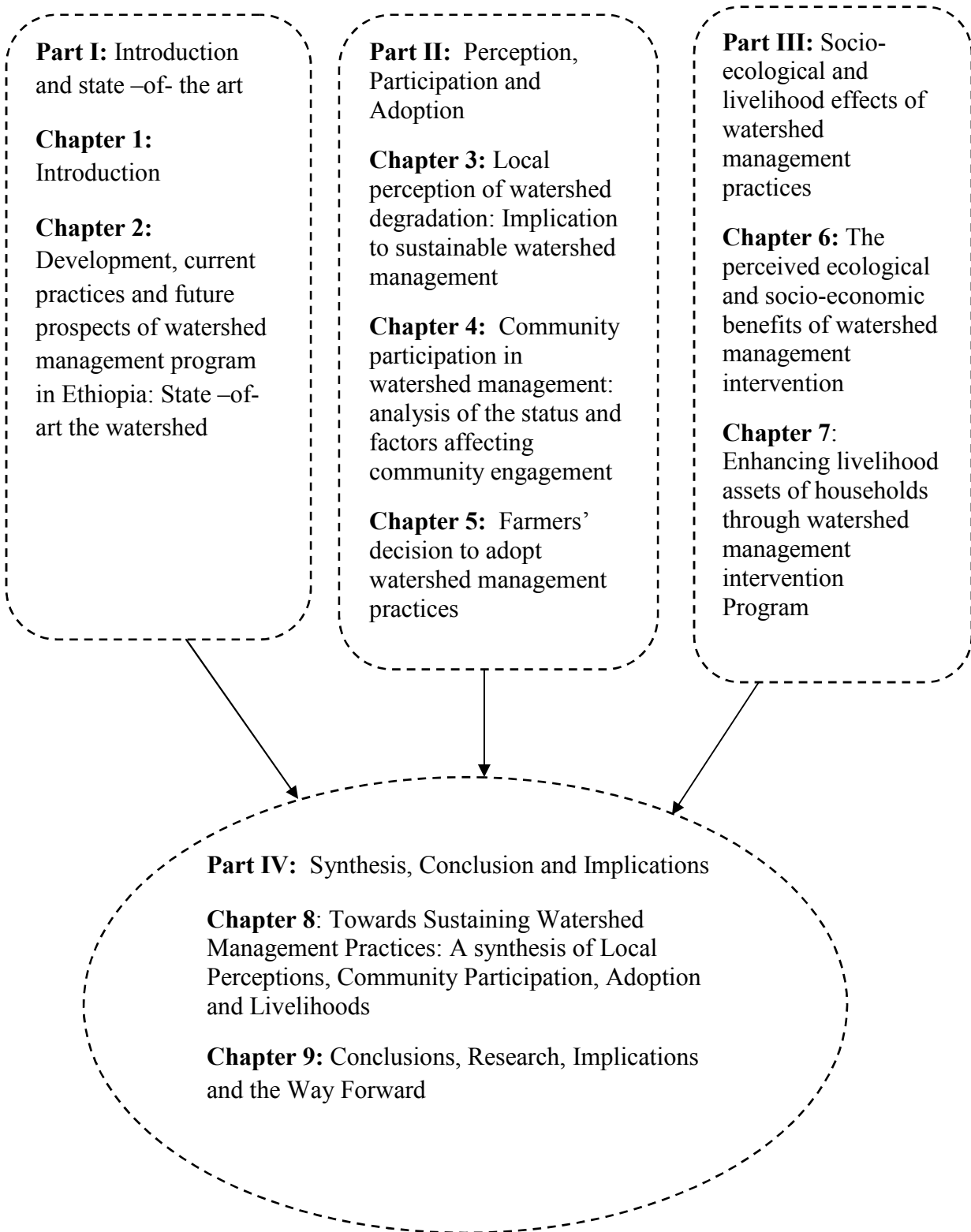
Data collected for this study were encoded and input in to Statistical Package for Social Sciences software (SPSS version 20) and Stata statistical software (Stata version 12) for the analyses. Descriptive analysis and various inferential statistics were used to analysis the results of the study. The demographic, socio-economic and institutional characteristics were summarized by descriptive statistics (percent; mean; cross tabs). Various data, such as for example, watershed degradations-soil erosion and soil fertility decline severity, causes and indicators, perceived ecological and socio economic outcomes of watershed management program, community participation indicators, adoption decision and livelihoods were used to analysis the results. A binary logistic regression model was employed to identify factors that influenced the farmers' perception of watershed degradation, and for the community participation. A, multivariate probit model was employed to identify significant factors affecting farmers' decision to adopt watershed management practices based on the conceptual framework that farmers are more

likely to adopt a combination of watershed management practices simultaneously to deal with multidimensional nature of environmental problems. An ordered probit model was used to analyze factors affecting the intensity (number of practices) of watershed management practices. After various scaling and indexing method employed for livelihoods assets indicators measurement, a propensity score matching method (PSM) was employed to examine the impact of watershed management program on the livelihood assets of households and probit model were used to determine the significant factors determining the differences of the participant and non participant households. The qualitative data gathered from personal observations, key informant interviews and focus group discussions were analyzed through interpretation, conceptual generalization and some quotes to substantiate the household survey.

### *1.7. Structure of the dissertation*

The dissertation is organized under IV parts as depicted in Figure 1.3. Part I incorporates chapter one and two that deals with the introduction and the development trends, current practices and future prospects of watershed management practices respectively. Part II covers chapter three which assessed local perception of watershed degradation indicated through soil erosion and soil fertility decline severity, causes and indicators and determinants towards the implication of sustainable watershed management. It also covers chapter four which focused on the levels and variations of community participation in watershed management at different stages- planning, implementation and evaluation and monitoring. Chapter five that analyzed the farmers' adoption decision and intensity of adoption of watershed management practices was also treated under this part. Part III covers chapter six that addressed the perceived ecological and socio-economic benefits of watershed management program from the farmers' perspectives at different topographic setting-upper, middle and lower and chapter seven deals with the enhancement of livelihood assets of households through the intervention of watershed management program. Finally, in part IV the synthesis and conclusion of the study: Chapter eight which presents the synthesis of the interaction of the perception, community participation, adoption decisions and livelihoods for the sustaining use and up scaling planning of watershed management practices. Chapter 9 presents the conclusions, implications and the way forward were presented under this part.

Figure 1.3, Sketch of the dissertation parts and chapters, 2020



**Chapter 2: Development, Current Practices and Future Prospects of Watershed Management Program in Ethiopia: State- of – the Art**

## Abstract

Wide spread of watershed management activities have been undertaken for several years in Ethiopia to improve environment and peoples' livelihoods. However, review results of watershed management program have been limited. This study by conducting an extensive review of articles, projects and government policy and program documents, highlighted review of development trends, current practices, challenges of implementation and future prospects of watershed management program in the context of Ethiopia. The results of the study indicated that extensive soil and water conservation activities were extended into many parts of Ethiopia since the 1970s. Watershed development program has become the primary objective of the policy, development plans and program of the country. There are also strong efforts in the implementation of the program. However, the emphasis still stresses on the attainment of economic growth rather than environmental concern. Top-down approach of planning the watershed development is still dominating. Inadequate community involvement, lack of efficient extension and training system, and lack of implementation and enforcement of policies and programs are some of the major constraints of the watershed management program implementation. The reviews implied that policy makers and planners need to develop win-win attitude between government requirements and local needs for sustainable improvements of biophysical as well as livelihoods improvements of people and /or watershed management strategies have to be carefully designed and constructed taking into ground realities. More attention also needed to raise awareness through training and capacity building to facilitate involvement of community from planning stage up to the long term maintenance of watershed management practices for the successful environmental management and livelihood improvement.

**Keywords:** watershed development trends; current practices; gaps; future prospects; Ethiopia

## *2.1. Introduction*

Ethiopia's relatively favorable conditions, particularly in the highlands, are supporting a long history of sedentary agriculture and settlements (Nyssen et al., 2007; Adimassu, Kessler, & Hengsdijk, 2012), the main promising resource sector of the economy (Matouš et al., 2013). However, its production is constrained mainly by watershed degradation in the form of soil erosion and soil fertility decline (Darghouth, Ward, Gambarelli, Styger, & Roux, 2008; Mekonnen, Keesstra, Baartman, & Ritsema, 2015). About 1.5 million tons of topsoil are lost from the Ethiopian highland areas each year due to erosion (Tamene & Vlek, 2008). The problem is associated mainly with land mismanagement, deforestation and overgrazing, and hilly topography, torrential rainfall and driven by underlying forces such as population growth, weak implementation of policies (Hurni et al., 2015; Asmame & Abegaz, 2017; Mekuriaw et al., 2018). This would result in both on-site effects (i.e. erosion and top soil loss) (Schmidt & Tadesse, 2012) and off-site effects including flooding, sedimentation, water salinization and pollution (Temesgen et al., 2012) and damage to infrastructure (Lai 2001; Pender & Gebremedhin 2007; Hurni et al. 2015).

In view of natural resource depletion, application of watershed management practices is becoming increasingly important for sustainability of agricultural systems, particularly in most environmentally and economically constrained agriculture-dependent regions such as sub-Saharan Africa including Ethiopia (Pretty, Toulmin, & Williams, 2011; Beddington et al., 2012). The watershed, as a socio-ecological entity, plays a very important role in providing food, social and economic security, as well as important life support services fuelling peoples' livelihoods (Wani & Garg, 2011). In recognition of their importance, the management and conservation of soil and water has been initiated since the early 1970s and consecutively watershed management approach- comprehensive approach integrating both resource conservation and rural livelihood development has been commenced since 1980s in Ethiopia (Desta, et al., 2005; Evans, Giordano, & Clayton, 2012; Haregeweyn et al., 2015; Gessesse, et al., 2016; Teshome, et al., 2016; Gebregziabher, et al., 2016; Gessesse, et al., 2016). A large scale of efforts have been made to implement watershed management practices in the country with the support gained from various international organizations to mitigate watershed degradation and to enhance sustainable

development of ecological balance and improvement in livelihood of households (Teshome, et al., 2016; Gebregziabher, et al., 2016; Gessesse et al., 2016).

There is now a supportive policy and legal framework in the form of policies, programs and development plans that facilitate decentralized and participatory development, institutional arrangements that allow and encourage watershed management practices at all levels in the country (MoARD, 2005; Desta, et al., 2005; Worku & Tripathi, 2015) and significant progresses have been obtained in its achievements. However, research results regarding review of watershed management program have been limited ( Raes et al., 2007; Haregeweyn et al., 2015). Keeping these in view, this study aimed to undertake review on 1) discuss the historical developments trends of watershed management, 2) describe the current practices, gaps and challenges of watershed management adoption 3) explore the biophysical and socio-economic benefits of watershed management and 4) discusses future prospects of watershed management program in the context of Ethiopia.

## *2.2. Methodology*

### *2.2.1. Physical and human environment of Ethiopia*

Ethiopia is a mountainous country located in the Horn region of East of Africa and is characterized by a central highland plateau that is divided into a northwestern and southeastern part by the Great Rift Valley and dominated by rugged terrains, deep gorges and associated lowland plains (Taddese, 2001). The climatic conditions within in the country are widely vary because of its location in the tropics combined with topographic induced variations, ranging from semi-arid to humid and warm or tropical monsoon climate (Ofcansky & Berry, 1993). The country is the second populous nation in Africa next to Nigeria (World Bank, 2017). The relative favorable conditions of the Ethiopian highlands, which represent areas exceeding 1,500 m a.s.l. and mean annual temperature of 20 °C or less, have attracted humans to make a living through farming for long time (B. Sonneveld & Keyzer, 2003).

Throughout history the favorable climatic conditions of the highlands have attracted humans to the Ethiopian highlands to settle and farm there. And hence, much of the country's agricultural production is concentrated in the highland domains-areas where there exist acute land shortages, rapid population growth, and high demand for food production. As a consequence,

overexploitation of the land resources in the highlands over a long period has resulted in severe soil and water degradations. In response to natural resource depletion, application of watershed management practices has becoming increasingly important for the improvements of environment and people's livelihoods in the country. Hence, this study tried to review the development trends, current status and challenges of watershed management program in the context of Ethiopia.

### 2.2.2. Data sources, collection and analysis

Qualitative data were sourced using an extensive review of articles, published literatures of project documents, relevant government policy and program documents related to watershed development and practices in the context of Ethiopia such as for example, Shiferaw & Holden, 2001; Desta et al., 2005; Amsalu & de Graaff, 2006; Bewket, 2007; Nyssen et al., 2007; Darghouth et al., 2008; Meshesha et al., 2012; Worku & Tripathi, 2015; Haregeweyn et al., 2015; Gebregziabher, et al., 2016; Chimdesa, 2016; Teshome et al., 2016; Adimassu, et al., 2017; Tadesse, et al., 2017; Mekuriaw, 2017 and Tesfaye, et al., 2018. Besides reviewing the published literatures, project documents and evaluation reports such as for example, MERET, 2013; 2014, FDRE, 2011 and GIZ, 2015 were reviewed. In addition, government policy and program documents that obtained from the Ministry of Agriculture and Rural Development(MoARD) of Ethiopia such as for example, Agricultural Development-Led Industrialization (ADLI- is the policy principle adopted by Ethiopia to promote its national development; and subsequent program plans such as Development Plan to Reduce Poverty (SDPRP) between 2000/01 to 2004/05; Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) (2006-2010), and Growth and Transformation Plan first phase (GTP) (2011-2015) and second phase (2015-2020) were also assessed. This review provides some background information on watershed development trends, outlines current practices and status of watershed management practices, and discusses achievements and gaps, and future prospects which were analyzed through reviewing documents, interpretation and conceptualization.

## 2.3. *Results of the study*

### 2.3.1. Watershed management program development and policies in Ethiopia

#### 2.3.1.1. Historical overview

Modern watershed management approach became prominent in developing countries since the 1970s and 1980s when the problems of watershed degradation first became apparent (FAO, 2006). Particularly, the concept of watershed management has internationally gained significance following the United Nations Conference on Environment and Development in 1992 in Rio de Janeiro (also known as the Earth Summit) (Forch & Schutt, 2004). Subsequently, from the 1990s, watershed management programs supported by the international community in developing countries typically incorporate livelihood improvements and poverty reduction objectives in addition to resource conservation (Darghouth et al., 2008).

The historical perspective of watershed management in Ethiopia was nearly the same to other developing countries. The government of Ethiopia with collaboration of international agencies have been trying to support better land use and promote massive soil and water conservation (SWC) program since the early 1970's (Chimdesa, 2016). With international institutions and NGO's help, extensive soil and water conservation activities such as: stone and soil bunds, hillside terraces, area enclosure, establishment of tree nurseries and tree planting through food for work were extended into many parts of the country. However, this approach were ineffective, insufficient and unsustainable due to lack of integration, adequate participation of stakeholders in problem prioritization, planning, implementation and monitoring and evaluation ( Desta, et al., 2005, German et al., 2006).

With increasing awareness about the problem related to land degradation and given the failure of the past attempts for successfully addressing the challenges of poverty and food insecurity, watershed approach has been becoming popular strategy since 1980s in Ethiopia that aimed to focus on integration of social, economic, and environmental than only on physical soil and water conservation (Desta et al., 2005). The lessons learned from this experience encouraged the Ministry of Agriculture (MoA) and supporting agencies such as the Food and Agriculture Organization of the United Nations (FAO) to initiate pilot watershed planning approaches on a bottom-up basis, using smaller units and community-based approaches.

Consequently, by the late 1990s (or early 2000s), watershed management program has increasingly been managed and developed for both poverty alleviation and environmental conservation and evolved as a comprehensive development concept for sustainable and efficient utilization of natural resources for the benefit of the local community with special attention to the rural poor (Worku & Tripathi, 2015). By 2005, a participatory community based watershed planning guidelines which were published and it still now used nationally as a practical guidance were introduced (Desta et al., 2005). Participatory community based watershed management has been considered as a significant factor in helping the government to achieve its aim of making agriculture the driving force of economic development in Ethiopia (Evans, et al., 2012). Today there is a massive movement in watershed management in almost all regions of the country.

#### 2.3.1.2. Policy, projects and institutions

In order to respond to watershed degradation through soil erosion and nutrient depletion, successive governments\_ (Imperial, Derg and current government) of Ethiopia have introduced watershed management strategies.

##### Imperial regime (before 1974)

During the Imperial regime, it is only during the second half of the 1960s; the government began to show greater concern for environmental problems and undertook several initiatives to promote afforestation and soil and water conservation ( Rahmato, 2001). Particularly, following the 1972/3 drought and famine in the food insecure areas of the country, the government introduced Food For Work (FFW) programs to address the problem of food shortage as well as to ensure the participation of farmers in environmental rehabilitation activities (Bewket, 2003; Desta et al., 2005). The main objective of the program was to construct Soil and Water Conservation (SWC) structures and carry out afforestation. However, much of the efforts were not successful as the planning of the program followed a top down approach and the participation of farmers was assumed to be achieved through their labor contribution in exchange for food items (Gebremedhin & Swinton, 2003). The government exploited natural resources to seek much needed economic growth (Rahmato, 2001). For instance, large forests were managed as crown property by emperors and kings basically as sources of fuel wood and timber for the royal households. Various government's development planning ,such as, for example, 1st Five Year

Development Plan (1957-61) and 2nd Five Year Plan (1962-67) and 3rd five year Plan (1968-73) (Rahmato, 2001), were also marked by the establishment of the planning institution and the restructuring of the state machinery to the needs of planning and stress the attainment of adequate rates of economic growth rather than environmental concern.

### Derg regime (1974-1991)

The socialist/ Derg/ regime, profoundly altered the agrarian structure and the mechanisms of access to land. The "Public Ownership of Rural Land Proclamation" nationalized all rural land and set out to redistribute it to its tillers and to organize farmers in cooperatives, thereby abolishing exploitative landlord-tenant relations so pertinent under the imperial regime (Rahmato, 2001). According to Rahmato (2001), state environmentalism during the Derge regime, had placed high emphasis on government control of environmental assets on one hand, and the restricting their uses by community. The paradigm seems shifted from the frontier economy to environmental conservation. For example, there were enforced mass mobilization and forced labor campaigns to rehabilitate degraded lands with vegetation and area closure, soil and stone bunds, hillside terraces (Bekele, 2011). Throughout the 1970s and 80s the *Derg* used the Peasant Associations (Pas) to implement their country-wide large-scale resource conservation projects, launched in reaction to the 1973/74 and particularly after 1984/85 droughts and famine. These activities were financed with support from various international donor organizations like the World Food Program (WFP) and focused on soil conservation projects on arable land as well as afforestation and the enclosure of highly degraded areas (Rahmato, 2001). The main objective of these initiatives was to cover the barren hillsides with vegetation and to reduce the level of erosion on agricultural fields through on-farm structures, particularly soil bunds.

Although various efforts were made, the main elements of the conservation policy of the regime were heavily biased in favor of physical structures which were constructed on- or off-farm using Food for Work (FFW) as inducements and mostly failed due to the top-down approach in the planning and implementation process, limiting the input of farmers to labor contributions through food-for-work schemes or coercion, a lack of adaption of soil and water conservation measures to site-specific conditions and a lack of integration of previously existing indigenous soil and water conservation technologies (Rahmato, 2001; Bewket, 2007). The emphasis was also on the need of establishments of the planning institutions and stress on the attainment of

economic growth rather than environmental concern (Asfaw, 1992). Hence, after the fall of the *Derg* regime, farmers demolished most of the SWC structures that were constructed on their cultivated fields, resorting to their traditional land use practices (W. Bewket, 2003).

#### Current regime-Federal Democratic Republic of Ethiopia (FDRE) (After 1991)

Also the current government has put in place numerous policies, programs and initiatives for the conservation and restoration of natural resources through watershed management. Several environmental issues has been incorporated into the supreme law of the land– the Constitution and several policies, programs and strategies to insure sustainable development and environmental health (Getu, 2012). For example, the 1994 Constitution of Ethiopia under Article 44 stated that all citizens shall have the right to live in a clean and healthy environment. Articles 89 and 92 require national policy and government activities to be compatible with environmental health. The broad national economic development policy of Ethiopia is known as the Agricultural Development-Led Industrialization (ADLI- 1993, is the policy principle adopted by Ethiopia to promote its national development that is to reduce poverty and achieve sustainable and fast economic growth) (Engeda et al., 2012). As part of the ADLI economic policy framework, Ethiopia has developed and implemented three generations of poverty reduction strategies. The first generation program was called Sustainable Development Plan to Reduce Poverty (SDPRP) between 2000/01 to 2004/05. Following the successful accomplishment of SDPRP, the second generation program called Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) (2006-2010), and now the third generation program called Growth and Transformation Plan first phase (GTP) (2011-2015) and second phase (2015-2020) is under way.

With regards to environmental management issues, natural resource conservation-based agriculture development became the primary objectives of the policy. In the 1990s the present government of Ethiopia changed its approach towards resource conservation activities. Soil and water conservation structures on cultivated land were built as part of agricultural extension packages (Bewket, 2003). The strategies gave impetus to improved watershed management, adopting different soil and water conservation practices, and rehabilitation of watershed through afforestation, community woodlots development and construction of micro and small scale irrigation projects (Hoben, 1995; Gebremedhin, Pender, & Tesfay, 2003).

However, effective implementation mechanisms (like laws, policies, and institutions) are needed to realize the implementation of the program (Tamrat, 2015). For example, the Constitution in many places underlines consultation and community participation as indispensable elements of development activities including watershed management, but these still require subordinate legislation to put effective mechanisms in place. Although, good progress had been made in many respects, the development plans prioritized economic growth and development while environmental and sustainability issues were relegated into the background. For example, the Ethiopia's new five year plan, the Growth and Transformation Plan (GTP I) for 2010/11–2014/15, and GTP II (2015-2020) sets even higher growth and investment targets (Getu, 2012). Hence, mainstreaming of environmental standards into every development endeavor is still an issue

With increase of the awareness of the importance of watershed conservation and afforestation in improving the country's productivity of subsistence agriculture in particular, the government of Ethiopia, with the support gained from various international and bilateral agencies, has been implementing different large-scale projects. For instance, the United Nations World Food Program-WFP (1973–2002) has been among the first to provide such support ( Haregeweyn et al., 2015). The early phase of WFP intervention has taken the form of emergency food assistance in famine affected areas. In the early 1980s, the support has evolved into the 'food-for-work' program that farmers provide their labor in implementing various mechanical conservation measures (e.g., stone bunds, soil bunds) in cultivated fields and the afforestation of hillsides, and in return they receive grain and edible oil—and employment generation schemes ( Amsalu & de Graaff, 2007). The FFW project was modified to become the Local Level Participatory Planning Approach (LLPPA) and later the Managing Environmental Resources to Enable Transitions (MERET) project.

Later on, similar large-scale interventions have been pursued across the country with the support of multiple international agencies (e.g., FAO, European community, World Bank, GIZ), including the Managing Environmental Resources to Enable Transitions -MERET (2003–2015), Productive Safety Net Program -PSNP (2005-present), community mobilization through free-labor days (1998–present), and the Sustainable Land Management Program- SLMP (2008–2018) ( Haregeweyn et al., 2015). For instance, under the MERET project alone, approximately 1

million hectares (Mha) of farmland and 0.3 Mha of hillside were covered with different types of soil and water conservation structures, such as farmland and hillside terraces (MERET, 2013; Nedassa, Seyoum, & Chadhokar, 2011). In addition, 0.7 Mha of land were cultivated with trees and 1.4 Mha of degraded lands were rehabilitated using area exclosures (MERET, 2014; Nedassa et al., 2011).

Institutional arrangements are crucial for successful watershed resources management (Tesfaye, Alamirew, Kebede, & Zeleke, 2018). The existing institutional arrangements for watershed development programs have been hierarchical in nature in the context of Ethiopia (Spielman, Kelemework, & Alemu, 2011). It consists of Regional Bureaus of Agriculture and Rural Development (BoARDS) under the supervision of the Federal Ministry of Agriculture and Rural Development (MoARD). The BoARDS are in turn comprised of *woreda* (district) offices and extension agents (known in Ethiopia as ‘development agents’ or DAs) working at *kebele* (PA) level. At *kebele level*, watershed team was established to coordinate the planning and implementation of watershed management practices. This watershed team was supervised by a district watershed team organized at the district level with different specialization. Again, the district’s watershed team was supervised by a regional level watershed team organized at the regional level.

#### 2.3.1.3. Watershed approaches – the paradigms

Watershed approach has received wide acceptance in its ability to restore land and minimize water degradation recently (GIZ, 2015). To be more specific, the watershed approach includes considerations such as soil erosion, siltation management, flood abatement, water supply improvement, wildlife conservation, fishery protection, forestry and agro-forestry management, protection of native vegetation and development of infrastructure. It requires the partnership and collaboration of all stakeholders – those people affected by land and water management decisions – in order that their economic, social, and cultural concerns can be considered and integrated. In an effort to reduce watershed degradation and ameliorate biophysical environment and farmers’ livelihoods, various paradigms/approaches to watershed conservation have evolved, such namely, top-down, populist or farmer-first and neo-liberal which are neither strictly sequential in their historical development nor exclusive (Biot, Blaikie, Jackson, & Palmer-Jones, 1995).

The top-down approach supposes completely and strictly follows a formal process to give main concern to the biophysical framework of watershed in the early periods of watershed management programs (Douglass & Lawrence, 1997). In this case, the government fixed the targeted plan and implemented it directly by contractor or their own staff without consulting the local people. The approach identifies mis-management of land by users, which are ignorant, irrational and traditional, and their subsistence fundamentalism as core problem in watershed conservation practices (Reij, 1991). The “populist” or farmer first approach in the late 1980s (Mazzucato, Niemeijer, Stroosnijder, & Röling, 2001) made the farmer the center of watershed conservation programs. It includes process of participation of the local people for planning, implementing and decision making for community development at the local level and bottom-up participatory interventions, often using indigenous technologies (Reij, 1991). The neo-liberal approach recognizes the appropriate roles for farmer innovation but brings to the centre stage of the critical role of markets, policies and institutions to stimulate and induce farmer innovation, adoption and adaptation of suitable options (Reddy, 2005).

The watershed management program in developing countries over many years generally have been trying to combine the goals of resource management and poverty alleviation, but have unfortunately not achieved a great deal in this regard (Perez & Tschinkel, 2003). It maintained top-down management approaches focusing on natural resources conservation, and not adequately considering productive livelihood options, the lack of inclusiveness and participation, the absence of long-term management mechanism, etc., (Bruneau, 2005). Similarly, watershed management programs implemented at first phase during the 1970s and 1980s were reported in effective and un sustainable in context of Ethiopia due to its top-down approach basically focused on physical soil erosion control measures and little attention was given to participation of local people in the planning and implementation of watershed program and livelihoods, and views and perceptions of farmers ( Achouri, 2003; Bewket, 2003; Desta et al., 2005; Haregeweyn et al., 2015).

Given the failure of the past attempts and in recognition of the importance of watershed approach- role in providing food, social and economic security, as well as important life support services fuelling households’ livelihoods, formal watershed development planning approach has emerged as a logical and the most effective holistic approach since 1980s in Ethiopia (Desta, et

al.2005; Haregeweyn et al., 2015). Particularly, since the end of the 1990s, therefore, the soil and water conservation activities were developed into a participatory integrated watershed management approach to promote sustainable water and land resources management based on partnerships with the community (German et al., 2007). The watershed management technologies have been shifted from physically dominated engineered structures to various activities such as physical and biological measures, agricultural intensification and income-generating activities.

Although, various efforts have been tried to combine the goals of resource management and poverty alleviation through combining community based participatory and neo-liberal approaches- critical role of markets, policies and institutions to stimulate watershed management, neither approach has, however, been able to fully shed the legacy of the past-top down approach and have unfortunately not achieved a great deal in this regard in the context of Ethiopia (Mazzucato & Niemeijer, 2000; Beshah, 2003).

### 2.3.2. Trends and status of watershed management practices in Ethiopia

At present, there is no globally approved or endorsed system to describe watershed management technologies (Haile et al., 2006). Generally, watershed management technologies are defined by World Overview of Conservation Approaches and Technologies (WOCAT) as activities at a local level which maintain or enhance the productive capacity of the land in areas affected by or prone to degradation(WOCAT, 2007) such as agronomic, vegetative, structural and management measures that prevent and control land degradation and enhance livelihood.

Efforts have been made by the farming communities to mitigate land degradation by developing local practices of conserving soil and water for long history in Ethiopia. Among others, some of these indigenous practices that took over 400 years in the country were indigenous agro forestry practices of Gedeo people, bench terraces practices of Konso people, and water resources and rangelands management of Borana community (Mulat, 2013; Chimdesa, 2016). Even though indigenous land resource management is known to have a long history in many parts of Ethiopia, large scale efforts led by government only dates back to the mid-1970s (Haregeweyn et al., 2015; Gessesse et al., 2016; Teshome et al., 2016; Gebregziabher et al., 2016) following a severe drought and famine, to which land degradation was identified as an underlying cause. Multiple

watershed management practices have been carried out at individual or community levels in the country since then ( Desta et al., 2005; Adimassu, Langan, Johnston, Mekuria, & Amede, 2017).

These include, soil and water management practices on cultivated lands (various physical soil and water conservation measures-stone and soil bunds, stone faced soil bund, *fanyajuu*, and bench terraces ; biological measures -mainly plantation of grass and other multi-purpose shrubs on farm terraces; soil fertility management practices- compost and mulching, and soil moisture management practices - tie ridging of different kinds, drainage of excess water, and deep trenches for semi-arid areas, etc.; area closure combined with various moisture management practices-trenches, micro-basin, eyebrow-basin and hill-side terraces, and enrichment plantation; gully rehabilitation using different kinds of check dams -mainly loose stone check dam, gabion, concrete and brush-wood check dams, combined with, gully reshaping, runoff diversion and gully re-vegetation and utilization arrangements among communities; runoff diversion and management - cut-off drains, water ways combined with different biological measures; small-scale water harvesting- individual and community ponds, shallow wells, small-scale diversion, spring development, percolation dams, etc.; Agro-forestry on farmlands; homestead development packages that includes- horticulture development, apiculture, small-scale fattening, dairy, forage development, aquaculture, live fencing and in some cases energy saving stoves, supported with small loans and credit and saving group functions and establishment of nurseries to produces different biological materials- tree and fruit seedlings, grass seeds and cuttings, grafted materials.

Some success stories were documented, particularly with regards to the lengths of soil and water conservation structures and area of land enclosed for regeneration (Desta, et al., 2005). For instance, between 1976 and 1985, some 600,000 km of soil and stone bunds and 470,000 km of hillside terraces were constructed through campaign works. During the same period, 80,000 ha of steep slopes were enclosed for regeneration (Zelege, et al., 2006). Generally, the period of 1975 to 1989, terraces were built on 1,188,000 ha, and a land of about 310,000 ha was vegetated ( Assefa & Bork, 2016).

### 2.3.3. Effects of watershed management practices in Ethiopia

The government of Ethiopia with the collaboration of international agencies launched and implemented a massive watershed management measures for more than three decades (Shiferaw

& Holden, 1998; Herweg & Ludi, 1999; Haile et al., 2006; Teshome et al., 2016; Chimdesa, 2016) to halt land degradation and improve peoples' livelihoods. Successful achievements have been achieved through improved natural resource management. Some of which were discussed below.

### Biophysical impacts

Various literatures indicated that physical watershed conservation measures such as bund structures, trenches, micro-basins, and hillside terraces modify the terrain through changing the length and degree of the slope, which reduces runoff velocity, enhances water infiltration and traps sediment at the downstream section of the structures in Ethiopia (Haile et al., 2006; Vancampenhout et al., 2006; Nyssen, et al., 2007). Biological watershed conservation such as hedge rows, grass strips, reforestation, bund stabilization with vegetation, and homestead plantations help to enrich soil organic matter content and restore vegetation cover and biodiversity (Boix-Fayos, et al., 2008; Amare et al., 2014). Restoration of vegetation cover also helps to control the detachability of soil by raindrop impact and transportability by surface runoff (Haileslassie et al., 2005). Besides controlling soil erosion and maintaining soil fertility, watershed management measures play a considerable role in improving the water supply through a better recharge. The vegetation cover enhances the infiltration capacity and reduces loss of water through surface runoff (Haileslassie et al., 2005).

Sediment accumulated behind bunds provides suitable growing conditions for crops through conservation of soil moisture and nutrients (Haile et al., 2006; Vancampenhout et al., 2006). Agronomic and biological conservation measures play a vital role to reduce soil erosion, conserve soil moisture, restore vegetation, and maintain biodiversity (Vancampenhout et al., 2006; Mekuriaw, 2017; Tadesse, et al., 2017). Vegetation cover on the soil reduces erosion by intercepting rainfall, decreasing the velocity and erosional power of runoff, increasing granulation and porosity, and reducing soil drying. Studies indicate that physical, multipurpose biological measures such as vetiver grass (*Vetiveria zizanioides*), Desho grass (*Pennisetum pedicellatum*), elephant grass (*Pennisetum purpureum*), and agronomic watershed management measures can help not only to reduce runoff and soil erosion but also to improve the physical and biochemical fertility status of the soil (Nyssen et al., 2007; Meshesha et al., 2012; Tadesse, et al., 2017). When agronomic measures or changing tillage practices and vegetative measures are

not enough to control erosion on the field, a combination of approaches or various conservation measures such as contour ploughing, strip-cropping or bund structures, water ways, cut-off drains, check dams and water and sediment control basins may be considered jointly.

### **Socio economic impacts**

Various literatures indicated that watershed management practices have various socioeconomic impacts, such as for instance, income diversification, improvement on assets owned by farm households, employment opportunities, food security, health and education in Ethiopia (Gebregziabher et al., 2016); improve yields, household annual income, dairy cow milk and honey bee yield (Yaebiyo, et al., 2015); improves both household income and savings (Assan & Beyene, 2013); enhances access to communal grazing land, access to grass, knowledge and skills, income from the sale of grass and tree seedlings (Assefa, et al., 2018), increases farm income, reduces risk of crop failure, improves access to health and education, empowered women and enhances various activities such as apiculture, livestock fattening and irrigation (Gebregziabher et al. 2016); increased crop yields and income generating activities (Vancampenhout et al., 2006; Nyssen et al., 2007; Gebregziabher, et al., 2016; Tesfaye, et al., 2018).

#### **2.3.4. Factors affecting sustainable development of watershed management practices**

Despite the growing concern over management of watershed in view of environmental and livelihood implication and has significant progress in restoring degraded watersheds in Ethiopia, the strategies faced various constraints to achieve the desired objective (Herweg & Ludi, 1999; Hengsdijk, Meijerink, Mosugu, 2005; Haile et al., 2006; Nyssen et al., 2010; Gebregziabher et al., 2016). Several constraints are listed below:

##### **Inadequate community participation**

Currently, the concept of community based participatory watershed development goes beyond traditional integrated technical interventions for watershed conservation to include proper institutional arrangements for collective action and market related innovations that support and diversify livelihoods in Ethiopia (Desta et al., 2005; Worku & Tripathi, 2015). However, community participation in watershed management intervention is mostly still taken as mere

labor contributors in the country (Bewket & Sterk, 2002; Snyder et al., 2014; Haregeweyn et al., 2015). Problem identification, planning, design, monitoring and evaluation of introduced watershed management techniques have been done separately with subject area specialists, experts and in some cases with consultants. Farmers were forced to implement the introduced watershed interventions mainly with top down approach with full of enforcement.

#### **Lack of efficient watershed management awareness/extension system**

The extension system in Ethiopia is characterized by lack of technical support from development agents and other development officers that negatively influences farmers' cooperation in adopting conservation measures (Bekele & Drage, 2003). Moreover, insufficient attention has been given to indigenous practices and the farmers' level of competence in solving their own problems, which is usually underestimated and deemphasized in the design of land management practices (Haile et al., 2006). Skills and learning ability with regard to technical improvements plays an important role and training and extension are effective means of translating knowledge into concrete approaches in order to adapt technical measures to changing contexts and enable people to implement sustainable land management accordingly (Breu, Hurni, Portner, & Schwilch, 2011).

#### **Lack of scientific and indigenous/local knowledge linkages**

Experience shows that efforts to create better knowledge of sustainable land management cannot rely solely on scientific knowledge; the knowledge of local actors and other stakeholders must also be incorporated (Breu et al., 2011). Various literatures in Ethiopia (Vancampenhout et al., 2006; Nyssen et al., 2007; Schmidt & Tadesse, 2012; Tadesse, et al. , 2017), indicated that there has been little attention paid to systematically documenting farmers' perceptions and experiences of watershed management practices. In fact, a wealth of farmers' knowledge and information exists, and there is a great demand to access it (Zhou, Luukkanen, Tokola, & Nieminen, 2008). Local knowledge, experiences and practices, along with the various visions of landscapes of farmers, can provide information complementary to that of conventional scientific appraisals (Campos et al., 2012).

## Policy and program implementation constraints

Even though the government designed sound environmental management policy and strategies that supports watershed development and management, but the effectiveness of the strategies are low and unsustainable (Shiferaw & Holden, 2001; Amsalu & de Graaff, 2006; Raes et al., 2007; Haregeweyn et al., 2015 ; Mekuriaw et al., 2018) as they are inadequate and poorly enforced and implemented. The various watershed management approaches that have been tried in watershed programs have been still influenced by top-down policies that have yielded limited success (B. Shiferaw & Holden, 2000).

### Inappropriate technological preference

Various studies in Ethiopia noted that the application of inappropriate technology relative to local conditions as a reason for the low adoption rate or the un sustained use of watershed management measures (Amsalu & de Graaff, 2006; Bewket & Sterk, 2002; Bewket, 2007; Adimassu et al., 2013). Land users' motivation and willingness – that is, their commitment – to invest in sustainable land management depends on a wide array of factors rooted in the economic, sociopolitical, and ecological environments in which they live and work (Breu et al., 2011). The introduction of new technology without giving due consideration to the socio cultural and economic condition was rejected by the society (Zeleeke et al., 2006). Many of the watershed management efforts were considered ineffective and unsustainable in Ethiopia due to among others, too much emphasis on natural resources conservation and little attention to human activities and the priorities and needs of people (Shiferaw & Holden, 1998; Desta, et al., 2005).

## *2.4. Discussion and future prospects*

### *2.4.1. Key findings*

The historical development of watershed development planning in Ethiopia was nearly the same to other developing countries. For example, soil and water conservation activities such as: stone and soil bunds, hillside terraces, area exclosure, establishment of tree nurseries and tree planting were extended into many parts of the country since the 1970s (Desta, et al.2005; Haregeweyn et al., 2015). There is now a supportive policy and legal framework in the form of policies that facilitate decentralized and participatory development, institutional arrangements that allow and

encourage the implementation of watershed management practices (MoARD, 2005). The federal and regional government now have formulated and issued several policies, programs and strategies to insure sustainable use of natural resources and incorporated environmental issues in various development plans (Cesar & Ekbom, 2013) For example, Sustainable Development Plan to Reduce Poverty (SDPRP), Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) and Growth and Transformation Plan first phase (GTP).

However, regardless of how sound the policy, development plan and management are today, their emphasis in different regimens of the country has been still on the economic aspect or focus on short-term economic gain and the mainstreaming of environmental standards in to every development effort is still an issue. For example, during the imperial regime, large forests were managed as crown property by emperors and kings basically as sources of fuel wood and timber for the royal households (Rahmato, 2001) followed top-down approach; the main elements of the conservation policy of the Derg regime were heavily biased in favor of physical structures and mostly failed due to the top-down approach in the planning and implementation process (Rahmato, 2001; Bewket, 2007) and the emphasis was also on the need of establishments of the planning institutions and stress on the attainment of economic growth rather than environmental concern (Asfaw, 1992). The Growth and Transformation Plan (GTP I) for 2010/11– 2014/15, and GTP II (2015-2020) sets even higher growth and investment targets and the development plans prioritized economic growth and development-puts a strong emphasis on industrialization, urbanization, and export promotion while environmental and sustainability issues were relegated into the background (Getu, 2012).

There are also strong efforts to realize the community based participatory approach to watershed management practices in Ethiopia. For instance, the basic watershed approach has shifted from top-down infrastructure solutions to community-based approaches in Ethiopia (Desta, et al., 2005; Worku & Tripathi, 2015). Several NGOs and bilateral organizations also adopted participatory land use-planning approach in the last decades in their respective areas of intervention and in close collaboration with government partners. For instance, GIZ has followed a Participatory Land Use-Planning (PLUP) approach and succeeded with this approach in South Gondar, North and West Shoa of Oromia and in some weredas of Tigray introduced and mainstreamed the participatory element into the land use-planning and natural resources

management approach introducing with biological and physical soil and water conservation measures, crops and farming practices (MoARD, 2005). Despite strong efforts have been done to implement of community based watershed management approach, there have not been able to fully shed the legacy of the past-top down approach and have unfortunately not achieved a great deal in this regard (Mazzucato & Niemeijer, 2000; Beshah, 2003).

Some successful achievement has been achieved through restoration and improved management of land at the watershed level in highlands of Ethiopia. For example, soil bund reduce erosion, improve infiltration, reduce surface runoff and soil loss and increases crop yields (Wolka, Moges, & Yimer, 2011; Adimassu et al., 2013; Sinore, Kissi, & Aticho, 2018). In addition to biophysical impacts, watershed management practices have also various socioeconomic impacts such as income diversification, improvement on assets owned by farm households, employment opportunities, food security, health and education (Gebregziabher et al., 2016); improves dairy cow milk and honey bee yield (Yaebiyo, et al., 2015); improves both household income and savings (Assan & Beyene, 2013); enhances access to communal grazing land, access to grass, knowledge and skills, income from the sale of grass and tree seedlings (Assefa, et al., 2018), increases farm income, reduces risk of crop failure, improves access to health and education, empowered women and enhances various activities such as apiculture, livestock fattening and irrigation (Vancampenhout et al., 2006; Nyssen et al., 2007; Gebregziabher, et al., 2016; Tesfaye, et al., 2018).

Despite the growing concern over management of watershed in view of environmental and livelihood implication and has significant progress in its positive achievements in Ethiopia, the strategies faced various constraints to achieve the desired objective and are not equally successful or effective in many parts of the country. Some of the constraints are for example, inadequate community involvement, lack of efficient extension and training system, lack of acknowledgement of farmer' perception, lack of linkages between scientific and local knowledge, lack of technology preferences or considering socio-economic profile, and policy implementation and enforcement (Herweg & Ludi, 1999; Hengsdijk, Meijerink, Mosugu, 2005; Haile et al., 2006; Nyssen et al., 2010; Gebregziabher et al., 2016). Level of farmers participation in soil conservation activities are influenced by inadequate expert follow-up and assistance and technical skills (Sinore et al., 2018).

#### 2.4.2. Future prospects

Though the Ethiopia's environmental resources has been deteriorating for many decades, some positive improvements have been observed in biophysical and socio economic conditions. In order to generate further improvements, the following areas deserve special attention.

##### Policies, programs and strategies

The federal and regional government of Ethiopia have formulated and issued several policies, programs and strategies to insure sustainable development and environmental health (Cesar & Ekbom, 2013). However, regardless of how sound the policy, development plan and management are today, watershed problems are dynamics as new developments, new problems and even new natural disasters will occur over time. In addition, strong emphasis has been made still on the economic aspect or focus on short-term economic gain than environmental concerns. Hence watershed planners and workers should strike a balance (win-win) or a compromise attitude between conservation and development, as well as between government requirements and local community's needs.

The government of Ethiopia gives more emphasis on rehabilitating the area to reverse the natural resource degradation process because it serves as a source of income generation for farm households. Watershed based harvesting of water as well as introducing the new high value diversified crops, livestock and agro forestry development are added in the new policy and strategy. The watershed conservation initiatives also incorporated household income-generating activities along with the rehabilitation of degraded lands. This is a good start but should be strengthened. The package should be thoroughly discussed with the local community and used as an incentive and satisfy urgent and basic needs of the local community that encourage them to adopt conservation measures and/or alleviate their constraints. Various regions of Ethiopia have already started land tenure certification to the farmers, which strongly supported the development and management of watershed in participatory mode (Desta et al., 2005). Government of Ethiopia also realized the need for community based participatory watershed management and prepared guideline that supported the program and implemented through ministry of agriculture and rural development. Good start and experience in community based watershed management should promoted more.

### **Institutional perspectives**

Integrated watershed management cuts across many sectors and institutions within a watershed. Hence, a close and effective coordination for pooling resources to achieve clearly identified mutual objectives and goals is better than everything being done by the watershed program itself. Strengthening the institutions dealing with land and water resources in Ethiopia, building their managerial capacity and improving co-operation and co-ordination between federal and regional governments are vital for sustainable development in the country.

### **Community participation**

Currently, the concept of community based participatory watershed development goes beyond traditional integrated technical interventions for environmental conservation to include proper institutional arrangements for collective action and market related innovations that support and diversify livelihoods in Ethiopia. This is a good signal on how both integrating small-scale and bottom-up participatory interventions approach often using indigenous technologies with the critical role of markets, policies and institutions to stimulate and induce farmer innovation in watershed management strategies. Hence, governmental and nongovernmental actors and the donor community must collaborate and coordinate their activities to achieve better results, and encourage the participation of different stakeholders in decision-making at all levels of planning, implementation and monitoring and evaluation.

### **Research and awareness**

Although, concerted efforts has been made so far, inefficient extension system, weak link between research and extension are root causes of unwise utilization and management of the natural resources and are major policy constraints discourage farmers from making investments on watershed management practices. Skills and learning ability with regard to awareness and technical improvements plays an important role and training and extension are effective means of translating knowledge into concrete approaches in order to adapt technical measures to changing contexts and enable people to implement sustainable land management. It is also essential to enhance indigenous practices and the farmers' level of competence in solving their own problems. Research is also helpful in assessing and publicizing the gravity of environmental

problems, developing adaptation methods for different problems, and updating scientific discoveries about technology or new threats.

### *2.5. Conclusion and policy implication*

Watershed degradation, particularly in the highlands, is the main environmental and socio-economic challenge facing Ethiopia. Over the years, various watershed management practices have been under taken to protect and manage the environmental resource bases and enhance livelihoods of households of the country. In the context of DPSIR application in the present study, the policy aspects of responses that is watershed management practices was mainly discussed. The result of the review indicated that, there are a number of provisions incorporated in the Constitution of Ethiopia relevant to the protection, sustainable use, and improvement of environmental resources however; effective implementation mechanisms are still an issue. The emphasis of the policy and plans in different regimens of the country has been still on the economic aspect or focus on short-term economic gain and the mainstreaming of environmental standards in to every development effort is still an issue. Despite, currently good signal on bottom-up participatory interventions approach in watershed management strategies; the legacy of the past-top down approach has been still dominating. In addition, watershed management efforts are constrained by various problems, namely, inadequate community participation, lack of efficient extension services, lack of appreciation of local farmers' perception, lack of linkage between scientific and indigenous knowledge, and lack policy, plan and program implementation and enforcement. The review also indicated that there are areas that need further concern, namely farmers' knowledge and awareness, program implementation, institutional strengthening and community participation in watershed management practices in different phases, adoption and livelihood options of watershed management practices.

The review paper recommends the following points. These include; strong efforts are needed from governments, policy makers, watershed planners and workers to implement policies, plans and programs to balance (win-win) or a compromise conservation and development, as well as between government requirements and local needs, and watershed restoration options have to be carefully designed and constructed taking into ground realities. In addition, governmental and nongovernmental actors and the donor community need to collaborate and coordinate to encourage the participation of farmers through awareness raising, training, and capacity building

in decision-making, planning, implementation up to the long term maintenance of watershed management practices for the successful environmental and livelihood improvement.

## **PART II: PERCEPTION, PARTICIPATION AND ADOPTION OF WATERSHED MANAGEMENT**

**Chapter 3:** Local Perception of Watershed Degradation

**Chapter 4:** Community Participation of the Watershed Management: Analysis of the Status and Factors Affecting community engagement

**Chapter 5:** Farmers' Decision to Adopt Watershed Management Practices

### **Chapter 3: Local Perception of Watershed Degradation**

## Abstract

Local perception of watershed degradation is a key social factor that plays a great role for sustainable watershed management strategies. However, there are little efforts in systematically documenting farmers' perception of watershed degradation in developing countries including Ethiopia. This study intended to explore farmers' perception of severity, causes and indicators of watershed degradation across different disaggregated sub-watersheds-upper, middle and lower, and analysis of factors affecting farmers' perception of watershed degradation in Rebu watershed, southwest Ethiopia. Data were obtained from transect walk observations, group discussions; key informant interviews and household survey. The data obtained were subjected to descriptive and binary logistic regression analysis. The results of the investigation showed that the majority of the households (96.6%) were aware of or perceived watershed degradation as a problem constraining agricultural production in their farm lands and surrounding landscapes. Farmers perceived exposed stone, gullies and rills erosion and tree root exposure as the major indicators of soil erosion, while crop yield decline, soil cultivability decline and crop color changes were for diminishing soil quality. Cultivation of steeper slopes by clearing vegetation induced by population pressure, overgrazing and land management practices were perceived as the major causes of watershed degradation. Problems of watershed degradation were better perceived in the upper and middle topographic settings and for watershed program participant households implying the need for site-specific appropriate watershed management alternatives. The majority of respondents (over 75%) also confirmed that they observed a decreasing trend in watershed degradation following the introduction of the watershed management program. Binary logistic regression results indicated that farm land size, topographic settings, extension services, group membership, credit services and the number of livestock owned were significant factors of farmers' perceptions. Hence, decision makers and planners need to consider location and/or socio economic context-specific conditions to understand watershed degradation and towards restoration activities in a given landscape.

Keywords: watershed degradation; perception; determinants; upper Gibe basin; Southwest Ethiopia

### 3.1. Introduction

Watershed degradation refers to a loss or continual decline in the capability of a watershed to provide ecosystem services, presents a major threat to global food security, economic well being and livelihoods (Lal, Safriel, & Boer, 2012; Mekonnen, Keesstra, Baartman, & Ritsema, 2015). The problem is severe in developing countries and require urgent attention (Wani, Sreedevi, Singh, Pathak, & Rego, 2002; Darghouth, Ward, Gambarelli, Styger, & Roux, 2008). Sub-Saharan Africa is particularly vulnerable to the threats of natural resource degradation mainly because of its consequences for subsistence agriculture from which about 75 percent of the population derive their livelihoods (Erkossa, Wudneh, Desalegn, & Taye, 2015; Tully, Sullivan, Weil, & Sanchez, 2015).

Ethiopia is one of the sub-Saharan African countries, experiencing high levels of watershed degradation through soil erosion and soil fertility decline, particularly in the highlands where the topography is rugged, steep lands are cultivated and erosive rainfall is high (Gessesse et al., 2016). For example, a recent estimates by Hurni et al (2015) indicated that soil erosion rate was 20 Mg. ha<sup>-1</sup> year<sup>-1</sup> on currently cultivated lands and 33 Mg. ha<sup>-1</sup> year<sup>-1</sup> on formerly cultivated degraded lands. These losses are mainly caused by human activity that might be associated with rapid population growth and the need to maximize agricultural production which is the economic mainstay for the overwhelming majority of the human population in the country (Shiferaw & Holden, 2000; Gessesse et al., 2016; Mekuriaw, Heinimann, Zeleke, & Hurni, 2018).

The degradation of watershed has resulted in on-site soil and nutrient losses and off-site impacts such as sedimentation and flooding (Lai 2001; Sonneveld & Keyzer, 2003; Pender & Gebremedhin 2007; Temesgen et al., 2012; Hurni et al. 2015). The consequence is not only decrease land productivity but also accelerate ecological degradation and increase social problems (Darghouth et al., 2008). For example, soil erosion estimated to cost 2 to 6.75 percent of Agricultural GDP per annum (Schmidt & Tadesse, 2012) and under business as usual scenario, Sonneveld & Keyzer (2003) predicted that, the agricultural production potential of the land will be reduced by 30 percent by the year 2030.

Recognizing the adverse effects of watershed degradation problems, the government of Ethiopia with collaboration of international agencies have been undertaken a great deal of efforts to

implement soil and water conservation (SWC) measures since the early 1970's (Chimdesa, 2016). However, the efforts were considered ineffective and unsustainable due to much emphasis on natural resources conservation and little attention to the needs of people (Haregeweyn et al., 2015). Given the unsuccessful past attempts that failed to address not only the challenges of land degradation but also of poverty and food insecurity, watershed approach is becoming popular strategy since the 1980s in the country (Desta, Carucci, Wendem-Ageñehu, Abebe, 2005) aimed to implement natural resource conservation and livelihood improvements. These watershed management programs included the development of physical and biological measures, a soil nutrient management program, an agro-forestry development program, introduction and development of high-yielding crop varieties and animal breeds, natural resource-based income – generating activities, reclamation of water sources, development of area closure and institutional strengthening activities. Likewise, in the study watershed, Rebu watershed of the upper Gibe basin, the same efforts have been under taken for many years (WARDO, 2013) to avert the widespread degradation of watershed resources and to enhance livelihoods.

Nevertheless, the program has had a relatively low level of success in arresting serious watershed degradation across the wider landscape and achieving livelihood improvements in Ethiopia (Kassie, Zikhali, Manjur, & Edwards, 2009; Teklewold, Kassie, & Shiferaw, 2013; Haregeweyn et al., 2015; Mekuriaw et al., 2018) including the study area. The lack of appreciation of farmers' perception of watershed degradation in the formulations, upscale planning and implementing watershed management strategy is among the major reasons for low level of success (Desta et al., 2005; Amsalu & de Graaff, 2006). With regards to the watershed degradation problems, farmers' perception refers to the perception to the relationship and processes of soil erosion and fertility decline or as he/she detects and expresses it as occurring on their watershed and surrounding landscapes( Pulido & Bocco, 2014). It partly controls awareness, goals and practical actions and is highly a certain socio cultural context specific in its very nature which is determined by personal, bio-physical and socio-economic and institutional factors that often differ from person to person and one region or locality to the other( Smit & Smithers, 1992).

Farmers' perception of watershed degradation as a problem to agricultural production and sustainable environment is a key social factor that plays a great role in their watershed management decision making (Pulido & Bocco, 2014). It is the social role of attitudes, which

provide an input into the planning process and serve as a vehicle for public participation in watershed management (Duruiehoma, Burek, Bonwick & Alexander, 2015). It is also noted that farmers may be interested to practice different watershed management practices depending on their degree of understanding on the management practices, status of land degradation, and roles of socioeconomic and environmental factors (Shiferaw & Bantilan, 2004 ; Kassa, Beyene, Haji, & Legesse, 2013). Studies by Shiferaw & Holden (1998), Assefa & Bork (2016) and Keshavarz & Karami (2016) also highlighted that farmers' environmental behaviors (i.e. watershed management decisions) depend on their own perceptions of conditions in their environment. Others like Tegene (1992), Bewket & Sterk (2002) and Assefa & Bork (2016) has also demonstrated farmers' considerable knowledge in categorizing their land according to their soil erosion severity. Thus, understanding farmers' perception on watershed degradation can help to provide specific and appropriate policy implications for designing, implementing, and evaluation of watershed management strategies.

Although, watershed degradation problems are an increasingly discussed phenomenon in the scientific literature as evidence of its presence and impacts continues to grow (Steffen et al., 2011; Zalasiewicz, Williams, Haywood, & Ellis, 2011), local perception of watershed degradation problems is still largely overlooked or there are few reports about farmers perception related to watershed degradation in the existing literature in developing countries (Moges & Holden, 2007; Mekonen & Tesfahunegn, 2011) including Ethiopia. In fact, most of the literature (Hurni, 1985; Hurni, 1990; Hurni, 1993; Gebremichael et al., 2005; Tesfahunegn, Vlek, & Tamene, 2012; Tesfahunegn & Vlek, 2014) have focused on the magnitude and rate of watershed degradation through soil erosion and nutrient depletion using field measurements and/or estimation using models in Ethiopia. However, watershed degradation and conservation are a phenomenon that requires not only the natural sciences analytical approach, but also the psycho-social understanding( e.g., local perception) (Boardman, Poesen, & Evans , 2003).The appreciation of psycho-social characteristics (e.g., perception) in these problems is essential as they are mainly caused by human behavior, and they can all be reversed by human behaviors (Oskamp, 2000).

Determinants for rates of watershed degradation and farmers perception on degradation can vary by physical, socio-cultural and economic context specific of the farming community (Nederlof & Dangbégnon, 2007). Hence, understanding of area specific farmers' knowledge and experiences about environmental problems and valuing of their knowledge in watershed management intervention strategies is therefore, absolutely essential to increase the effective implementation of the conservation measures for sustainable agricultural production and livelihood improvement (Baartman, Godert, Reed, Ritsema, & Hessel, 2007). It is also important in identifying the socio-economic, biophysical and institutional characteristics of farmers' perception for the up scaling planning and implementing watershed management strategies. Furthermore, appreciation of local perceptions, experiences and practices along with the various visions of landscapes of farmers can provide information complementary to that of conventional scientific appraisals (Campos et al., 2012).

In cognizant with this, this study examined farmers' perception of watershed degradation severity, causes and indicators across different disaggregated sub watersheds in the Rebu watershed of the upper Gibe basin, southwest Ethiopia. Specifically the objectives of the study were: 1) asses the severity; causes and indicators of soil erosion and soil fertility decline across different disaggregated sub watersheds-upper, middle and lower; 2) explore determinant factors of perception and 3) trends of soil erosion and soil fertility decline after the program intervention.

### *3.2. Watershed degradation, perception and sustainable development: concept and theories*

#### **3.2.1. Watershed degradation**

Watershed degradation defined as loss or persistent decline in the potential productive capability of watershed resources (Lal et al., 2012) which comprises various forms such as soil erosion, soil nutrient depletion, chemical degradation, water resources degradation, and vegetation resources (Young, 1998). The degradation of watershed through soil erosion and soil fertility decline is the most widespread form of land degradation (Lal, 1990; Katyal & Vlek, 2000) which is mainly associated to the unsustainable use watershed resources-soil, water and vegetation ( Oldeman, Hakkeling, & Sombroek, 1991; Katyal & Vlek, 2000), and presents a major threat to global food security, economic well being and livelihoods (Lal, Safriel, & Boer, 2012; Mekonnen, Keesstra,

Baartman, & Ritsema, 2015). Despite of this fact, causes, processes and indicators of watershed degradation can vary spatially and temporarily (Barrow, 1991; Lipper et al., 2011). Furthermore, results associated to the deterioration of watershed resources are not the same due to methodological differences as some approaches are complex and data intensive to apply in data scant areas and others are quite simple (Mekonen & Tesfahunegn, 2011; Gebregziabher, Abera, Gebresamuel, Giordano, & Langan, 2016 ). Farmers' perception of processes, causes and indicators of watershed degradation are not adequately understood though such issues are site and time specific. Therefore, the application of local knowledge to understand watershed degradation related issues can give reliable scientific information for sustainable watershed management (Biddlecom, Axinn, & Barber, 2005; Moges & Holden, 2007).

There are various theories such as social cost, collective goods and property rights theories that explain watershed degradation. The theory of social cost explains watershed degradation as the result of farmers' implemented practices that do not bear the full costs such as, for example, downstream costs due to off-site effects of erosion which force farmers to implement appropriate watershed management practices; the theory of collective goods explains watershed problems such as watershed degradation emerge when farmers overuse scarce watershed resources such as, for example, soil, water and vegetation without maintenance and conservation as benefits are distributed among all users; while, property rights theory argues that the main problem of watershed degradation is not associated with externalities; rather it is due to absent or poorly defined property rights to watershed resources in which land use types are less likely for being interested to improve watershed productively in the long term ( Wachter, 1992; Maiangwa, Ogunbible, Olukosi, & Atala, 2007)

Other theories such as Malthusian, and the Boserupian theory of agricultural change (Boserup, 1965) explain the relationship of resource management and watershed degradation using population and technology. According to Malthusian perspective, population pressure is the key cause of watershed degradation in developing countries through overexploitation. This perspective underestimates the capacity of technology to overcome the problem of watershed degradation. However, according to the Boserupian perspective, population growth with better knowledge to apply and access to favorable policy, improve technology such as land conservation, available resources (Boserup, 1965; Hunt, 2000) is the sources of agricultural

development. This perspective emphasizes more on technological development and adoption that supported by labor intensification and technological innovation. However, watershed degradation through soil erosion and soil fertility decline are not exclusively caused by population excess and the high use of natural resources (Essahli & Sokona, 2008). It is an intermingled effect of anthropogenic and physical factors accompanied by unfitting development programs and policy, technology, as well as a weak comprehension of the possibilities and limitations for adopting watershed conservation measures. Hence, understanding area specific scientific information about local knowledge of severity, causes and indicators of watershed degradation considering the different theories is crucial for guiding appropriate watershed management interventions and target policy actions.

### 3.2.2. Perception of watershed degradation

Environmental perception refers to our sensory experience of acquiring knowledge about surrounding world and entails recognizing the environmental conditions and reaction to these conditions which varies depending on several factors (Armstrong, 1961; Vincenzi et al., 2018). It is the understanding of the environment resulting from visual, auditory, and tactile experience, and also by information disclosure. These include, household characteristics such as for example, age, sex, family size, educational status and income level; institutional factors such as agricultural and environmental policies, access to credit services, access to extension and training services and socioeconomic and physical characteristics that affect farmers' perception of watershed degradation (Biddlecom et al., 2005; Ghimire & Mohai, 2005). However, the influence of such factors can vary with physical, availability of resources and socio-economic conditions which shows the demands for conducting site specific research.

### 3.2.3. Sustainable development

As defined by Brundtland Commission (WCED, 1987) sustainable development refers to development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. This concept of sustainable development aims to maintain economic advancement and progress while protecting the long-term value of the environment (e.g., watershed resources-soil, water and vegetation). It has become popular to reflect environmental sustainability and analyze environment-development relations. However,

the issue of sustainability varies due to different perspectives. For example, economists usually do not pay enough attention to the issue of sustainability as their definition of development mainly focuses on economic growth and human wealth while, ecologists focuses on natural biological process and the continued productivity and functions of ecosystem (Cheng, 1998). There is over lap among economic, social, and environmental sustainability, particularly the strong linkage between economic sustainability and environmental sustainability. Sustainability development is therefore described as a simultaneous achievement of economic prosperity, a healthy environment, and social equity for current and future generations (Basiago, 1999; Sneddon, 2000).

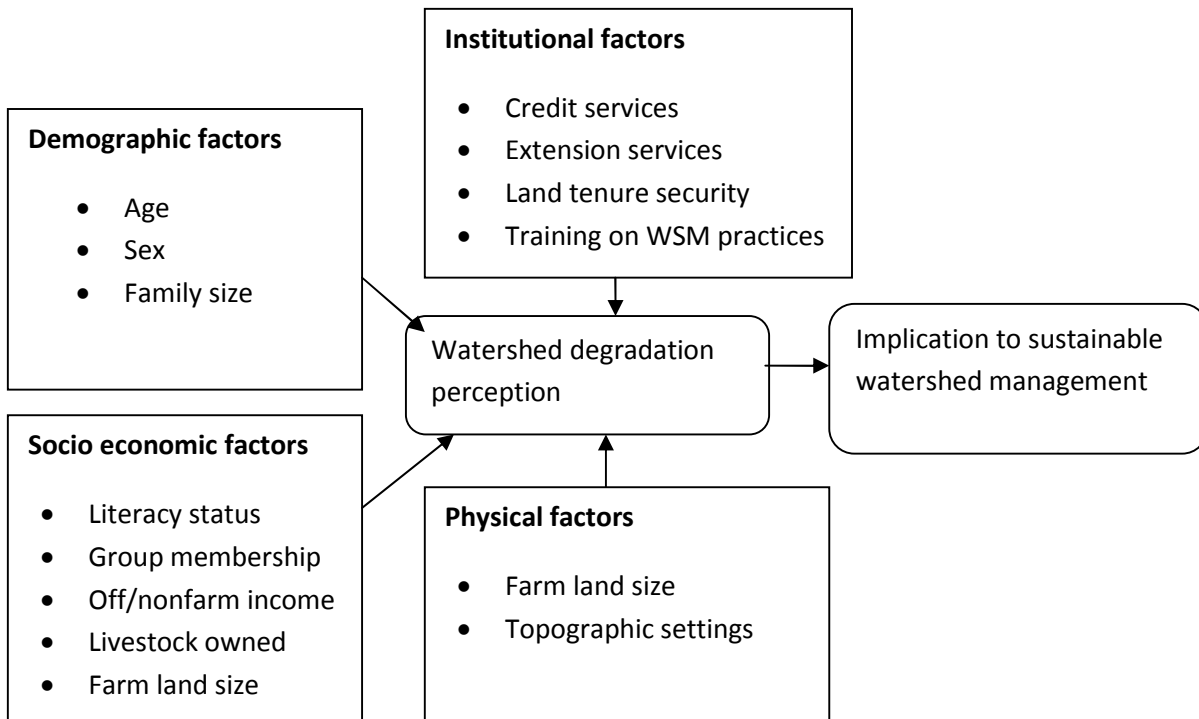
There are also various theories namely, neo-classical growth theory, endogenous growth theory, social sustainability theory and environmental sustainable theory that explain sustainable development. The neo-classical growth theory has equated sustainable development to sustainable economic growth. This means that costs of environmental deterioration or natural capital can be compensated by benefits from human capital as an income; the endogenous growth theory focuses on the contribution of technological innovation to the conditions under which economic growth can be sustained by resources and the environment ( Aghion & Howitt, 1998); the theory of social sustainability calls for economic growth constrained by the requirements of social equity and the theory of environmental sustainability suggests a planning process that allows human society to live within the limitations of the biophysical environment( Basiago, 1999; Sneddon, 2000). However, the key principle of sustainable development is to stabilize the long-term economy and environment through the integration of economic, environmental, and social concerns in the decision making process (Dernbach, 2003; Stoddart, 2011). For a watershed to be sustainably utilized, sustainability of land, water and forest are to be considered. Thus, sustainable watershed management have to be technically appropriate, economically viable, and socially acceptable and ensure the sustained productivity of natural resources (Vishnudas, Savenije, & Zaag, 2005).

### ***3.3. Conceptual framework***

Farmers' perception of watershed degradation problems is a key social factor that plays a great role to provide an input into the planning process and serve as a vehicle for public participation in watershed management decisions (Pulido & Bocco, 2014; Duruiheoma et al., 2015). This in

turn is determined by a number of factors such as demographic, socio-economic, institutional and physical characteristics (Shiferaw & Holden, 1998; Cramb, Garcia, Gerrits, & Saguiguit, 1999; Mbaga-semgalawe & Folmer, 2000; Gebremedhin & Swinton, 2003; Amsalu & de Graaff, 2006; Tesfaye, Negatu, Brouwer, & van der Zaag, 2014; Haregeweyn et al., 2015; Tesfahunegn, Mekonen, & Tekle, 2016; Tesfahunegn, Tamene, Vlek, & Mekonnen, 2016). However, the determinants for rates of watershed degradation and farmers' perception of degradation can vary from place to place and from household to household due to variations in biophysical, socio-cultural and economic context-specific to the farming community (Nederlof & Dangbégnon, 2007). Thus, a better understanding of factors that influence farmers' perception of watershed degradation is very important for designing and implementation of efficient, effective and people friendly technologies (Fentie, Fufa, & Bekele, 2013). In this study, different factors determine farmers' perception of watershed degradation (Figure 3.1).

Figure 3.1, A schematic diagram depicting the relationship between local perception of watershed deterioration and its determinants



Source: own construction, 2020

### 3.4. Methods and materials

#### 3.4.1. Indicator measurements, specification and assumption of empirical model

##### Indicator measurements

To determine farmers' level perception of the watershed degradation a perception index was adopted following a modified formula given by Sharma, Singh, & Padaria (2011), Obadire, Mudau, & Zuwarimwe (2014) and Bagdi & Kurothe (2016).

Farmers' perception index for respondents is computed as:

$$PI_i = \frac{\sum_{j=1}^K Y_{ij}}{K} + 100 \quad \text{equation (1)}$$

Where  $PI_i$  is the perception index for  $i^{\text{th}}$  respondent;  $Y_{ij}$  is the score of  $j^{\text{th}}$  item for  $i^{\text{th}}$  respondent;  $K$  is the maximum perception score

$$PI = \frac{\sum_{i=1}^N PI_i}{N} \quad \text{equation(2)}$$

Where  $PI$  is the perception index for the watershed degradation;  $PI_i$  is the perception index for the  $i^{\text{th}}$  respondent;  $N$  is the total number of respondents. That is the perception index for each indicator of soil degradation (soil erosion indicators, causes, and soil fertility decline indicators, causes). The formula (2) above was used to calculate the overall Likert score for watershed degradation.

Perception on watershed degradation was studied under four dimensions (soil erosion indicators, causes, and soil fertility decline indicators, causes). Out of 20 questions that measure farmers' perception about causes and indicators of watershed degradation; 10 indicators (5 for causes and 5 for indicators) were used for soil erosion and 10 indicators (5 for causes and 5 for indicators) were used for the soil fertility decline. The causes and indicators were rated as very low, low, medium and high and very high with corresponding rates of 1, 2, 3, 4 and 5 respectively using a five point Likert scale (Likert, 1932) for positive statements and reverse scoring was undertaken for negatively statements. This was through discussion with local farmers during the transect walk observation and discussion with program experts and officials, plus a literature review (e.g., Shiferaw & Holden, 1998; Tegene, 1992; Bewket & Sterk, 2002; Shiferaw & Bantilan,

2004; Amsalu & de Graaff, 2006; Kassa et al., 2013; Haregeweyn et al., 2015; Assefa & Bork, 2016; Keshavarz & Karami, 2016; Tesfahunegn et al., 2016). The internal consistency/reliability of the scale was measured using the reliability coefficient of Cronbach's alpha (Cronbach, 1951) which ranges from 0 to 1; the larger the value the greater the reliability of the scale( above 0.7). Here the Cronbach' alpha result is 0.872 for all 20 statements about watershed degradation indicators, suggesting that it was deemed acceptable (Appendix table A1). Responses to each of the statements were graded and summed resulting in an overall score for each respondent on this perception scale. Therefore, using the Likert scoring method, point scores from the respondents were calculated for each statement. The overall score was obtained by adding up all the scores from all the respondents and the total score was expressed as a percentage of the maximum possible score for all the statements. We merged the three dimensions to create an overall perception.

The classification of the overall perception in to high/more severe, moderately severe and less severe was also made based on obtained possible score. Thus, the highest possible score was  $100(20*5)$  if a respondent score 5 for each of the 20 statements. The moderate possible score was  $60(20*3)$  if a respondent score 3 for each the 20 statements. The lowest possible score was  $20(20*1)$ , if a respondent scores 1 for each of the 20 statements. Accordingly, scores above 60 shows more severe, equals to 60 shows moderately severe and below 60 shows less severe watershed degradation.

### Specification of empirical model

To identify whether socio-demographic, institutional and physical variables explain why some of the respondents perceived watershed degradation more than others, the binary logistic regression model was employed. The logistic model was selected because it is more computationally easier and has interpretable results than the other models such as probit ( Long, 1997; Southavilay, Nanseki, & Shigeyoshi, 2012). In addition, when the response variable is binary, the logistic regression model enabled the assessment of the association between response variable and set of independent variables that may be continuous, discrete, and dichotomous or a mix of these variable types (Manor, Matthews, & Power, 2000; Hyeoun-Ae, 2013). In logistic regression, there is no assumption of normality and equal variance within each group of the independent variables ( Halperin, Blackwelder, & Verter, 1971; Southavilay et al., 2012). Thus, for the

logistic regression model requirement, the overall perception score was dichotomized into a dummy variable by using the mean score for perception. This categorization does not affect the size and significance of main effects, types of association, and interactive effects (Manor et al., 2000; Greene, 2002). The perception level on watershed degradation equals 1 (if respondents scored higher than or equal to the mean perception score) and other wise 0 (if respondents scored less than the mean perception score). Let  $Y_i$  represent a dichotomous variable that equals 1 if the respondent scored higher than or equal to the mean perception score, otherwise 0. The probability of a farmers' expressing higher perception about watershed degradation  $\Pr(Y_i = 1)$  is a cumulative density function (likelihood function) evaluated at  $(X_i\beta)$ , where  $X_i$  is a set of explanatory variables and  $(\beta)$  represents the parameters to be estimated. This kind of cumulative density function can be modeled using a logistic probability function which has the following form (Greene, 2002).

$$\Pr(Y_i = 1) = \frac{\exp(X_i\beta)}{1 + \exp(X_i\beta)} \quad \text{equation (3)}$$

The estimation form of this logistic transformation for the probability that a respondent will express higher perception,  $\Pr(Y_i=1)$  is represented as (Greene, 2002).

$$\ln \left[ \frac{\Pr(Y_i = 1)}{1 - \Pr(Y_i = 1)} \right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \dots \beta_n X_n \quad \text{Equation(4)}$$

Where  $\Pr$  denotes the probability that the  $i^{\text{th}}$  respondent had for higher perception, then  $1 - \Pr$  represents the probability that does not perceive degradation (perceived as less to no problem):  $X_n$  is a vector of the explanatory variable;  $\beta_0$  represents the intercept,  $\beta_1 X_1 + \beta_2 X_2 \dots \beta_n$  represent the regression coefficients.

#### Goodness-of-fit of the model

Before estimation of the determinant factors that affect perception on watershed degradation, various common tests were carried out. Namely, Hosmer and Lemeshow's Test, log likelihood chi-square or the Omnibus test and pseudo R-square were used to evaluate the goodness of fit of the logistic regression model. The multicollinearity among independent variables was also checked.

### 3.4.2. Hypothesizing the independent variables

There are various respondents' demographic, socio-economic, institutional and physical attributes that facilitate farmers' perception on watershed degradation. As shown in the table 3.1, the positive or negative sign shows whether they more likely or less likely perceived watershed degradation (it is ambiguous before estimation) and the positive sign indicates higher likelihood of perception of watershed degradation. The hypothesized relationships of these variables with the dependent variables was determined based on theoretical background in literature (e.g., Shiferaw & Holden, 1998; Cramb, Garcia, Gerrits, & Saguiguit, 1999; Mbagasemgalawe & Folmer, 2000; Gebremedhin & Swinton, 2003; Amsalu & de Graaff, 2006; Tesfaye, Negatu, Brouwer, & van der Zaag, 2014; Haregeweyn et al., 2015; Tesfahunegn, Mekonen, & Tekle, 2016; Tesfahunegn, Tamene, Vlek, & Mekonnen, 2016)) and the researcher judgment on the nature of surveyed farmers.

Table 3.1, Expected sign of the explanatory variables

Variable name	Variable description	Expected sign
Age	Continuous variable measured in years(average)	±
Sex	Dummy = 1 if household head is male, otherwise 0	+
Family size	Continuous variables- number of members who are currently living within the family(average)	±
Literacy status	Dummy = 1 if household head literate, otherwise 0	±
Farm land size	Continuous variables -total size of farm landholding in ha(average)	±
Livestock TLU	Continuous variable -number of livestock owned measured in TLU(average)	±
Off/nonfarm activities	Dummy= 1 if household head has access to off/nonfarm activities, otherwise 0	+
Agricultural extension services	Continuous variable measured in the number of extension contact(average)	+
Access to WSM training services	Dummy = 1 if household head attended training on WSMP	+
Land tenure security	Dummy = 1 if the farmer feels secured , otherwise 0	+
Credit services	Dummy =1 if the farm household access to credit , otherwise 0	+
Group membership	Dummy = 1 if the farm household belongs to local institutions, otherwise 0	+
Farm land distance	Continuous variable measured in walking minutes from home to the nearest farm land(average)	-
Topographical setting	Dummy = 1 for upper , otherwise 0	+

### 3.5. Results of the study

#### 3.5.1. Households' characteristics

Households' socio demographic, economic, institutional and physical characteristics and level of farmers' perception on watershed degradation are presented in tables 3.2 and 3.3.

#### Respondents' socio-demographic, economic and institutional characteristics (continuous variables)

The results of the continuous variables were presented in table 3.2. As indicated, the average age of the study respondents was 46.73 years with the minimum and maximum ages of 25 and 75 years respectively. The average number of members who are currently living within the family was 4.8 with the minimum and maximum number of 1 and 9 respectively. As revealed from the survey result, the average land holding of the respondents was found to be 2.2 hectares ranging between 0.77 and 7.11 hectares. Average livestock owned by the study household which was measured in terms of TLU was found to be 5.49. Farmers were also asked to indicate the frequency of extension contact in the last production year (2016/17), and the average frequency of extension contact for the respondents was 2.18 with a range of 0-5 times. The average walking distance traveled to the nearest farm land was 11.14 minutes ranging from 1 -25 minutes.

Table 3.2, Description of socio economic and demographic profile of households (continuous variables)

Variable	Description	Mean	Std. Dev.	Min	Max
Age	Continuous variable measured in years	46.72	9.58	25	75
Family size	number of members who are currently living within the family	4.84	1.51	1	9
Farm land size	Total size of farm landholding in ha	2.20	0.93	.77	7.11
Livestock TLU	number of livestock owned measured in TLU	5.49	2.05	1.95	17.45
Extension contact	Continuous variable measured in the number of extension contact	2.18	1.21	0	5
Farm distance	Continuous variable measured in walking minutes from home to the nearest farm land	11.14	4.75	1	25

Sources: computed from survey result, 2018

## Respondents' socio-demographic, economic and institutional characteristics (dummy variables)

The results of the dummy variables were presented in table 3.3. As indicated, about 87 percent were male and 13 percent were female. A larger proportion of the respondents (60 percent) were literate, whereas the remaining 40 percent were illiterate. With regards to off/non-farm income activities, survey households were asked whether or not they accessed activities such as; hand crafting, employment, petty-trade, etc.) and hence, the proportion of households accessing at least one of these activities was 29 percent. Respondents were also asked to reflect on land tenure security and their expectation of using farm-land throughout or at least within, their life-time and 86 percent feel that they would use the farm-land throughout their life-time. Respondents who attained training on watershed management practices accounted 77 percent. About 76 percent of the respondents had access to credit availability. Respondents' membership in rural institutions/ associations such as watershed committees/ teams, self-help groups and cooperatives, etc. was used as proxy for social capital and about 68 percent of the respondents were participating in at least one of these local institutions. About 34 percent of the respondents were within the upper site of topographical setting.

Table 3.3, Respondents' socio demographic, economic and physical characteristics (dummy variables)

Variables	Descriptions	Category	Total sample(N= 304)	
			N	%
Sex	Dummy = 1 if household head is male, otherwise 0	Male	264	87
		Female	40	13
Literacy status	Dummy = 1 if household head literate, otherwise 0	Literate	181	60
		Illiterate	123	40
Access to off/nonfarm activities	Dummy= 1 if household head is access to off/nonfarm activities, otherwise 0	Yes	88	29
		No	216	71
Access to training services	Dummy = 1 if household head attended training on WSMP	Yes	234	77
		No	70	23
Land tenure security	Dummy = 1 if the farmer feels secured , otherwise 0	Yes	260	86
		No	44	14
Access to credit services	Dummy =1 if the farm household access to credit , otherwise 0	Yes	230	76
		No	74	24
Access to group membership	Dummy = 1 if the farm household belongs to local institutions, otherwise 0	Yes	207	68
		No	97	32

Topographical settings	Dummy = 1 for upper , otherwise 0	Upper	102	34
		Middle and Lower	202	66

Source: Computed from survey results, 2018

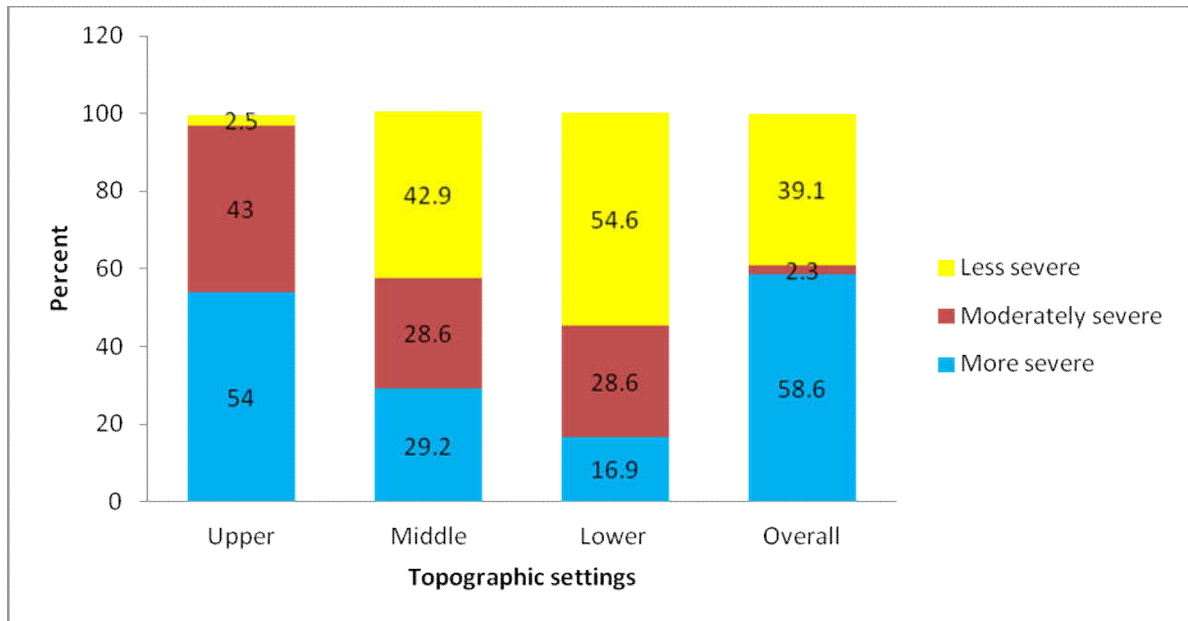
### 3.5.2. Local perception of watershed degradation: severity, causes and indicators

#### Soil erosion

As the finding of the study indicated, farmers were well aware that soil erosion was damaging their land and surrounding landscapes. About 96.4 percent of the sampled respondents experienced soil erosion problems on their land and surrounding landscapes. They were also reported when soil erosion was severe in their areas. Accordingly, 24 percent of the total sample households reported that severe erosion started 20 years and before, 69.1 percent replied that sever erosion was started 10-20 years, 3.3 percent reported that it had happened over the last 10 years. It was only about 3.6 percent reported unaware about the problem.

As indicated from the survey results, most of the respondents (59 percent) perceived the extent of soil erosion more severe either very high or high while (39.1 percent) of them showed less perception either low or very low (Figure 3.2). Only (2.3 percent) of them took the moderate point having moderately severe position. With regards to different topographic settings, out of the respondents who perceived the extent of soil erosion more severe either very high or high, the majority (54 percent) were in the upper, (29.2 percent) in the middle, (16.9 percent) in lower topographic settings. Similarly, out of the respondents who perceived the extent of soil erosion moderate, the majority (43 percent) in the upper, (28.6 percent) in middle and lower topographic settings. However, out of the respondents who perceived the extent of soil erosion less severe either very low or low, the majority (54.6 percent) in the lower followed by (28.6 percent) in middle and (16.9 percent) in the upper topographic settings. This indicates that soil erosion severity is more severe in the upper and middle topographic settings than in the lower one.

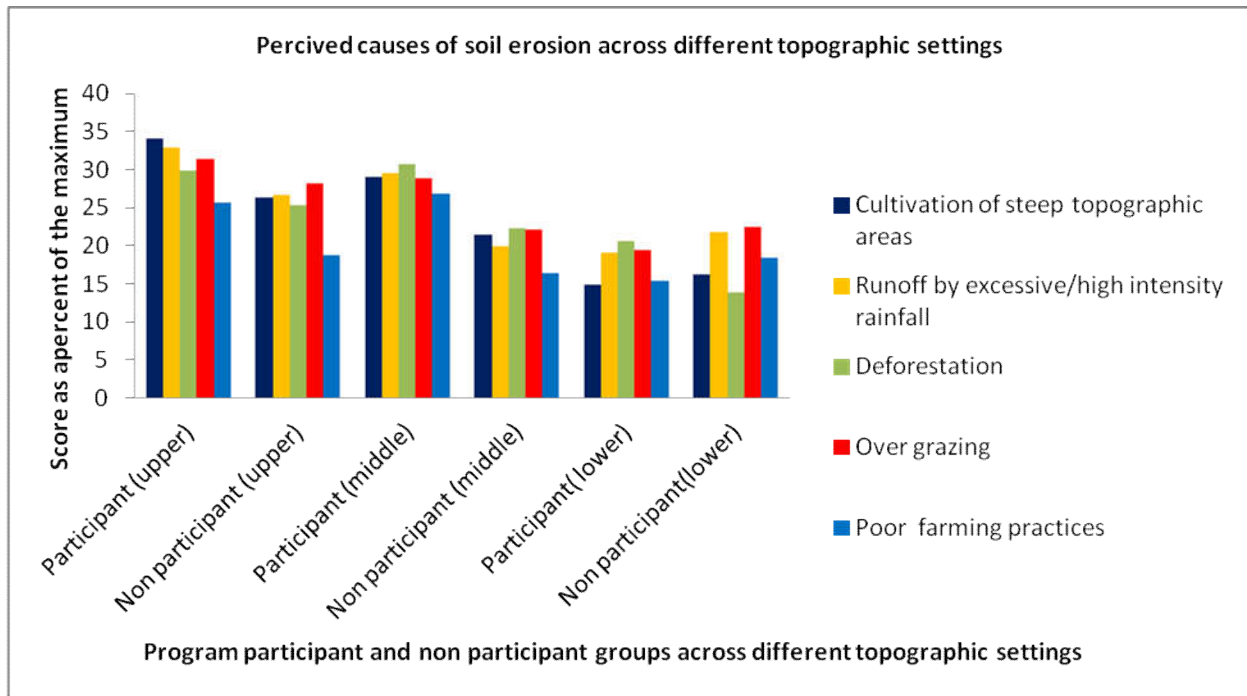
Figure 3.2, Levels of soil erosion severity across different topographic settings



Source: computed from survey results, 2018

Farmers' perceived reasons of soil-erosion processes were presented in (Figure 3.3). Cultivation of steeper geographic areas (34 percent), runoff associated to high and intensive rain (33 percent), overgrazing (32 percent) and deforestation (30 percent) were more perceived in the upper sub catchments than in the middle (29, 30, 29, 31 percent) and lower (15, 19, 20, 21 percent) one respectively for program participants. Program non participants also perceived better indicators of soil erosion such as cultivation of steeper slopes (26 percent), runoff related to high and intensive rain (27 percent), overgrazing (28 percent) and deforestation (22 percent) in upper sub catchment than middle (22,20, 22 , 22 percent) and lower (16, 22, 23, 14 percent) one respectively. Poor farming practices (over cultivation, expansion to marginal areas) were also identified in all area. Interview and focus group discussion reports confirmed the results. Generally, the causal factors for soil erosion were noticed relatively more in the upper and less in lower sub catchments suggesting that farmers in the degraded areas perceived environmental problems better.

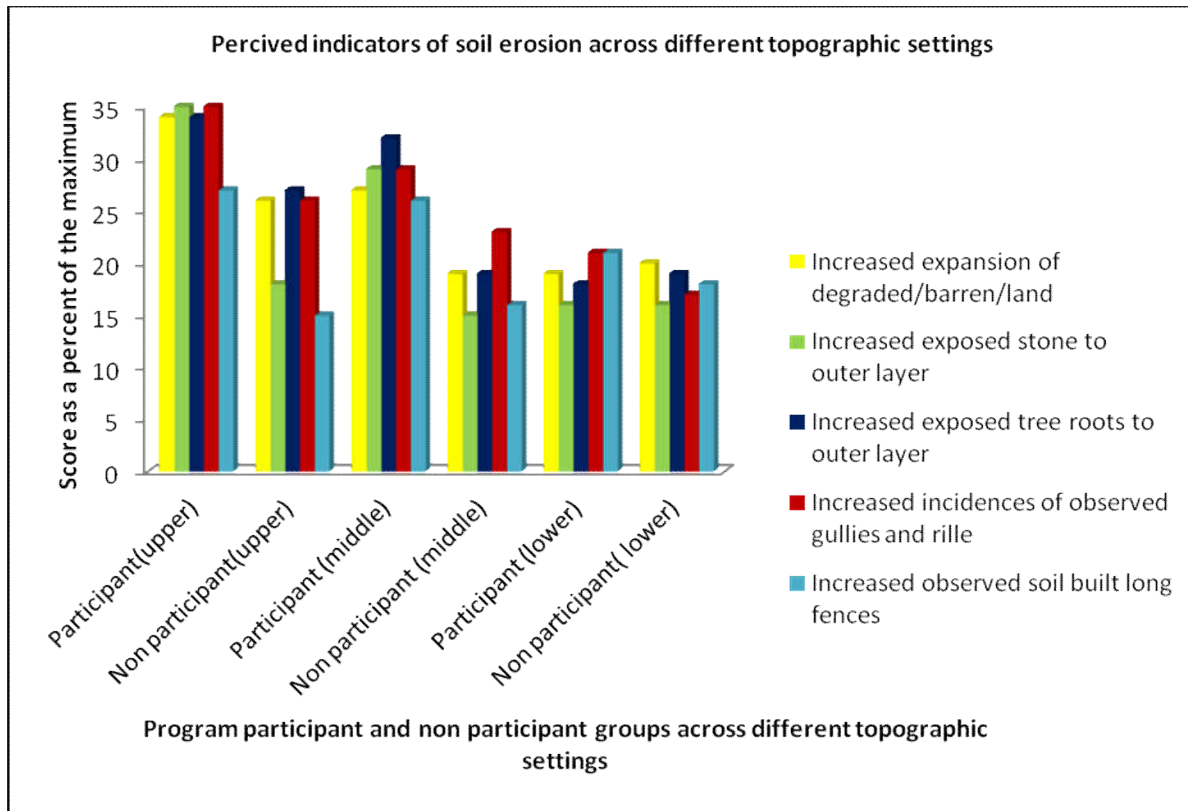
Figure 3.3, Farmers’ perceived causes of soil erosion across different topographic settings



Source; computed from survey results, 2018

Several soil erosion indicators across different topographic settings for program participants and non participants were depicted in (Figure 3.4). Exposed stone to outer layer (35 percent), formation of gullies and rills (35 percent), expansion of degraded land (34 percent) and tree root exposure (34 percent) were perceived higher in the upper geographic setting than in the middle (29, 29, 27, 32 percent, and lower (16, 21, 19, 18 percent) respectively for program participants. For program non participants, exposed tree roots to outer layer (27 percent), observed gullies and rills and expansion of degraded land (26 percent) were perceived higher in the upper sub catchment and (20, 23, 19, percent) for the middle and (19, 17, 20 percent) for the lower one respectively. To sum up, the occurrence of all indicators was relatively better perceived on upper topographic setting than middle and lower sub catchments in both program participants and non participants. This indicated that farmers of the highly degraded areas better perceived the indicators of soil erosion. As compared to non participants, the program participant households were better cognizant about the problem as they could have a chance to access to information and knowledge of watershed degradation problem.

Figure 3.4, Farmers' perceived indicators of soil erosion across different topographic settings



Source; computed from survey results, 2018

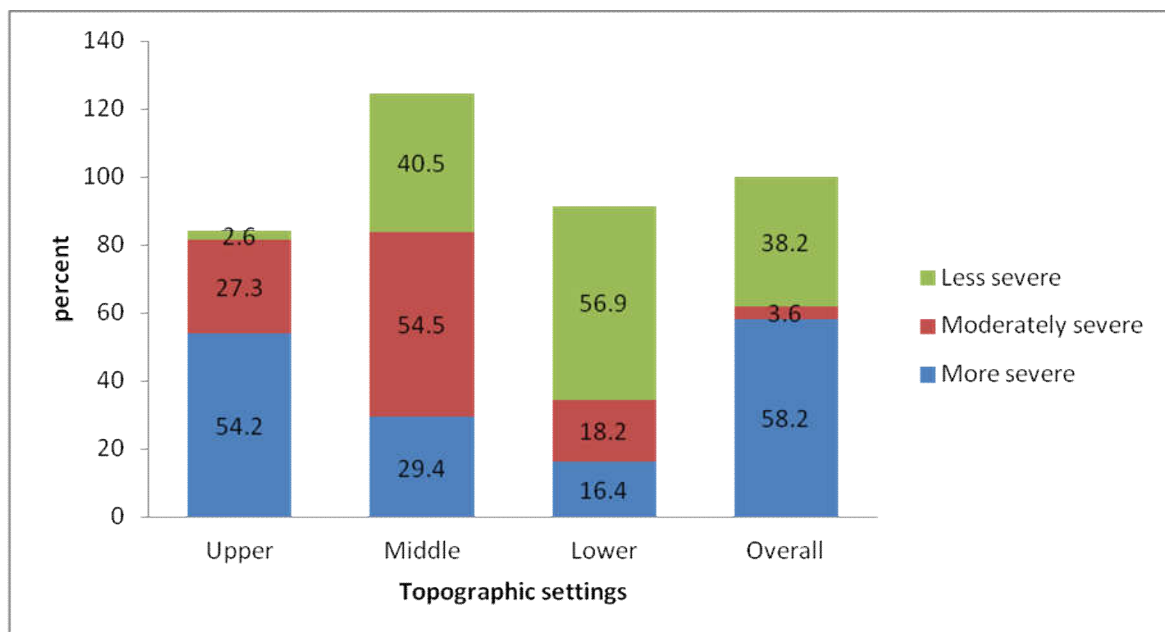
### Soil fertility decline

The survey results showed that, the majority (96.7 percent) of the sampled respondents reported that they were well aware about soil fertility decline on their land and surrounding landscapes. They were also asked when soil fertility decline was severe in their area. Accordingly, 9.9 percent of the total sample households reported that severe erosion started 20 years and before, 59.5 percent replied that sever erosion was started 10-20 years, 27.3 percent reported that it had happened over the last 10 years. About 3.3 percent reported that they unaware about the problem.

As depicted in figure 3.5, the overall results of soil fertility decline severity indicated that most of respondents (58.2 percent) perceived the extent of soil fertility decline more severe either very high or high while, 38.2 percent of them showed less perception either low or very low. Only 3.6 percent of them took the moderate point having moderately severe position. With regards to different topographic settings, out of the respondents who perceived the extent of soil fertility

decline more severe either very high or high, the majority (54.2 percent) were in the upper, 29.4 percent in the middle, 16.4 percent in lower topographic settings. Out of the respondents who perceived the extent of soil fertility decline moderate, the majority (54.5 percent) in the middle, 27.3 percent in upper and 18.2 percent in the lower one. However, out of the respondents who perceived the extent of soil fertility decline less severe either very low or low, the majority (56.9 percent) in the lower, 40.5 percent in middle, and 2.6 percent in the upper topographic settings. This indicated that soil fertility decline is also experienced in the upper and middle than lower topographic settings.

Figure 3.5, Levels of soil fertility decline severity across different topographic settings

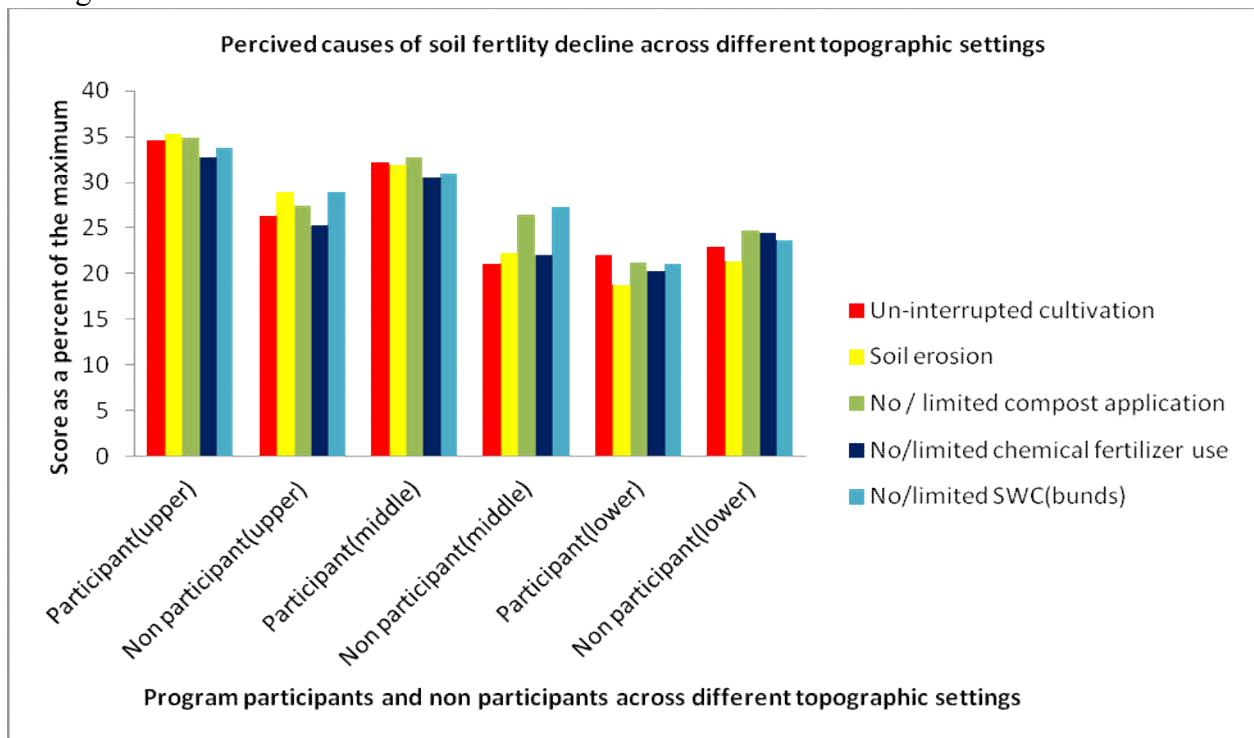


Source; computed from survey results, 2018

Farmers were also identified various casual factors of soil quality decline as presented in (Figure 3.6). Soil erosion (35.5 percent), limited use of organic input namely compost/manure application (34.9 percent), uninterrupted or continuous cropping (34.6 percent) and no/limited conservation of SWC measures like soil bund (33.8 percent) were major perceived causes in the upper followed by the middle (32, 33, 32, 31 percent) and lower (19, 21, 22, 21 percent) areas respectively for the program participants. The program non participants also perceived the problems such as soil erosion (29 percent), limited use of organic input such as compost/manure application (27percent), uninterrupted or continuous cropping (26 percent) and no/limited

conservation of soil and water conservation measures like soil bund (29 percent) better in the upper than in the middle (22, 27, 21, 27 percent) and lower (21, 25, 23, 24 percent) sub catchment respectively. Limited use of chemical fertilizer was also perceived as one of the problem of soil fertility decline in the study area. Generally, the upper sub watershed is more prone to the causes of the soil fertility decline than the lower one for both program participants and non participants.

Figure 3.6, Farmers’ perceived causes of soil fertility decline across different topographic settings

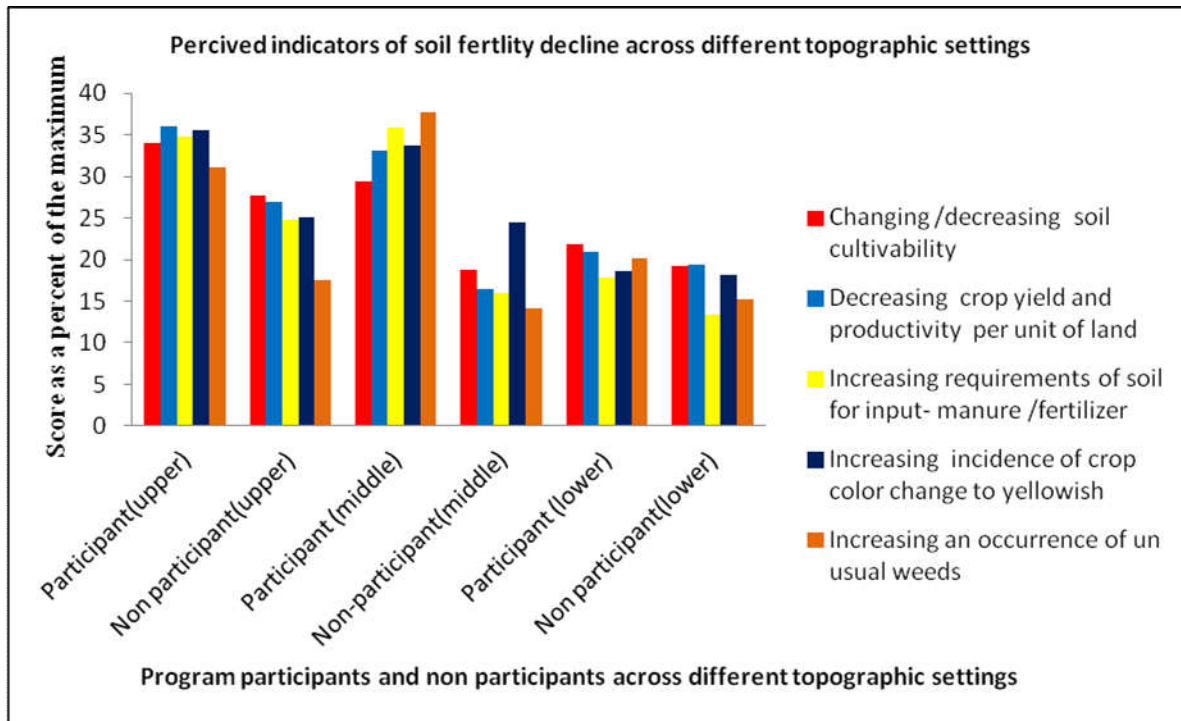


Source: computed from survey results, 2018

Results about how farmers distinguish indicators of diminishing soil quality were indicated in (Figure 3.7). It was revealed that crop yield and productivity decline (36 percent), crop color change (35.6 percent) and soil cultivability decline (34.1 percent) were better noticed in the upper followed by middle( 33.1, 33.8, 29.4 percent) and lower (21, 18.6, 21.9 percent) sub catchments respectively for program participants. Soil’s input requirement was better perceived in both upper and middle sub catchments. Similarly, indicators namely decreasing crop yield and productivity (26.9 percent), increased incidence of crop color change(25 percent), decreasing soil

cultivability(27.7 percent) were better noticed in upper than middle(16.5, 24.5, 18.7 percent) and lower( 19.4, 18.1, 19.3 percent) sub catchment respectively for program non participants.

Figure 3.7, Farmers’ perceived indicators of soil fertility decline across different topographic settings



Source: computed from survey results, 2018

### Over all perception level of watershed degradation

The overall perception level of farmers about soil degradation was measured based on mean of overall perception score for watershed degradation (soil erosion indicators and causes, and soil fertility decline indicators and causes). Accordingly, about 60 percent of the respondents scored higher than or equal to the mean perception score whereas, 40 percent scored less than the mean perception score.

### 3.5.3. Farmers’ perceived over changes of watershed deterioration

Farmers were asked to judge the trends of soil erosion and soil fertility decline on their land and over all surrounding landscapes over time in the last ten years (Table 3.4). Unlike the previous time, the majority of farmers (75 percent) of the total respondents confirmed that they observed a decreasing trend in the soil erosion status following the introduction of watershed management

intervention measures while, 24 percent perceived that there is no change in the prevailing situation of soil erosion and only 1 percent un aware about the trends. Over 80 percent of the respondents observed an improvement in soil quality in their farm fields over the years. The participant households better stated the condition of the trends of soil erosion and soil fertility decline changes as compared to the program non participants. This might be due to implementation of different physical and biological soil and water conservation management practices.

Table 3.4, Perceived changes in soil erosion and soil fertility improvement over the last 10 years

Statements	Participant(145)	Non-participant(159)	% of total (304)
Soil erosion problem			
aggravating	-	-	-
reducing	133(91.7)	95(59.7)	228 (75.0)
no change	12(8.3)	61(38.4)	73 (24.0)
not aware	-	3(1.9)	3 (0.9)
Soil fertility improvement			
increasing	137(94.5)	111(69.8)	248 (81.6)
decreasing	-	-	-
no change	7(4.8)	45(28.3)	52 (17.1)
un aware	1(0.7)	3(1.9)	4 (1.3)

Source: computed from survey result, 2018

### 3.5.4. Determinants of farmers' perception on watershed degradation

#### Fitness of the model

A binary logistic regression model was used to estimate socio-demographic, economic, institutional and physical factors that affect local perception on watershed degradation. Before estimation various common tests were carried out. The chi-square value for the log likelihood function-an Omnibus test- was highly significant indicating that all the coefficients for independent variables in the model were significantly different from zero. Such as LR chi2 (14) = 192.97; Prob > chi2 = 0.0000) suggested that the model had strong explanatory power. Hosmer and Lemeshow Test of 0.768 showed that the model is fitted. The fitness of the model was also assessed using pseudo R2 and about 46.88 percent of the variance was explained by the combined independent variables for perception. The average VIF was 1.24 with all values within 1 and 2 (Appendix table A2). This suggests non concern over a linear combination of other

independent variables in the model, as all VIF values were less than the threshold value of 10 (Gujarati, 2004).

### Determinants of local perception of watershed degradation

Various socio demographic, economic, institutional and biophysical factors influencing farmers' perception on watershed degradation were presented in table 3.5. Of the 14 explanatory variables tested in the binary regression model seven were proved statistically significant at 1%, 5% and 10% probability levels. Result of the model indicated that, farmland size, access to agricultural extension services and topographic setting had positive correlation with perception on watershed degradation at 0.01 statistically significant levels. While, access to training on watershed management intervention practices and access to credit services have correlated positively and significantly with the farmers' perception at 0.1, level of significance. Furthermore, group membership of farmers also correlated positively and significantly with the farmers' perception at 0.05, level of significance. However, livestock ownership has negative relationship with perception of farmers at 0.1 statistically significant levels. In this study, Age, sex, family size and distance to nearest farm land from home of the household were found negative and insignificant. Access to off/non-farm income sources, land ownership security and literacy status were found positive but insignificant.

Table 3.5, Logistic regression result; factors affecting farmers' perception of soil degradation

Variables	Coef.	Std. Err.	z	P>z
Age of the household head	-.0058463	.0194991	-0.30	0.764
Sex of the household head	-.2799065	.5596325	-0.50	0.617
Family size of the household	-.0723771	.1217145	-0.59	0.552
Literacy status of the household head	.2096624	.3612392	0.58	0.562
Total land size owned(ha)	1.341532***	.3142645	4.27	0.000
Total livestock owned (TLU)	-.2174132*	.1144943	-1.90	0.058
Access to off/non-farm income sources	.5089356	.5102414	1.00	0.319
Frequency of extension contact	.6666391***	.1729259	3.86	0.000
Training on watershed management practices	.7646216*	.4485455	1.70	0.088
Land ownership security	.7409325	.4879362	1.52	0.129
Access to credit services	.7820045*	.4378199	1.79	0.074
Group membership	.938118**	.3975826	2.36	0.018
Nearest distance of farm land from home	-.0455041	.0396405	-1.15	0.251
Topographic setting	2.21072***	.4685431	4.72	0.000
_cons	-4.504199	1.501968	-3.00	0.003

LR chi2 (14) = 192.37, Prob > chi2 = 0.0000, Pseudo R2 = 0.4688, Log likelihood = -108.96595, Number of obs = 304  
 \*p-value significant at 10%; \*\* p-value significant at 5%; \*\*\* p-value significant at 1%

### *3.6. Discussion*

#### 3.6.1. Local perception of watershed degradation: severity, causes and indicators

##### Soil erosion

Under this section soil erosion severity, causes and indicators were presented. The result of the study indicated that local communities are well aware of the problem of ongoing soil erosion on their land and surrounding landscapes. The result agree with Biratu & Desale (2016) who indicated that soil erosion problem has been widely recognized by farmers. The study also agreed with the study by Amsalu & de Graaff (2006) who have reported that farmers are knowledgeable about erosion induced watershed degradation variability and as a main constraint for boosting agricultural production in the highlands of Ethiopia.

Respondents believe that soil loss is highly influenced by topographic settings and the severity varies in different topographic settings. As cited by farmers, soil erosion severity is more in the upper and middle topographic settings than in the lower one. Reports from group discussion stated that areas they considered the most degraded were their highest priority for restoration. This result conform with the study by Ziegler et al (2006), Tiwari, Sitaula, Nyborg, & Paudel (2008), Kimaro, Poesen, Msanya, & Deckers (2008), Gomi et al (2010) and Wauters, Biielders, Poesen, Govers, & Mathijs (2010) who found that soil erosion is better perceived among farmers of the highly degraded areas.

According the respondents, the major indicators of soil erosion were higher incidence and extent of exposed stoniness, observed gullies, tree root exposure and expansion of degraded lands. These have been observed more on the upper topographic settings than middle and lower one. During the transect-walks, focus group discussions and interviews, different indicators of soil erosion were identified by the participant groups and individuals who participated during the walks and interviews. These indicators include biophysical characteristics such as tree root exposure (shallow soil depth), exposed stone to outer layer, high soil erosion indicated by formation of gullies and rills erosions. Hence, knowing the location and status of watershed degradation can support for introducing site-specific watershed management interventions.

Respondents also associated major causes of soil erosion to the cultivation of steeper topographic settings through clearing vegetation, runoff associated to high and intensive rain, overgrazing

and poor land management. As indicated by the participants of transect walk, group discussions and interview, cultivation of steeper topographic areas by clearing forests or removal of natural vegetation induced by population pressure and shortage of land causes severe soil erosion. They also identified overgrazing and improper soil management as important contributors to watershed degradation. Intensity of rainfall was also identified as part of the major causes of land degradation. Consistent to this study, UN/FAO (1997), Amsalu & de Graaff (2006) and Tesfahunegn et al (2012) have indicated soil erosion induced by clearing vegetation, poor cultivation and overgrazing is the most important form of degradation in the highlands of Ethiopia. However, such causes and severity of watershed degradation have believed to be determined for site-specific as there is variability across sites.

Respondents also indicated that the program participants were better cognizant about the problem of watershed degradation-soil erosion and soil fertility decline than the non participants. The result agreed with Wei et al (2009) who reported that program participants were cognizant of the problems of environmental degradation through more exposure to information by the program. Tesfaye, Debebe & Yakob (2018) also reported that watershed management intervention measures were better performed in experimental watershed than control one to mitigate soil degradation. Reports from group discussions and interview also indicated that as compared to the program non- participant households, the program participant households could have a chance to access to information and knowledge about watershed degradation problem. Generally, having a clear perception on the forms of watershed degradation by farmers is a key step for sustainable watershed management intervention, targeting the nature of the problem (Oldeman, 1997; Tesfahunegn et al., 2012).

### Soil fertility decline

Farmers are also well aware of the problem of ongoing soil fertility decline. The survey results showed that, the majority of the sampled respondents reported that they aware of about soil fertility decline on their land and surrounding landscapes. The result agreed with Biratu & Desale (2016), who indicated that soil degradation problems have been widely recognized by farmers. According to the respondents, there were many indicators of watershed degradation in the study watershed. The major frequently noted indicators of watershed degradation through soil fertility decline by farmers included crop yield and productivity decline, crop color change

and soil cultivability decline and soil's input requirements. Similar to this study Pulido & Bocco (2014) , Félix, Pascal, Anastase, Houinsou, & Armel (2015, and Meshesha & Tripathi (2016) have reported that several indicators of soil degradation such as for example, yield reduction decreasing in soil fertility and increasing in soil loss among the most important of watershed degradation. Respondents also identified various casual factors of soil quality decline among which, soil erosion, limited use of organic input namely compost/manure application, uninterrupted or continuous cropping and no/limited conservation of watershed management practices. Reports from focus group discussions and interviews identified that deforestation; over grazing, improper soil management, continuous cultivation and climate change as heavy intensity rainfall are the major causes for widespread of watershed degradation. Consistent to this study, UN/FAO (1997), Amsalu & de Graaff (2006) and Tesfahunegn et al (2012) have reported soil degradation induced by clearing vegetation, poor cultivation and overgrazing is the most important form of watershed degradation.

Respondents also believe that soil loss is highly influenced by topographic settings and the severity of degradation varies in different topographic settings. This result also congruent with Ziegler et al(2006) who found that soil fertility decline severity, causes and indicators are better perceived among farmers of the highly degraded areas than their counterparts in less degraded. The result also agreed with Tiwari, Sitaula, Nyborg, & Paudel (2008) who found that farmers are more likely to adopt soil conservation technologies to mitigate soil degradation in the areas of more steeply terraces. Program participant households were better noticed about the problem of soil fertility decline than the non participants. Reports from focus group discussion and key informant indicated that soil fertility decline is also experienced in the upper and middle than lower topographic settings and better perceived by watershed program participant households as they have more accessed to extension services and training. The result agreed with Wei et al (2009) who reported that program participants were cognizant of the problems of environmental degradation through more exposure to information by the program. Tesfaye, Debebe & Yakob (2018) also reported that watershed management intervention measures were better performed in experimental watershed than control one to mitigate soil fertility decline.

### 3.6.2. Trends of watershed degradation

Respondents' also perceived that the trend of watershed degradation is slowly decreasing following the introduction of watershed management program. This could be associated with the role of soil and water conservation practices which intensively implemented to reduce erosion and runoff. Reports from field observation, group discussion and key informant interview also indicated that farmers undertook a range of practices to control soil erosion and to enhance soil fertility. Namely, soil bund, stone faced soil bund, grass strip with mostly soil bund, gully rehabilitation through check dam and grass, trenches, micro basins, application of organic matter (animal manure, compost) and agro forestry practices, and following the practice the problems has been becoming reduced. This result is congruent with the study by Alemu, Kebede, & Moges (2019) who found an increasing trend in the soil fertility status following the introduction of soil conservation practices as perceived by the farmers. On the contrary to the present finding, Amsalu & de Graaff (2006), Thiombiano & Tourino-Soto (2007) and Ibrahim, Balzter, Kaduk, & Tucker (2015) have reported that the trend and severity of land degradation is increasing over time.

### 3.6.3. Determinants of watershed degradation

The perceived variation in the extent and severity watershed deterioration through soil erosion and soil fertility decline in this study attributed to physical, socioeconomic and institutional factors. Farmland size had positive and significant correlation with perception on watershed degradation. This indicates that farmers with larger farm land holdings are more likely to adopt technologies for erosion control and soil fertility enhancement than those with smaller holdings. This result agreed with Amsalu & de Graaff (2007) and Moges, Dagnachew, & Yimer (2013) who stated a positive association between farm size and practice of soil erosion and fertility depletion measures. Conversely, study by Bayard, Jolly, & Shannon (2006) asserted a negative and significant relationship between farmland size and perception on soil erosion. Farmers who had access to group membership were found to be positively and significantly influenced their perception on watershed degradation. This implies farmers who are members of for example institutions or self-help groups incline to aware about the problem of soil erosion and tends to adopt soil conservation measure as compared to those who are not the member of local institutions. This is in fact due to the fact that, group membership to social groups or

organizations enables farmers to acquire information on proper watershed management practices as well as attend training and workshops at which stakeholders meet and exchange ideas. This study agreed with the study by Adesina, Mbila, Nkamleu, & Endamana (2000) who reported a positive and significant influence of membership with the watershed degradation.

Livestock size was found to be less likely to influence farmers' perception on watershed degradation. This result agreed with Mbaga-semgalawe & Folmer (2000) and Tesfaye et al (2014) who stated that large number of livestock may trigger land degradation because of over grazing or large livestock size may discourage conservation investments perhaps due to the tendency of households to focus more on livestock than on crop production or large livestock may compete for land that could otherwise be used for grazing.. Farmers who had access to agricultural extension services and training services on watershed management practices were found to be positively and significantly influenced their perception on watershed degradation. This implies that frequently contacts with extension agents enable farmers to have access and share to existing knowledge intensive information on watershed degradation and management practices. This result agreed with the study by Tiwari et al (2008) and Asfaw & Neka (2017) who reported that extension contact has a positive correlation and significant with watershed degradation control measures ( e.g., the adoption of introduced soil and water conservation practices).

Farmers who had access to credit services were found to be positively and significantly affected their perception on watershed degradation. This implies that farmers with accessed to credit availability are more likely to use it for improving their farm production or control watershed degradation. Study by Simtowe & Zeller (2006), Mohamed & Temu (2008) and Deressa, Hassan, Ringler, Alemu, & Yesuf (2009) who stated that access to credit has a significant positive impact on the likelihood of using soil conservation techniques to minimize watershed degradation. Topographic settings have positive and significant correlation with perception on watershed degradation. Studies in different parts of Ethiopia (Shiferaw & Holden, 1998; Gebremedhin & Swinton, 2003; Amsalu & de Graaff, 2007), Tiwari et al (2008) and Kerse (2018) have found a significant positive effect of topographic setting on the perception to adopt soil and water conservation measures to mitigate the soil erosion. They detailed that soil degradation is better perceived among farmers of the highly degraded areas than their

counterparts in less degraded areas. Hence, farmers located in steeper areas tend to control soil erosion through the use of appropriate measures. Generally, the variation in the spatial and type of watershed management practices implies that, conservation alternatives can be adopted or not by farmers depending on the farmers' awareness of their exposure level to soil erosion and soil fertility decline and specific topographic and/or socioeconomic conditions of each place or community.

### *3.7. Implication of this study*

Watershed degradation through soil erosion and soil fertility decline is identified by farmers as a potentially serious challenge to agricultural production and natural environment. This study indicated that there is variation in farmers' perception on severity, causes and indicators of watershed degradation as a function of various factors such as socioeconomic, institutional and physical factors. From this study perspective, the implication is that all the factors are not equally important to influence farmers' perception on watershed degradation and the variability in farmer's perception would imply and suggest for site-specific appropriate watershed management alternatives. Effective watershed management using suitable interventions can be realized when farmers perceived watershed degradation and the factors that influence their perception and challenges for implementation and maintenance of technologies. Thus, the inclusion of farmers in all decision making processes during problem identification, and technology selection, planning and implementation to halt degradation is too crucial. In support to this, previous study by Pulido & Bocco (2014) found that local communities use several strategies to cope with land degradation, but the adoption of strategies depends on their agro-ecological conditions and decisively on their socio-economic and cultural characteristics; Hammad & Børresen (2006) also found in that the adoption of stonewall terraces depended on factors such as farmers' perceptions of erosion, land tenure and geomorphology and Assefa & Bork (2016) and Moges & Taye (2017) have shown that farmer's decisions to use and manage natural resources from being highly degraded depends on their perception across a landscape.

In addition, this study result shows that there is variability among farmers in their perception on watershed degradation in different topographic settings and across program participant and non-participant households. This indicates that it is advisable to consider any opportunity for farmers to modify technologies for their own conditions of watershed degradation due to differences in

perception and experiences. Location and/or socio economic specific efforts to understand all factors that influence farmers' perception on watershed degradation and towards its restoration is very important to design and implement socially acceptable, economically viable and environmental friendly technologies in a given landscape (Fentie, Fufa, & Bekele, 2013; Moges & Taye, 2017). This study thus generalized that farmers' watershed management decisions should depend on their own perceptions of degradation and other socio economic factors in their environment.

### ***3.8. Conclusions***

This study investigated local perception of watershed degradation in the Rebu watershed of the upper Gibe basin, southwest Ethiopia. The result showed that the majority of respondents (96.6%) were well aware of the severity, causes and indicators of watershed degradation indicating that farmers have abundant long established traditions that used to judge the land they are cultivating and surrounding landscapes. They identified exposed stone, gullies and rills formation, expansion of degraded land and tree root exposure as soil erosion indicators while, decreasing crop yield and productivity, the incidence of crop color change and decreasing soil cultivability as indicators of soil fertility decline.

Farmers perceived that the severity of watershed degradation varies across different topographic settings of the study watershed and across program participant and non participant households. The severity of the problems was better noticed relatively in upper and middle sub catchments than in the lower one and by program participant households. This indicated that farmers may not share the same priorities, in terms of where, when and how to address deterioration problems which suggests to consider any opportunity for farmers to modify technologies for their own conditions of watershed degradation due to differences in perception and experiences.

Farmers have also identified the major causes of soil erosion such as cultivation of steeper slopes through clearing vegetation, runoff, overgrazing and poor farming practices. They have also associated factors such as limited use of organic input, uninterrupted cropping, and no/ limited conservation measures to the soil quality decline. The majority of the respondents (over 75 %) also confirmed that they observed a decreasing trend in watershed deterioration following the introduction of watershed management intervention measures indicating that their perception is

important to consider while designing appropriate watershed management practices. Various socioeconomic, institutional and physical factors affect farmers' perception on watershed degradation. These include, farm land size, frequency of extension contact, training services on watershed management intervention practices, access to credit services, group membership and topographic settings affect positively and significantly farmers' perceptions of watershed degradation. Hence, decision makers and planners need to consider location and/or socio economic context-specific efforts to understand all factors that influence farmers' perception of watershed degradation and towards its restoration activities to up-scaling planning and implementing sustainable watershed management practices in a given landscape.

**Chapter 4:** Community Participation of the Watershed Management: Analysis of the Status and Factors Affecting community engagement

## Abstract

A lack of appreciation of community participation is one of the factors constraining the sustainability of the watershed management program in Ethiopia. Households' survey of 304 household heads, focus group discussions and key informant interviews were used to collect data. Descriptive and inferential statistics were used to analyze the data. Results of the overall community participation index value showed a moderate level of participation. There was variation in the level of participation by the community at different stages of watershed management. The results of logistic regression indicated that overall community participation was significantly affected by the frequency of extension contact, access to credit services, access to off/non-farm income sources and group membership. Thus, program planners should give due consideration to variations in the level of involvement by the community in different activities of watershed programs at different stages and the subsequent factors for future sustainable watershed development planning.

Keywords: watershed management practices; community participation; binary regression marginal effect; Gibe basin; Ethiopia

#### *4.1. Introduction*

Watershed deterioration, defined as the loss or continual decline in the capability of a watershed to provide ecosystem services, presents a major threat to food security, economic well being and the livelihoods of many people across the globe (Lal, Safriel, & Boer, 2012; Mekonnen, Keesstra, Baartman, & Ritsema, 2015). Estimates indicate that up to 25 percent of the Earth's land area may be severely degraded (FAO, 2011) and that, despite global efforts to halt land degradation, the area affected continues to increase (Bai, Dent, Olsson, & Schaepman, 2008). The problem is severe in developing countries and require urgent attention (Wani, Sreedevi, Singh, Pathak, & Rego, 2002; Darghouth, Ward, Gambarelli, Styger, & Roux, 2008). Sub-Saharan Africa is particularly vulnerable to the threats of natural resource deterioration mainly because of its consequences for subsistence agriculture from which about 75 percent of the population derive their livelihoods (Erkossa, Wudneh, Desalegn, & Taye, 2015; Tully, Sullivan, Weil, & Sanchez, 2015).

Ethiopia is one of the sub Saharan African countries, experiencing high levels of soil erosion and soil nutrient depletion, particularly in the highlands where the topography is rugged, steep lands are cultivated and erosive rainfall is high (Gessesse, Bewket, & Bräuning, 2016; Debie, Singh, & Belay, 2018). Recent estimates by (Hurni et al., 2015), indicated rates of 20 Mg ha<sup>-1</sup> year<sup>-1</sup> on currently cultivated lands and 33 Mg ha<sup>-1</sup> year<sup>-1</sup> on formerly cultivated degraded lands. These losses are mainly caused by human activity that might be associated with rapid population growth and the need to maximize agricultural production which is the economic mainstay for the overwhelming majority of Ethiopian people (Gessesse et al., 2016; Mekuriaw, Heinimann, Zeleke, & Hurni, 2018). This would result in not only decreases in land productivity but also accelerated ecological degradation and increased social problems (Darghouth et al., 2008).

Globally, the response to watershed deterioration in its modern form can be traced back to several parallel and independent movements for the restoration of the Alps, which started in the last quarter of the 19th century in Europe; the conservation movement in the United States in the 1930s; and the watershed rehabilitation activities of colonial governments in Africa (Darghouth et al., 2008). However, it was in the 1970s and 1980s that the watershed management approach became prominent in developing countries when the problems of watershed degradation first became apparent (FAO, 2006). The concept of watershed management gained international

significance following the United Nations Conference on Environment and Development in 1992 in Rio de Janeiro (also known as the Earth Summit) (Forch & Schutt, 2004). Subsequently, from the 1990s, watershed management programs supported by the international community in developing countries typically incorporate livelihood improvements and poverty reduction objectives in addition to resource conservation (Darghouth et al., 2008).

While the practices of watershed management programs are focused primarily on biodiversity and ecosystem integrity aspects, followed by land-use changes, waste production, water quality, resource use and water availability in developed countries (Walmsley, Carden, Revenga, Sagona, & Smith, 2001), resource management and socio economic development or poverty alleviation are the main focus in developing countries (Perez & Tschinkel, 2003). It appears that watershed management programs were thought to be unsustainable in developing countries because of their major focus on natural resource conservation without adequate consideration of productive livelihood options, the lack of inclusivity and participation, the absence of long-term management mechanisms, etc. (Bruneau, 2005).

The historical perspective on watershed management in Ethiopia was very similar to other developing countries. Recognizing the adverse effects of watershed deterioration problems, the government of Ethiopia, with the collaboration of international agencies, has been trying to support better land use and promote a soil and water conservation program since the early 1970s (Teshome et al., 2016). At the initial stages, the program faced difficulties due to its sole emphasis on physical planning units, lack of integration and adequate participation by stakeholders in problem prioritization, decision-making, planning, implementation and monitoring and evaluation (German et al., 2006). As a result, the need for public participation in the planning, implementation and evaluation of watershed management programs at local level was considered imperative. Consequently, the watershed management approach has gained increasing momentum as a promising approach since the 1980s (Desta et al., 2005).

Given a shift in the watershed management program to a more comprehensive approach integrating both resource conservation and rural livelihood development in developing countries since the 1990s (Darghouth et al., 2008), the program adopted a community-based participatory watershed development program as its main guiding principle in Ethiopia (Desta et al., 2005; Evans, Giordano, & Clayton, 2012; Worku & Tripathi, 2015). This watershed management

program included the development of physical and biological measures, a soil nutrient management program, an agro-forestry development program, introduction and development of high-yielding crop varieties and animal breeds, natural resource-based income-generating activities, reclamation of water sources, development of small-scale irrigation and energy saving stoves, and institutional strengthening activities.

In spite of many efforts, the program has had a relatively low level of success in arresting serious land degradation across the wider landscape and achieving sustainable livelihood improvements (Haregeweyn et al., 2015). This is attributed to various factors such as low immediate profitability and/or high risks associated with the promoted land management technologies, lack of confidence in the positive effects of the activities on crop yields, the high labor demand of the measures, and lack of short-term benefits (Bewket, 2001; Kassie, Pender, Yesuf, Köhlin, & Mulugeta, 2008). The most important of all, however, is said to be the top-down approach or lack of beneficiaries' participation in the planning and implementation of the processes (Desta et al., 2005; Kidane, Mekonnen, & Teketay, 2014).

Participation denotes a different concept (Jumbe & Angelsen, 2007; Reed et al., 2009; Eilola, Fagerholm, Mäki, Khamis, & Käyhkö, 2015). However, it is generally used to mean an act of involvement or contribution or to play a role. In participatory watershed management program development, local farmers, other land users and the wider community who depend on the land must be involved from the very beginning of the watershed development process. Desta et al (2005) explained participation as the involvement of households and communities in the planning, implementation, monitoring and evaluation stages and sharing the benefits of watershed development.

Different studies have shown that community participation in decision-making and developmental activities occurs at different stages of watershed management intervention programs:- These include, for instance, activities such as making decisions about delineating the boundary of the area to be managed; analysis of available resources; preparing a resource management action plan; agreeing on responsibilities for implementation; assigning roles and responsibilities to the parties and developing subsidiary bylaws that govern the activities at the planning stage (Chowdhury, 2004). The local people should take an interest and participate in the community development and resource management activities at the implementation stage (Reed

et al., 2009). Participation in the monitoring and maintenance stage is also required to examine the whole process because, without protection and care by the local people, the program will fail (Kazi Kamrul Islam, Rahman, Fujiwara, & Sato, 2013).

The degree of community participation in sustainable resource management is of critical importance for sustainable resource conservation and livelihood improvement. For instance, community participation in the program affects the selection and continued use of watershed conservation practices (Bandara & Thiruchelvam, 2008), helps to ensure the sustainability of a watershed management program and increases acceptance, makes environmental policy more cost efficient and effective (Ferranti, Beunen, & Speranza, 2010); reduces conflicts with local authorities (Newig & Fritsch, 2009), and promotes better governance; builds trust between the community and institutions and develops a sense of responsible ownership (Agrawal & Gupta, 2005). However, to date, watershed management intervention plans in Ethiopia have failed to consider and have often overlooked such abilities of local farmers (Snyder et al., 2014). Participation is taken as mere labor contribution (Bewket & Sterk, 2002; Haregeweyn et al., 2015). In fact, farmers' involvement in development programs is highly socio-cultural context-specific in its very nature: this is affected by demographic, socio-economic and institutional attributes and remains a critical input in the design and implementation of the management of watershed resources (Tesfaye, Deneke, Selassie, Deneke, & Selassie, 2014).

Various literatures have evaluated the implementation of watershed management program interventions. For example, the impact of stone bunds on soil fertility and crop yields (Vancampenhout et al., 2006); on-site effects of stone bunds to control soil erosion (Nyssen et al., 2007); effects of soil and water conservation measures on key soil properties (Demelash & Stahr, 2010); effects of land resource management practices on soil erosion and vegetative cover (Mekuriaw, 2017); effects of terracing on combating soil erosion by water (Debie et al., 2018), soil erosion problems and their conservation knowledge (Amsalu & de Graaff, 2006); combined effects of soil bunds with biological soil and water conservation measures (Amare et al., 2014); and the effects of integrated watershed management on curbing land degradation (Haregeweyn, Berhe, Tsunekawa, Tsubo, & Meshesha, 2012). However, most of them are biased towards evaluating the watershed management intervention in terms of biophysical characteristics and their effect on reducing soil loss rather than on community participation at different stages (such

as planning, implementation, and monitoring). Intervention programs still lack a concerted focus on sustainability issues from their early diagnostic phases of planning, implementation and monitoring (Amsalu & de Graaff, 2006; Nigussie et al., 2017). Moreover, there is barely any attempt to examine the different factors involved in effective and sustainable community participation at the planning, implementation and monitoring stages of watershed intervention programs. No such study has been undertaken in the study area.

Understanding the status and factors affecting community participation in watershed management programs right from the planning to the implementation and monitoring stages provides valuable socio-cultural, ecological, economic and local knowledge ensuring sustainable development in the agricultural sector and livelihood improvements. In light of this, the objective of this study was to explore status and factors affecting community participation in a watershed management program at different stages, from the conception of the problem to the monitoring and the evaluation stage in the Rebu watershed, upper Gibe basin, Ethiopia.

#### *4.2. Conceptual framework*

Watershed management implies a process of wise use of land and other resources in the watershed to avert land degradation and enhance livelihoods (Wang et al., 2016). It has developed into a participatory multi-stakeholder exercise requiring institutional and organizational coordination to take into account economic, social, political and cultural dimensions (Perez & Tschinkel, 2003). Local communities are important aspects in the management and conservation of socio-ecological systems (Ostrom, 2009). Contrary to the top-down command and control management of watershed resources, community-based approaches rely on self-governance by local communities while supervised and guided by local or higher-level government (Hutchings et al., 2015). It has been increasingly acknowledged as an important component in natural resource management (Human & Davies, 2010).

The arguments for community participation could be divided into two main groups: (i) normative arguments; which include enhanced democracy and basic human rights, and, (ii) functional arguments, which include effective implementation of policies, capacity-building and learning (Webler & Renn, 1995). In this paper, we focus mainly on the latter rationales for community participation in local watershed management programs. An important distinction concerning

participation processes is to what degree communities are requested or expected to participate. There are several conceptual models that define participation at various levels of integration ranging from passive access to information towards higher levels of integration such as consultation and collaborative planning, to local self-control (Arnstein, 1969; Pretty, 1995). In this study, participation refers to active involvement of the community in watershed management process at each stage of the watershed management and development practices.

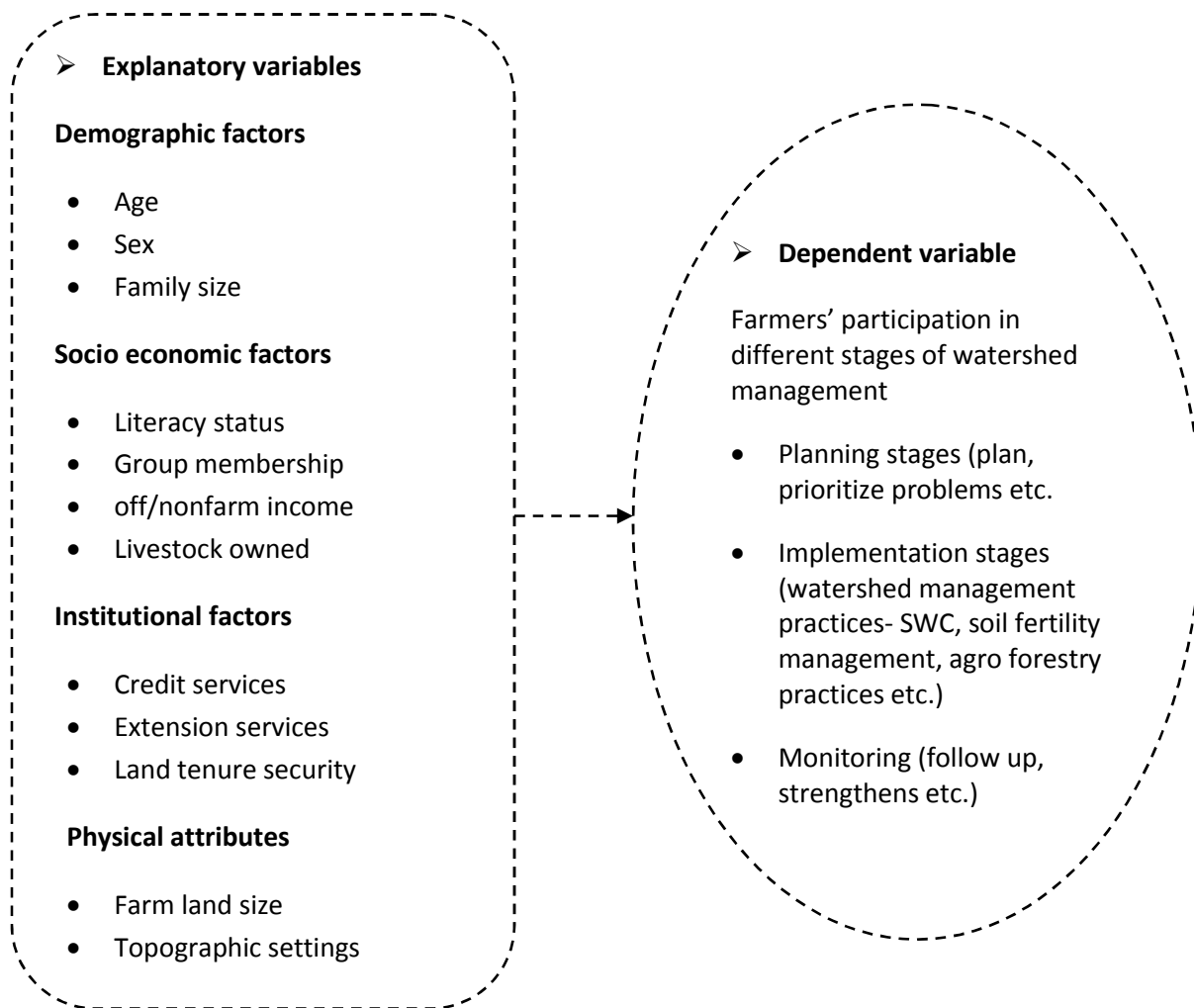
Ethiopia has adopted active community-based participatory watershed development and management as its main guiding principle (Desta et al., 2005; Evans, Giordano, & Clayton, 2012) to enhance sustainable development of ecological balance and improvement in the livelihoods of households in many parts of the country, including the study area. Much watershed conservation related research in Ethiopia is fragmented, focusing on biophysical (Nyssen et al., 2010; Taye et al., 2015) and economic returns ( Nyssen et al., 2007; Kassie, Köhlin, Bluffstone, & Holden, 2011). There is hardly any attempt at documenting sustainability issues from their early diagnostic phases of planning, implementation and monitoring of watershed management programs (Amsalu & de Graaff, 2006; Haregeweyn et al., 2017). No such study has been undertaken in the study area. Hence, this study seeks to address the status and factors affecting community participation at different stages of watershed management.

The involvement of the community in the development and management of watershed programs is socio-cultural context- specific in its very nature (Tegene, 1992; Tesfaye et al., 2014). Faham, Hosseini, & Darvish (2008) reported that some demographic, socio economic and institutional factors are significant in determining community participation in watershed development activities. Warne (1965) indicated that factors influencing participation belong to three groups namely, attributes of the participants, physical and social environment and organizational structures. Dolisca et al (2006) have also shown that participation may depend on an individual characteristic such as age, gender, marital status, household size, and income.

Specifically, various studies elsewhere including Ethiopia, have indicated that there are various explanatory variables such as age of the household head ( Ersado, Amacher, & Alwang, 2004; Gebregziabher, Abera, Gebresamuel, Giordano, & Langan, 2016); gender (Mignouna, Manyong, Mutabazi, & Senkondo, 2011); literacy (Faham et al., 2008; Kassie, Jaleta, Shiferaw, Mmbando, & Mekuria, 2013); family size (Doss, 2006; Tizale, 2007); farm land size ( Zarafshani, Alibaygi,

Afshar, 2008; Sharma & Sisodia, 2008); access to off/non farm income sources ( Demelash & Stahr, 2010; Asfaw & Neka, 2017); numbers of livestock owned (Mbage-Semgalawe, 1998; Shiferaw & Holden, 1998); frequency of extension contact (Tiwari et al., 2008; Asfaw & Neka, 2017); land tenure security (Gebremedhin & Swinton, 2003; Belay & Bewket, 2013; Asmame & Abegaz, 2017); access to credit services (Joel, 2005; Mohamed & Temu, 2008); group membership (Degefa, 2010; Amare & Simane, 2017) and topographic setting ( Gebremedhin & Swinton, 2003; Amsalu & de Graaff, 2007; Tiwari et al., 2008) that have affected community participation in watershed management practices. The dependent variable in this study is farmers' participation at different stages of the watershed management program-planning, implementation and monitoring, and was coded as 1 if the respondent had participated and 0 other-wise. These explanatory and dependent variables are depicted in figure 4.1.

Figure 4.1, A schematic diagram depicting the relationship between community participation in watershed management and explanatory variables



Source: own construction, 2020

### 4.3. Methodology

#### 4.3.1. Indicators measurement, specification and assumption of empirical model

##### 4.3.1.1. Indicators measurement

To determine farmers' level of participation at each stage of the watershed management program i.e., planning, implementation and monitoring, a participation index was adopted following a modified formula (Sharma et al., 2011; Obadire et al., 2014; Bagdi & Kurothe, 2016). Farmers' participation index for respondents is computed, as:

$$PI_i = \frac{\sum_{j=1}^{100} Y_{ij}}{K} \quad \text{equation (1)}$$

Where  $PI_i$  is the participation index for the  $i^{\text{th}}$  respondent;  $Y_{ij}$  is the score of  $j^{\text{th}}$  item for  $i^{\text{th}}$  respondent;  $K$  is the maximum participation score:

$$PI = \frac{\sum_{i=1}^N PI_i}{N} \quad \text{equation(2)}$$

Where  $PI$  is the participation index for the watershed management program;  $PI_i$  is the participation index for the  $i^{\text{th}}$ , respondent;  $N$  is the total number of respondents.

The overall Participation index was developed by adding scores for participation at the three stages. Classification of the participation index in to three categories was adopted based on Bagdi & Kurothe (2016), and the normal distribution curve and standard deviation(SD) of marks were used to separate participants in to- low, moderate and high levels of participation. That is, when the participation index value range is less than Mean-SD, Mean-SD to Mean +SD and greater than Mean + SD, the participation index classification is considered as low, moderate and high respectively.

Farmers' levels of participation were studied under three dimensions (such as, planning, implementation and monitoring). Out of 27 questions that measure farmers' level of participation in the watershed management program at different stages; 8 indicators were used for the planning stage, 13 for the implementation stage (communal land and private resource conservation participation), and 6 for the monitoring stage. These indicators were identified through discussion with local elders, watershed conservation work experts and officials, plus a literature review ( Desta et al., 2005; Bagdi & Kurothe, 2016; Gebregziabher et al., 2016; Tesfaye et al., 2018). Farmers were asked to rate each statement using a five-point Likert scale i.e. (1) = very low; (2) = low; (3) = neutral; (4) = high; and (5) = very high and reverse scoring was undertaken for negative statements (Likert, 1932). The internal consistency of the scale was measured using the reliability coefficient of Cronbach's alpha (Cronbach, 1951), which ranges from 0 to 1; the larger the value the greater the reliability of the scale(above 0.7). Here, the Cronbach' alpha result is 0.915 for all 27 statements about levels of participation indicators suggesting that it was deemed acceptable (Appendix table A1).

Responses to each of the statements were graded and summed, resulting in an overall score for each respondent on this participation scale and therefore, using the Likert scoring method, point scores from the respondents were calculated for each statement. The overall score was obtained by adding up all the scores from all the participants and the total score was expressed as a percentage of the maximum possible score for all the statements.

#### 4.3.1.2. Specification of empirical model

To identify whether personal and socio-demographic, institutional and physical variables explain why some respondents participated more than others in the watershed management program, the binary logistic regression model was employed. When the response variable is binary, the logistic regression model enabled assessment of the association between an independent variable and the response variable (Manor, Matthews, & Power, 2000; Hyeoun-Ae, 2013). Thus, for the logistic regression model requirement, the overall participation score was dichotomized into a dummy variable by using the mean score for participation. This categorization does not affect the size and significance of main effects, types of association, and interactive effects (Manor et al., 2000; Greene, 2008).

Active/high participation in the watershed management program equals 1 (if respondents scored higher than or equal to the mean participation score) and a minor/low level of participation in the watershed management program equals 0 (if respondents scored less than the mean participation score). Let  $Y_i$  represent a dichotomous variable that equals 1 if the respondent has active/high participation in the program, otherwise 0. The probability of a farmer's expressing active participation in the watershed management program  $\Pr(Y_i = 1)$  is a cumulative density function (likelihood function) evaluated at  $(X_i\beta)$ , where  $X_i$  is a set of explanatory variables and  $(\beta)$  represents the parameters to be estimated. This kind of cumulative density function can be modeled using a logistic probability function which has the following form (Greene, 2002).

$$\Pr(Y_i = 1) = \frac{\exp(X_i\beta)}{1 + \exp(X_i\beta)} \quad \text{equation (3)}$$

The estimation form of this logistic transformation for the probability that a respondent will express higher perception,  $\Pr(Y_i=1)$  is represented as (Greene, 2002).

$$\ln \left[ \frac{\Pr(Y_i = 1)}{1 - \Pr(Y_i = 1)} \right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \dots \beta_n X_n \quad \text{Equation(4)}$$

Where Pr denotes the probability that the  $i^{\text{th}}$  respondent had higher participation in the watershed management program:  $X_i$  is a vector of the explanatory variable;  $(\beta)$  represents the parameters to be estimated.

In analyzing binary choice models, the parameter of interest is not the index coefficients, rather the marginal effects. The marginal effects for binary variables measure discrete change. For continuous variables, they measure the instantaneous rate of change.

#### 4.3.1.3. Goodness -of-fit of the model

Before estimation of the determinant factors that affect community participation in the watershed management program, various assumptions or common tests were carried out. The goodness of fit of the model was checked using Hosmer and Lemeshow's Test, log likelihood chi-square (the Omnibus test), and pseudo R-square. The multicollinearity among independent variables was also checked.

#### 4.3.2. Hypothesizing the variables

There are various household' demographic, socio-economic, institutional and physical attributes that facilitate farmers' participation in the watershed management program. As depicted in Table 4.1, the positive or negative sign shows whether they are more likely or less likely to participate in watershed management practices (it is ambiguous before estimation) and the positive sign indicates greater likelihood of participating in watershed management practices. The hypothesized relationships of these variables with the dependent variables was determined based on theoretical background in literature ( e.g., Warner, 1965; Mcmillan, Hoban, William, & Brant, 1996; Dolisca et al., 2006; Faham et al., 2008; Tesfaye, et al., 2014; Kassie, Teklewold, Jaleta, Marennya, & Erenstein, 2015; Haregeweyn et al., 2015; Teshome et al., 2016) and the researcher judgment on the nature of surveyed farmers. The dependent variable of this study is farmers' participation at different stages of watershed management program-planning, implementation and monitoring, which coded as 1 if the respondent had participated and 0 other wise.

Table 4.1, Expected sign of the explanatory variables

<b>Variable name</b>	<b>Variable description</b>	<b>Expected sign</b>
Age	Continuous variable measured in years	±
Sex	Dummy = 1 if household head is male, otherwise 0	+
Literacy status	Dummy = 1 if household head literate, otherwise 0	±
Family size	Continuous variables- number of members who are currently living within the family	±
Farm land size	Continuous variables -total size of farm landholding in ha	±
Livestock TLU	Continuous variable -number of livestock owned measured in TLU	±
Off/nonfarm activities	Dummy= 1 if household head is access to off/nonfarm activities, otherwise 0	+
Extension services	Continuous variable measured in the number of extension contact	+
Land tenure security	Dummy = 1 if the farmer feels secured , otherwise 0	+
Credit services	Dummy =1 if the farm household access to credit , otherwise 0	+
Group membership	Dummy = 1 if the farm household belongs to local institutions, otherwise 0	+
Topographical setting	Dummy = 1 for upper , otherwise 0	+

#### *4. 4. Results of the study*

##### *4.4.1. Households Characteristics*

Household's socio-demographic, economic, institutional and physical characteristics and level of farmers' participation in the watershed management program are presented in tables 4.2 and 4.3.

##### *4.4.1.1. Respondents socio-demographic, economic and institutional characteristics (Continuous variables)*

The results of the continuous variables were presented in table 4.2. As indicated, the average age of the study respondents was 46.73, years with the minimum and maximum ages of 25 and 75 years respectively. The number of members in the family was 4.8 on average, with the minimum and maximum number of 1 and 9 members respectively. As revealed from the survey result, the average land holding of the respondents was found to be 2.2 hectares ranging between 0.77 and 7.11 hectares. Livestock owned by the study households was measured in terms of TLU and was found to be 5.49 on average. Farmers were also asked to indicate the frequency of

extension contact in the last production year(2016/17) and the average frequency of extension contact for the respondents was 2.18; with a range of 0-5 times.

Table 4.2, Respondents’ socio demographic, economic and institutional characteristics (continuous variables)

Variable	Description	Mean	Std. Dev.	Min	Max
Age	Continuous variable measured in years	46.72	9.58	25	75
Family size	Continuous variables- number of members who are currently living within the family	4.84	1.51	1	9
Farm land size	Continuous variables -total size of farm landholding in ha	2.20	0.93	.77	7.11
Livestock TLU	Continuous variable -number of livestock owned measured in TLU	5.49	2.05	1.95	17.45
Extension services	Continuous variable measured in the number of extension contact	2.18	1.21	0	5

Source: computed from survey results, 2018

#### 4.4.1.2. Respondents’ socio demographic, economic and physical characteristics (dummy variables)

The results of the dummy variables were presented in table 4.3. As indicated, about 87 percent were male and 13 percent were female. A larger proportion of the respondents (about 60 percent) were literate, whereas the remaining (40 percent) were illiterate. With regards to off/non-farm income activities, survey households were asked whether or not they accessed activities such as; hand crafting, employment, daily labor, rents, remittances, petty-trade (salt, soap, food and drinks, local drinks) and hence, the proportion of households accessing to at least one of these activities was 29 percent. Respondents were also asked to reflect on land tenure security and their expectation of using farm-land throughout or at least within, their life- time and 86 percent feel that they would use the farm-land throughout their life-time. About 76 percent of the respondents had accessed to credit availability. Farmers’ membership in rural institutions/associations such as watershed committees/teams, self-help groups and cooperatives, etc., was used as proxy for social capital and about 68 percent of the respondents were participating in at least one of these local institutions. About 34 percent of the respondents were within the upper topographical setting.

Table 4.3, Respondents' socio demographic, economic and physical characteristics (dummy variables)

Variables	Description	Category	Total sample(N= 304)	
			N	%
Sex	Dummy = 1 if household head is male, otherwise 0	Male	264	87
		Female	40	13
Literacy status	Dummy = 1 if household head literate, otherwise 0	Literate	181	60
		Illiterate	123	40
Access to off/nonfarm activities	Dummy= 1 if household head is access to off/nonfarm activities, otherwise 0	Yes	88	29
		No	216	71
Land tenure security	Dummy = 1 if the farmer feels secured , otherwise 0	Yes	260	86
		No	44	14
Access to credit services	Dummy =1 if the farm household access to credit , otherwise 0	Yes	230	76
		No	74	24
Access to group membership	Dummy = 1 if the farm household belongs to local institutions, otherwise 0	Yes	207	68
		No	97	32
Topographical settings	Dummy = 1 for upper , otherwise 0	Upper	102	34
		Middle and Lower	202	66

Source: Computed from survey results, 2018

#### 4.4.2. Community participation in different stages of watershed development practices

##### 4.4.2.1. Planning stage

Various scores and Standard Deviations given for activities undertaken at the planning stage were presented in Table 4.4. As indicated in the table, a public meeting calling for the formation of users' committee selection obtained a higher score (49.1 percent with a Std. deviation of 1.491), followed by capacity building such as training related to resource management objectives, benefits, challenges and guide-lines (48.9 percent with a Std. Deviation of 1.346). The overall farmers' Participation Index (PPI) during the planning stage of the watershed management program was calculated as 43.5 percent. This value indicated that the PPI for the study area was categorized as having a moderate level of participation, suggesting that some areas were undertaking consultation with local farmers. The program participants were better involved for all indicators at the planning stages (overall PPI of 55.9 percent) than the non-participants (overall PPI of 32.3 percent).

Table 4.4, Distribution of community participation in planning stage of watershed management practices

Watershed management practices at planning stage	Participants		Non participants		Total sample	
	Score & Std. Deviation	% of the max (145*5)	Score	% of the max (159*5)	Score & Std. Deviation	% of the max (304*5)
Village resource assessment and use and problems identification process	416 (1.415)	57.4	274 (1.179)	34.5	690 (1.416)	45.4
Prioritization of felt need and problem identified	404 (1.375)	55.7	240 (0.954)	30.2	644 (1.335)	42.4
Village resource management committee selection/reformation	475 (1.362)	65.5	272 (1.182)	34.2	747 (1.491)	49.1
Training on resource management objectives, benefits and challenges and guide lines	459 (1.280)	63.3	285 (1.038)	35.8	744 (1.346)	48.9
Encouraging others to participate in WSM program planning activities	357 (1.349)	49.2	238 (0.833)	29.9	595 (1.208)	39.1
Preparing village resource management plan	340 (0.989)	46.9	232 (0.855)	29.2	572 (1.021)	37.6
Developing village resource management rules/bylaws	401 (1.167)	55.3	256 (1.043)	32.2	657 (1.244)	43.2
Approval of the village resource management agreement	389 (1.122)	53.7	256 (1.043)	32.2	645 (1.206)	42.4
<i>PPI (%)</i>	<i>405.1</i>	<i>55.9</i>	<i>256.6</i>	<i>32.3</i>	<i>661.7</i>	<i>43.5</i>

Figures in parentheses are the Std. Deviation  
Source: computed from survey result, 2018

#### 4.4.2.2. Implementation stage

Different scores and Standard Deviation given for activities undertaken at the implementation stages of the watershed management program are presented in Table 4.5. In the implementation stage, indicators were grouped into two categories namely, development of common land resources and development of private land resources. It can be observed from the table that participation was higher (52.7 percent) in the development of common land than private land (45.1 percent). Reforestation/vegetation activities attracted higher participation (56.3 percent with a Std. deviation of 1.522), followed by gully rehabilitation through checking dams and grass (55.5 percent with a Std. Deviation of 1.636). However, participation in the side slope tree/shrub plantations on communal areas was relatively low (45.3 percent with a Std. Deviation of 1.512).

In the case of development of private/own land resources, activities such as planting of horticultural practices (fruit-bearing trees- cabbages, avocado, mango, apples) on private land(60.4 percent with a Standard Deviation of 1.075) and checking soil erosion through vegetative barriers and field bunds (56.2 percent with a Standard Deviation of 1.473) attracted participation. However, the participation of farmers was found to be low in some other activities such as, developing tree nursery establishment for private households (31.1 percent with a Standard Deviation of 1.236), income-generating activities such as modern beekeeping activities \_ (34.4 percent with a Standard Deviation of 1.362) and soil fertility management practice such as compost preparation\_(39.5 percent with a Standard Deviation of 1.059). The overall farmers' Participation Index (PPI) during the implementation stage of the watershed management program was calculated as 48.9 percent. These values indicate that the PPI for the study area was categorized as having a moderate level of participation, suggesting that there was less participation in some activities. The program participants were better involved in all indicators in the implementation stages (overall PPI of 59.8 percent) than the non-participants (overall PPI of 38.8 percent).

Table 4.5, Distribution of community participation in implementation stage of watershed management practices

Watershed management practices at implementation stage	Participants		Non participants		Total sample	
	Score & Std. Deviation	% of the max	Score & Std. Deviation	% of the max	Score & Std. Deviation	% of the max
<b>Participation in communal land development activities</b>						
Reforestation and protecting of degraded communal areas	540 (1.421)	74.5	315 (1.070)	39.6	855 (1.522)	56.3
Side slope tree/shrub plantations on communal areas	370 (1.720)	51.0	318 (1.243)	40.0	688 (1.512)	45.3
Gully plugging by gabion/brush wood check dam on communal areas	507 (1.646)	69.9	336 (1.321)	42.3	843 (1.636)	55.5
Hill side trench and micro basin development on communal areas	477 (1.616)	65.8	352 (1.384)	44.3	829 (1.590)	54.5
Development grassed waterways on communal areas	455 (1.593)	62.8	332 (1.280)	41.8	787 (1.528)	51.8
PPI(%)	469.8	64.8	330.6	41.6	800.4	52.7
<b>Participation in own/private land development activities</b>						
Practicing SWC practices on private land	460 (1.455)	63.4	393 (1.413)	49.4	853 (1.473)	56.1

Planting of horticultural practices (fruit bearing trees- cabbage, avocado, mango, apple) on private land	492 (0.952)	67.9	426 (1.069)	53.6	918 (1.075)	60.4
Planting trees and management around homesteads	441 (1.374)	60.8	299 (0.950)	37.6	740 (1.306)	48.7
Planting grass and fodder on private land	416 (1.355)	57.4	247 (0.959)	31.1	663 (1.336)	43.6
Developing tree nursery establishment for household privately	304 (1.556)	41.9	169 (0.460)	21.3	473 (1.236)	31.1
Participation on modern beekeeping work privately	346 (1.524)	47.7	238 (1.030)	29.9	584 (1.362)	38.4
Compost preparation on private land	325 (1.138)	44.8	275 (0.919)	34.6	600 (1.059)	39.5
Attending on knowledge and skill development training on how to implement activities	399 (1.267)	55.0	249 (1.088)	31.3	648 (1.316)	42.6
PPI (%)	397.9	54.9	287	36.1	684.9	45.1
Overall PPI (%)	433.8	59.8	308.8	38.8	742.6	48.9

Figures in parentheses are the Std. Deviation  
Source: computed from survey result, 2018

#### 4.4.2.3. Monitoring and evaluation stage

Scores and Standard Deviation given for various activities undertaken at the monitoring stage of watershed management were presented in Table 4.6. Protecting and maintaining the rehabilitated areas (44.6 percent); protecting and maintaining trees /grass planted from damage (40.6 percent) attracted farmers' participation. However, it was low for frequent visiting/supervising the soil and for the water conservation measures developed (31.3 percent). It was also revealed that the overall farmers' Participation Index (PPI) was computed as (37.7 per cent) for the monitoring stage of the watershed management program. This reflects a moderate level of participation. The program participants were better involved in all indicators in the monitoring and evaluation stages (overall PPI of 48.2 percent) than the non-participants (overall PPI of 28.1 percent).

Table 4.6, Distribution of community participation in monitoring and evaluation stage of watershed management practices

Watershed management practices at monitoring and evaluation stage	Participants		Non participants		Total	
	Score & Std. Deviation	% of the max (145*5)	Score & Std. Deviation	% of the max(159*5)	Score & Std. Deviation	% of the max(304*5)
Frequent visiting or supervising the watershed management activities developed	304 (0.884)	41.9	172 (0.275)	21.6	476 (0.818)	31.3
Protecting and maintaining trees or grass planted from damage	381 (1.258)	52.6	236 (0.899)	29.7	617 (1.225)	40.6
Protecting and maintaining the rehabilitated areas from illegal activities	426 (1.386)	58.8	252 (0.957)	31.7	678 (1.360)	44.6
Strengthening and maintaining of SWC measures developed	333 (1.055)	45.9	221 (0.737)	27.8	554 (1.009)	36.4
Informing others to repair the damaged SWC measures	336 (0.970)	46.3	235 (0.762)	29.6	571 (0.962)	37.6
Attending meeting on how to monitoring activities	319 (0.983)	44.0	225 (0.866)	28.3	544 (1.003)	35.8
<i>PPI (%)</i>	<i>349.8</i>	<i>48.2</i>	<i>223.5</i>	<i>28.1</i>	<i>573.3</i>	<i>37.7</i>

Figures in parentheses are the Std. Deviation

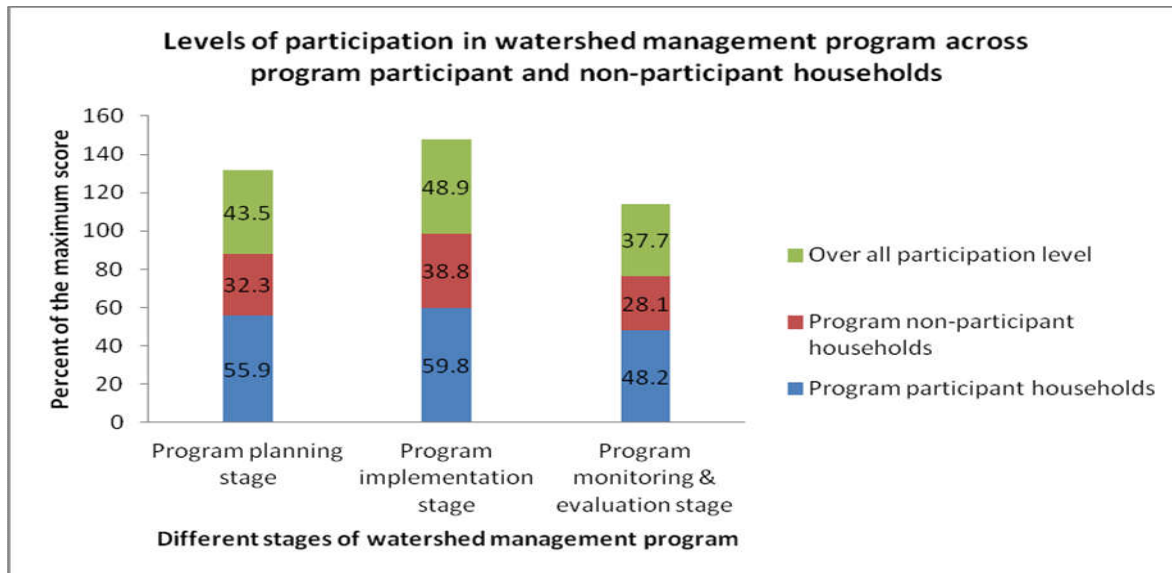
Source: computed from survey result, 2018

#### 4.4.2.4. Over all community participation

The overall level of farmers' PI (participation index) at different stages (planning, implementation and monitoring and evaluation) of the watershed management program across program participant and non-participant households was presented in Figure 4.2. The result shows that 43.5 percent of the farmers participated at the planning stage, compared to 48.9 percent at the implementation and 37.7 percent at the monitoring stages. The implementation stage better attracts farmers' participation followed by the planning and monitoring stages. Overall, the PI value showed that, the farmers had a moderate level of participation in the watershed management program (43.4 percent), as calculated from the average of the three different stages, suggesting that only some decisions were taken in consultation with local people in the study area. The program-participant households participated more at the implementation stage (59.8 percent) followed by the planning stage (55.9 percent) and monitoring stage (48.2

percent). Similarly, the program non-participant households participated more in the implementation stage (38.8 percent) followed by the planning stage (32.3 percent) and monitoring stage (28.1 percent). At all stages of watershed management program participation, the program-participant households participated more than the non-participant households.

Figure 4.2, A schematic diagram depicting the level of community participation in different stages of watershed management across program participant and non participant households



source, survey results, 2018

#### 4.4.3. Determinants of community participation in watershed management practices

##### 4.4.3.1. Fitness of the model

A, binary logistic regression model was used to estimate determinant factors that affect community participation in watershed management program practices. Before estimation, various common tests were carried out. The chi-square value for the log likelihood function- an Omnibus test- was highly significant, indicating that all the coefficients for independent variables in the model were significantly different from zero. Such as LR chi2 (12) = 158.02, Prob > chi2 = 0.0000 for over all status of participation; LR chi2 (12) = 130.41, Prob > chi2 = 0.0000 for the planning stage; LR chi2 (12) = 125.20, Prob > chi2 = 0.0000 for the implementation stage and LR chi2 (12) = 121.81, Prob > chi2 = 0.0000 for the monitoring stage. A statistically significant fitted model suggested that the model had strong explanatory power. Hosmer and Lemeshow

Test of 0.146, 0.160, 0.651 and 0.798 for all stages that is, over all participation, planning, implementation and monitoring stages respectively showed that the model is fitted.

The fitness of the model was also assessed using pseudo R<sup>2</sup> and about 37.8 percent of the variance was explained by the combined independent variables for over-all participation, 35.3 percent of the variance was explained by the combined independent variables for the planning stage, 39.7 percent of the variance was explained by the combined independent variables for the implementation stage and 34.2 percent of the variance was explained by the combined independent variables for the monitoring stages. The average VIF was 1.22 with all values within 1 and 2 (Appendix table A2). This suggests no concern over a linear combination of other independent variables in the model, as all VIF values were less than the threshold value of 10 (Gujarati, 2004). The Breusch–Pagan test (hettest) in Stata showed that the chi-square statistic was (chi2 (1) = 0.35, Prob > chi2 = 0.5552) which was insignificant indicating no concern about heteroskedasticity. The link test in Stata showed that the hat-squared was not significant ( $P > |t| = 0.609$ ) therefore we failed to reject the null hypothesis and concluded that the model was correctly specified.

#### 4.4.3.2. Determinants of community participation in different stages of watershed management practices

Table 4.7, showed the marginal effects that were computed for the three stages of community participation in the watershed management program (planning, implementation and monitoring and evaluation). The marginal effects are interpreted as effects of changes in the independent variables on the predicted probabilities of the dependent variable. In general, family size, total livestock owned, farmland size, access to off/non-farm income sources, frequency of extension contact, land ownership security, group membership and topographical settings of households significantly explained the level of community participation in watershed management at different stages.

A unit increase in a hectare of farm land size reduced the probability of farmers participating in the implementation of watershed management programs by 5 percent. A one-person increase in family size for the households increased the probability of farmers' participation in monitoring of watershed management practices by about 4 percent. A one-unit increase in livestock size owned by the households increased the probability of farmers' participation in the

implementation of watershed management practices by about 2 percent. Households' access to off/non-farm income increased the probability of participating in planning of watershed management program practices by about 19 percent. A one-unit increase in the number of extension contacts increased the probability of farmers' participation in planning, implementation and monitoring of watershed management program practices by about 12 percent, 6 percent and 12 percent respectively. Land tenure security increased the probability of participating in planning, implementation and monitoring of watershed management program practices by about 19 percent, 11 percent, and 16 percent respectively. Households' membership of local institutions increased the probability of participating in planning, implementation and monitoring of the watershed management program practices by about 22 percent, 11 percent and 16 percent respectively. Topographic location also increased the probability of participating in planning and implementation of watershed management program practices by about 13 percent and 30 percent respectively. With regards to planning, implementation and monitoring levels of participation in the watershed management program, about 30, 21.4 and 27.3 percent of the respondents scored higher than, or equal to, the average participation score respectively.

Table 4.7, Logistic regression marginal effects, for community participation in different stages of watershed management program practices

Variables	Planning stage		Implementation stage		Monitoring	
	Odds Ratio	dy/dx	Odds Ratio	dy/dx	Odds Ratio	dy/dx
age	1.008726 (.0180919)	.0013345 (.00274)	1.036559 (.022427)	.0030919 (.00186)	1.016924 (.0187712)	.0022301 (.00243)
sex(*)	1.351267 (.6794436)	.0431052 (.06696)	.7094076 (.3782345)	-.0327736 (.0561)	.5079078 (.2382239)	-.1059824 (.08371)
famsize	1.121541 (.1337448)	.0176181 (.0183)	1.199644 (.1615572)	.015674 (.01179)	1.314261 (.1556178)	.0363148** (.0156)
literacy(*)	1.436071 (.4936111)	.0544283 (.05059)	1.760867 (.716042)	.046939 (.03262)	1.201773 (.4171289)	.0241393 (.04502)
farmsize	.8743866 (.1741902)	-.0206178 (.03074)	.5298947 (.1409562)	-.054686** (.02528)	1.044723 (.2055883)	.0058141 (.02615)
totlvest	.9625168 (.080872)	-.005868 (.0129)	1.224554 (.1113978)	.0174437** (.0082)	.941437 (.0754791)	-.0080195 (.01074)
credit_se(*)	1.621521 (.7114138)	.06868 (.05748)	1.648407 (.8725492)	.0389555 (.03738)	2.07118 (.9749296)	.0853206 (.04818)
offainco(*)	2.958867 (1.181804)	.1898359** (.07867)	1.440169 (.6410952)	.03349 (.04469)	1.440539 (.5768367)	.0511301 (.05945)
freqvis ex	2.189966 (.3369761)	.1204029*** (.0252)	2.160119 (.3887214)	.0663181*** (.01789)	2.543684 (.4173183)	.1240658*** (.02369)
land_sec(*)	6.42911 (4.420023)	.1889132*** (.04351)	10.47066 (11.21699)	.1148182*** (.03019)	5.990096 (4.224121)	.1563864*** (.03904)

member(*)	5.448347 (2.615169)	.2178873*** (.04824)	4.653702 (2.58255)	.111003*** (.03576)	4.318337 (2.070373)	.1653358*** (.0441)
topograp(*)	2.212518 (.815413)	.1319197** (.06665)	11.07873 (4.804908)	.2972493*** (.07173)	1.424729 (.5266297)	.048973 (.0536)
_cons	.0004134 (.0006459)		.000025 (.0000514)		.0002229 (.0003632)	

Number of obs = 304, LR chi2(12) = 130.41, Prob > chi2 = 0.0000, Pseudo R2 = 0.3531, Log likelihood = 119.4691; Number of obs = 304 LR chi2(12) = 125.20, Prob > chi2 = 0.0000, Pseudo R2 = 0.3968, Log likelihood = -95.167513; Number of obs = 304, LR chi2(12) = 121.81, Prob > chi2 = 0.0000, Pseudo R2 = 0.3418, Log likelihood = 117.31194; Number of obs = 304, LR chi2(12) = 158.02, Prob > chi2 = 0.0000, Pseudo R2 = 0.3780, Log likelihood = -130.02094; Figures in parentheses are the standard errors; \*significant at 10%\*\* significant at 5% \*\*\* significant at 1%; (\*) dy/dx is for discrete change of dummy variable from 0 to 1

Source: survey result, 2018

#### 4.4.3.3. Determinants of the overall community participation in watershed management practices

Table 4.8, shows the marginal effects that were computed for the overall levels of community participation in the watershed management program. In general, access to credit services, access to off/non-farm income sources, frequency of extension contacts, and group membership of households significantly explained the level of community participation in watershed management. Households' access to credit services, off/non-farm income sources and group membership increased the probability of participating in watershed management practices by about 24 percent, 29 and 27 percent respectively. A one-unit increase in the number of extension contacts increased the probability of farmers' participation in overall watershed management program practices by about 24 percent. With regards to overall levels of participation in the watershed management program, about 44.74 percent of the respondents scored higher than or equal to the average participation score.

Table 4.8, Logistic regression marginal effects, for overall community participation in watershed management program practices

Variables	Overall participation	
	Odds Ratio	dy/dx
Age of the household head	1.018301 (.0172362)	.0044611 (.00416)
Sex of the household head(*)	1.599601 (.7391857)	.1117767 (.10531)
Family size of the household	1.153307 (.1270031)	.0350855 (.02707)
Literacy status of the household head(*)	1.702052 (.5606045)	.1291938 (.07844)
Farm land size of the household	.9535896 (.1951325)	-.0116896 (.05035)

Total livestock owned (TLU)	.9544538 (.0931478)	-.0114668 (.02401)
Access to credit services(*)	2.792701 (1.158207)	.2360624*** (.08597)
Access to off/non farm income(*)	3.250995 (1.384623)	.286489*** (.09784)
Frequency of extension contact	2.622599 (.4205004)	.2399669*** (.03978)
Land ownership(*)	1.995683 (.9331669)	.1610573 (.10069)
Group membership(*)	3.21957 (1.194318)	.2704925*** (.07702)
Topographic location(*)	1.803676 (.6521013)	.1455083 (.08857)
_cons	.0009201 (.0012726)	

*Number of obs = 304, LR chi2 (12) = 158.02, Prob > chi2 = 0.0000, Pseudo R2 = 0.3780, Log likelihood = 130.02094; Figures in parentheses are the standard errors; \*significant at 10%\*\* significant at 5% \*\*\* significant at 1%; (\*) dy/dx is for discrete change of dummy variable from 0 to 1; Source: survey result, 2018*

## 4.5. Discussions

### 4.5.1. Community participation in different stages of watershed management practices

Various watershed management program practices were identified to assess the level of community participation at different stages (planning, implementation and monitoring and evaluation) of watershed management program practices.

#### 4.5.1.1. Planning stage

There is variation in the involvement of farmers in activities during this stage. Farmers' showed less involvement particularly in the areas of plan preparation for resource management, problem prioritization and formulation of watershed resource management by-laws, as compared to other indicators in the planning stages. This might be due to the prior establishment of plans and problem identification without the involvement of the farmers. The results from the interviews and focus group discussions indicated that farmers come for the meeting but the actual planning of work is a challenge and some planned work was set by the authorities without involving farmers. This result accords with research by Sanginga, Kamugisha, Martin, Kakuru, & Stroud (2004) whose study in southwestern Uganda showed limited involvement of local communities in natural resource management policy development and the formulation of bylaws. Further, it was revealed that the overall People's Participation Index (PPI) was calculated as 43.5 percent

for the planning stage of the watershed management program. This value indicates that the PPI for the study area was categorized as having a moderate level of participation. This indicates that only some decisions were taken in consultation with local people. This is in line with the study by the Bagdi & Kurothe (2014) and Teressa (2018) who found moderate participation during watershed programme planning, indicating that only some decisions were taken in consultation with local people and the remaining decisions were undertaken solely by government officers at an organizational level.

An interviewed natural resources conservation expert indicated:

*Although theoretically said, in a practical sense there is a top-down approach- without full participation and decision making by the community are noticed at the planning stage. For example, full community involvement in plan preparation for resource management, problem prioritization and decision making and formulation of watershed resource management by laws are very minimal. Communities are asked to participate in meetings and training alone (Expert opinion, April, 20147).*

#### 4.5.1.2. Implementation stage

Levels of participation at the implementation stage were categorized into activities on communal land and private land. Results indicated that average participation was higher in the development of communal land than private land. This is due to the fact that activities undertaken such as hill side trench and micro-basin development and reforestation or vegetation and protect on affected a large number of farmers. The results from the interview and focus group discussions indicated that before the rehabilitation and conservation of the areas, farmers, especially in the, far upper lands, were severely affected through high runoff and formation of gullies that necessitate greater participation of people in communal activities. The study is in line with the study by Badal, Kumar, & Bisaria (2006) who found that community participation was much higher in the development of communal land than private land.

There is also variation in the level of participation for some indicators at the implementation stage of the watershed management program. For example, farmers showed lower participation in income-generating activities such as tree nursery and beekeeping activities. This might be due to a capacity-building problem and lack of resources. Results from interviews and focus group

discussions revealed that participation in some activities such as tree nursery development and beekeeping was possible but required support and was difficult to implement. This implies that there is a need to create awareness and support to ensure farmers' participation in a larger number of activities to ensure sustainable livelihoods. The variation in participation between program participants and non-participants might be related to support in terms of training in knowledge and skills for watershed conservation and management. The overall People's Participation Index (PPI) was computed as 48.9 percent at the implementation stage of the watershed management program. It reflects that a moderate level of participation was exhibited by farmers at the implementation stage of the watershed management program. This is in line with the study by Bagdi & Kurothe (2014) who also found a moderate level of community participation in watershed management at the implementation stage.

An interview was undertaken with one agricultural expert as follows:

*In my opinion, a top-down approach to participation by the community and weak intuitional set-up were the challenges observed in the implementation and sustainable use of the watershed management practices. For instance, there is lack of support and awareness creation to participate in natural resources-based income-generating activities. In some localities, there is a serious problem in getting materials such as stone for construction (Expert opinion, April 2017).*

#### 4.5.1.3. Monitoring and evaluation stage

At the monitoring and evaluation stage, there is also variation in farmers' participation in different activities. The activities such as visiting the conserved or developed land to maintain the activities, strengthening the implemented conservation measures and attending meetings to give opinions and suggestions about the activities scored less compared to others, indicating a need to create awareness and support about monitoring activities. Results from interviews and focus group discussions showed that farmers' participation in some activities at the monitoring and evaluation stage was relatively less as they feel that it is not part of their role. Results from the same group also showed a greater need to strengthen and maintain the implemented watershed management practices. This implies a need to make experts see beyond meetings and evolve a mechanism to assess the bio-physical and socio-economic impacts of the programs they implement which will make them sensitive to involving the community at all stages of watershed

management programs (Turton & Farrington, 1998). A study by Islam et al (2013), reported that lack of community participation in the monitoring and evaluation stage led to failure of the projects. The overall participation index in this stage was also 37.7 percent). This is contrary to the study by Bagdi & Kurothe (2014) who found a higher level of participation at the maintenance stage of watershed management programs.

An interview was undertaken with one watershed management program expert as follows:

*Watershed management practices such as physical and biological measures implemented through public or own land lack maintenance and integration to use for the future. For example, I observed that during the growing season the stone and soil bunds constructed across farmland are destroyed by the owner due to scarcity of farmland and less awareness of its importance. This is rooted in a lack of sense of ownership and preference for interventions that offer short-term benefits (Expert opinion, May 2017).*

#### 4.5.1.4. Over all community participation

Considering the participation of farmers at the different stages of the watershed management program, it was better at the implementation stage (48.9 percent) than at the planning (43.5 percent) and monitoring and evaluation stages (37.7 percent). This indicates that, there was greater enforcement by the government for labor contribution. The overall People's Participation Index (PPI) in this study showed moderate (43.4 percent) levels of farmers' participation indicating that only some decisions were taken in consultation with local people in the study area. This is in line with the study by Bagdi & Kurothe (2014 and Teressa (2018) who found a moderate overall level of community participation in watershed management programs. The program participants were better involved in all indicators at all stages than the non-participants. This study conforms with the study by Wei et al (2009) and Tesfaye et al (2018), who found that program participants were more likely to participate in the watershed management program than non-participants. This might be due to exposure to information and training on environmental management.

#### 4.5.2. Determinants of community participation indifferent stages of watershed management practices

Community levels of participation in the watershed management program at different stages were influenced by various socio demographic, economic and institutional factors. We found that family size, farm land size, total livestock owned, access to off/non-farm income sources, frequency of extension contacts, land tenure security, access to group membership and topographic location significantly affects community levels of participation in the watershed management program at different stages. Specifically, family size affected households' participation in watershed monitoring and maintenance positively and significantly. This implies that larger families might not face the constraint of labor supply on participation. This study conforms with Doss (2006) who stated that large families would be expected to positively relate to participation. The study is also consistent with the findings of Belay (2004) and Tiwari et al (2008) who found that a farmer with larger family size is more likely to participate in the watershed program.

Farmland size also affected farmers' participation in watershed management program practices implementation negatively and significantly. This implies that households with a large farm size could decide to participate less in watershed management program practices. This might be due to the fact that those farmers who cultivate large farm sizes are older and have short term plans and/ or lack the work force to maintain conservation practices. This study conforms with the study by Bayard, Jolly, & Shannon (2006) who indicated that there is a negative and significant relationship between farmland size and the decision to participate in watershed management program practices. Farmers' involvement in off/non-farm income-generating activities also positively and significantly affected farmers' participation in the planning of watershed management program practices, suggesting that income from off-farm activity increases the financial potential of farmers which, in turn, encourages investment in watershed conservation practices. This result agreed with the study by Demelash & Stahr (2010) who found that, off-farm activity positively affects, at a statistically significant level, participation in watershed management practices. The number of livestock owned positively and significantly affected farmers' participation in the implementation of watershed management practices. This result agreed with the study by Shiferaw & Holden (1998) who reported that the number of livestock

owned is expected to be positively related to participation, as the development of watershed leads to greater availability of fodder and water, or livestock serves for manure.

Extension services had a significant positive effect on farmers' participation in the planning, implementation and monitoring of watershed management program practices. This implies that intervention through extension services is a means of creating awareness and provision of support for understanding the environment that improves participation in the program. This result agreed with the study by Dolisca et al(2006); Tiwari et al (2008 and Asfaw & Neka (2017) who stated that access to extension services and training on watershed management practices is expected to motivate farmers towards greater participation and the expected sign is positive. Land tenure security had also shown a significant and positive effect on farmers' levels of participation in all stages of watershed management program practices. The result conforms with studies by Gebremedhin & Swinton (2003) and Asmame & Abegaz (2017) who reported the importance of tenure security in participation in watershed management practices.

Group membership had a significant positive effect on farmers' levels participation at all stages of watershed management practice, suggesting that, membership of social groups or local institutions enables farmers to acquire information as well as attend training as an incentive factor to participate in the program. This result agreed with the studies by Adesina et al (2000), Degefa (2010) and Amare & Simane (2017) who confirmed that farmers who are members of institutions are more inclined to participate in watershed management practices. The topographical setting also positively and significantly affected farmers' participation in the planning and implementation of watershed management practices. This implies that topographical setting is an indicator of the erosion potential of an area. Therefore, farmers whose farmland is located in an upper topographical setting are more interested in participating in watershed management programs. This result agreed with the study by Shiferaw & Holden (1998), Gebremedhin & Swinton (2003), Amsalu & de Graaff (2007) and Tiwari et al(2008).

The overall community level of participation in watershed management program practices was affected positively and significantly by access to credit services, access to off/non-farm income sources, frequency of extension contacts and access to group membership. Credit services had shown a significant positive effect on farmers' participation in the watershed conservation program, suggesting that benefiting from the availability of credit services may provide farmers

with alternative cash sources to address credit constraints, and therefore to afford the high-investment costs associated with watershed management program practices. This study is congruent with the studies by Simtowe & Zeller (2006) and Mohamed & Temu (2008), who observed that access to credit services has been reported to stimulate technology adoption. Factors such as extension services (Tiwari et al., 2008; Asfaw & Neka, 2017); access to off/non-farm income sources (Demelash & Stahr, 2010) and access to group membership (Degefa, 2010; Amare & Simane, 2017) positively and significantly affected community participation in watershed management program practices, with which this study result agreed.

Generally, the lesson learned from this study indicates that, despite some successes of participatory watershed management activities, the sustainability of the practices is a pressing issue. As indicated in this study, there is a lack of effective and genuine community participation at different stages-planning, implementation and monitoring and evaluation-in most watershed management practices. Hence, extension workers and planners need to provide communities with further incentives (extension services outreach, training) and promote a sense of ownership and long-term benefits to become fully involved in watershed activities at various stages of watershed management practices. This is, in fact, due to the fact that community participation remains a critical input in the design, planning, and implementation of successful watershed management strategies that are adequate for local realities, be they social, cultural, or environmental and is essential for sustainable resource conservation and livelihood improvement.

#### *4.6. Conclusions and policy implications*

This study investigated levels of participation and determinants by farmers in the watershed management program in the Rebu watershed of the upper Gibe basin, south west Ethiopia. The participation by farmers in different activities at the planning stage of the watershed development program was relatively higher for some activities such as meetings called for watershed committee selection and training related to watershed conservation and management practices. Participation was relatively less in other activities such as formulation of watershed resource management rules/by-laws and plan preparation. This indicated that there is prior establishment of plans and problem identification without the involvement of farmers. There is also variation in the level of participation in some activities at the implementation stage of the watershed

management program. For example, farmers showed lower levels of participation in income-generating activities such as tree nursery and beekeeping activities, suggesting capacity-building problems and lack of resources. Farmers' participation in the monitoring and evaluation stage was also relatively lower for some activities, such as visiting the conserved or developed land to maintain the activities and strengthening the implemented conservation measures, as they feel that it is not part of their role. Watershed program participants participated more in all stages of the watershed management program than non-participants. Participation by farmers was better at the implementation stage than the planning and monitoring and evaluation stages. The overall People's Participation Index (PPI) value showed moderate levels of community participation indicating that only some decisions were taken in consultation with local people in the study area.

The binary regression marginal effect analysis indicates that frequency of extension contacts, land tenure security and group membership explained positively and significantly community participation in all stages of watershed management program practices. Specifically, the results of the study also indicate that community participation at the planning stage was positively and significantly affected by access to off/non-farm income sources, frequency of extension contact, land ownership security, group membership and topographic setting. Number of total livestock owned, frequency of extension contacts, land ownership security, group membership and topographic setting positively and significantly affected community participation at the implementation stage. However, farmland size owned affected participation negatively and significantly at the same stage. Community participation at the monitoring and evaluation stage of watershed management practices was positively and significantly affected by family size, frequency of extension contacts, landownership security and group membership. The overall community participation in watershed management practices was also positively and significantly affected by the frequency of extension contacts, access to credit services, access to off/non-farm income sources and group membership. In this study, variables such as age and literacy status were positive but insignificant factors. However, gender was negative but insignificant.

Watershed management program planners and practitioners can benefit from this study because we illustrated a grassroots view of community levels of participation at each stage of watershed management program practices and its determinants. Such a perspective provides support for how rural communities deal with watershed management issues and promote the sustainable development of rural communities. It also gives support for building relationships between rural communities and ways to enhance

interactional capacity in order to reduce the adverse impacts of watershed problems and improve adaptability.

The study, therefore, suggests the following points. The variation in involvement of the community in different activities of the watershed development program at different stages is a matter of serious concern to policy makers and planners. More effort is needed to raise farmers' awareness through delivering information on the importance of watershed management programs for them to become fully involved in watershed activities at all stages. Experts need to see beyond meetings and evolve a mechanism that lets farmers get involved in assessing the bio-physical and socio-economic impacts of programs and that involves them at all stages of watershed management programs. Hence, the watershed management planners and policy makers should also give due consideration to these aforementioned factors for future sustainable watershed development planning.

## **Chapter 5: Farmers' Decision to Adopt Watershed Management Practices**

## Abstract

Watershed management practices have been implemented to avert land degradation and to enhance people's livelihoods in the highlands of Ethiopia for several years. However, the successes of these practices have been quite limited and the main factors affecting these practices have not been examined in detail. This study intended to investigate rates and intensities of adoption of watershed management practices and to determine the main factors affecting farmers' adoption decisions in the upper Gibe basin. Data were collected from 304 household heads in six sub catchments across different topographic settings using household interview. Focus groups discussions, key informant interviews and transect walk observations were also used. Descriptive statistics and econometric models such as, multivariate and ordered probit were used to analyze the data. The results revealed that the majority of households (82.6 percent) used at least one of the six practices considered in this study. Soil bund, grass strip cultivation with soil bund and compost were the major watershed management practices adopted by farmers. Adoption rate and intensity of adoption were better for program participants and in upper and middle topographic settings. The results of the multivariate and ordered probit analysis indicated that household size, extension services, credit services, training services and perception of soil erosion had positive significant relationship with both rate and intensity of adoption of most practices. Hence, policy makers and planners need to consider labor, knowledge and awareness, and capital intensive nature of the practices for the up scaling planning and implementations of watershed intervention technologies.

Keywords: watershed management practices; farmers' decision; adoption; determinants; Gibe River basin

## 5.1. Introduction

Watershed resources such as natural and socio-economic components play crucial role in ecosystem services and in determining food, social, and economical security of people (Wani, Sreedevit, Vamsidhar Reddy, Venkateshvarlu, & Shambhu Prasad, 2008). However, the degradation of watershed has been the major threat across the globe (Mekonnen et al., 2015), mainly in developing countries, requiring urgent attention (Wani, Sreedevi, Singh, Pathak, & Rego, 2002; Darghouth, Ward, Gambarelli, Styger, & Roux, 2008). Watershed degradation is of a concern in many countries of sub Saharan Africa mainly because of its consequences for subsistence agriculture from which about 75 percent of the population derive their livelihoods (Erkossa, Wudneh, Desalegn, & Taye, 2015; Tully, Sullivan, Weil, & Sanchez, 2015). Ethiopia is one of the sub Saharan African countries where soil erosion and soil nutrient depletion, particularly in the highlands, are the threatening factors affecting biophysical and livelihoods of people (Asmame & Abegaz, 2017; Mekuriaw, Heinimann, Zeleke, & Hurni, 2018). For example, recent estimates by Hurni et al.(2015), indicated that soil erosion rates were 20 Mg ha<sup>-1</sup> year<sup>-1</sup> on currently cultivated lands and 33 Mg ha<sup>-1</sup> year<sup>-1</sup> on formerly cultivated degraded lands. These losses had been associated with the interacting effects of biophysical and socio-economic factors and exacerbated by rapid population growth which would be resulted in not only decreasing land productivity but also aggravated ecological degradation and social problems (Teklewold, Kassie, & Shiferaw, 2013; Kerse, 2018).

Recognizing land degradation as major environmental and socio economic problem, the government of Ethiopia in collaboration with international agencies has been trying to support better land use and promote massive soil and water conservation(SWC) program since early 1970's (Chimdesa, 2016). As a result, large areas have been converted to terraces, covered by soil bunds, closed by area closures and planted with millions of tree seedlings. Despite many efforts of promoting various watershed management intervention measures, adoption remained low by farmers in Ethiopia (Kassie, Zikhali, Manjur, & Edwards, 2009; Teklewold, Kassie, & Shiferaw, 2013) since its main constraints were not investigated in detail (Mekuriaw et al., 2018). As a result, there is no significant reduction in soil loss and depletion of soil fertility to acceptable levels and it remained one of major problems in watershed development (Amsalu & de Graaff, 2007).

Evidence suggests that the adoption of watershed management practices by farmers varies with respect to a range of demographic, socio-cultural, economic, institutional, and biophysical factors (Teklewold, et al., 2013; Kassie, Teklewold, Jaleta, Marenya, & Erenstein, 2015; Haregeweyn et al., 2015; Teshome, de Graaff, & Kassie, 2016; Asmame & Abegaz, 2017; Mekuriaw et al., 2018). More specifically, Teshome et al.(2016) and Mbaga-semgalawe & Folmer (2000) found that, high perceived erosion risk promotes farmers' adoption of watershed management practices. Moreover, various factors such as, endowments of physical and human capital (Gebremedhin & Swinton, 2003; Teklewold, Kassie, Shiferaw, & Köhlin, 2013; Teshome et al., 2016); tenure insecurity (Gebremedhin & Swinton, 2003); access to off farm opportunities (Holden, Shiferaw, & Pender, 2004); credit (Tiwari et al., 2008a); social capital and networks, quality of extension services, tenure security, education, and market access (Menale Kassie et al., 2015) affect farmers' adoption decisions of watershed management practices .

However, the majority of earlier studies (Amsalu & de Graaff, 2007; Beshir, Emanu, Kassa, & Haji, 2012; Belay & Bewket, 2013; Wolka, 2014), did not consider the possibility of farmers applying multiple watershed management technologies to solve the problem of watershed degradation. They treated the use of various practices as a separate decisions whereas, watershed management adoption decisions are interdependent (Teklewold, et al., 2013; Gebregziabher, Rebelo, & Langan, 2015). Various studies such as, Kassie, et al.(2015) analyzed the determinants of adoption of five sustainable agricultural practices in Ethiopia, Malawi, Kenya and Zambia, reported that, some practices were complementary while others were substitutable; Teklewold, Kassie, Shiferaw, & Köhlin (2013) reported that, adopting a combined set of sustainable intensification practices provided more benefit than adopting them individually; Yu, Hurley, Kliebenstein, & Orazem (2012) found that, complementarities among new technologies can indeed increase income and stimulate adoption of multiple technologies and Moyo & Veeman (2004) and Kassie, Zikhali, Manjur, & Edwards (2009) found that, farmers consider a set (or bundle) of possible technologies and choose the particular technology bundle that maximizes expected utility. Thus, the adoption decision is inherently multivariate and this suggests the importance of considering such issues in any analysis of farmer decision making to adopt watershed management practices.

Accordingly, the objective of the study was to examine major factors affecting farmers' adoption of watershed management practices in upper Gibe River basin, Rebu watershed, south west Ethiopia. Specifically, the study tried to address the following objectives: 1) To describe the specific type and spatial variations in the implementation of watershed management practices across different topographic settings for program participant and non participant households; 2) To identify the intensity or number of watershed management technologies adopted across different topographic settings for program participants and non participants and 3) To determine major factors affecting farmers' adoption of multiple watershed management practices. Results of the study contribute to the existing literature on watershed management with a multivariate analysis of watershed management practices. It also contributes to understand households' multiple technology adoption behaviors to tackle multiple problems for sustainable agricultural production and livelihoods of farmers.

Similar to the other highland parts of Ethiopia, the study watershed, Rebu watershed of the upper Gibe River basin, is not an exception to the realities of soil degradation problems that affect the productivity of the majority of the rural people who live in the mountainous, steep and fragile high lands. Therefore, any change in natural resources as a result of severe soil degradation has its own greater impacts on biophysical environment but also on the agricultural dependent livelihoods of people in the area. These necessitated the implementation of various integrated watershed management intervention strategies since the year 2008 under the sustainable land management program in collaboration with international non-governmental organizations namely GTZ to reduce land degradations and enhance agricultural production (WARD0, 2013). These include: soil and water conservation measures, agro forestry practices, area closure development, soil fertility management and livestock development and institutional strengthening activities. The study watershed was thus, selected purposively because of its specific watershed management program intervention experiences, states of soil erosion, ability to capture biophysical and socioeconomic heterogeneity, and represent higher, medium and lower elevation watersheds within the highlands of the basin. Hence, it provides suitable environment for the empirical study, as differential characteristics of farmers' decisions to adopt and intensify watershed management intervention strategies can be found.

## 5.2. Methodology

### 5.2.1. Conceptual framework and estimation methods

The adoption of various land management technologies has focused on single versus joint analysis frameworks (Dorfman, 1996; Kassie, et al., 2015). Single adoption models often analyze the decision to adopt a single technology by using univariate econometric modeling frameworks, with no attention to the other interrelated technologies. Empirical studies by Teklewold, et al. (2013) and Kassie, et al. (2015), argued that farmers usually consider a portfolio of sustainable agricultural practices and therefore the adoption decision is multivariate. Against this background, the conceptual framework here is based on the premise that farmers are more likely to adopt a combination of land management practices simultaneously to deal with multidimensional nature of environmental problems that affect their agricultural productivity and livelihoods. Here, we employed multivariate probit (MVP) modeling approach which simultaneously allows estimating interdependent multiple adoption decisions while allowing the unobserved and unmeasured factors (errors terms) to be correlated freely and estimates a set of binary probit models simultaneously (Cappellari, & Jenkins, 2003; Kassie, et al., 2015).

Our MVP model consists of six binary choice equations, according to the type of soil degradation (Amsalu & de Graaff, 2007; Barrera-Bassols, Zinck, & Van Ranst, 2009) namely soil erosion control measure (soil bund, stone faced soil bund, grass strip cultivation with soil bund, gully rehabilitation with check dam and grass); soil fertility management practice (compost application), and mixed method (agro forestry practices).

The MVP model is specified as:

$$Y_{im}^* = \beta m + X_{im} + \epsilon_{im} \quad m = 1 \dots 6 \text{ and} \quad \text{equation(1)}$$

$$Y_{im} = 1 \text{ if } Y_{im}^* > 0 \text{ and } 0 \text{ otherwise} \quad \text{equation (2)}$$

Where  $Y_{im}^*$  is a latent variable that captures the unobserved preferences associated with the choice of practice ( $m = 1, 2 \dots 6$  available technologies). This latent variable is assumed to be a linear combination of observed characteristics,  $X_{im}$ , (including household characteristics, access to services, markets, social capital (captured by household's membership in formal and/or informal social groups), and biophysical characteristics) and unobserved characteristics captured

by the stochastic error terms,  $\epsilon_{im}$ . The vector of parameter to be estimated is denoted by  $\beta_m$ . Given the latent nature of  $Y_{im}^*$ , estimation is based on observable binary variables  $Y_{im}$ , which indicate whether or not a household used a particular technology. The error terms  $\epsilon_{im}$ ,  $m = 1, 2, \dots, 6$  are distributed multivariate normal each with mean 0 and a variance-covariance matrix V, where V has 1 on the leading diagonal, and non zero correlation  $\rho_{jk} = \rho_{kj}$  as off diagonal elements (Cappellari, & Jenkins, 2003). The nonzero value of the off diagonal elements allows for correlation across the error terms of several latent equations, which represent unobserved characteristics that affect the choice of alternative watershed management technologies (Menale Kassie, Jaleta, Shiferaw, Mmbando, & Mekuria, 2012). In this model, the sign and significance of the correlation coefficient provide evidence on the nature of the relationship between adoption equations. A positive correlation is interpreted as a complementary relationship, while a negative correlation is interpreted as being substitutes (Kassie, et al., 2015):

The covariance matrix V is given in equation (3).

$$V = \begin{pmatrix} 1 & \rho_{12} & \rho_{13} & . & . & \rho_{1k} \\ \rho_{21} & 1 & \rho_{23} & . & . & \rho_{2k} \\ \rho_{31} & \rho_{32} & 1 & . & . & \rho_{3k} \\ . & . & . & 1 & . & \rho_{4k} \\ . & . & . & . & 1 & \rho_{5k} \\ . & . & . & . & . & 1 \\ \rho_{j1} & \rho_{j2} & \rho_{j3} & \rho_{j4} & \rho_{j5} & . \end{pmatrix} \quad (3)$$

The multivariate probit model only considers the probability of adoption of particular watershed management practice with no distinction made between farmers who adopt a single practice and those who adopt many practices jointly. However, there are evidences that farmers who combine several watershed management technologies have better pay-offs than those who rely on a single or very few practices (Zougmore, Mando, & Stroosnijder, 2010). Consequently, the second part of our econometric approach consists of using an ordered probit modeling technique to analyze the factors that influence the intensity of adoption of watershed management practices. Here, intensity of adoption is measured through a count variable representing the number of practices

used. In this case, the probability of adopting the first practice could differ from the probability of adopting a second or third practice, given that in the latter cases the farmer has already gained some experience with and has been exposed to the benefits and other characteristics of watershed management practices. Hence, we considered the number of watershed management technologies adopted as an ordinal variable, and used in an ordered probit model which allows estimating the relationship between an ordinal dependent variable and a set of independent variables.

### *5.3. Results of the study*

#### **5.3.1. Description of socio demographic, economic, institutional and physical characteristics**

Households' socio demographic, economic, institutional and physical characteristics were presented in (Table 5.1). The average age of the study respondents was 46.72, years with the minimum and maximum ages of 25 and 75 years respectively. About 87 percent were male and 13 percent were female. The larger proportions of the respondents (60 percent) were literate, whereas the remaining (40 percent) were illiterate. The average number of members who are currently living within the family was 4.8 with the minimum and maximum number of 1 and 9 members respectively. The average land holding of the respondents was found to be 2.2 hectares ranging between 0.77 and 7.11 hectares. The livestock owned by the study respondents measured in terms of TLU (Tropical Livestock Unit) was found to be 5.49 on average. Households were asked whether they accessed to various off/nonfarm income activities (such as, hand crafting, daily labor, petty-trade, etc.) and households accessed to at least one of these activities were 29 percent.

Respondents were also asked to reply frequency of extension contact in the last production year (2016/17) and the average frequency of extension contact of the respondents was 2.18; ranged from 0-5 times. About 77 percent of the respondents attained training on watershed management practices. Respondents were also asked to reflect on land tenure security whether their expectation to use farm land throughout or at least in his/her life time and 86 percent stated that they use farm land throughout their life time. About 76 percent of the respondents were accessed to credit availability. As indicated from the survey, about 68 percent of the respondents reported

that they participated at least in one of the local institution (watershed committee, self help groups, etc.). Perception index of household on soil degradation (soil erosion causes and indicators, soil fertility decline causes and indicators) was used as a proxy of households' perception. About, 60 percent of the survey respondents scored value of higher than or equal to the mean perception score of soil degradation. Distance walked to the nearest farm land was used as a proxy for physical characteristics and the average walking distance traveled was 11.14 minutes ranging from 1-25 minutes. Topographical settings also affected adoption decision of farmers. About 34 percent of the respondents were from upper topographical setting.

Table 5.1, Description of households' socio demographic, economic and institutional characteristics

Variable	Description	Mean (%)	Std. Dev.	Min	Max
Age	Continuous variable measured in years	46.72	9.58	25	75
Sex	Dummy = 1 if household head is male	87%			
Education	Dummy = 1 if household head literate	60%			
Family size	number of members who are currently living within the family	4.84	1.51	1	9
Land size	Total size of landholding in ha	2.20	.93	.77	7.11
Livestock TLU	number of livestock owned measured in TLU	5.49	2.05	1.95	17.45
Off/nonfarm activities	Dummy= 1 if household head is access to off/nonfarm activities	29%			
Extension services	Continuous variable measured in the number of extension contact	2.18	1.21	0	5
Training services	Dummy = 1 if household head attended training on WSMP	77%			
Land tenure security	Dummy = 1 if the farmer feels secured	86%			
Credit services	Dummy =1 if the farm household access to credit	76%			
Group membership	Dummy = 1 if the farm household belongs to local institutions	68%			
Perception index on soil degradation	Dummy=1 if respondents scored higher than or equal to the mean perception score , other wise 0	60%			
Farm distance	Continuous variable measured in walking minutes from home to the nearest farm land	11.14	4.75	1	25
Geographical setting	Dummy = 1 for upper	34%	0.47	0	1

Sources: computed from survey results, 2018

### 5.3.2. Types and spatial variation of watershed management practices

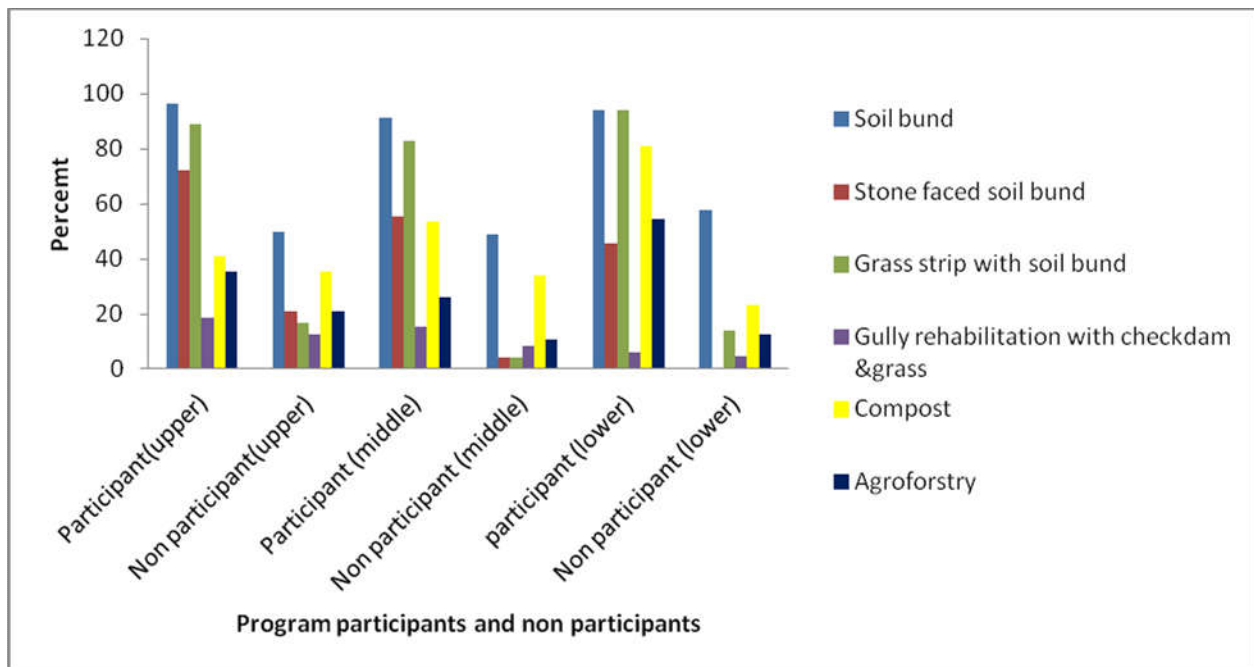
The specific type and spatial variations in the implementation of watershed management practices were presented in (Figure 5.1). The result revealed that, among others, soil bund was dominant practice across different topographic settings for program participant households. It was relatively applied more in the upper (96.30 percent) than middle (91.38 percent) and lower (93.94 percent). With regards to grass strip cultivation mostly with soil bund, better performance was observed in the lower (93.94 percent) than upper (88.89 percent) and middle (82.76 percent). More differences were observed with regards to stone faced soil bund implementation. It was more implemented in the upper (72.22 percent) than middle (55.17 percent) and lower (45.45 percent) topographic settings. Similarly, gully rehabilitation with check dam and grass was implemented more in upper (18.52 percent) than middle (15.52 percent) and lower (6.06 percent). This indicates that soil and water erosion controlling practices were implemented more in the upper topographic settings. Although practiced in all catchments, soil fertility management practice such as compost in this case, was implemented more in lower (81.2 percent) than middle (53.45 percent) and upper (40.74 percent) catchment areas. Similarly, mixed approach practices such as agro forestry practices were implemented relatively higher in lower (54.55 percent) than upper (35.19 percent) and middle (25.86 percent) topographic settings. Generally, about 93.79 percent soil bund; 87.59 percent grass strip cultivation with mostly soil bund; 59.31 percent stone faced soil bund; 55.17 percent compost application; 35.86 percent agro forestry practices and 14.48 percent gully rehabilitation with check dam and grass were implemented in overall topographic setting for program participants.

Major practices in program non participants were also soil bunds. Although it varies, it was mostly practiced in all topographic settings. Its extent of implementation was 50 percent in the upper, 48.9 percent in the middle and 57.81 percent in the lower catchment areas. Except soil bund, the proportions of other practices were implemented less than 50 percent. Like the program participants, the practices of soil erosion controlling measures were generally implemented better in the upper topographic settings for program non participants. For example, the practice of stone faced soil bund accounted 20.83 percent in the upper and 4.26 percent in the middle and no practice in the lower geographic catchments. Generally, about 57.81 percent soil bund, 23.44 percent compost application, 14.06 percent grass strip cultivation with mostly soil

bund, 12.5 percent agro forestry practices and 4.69 percent gully rehabilitation with check dam and grass were implemented in overall topographic settings for program non participants.

With regards to overall respondents (program participants and non participants), the rates of implementation for all respondents ranged from 11 percent for gully rehabilitation through check dam and grass strip to 72 percent for soil bund. Grass strip cultivation with mostly soil bund accounted 48 percent followed by compost application (42 percent), stone faced soil bund (32 percent) and agro forestry practices (25 percent). Observations through transect walk, focus group discussion and interview also confirmed the same results, revealing that there is variation in the implementation of the practices. In the multivariate probit model we excluded gully rehabilitation with check dam and grass (11 percent adoption rate) as there was less variability within the sample.

Figure 5.1, Specific type and extent of implementation of watershed management practices across different geographic settings for program participants and non participants



Sources: computed from survey results, 2018

### 5.3.3. Interdependence of multiple watershed management practices

The binary correlations between the error terms of the five adoption equations were presented in (Table 5.2). The pair wise correlations between the errors terms were statistically significant at ( $p < 0.01, 0.05$  and  $0.1$ ) for 7 of 10 combinations of the five watershed management measures. Almost all practices correlated positively and supported the premises that farmers usually adopt combination of watershed management technologies. Soil bund had a significant correlation ( $p < 0.01$ ) with grass strip with mostly soil bund. Soil fertility management practices such as compost application had a positive significant correlation with soil erosion control measures such as soil bund ( $p < 0.01$ ), stone faced soil bund ( $p < 0.1$ ) and grass strip cultivation ( $p < 0.01$ ). Mixed approach such as agro forestry practices had a positive significant correlation with both soil erosion control measures such as soil bund ( $p < 0.05$ ) and grass strip cultivation ( $p < 0.01$ ), and soil fertility management practice, namely compost application ( $p < 0.05$ ). The positively correlated practices supported the premises that farmers usually adopt combination of watershed management technologies. These results justified our decision to deploy the multivariate probit model (MVP) rather than five independently estimated probit equations.

Table 5.2, Correlation matrix of the error terms

	Rho1	Rho2	Rho3	Rho4	Rho5
Rho1	1	0.137(0.130)	0.647***(0.085)	0.360***(0.090)	0.225**(0.103)
Rho2		1	0.143(0.127)	0.206*(0.123)	0.141(0.113)
Rho3			1	0.522***(0.096)	0.420***(0.089)
Rho4				1	0.276**(0.094)
Rho5					1

*Likelihood ratio test of  $\rho_{12} = \rho_{13} = \rho_{14} = \rho_{15} = \rho_{23} = \rho_{24} = \rho_{25} = \rho_{34} = \rho_{35} = \rho_{45} = 0$ :  $\chi^2(10) = 78.4321$ ,  $Prob > \chi^2 = 0.0000$ , 1=soil bund, 2= stone faced soil bund, 3= grass cultivation with soil bund, 4= compost application, 5= agro forestry practices, Standard errors within brackets, \*significant at 10% level, \*\* Significant at 5% level, \*\*\* Significant at 1%level*

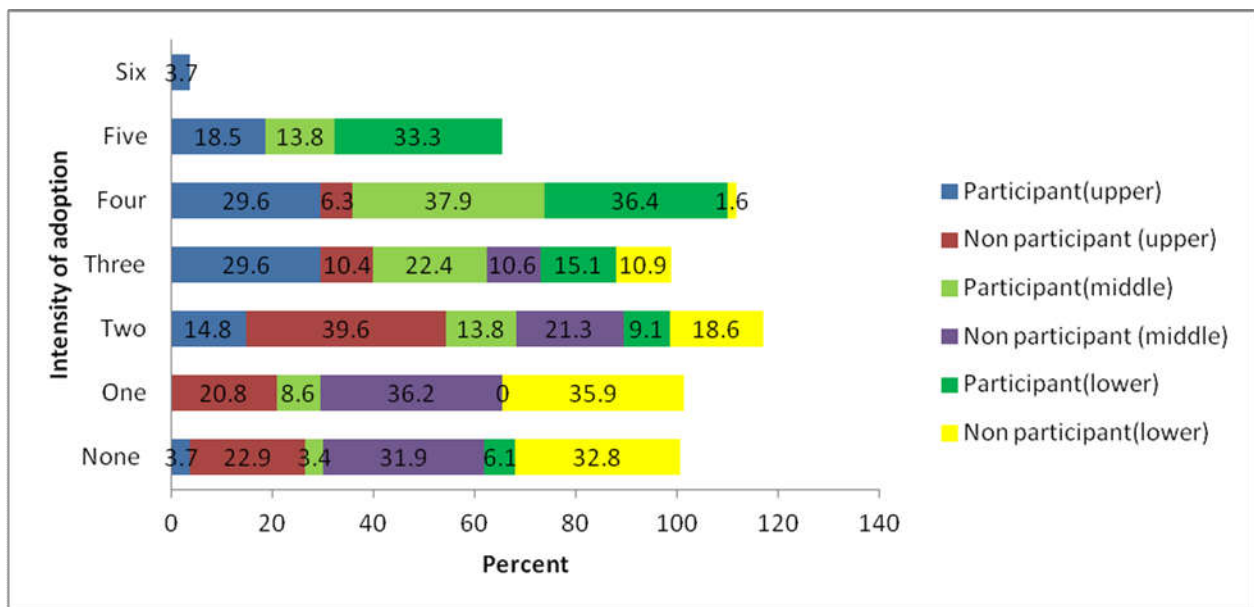
### 5.3.4. Intensity of adoption of technologies and factors affecting the adoption

#### 5.3.4.1. Intensity of adoption

The intensity of the specific adoption of watershed management technologies across different topographic settings for program participants and non participants was presented in (Figure 5.2). As it is observed more practices were implemented at upper and middle catchments for program participants. This is confirmed by focus group discussion and interview as they reported that, upper catchments exposed to severe soil erosion problems promoting watershed conservation

practices to curb land degradation. For example, more than 92 percent of the upper catchment implemented two to five practices and only 3.7 percent of the upper catchment used six practices for program participants. More than 96 percent of the middle catchment used one to five practices, 94 percent of the lower catchment used two to five practices for program participants. On other hand, 77 percent of the upper catchment used one to four practices, 68 percent of the middle catchment used one to three practices and 67 percent of the lower catchment used one to four practices for program non participants.

Figure 5.2, Intensity of the adoption of watershed management practices across different geographic settings for program participants and non participants



Source: computed from survey results, 2018

With regards to overall respondents (program participants and non participants), the intensity of adoption ranged between zero to six practices, indicating that, while some farmers used up to six practices, there were still a few who used none of the six practices( Table 5.3). Specifically, the majority of farmers (82.6 percent) used at least one practice. More than 72 percent of the farmers used one to four practices, 9.5 percent of them used five and only 0.7 percent of them used six practices. For the intensity of adoption we included all six practices in the ordered probit model.

Table 5.3, Intensity of adoption for over all respondents (program participant and non participant households)

Intensity of adoption	Freq.	Percent	Cum.
0	53	17.0	17.43
1	55	18.1	35.53
2	60	19.7	55.26
3	51	16.8	72.04
4	54	17.8	89.80
5	29	9.5	99.34
6	2	0.7	100.00
Total	304	100.00	

Source: Computed from survey results, 2018

#### 5.3.4.2. Factors affecting intensity of adoption

The estimated coefficients of ordered probit model were presented in (Table 5.4). As indicated from the result, the coefficient for family size was significantly positive ( $p < 0.05$ ) with the intensity of adoption, suggesting that a large household size was associated with more likely to intensify the use of watershed management practices. The result also revealed a positive significant impact of extension contact ( $p < 0.01$ ) and training ( $p < 0.05$ ) on the intensity of adoption of watershed management practices. Access to credit services had also a positive significant association ( $p < 0.1$ ) with the intensity of adoption. The result also indicated that perception on soil erosion is significantly positive ( $p < 0.05$ ), suggesting that, knowledge about soil erosion problem was associated with an increased probability to intensify the use of conservation practices.

Table 5.4, Estimated coefficients of the ordered probit model

Variables	Coef.	Std. Err.	z	P>z
<b>Socio demographic factors</b>				
Age	.0082873	.0063736	1.30	0.194
Sex	.1743679	.1937286	0.90	0.368
Educational status	.0763848	.1300522	0.59	0.557
Family size	.0832247**	.038802	2.14	0.032
<b>Economic asset endowment</b>				
Land size	.0765316	.0819613	0.93	0.350
Total livestock(TLU)	.0386114	.0355443	1.09	0.277
Access to off/non farm income sources	.173272	.1654991	1.05	0.295
<b>Institutional factors</b>				
Frequency of extension contact	.3711187***	.0690206	5.38	0.000
Access to training services on watershed practices	.3673592**	.1573907	2.33	0.020
Land security	.1643329	.1742887	0.94	0.346
Access to credit services	.2488505*	.1437778	1.73	0.083
<b>Social and attitudinal factors</b>				
Group membership	.1249768	.1349817	0.93	0.355
Perception on soil degradation	.4606454**	.1724607	2.67	0.008
<b>Physical factors</b>				
Farmland distance from home	-.0079434	.0134219	-0.59	0.554
Topographic setting	.1501105	.1660104	0.90	0.366

*Number of obs = 304 , Wald chi2(15) = 164.63 , Prob > chi2 = 0.0000 , Pseudo R2 = 0.1430 , Log pseudo likelihood = -468.38777 , Standard errors within brackets, \*significant at 10% level, \*\* Significant at 5% level, \*\*\* Significant at 1% level*

### 5.3.5. Determinants of adoption of watershed management practices

The empirical results obtained from multivariate probit model were reported in Table 5.2 and 5.5. The likelihood ratio test of the null hypothesis that stated, covariance of the error terms across equations were not correlated was also rejected ( $\chi^2(10) = 78.4321$ ;  $\text{prob} > \chi^2 = 0.000$ ), rendering the multivariate probit model more appropriate than univariate probit models (Table 5.2). This is to mean the error terms across the adoption equations were correlated. As shown by a Wald test,  $\chi^2(75) = 352.35$ ;  $\text{prob} > \chi^2 = 0.000$ , the model fits the data very well, meaning that the null hypothesis that all regression coefficients are jointly equal to zero is rejected (Table 5.5). The average VIF was 1.33 with all values within 1 and 2 (Appendix Table A). This suggests no concern of a linear combination of other independent variables in the model, as all VIF values were less than the threshold value of 10 (Gujarati, 2004).

As indicated from the result, the educational status of the household head positively influenced the adoption of stone faced soil bund ( $p < 0.05$ ). It had also positively influenced the adoption of soil bund, grass strip with mostly soil bund and agro forestry practices, but insignificant. Family

size of the household head had a significant positive effect on the adoption of grass strip cultivation with mostly soil bund ( $p < 0.1$ ) and agro forestry practices ( $p < 0.1$ ). The age and sex of the household head had a positive relation with the probability of all of the adoption of technologies but not significant. The farm land size had a significant positive effects on the adoption of stone faced soil bund ( $p < 0.05$ ), grass strip cultivation with mostly soil bund ( $p < 0.01$ ) and compost application ( $p < 0.05$ ). Total number of livestock (TLU) ownership had a significant negative effect on the adoption of grass strip with mostly soil bund ( $p < 0.1$ ), suggesting the larger the size of the livestock ownership, the less likely the adoption of grass strip cultivation.

Frequency of extension contacts had a significant positive effect on the adoption of soil bund ( $p < 0.01$ ), stone faced soil bund ( $p < 0.05$ ), grass strip with mostly soil bund ( $p < 0.01$ ) and compost application ( $p < 0.05$ ). This means those households with more number of extension contacts had more likelihood of adopting soil bund, stone faced soil bund, grass strip with mostly soil bund and compost application. Training services related to watershed management practices had a significant positive effect on the adoption of stone faced soil bund ( $p < 0.05$ ), grass strip cultivation with mostly soil bund ( $p < 0.05$ ) and agro forestry practices ( $p < 0.1$ ). Land tenure security positively affected the adoption of stone faced soil bund ( $P < 0.05$ ), indicating that secured land tenure is an incentive factor to adopt conservation technologies. Households' access to credit services had also shown a significant positive correlation with soil bund ( $p < 0.05$ ) and grass strip with mostly soil bund ( $p < 0.05$ ).

Group membership had a significant positive relationship with the adoption of stone faced soil bund ( $p < 0.1$ ). Local area or catchments that were perceived as having severe soil erosion were more likely to adopt stone faced soil bund ( $p < 0.05$ ), grass strip with mostly soil bund ( $p < 0.05$ ) and agro forestry practices ( $p < 0.05$ ). Distance of farm land from home had an inverse relation with the probability of most of adoption of technologies but not significant. But, unexpectedly, it had a significant positive relationship with the adoption of grass strip cultivation with mostly soil bund ( $p < 0.05$ ). This indicated that far distant land might be used for grazing. The upper topographical setting was more likely to be treated with stone faced soil bund ( $p < 0.05$ ).

Table 5.5, Estimated coefficient of the multivariate probit model

Variables	Soil bund	Stone faced soil bund	Grass strip with soil bund	Compost	Agro forestry
Age	.001 (.009)	.004 (.010)	.014 (.010)	.001 (.008)	.010 (.009)
Sex	.405 (.248)	.297 (.300)	.076 (.265)	.004 (.232)	.217 (.259)
Educational status	.004 (.177)	.381** (.188)	.228 (.191)	-.064 (.155)	.059 (.165)
Family size	.066 (.056)	.063 (.071)	.116* (.062)	.031 (.059)	.095* (.057)
Land size	-.157 (.113)	.332** (.128)	.486*** (.135)	.242** (.107)	.052 (.111)
Livestock TLU	-.072 (.059)	.096 (.071)	-.098* (.054)	.070 (.046)	.049 (.047)
Off/nonfarm activities	.378 (.277)	.153 (.230)	-.010 (.271)	.111 (.208)	-.050 (.220)
Extension services	.536*** (.112)	.224** (.095)	.729*** (.114)	.150** (.075)	-.038 (.080)
Training services	-.132 (.230)	.886** (.256)	.512** (.239)	.064 (.197)	.392* (.224)
Land tenure security	.154 (.230)	.777** (.297)	.008 (.274)	-.091 (.212)	-.171 (.239)
Credit services	.569** (.205)	.081 (.229)	.510** (.216)	-.277 (.193)	.225 (.209)
Group membership	.279 (.180)	.409* (.233)	.243 (.207)	-.043 (.174)	-.232 (.188)
Perception of soil erosion in the catchment	.357 (.224)	.516** (.260)	.770** (.235)	-.074 (.200)	.538** (.225)
Farm distance	-.006 (.019)	-.004 (.023)	.050** (.020)	-.025 (.017)	-.011 (.020)
Topographical setting	-.011 (.240)	.748** (.222)	-.132 (.237)	-.297 (.192)	.032 (.201)
Constant	-1.248 (.703)	-5.724 (.888)	-5.376 (.897)	-.990 (.670)	-2.577 (.716)

Number of obs. = 304, Wald statistics  $\chi^2(75) = 352.35$ ,  $Prob > \chi^2 = 0.0000$ , Log likelihood = -672.76737, Standard errors within brackets, \*significant at 10% level, \*\* Significant at 5% level, \*\*\* Significant at 1% level  
source: computed from survey result, 2018

## 5.4. *Discussions*

### 5.4.1. Types and spatial variation of adoption of watershed management practices

There were wide ranges of watershed management practices implemented in the study watershed. Among others, the major practices include: soil bund; stone faced soil bund; grass strip cultivation with mostly soil bund; gully rehabilitation through check dam and grass; compost application and agro forestry practices. The result indicated that, mostly soil and water erosion controlling practices( stone faced soil bund, gully rehabilitation practices, soil bund) were implemented more in the upper topographic settings than soil fertility management practices( compost, agro forestry practices). The result agreed with Tiwari, Sitaula, Nyborg, & Paudel (2008b), who found that in the villages that have more steeply terraces, the farmers are more likely to adopt soil erosion controlling technologies to mitigate soil degradation.

With regards to overall respondents (program participants and non participants), the rates of implementation for all respondents ranged from 11 percent for gully rehabilitation by check dam and grass strips to 72 percent for soil bunds. The variation in the spatial and type of watershed management practices suggest that, conservation alternatives can be adopted or not by farmers depending on the specific topographic and/or socioeconomic conditions of each place or community. This is in line with the study by Pulido & Bocco (2014), who found that local communities use several strategies to cope with land degradation, but the adoption of strategies depends on their topographical conditions and decisively on their socio-economic and cultural characteristics. Study by Hammad & Børresen (2006), also found in their research in Palestine that, the adoption of stonewall terraces depended on factors such as farmers' perceptions of erosion, land tenure and geomorphology.

Program participants implemented the watershed management practices better than the non participants which conform with the study by Wei et al. (2009), reported that program participants group were cognizant of the problems of environmental degradation through exposure to information on environmental management. They also exposed more to trainings to improve conservation practices and therefore more likely to adopt the technologies to reduce environmental problems. Study by Meshesha & Birhanu (2015) also revealed that, an area with

watershed management intervention was improved in watershed management practices like tree plantation than the non intervention one.

#### 5.4.2. Interdependence of multiple watershed management practices

The pair wise correlations between the errors terms were statistically significant at ( $p < 0.01$ , 0.05 and 0.1) for 7 of 10 combinations of five watershed management measures (Table 5.2). Almost all practices correlated positively and supported the premises that farmers usually adopt combination of watershed management technologies. The highest positive correlation (64.7 percent) was between soil bund and use of grass strip with mostly soil bund. Soil bund conserves soil and moisture, while grass strip increases both soil conservation and stabilization of bunds, so combining both could lead to synergies. The positive correlation (52.2 percent) between compost application and grass strip with mostly soil bund showed the positive correlation between the two technologies. Grass strip conserves soil and moisture while compost increases soil fertility. The positive correlation between agro forestry practices and grass strip with mostly soil bund was 42 percent which showed the positive relationship between the two technologies. Grass strip conserve soil moisture and stabilize bunds, agro forestry practices mixed effects both conserve soil and increase soil fertility. The positive correlation (36 percent) between compost application and soil bund showed the positive relationship between the two technologies. Soil bund conserves soil and moisture while compost application increases soil fertility. The results agreed with the studies by Kassie, et al. (2009), Teklewold et al.(2013) and Kassie, et al.(2015), who stated that, farmers face various environmental problems such as soil erosion; climate variability as well as limited resources access that affects their agricultural productivity and livelihoods and consequently adopts a combination of technologies to deal with these problems.

#### 5.4.3. Determinants of adoption of watershed management practices

##### 5.4.3.1. Socio demographic and economic factors

In our study area, farmers' decisions to implement one or more watershed management practices were influenced by various factors. We found a positive significant correlation of educational status with stone faced soil bund. This may be linked to the knowledge intensive processes for producing and implementing the practices. The result agreed with the studies by Ersado, Amacher, & Alwang (2004), and Kassie, et al.(2015) who stated that education is important in

accelerating the adoption of knowledge intensive technologies. The coefficient for family size was positive in all of the equations with a significant correlation in the grass strip with mostly soil bund and agro forestry practices, suggesting that a larger household size is associated with a higher probability to adopt the practice. The result conform with the study by Doss (2006), who reported that farming is highly labor intensive activity and opt for the soil and water conservation measures. The coefficients of age and sex were found positive but insignificant relationship with the adoption of most of the practices.

With regards to wealth of household characteristics, we found a significant positive correlation of farm land size with stone faced soil bund, grass strip with mostly soil bund and compost application, suggesting that the larger the farm size owned by the household is associated with a higher probability to adopt those practices. This result congruent with the studies by Ersado et al. (2004), Tadesse & Belay (2004), Amsalu & de Graaff (2007), who found positive relationships between the adoption of conservation measures and farm size, i.e. farmers who hold large farms are more likely to adopt improved soil conservation technology. However, the coefficient for livestock ownership was significantly negative correlation with the grass strip cultivation with mostly soil bund, suggesting the lager the size of the livestock ownership, the less likely the adoption of grass strip cultivation. This could be explained by the fact that, grass is required for feeding the animals rather than for soil conservation. This result conform with the study by Mbagalawe (1998) who reported livestock ownership may trigger land degradation because of over grazing or large livestock size may discourage conservation investments, perhaps due to the tendency of households to focus more on livestock than on crop production. Off/non farm income of the household head was found positive but insignificant relationship with the adoption of most of the practices.

#### 5.4.3.2. Institutional factors

Various institutional characteristics affected the adoption of watershed management practices. Extension services had a significant positive effect on soil bund, stone faced soil bund, grass strips cultivation with mostly soil bund, and on compost application. We also found a significant positive correlation of households' access to training related to watershed management practices with stone faced soil bund, grass strip with mostly soil bund and agro forestry practices, suggesting that access to knowledge and awareness creation are important in accelerating the

adoption of knowledge intensive technologies. This result agreed with the studies by Adesina, Mbila, Nkamleu, & Endamana (2000), Tiwari, et al. (2008b), and Asfaw & Neka (2017), who reported intervention through training and extension services is a means of creating awareness and provision of support for the adoption of new technologies. Land tenure security had shown significant positive association with stone faced soil bund, indicating that secured land tenure is an incentive factor to adopt conservation technologies. The result conform with studies by Gebremedhin and Swinton (2003) and Asmame & Abegaz (2017), reported the importance of tenure security in the adoption of land management practice. Credit services had also shown a significant positive correlation with soil bund and grass strip with mostly soil bund, suggesting that benefiting from availability of credit services may provide poor farmers with alternative cash sources to address credit constraints, and therefore to afford the high-investment costs associated with conservation practices. This study congruent with the studies by Simtowe & Zeller (2006) and Mohamed & Temu (2008), who reported access to credit services has been reported to stimulate technology adoption.

#### 5.4.3.3. Socio-cultural factors

As to social capital, group membership had a significant positive relationship with the adoption of stone faced soil bund, suggesting that, group membership showed more likely to adopt the practice. This implies that membership to social groups or local institutions enable farmers to acquire information as well as attend training as an incentive factor to adopt conservation measure. This result agreed with the studies by Adesina et al. (2000), Degefa (2010) and Amare & Simane (2017), who confirmed that farmers who were members of institutions incline to adopt soil and water conservation measures. Perception of soil erosion in the local area or catchment had a significant positive correlation with the adoption of stone faced soil bund, grass strip with mostly soil bund and agro forestry practices. This result conform with the studies by Baidu-Forson (1999) and Tadesse & Belay (2004), who reported that better perception and knowledge of farmers about the soil erosion problem contribute to the sustainable use of introduced soil and water conservation practices.

#### 5.4.3.4. Physical factors

Physical characteristics also affected the adoption of watershed management practices. Distance of farm land from home had an inverse relation with the probability of most of adoption of technologies but not significant. This result conform with the studies by Gebremedhin & Swinton (2003) and Tiwari et al.(2008b), who reported that longer walking distance between farmlands and household residences correlated negatively to the adoption of introduced soil and water conservation practices. But, unexpectedly, distances of farm land from home had a significant positive relationship with the adoption of grass strip cultivation. This indicated that land in far or distant place might be used for grazing. The probability of adopting stone faced soil bund is higher for farmers in the upper geographical setting as there was a significant positive correlation between them. This conform with the studies by Amsalu & de Graaff (2007) and Kerse (2018), who reported that slope of a land influences the adoption of soil and water conservation technologies positively.

#### 5.4.4. Intensity of adoption of technologies and factors affecting the adoption

The results of the study revealed that, the majority of households (82.6 percent) used at least one of the six practices considered in the study. The variation in the intensity of the adoption of watershed management practices across different type of practices and farmers shown that, there is still an important potential to upscale the adoption of watershed management practices. Farmers' decisions to intensify watershed management practices were influenced by various factors. Households' family size had a positive significant impact on the intensity of adoption. This finding significantly collaborated with those reported in the previous section, and clearly underscored the role of family size in soil and water conservation adoption process. It conform with the study by Doss (2006), who reported that farming is a highly labor intensive activity and opt for the soil and water conservation measures.

Knowledge and awareness are also important in shaping farmers decisions toward the intensive use of watershed management practices, suggesting the significant positive coefficient for frequency of extension contacts and attending training related to watershed management practices. It agreed with the studies by Tiwari et al.(2008b) and Asfaw & Neka (2017), who stated that training and extension services is a means of creating awareness and provision of support for the adoption of watershed management practices. Farmers' access to credit services

was also a positive significant association with the intensity of adoption as it may provide farmers with alternative cash sources to address credit constraints and invest more in the use of watershed management practices. This result agreed with the study by Mohamed & Temu (2008), who indicated that, households' access to credit services stimulate technology adoption. The result also indicated that perception on soil erosion is significantly positive suggesting that awareness about soil erosion problem was associated with an increased probability to intensify the use of conservation practices. This is agreed with the study by Tadesse & Belay (2004), who found that better awareness by farmers about the soil erosion problem contribute to the intensive use of watershed management practices.

### *5.5. Conclusion and Policy implication*

The main objective of the study was to examine farmers' adoption decisions and intensity of adoption of watershed management practices in Rebu watershed of the upper Gibe basin, Ethiopia. The result revealed that the specific adoption rates of over all respondents for many of the practices were low (below 50 percent). The intensity of adoption of these practices was also low (about 54 percent of the farmers use only one to three practices). Most of practices were more implemented in the upper topographic settings and for watershed program participants. Results of the multivariate model indicated that, access to extension services and training, farmland size and perceptions of soil erosion problems had positively significant relationship with most of the practices. Both multivariate and ordered probit results also revealed that access to extension services, access to training on watershed management practices, family size and perception on soil erosion had positive significant relationship with both adoption rate and intensity of adoption of most of the practices. Results also indicated that, almost all practices correlated positively and supported the premises that say farmers usually adopt combination of watershed management technologies.

An important implication of the results was that, extension workers and planners need to target practices with lower adoption rates and provide farmers with further incentives (extension services outreach, training) towards the intensification of their use. In addition, results implied that local administrators and planners should recognize heterogeneity in households' socio economic and topographic specific characteristics in the up scaling and implementation of watershed management practices in the study area. Furthermore, policymakers and planners need

to consider these determining factors such as access to extension and training services and capital intensive nature of practices to augment the adoption of watershed management practices. The interdependency of practices also suggested the need of promoting each practice as a package that contribute to upscale watershed management practices adoption and broaden farmer options while harnessing the synergies between them.

### **PART III: SOCIO-ECOLOGICAL AND LIVELIHOOD EFFECTS OF WATERSHED MANAGEMENT PRACTICES**

**Chapter 6:** The Perceived Ecological and Socio-economic Benefits of the Watershed Management Intervention Program

**Chapter 7:** Enhancing Livelihood Assets of Households through Watershed Management Intervention Program

**Chapter 6: The Perceived Ecological and Socio-Economic Benefits of the Watershed Management Intervention Program**

## Abstract

Watershed management measures have been implemented in Ethiopia for a long period of time with the intension for the enhancement of socio-economic and ecological conditions. The perceptions of farmers on the benefits of the intervention play a pivotal role for the future continuous uses and sustainability of the intervention measures. However, there is little known, in detail, the farmers' perception of the socio-ecological outcome of the interventions. This study was conducted in the upper Gibe basin to assess farmers' perception of socio-ecological benefits of watershed management program. We used transect walk observations, group discussions, key informant interviews and household survey with 304 households in six sub watersheds differing in topographic settings. The data were analyzed by using various qualitative indicators and weightings based on the socio ecological and economic indicator factors of the interventions. Descriptive statistics were used to summarize information while Fisher's Exact Test was used to establish the associations between respondents' socioeconomic factors and their perceptions. The result indicated that while the ecological benefits were perceived higher in the upper topographic areas, the socio economic benefits were in the middle and lower areas suggesting an integrated approach. The program participants better perceived the benefits of the practices than the non participants suggesting the need of up scaling the program non-participant areas. Farmland size, off/non farm income, extension and credit services were significantly associated with farmers' perceptions. Hence, there is a need of taking in to consideration the perception of farmers for adjusting and optimizing watershed management strategies employed in the area so that households can move towards more sustainable watershed and sustainable agricultural livelihoods.

Keywords: Watershed management practices; socio-ecology impacts; farmers' perspectives; Gibe River basin; Ethiopia

## 6.1. Introduction

Soil degradation in the form of soil erosion by water is a severe environmental problem mainly in sub-Saharan Africa because of its consequences for subsistence agriculture, from which about 75 percent of the population derives their livelihoods (Tully et al., 2015). It can be defined, as the processes by which soils can no longer maintain the provisioning, supporting and regulating ecosystem services. Soil degradation is caused mainly by the interacting effects of factors, such as biophysical characteristics and socio-economic aspects (Kerse, 2018). It further exacerbated by rapid population growth which resulted in shrinking and increasingly fragmented cultivated lands as well as expansion of cultivated lands to vulnerable hillsides, which has further contributed to a high level of land degradation, low productivity, and greater poverty (Aglanu, 2014). Ethiopia is one of the sub-Saharan African countries with no exception to these realities. Soil degradation induced by water erosion, particularly in the highlands of the country where the topography is rugged, steep lands are cultivated and the erosive rainfall is high is the most widespread and damaging process (Debie et al., 2018). For example, recent estimates by (K. Hurni et al., 2015), indicated that soil erosion rates of 20 Mg ha<sup>-1</sup> year<sup>-1</sup> on currently cultivated lands and 33 Mg ha<sup>-1</sup> year<sup>-1</sup> on formerly cultivated degraded lands.

Recognizing these connections, the government of Ethiopia with collaboration of international agencies have been trying to support better land use and promote massive soil and water conservation (SWC) program since in the early 1970's to reduce land degradation and improve people's livelihood (Gessesse et al., 2016). However, the efforts were considered ineffective and unsustainable due to among others, too much emphasis on natural resources conservation and little attention to human activities and the priorities and needs of people (Shiferaw & Holden, 1998; Desta, Carucci, Wendem-Ageñehu, & Abebe, 2005). Given the failure of the past attempts, a growing interest is now being placed on land management technologies through watershed approach and it is becoming popular strategy since 1980s in the country that aimed to implement natural resource conservation and development program (Desta et al., 2005).

Despite the government's and non-governmental organizations' efforts to increase agricultural productivity and reduce land degradation through the promotion of various watershed management intervention measures, the implementation of program are relatively low level of success (Mekuriaw et al., 2018), largely as investments by farmers in watershed management

intervention strategies are influenced by the ecological, economic and social impacts of the intervention practices. Policies, in general, have also not furthered the adoption of watershed management practices because they have not recognized that landscapes are social–ecological systems (Gobster, 2014). As a result, policies may be contradictory, subsidies inefficient (Fleskens, Nainggolan, & Stringer, 2014), or practitioners not conscious of environmental and socioeconomic benefits of sustainability and environmental restoration. In this puzzling context, policy makers must consider the combined social–cultural, economic and ecological benefits of watershed management practices whilst accounting for trade-offs as well as off-site effects (Schwilch, Liniger, & Hurni, 2014).

Since soil and water constitute the physical basis of agricultural production, this usually means that watershed management intervention measures are aimed at increasing agricultural production and decreasing soil loss. A successful watershed management intervention technologies are typically not just technically feasible but also adapted to the local environment, ecologically sound, economically viable and socially accepted (Herweg & Ludi, 1999). Their impacts have not only evaluated in monetary terms, but also have ecological and socio economic impacts that cannot be easily quantified in monetary values (Tenge, 2005). Hence, ecological, economic and social assessments of watershed management intervention strategies are of paramount importance to ensure better decision-making processes of policy makers and development practitioners.

Farmers' perception and experiences on socio economic and ecological impacts of watershed management practices is very vital for the better design and adoption of sustainable land management policies so that rural households can move towards more sustainable land use and land management practices, as well as more sustainable agricultural livelihoods, over the longer term (Sallu, Twyman, & Stringer, 2010; Pulido & Bocco, 2014). It is the social role of attitudes which provide an input into the planning process and serve as a vehicle for public participation in decision-making (Duruiheoma, et al., 2015). Theoretically, the positive perception of the problem and the benefits are likely to decide in favor of adopting sustainably the available conservation technologies (Tesfa & Mekuriaw, 2014). On the other hand, when farmers do not acknowledge the problems and the benefits leads to the poor maintenances of the measures. As a matter of fact, the farmers' perception is highly a certain socio-culture context specific in its very

nature and the emergence of and development of perception have been highly associated with the accessibility and exposures to the policy, and local ways of transferring information (depends on the accessibility to the extension workers) along with personal experiences, memories and culture (Smit & Smithers, 1992). Understanding the process and factors influencing of the people's perceptions on the impacts of environmental management issues is thus a prerequisite in making successful and sustainable resource management strategies (Bekele & Drage, 2003; Bewket & Teferi, 2009; Haregeweyn et al., 2015a).

Sustainable watershed management intervention strategies exists throughout the world and has in many cases largely evolved through local traditional practices rather than being adopted on basis of scientific evidences (Shiferaw & Holden, 2001; Schwilch et al., 2012). There is a wide range of researches on the perception of the farmers in Ethiopia on soil erosion hazards and attitudes towards soil conservation (Tegene, 1992), resource degradation and adoption of land conservation technologies( Shiferaw & Holden, 1998), participation in soil and water conservation activities (Bewket & Sterk, 2002b), land management, erosion problems and soil and water conservation (Tefera & Sterk, 2010) and land degradation and traditional Knowledge (Assefa & Bork, 2016). All findings revealed that farmers' perception has a paramount importance for reverse the trend of increasing environmental degradation and for the widespread implementation and ensuring the sustainable positive impacts of the intervention measures. Likewise, it is often highlighted that farmers' environmental behaviors (i.e. land management decisions) depend on their own perceptions of conditions in their environment (Shiferaw & Holden, 1998; Assefa & Bork, 2016; Keshavarz & Karami, 2016).

However, the focuses of most of the studies have been on assessing implementation of conservation measures ( Vancampenhout et al., 2006; Nyssen et al., 2007; Schmidt & Tadesse, 2012; Tadesse, Suryabhadgavan, Sridhar, & Legesse, 2017). There is little attention has been paid to systematically documenting farmers' perceptions of, and experiences of socio-cultural, economic, and ecological impacts that stem from the watershed management interventions. In fact, a wealth of watershed management interventions' knowledge and information exists, and there is a great demand to access it (Zhou et al., 2008). Therefore, active inclusion of local farmers' understanding and valuing of local knowledge in watershed management intervention strategies is absolutely essential to increase the uptake of the conservation measures and promote understanding of their functioning (Baartman et al., 2007).

The degree of public awareness of watershed management intervention measures, which is directly related to knowledge and experience of farmers, is of critical importance in order to reverse the trend of increasing environmental degradation (Stringer et al., 2017). Literatures also indicated that soil erosion and conservation cannot be understood without studying how people use the land and the reasoning that guides their decisions about land use (Mazzucato & Niemeijer, 2000; Mbagalaw & Folmer, 2000). Conversely, watershed management intervention plans in the country to date have not considering and have often overlooked such abilities of local farmers for better transfer, adaptation and improving watershed management interventions (Haregeweyn et al., 2015).

Farmers generate know how related to the impacts of watershed management intervention strategies on ecological (such as reduces soil loss, increases soil fertility, soil moisture, and biodiversity), economic (such as increase crop yield and livelihood strategies) and social (such as reduces conflicts over resources and build community institutions). However, most of this valuable knowledge remains a local individual resource, unavailable to others working in similar areas and seeking to accomplish similar tasks (WOCAT, 2007). This may be one of the reasons why soil degradation persists despite many years of effort and high investment in watershed management intervention strategies in Ethiopia (W. Bewket & Sterk, 2002b) and possibly explaining the little success in the past decades (Tesfaye, Negatu, Brouwer, & van der Zaag, 2014).

To increase the effectiveness and sustainability of watershed management intervention strategies and to have promising conservation measures, considering farmers' understanding of implementation and evaluation of the socio-cultural, economic and ecological impacts of watershed management intervention strategies remains a critical input (Schwilch et al., 2012). This approach seeks to maximize and strengthen the use of farmers' knowledge systems to generate qualitative knowledge that is scientifically credible (Yitaferu, 2007). It will also be important to influence policy for future design and effective promotion of acceptable watershed management intervention strategies for the development of the agriculture and livelihood of people (Tesfaye et al., 2014).

Similarly, to avert land degradation problems, integrated watershed management program has been implementing since the year 2008 under the sustainable land management program in

collaboration with international non-governmental organization namely GTZ in the study watershed (WARDO, 2013). Various interventions such as soil and water management practices, water harvesting, provision of improved technologies, natural resources management based income generating activities and capacity building activities have been undertaken to improve the biophysical and socioeconomic conditions of the area. Hence, any changes in these natural resources have not only been greater impacts on ecology but also the agriculture-dependent livelihoods of people in the area. In line with this, the objective of the study was to assess farmers' perception on the ecological and socio economic impacts of watershed management intervention strategies and factors that affect the level of perception by systematically documenting the views and experiences of farmers in the Rebu watershed of the upper Gibe basin, south west Ethiopia.

## *6. 2. Methodology*

### *6.2.1. Measurement indicators*

Information on perception towards the socio-ecological effects of watershed management intervention strategies was studied under the three dimensions (ecological, economic and social). Out of the 13 impact indicators, six of them were designed to assess ecological restoration impacts (such as, reduce soil loss, reduces runoff, reduces down sub watershed/plots flood, enhances soil fertility, increases soil moisture, enhances vegetation and biodiversity); four of them were designed to assess economic impact indicators (improve crop yields and farm income, improve livelihood strategies, create job opportunities for disadvantaged groups, enhances food supplements for livestock) and the remaining three were social impact indicators (enhances farmers' involvement in resource conservation, build and strengthen community institutions like self help groups and watershed committee, reduces conflict over resources like water and forest).

The impact statements were rated as strongly disagree, disagree, neutral/undecided and agree and strongly agree for each of the purposes, with corresponding rates of 1, 2, 3, 4 and 5 respectively adhered to a five point Likert scale (Likert, 1932) for positive statements and reverse scoring for the negatively worded items. This was through discussion with local farmers, watershed management program experts and officials. In addition, the World Overview of Conservation

Approaches and Technologies (WOCAT) guidelines were used to evaluate the impact of watershed management on socio economic and ecology. The internal consistency/reliability of the questionnaire was measured through a pilot study using the reliability coefficient of Cronbach’s alpha (Cronbach, 1951), which ranges from 0 to 1; the larger the value the greater the reliability of the scale( above 0.7). Here the Cronbach’ alpha result is 0.878 (Appendix Table A) for all 13 statements about the impacts of watershed management intervention strategies suggesting that it was deemed acceptable.

Reponses to each of the statements were graded and summed, resulting in an overall score of each respondent on this perception scale and therefore, using the Likert scoring method, point scores from the respondents were calculated for each statement. The overall score was obtained by adding up all the scores from all respondents and the total score expressed as a percentage of the maximum possible score for all the statements. We merged the three dimensions to create an overall perception towards the impacts of watershed management intervention strategies. Thus, the highest possible score was 65(13\*5) if a respondent score 5 for each of the 13 statements. The moderate possible score was 39(13\*3) if a respondent score 3 for each the 13 statements. The lowest possible score was 13(13\*1), if a respondent scores 1 for each of the 13 statements. Accordingly, scores above 39 shows high perception, equals to 39 shows moderate perception and below 39 shows lower perception towards the impacts of watershed management intervention strategies. To establish the associations between respondents’ demographic and socio-economic variables and their levels of perception towards the impacts of watershed management intervention strategies Fisher’s Exact Test was used.

To determine the farmers’ perceived impacts of watershed management intervention strategies a perception index was adopted following a modified formula (Sharma, Singh, & Padaria, 2011; Obadire, Mudau, & Zuwarimwe, 2014; Bagdi & Kurothe, 2016).

Farmers’ perception index of impacts of watershed management intervention strategies is computed, as:

$$PI_i = \sum_{j=1}^K Y_{ij} \quad \text{equation (1)}$$

Where  $PI_i$  is perception index for  $i^{th}$  respondent;  $Y_{ij}$  is the score of  $j^{th}$  item for  $i^{th}$  respondent;  $K$  is the maximum perception score

$$PI = \frac{\sum_{i=1}^N PI_i}{N} \quad \text{equation(2)}$$

Where  $PI$  is perception index for impacts of watershed management intervention strategies;  $PI_i$  is perception index for  $i^{th}$  respondent;  $N$  is the total number of respondents. That is the perception index for each indicator of impacts of watershed management intervention practices (ecological, economic and social). The formula (2) above was used to calculate the overall Likert score for impacts of watershed management intervention strategies.

### 6.3. Results and discussion

#### 6.3.1. Demographic and socio economic characteristics of respondents

Households' demographic and socio economic characteristics were presented in (Table 6.1). The average age of the study respondents was 46.73, years with the minimum and maximum ages of 25 and 75 years respectively. About 87 percent were male and 13 percent were female. The average number of members who are currently living within the family was 4.84 with the minimum and maximum number of 1 and 9 respectively. The larger proportion of the respondents (60 percent) was literate, whereas the remaining (40 percent) were illiterate. As indicated from the survey result, the average land holding of the respondents was found to be 2.2 hectares ranging between 0.77 and 7.11 hectares. The average livestock owned by the study household which was measured in terms of Tropical Livestock Unit (TLU) was found to be 5.49. In case of off/non-farm income sources, households were asked whether they accessed or not, to various activities (such as; hand crafting, employment, daily labor, petty-trade, etc.) and hence, households accessed to at least one of these activities were 29 percent. Farmers were asked to reply frequency of extension contact in the last production year and the average frequency of extension contact of the respondents were 2.18 ranged from 0-5 times. About 77 percent of the respondents attained training on watershed management practices. About 76 percent of the respondents were accessed to credit services. Farmers' membership in rural institutions/associations (such as watershed committee/team, self help groups, etc.) was used as

proxy of social capital. About 68 percent of the respondents were participated at least in one of the local institutions.

Table 6.1, Households’ demographic and socio economic characteristics

Characteristics	Descriptions	Mean (%)	Min	Max
Age	Continuous variable measured in years(average)	46.72	25	75
Sex	Dummy = 1 if household head is male, other wise 0	87 %		
Literacy status	Dummy = 1 if household head literate, other wise 0	60 %		
Family size	Number of members who are currently living within the family(average)	4.84	1	9
Farm land size	Total size of landholding in ha(average)	2.20	0.77	7.11
Livestock TLU	Continuous variable number of livestock owned measured in TLU(average)	5.49	1.95	17.45
Off/nonfarm activities	Dummy= 1 if household head is access to off/nonfarm activities, other wise 0	29%		
Extension contact	Continuous variable measured in the number of extension contact(average)	2.18	0	5
Training services	Dummy = 1 if household head attended training on watershed management practices, other wise 0	77%		
Credit services	Dummy =1 if the farm household access to credit , otherwise 0	76%		
Group membership	Dummy = 1 if the farm household belongs to local institutions, otherwise 0	68%		

Sources: computed from survey result, 2018

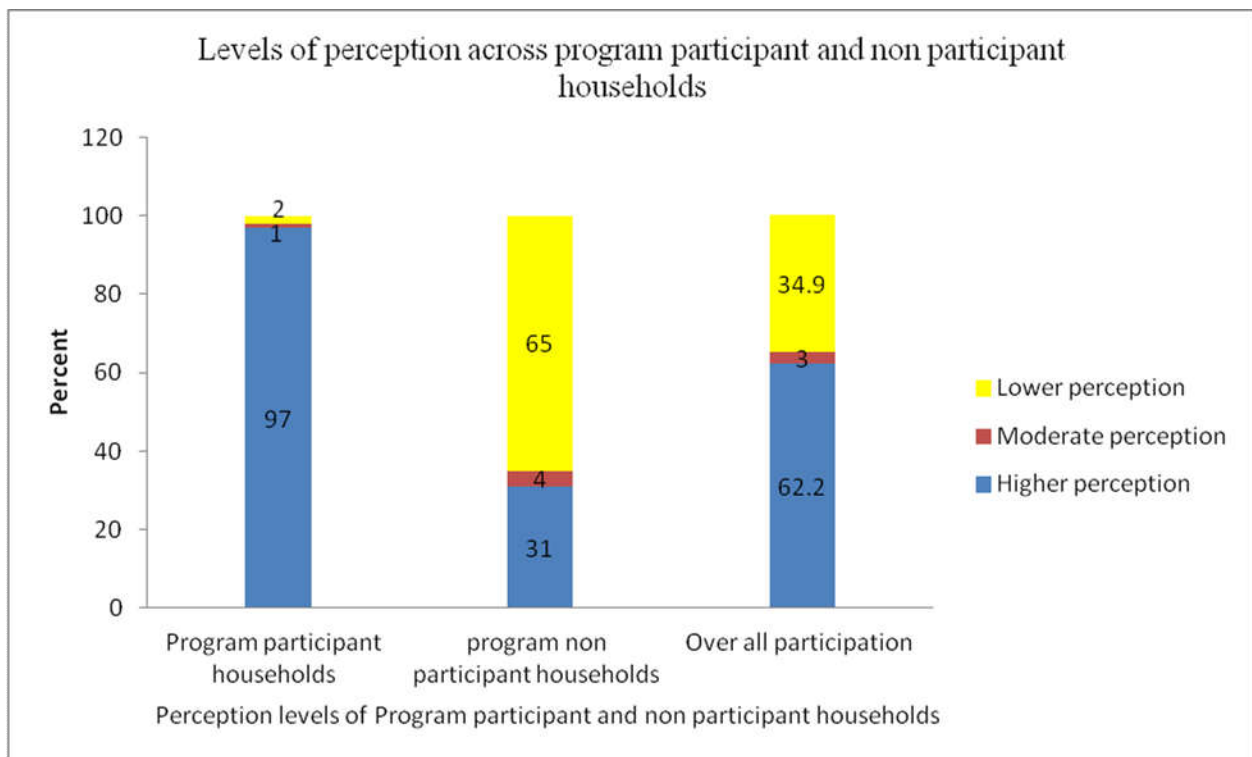
### 6.3.2. Perceived status and type of benefits of watershed management

#### 6.3.2.1. The perceived status of the benefits of watershed management intervention

Overall, the results of the study indicated that most of respondents (62. 2 percent) perceived higher level of the effects of watershed management intervention strategies either strongly agree or agreeing while (34. 9 percent) of them showed lower perception either disagreeing or strongly disagreeing towards the program (Figure 6.1). Only (3 percent) of them took the moderate point without having clear position. The program participants perceived higher level (97 percent) about the effects of watershed management intervention strategies than non program participants (31 percent). About (65 percent) of the program non participants had lower perception level about the effects of watershed management intervention strategies. The overall perception index

value was on average 42.5 percent indicating a moderate level of perception. The higher level of perception was might be linked to awareness creation made by the project to the households about the program and its associated benefits and involvement of farmers in conservation activities. Study by Wei et al. (2009), confirmed that the program participant farmers are more cognizant to watershed management strategies as a result of exposure to information and training on environmental management and conservation practices.

Figure 6.1, Levels of farmers’ perception about the effects of watershed management practices



Source: computed from survey results, 2018

### 6.3.2.2. Perceived type of benefits of watershed management practices

#### 6.3.2.2.1. Ecological benefits

According to key informant interview and focus group discussions, loss of forest has been a severe problem before treated by the program intervention in the study area. The loss of forest in turn has caused flight of wild animals and created aggressive runoff that moved huge amount of soil down the hills. This massive soil erosion by flood and farming on the hilly and higher slopes

and livestock population pressure has contributed for both soil and pasture degradation which necessitates watershed interventions. Consequently, large areas of degraded and deforested land was covered by tree plantation within the last eight years and others were rehabilitated after demarcation and protected from human and animal encroachment through area closure. Figure 6.2 confirms the result. Furthermore, vegetation and biodiversity improvement scored (73.75 percent) by the respondents since they started to participate on watershed management activities (Table 6.2). The FGD and key informants were also stated that due to integration of in-situ moisture conservation structures ( such as micro-basin and trenches) with tree plantation, the survival rates of the planted trees, forages seedlings and grasses growth were improved in the area. The effects of the watershed management program on vegetation and biodiversity enhancement were perceived better by program participants (92.97percent) than the non participants (56.23 percent (Table 6.2)). This result agree with Meshesha & Birhanu (2015) finding which stated that watershed management intervention was improved regular trees planting than the non intervention one.

Figure 6.2, Rehabilitated closures and protected forest



*Source: Photograph, 2017*

As stated earlier, most landscape of the study area were mountainous, steep and highly fragile lands in which farmers have cultivating sloppy land for various purposes that in turn resulting in soil loss, frequent runoff and floods prior to watershed treatment. Currently, due to watershed management interventions practices such as soil bunds, grass strips with soil bunds etc. (Figure 6.3), the area showed multiple positive effects on soil loss, runoff and floods. With regards to this, soil loss reduction scored (72.37 percent), runoff reduction scored (64.86 percent) and

reduction of flood scored (70.86 percent) by the respondents (Table 6.2). The effects of watershed management on runoff reduction scored (81.24 percent), down sub watershed/ plot flood reduction scored (87.17 percent), soil loss reduction scored (89.38 percent) by the program participants whereas (49.81 percent), (55.97 percent) and (56.86 percent) respectively for non participants (Table 6.2).

Figure 6.3, Soil bunds and integrated practices (grass & fodder and trees)



*Source: Photograph, 2017*

#### 6.3.2.2.2. Economic benefits

Reports from key informant interview and focus group discussion indicated that, due to watershed management activities, previously degraded areas and gullies have been rehabilitated and reclaimed, contributed a significant role by reducing soil erosion, improving moisture retention and productivity of soil, allowing farmers to grow fruits, forages, trees and vegetables (Figure 6.4). Livestock fattening, poultry, honey production have also emerged following watershed management programs. Moreover, the introduction of watershed management programs has had a positive impact on women's empowerment. Women farmers were trained to produce locally-made, energy-saving stoves for the market and this generated additional income.

Furthermore, the enhancement of soil fertility and soil moisture improvement were rated (71.38 percent) and (68.55 percent) respectively by the respondents (Table 6.2). In addition result also reveals that the program enhances the availability of grass and trees for food supplement of livestock (71.58 percent), improved land productivity/crop yields (64.41 percent) followed by

livelihood improvement (62.83 percent) are the major benefits rated (Table 6.2). This result agrees with the studies such as (Vancampenhout et al., 2006; Nyssen et al., 2007; Gebregziabher, Abera, Gebresamuel, Giordano, & Langan, 2016; Tesfaye et al., 2018), showed that watershed has reduced the rate of soil erosion and floods, improved soil moisture, increased crop yields and income generating activities.

Figure 6.4, Rehabilitated gullies and Agro forestry practices (apple, cabbage, garlic etc.)



*Source: photograph, 2017*

#### 6.3.2.2.3. Social benefits

The result from social effects of the watershed management practices also revealed that, strengthen community institutions (such as watershed committee, self help groups), reduces conflict over resources (for example conflict on forest and water sources) and enhances people's involvement in the conservation of environmental resources were rated as (57.43 percent, 56.05 percent, 53.75 percent) respectively (Table 6.2). Study by Tesfaye et al.(2018) showed that institutional supports are crucial for successful watershed resources management practices. Key interview and focus group discussion reported that various local institutions were established, but need support for effective functioning.

Generally, the result also indicated that households were well aware of the socio-ecological and economic benefits of watershed management. The result agreed with study by Wani et al(2008), stated that the conservation and management of watershed plays crucial role in determining food,

social, and economical security and provides ecosystem services. As the result indicated, the perceived ecological benefits attracts more followed by economic and social one and for program participant households (Table 6.2). This result is also agreed with the study by Tesfaye et al.(2018), reported that participatory integrated watershed management have a positive impact on hydrology, socio-economic and environment of the watershed and better performed in program watershed than control one.

Table 6.2, Effects of watershed management intervention strategies

Factors	Program participant	Program non participant	Total
	score & % of max(145*5)	score & % of max(159*5)	Score & % of max(304*5)
<b>Ecological factors</b>			
Reduces soil loss	648(89.38)	452(56.86)	1100(72.37)
Reduces storm/intensive runoff	589(81.24)	396(49.81)	985(64.80)
Reduces down sub watershed/plot flood	632(87.17)	445(55.97)	1077(70.86)
Increase soil fertility	630(86.90)	455(57.23)	1085(71.38)
Increase soil moisture	604(83.31)	438(55.09)	1042(68.55)
Biodiversity enhancement	674(92.97)	447(56.23)	1121(73.75)
<b>Average</b>	3777(86.83)	2633(55.20)	6410(70.29)
<b>Economic impacts</b>			
Enhances crop yield and farm income	577(79.57)	402(50.57)	979(64.41)
Flexibility/ improve livelihood strategies	585(80.69)	370(46.54)	955(62.83)
Create job opportunity for disadvantaged groups(youth)	559(77.10)	404(50.82)	963(63.36)
Food supplement for livestock(grass)	609(84.0)	479(60.25)	1088(71.58)
<b>Average</b>	2330(80.34)	1655(52.04)	3985(65.54)
<b>Social impacts</b>			
Enhances farmers' involvement in resources conservations	486(67.03)	331(41.64)	817(53.75)
Build community institutions(WSM committee, self help groups for resource conservation	527(72.69)	346(43.52)	873(57.43)
Reduces conflict over resources( water, forest)	515(71.03)	337(42.39)	852(56.05)
<b>Average</b>	1528(70.25)	1014(42.52)	2542(55.75)

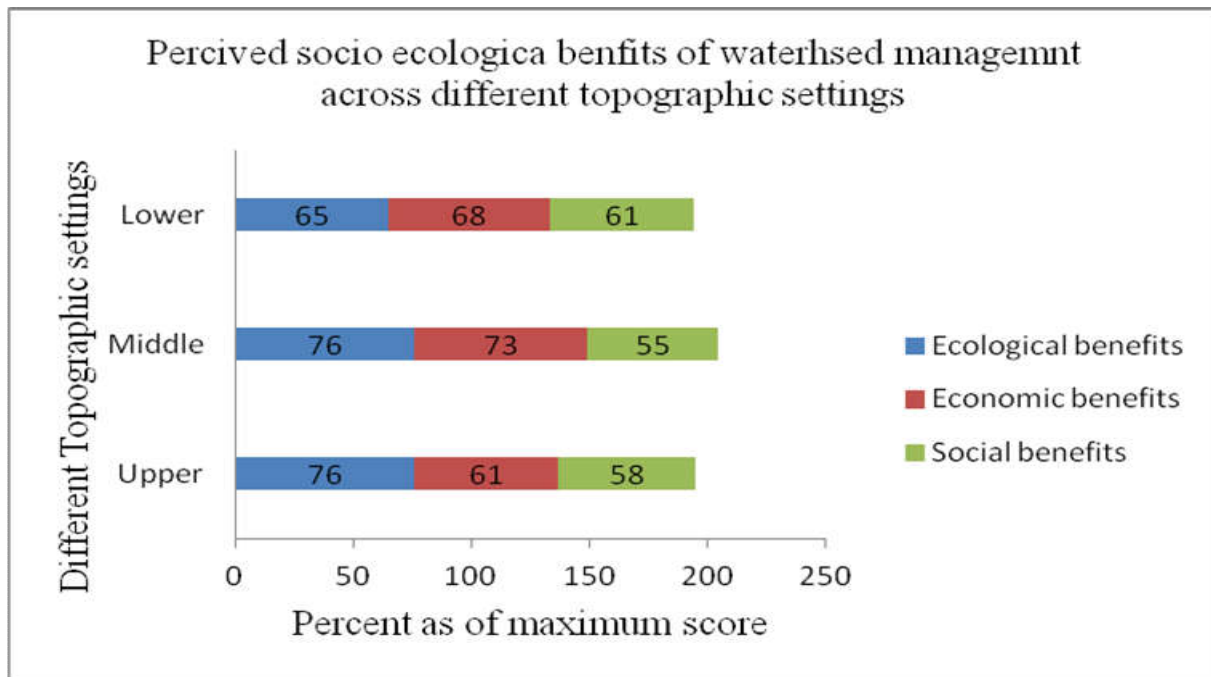
Source: computed from survey results, 2018

### 6.3.2.3. Perceived benefits of watershed management across different topographic settings

The result the study also indicated that ecological benefits were perceived better followed by economic and social one (Figure, 6.5). Specifically, the ecological benefits were well perceived in the upper while the economic and social benefits were in the middle and lower topographic

setting. This result conform with the study by Teshome, de Graaff, & Stroosnijder (2014), reported that in steeply sloping areas, farmers assigned the highest score for criteria related to ecological impacts; whilst preferring practices with stronger positive economic impacts in moderate and gentle sloping areas. Study by Tesfaye et al.(2018), reported that participatory integrated watershed management have a positive impact on hydrology, socio-economic and environment of the watershed

Figure 6.5, Perceived socio ecological benefits of watershed management across different topographic settings



source: Computed from survey results, 2018

#### 6.3.2.4. Association between socio-economic variables and farmers' perception

The computed Fisher's Exact Test value indicated that there was a significant association between size of land owned and perception (Fisher's Exact Test = 31.272,  $p = 0.000$ ; Table 6.3), suggesting that respondents who owned larger land size ( $\geq 2.2$  ha; Table 6.3) were more likely to have higher perception towards the effects of watershed management intervention practices than their respondents who owned ( $\leq 2.2$  ha). This study agree with the study by Amsalu & de Graaff (2007) and Moges, Dagnachew, & Yimer (2013), stated that a positive association between farm land size and practice of watershed management intervention measures. The association between access to off farm income and perception was also significant (Fisher's Exact Test = 41.392,  $p =$

0.000), suggesting that respondents who derived more benefits from the off/non farm income expressed higher perception than those who did not. This might be due to the fact that the introduction of watershed management programs has had a positive impact on the income of farmers through creating income generating activities (like locally-made energy-saving stoves for the market) that generated additional income and increases the financial potential of farmers which in turn encourage their perception. This study conform with the study by Tiwari, Sitaula, Nyborg, & Paudel (2008) and Demelash & Stahr (2010), reported that off farm activity is correlated positively at statistically significant level with the adoption of soil and water conservation practices.

Frequency of extension contact and perception towards watershed management intervention strategies was associated significant (Fisher's Exact Test = 116.824,  $p = 0.000$ ). This means that respondents who have more frequency extension contact showed higher perception towards the impacts of watershed management intervention than those who obtained less frequent extension contacts. This result agree with the studies of (Tiwari et al., 2008; Asfaw & Neka, 2017), indicated that access to extension service has a positive correlation and significant with the practice of watershed management measures. Training on watershed management practices and perception was associated significant (Fisher's Exact Test = 14.349,  $p = 0.001$ ), suggesting that respondents who more accessed to training has higher perception than those who less accessed. This result conform to the study by Asfaw & Neka (2017), reported that access to training correlated positively and significantly with the watershed management intervention measures.

There was also a significant association between access to credit services and perception towards the impacts of watershed management intervention strategies (Fisher's Exact Test = 24.399,  $p = 0.000$ ). This implies that farmers with more accessed to credit services has higher perception towards the impacts of watershed management practices than those who not accessed. This finding agree with the study by Deressa, Hassan, Ringler, Alemu, & Yesuf (2009), stated that access to credit has a significant positive impact on the likelihood of using soil conservation techniques, changing planting dates and using irrigation in the Blue Nile Basin. Respondents' group membership was also associated with the perception towards the impacts of watershed management intervention strategies (Fisher's Exact Test =32.873,  $p = 0.000$ ), suggesting that respondents who were a member of local institutions has higher perception than those who was

not member. This result conform to the study by Adesina, Mbila, Nkamleu, & Endamana (2000), that reported positive relationship between practices of soil erosion control measures and group membership. In the study some of the demographic and socio economic factors such as sex of the household head, age, educational status, household size and livestock size did not have significant association with the perception of the effects of watershed management practices (Table 6.3).

Table 6.3, Fisher's Exact Test results; associations between perception and socioeconomic variables

Variables	Perception of the respondents (%)			Fisher's Exact Test	P-value
	Higher	Moderate	lower		
Sex					
Male	162(53.3)	7(2.3)	95(31.2)	1.906	0.349
Female	27(8.9)	2(0.7)	11(3.6)		
Age category					
≤46.72	86(28.3)	5(1.6)	57(18.8)	2.074	0.365
≥46.72	103(33.9)	4(1.3)	49(16.1)		
Family size category					
≤ 4.84	72(23.7)	2(0.7)	53(17.4)	5.247	0.065
≥4.84	117(38.5)	7(2.3)	53(17.4)		
Literacy status					
Illiterate	73(24)	3(1)	47(15.5)	1.114	0.608
Literate	116(38.2)	6(2)	59(19.4)		
Total land owned category					
≤ 2.20ha	80(26.3)	4(1.3)	80(26.3)	31.272	0.000
≥ 2.20 ha	109(35.9)	5(1.6)	26(8.6)		
Livestock size category					
≤ 5.49	104(34.2)	7(2.3)	70(23)	4.540	0.101
≥ 5.49	85(28)	2(0.7)	36(11.8)		
Access to off farm income					
Yes	77(25.3)	3(1)	8(2.6)	41.392	0.000
No	112(36.8)	6(2)	98(32.2)		
Freq. extension contact					
≤ 2.18	82(27)	8(2.6)	105(34.5)	116.824	0.000
≥ 2.18	107(35.2)	1(0.3)	1(0.3)		
Access to training services					
Yes	159(52.3)	6(2)	69(22.7)	14.349	0.001
No	30(9.9)	3(1)	37(12.2)		
Access to credit services					
Yes	161(53)	5(1.6)	64(21.1)	24.399	0.000
No	28(9.2)	4(1.3)	42(13.8)		
Group membership					
Yes	151(49.7)	6(2)	50(16.4)	32.873	0.000
No	38(12.5)	3(1)	56(18.4)		

Sources: computed from survey results, 2018

#### *6.4. Conclusion and policy implications*

The objective of the study was to assess the socio-ecological impacts of watershed management intervention strategies based on farmers' perspectives across different topographic settings for program participants and non participants. It was identified that, the relative importance of watershed management intervention strategies are influenced by topographic settings in both for program participants and non participants. Farmers in the study watershed gave higher score for indicators related to ecological impacts (soil loss reduction, runoff reduction, soil fertility and moisture improvement), in the upper geographic settings, and socio-economic enhancement (crop yield and income improvement, livelihood strategy improvement) in middle and lower geographic settings suggesting an integrated approach. The program participants better perceived the impacts of watershed management intervention strategies than the non participants. Farm land size, access to off/nonfarm income, frequency of extension contact, access to training on watershed management practices, access to credit services and group membership were associated with the levels of perception about the impacts of watershed management intervention strategies.

The study indicated that conservation alternatives can be adopted or not by farmers' specific topographic and/ or socioeconomic contexts. Hence, there is a need of taking in to consideration the perception of farmers for adjusting and optimizing watershed management measures employed in the area. It is also apparent that the knowledge and efforts of local farmers' need to be encouraged and appreciated as they are crucial for sustainable watershed management planning and implementation. It is also vital to take in to account those determinants of farmers' perceptions for design and effective implementation of sustainable watershed management intervention strategies.

**Chapter 7: Enhancing Livelihood Assets of Households through Watershed Management Intervention Program**

## Abstract

A wide spread watershed management intervention strategies have been implemented in Ethiopia to enhance farmers' livelihoods. However, there is hardly any attempt to document the interface of watershed management and livelihood assets. The purpose of this study was to assess the effects of watershed management intervention program on the sustainable livelihood assets of households in Gibe basin, south west Ethiopia. A cross sectional survey research design was employed to collect data from 304 randomly selected watershed management program participant and non participant households in six rural villages. Household survey, key informant interviews and focus groups discussions were employed to collect data. Descriptive analysis, independent t-test and radar diagram were used to analyze the data. Propensity score matching method and probit model were also used to determine the significance of the differences of the participants and non participants and causal treatment effects. The result of the study indicated that, the aggregated value of overall livelihood assets and the specific principal components that encompasses human, natural, financial, social and physical assets were better for watershed management program participants than those of non-participants, but, both belongs to the average category of livelihood asset improvement scale. The radar diagram depicted imbalance in the five principal assets for respondents in the study area suggesting the livelihood assets structure is not sustainable. The probit model result showed that program participation decision of the households are affected by age, livestock ownership, distance to farmers' training center, topographic location, distance of farmland and access to watershed program training. Estimates of the propensity score matching indicated that the existence of a positive additional significant livelihood assets value of 24.8 % for program participants compared to non-participants. Findings of the study suggested that further emphasis is needed to enhance the households' livelihood assets for sustainability of both livelihoods and natural resources by minimizing gaps in the improvement of the five dimensions of livelihood assets. It also suggested the extension of the program to non participant areas. Policy makers and development practitioners have to focus on the aforementioned factors of group differences.

Keywords: watershed management program; program participants; livelihood assets; impacts; Gibe River; Southwest Ethiopia.

### *7.1. Introduction*

Livelihood sustainability is a growing issue particularly in the developing countries given the mounting challenge of poverty, low economic development and poor agricultural system (Ashley, 2000; Baumann, 2000). Ethiopia is not an exception where the degradation of land resource base and associated decreasing land productivity have been a major challenge for the sustenance of livelihoods of people (Teklewold, Kassie, & Shiferaw, 2013). Agriculture is the economic mainstay of the overwhelming majority of people in Ethiopia and will continue to be the base for sustainable livelihood of the country (Gessesse et al., 2016). However, the ongoing watershed degradation in the form of soil erosion and soil nutrient depletion is the threatening factor for agricultural development (Shiferaw & Singh, 2010; Gessesse et al., 2016). It is getting worse in many parts of the Ethiopia, particularly in the humid/sub humid highland areas of the country (Shiferaw & Holden, 1998). The degradation of watershed have been associated with the interacting effects of biophysical and socio-economic factors and exacerbated by rapid population growth which would be resulted in not only decreasing land productivity but also aggravate ecological degradation, hampered households' livelihood improvement and social development (Teklewold, et al., 2013; Kerse, 2018).

Thus, sustainable use and management of natural resources have become a key issue for biophysical and socio-economic development, particularly in agriculturally dominated countries (Chambers & Conway, 1991) including Ethiopia. As a result of which, most international, regional and local policies have paid much attention on watershed resources such as soil, water, and vegetation in trying to enhance human livelihoods as well as conserving these resources for future generation (Darghouth et al., 2008). It is with this regards that, watershed management approach has been seen as one of the solutions to confront challenges of sustainable livelihood improvement of households.

Experiences from various countries have shown that the adoption of watershed management program enhance the livelihoods of people. For example, study by Joshi, Jha, Wani Suhas, Sreedevi, & Shaheen (2008) in India revealed that watershed program has had augmented income, generated rural employment, increased crop yields, enhanced cropping intensity, reduced run-off and soil loss, increased groundwater, enhanced social capital and reduced poverty; Barron, Noel, & Mikhail (2009) in Latin America, Middle East and sub-Sahara Africa

concluded that, various agricultural soil and water management interventions increased income, improved on-farm yield output, enhanced users' governance structure, improved water infrastructure and increased skills and knowledge; Chen et al. (2013) in northern China showed that Community Based Co-Management (CBCM) projects has had changed each aspect of the five types of livelihood asset capital of program participants and Islam, Quli, Rai, & Ali (2014) in Bangladesh similarly showed that participatory forestry programs have had a positive impact on the livelihood assets of the program participants.

Recognizing the adverse effects of watershed degradation on biophysical and livelihoods of people, the government of Ethiopia with the support of international agencies have been trying to support better land use and promote soil and water conservation technologies since the early 1970s (Teshome, de Graaff, & Kassie, 2016; Chimdesa, 2016). As a result, large areas have been converted to terraces, covered by soil bunds, closed by area closures and planted with millions of tree seedlings. However, the program was reported ineffective and failed due to basically focused on physical soil erosion control measures (Haregeweyn et al., 2015; Gebregziabher, Gebresamuel, & Langan, 2016). In response to the failure of the past effort, watershed management approach became a key strategy since 1980s (Worku & Tripathi, 2015) to reduce land degradation, increase land productivity, enhance ecosystem service, and improve farmers' livelihood.

Various studies in Ethiopia reported prospectus positive effects of watershed management practices. For instance, watershed management practices reduce soil loss and improve vegetative cover and grass land (Tadesse, Suryabhagavan, Sridhar, & Legesse, 2017; Mekuriaw, 2017) reduce runoff velocity and enhance water infiltration (Nyssen et al., 2007; Vancampenhout et al., 2006) enhance soil structure, crop yield, biomass production, ground water recharge and prevention of flood hazards (Nyssen et al., 2007); reduce soil erosion, enhance water availability and quality, develop tree plantation and diversifying household income sources (Berhanu & Simane, 2015); augment grain yields, household annual income, dairy cow milk and honey bee yield (Yaebiyo et al., 2015); improve both household income and savings (Assan & Beyene, 2013). However, most of them are biased towards evaluating the watershed management intervention from the physical structures, erosion and adoption of technologies rather than from

various households' livelihood assets perspectives through highlighting sustainable livelihoods approach (SLA).

The study site, Rebu watershed of upper Gibe basin in south west Ethiopia, is not far different from the national scenario. It is characterized by rain-fed agricultural activities and the degradation of natural resources therefore has greater impacts on agricultural productivity and the agriculture dependent livelihoods in the area. In recognition of these problems, aiming at improving livelihood opportunities through sustainable use of the natural resource base, the government of Ethiopia with the support of non-governmental organization (GTZ) undertaken integrated watershed management practices since 2008 (WARDO, 2013). Various types of watershed management practices have been implemented within the framework of community based watershed development plans; namely: soil and water management measures; water harvesting practices, agro forestry practices; area closure development; crops and soil fertility management; provision of improved technologies, livestock development, natural resource based income generating activities and institutional strengthening practices.

Cognizant to this, the study aimed to assess the effects of watershed program on sustainable livelihood assets of households using sustainable livelihood framework. Specifically the study tried to; 1) characterize the state of the livelihood of the households from the perspectives of sustainable livelihood asset; 2) examines the structure of sustainable livelihood assets among farming households and 3) analyze the effects of watershed management intervention on natural, physical, financial, human and social assets. An understanding of the sustainability of farmers' livelihood aspects is important to be aware of the livelihood condition of households undertaking watershed management program; enables to build the strong base to farmers weather offered watershed management practices are worthwhile undertaking or not. It also contributes for decision makers and planners to decide on especially the magnitude of intervention and up scaling planning of watershed management intervention strategies.

## *7.2. Conceptual framework*

This study employed Sustainable Livelihood Analysis (SLA) framework developed by the Department for International Development (DFID) to examine the effects of watershed management program on livelihood assets of households. Drawing on the study by DFID (1999)

and various authors such as Chambers & Conway (1991), Krantz (2001) and Scoones (1998), a livelihood is defined as comprising the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets, while not adversely affecting the environmental resource base.

Sustainable livelihood approach would take in to consideration the basic dynamics of livelihoods and explained how people are represented on a set of assets as a basis for their livelihoods (Hussein & Nelson, 1998). The approach is more of adaptable to various local settings (Kollmair & Gamper, 2002; Batterbury, 2008) which helps to explain the effects of specific changes brought about through external interventions that intended to improve people's lives (Ellis, 2000). It also examines poverty issue in relation to five livelihood assets (human, physical, financial, natural, and social) identified in the framework beyond the traditional methods of employment generation and income. Participatory initiative like community based participatory watershed management program is a strategy to address rural livelihood assets' enhancement and sustainable management of resources which typify this approach. The points of intervention and impact of such programs can be explored on the livelihoods model, which is a core objective of this study.

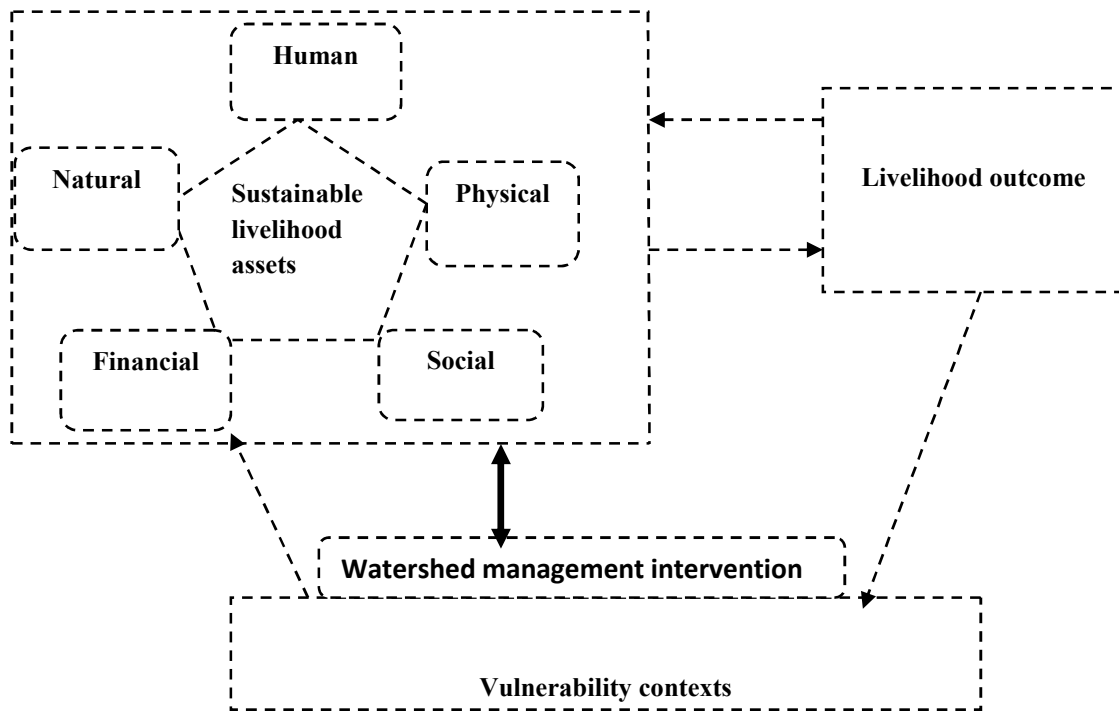
The framework defined livelihood assets as tangible and non tangible goods and services upon which livelihoods are built and to which people need access (DFID, 1999). These livelihood assets also called livelihood capitals which are composed of human assets (knowledge, skills, exposure visit, and health status) that enable individuals to pursue different livelihood strategies; social assets (membership to various formal and informal institutions and participation, and status of farmers' participation in watershed management practices) upon which people draw in pursuit of livelihoods; physical assets (housing conditions, assets such as cooking fuel stove, use of solar light, access to clean water tap, availability of improved latrine, and soil and water conservation measures) that enable people to pursue their livelihood; natural assets are resources and services improved through watershed management practices such as cultivated land size, soil quality potential, livestock size, access to home stead tree stocks, availability of fodder for livestock and access of water sources which are useful to improve the livelihood of people and financial assets (family access to credit services, wage works on various activities, tree nursery

establishment for sale, poultry production and sheep fattening for sale, bee keeping for sale) which provide different livelihood options (DFID,1999 ; Ashley & Carney, 1999).

In investigating the level of sustainability of household livelihood, the five principal assets are usually considered (Scoones, 1998; Odero, 2006; Morse, McNamara, & Acholo, 2009). These assets enhance the situation of households by responding to shocks and stresses as they adjust to overcome them and stayed sustainable over a period of time. Individual's ability to make a living for themselves is affected by the diversity, amount and balance of livelihood assets which a household can accumulate and draw upon to pursue various livelihood strategies (Farrington, Carney, Ashley, & Turton, 1999). The enhancements of five principal livelihood assets could be termed as strong sustainable livelihood assets, whereas enhancement in only some of the assets that compensate for any decline in other assets could be termed as weak sustainable livelihood assets (Islam & Sato, 2012).

Livelihood vulnerability, assets, and outcomes belong to state variables that might be affected by watershed management program intervention. Livelihood strategies belong to process variables meaning that the choices farmers employ in pursuit of outcomes might be affected as watershed management practices have an impact on their concepts, information structures, and capital. Taking vulnerability into consideration, the framework emphasizes watershed management practices as transforming processes that run through the holistic circle from livelihood assets to livelihood outcomes and is expected to have an effect on the livelihood of farmers (Figure 7.1). Therefore, an understanding of people's livelihood assets is crucial to be able to analyze how they make an effort to convert their assets into positive livelihood outcomes (Bebbington, 1999). In this study we therefore considered only the livelihood assets endowment part of the sustainable livelihood framework that changed due to the watershed management intervention program. For these five types of livelihood assets, different indicators and variables was constructed and adapted from literatures like (Chambers & Conway (1991), Thoms (2008), Tang, Bennett, Xu, & Li (2013), Donohue & Biggs (2015) and Zhifei, Qianru, & Hualin (2018) and contextualized based on reconnaissance survey and discussions with local elders and watershed management program experts and officials.

Figure 7.1, Sustainable livelihoods framework adapted from (DFID, 1999).



Source: DFID, 1999.

### 7.3. Methodology

#### 7.3.1. Measurement of indicators

The study followed the livelihood asset measurement design used by Udayakumara & Shrestha (2011); Chen et al.(2013) and Islam et al. (2014). It employed various scaling and indexing methods to measure the natural, physical, financial, human and social capitals so as to make them comparable and to allow meaningful interpretation (Table, 7.1). Most of the indicators were determined by using rating scale methods in terms of different weight. Livelihood asset indices of ( $\leq 0.33$ ), (0.34-0.66), and (0.67-1) were interpreted as poor or low; medium and good or high respectively. The questions that had three answer choices measured as:  $I = \text{Good \%} \times 1 + \text{medium\%} \times 0.66 + \text{Poor \%} \times 0.33$ . The two answer questions, Yes or No were interpreted as:  $I = \text{Yes\%} \times 1 + \text{No\%} \times 0$ . For the questions in the form of numbers the “Mean” value is the key point in the design of this type of method. Less than the mean value was classified as poor with the weight of 0.33; more than the mean but less than  $1.5 \times \text{mean}$  was treated as average with the weight of 0.66; and more than  $1.5 \times \text{mean}$  was classified as good with the weight of 1. After weight calculation of each indicator, we calculated the value of each type of livelihood asset and

finally the overall livelihood asset value. The integrated measurement equation was adopted following (Chen et al., 2013) as follows:

$$C = \sum_{n=0}^n I_n / T_n$$

Where C is the criteria score for each asset ( $0 \leq C \leq 1$ ), n denotes *nth* indicators of criteria ( $n = 1, 2, 3 \dots n$ ); I denotes indicator; T denotes the total number of indicator; Livelihood Asset was the sum i.e. (Human asset + Natural asset + Physical asset + Financial asset+ Social asset)/5.

Table 7.1, Description of measurement of sustainable livelihood asset indicators

Livelihood asset and its indicators	Measurement (weight)	Variable nature
<b>Human asset</b>		
Training on watershed management practices	Yes = 1 No = 0	binary
Exposure visit of model sub watersheds/villages	Yes = 1 No = 0	binary
Training on a cross cutting issues (improved toilet, HIV AIDS)	Yes = 1 No = 0	binary
<b>Natural asset</b>		
Cultivated/crop land (ha)	number (mean value)	continuous
Livestock owned (TLU)	number (mean value)	continuous
Land allocated for homestead tree stocks plantation	number (mean value)	continuous
Improvement fodder/grass availability	Yes = 1 No = 0	binary
Perceived status of soil quality potential	poor=.33, fair/average = .66, good= 1	Likert scale
Increase in water sources availability (springs)	Yes = 1 No = 0	binary
<b>Physical asset</b>		
Housing improvement (construction, equipment, etc.)	high =1, medium = .66, poor =.33	Likert scale
Improved cooking fuel stove/ <i>Lakech</i> / availability	Yes =1 No = 0	binary
Improvement in use of solar light	Yes = 1 No =0	binary
Increase access to clean water tap	Yes = 1 No = 0	binary
Soil and water conservation measure(soil bund)	Yes = 1 No = 0	binary
Soil fertility management measure (compost)	Yes = 1 No = 0	binary
<b>Financial asset</b>		
Credit service	yes = 1 No=0	binary
Access to wage earning activities	Yes = 1 No=0	binary
Access to poultry production and sheep fattening	Yes = 1 No = 0	binary
Access to beekeeping - beehives and wax	Yes = 1 No=0	binary
Access to seeds and tree seedlings for sale	Yes = 1 No=0	binary
<b>Social asset</b>		
Participation in various watershed committees	Yes = 1 No = 0	binary
Membership - self help groups	Yes = 1 No = 0	binary
Status of participation in watershed management	high =1, medium = .66, low =.33	Likert scale

### 7.3.2. Evaluating the impact of watershed management program

A number of econometric methods have been used elsewhere to study impact of programs (Pender & Gebremedhin, 2006), but there is no superior as each of them had its own limitations. However, the propensity score matching (PSM) has become a popular approach to estimate causal treatment effects and is being increasingly applied in policy program evaluations (Heinrich, Maffioli, & Vazquez, 2010) mainly because it is based on comparable observations which reduces the selection problem when there are two categories of response. This study used PSM to analyze the impact of watershed management program practices on farmers' livelihood assets.

#### 7.3.2.1. Estimation Procedure

Here, the estimation process and results of the propensity score matching were presented in detail. First, the predicted probability values of participation in the watershed management program (propensity scores) were estimated using the probit model for all participants of the watershed management program (treated) and non-participants of watershed management program (control) households. Next a matching estimator that best fit to the data was selected. Then based on estimated scores and matching estimator selected, matching between program participants and non-participants was done to find out the impact of the watershed management program on the overall mean values of the outcome variable which is calculated by just averaging the differences in outcomes between each treated unit and control unit. Before proceeding to the estimation process, appropriate diagnostic measures were used on the data.

The method PSM compares the livelihoods assets of program participant households with their counterfactual group that did not participate. The propensity score is defined (Rosenbaum & Rubin, 1983),  $P(X)$ , as the conditional probability of receiving a treatment given pre-treatment characteristics:

$$P(X) \equiv \Pr(D = 1|X) = E(D|X) \dots \dots \dots (1)$$

Where  $D = (0, 1)$  denotes the indicator of exposure to treatment (variable for treatment group selection) and  $X$  is a vector of pre-treatment characteristics. The propensity scores are predicted with probit model (Sianesi, 2004). The assumption of the conditional independence of the score result extends the use of the propensity scores for the computation of the conditional treatment

effect. The predicted propensity scores are used to measure the treatment effect. According to (Rosenbaum & Rubin, 1983), average treatment effect on the treated (ATT) is the parameter of interest in propensity score matching analysis. Thus, ATT was used to assess the effects of participation on households' livelihood assets enhancements. As a result, given a population of units denoted by  $i$ , if the propensity score  $P(X_i)$  is known, the Average effect of Treatment on the Treated (ATT) was estimated as follows:

$$ATT \equiv E\{Y_{1i} - Y_{0i} | D_i = 1\} \dots \dots \dots (2)$$

$$= E\{E\{Y_{1i} - Y_{0i} | D_i = 1, p(X_i)\}\}$$

$= E\{E\{Y_{1i} | D_i = 1, p(X_i)\} - E\{Y_{0i} | D_i = 0, p(X_i)\} | D_i = 1\}$  Where, the outer expectation is over the distribution of  $(p(X_i) | D_i = 1)$  and  $Y_{1i}$  and  $Y_{0i}$  are the potential outcomes in the treatment (i.e. watershed management program participation) and non-treatment (watershed management program non-participation) groups respectively.

The alternative matching estimators (algorithms) such as near neighbor, radius, kernel and stratification matching were searched in matching the treatment and control households in the common support region. Comparing results across different matching methods can reveal whether the estimated program effect is robust (Rosenbaum & Rubin, 1983). Based on this, Kernel matching was used in this study to quantify the impacts of households' participation in watershed management activities on their livelihood assets. This is because, although the Kernel matching estimates of the livelihood assets effects were consistent with other methods, the outcome was slightly higher than that of the other technique.

### 7.3.2.2. Definition of variables

The dependent variable used in the model was the participation in watershed management program: A binary variable taking a value 1 if the household participated in the program and 0 otherwise. Households' livelihood assets were the outcome variable used in the model to evaluate the impact of watershed management program in the study area. In the model, households' livelihood assets were measured by overall index value of the livelihood assets (human, physical, natural, financial and social assets). The observable variables explaining the characteristics of the households are used to measure the predicted propensity scores. Farmers' involvement in watershed management program is highly a certain socio cultural, economic, demographic, institutional and physical environment context specific in its very nature

(Warner,1965; Tegene, 1992; Faham, et al., 2008; Tesfaye et al., 2014). Dolisca et al. (2006) have also shown that participation may depend on an individual characteristic such as age, gender, marital status, household size, and income. Generally, demographic, socio-economic and institutional attributes facilitate farmers' participation in the watershed management program. The variables used in this study include age, sex, family size, literacy status, total livestock(TLU) owned, distance of farmland from home, topographical location, distance of farmers' training center(FTC) from home and access to training on watershed management program.

#### *7. 4. Results of the study*

##### *7.4.1. Profiles of respondents*

Under this section, descriptive results of sample respondents' demographic, socio cultural and livelihood characteristics were presented. Mean and proportion comparison tests (independent sample t-test and  $\chi^2$  -test), respectively were used to test whether or not there is significant difference between participants and non-participants in terms of continuous and discrete variables.

Demographic characteristics such as age, sex and family size of the study households and socio economic profile of respondents were presented in (Table7.2). The mean age of the study respondents was 46.72, years with the minimum and maximum ages of 25 and 75 years respectively. The average age of watershed management program participating respondents was slightly higher (M=49.16, SD= 8.88) as compared to non participating respondents (M = 44.50, SD = 9.70) with mean age difference between the two groups being statistically significant at 1 percent significance level. The total respondents for the study were 304, out of which 264 (86.8 percent) were male and 40 (13.2 percent) were female. The proportion of male and female program non-participating and participating respondents were 138(86.8 percent) and 126(86.9 percent), and 21(13.2 percent) and 19 (13.1 percent) respectively. There was almost similar distribution among watershed management program participant and non participant households in terms of sex of the household heads. The average family size of the total sample households was 4.84 persons ranging from the minimum 1 to the maximum of 9 members. The mean family size of program participant households was relatively larger in sizes (M = 5.03, SD = 1.37) than non- participant households (M = 4.67, SD = 1.61) with mean difference being statistically

significant at 5 percent significance level. With regards to educational status, the larger proportions of the respondents (60 percent) were literate whereas the remaining (40 percent) were illiterate. Although program participants were slightly better in literacy level, there was no statistically significant percentage difference between the two groups. The average walking distances (measured in minutes) of farm land from home of the study households was (M = 11.14, SD = 4.75) with mean difference between watershed management program participants and non participants was statistically significant at 5 percent significance level. The mean walking distances (measured in minutes) of Farmers' Training Center (FTC) from home of the survey households was (M = 26.83, SD = 7.83) with mean difference between watershed management program participants and non participants was statistically insignificant. With regards to access to training on watershed management practices, the larger proportions of the respondents (77 percent) were accessed to training whereas the remaining (23 percent) were not accessed with percentage difference between program participants and non participants was statistically significant at 1 percent significance level.

Table 7.2, Demographic and socioeconomic characteristics of households

Farmers characteristics	Program participant (n = 145)	Program non-participant (n = 159)	Over all (n= 304)	t-value / $\chi^2$ -value
Age ((mean± SD)	49.16± 8.88	44.50 ±9.68	46.72 ± 9.58	-4.36***
Sex (% male)	86.9	86.8	86.8	0.979(NSD)
Family size (mean± SD)	5.03 ± 1.37	4.67 ± 1.61	4.8 ± 1.51	-2.109**
Literacy status ( % literate)	63.4	56.0	60.0	0.185(NSD)
Distance of farm land(mean walk in minutes± SD)	10.28 ± 4.20	11.93 ± 5.09	11.14 ±4.75	3.104**
Distance of FTC(mean walk in minutes ± SD)	25.97 ± 6.94	27.61 ±8.51	26.83 ±7.83	1.853(NSD)
Training on watershed program practice(% received)	93.8	61.6	77.0	44.249***
Topography(% upper)	37.2	30.2	34.0	1.692(NSD)

\*\*\*and \*\* indicate the level of significance at 1 and 5 percent, respectively

NSD: No statistical significant difference

Source: developed from survey result, 2018

The socio cultural characteristics such as ethnicity, marital status and religion of households were showed in (Table 7.3). Overall, more than (95 percent) of the households were from Oromo ethnic group while others were from Gurage ethnic group. About (95 percent) of program non participants and (95.9 percent) of the participants were Oromo ethnic group whereas, (5 percent)

of the program non-participants and (4.1 percent) of program participants were Gurage ethnic group. There was also similar ethnic distribution between program participant and non-participant household heads. The largest proportion of the respondents was married (84.2 percent) while, (4.6 percent), (5.9 percent) and (5.3 percents) of the respondents were divorced, widowed and separated respectively. About (82.8 percent) and (85.5 percent) of watershed program participants and non participants were married respectively. The marriage status distribution of respondents was also similar among program participants and non participants.

The majority of the respondents (above 52 percent) were followers of Orthodox religion followed by protestant (45 percent) and Muslim (4.9 percent). About (51.6 percent) and (52.4 percent) of the program non-participating and participating households were followers of Orthodox religion respectively, whereas, (44.7 percent) and (41.4 percent) were followers of the Protestant religion. Program non participant and participant Muslim followers were (3.8 percent) and (6.2 percent) respectively. There was almost similar distribution of religious followers between program participant and non-participant household heads.

Table 7.3, Socio-cultural characteristics of respondents

Farmers characteristics	Program participant (n = 145)	Program non-participant (n =159)	Over all (n= 304)	$\chi^2$ -value
Ethnic group (%)				
• Oromo	139(95.9%)	151(95.0%)	290(95.4%)	0.138(NSD)
• Gurage	6(4.1%)	8(5.0%)	14(4.6%)	
Marital status (%)				
• Married	120(82.8 %)	136(85.5%)	256(84.2%)	2.897(NSD)
• Divorced	6(4.1 %)	8(5.0%)	14(4.6%)	
• Widowed	12(8.3%)	6(3.8%)	18(5.9%)	
• Separated	7(4.8 %)	9(5.7 %)	16(5.3 %)	
Religion (%)				
• Orthodox	76(52.4 %)	82(51.6%)	158(52.0%)	1.109(NSD)
• Protestant	60(41.4 %)	71 (44.7 %)	131(43.1 %)	
• Muslim	9(6.2%)	6(3.8%)	15(4.9%)	

NSD: No statistical significant difference

Source: developed from survey result, 2018

#### 7.4.2. Livelihood characteristics/activities/of households

Livelihood characteristics (continuous variables) such as land holding and utilization pattern, livestock ownership and major crops yield harvested (qt/ha) were depicted in (Table 7.4). The

major land use pattern of the study respondents includes land allocated for cultivated or farm, homestead tree stocks and grazing. The average size of land holding of the respondents was found to be 2.88 hectares ranging between 1.03 and 8.36 hectares. The watershed program participating respondents was slightly higher on average land holding (3.45 hectares) with minimum average of 1.36 hectares and maximum 8.36 hectares than program non-participating respondents (2.35 hectare) with minimum average of 1.03 hectares and maximum average of 5.25 hectares. Out of the total land holding, about 2.20 hectare on average was cultivated land with minimum average of 0.77 hectares and maximum average of 7.11 hectares which covered both annual and perennial crops. The mean land size allocated to homestead tree stocks was 0.38 hectares with the minimum average of 0.00 and maximum average of 1.50 hectares. The mean grazing land holding of the respondents was 0.30 hectares with minimum average of 0.00 and maximum average of 0.75 hectares respectively.

Livestock ownership is one of the indicators used to describe the socio-economic characteristics of the respondents in the study area. The total livestock owned by the study respondents measured in terms of TLU was found to be 5.49. Program participants hold relatively larger number of livestock (5.88 TLU) than non-participants (5.13 TLU) with a statistically significant mean difference at 5 percent level of significance. During focus group discussions, the discussant stated that, because of shortage of land, most farm households are using zero grazing and the number and productive performance of animals has been declining due to shortage of feed resources.

Various crops types produced by respondents in the study area were wheat (*Triticum aetivum*), *teff* (*Eragrostis tef*), barley (*Hordeumvulgare*), beans (*Phaseolus lunatus*), peas (*Pisum sativum*), potato (*Solanum tuberosum*), chat (*Catha edulis*), *enset/kocho/warqe* (*Ensete Venter cosum*), and fruits and vegetables. Among the major crops grown in the study watershed, the higher proportion of average crop yield per hectare produced by respondents in the cropping season of 2016/17 year were wheat (10.51 qt/ha) followed by *teff* (5.52 qt/ha), barley (2.41 qt/ha) and bean (1.52 qt/ha). The program participants have better average crop yield harvested such as wheat (12.70 qt/ha), *teff* (7.22 qt/ha) and barley (2.73 qt/ha) than nonparticipants who have average crop yield harvested of wheat (8.51 qt/ha), *teff* (3.97 qt/ha) and barley (2.11qt/ha) with a statistically significant mean difference between the two groups.

Table 7.4, Livelihood characteristics of respondents (continuous variables)

Characteristics	Program participant (n = 145)	Program non-participant (n=159)	over all (n= 304)	t-value
Total land holding (ha) (mean± SD)	3.45±1.04	2.35 ± 1.04	2.88 ±1.17	-9.236***
• Cultivated /crop land(ha)	2.61 ± .85	1.82 ± .83	2.20 ± .93	-8.265***
• Grazing/fodder land (ha)	0.34 ± .19	0.26 ± .15	0.30 ± .18	-3.919***
• Homestead tree stocks land(ha)	0.50 ± .28	0.27 ± .14	0.38 ± .24	-8.778***
Major livelihood activities				
Livestock (TLU) (mean± SD)	5.88 ± 2.55	5.13 ± 1.35	5.49 ± 2.05	-3.152**
Major crop type produced (yield harvested kg/ha) (mean± SD)				
• Wheat	1270 ± 362	851 ± 302	1051± 392	-10.898***
• <i>Teff</i>	722 ± 505	397 ± 383	552 ± 473	-6.277***
• Barley	273 ± 293	211 ± 282	241 ± 289	-1.885*
• beans	194 ± 224	115 ± 308	152 ± 274	-2.533**

\*\*\*, \*\*, \* indicate the level of significance at 1, 5 and 10 percent, respectively

Source: developed from survey result, 2018

In addition to crop and livestock activities, major off/non-farm activities in the study area include handcrafting, daily labor work, remittances and petty-trade (salt, soap, food and drinks) were indicated in (Table 7.5). The survey result shows that the major off/nonfarm activities of the households include; handcrafts (such as carpenter, wood work etc.), daily labor work, petty trade (such as food and drinks, sales of salt, soap). The program participants have better access to those activities than the non participants.

Table 7.5, Livelihood characteristics of households (dummy variables)

Characteristics	Program participant (N=145)	Program non-participant (N =159)	Overall (N =304)	χ <sup>2</sup> -value
Off/non –farm activities/sources (%)				
• Hand craft	55(38%)	10(6.3%)	65(21.4%)	45.170***
• Wage earning through daily labor work	28(19.3%)	23(14.5%)	51(16.8%)	1.275(NSD)
• Petty trade(salt, soap, drinks and foods)	36(24.8%)	24(15.1%)	60(19.7%)	4.535**
• Remittance availability	15(10.3%)	20(12.6%)	35(11.5%)	0.371(NSD)

\*\*\*, \*\*, indicate the level of significance at 1 and 5 percent, respectively

Source: computed from survey result, 2018

Generally, when we observe the demographic, socio cultural, and livelihood characteristics of the study respondents discussed in table 7.2, 7.3, 7.4 and 7.5, there is a very close similarity

between the watershed management program participants and non participants with regards to all the surveyed characteristics (among others such as, sex distribution, educational status, ethnicity, religion, livelihood activities, etc.), confirming that the program non-participants may meaningfully be compared to the program participants in terms of their differences in their five livelihood assets, and that these differences may reasonably be attributed to the influence of being participating in the watershed management program.

#### **7.4.3. Livelihood asset dimensions of households**

Under this section, each indicators of livelihood assets namely natural, physical, financial, human and social assets were described at the spatial scale (across program participants and non participants). In addition, the overall sustainable livelihood asset values of both groups were described in (Table 7.6). Independent t-test was use to compare the livelihood asset values between program participants and non participants. The livelihood asset capacity structure of the study households was also depicted by Rader diagram.

##### **7.4.3.1. Natural asset**

In this study, size of land allocated for farm and homestead tree stocks, improvement on grass/fodder availability; number of livestock owned (TLU); perceived soil quality potential of farm land and improvement in water availability like springs were selected as indicators to measure natural asset. The survey results showed that over all natural asset index value of program participants was higher (0.69) than the non-participants (0.42), and this difference was statistically significant at 1 percent level. When the detail indicators index value were noticed, the program participants perceived higher soil quality potential of farm land (0.98); improvement in grass or fodder availability(0.88) and improvement of homestead tree stocks plantation(0.63) than the non participants, where (0.90), (0.12) and (0.39) of the same indicators respectively. In addition, the improvement of water resources like springs and increase in the size of cultivation of farm lands was also better in program participants. There is no difference in the size of livestock owned.

##### **7.4.3.2. Physical asset**

With regard to physical asset indicators like housing improvement and investment in housing construction and equipments; cooking fuel stove and use of solar light; necessary infrastructure development like clean water tap ; improvement and investment in production and resources that

facilitate farmers to make their livelihoods namely investment on soil and water conservation and soil fertility management technologies were used. The results showed that the overall physical asset index value of program participants (0.61) was greater than the non participants (0.39) with statistically significant difference at 1 percent level. But, both groups belong to average category of livelihood improvement. The difference between the two groups was more important for program participants in the improvement of household condition like its construction and equipment (0.89); using improved cooking fuel stoves (*lakech*)(0.42), using soil and water conservation technologies(0.94) and soil fertility management technology (0.55) than the non participants with the index of 0.77, 0.13, 0.53, 0.30 for the same indicators respectively.

#### 7.4.3.3. Financial asset

Major financial capital indicators used in this study were household' access to credit and saving services, improvement in access to wage earning activities, improvement in access to poultry production and sheep fattening activities, access to beekeeping-beehives and wax and seed and seedling availability. As revealed from the result, the overall financial asset index value of program participants (0.44) was greater than the non participants (0.28) with statistically significant difference at 1 percent level. The program participants belongs to average financial asset whereas, the non participants belongs to poor financial asset measurement scale.

#### 7.4.3.4. Human asset

For this study important indicators selected for the analysis of human asset were access to knowledge and skills through training on watershed management practices, exposure visits of best practices, perceived access to health related know how and work. As revealed from survey result, over all human asset index value of program participants was higher (0.81) than the non-participating group (0.45 percent), and this difference was statistically significant at 1 percent level. The program participants were belongs to the good category of human asset while the program non participants belong to average category of human asset improvement scale.

#### 7.4.3.5. Social asset

For this study important indicators selected for the analysis of social asset were participation in watershed management program committees, membership in self help groups and participation in watershed management program. The study result indicated that the overall social asset index value of the program participants (0.62) was better than program non participants (0.32) with

significance difference of 1 percent level. In the improvement of social asset the program participants belongs to average category whereas, the non participants belongs to poor category.

Table 7.6, Comparisons of sustainable livelihood asset at a spatial scale (between participants and non-participants of watershed management program)

Livelihood asset and its indicators	Indicator weight		t-test
	Participants	Non participants	
<b>Human asset</b>			
Access to training on watershed management	0.94	0.62	-7.38***
Access to exposure visit of model farmers	0.71	0.10	-13.63***
training on a cross cutting issues ( improved toilet, HIV AIDS)	0.79	0.64	-2.921**
<b>Asset value</b>	<b>0.81</b>	<b>0.45</b>	<b>-14.261***</b>
<b>Natural asset</b>			
Cultivated/crop land owned	0.59	0.45	-5.603***
Livestock owned (TLU)	0.48	0.49	0.114
Land allocated for homestead tree stocks plantation	0.63	0.39	-10.503***
Improvement fodder/grass availability	0.88	0.12	-20.080***
perceived status of soil quality potential	0.98	0.90	-5.991***
Increase in water sources availability (springs)	0.57	0.19	-7.286***
<b>Asset value</b>	<b>0.69</b>	<b>0.42</b>	<b>-19.075***</b>
<b>Physical asset</b>			
Housing improvement (construction, equipment, etc.)	0.89	0.77	-5.997***
Improved cooking fuel stove use /Lakech/	0.42	0.13	-6.034***
Improvement in use of solar light	0.41	0.26	-2.898**
Increase access to clean water tap	0.45	0.33	-2.174**
Soil and water conservation measure(soil bund)	0.94	0.53	-9.202***
Soil fertility management measure (compost)	0.55	0.30	-4.523***
<b>Overall Asset value</b>	<b>0.61</b>	<b>0.39</b>	<b>-10.250***</b>
<b>Financial asset</b>			
Access to credit services	0.88	0.65	-4.863***
Wage earning from watershed activities	0.19	0.15	-1.122
Poultry production and sheep fattening	0.49	0.35	-2.438**
Access to beekeeping - beehives and wax	0.44	0.21	-4.319***
Access to seeds and tree seedlings for sale	0.17	0.02	-4.613***
<b>Asset value</b>	<b>0.44</b>	<b>0.28</b>	<b>-6.811***</b>
<b>Social asset</b>			
Participating in the watershed committees	0.71	0.37	-6.294***
Membership in self help groups	0.29	0.05	-5.752***
status of participation in watershed management program	0.85	0.53	-15.246***
<b>Asset value</b>	<b>0.62</b>	<b>0.32</b>	<b>-13.128***</b>
<b>over all livelihood asset value</b>	<b>0.63</b>	<b>0.37</b>	<b>-22.147***</b>

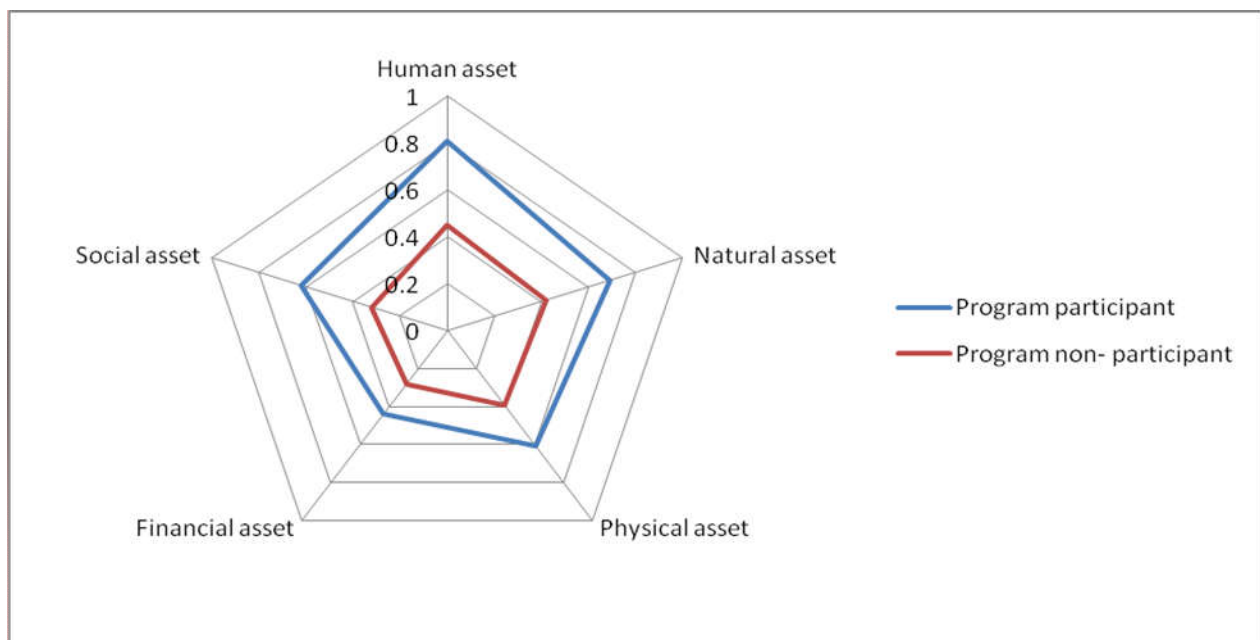
\*10 % significance, \*\* 5% significance , \*\*\* 1% significance

Source: survey result, 2018

#### 7.4.3.6. Overall livelihood assets value of households

Comparison of livelihood asset pentagon of watershed management program participants versus non-participants was made by radar diagram plotted by inserting the overall index value of the five livelihood assets (Figure 7.2). The pentagon gives information about people's assets presented visually, thereby bringing to life important inter-relationships among various assets. From the diagram, it can be observed that this capacity is skewed and does not form a perfect pentagon for both program participants and non participants. The asset with the highest capacity is the human asset (0.81), followed by natural asset (0.69), social asset (0.62), physical asset (0.61) and financial asset (0.44) for program participants (Table 7.6, Figure 7.2). The financial asset has the least capacity index compared to others. Similarly, for the program non participants, the asset with the highest capacity is human asset (0.45), followed by natural asset (0.42) (Table 7.6; Figure 7.2). The financial asset has the least capacity index compared to others. The aggregated values of livelihood asset were (0.63) and (0.37) for program participants and non participants respectively (table 7.6).

Figure 7.2, Comparison of overall livelihood asset value across a spatial scale (between program participants and non-participants)



Source: Constructed from survey result, 2018

#### 7.4.4. Impacts of watershed management program on households' livelihood assets

In this section, the study provides results about estimation of the propensity scores, region of common support, optimal number of blocks and test of balancing property, and estimates of watershed management intervention impacts.

##### 7.4.4.1. Estimation of the propensity scores

The result of multicollinearity test using the values of the variance inflation factor (VIF) showed that there was no serious problem of multicollinearity (Appendix Table A). The probit estimate result appeared to perform well for the intended matching exercise. The pseudo-R2 value of (0.2476) showed that the competing households do not have many distinct characteristics overall, so that finding a good match between the treated and non-treated households becomes easier. The maximum likelihood estimate of the probit regression model result showed that program participation status has been significantly influenced by six variables (table 7.7). These include age of household head, distance of farm land from home, distance from office of extension agents, training on watershed management, number of livestock holding in tropical livestock unit and topographical location (Table 7.7).

Table 7.7, Probit regression /estimates of propensity score

Variables	Coef.	Std. Err.	z	P>z
Age of the household head	0.036***	.0091234	3.90	0.000
Sex of the household head	0.191	.2438926	0.78	0.434
Family size	0.082	.056614	1.44	0.150
Literacy status	0.125	.1677539	0.74	0.458
Total livestock owned(TLU)	0.165***	.0455181	3.63	0.000
Distance of farmland form home	-0.056**	.018109	-3.08	0.002
Topographical location	0.587**	.1950993	3.01	0.003
Distance of FTC from home	-0.034**	.0116747	-2.95	0.003
Training on watershed program	1.427***	.2303283	6.20	0.000
_cons	-3.070	.7660712	-4.01	0.000

Number of obs. 304, LR chi2(9) =104.17, Prob >chi2= 0.0000, Log likelihood = - 158.30823, Pseudo R2 = 0.2476

\*\*\* and \*\* indicate the level of significance at 1 and 5 percent, respectively.

Source: Model output, 2018

#### 7.4.4.2. Region of common support

The minimum and maximum comparison was made for setting the common support conditions. The basic criterion for determining the common support is to delete all observations whose propensity score is smaller than the minimum of the program participants and larger than the maximum in the program non participants (Caliendo & Kopeinig, 2008). The estimated propensity scores as shown in (Table 7.8) vary between 0.1027723 and 0.9638067 (mean = 0.5332895) for program participant households and between 0.0018643 and 0.904725 (mean = 0.45329765) for the program non-participant households. Therefore our common support region would then lie between 0.10277226 and 0.96380666. As a result of this restriction, 36 households from program non participant were dropped from the analysis in estimating the average treatment effect on the treated.

Table 7.8, Distribution of estimated propensity scores

Groups	Obs.	Mean	Std. Devi	Min	Max
Total	304	0.48	0.275	0.002	0.964
Program participant	145	0.63	0.216	0.103	0.964
Program non-participant	159	0.33	0.243	0.002	0.905

Source: model output, 2018

#### 7.4.4.3. Optimal number of blocks and test of balancing property

The final number of blocks was 5 and this number of blocks ensures that the mean propensity score is not different for treated and controls in each blocks. A test of the balancing property was also conducted and the results of the model showed that matching property was satisfied. This implies that the distribution of the conditioning covariates did not differ across the treatment and comparison group in the matched samples.

#### 7.4.4.4. Estimating watershed management intervention program impacts

After controlling for other characteristics, the propensity score matching model using the kernel matching estimator result indicated the existence of a positive additional significant livelihood assets value of 24.8 % for program participants compared to non-participants (Table7.9). This indicated that on average participant households showed 24.8 % percent more improvement in livelihood assets value than non participants. This result strongly suggested that households'

participations in watershed management program have shown a positive sign and could be a pathway for improvement in the livelihood of rural households in Ethiopia. Policymakers and planners should promote households' participation in watershed management activities by providing adequate socio economic as well as institutional facilities needed by the households.

Table 7.9, ATT for outcome variables of interest

Kernel Matching Method						
Treatment	Outcome variable	Number of Treated	Number of control	ATT	Std. Err.	t-value
Participation	Overall index value of the livelihood assets	145	123	0.248	0.011	22.435***

\*\*\* indicates the level of significance at 1 percent level

Source: model output, 2018

## 7.5. Discussions

### 7.5.1. Livelihood asset dimensions of households

#### 7.5.1.1. Natural asset

The survey results showed that over all natural asset index value demonstrated the positive efforts of watershed management program. The program participants belong to good category while the non participant group belongs to average category of measurement scale. The result conform with the study by Bewket (2003) in the Chemoga watershed that farmlands with watershed management program has had shown improvement as compared with farmlands without watershed management program. In addition it also agreed with the study by Rigg (2006) who stated that availability and quality land is the most valuable asset for farming population and water as natural capital provides support for livelihood improvements of households through provision healthy ecosystem. Results of focus group discussion and interview reported that, watershed management intervention have had enabled reclamation or restoration of degraded land into an improved production state which of course is positive and desired, but the demand for land would increase pressure to areas enclosed that affect the sustainability of resource conservation. On the other hand, although very much efforts to plant trees, continuous follow up and maintenances was low. Therefore, natural capital asset has much more space to improve in the study area.

#### 7.5.1.2. Physical asset

The study results showed that over all physical asset index value demonstrated the positive efforts of watershed management program. But, both groups belong to average category of livelihood improvement. This result agreed with the study by Barungi, Ng'ong'ola, Edriss, & Mugisha (2013) in Eastern Uganda that revealed farmers with the support of watershed management program invested significant quantity of labor for the construction of physical soil and water conservation program such as soil and stone bunds. It also conform with the study stated that access to modern energy such as cooking fuel stoves and solar light has been necessary condition towards the economic, social and environmental development of human development (Byrne, Zhou, Shen, & Hughes, 2007). The use of alternative energy sources will optimize the household energy structure and decrease the amount of firewood used. The access to safe drinking water also vital for human wellbeing (Curtis et al., 2011). Focus group discussant and interview also confirmed that there are differences in the improvements of physical asset indicators.

#### 7.5.1.3. Financial asset

The survey results showed that overall financial asset index value demonstrated positive improvements for watershed management program participants as compared to non participants. Better differences were indicated in access to credit services, poultry and beekeeping activities for program participants than non participants. This result conform with the study stated that financial services stimulate economic growth and have a positive impact on livelihood of households (Claessens, 2006). The main income sources of households were agriculture both crop and livestock production and in addition *chat* and *ensset* plays important role in households' income sources. During field observation and focus group discussion and interview, beekeeping and wax, poultry, sheep fattening, nursery establishment and selling tree seedlings were considered as an alternative income generating activities by watershed management program. However, as the focus group discussant and key informant interview stated the activities had not generated sufficient economic benefits and up scaled yet due to lack of technical and financial support from the government. With regards to credit services, our study indicated that, the main sources of credit for both program participants and non participants were micro finance institutions. As indicated during focus group discussion and key informant interview, in an

attempt to address the need for credit, the program provided credits in the form of inputs needed for each type of livelihood activity. The inputs include sheep, hens, modern bee hives, wax, fuel saving stoves and others. But as stated during focus group discussion, it was not sufficient for further activities to generate additional income.

#### 7.5.1.4. Human asset

The survey results showed that overall human asset index value demonstrated positive improvements for both watershed management program participants as compared to non participants, although there were differences between the two groups. Highest improvement in human capital was attributed to better access to knowledge and skill developed through access to training and extension services. The knowledge and skill improvement was a direct result of various training sessions provided under the program. This result agreed with the study stated that skills, knowledge, labor and good health constitutes the core of the human capital (DFID, 1999; UNDP, 2003). During focus group discussion and key informant interview, these trainings aimed at improving program participants' knowledge and skills as well as decision making capacities in soil and water conservation technologies. It also enhanced awareness creation on alternative income generating activities (e.g. tree nursery establishment, beekeeping, hand craft works, honey and species processing and marketing); credit and saving services and raised participants' awareness of conservation and rehabilitation of degraded areas.

#### 7.5.1.5. Social asset

The conceptualization of social network in the context of the watershed management program refers to a strategy designed to bring about enhanced and active participation towards environmental conservations through the improvement of livelihoods in the watershed. It is increasingly being recognized that social asset has high influence on success of adoption of improved watershed management interventions (Noble, Bossio, Penning de Vries, Pretty, & Thiyagarajan, 2006). To that end, watershed committee, cooperatives, self help groups, associations and production groups have been established with the main objective of improving households' livelihoods through the integration of interventions into the conservation of natural resources. The findings of the study showed that program participants gained highest social asset mostly related to increase participation in watershed management program practices and creation

and strengthening of associations like self help groups and membership in watershed committee than program non-participants. This study result conform with the study indicated that social resources in the form of networks and connections that increases the ability of people to work together enhances for livelihoods (DFID, 1999; Spence & Smith, 2010). During focus group discussion, it was indicated that, although different associations were formulated and to some extent work, they were not fully functional due to lack of support and follow up and the benefits were limited to some groups like youth and female.

#### 7.5.1.6. Over all livelihood asset value of households

The findings of the study implied that households have more of human assets, natural assets and social and physical asset while they have less of financial asset, implying that study households have low economic production potentials and ownership or control of physical capital generated by the program. This structure was not sustainable because it is not represented by a perfect pentagon which should best describe a sustainable livelihood status. The result of the comparison revealed that program participants had better overall access than non participants but both belong to the average category of livelihood asset measurement scale. The difference was better for program participants in all dimension of livelihood assets value. This suggested that there are gaps in the improvement of the five dimensions of livelihood asset in the study area, so that it needs emphasis to enhance the household asset for sustainable livelihood improvement of households. This result agreed with the study by (Udoh, Akpan, & Uko, 2017) on sustainable livelihood assets of farming households in Nigeria found that, livelihood structure of households is not sustainable because it is not represented by a perfect pentagon which should best describes a sustainable livelihood status. This study also agreed with the study in northern China that showed that Community Based Co-Management (CBCM) projects on forest (as an aspect of watershed management) changed the livelihood assets of local community residents, including each aspect of the five types of livelihood asset capital (Chen et al., 2013). The changes in livelihood assets between participators in CBCM projects and non-participators are significantly different. The study in Bangladesh similarly agreed with this study showed that participatory forestry programs have had a positive impact on the livelihood assets of the participants and their entire five livelihood assets showed increasing trends compared to non-participants (Islam et al., 2014).

## 7.5.2. Factors affecting program participation status and impacts of watershed management on livelihood assets

### 7.5.2.1. Factors affecting program participation status

The maximum likelihood estimate of the probit regression model of program participation status has been influenced by various factors (Table 7.7). Age of the household head affected participation positively at 1% level of significance. Meaning those older household head might have better farm experience and have high chance of being participant. Amsalu & de Graaff, 2007, who conducted their study in an Ethiopian highland watershed, found a positive relation between age and the adoption of stone terraces. Reports by Gebregziabher et al.(2016) also states that older farmers could have more experience that helps them to perceive erosion problems and participate in watershed management practices. Training on watershed management program affected participation positively at 1% significance level. This is to mean households having training on watershed management program have better chance of being participant. Farmers' access to training, has a positive correlation and significant with the participation in watershed management practices (Tiwari, Sitaula, Nyborg, & Paudel, 2008; Asfaw & Neka, 2017). Number of livestock owned also affected participation positively at 1% significance level. Meaning those household heads who have more number of livestock are more likely to be a participant in watershed management program. This conform with the study by Shiferaw & Holden(1998), who suggested that large livestock owned has a positive influence on participation in conservation work as it serves for manure and income or wealth, wealthy landholders are less risk averse and are more likely to participate in watershed management practices.

Whereas the distances of farmers' training center (FTC) from their home and distance of farm land from homestead determine the participation negatively at 5% significance level. Meaning that living relatively near the office of extension agents and farm land has high chance of being participant. Study by Tiwari et al.(2008), reported that longer walking distance between farmlands and household residences correlated significantly and negatively to the adoption of watershed management practices. This is because farmlands and training center far away from homesteads require more time and energy for the conservation of farmlands. Similarly, Gebremedhin & Swinton (2003), also confirmed that far away farmlands discouraged adoption

of watershed conservation practices. Similarly, topographical location of farmers influenced the probability of watershed management program participation positively and significantly at 5%. Villages that have more steeply terraces, the farmers are more likely to adopt watershed conservation technologies (Amsalu & de Graaff, 2007; Tiwari et al., 2008).

#### 7.5.2.2. Estimating watershed management intervention impacts

The empirical findings of the study showed that watershed management program has a significant contribution in increasing households' livelihood assets. Estimates of propensity score matching model using the kernel matching estimator result showed the existence of a positive significant livelihood assets value for program participants compared to non-participants. This result implied that households' participations in watershed management program have shown a positive sign and could be a pathway for improvement in the livelihood of rural households in Ethiopia. Hence, policymakers and planners should promote households' participation in watershed management activities by providing adequate socio economic as well as institutional facilities needed by the households. This study agreed with the study by Kabubomariara, Linderhof, Kruseman, Atieno, & Mwabu (2010), who revealed that watershed management programs have positive and significant impact on households' livelihoods. Reports by Olarinde et al.(2011) also revealed that watershed management programs have positive and significant impact on households' livelihood activities.

#### 7.6. *Conclusion and policy implications*

This study examined the state of sustainable livelihood asset (natural, physical, financial, human and social assets) at spatial scale (between program participant and non participant groups in upper Gibe basin of Rebu watershed, south west Ethiopia, using sustainable livelihood framework. The findings of this study revealed imbalance in the five principal assets for respondent households in the study area for both program participants and non participants. The result showed that financial capital was a serious constraint among respondents. The aggregated values of overall livelihood asset were better for program participants than non participants, but, both belong to the average category of livelihood asset measurement scale. The difference was better in all index value of different dimensions of livelihood assets for program participants.

The study also empirically showed that watershed management program has a significant contribution in increasing households' livelihood assets. But, as the probit model result showed; age of household head, livestock ownership, distance of the farmers' training center from the home, distance of farm land from home of framers, topographic location and training on watershed management program were the major factors of group (program participants and non participants) differences. Estimates of propensity score matching model using the kernel matching estimator result indicated the existence of a positive significant livelihood assets value of 24.8 % for program participants compared to non-participants. Hence, it can be concluded that in developing economies where agriculture is the dominant economic activity like Ethiopia, watershed management program is crucial in improving the livelihoods of the households. This indicates an encouraging sign for watershed management program designers and implementers to address the sustainable development goals such as, among others, poverty reduction, improving ecosystem services and improving households' sustainable livelihoods.

The study results have shown important policy implications. First, though there were promising improvements in the livelihood asset of households, still there is space to enhance the livelihood assets of program participant group while ensuring the sustainable management of natural resources. For instance, many efforts needed to enhances the financial, physical and social assets to support livelihood benefits and long-term sustainability of natural resources. Secondly, the program could be extended and up scaled to all areas, so that the program non participants have got opportunity to improve their livelihood assets. Policy makers and development practitioners have to focus on the aforementioned factors of group differences.

## **PART IV: SYNTHESIS, CONCLUSION AND IMPLICATIONS OF THE STUDY**

**Chapter 8:** Towards Sustaining Watershed Management Practices in Ethiopia: A synthesis of Local Perception, Community Participation, Adoption and Livelihoods

**Chapter 9:** Conclusions, Research and Policy Implications and the Way forward

**Chapter 8:** Towards Sustaining Watershed Management Practices in Ethiopia: A synthesis of Local Perception, Community Participation, Adoption and Livelihoods

## Abstract

The sustainability of the environmental management programs such as watershed intervention program relies on the understanding of the nexus of the community's perception, participation, and livelihoods. However, there are little studies on the interactions of these very important parameters. This study examined the nexus of farmers' perception, participation, livelihoods and their implication for sustaining watershed management program in Ethiopia, case of upper Gibe basin. To this end, household survey, focus group discussion and key informant interview were employed to collect and analyze the data. Likert-scale was used to rate the indicators or items of perception, participation, socio-ecological indicators; Coefficient of Cronbach alpha was used to test the reliability of items; Independent t-test was used to compare the mean value of livelihood assets between program participant and non-participant households and Radar diagram was used to depict the overall livelihood assets value. Descriptive (mean, percentage) analysis was used to summarize the results of local perception, community participation, socio-ecological benefits of watershed management while, chi-square statistics were applied to analyze the association between important components of watershed management such as local perception, community participation, intensity of adoption and livelihoods. The results of the study indicated that local communities were well aware of the degradation of watershed as a problem constraining agricultural production in their farm lands and surrounding landscapes. Problems of watershed degradation were better perceived in the upper and middle topographic settings and for watershed program participant households implying the need for site-specific appropriate watershed management alternatives. While the ecological benefits of watershed management were perceived better in the upper topographic areas, the socio economic benefits were in the middle and lower areas suggesting an integrated approach to address the biophysical and socioeconomic conditions. The overall community participation index value showed moderate levels of participation indicating that only some decisions were taken in consultation with local people. Specific adoption rates for many of the practices and the intensity of adoption were low. There were gaps in the progress of the five dimensions of livelihood assets-human, natural, financial, social, physical. The interaction of perception, participation and livelihoods in watershed management practices suggested more participatory and integrated approach need to be encouraged to upscale and sustaining of watershed management practices. Less awareness and extension services, lack of finance, interest in short-term agricultural production are the major challenges constraining the sustainability of watershed management. Hence, local administrators and planners need to recognize heterogeneity in households' socio economic and topographic specific characteristics as well as the aforementioned constraints so as to involve community fully in various activities of watershed management.

**Keywords:** Watershed management; perception; participation; livelihoods; sustainability; Gibe basin of Ethiopia

### *8.1. Introduction*

Ethiopia is one of the sub Saharan African countries where watershed deterioration in the form of soil erosion and soil nutrient depletion, particularly in the highlands, are the threatening factors affecting biophysical and livelihoods of people (Asmame & Abegaz, 2017; Mekuriaw, Heinimann, Zeleke, & Hurni, 2018). The region of the south western highlands of Ethiopia in which the study area is found is not far different from the national scenario. Recent estimates by Hurni et al (2015), indicated rates of 20 Mg ha<sup>-1</sup> year<sup>-1</sup> on currently cultivated land and 33 Mg ha<sup>-1</sup> year<sup>-1</sup> on formerly cultivated degraded land. These losses are mainly caused by human activity that might be associated with rapid population growth and the need to maximize agricultural production which is the economic mainstay for the overwhelming majority of people (Gessesse et al., 2016; Mekuriaw et al., 2018). This would result in not only decreases in land productivity but also accelerated ecological degradation and increased social problems (Darghouth et al., 2008).

The conservations of soil and water have got policy attention in Ethiopia only since the early 1970s (Haregeweyn et al., 2015; Gebregziabher, et al., 2016; Gessesse, et al., 2016). At the initial stages, the program emphasis on physical planning units, lack of integration and adequate participation of stakeholders in watershed management practices (L. A. German et al., 2006). Consequently, the watershed management approach- comprehensive approach integrating both resource conservation and rural livelihood development has gained increasing momentum as a promising approach since the 1980s (Desta, Carucci, Wendem-Ageñehu, & Abebe, 2005; Evans, Giordano, & Clayton, 2012). And now the country adopted community-based participatory watershed development as its main guiding principle (Desta et al., 2005). As a result, large areas have been converted to terraces, covered by soil bunds, closed by area closures and planted with millions of tree seedlings.

However, watershed degradation in the form of soil erosion and soil fertility decline, and unsustainable use of natural resource base is still continuing ( Raes et al., 2007; Haregeweyn et al., 2015). This is due to the fact that, the conservation and management of watershed natural resources was basically emphasizing only on physical planning, over looked local perception, lack of adequate stakeholders' participation, and little attentions given to livelihood perspectives (Desta et al., 2005; German, et al., 2006; Teklewold, Kassie, & Shiferaw, 2013; Kerse, 2018).

The need to achieve effective and sustainable watershed management need careful analysis of the social and environmental dynamics to successfully address livelihood and conservation concerns ( Raes et al., 2007; Haregeweyn et al., 2015). In addition, suitable and/or appropriate watershed management strategies need to be promoted to enhance sustainable development of ecological balance and improvement in livelihood of households (Morgan, 1985; Adimassu, Kessler, & Hengsdijk, 2012).

Although, watershed deterioration problems and management practices are an increasingly discussed phenomenon in the scientific literature as evidence of its presence and impacts continues to grow (Steffen et al., 2011; Zalasiewicz, Williams, Haywood, & Ellis, 2011), there is lack of concerted focus on psycho-social and livelihood perspectives. Indeed, most research to date has focused on the biophysical aspects of environmental problems and/or assessing implementation of watershed conservation measures ( Nyssen et al., 2010; Schmidt & Tadesse, 2012; Taye et al., 2015; Tadesse et al., 2017). In addition, much watershed conservation related research in Ethiopia is focusing on economic returns ( Nyssen et al., 2007; Kassie, Köhlin, Bluffstone, & Holden, 2011). Furthermore, a more specific conceptual framework that explains the nexus of the perception, community participation, and livelihoods towards sustained watershed management program is rarely found. Therefore, an understanding of the nexus of perception, community participation and livelihood remains a critical input in the design, planning, and implementation of successful watershed management strategies (Schwilch et al., 2012; Patt & Weber, 2014). It brings to the fore the appreciation of integrated perspectives of the aforementioned principal components of watershed management towards sustainable watershed management. It also offers important reflections for future participatory schemes. Hence, this study looked at the nexus of very important components of watershed management such as perception, participation, and the subsequent socio-ecological and livelihood and their implication for sustaining watershed management program. Addressing the components all together provide an essential input to enlarge participatory and integrated approach for the up scaling and sustaining of watershed management practices.

## *8.2. Conceptual framework*

The framework briefly explains the essential components of watershed management such as local perceptions, community participation and livelihoods and their nexus towards watershed towards sustainable watershed management practices as shown in Figure 8.1

### *8.2.1. Perception of watershed degradation*

Local perception, that is, perception held by people in a particular locality derived through observation and experience (Sinclair & Walker, 1999), has often been found to be largely complementary to global scientific knowledge on soils and environmental change (Berkes, 2009). An understanding of the degree of public awareness of watershed degradation problems and conservation measures, which is directly related to knowledge and perceptions of farmers (Herweg, Steiner, & Slaats, 1998), is of critical importance in order to integrate local experiences with scientific evidences. Farmers' perception of watershed deterioration is also essential to reverse the trend of increasing watershed deterioration (Yitaferu, 2007; Tefera & Sterk, 2010; Campos et al., 2012; Tamene, Adimassu, Aynekulu, & Yaekob, 2017). Local perception of watershed deterioration may well determine their behavior toward participating in the sustainable management of natural resources (Stern, 2000; Vignola, Koellner, Scholz, & McDaniels, 2010). For example, study by Assefa & Bork (2016) indicated that the decisions of farmers to use and manage natural resources highly depend on their perception of the landscape.

### *8.2.2. Community participation in watershed management*

Community participation remains a critical input in the design, planning, and implementation of successful watershed management strategies that are adequate for local realities, be they social, cultural, or environmental (Human & Davies, 2010; Schwilch et al., 2012; Patt & Weber, 2014). It is also essential for sustainable resource conservation and livelihood improvement of people (Agrawal & Gupta, 2005; Bandara & Thiruchelvam, 2008 ; Newig & Fritsch, 2009; Ferranti, Beunen, & Speranza, 2010). For instance, people's participation in the program affects the selection and continued use of watershed conservation practices (Bandara & Thiruchelvam, 2008), helps to ensure the sustainability of a watershed management program and increases acceptance, makes environmental policy more cost efficient and effective (Ferranti et al., 2010); reduces conflicts with local authorities( Newig & Fritsch, 2009), and promotes better governance; builds trust between community and institutions and develops a sense of responsible

ownership (Agrawal & Gupta, 2005). However, watershed management intervention plans in Ethiopia to date have not considering and have often overlooked such abilities of local farmers (Snyder et al., 2014). Participation is taken as mere labor contributors (Bewket & Sterk, 2002; Haregeweyn et al., 2015). In fact, farmers' involvement in development program is highly a certain socio cultural context specific in its very nature which affected by demographic, socio-economic and institutional attributes and remains a critical input in the design and implementation of management of watershed resources (Tesfaye, Deneke, Selassie, Deneke, & Selassie, 2014)

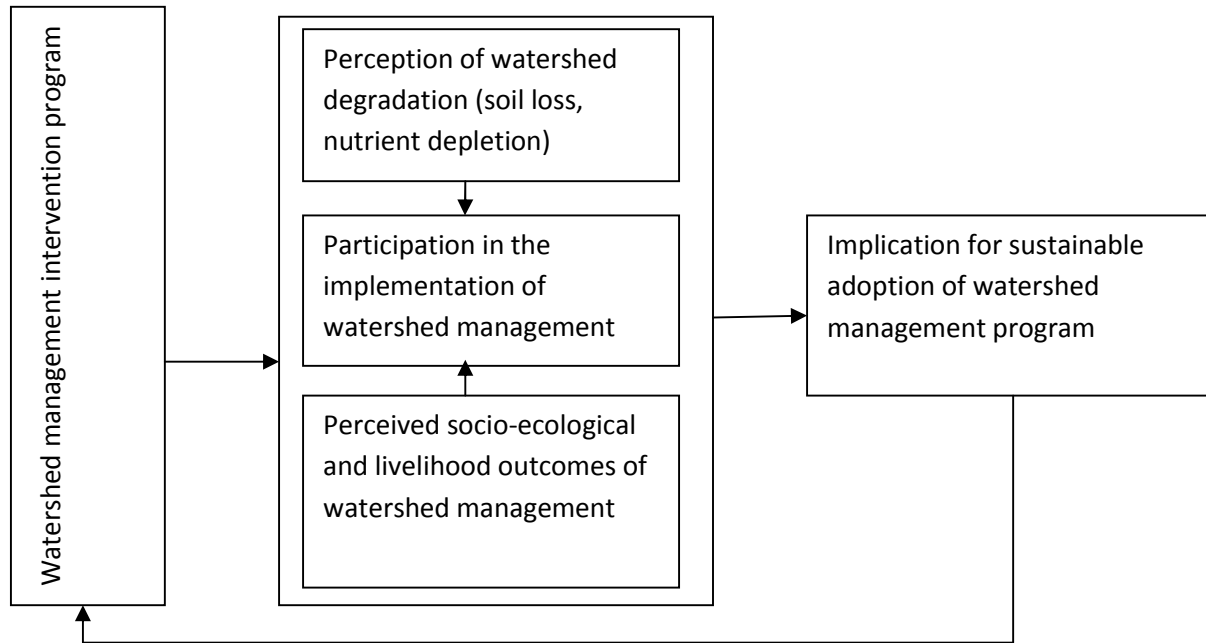
### *8.2.3. Socio-ecological and livelihood implications of watershed management*

Watershed management practices have various socio economic and livelihood impacts. For example, results from various literatures have shown that the participation and adoption of watershed management program has had augmented income, generated rural employment, increased crop yields, enhanced cropping intensity, reduced run-off and soil loss, increased groundwater, increased skills and knowledge, enhanced social capital, reduced poverty, augmented livelihood assets, increased dairy cow milk and honey bee yield ( Vancampenhout et al., 2006; Nyssen et al., 2007; Joshi, Jha, Wani Suhas, Sreedevi, & Shaheen, 2008; Barron et al., 2009; Chen et al., 2013; Assan & Beyene, 2013; Islam, Quli, Rai, & Ali, 2014; Yaebiyu, Tesfay, & Assefa, 2015; Tadesse, Suryabhagavan, Sridhar, & Legesse, 2017; Mekuriaw, 2017). These in turn, essential to increase the uptake and sustained use of watershed management and conservation measures (Bartman et al., 2007). It also enhances access to grass, knowledge and skills, income diversification (Assefa, et al., 2018), increases farm income, reduces risk of crop failure, improves access to health and education, empowered women and enhances various activities such as apiculture, livestock fattening and irrigation (Gebregziabher et al. 2016); increased crop yields and income generating activities (Vancampenhout et al., 2006; Nyssen et al., 2007; Gebregziabher, et al., 2016; Tesfaye, et al., 2018). Furthermore, watershed management practices affect aspect of the livelihood assets- social, human, physical, natural and financial (Chen et al., 2013; Islam, Quli, Rai, & Ali, 2014).

#### *8.2.4. The nexus of local perception, participation, livelihoods and their implication for sustaining watershed management program*

Understanding the nexus of local perception, participation and livelihood perspectives of the watershed management practices are the decisive element for the success of a watershed management intervention (Bekele & Drage, 2003; Bewket, 2007; Bewket & Teferi, 2009; Demelash & Stahr, 2010; Kassie, et al., 2015; Haregeweyn et al., 2015). Perception of watershed deterioration through soil erosion and soil nutrient depletion, and outcomes of the watershed management intervention program motivated farmers to participate in watershed conservation and management practices (Sallu, Twyman, & Stringer, 2010; Pulido & Bocco, 2014; Tesfa & Mekuriaw, 2014). The participation in watershed management is essential component for sustainable resource conservation and livelihood improvement of people (Agrawal & Gupta, 2005). Improvement in socio-ecological and livelihoods through watershed management remains a critical input to increase the sustainability of watershed intervention strategies (Kassie, et al., 2015; Adimassu, Langan, Johnston, Mekuria, & Amede, 2017). This inturn affects the use, upscaling and maintenances of watershed mangemnt practices as well as enhnacemets of environemnt and livelihoods of people. This implies that positive perception, better design and adoption of sustainable land management policies so that rural households can move towards participating more in planning and policy formulation for the sustainable watershed use and land management practices, as well as more sustainable agricultural livelihoods over the longer term.

Figure 8.1, Linkage of perception, community participation, socio-ecological and livelihoods outcomes and their implication to sustainable adoption of watershed management program



### 8.3. Methodology

#### 8.3.1. Measurement of indicators and Method of data analysis

The data were encoded and analyzed using SPSS (SPSS version 20) and Stata statistical software (Stata version 12). Watershed degradation (soil erosion and soil fertility decline indicators) perception was determined by asking each household to rate very low, low, medium and high and very high, with corresponding rates of 1, 2, 3, 4 and 5 respectively using a five point Likert scale (Likert, 1932a) for positive statements and reverse scoring for the negatively worded items. The perceived ecological and socio economic benefits of watershed management programs was determined by asking households to rate (1=strongly disagree, 2= disagree, 3=neutral/undecided, 4 =agree and 5=strongly agree for each of the purposes to what extent they agree with indicators. Community participation in the watershed management program was also determined by asking farmers to rate each statements using a five point Likert scale i.e. (1) = very low; (2) = low; (3) = neutral; (4) = high; and (5) = very high and reverse scoring was done for negative statement (Likert, 1932a). Classification of participation index into three categories- low, moderate and high level were adopted based on (Bagdi & Kurothe, 2016), which based on normal distribution

curve and standard deviation(SD). That is, when the value falls within the range, 0 - 0.34, and 0.35- 0.68, the participation index classification is considered as low and moderate respectively, and when the value is greater than 0.68, the participation index classification is considered as high. Various scaling and indexing method was employed for livelihoods assets measurements based on Udayakumara & Shrestha (2011), Chen et al (2013), Islam et al (2014). Independent t-test was use to compare the livelihood asset values between program participants and non participants. The livelihood asset capacity structure of the study households was also depicted by Rader diagram.

All the items/indicators for perception of watershed degradation, socio-ecological and socio economic outcomes and community participation were identified and obtained mainly through discussion with local farmers during the transect walk and discussion with program experts and officials. Cronbach alpha was used to assess reliability or internal consistency of the items for soil erosion and soil fertility decline indicators (0.872), ecological and socioeconomic benefits of watershed management practices (0.878) and community participation in the watershed management program (0.915). The Cronbach alpha values from 0.7 to 0.9 are considered a good indicator of the reliability of items in a composite measure (Cronbach, 1951).

Responses to each of the statements were summed, resulting in an overall score for each respondent and therefore, using the Likert scoring method, point scores from the respondents were calculated for each statement. For description purpose, the overall score was obtained by adding up all the scores from all the participants and the total score was expressed as a percentage of the maximum possible score for all the statements. Score given by each respondent for all indicator statement of each perception, participation, socio-ecological benefits, and livelihoods were added up. Then average score was obtained by dividing the obtained actual score to the maximum possible score. Then using the obtained mean score, the overall score value was dichotomized into a dummy variable (values greater than average is coded as 1, while value less than average is coded as 0) for each perception, participation, socio-ecological benefits. This categorization does not affect the size and significance of main effects, types of association, and interactive effects (Manor, Matthews, & Power, 2000; Greene, 2002). This is to determine the association between perception, participation, watershed management outcomes and adoption of watershed management towards sustainable watershed management.

Descriptive analysis (mean, percentage) was employed by using various qualitative criteria and weightings based on soil degradation indicators, outcomes of watershed management program, community participation indicators, adoption and livelihoods. Pearson Chi-Square Test was employed to determine the association between perception, participation, decision to adopt watershed management practice and livelihood enhancement. The qualitative data gathered from key informant interviews and focus group discussions were analyzed through interpretation, conceptualization and some quotes. This used to supplement information obtained from household survey.

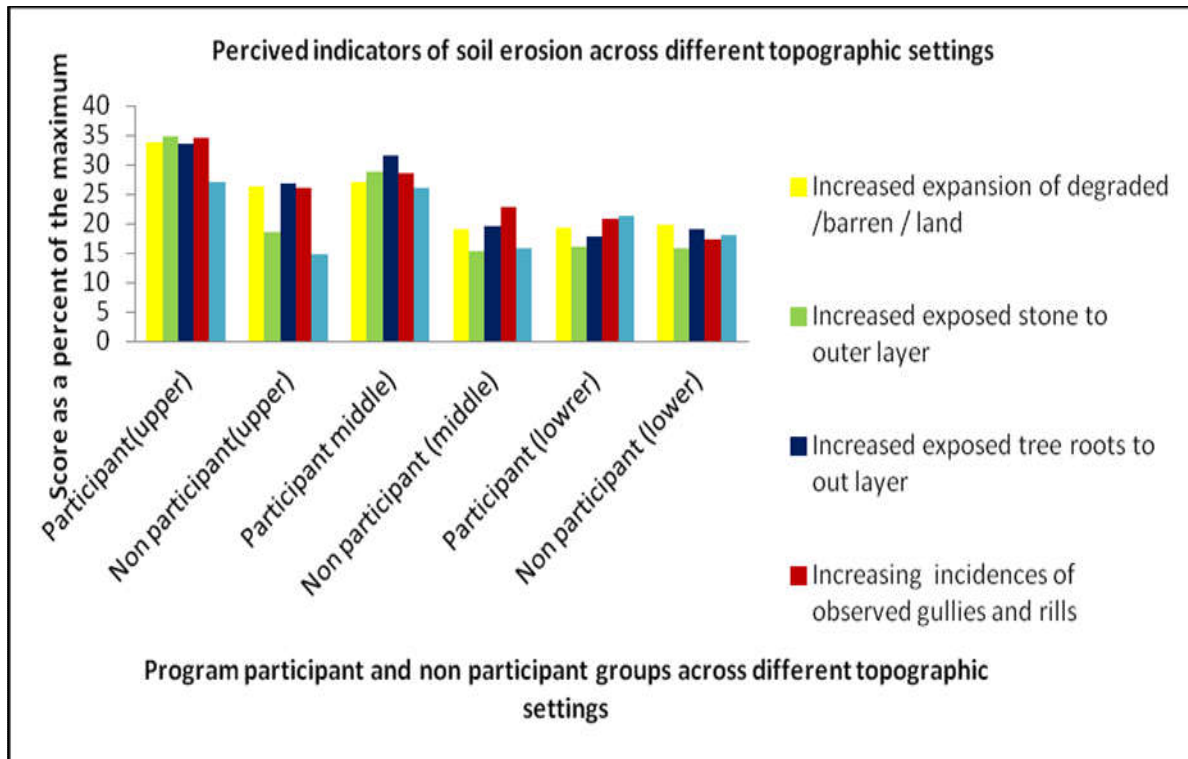
#### *8.4. Results of the study*

##### *8.4.1. Perceptions of watershed degradation*

###### *8.4.1.1. Soil erosion problem*

Under this section soil erosion severity, causes and indicators were presented. The result of the study indicated that local communities are well aware of the problem of ongoing soil erosion. About 96.4 percent of the sampled respondents experienced soil erosion problems on their land and surrounding landscapes. Farmers believe that soil loss is highly influenced by topographic settings and is considered to be variable between upper, middle and lower settings. As cited by farmers, soil erosion severity is more in the upper and middle topographic settings than in the lower one due to cultivation of steeper topographic settings, runoff associated to high and intensive rain, overgrazing, deforestation and poor farming practices. The massive soil erosion by flood and farming on the hilly and higher slopes and livestock population pressure has contributed for both soil and pasture degradation which necessitates watershed interventions. According the farmers, the major indicators of soil erosion were higher incidence and extent of exposed stoniness, observed gullies, tree root exposure and expansion of degraded lands and have observed on upper topographic settings than middle and lower one (Figure 8.2).

Figure 8.2, Farmers' perceived indicators of soil erosion across different topographic settings

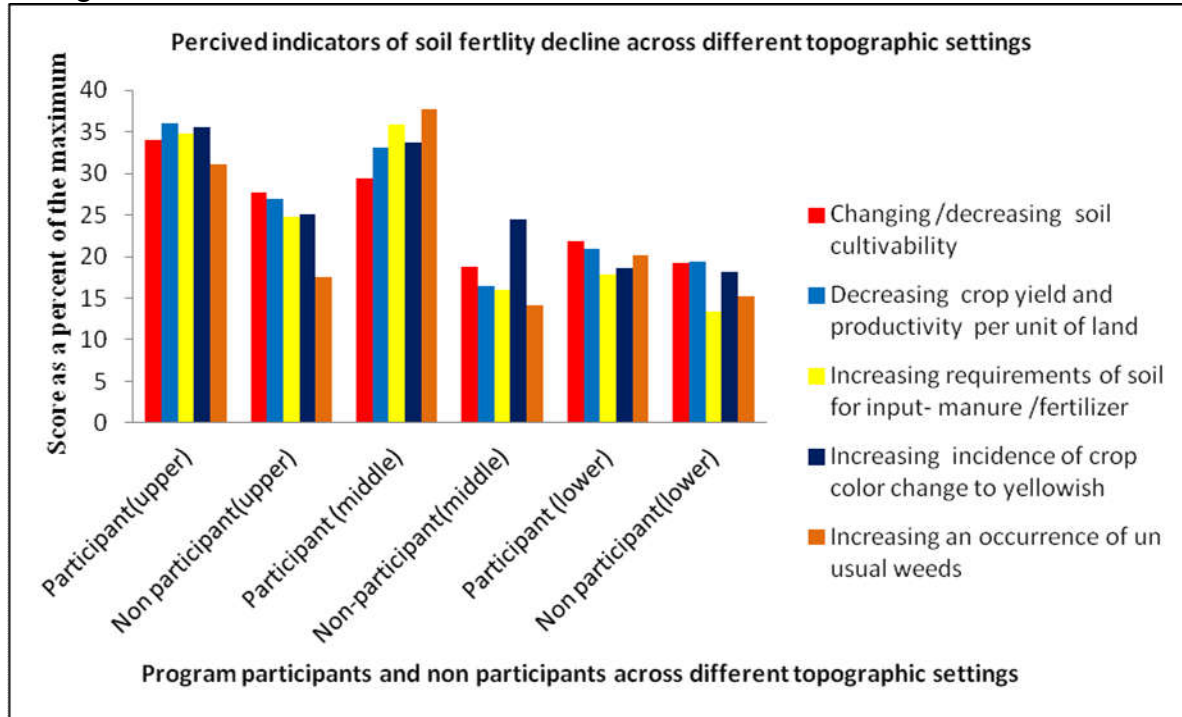


Source; computed from survey results, 2019

#### 8.4.1.2. Soil fertility decline problem

Farmers are also well aware of the problem of ongoing soil fertility decline. The survey results showed that, the majority (96.7 percent) of the sampled respondents reported that they aware of about soil fertility decline on their land and surrounding landscapes. They identified various casual factors of soil quality decline such as soil erosion, limited use of organic input namely compost/manure application, uninterrupted or continuous cropping and no/limited conservation of watershed management practices. They perceived the problem is severe in the upper topographic settings than middle and lower one. According to the farmers, major indicators of soil fertility decline are crop yield and productivity decline, crop color change and soil cultivability decline and soil's input requirement. These problems are also better noticed in the upper topographic setting (Figure 8.3).

Figure 8.3, Farmers' perceived indicators of soil fertility decline across different topographic settings



Source: computed from survey results, 2019

An understanding of soil erosion and soil fertility decline using local perception would have resulted in acquiring lessons in soil erosion problems and has an implication to implement watershed management practices. Farmers said that the areas they considered the most degraded were their highest priority for restoration. Farmers also stated soil and water erosion control practices such as for example, soil bund, stone faced soil bund and gully rehabilitation practices were implemented well in the upper topographic setting where erosion is severe. Although practiced in all catchments, soil fertility management practices such as for example compost and mixed approach practices such as agro forestry practices were implemented more in the lower and middle catchments. As compared to non participants, the program participants were better cognizant about the problem as they could have a chance to access to information and knowledge of soil degradation problem. The result agreed with Biratu & Desale (2016), who indicated that watershed degradation problems have been widely recognized by farmers. The result also agreed with Tiwari, Sitaula, Nyborg, & Paudel (2008), who found that in the villages that have more steeply terraces, the farmers are more likely to adopt soil conservation technologies to mitigate watershed degradation. This is to mean a farmer's awareness of soil erosion is consequently a

critical parameter for willingness to adopt. This result also congruent with Ziegler et al.(2006), who found that watershed degradation is better perceived among farmers of the highly degraded areas than their counterparts in less degraded areas. The result also conform with the study by Wei et al.(2009), who reported that program participants group were cognizant of the problems of environmental degradation through exposure to information and training on environmental management. Reports from focus group discussion and key informant indicated that soil fertility decline is also experienced in the upper and middle than lower topographic settings and better perceived by watershed program participant households as they have more accessed to extension services and training.

Generally, the result shows that there is variability among farmers in their perception on watershed degradation in different topographic settings and across program participant and non-participant households. This indicates that it is advisable to consider any opportunity for farmers to modify technologies for their own conditions of watershed degradation due to differences in perception and experiences. This is essential to design and implement socially acceptable, economically viable and environmental friendly technologies in a given landscape (Fentie, Fufa, & Bekele, 2013; Moges & Taye, 2017).

#### *8.4.2. Community participation in watershed management program*

The result of the study indicated that there are variations in involvement of the people in different activities of watershed development program and across program participant and non participant households. For this study, watershed management activities were grouped into two categories namely, development of common land resources and development of private land resources (Table 8.1). It can be observed that the participation was higher in the development of common land than private land. The participation of farmers was found better in some selected activities of the watershed development such as planting trees and management around homesteads, planting grass and fodder on private land, capacity building activities such as participating in training on how to implement activities whereas, it was found relatively low in some other activities such as, developing tree nursery establishment for household privately, income generating activities like modern beekeeping activities and soil fertility management practice like compost preparation.

The overall farmers' Participation Index (PPI) during the implementation stage of watershed management program was 48.9 percent which was categorized within moderate level of participation suggesting that there was less participation in some areas of activities. This is in line with the study by Bagdi & Kurothe (2014 and Teressa (2018) who found moderate overall level of people's participation in watershed management program. The program participants were better involved in all activities than the non participants. This study conform with the study by Wei, et al (2009) and Tesfaye, et al (2018), who found that program participants more likely to participate in watershed management program than non participants. This might be due to exposure to information and training on environmental management. Results from interview and focus group discussion revealed that participation in some activities like tree nursery development and beekeeping were there, but require support and difficult to implement. This implies that there is a need to create awareness and support to ensure farmers' participation in a larger number of activities that ensure sustainable livelihood of farmers.

Table 8.1, Distribution of community participation in watershed management practices

Watershed management practices at implementation stage	Participants		Non participants		Total sample	
	Score & Std. Deviation	% of the max	Score & Std. Deviation	% of the max	Score & Std. Deviation	% of the max
<b>Participation in communal land development activities</b>						
Reforestation and protecting of degraded communal areas	540 (1.421)	74.5	315 (1.070)	39.6	855 (1.522)	56.3
Side slope tree/shrub plantations on communal areas	370 (1.720)	51.0	318 (1.243)	40.0	688 (1.512)	45.3
Gully plugging by gabion/brush wood check dam on communal areas	507 (1.646)	69.9	336 (1.321)	42.3	843 (1.636)	55.5
Hill side trench and micro basin development on communal areas	477 (1.616)	65.8	352 (1.384)	44.3	829 (1.590)	54.5
Development grassed waterways on communal areas	455 (1.593)	62.8	332 (1.280)	41.8	787 (1.528)	51.8
PPI(%)	469.8	64.8	330.6	41.6	800.4	52.7
<b>Participation in own/private land development activities</b>						
Practicing SWC practices on private land	460 (1.455)	63.4	393 (1.413)	49.4	853 (1.473)	56.1
Planting of horticultural practices (fruit bearing trees- cabbage, avocado, mango, apple) on private land	492 (0.952)	67.9	426 (1.069)	53.6	918 (1.075)	60.4
Planting trees and management around homesteads	441 (1.374)	60.8	299 (0.950)	37.6	740 (1.306)	48.7

Planting grass and fodder on private land	416 (1.355)	57.4	247 (0.959)	31.1	663 (1.336)	43.6
Developing tree nursery establishment for household privately	304 (1.556)	41.9	169 (0.460)	21.3	473 (1.236)	31.1
Participation on modern beekeeping work privately	346 (1.524)	47.7	238 (1.030)	29.9	584 (1.362)	38.4
Compost preparation on private land	325 (1.138)	44.8	275 (0.919)	34.6	600 (1.059)	39.5
Attending on knowledge and skill development training on how to implement activities	399 (1.267)	55.0	249 (1.088)	31.3	648 (1.316)	42.6
PPI (%)	397.9	54.9	287	36.1	684.9	45.1
Overall PPI (%)	433.8	59.8	308.8	38.8	742.6	48.9

Figures in parentheses are the Std. Deviation

Source: computed from survey result, 2018

### ***8.4.3. Adoption of watershed management practices***

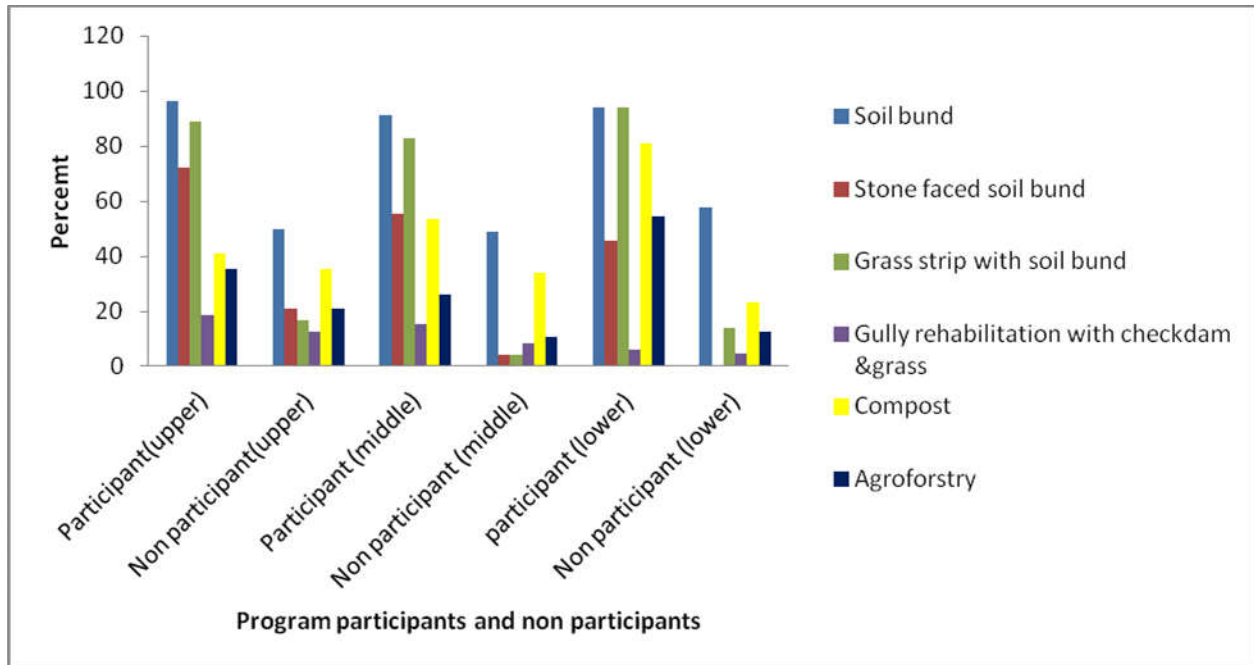
#### **8.4.3.1. Adoption of various watershed management practices**

There were wide ranges of watershed management practices implemented in the study watershed (Figure 8.4). Among others, the major practices include: soil and water conservation practices such as, soil bund, stone faced soil bund, grass strip cultivation with mostly soil bund, gully rehabilitation through check dam and grass; soil fertility management practices such as, compost application and mixed approach such as agro forestry practices. The results agreed with the studies by Kassie, et al. (2009), Teklewold et al.(2013) and Kassie, et al.(2015), Mengistu & Assefa (2019) who stated that farmers face various environmental problems such as soil erosion; climate variability as well as limited resources access that affects their agricultural productivity and livelihoods and consequently adopts a combination of technologies to deal with these problems.

The result of the study indicated that there was variation in the adoption of watershed management of the practices. The specific adoption rates of over all respondents for many of the practices ranges from 11 percent to 72 percent. There is also variation in different topographic setting and across watershed management program participants and non participants. For example, mostly soil and water erosion controlling practices( stone faced soil bund, gully rehabilitation practices, soil bund) were implemented more in the upper topographic settings than soil fertility management practices( compost, agro forestry practices). This result congruent with the study by Ziegler et al.(2006), who found that soil degradation is better perceived

among farmers of the highly degraded areas than their counterparts in less degraded areas. Watershed program participants implemented the practices better than the non participants.

Figure 8.4, Specific type and extent of implementation of watershed management practices across different geographic settings for program participants and non participants



Sources: computed from survey results, 2019

#### 8.4.3.2. Intensity of adoption of watershed management practices

The intensity of adoption ranged from zero to six practices (Table 8.2). There is also variation with regards to the intensity of adoption of watershed management practices indicating that, while some farmers used up to six practices, there were still a few who used none of the six practices. However, the majority of farmers used at least one practice and the intensity of adoption was low. Observations through transect walk, focus group discussion and key informant interview also confirmed the same results, revealing that there is variation in the implementation of the practices across topographic settings and program participant and non participant households.

Table 8.2, Distributions of intensity of adoption of watershed management practices

Intensity (number) of adoption of watershed management practices	Frequency	Percent
0	53	17.43
1	55	18.09
2	60	19.74
3	51	16.78
4	54	17.76
5	29	9.54
6	2	0.66
Total	304	100.00

Sources: survey results, 2018

#### 8.4.4. *Perceived benefits of watershed management practices*

Farmers' persevered ecological and socio-economic benefits were presented in table 8.3

##### 8.4.4.1. Ecological benefits of watershed management practices

Farmers indicated various ecological benefits of watershed management practices (Table 8.3). Results of the study indicated that soil loss reduction scored (72.37 percent), runoff reduction scored (64.86 percent) and reduction of flood scored (70.86 percent) by the respondents. Furthermore, the enhancement of soil fertility and soil moisture improvement were rated (71.38 percent) and (68.55 percent) respectively by the respondents. Vegetation and biodiversity improvement scored (73.75 percent) by the respondents since they started to participate on watershed management activates and were perceived better by program participants (92.97percent) than the non participants (56.23 percent). The effects of watershed management on runoff reduction scored (81.24 percent), down sub watershed/ plot flood reduction scored (87.17 percent), soil loss reduction scored (89.38 percent), enhancement of soil fertility scored (86.90 percent), soil moisture improvement scored (83.31 percent) by the program participants whereas (49.81 percent), (55.97 percent), (56.86 percent), (57.23 percent) and (55.09 percent) respectively for non participants. This result agree with the studies such as Vancampenhout et al ( 2006), Nyssen et al (2007), Gebregziabher, Abera, Gebresamuel, Giordano, & Langan (2016) and Tesfaye et al (2018) who showed that watershed has reduced the rate of soil erosion and floods, improved soil moisture, increased crop yields and income generating activities. Field observation, group discussion and key informant interview also indicated that farmers undertook a range of practices for soil erosion and soil fertility maintenance: soil bund, stone faced soil

bund, grass strip with mostly soil bund, gully rehabilitation through check dam and grass, trenches, micro basins, application of organic matter (animal manure, compost), agro forestry practices and following the practice, watershed degradation problems have becoming reduced-soil loss reduced, soil moisture increased, and biodiversity enhanced.

#### 8.4.4.2. Socio economic benefits of watershed management practices

Local communities not only recognize the extent, severity, causes and indicators of soil erosion and soil fertility decline but also the socio economic and ecological impacts of watershed management practices (Table 8.3). According to the farmers, the ecological impacts of watershed management practices include; runoff decreased, soil loss decreased, down slope/plot flood reduced, an improvement in the availability of grass and trees for food supplement of livestock and soil fertility and moisture improvements increased. They also indicated socio economic effects of watershed management practice namely; improved land productivity and improvement in livelihood strategies, an improvement in strengthening of community institutions such as watershed committee, self help groups and community involvement in watershed management practices.

Table 8.3, Perceived ecological and socio-economic benefits of watershed management strategies

Indicators of the benefits of watershed management program	Program participant	Program non participant	Total
	score & % of max(145*5)	score & % of max(159*5)	Score & % of max(304*5)
<b>Ecological indicators</b>			
Reduces soil loss	648(89.38)	452(56.86)	1100(72.37)
Reduces storm/intensive runoff	589(81.24)	396(49.81)	985(64.80)
Reduces down sub watershed/plot flood	632(87.17)	445(55.97)	1077(70.86)
Increase soil fertility	630(86.90)	455(57.23)	1085(71.38)
Increase soil moisture	604(83.31)	438(55.09)	1042(68.55)
Biodiversity enhancement	674(92.97)	447(56.23)	1121(73.75)
Average	3777(86.83)	2633(55.20)	6410(70.29)
<b>Socio economic indicators</b>			
Enhances crop yield and farm income	577(79.57)	402(50.57)	979(64.41)
Flexibility/ improve livelihood strategies	585(80.69)	370(46.54)	955(62.83)
Create job opportunity for disadvantaged groups(youth)	559(77.10)	404(50.82)	963(63.36)
Food supplement for livestock(grass)	609(84.0)	479(60.25)	1088(71.58)

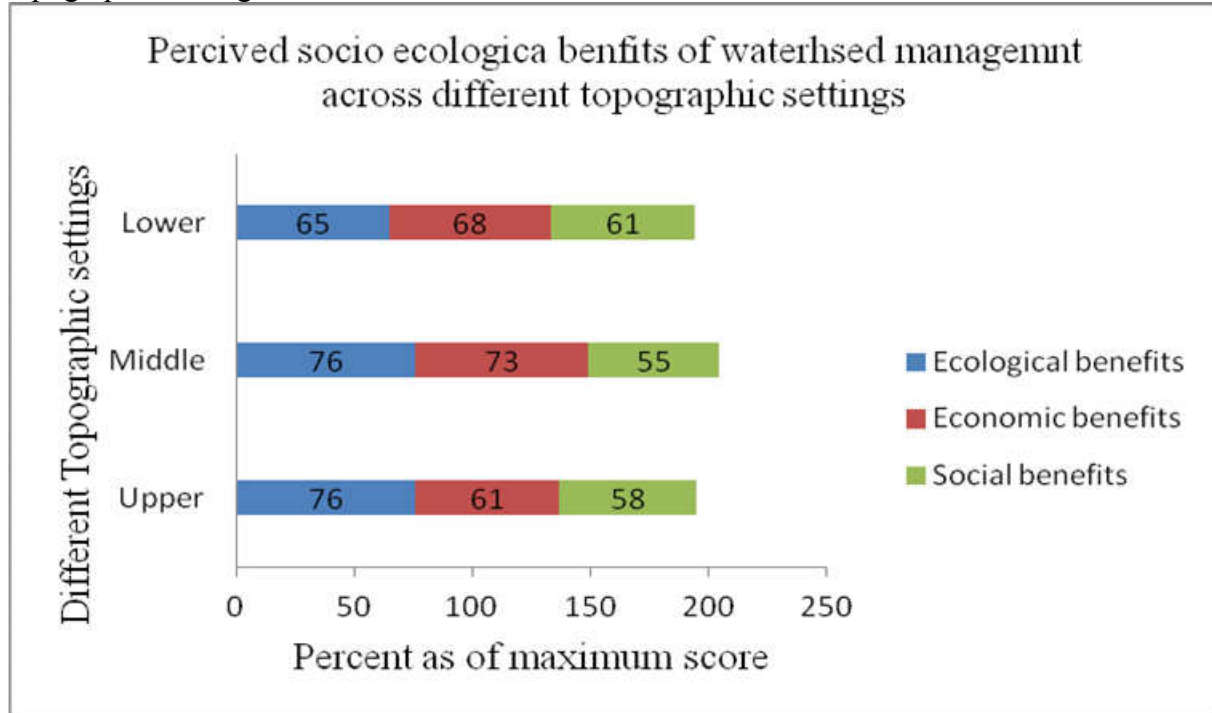
Enhances farmers' involvement in resources conservations	486(67.03)	331(41.64)	817(53.75)
Build community institutions(WSM committee, self help groups for resource conservation	527(72.69)	346(43.52)	873(57.43)
Reduces conflict over resources( water, forest)	515(71.03)	337(42.39)	852(56.05)
<b>Average</b>	551(76.0)	381(48.0)	932(61.3)

Source: computed from survey results, 2019

#### 8.4.4.3. Perceived ecological and socio economic benefits across various topographic settings and program participant and non-participant households.

There is spatial variation in the perception of desired socio economic and ecological benefits of watershed management practice by farmers in different topographic settings and across watershed program participants and non participants (Figure 8.5). As indicated by farmers more ecological benefits were perceived in the upper topographic setting, while the socio economic benefits were more perceived in the middle and lower topographic settings. The program participants were better perceived the benefits. During field observation and focus group discussion and interview, beekeeping and wax, poultry, sheep fattening, nursery establishment and selling tree seedlings were considered as an alternative income generating activities by watershed management program and better improved in watershed management program participant than non participant households. This result conform with the study by Teshome, de Graaff, & Stroosnijder (2014) reported that in steeply sloping areas, farmers assigned the highest score for criteria related to ecological impacts; whilst preferring practices with stronger positive economic impacts in moderate and gentle sloping areas. Study by Tesfaye et al (2018) reported that participatory integrated watershed management have a positive impact on hydrology, socio-economic and environment of the watershed.

Figure 8.5, Perceived socio ecological benefits of watershed management across different topographic settings



source: Computed from survey results, 2018

#### 8.4.5. Enhancing livelihood assets through watershed management program

Under this section, enhancements of households' livelihood assets through watershed management program were presented (Table 8.4). These include human assets such as knowledge, skills, exposure visit, and health status; social assets namely membership to various formal and informal institutions and participation, and status of farmers' participation in watershed management practices); physical assets such as housing conditions, assets such as cooking fuel stove, use of solar light, access to clean water tap, availability of improved latrine, and soil and water conservation measures; natural assets are resources and services improved through watershed management practices such as cultivated land size, soil quality potential, livestock size, access to home stead tree stocks, availability of fodder for livestock and access of water sources and financial assets namely family access to credit services, wage works on various activities, tree nursery establishment for sale, poultry production and sheep fattening for sale, bee keeping for sale.

The findings of the study indicated that the implementation of watershed management practices have positive impacts on the various livelihood assets-natural, physical, human, financial and social of households in the study area (Table 8.4). The asset with the highest capacity is the human asset (0.81), followed by natural asset (0.69), social asset (0.62), physical asset (0.61) and financial asset (0.44) for program participants. The financial asset has the least capacity index compared to others. Similarly, for the program non participants, the asset with the highest capacity is human asset (0.45), followed by natural asset (0.42). The financial asset has the least capacity index compared to others. The aggregated values of livelihood asset were (0.63) and (0.37) for program participants and non participants respectively. Generally, the difference was better for watershed program participants in all dimension of livelihood assets value. This indicates an encouraging sign for watershed management program designers and implementers to address the sustainable development goals such as, among others, poverty reduction, improving ecosystem services and improving households' sustainable livelihoods. The aggregated livelihoods asset value was average in the category of livelihood asset measurement scale, indicating imbalance in the improvements of various livelihood assets. This result agreed with the study by Chen et al (2013) and Islam et al (2014) showed that participatory watershed management programs have had a positive impact on the livelihood assets of the participants and their entire five livelihood assets showed increasing trends compared to non-participants.

Table 8.4, Specific comparisons of sustainable livelihood asset at a spatial scale (between participants and non-participants of watershed management program)

Livelihood asset and its indicators	Indicator weight		t-test
	Participants	Non participants	
<b>Human asset</b>			
Access to training on watershed management	0.94	0.62	-7.38***
Access to exposure visit of model farmers	0.71	0.10	-13.63***
training on a cross cutting issues ( improved toilet, HIV AIDS)	0.79	0.64	-2.921**
<b>Asset value</b>	<b>0.81</b>	<b>0.45</b>	<b>-14.261***</b>
<b>Natural asset</b>			
Cultivated/crop land owned	0.59	0.45	-5.603***
Livestock owned (TLU)	0.48	0.49	0.114
Land allocated for homestead tree stocks plantation	0.63	0.39	-10.503***
Improvement fodder/grass availability	0.88	0.12	-20.080***
perceived status of soil quality potential	0.98	0.90	-5.991***
Increase in water sources availability (springs)	0.57	0.19	-7.286***
<b>Asset value</b>	<b>0.69</b>	<b>0.42</b>	<b>-19.075***</b>
<b>Physical asset</b>			
Housing improvement (construction, equipment, etc.)	0.89	0.77	-5.997***

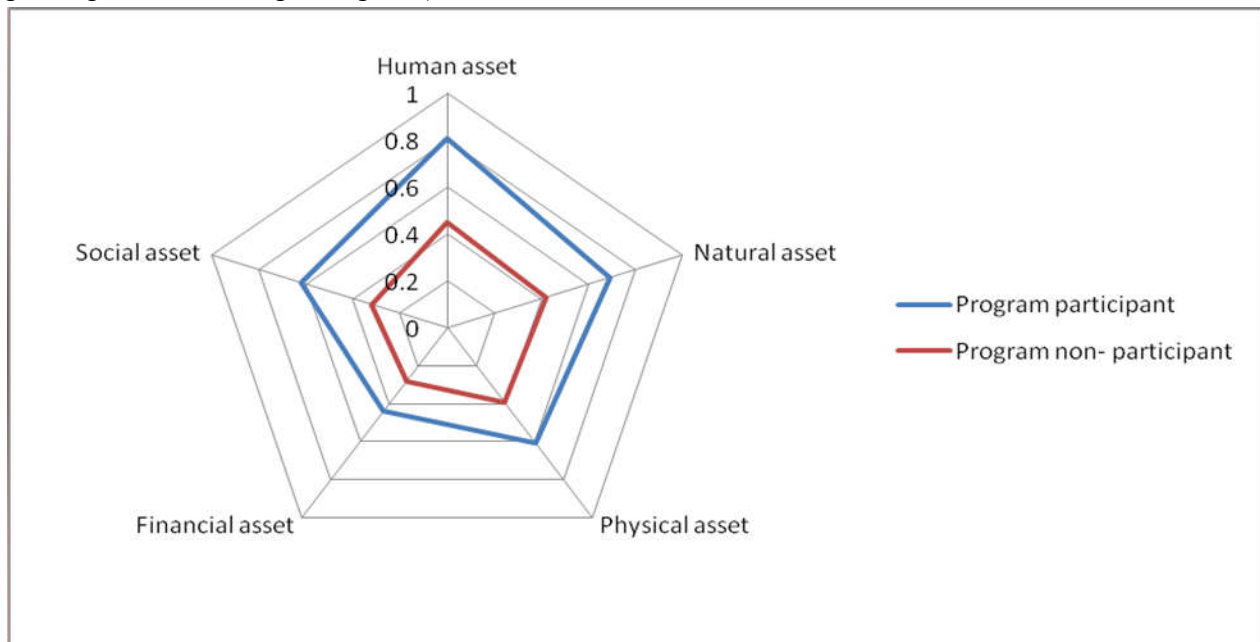
Improved cooking fuel stove use /Lakech/	0.42	0.13	-6.034***
Improvement in use of solar light	0.41	0.26	-2.898**
Increase access to clean water tap	0.45	0.33	-2.174**
Soil and water conservation measure(soil bund)	0.94	0.53	-9.202***
Soil fertility management measure (compost)	0.55	0.30	-4.523***
<b>Overall Asset value</b>	<b>0.61</b>	<b>0.39</b>	<b>-10.250***</b>
<b>Financial asset</b>			
Access to credit services	0.88	0.65	-4.863***
Wage earning from watershed activities	0.19	0.15	-1.122
Poultry production and sheep fattening	0.49	0.35	-2.438**
Access to beekeeping - beehives and wax	0.44	0.21	-4.319***
Access to seeds and tree seedlings for sale	0.17	0.02	-4.613***
<b>Asset value</b>	<b>0.44</b>	<b>0.28</b>	<b>-6.811***</b>
<b>Social asset</b>			
Participating in the watershed committees	0.71	0.37	-6.294***
Membership in self help groups	0.29	0.05	-5.752***
status of participation in watershed management program	0.85	0.53	-15.246***
<b>Asset value</b>	<b>0.62</b>	<b>0.32</b>	<b>-13.128***</b>
<b>over all livelihood asset value</b>	<b>0.63</b>	<b>0.37</b>	<b>-22.147***</b>

\*10 % significance, \*\* 5% significance , \*\*\*\* 1% significance

Source: survey result, 2018

Overall livelihood asset values across a spatial scale (between program participant and non-participant households) were presented in Figure 8.6. Though, the watershed management program has a positive effect on rural livelihood; the sustainability of this has been a pressing question. There were differences in the improvements of various indicators of all livelihood assets and have showed an imbalance in the five principal assets for respondent households in the study area for both program participant and non participant households. This suggested that there are gaps in the improvement of the five dimensions of livelihood asset in the study area, so that it needs emphasis to enhance the household asset for sustainable livelihood improvement of households. Hence, though there were promising improvements in the livelihood asset of households, still there is space to enhance the livelihood assets of households while ensuring the sustainable management of natural resources. For instance, many efforts needed to enhances the financial, physical and social assets to support livelihood benefits and long-term sustainability of natural resources.

Figure 8.6, Comparison of overall livelihood asset value across a spatial scale (between program participants and non-participants)



Source: Constructed from survey result, 2019

## 8.5. Synthesis

### 8.5.1. Perception on watershed deterioration and level of participation in watershed management program

Under this section, the association of farmers' perception of watershed degradation and their participation in watershed management practices was assessed (Table 8.5). To this end, Pearson Chi-Square was used to analyse the association between the scores that represent farmers' perceived watershed degradation in the form of soil erosion and soil fertility decline indicators and their participation score. The result showed that there was a statistically significant relationship between farmers' perceived watershed degradation and their participation in the watershed management practices. This implies that farmers' prior perception of soil erosion and soil fertility decline indicators is a key social factor that plays a great role in their decision making on land management practices for controlling soil losses. Study by Pulido & Bocco (2014) indicated that perception to environmental problems affects the selection and continued use of watershed conservation practices. This study also conforms with study by Assefa & Kidane (2016) and Amsalu & de Graaff (2006) that farmers have a general awareness about the

problem of soil deterioration and its indicators and had good motives to participate in watershed management activities. Studies by Bewket & Sterk (2002) also indicated that soil degradation problems have been widely recognized by farmers.

Table 8.5, Pearson Chi-Square Test results; associations between perception of watershed deterioration and level of participation in watershed management program

Level of perception	Level of participation (%)		Pearson Chi- Square	P-value
	(≥ mean value) Higher/active	(≤ mean value) lower/passive		
Watershed degradation perception( soil erosion and soil fertility decline)				
≤ mean value- lower	37(27.2 %)	85(50.6 %)	17.113	.000
≥ mean value-higher	99(72.8 %)	83(49.4 %)		

Sources: computed from survey results, 2019

#### ***8.5.2. Perceived outcome of watershed management program and decision to participate in watershed management program***

Under this section, farmers’ perception of the outcomes of the watershed management practices and how this influences their willingness to participate in the program was assessed (Table 8.6). To this end, Pearson Chi-Square association was used to analyze the association between the scores that represent farmers’ perceived ecological and socio economic outcomes of the program and their participation score. The result showed that there was a statistically positive and significant association between farmers’ perceived outcomes score and participation score. This indicates that prior outcomes of the watershed management intervention program motivated farmers to participate in the program. Farmers’ perception and experiences on socio economic and ecological impacts of watershed management practices is very vital for the better design and adoption of sustainable land management policies so that rural households can move towards more sustainable land use and land management practices, as well as more sustainable agricultural livelihoods, over the longer term (Sallu, Twyman, & Stringer, 2010; Pulido & Bocco, 2014). Study by Tesfa & Mekuriaw (2014) also indicated that positive perception of the problem and the benefits are likely to decide in favor of adopting sustainably the available conservation technologies.

Table 8.6, Pearson Chi-Square test results; associations between perceived outcomes of watershed management practices and level of participation in watershed management program

Level of perception	Level of participation (%)		Pearson Chi-Square	P-value
	Higher/active ( $\geq$ mean value)	lower/passive ( $\leq$ mean value)		
Perceived ecological and socio economic benefits of watershed management program				
lower ( $\leq$ mean value)	17(12.5%)	120(71.4 %)	105.423	.000
higher ( $\geq$ mean value)	119(87.5%)	48(28.6 %)		

Sources: computed from survey results, 2019

### 8.5.3. Interaction of perception, participation, perceived outcomes livelihoods and intensity of adoption of watershed management practices

The association between farmers' perception of watershed degradation, the perceived outcomes of the watershed management practices, farmers' levels of participation and intensity of adoption of the watershed management practices and livelihood enhancement was indicated (Table 8.7). The computed Chi-square test value indicated that there was a significant association between intensity of adoption of watershed management practices and perception of watershed degradation (Chi-Square Test = 8.763,  $p = 0.003$ ); perceived ecological and socioeconomic benefits of watershed practices (Chi-Square Test = 87.241,  $p = .000$ ); level of participation in watershed management practices (Chi-Square Test = 124.813,  $p = .000$ ); livelihood asset value (Chi-Square Test = 118.882,  $p = .000$ ). This implies that farmers' perception of watershed degradation, prior outcomes of the watershed management intervention program and level of participation motivated farmers to participate in the adoption of watershed management practices.

Table 8.7, Pearson Chi-Square Test results; associations between perception, level of participation, livelihood assts and intensity of watershed management practices

Level of perception	Intensity(number) of Watershed management practice		Chi-Square	P-value
	$\leq$ mean value	$\geq$ mean value		
Watershed degradation perception( soil erosion and soil fertility decline)				
Lower( $\leq$ mean value)	47.6%	30.9%	8.763	.003
Higher ( $\geq$ mean value)	52.4%	69.1%		
Perceived ecological and socio economic benefits of watershed management program				

Lower( $\leq$ mean value)	69.0%	15.4%	87.241	.000
Higher( $\geq$ mean value)	31.0%	84.6%		
Level of participation in watershed management				
Lower/passive ( $\leq$ mean value)	83.9	19.9	124.813	.000
Higher/active( $\geq$ mean value)	16.1	80.1		
Livelihood asset value				
$\leq$ mean value	79.8	16.9	118.882	.000
$\geq$ mean value	20.2	83.1		

Sources: computed from survey results, 2019

## 8.6. Discussion

### 8.6.1. Nexus of perception, participation, adoption and perceived outcomes towards sustainable watershed management

Farmers' awareness, knowledge and experiences combined with other variables on magnitude, causes and dynamics of soil degradation and conservation measures could provide information that helps to determine level of watershed management intervention practices. Local perception, that is, perception held by people in a particular locality derived through observation and experience (Sinclair & Walker, 1999), has often been found to be largely complementary to global scientific knowledge on soils and environmental change (Berkes, 2009). The degree of public awareness of soil erosion and soil fertility decline and conservation measures, which is directly related to knowledge and perceptions of farmers (Herweg, Steiner, & Slaats, 1998), is of critical importance in order to integrate local experiences with scientific evidences and to reverse the trend of increasing watershed degradation (Yitaferu, 2007; Tefera & Sterk, 2010; Campos et al., 2012; Tamene, Adimassu, Aynekulu, & Yaekob, 2017). Farmers' understanding of implementation and evaluation of the socio-cultural, economic and ecological impacts of watershed management intervention strategies remains a critical input to increase the effectiveness and sustainability of watershed intervention strategies and to have promising conservation measures (Kassie et al., 2015; Adimassu, Langan, Johnston, Mekuria, & Amede, 2017).

Understanding of community participation watershed management program provide valuable social-cultural, ecological, economic and local knowledge ensuring sustainable development in agricultural sector and livelihood improvement of people (Bandara & Thiruchelvam, 2008; Newig & Fritsch, 2009; Ferranti et al., 2010). It also provides support to how rural communities

deal with watershed management issues and promote the sustainable development of the rural communities. It also gives support for building relationships between rural communities and ways to enhance interactional capacity in order to reduce adverse impacts of watershed problems and to improve adaptability. An understanding of households' watershed technology adoption behaviors would lead to more conscious perception of the complex link between agricultural practices, environmental impacts and socioeconomic effects. An understanding of the sustainability of farmers' livelihood aspects is important to be aware of the livelihood condition of households undertaking watershed management program; enables to build the strong base to farmers whether offered watershed management practices are worthwhile undertaking or not. It also contributes for decision makers and planners to decide on especially the magnitude of intervention and up scaling planning of watershed management intervention strategies.

#### *8.6.2. Sustaining of watershed management program*

Local perception, participation and adoption and livelihood perspectives of the watershed management practices by the farmers are the decisive element for the success of a watershed management intervention (Bekele & Drage, 2003; Bewket, 2007; Bewket & Teferi, 2009; Demelash & Stahr, 2010; Kassie, et al., 2015; Haregeweyn et al., 2015). Hence, an understanding of the interaction process and factors influencing of the people's perceptions of watershed degradation, the perceived on the outcomes of environmental management, level of community participation, adoption and implication to livelihood improvement implied an participatory and integrated approached that encourage the up scaling and sustaining of watershed management practices.

However, as the results of this study indicated, despite the progress and better achievements in the sustainable development of watershed management practices, the sustainability of this has been a pressing question. Effective and full participation of the community has still an issue as there is variation in the participation of community in different activities. The variation in the rate of adoption (less than fifty percent for the majority of watershed management practices) and intensity adoption of watershed management practices across different type of practices and farmers implied that, there is still an important potential to upscale the adoption of watershed management practices (Mengistu & Assefa, 2019). The study also indicated that there were differences in the improvements of various indicators of all livelihood assets. This indicated an

imbalance in the five principal assets for respondent households in the study area for both program participants and non participants suggesting which in turn affect the sustainability of watershed management practices.

### ***8.6.3. Challenges of Sustaining of watershed management***

In Ethiopia, to grapple with the problem of watershed degradation and improve peoples' livelihoods, large-scale conservation schemes to promote watershed management technologies were initiated (Tefera & Sterk, 2010; Tesfaye, Negatu, Brouwer, & van der Zaag, 2014; Gessesse et al., 2016; Haregeweyn et al., 2017). Despite the successes, some studies claimed that the watershed management program in the country did not succeed in triggering voluntary participation and adoption of conservation practices (Bekele & Drage, 2003; Amsalu & de Graaff, 2007). Furthermore, reports by Bewket & Sterk (2002), Tesfaye et al (2014) and Nigussie et al (2017) have indicated a relatively low level of success and weak evaluation in terms of environmental, socio-economical and cultural perspectives.

*An interview was undertaken with one watershed management program team leader as follows: Physical and biological measures implemented through public or own land lack maintenance and integration to use for the future. For example, I observed that during the growing season physical structures such as the stone and soil bunds constructed across farmland are destroyed by the owner due to scarcity of farmland and less awareness and extension services of its long-term importance. This is rooted in a lack of sense of ownership and preference for interventions that offer short-term benefits (watershed management team leader opinion, May 2017).*

The factors affecting perception, participation and adoption determine the sustainable utilization of the measures by the farmers (Amsalu & de Graaff, 2006; Kessler, 2006). As indicated in this study lack of effective and genuine community participation in watershed management and consequent low adoption in most watershed management practices affected the sustainable enhancement environmental management practices and peoples' livelihoods. In addition, a review reports from focus group discussion and interview indicated lack of continues extension services in general and training on watershed management practices in particular, lack of incentives like availability of credit services were challenges mentioned. Literatures also indicated the challenges of sustaining watershed management practices such as lack of farmers'

perception of soil erosion, participation and adoptions of conservation technologies and poor extension approaches (Amsalu & de Graaff, 2006; Sileshi, Kadigi, Mutabazi, & Sieber, 2019), land tenure insecurity, the inability to make watershed conservation productive and high cost demanding of interventions (W. Bewket, 2007) and uniform application of similar watershed conservation measures disregarded agro-ecological variations (Ali & Surur, 2012).

An interview was undertaken with chairman of kebele administration and development agent as follows:

*In my opinion, various factors, such as lack of finance, working materials and lack of training were the major challenges households faced in participating in watershed management practices, such as, terracing. Furthermore, lack of technical knowledge and skills of households and fearing of consuming scarce farmland were the major obstacles in construction of physical structures, such as terraces. Farmers also interested in short-term agricultural production benefits than investments (Kebele chair man and Development agent opinion, May 2017).*

#### **8.7. Conclusion and policy implications**

The main objective of this study was to look at the interaction of very important components of watershed management such as perception, participation and decisions to adopt and the subsequent livelihood enhancement and sustained watershed management practices in the upper Gibe basin, south west Ethiopia. The results of the study indicated that local communities are well aware of the problem of watershed deterioration in the form of ongoing soil erosion and soil fertility decline-higher incidence and extent of exposed stoniness, observed gullies, tree root exposure and expansion of degraded lands, crop yield and productivity decline, crop color change and soil cultivability decline and soil's input requirement. These have observed better on upper topographic settings and by program participant households implying the need for site-specific appropriate watershed management alternatives. Farmers also well aware of the socio economic and ecological benefits of watershed management practices. The biophysical benefits were more perceived in the upper topographic settings, while the socio economic benefits were more perceived in the middle and lower topographic settings suggesting an integrated approach to address the biophysical and socioeconomic conditions. There are variations in involvement of the community in different activities of watershed development practices and across watershed program participant and non participant households. The participation index value showed

moderate levels of participation indicating that only some decisions were taken in consultation with local people. Specific adoption rates for many of the practices and the intensity of adoption were low. The upper topographic setting and the watershed program participant households better implemented the practices. The findings of the study also indicated that the implementation of watershed management practices have shown positive on the various livelihood assets-natural, physical, human, financial and social, in spite of their variation/imbalance for program participant than non participant households. The findings of the study also indicated that there was a significant association between intensity of adoption of watershed management practices and perception of watershed degradation; perceived ecological and socioeconomic benefits of watershed practices; level of participation in watershed management practices and livelihood assets value indicating the need for more participatory and integrated approach to sustain watershed management practices. Less training and extension services, lack of finance, interest in short-term agricultural production are the major challenges constraining the sustainability of watershed management. Hence, local administrators and planners need to recognize heterogeneity in households' socio economic and topographic specific characteristics as well as the aforementioned constraints so as to involve community fully in various activities of watershed management for the up scaling planning and sustainable watershed management program.

## **Chapter 9: Conclusions, Research and Policy Implications and the Way Forward**

### *9.1. Conclusions*

The main focus of this study is to investigate the interface between watershed management intervention strategies and livelihoods of households. Through the process, the study examined a state-of-the-art of the watershed management practices- development trends, status and future prospects, watershed degradation perceptions and its determinants- implication to the sustainable watershed management practices, status and determinants of community participation at different stages of watershed management, adoption decision, perceived ecological and socio economic benefits and livelihood impacts of watershed intervention program.

The results of the review indicated that, environmental issues such as natural resource conservation-based agriculture development became the primary objectives of the policy, development plan and program in different regimes of Ethiopia. However, the emphasis has been still stress on attaining the economic aspect or focus on short-term economic gain than mainstreaming environmental concerns. Although, community based participatory watershed approach was emphasized through integrating small-scale and bottom-up participatory interventions approach with the role of markets, policies and institutions to stimulate farmer innovation in watershed management strategies, top-down approach is still dominating watershed management practices. Despite some positive biophysical and socio economic effects, watershed management strategies faced various constraints to achieve the desired objective such as, inadequate community involvement, lack of efficient extension and training system, lack of acknowledgement of farmer' perception, lack of linkages between scientific and local knowledge, lack of technology preferences or considering socio-economic profile, and policy implementation and enforcement(Chapter 2).

Local communities are well aware of the problem of ongoing soil erosion severity, causes and indicators (chapter3). Farmers believe that soil loss is highly influenced by topographic settings and is considered to be variable between upper, middle and lower settings. As cited by farmers, soil erosion severity is more in the upper and middle topographic settings than in the lower one due to cultivation of steeper topographic settings, runoff associated to high and intensive rain, overgrazing, deforestation and poor farming practices. The massive soil erosion by flood and farming on the hilly and higher slopes and livestock population pressure has contributed for both

soil and pasture degradation which necessitates watershed interventions. According to the farmers, the major indicators of soil erosion were higher incidence and extent of exposed stoniness, observed gullies, tree root exposure and expansion of degraded lands and have observed on upper topographic settings than middle and lower one.

Farmers are also well aware of the problem of ongoing soil fertility decline. They identified various casual factors of soil quality decline such as soil erosion, limited use of organic input namely compost/manure application, uninterrupted or continuous cropping and no/limited conservation of watershed management practices. They perceived the problem is severe in the upper topographic settings than middle and lower one. According to the farmers, major indicators of soil fertility decline are crop yield and productivity decline, crop color change and soil cultivability decline and soil's input requirement. These problems are also better noticed in the upper topographic setting (chapter 3).

Understanding of soil erosion and soil fertility decline using local perception would have resulted in acquiring lessons in soil erosion and severity, causes and indicators, and has an implication to implement watershed management practices. Farmers said that the areas they considered the most degraded were their highest priority for restoration. Farmers also stated soil and water erosion control practices such as for example, soil bund, stone faced soil bund and gully rehabilitation practices were implemented well in the upper topographic setting where erosion is severe. Although practiced in all catchments, soil fertility management practices such as for example compost and mixed approach practices such as agro forestry practices were implemented more in the lower and middle catchments.

The perceived variation in the extent and severity of soil erosion and soil fertility decline by farmers in this study attributed to topographic settings and socioeconomic factors such as land size, frequency of extension contact, training services on watershed management intervention practices, access to credit services and group membership. The variation in the spatial and type of watershed management practices implies that, conservation alternatives can be adopted or not by farmers depending on the farmers' awareness of their exposure level to soil erosion and soil fertility decline and specific topographic and/or socioeconomic conditions of each place or community.

Community participation has been increasingly acknowledged as important component for the sustainable natural resource management. In this study community participation and factors affecting in watershed management program were studied under three dimensions (such as, planning, implementation and monitoring). The result of the study indicated that there are variations in involvement of the people in different activities of watershed development program at different stages- program planning, implementation and monitoring and evaluation, and across program participants and non participants. The participation of community in different activities at planning stage of watershed management practices was relatively better for some activities such as, meeting and training, while less in other activities like watershed resources management planning and formulation and enforcement of watershed management rules/bylaws. This suggested that there is prior setting of plans and problem identifications without the involvement of farmers. Further, the study revealed that overall People's Participation Index (PPI) value calculated was categorizes within moderate level of participation. This implies that only some decisions were taken in consultation with local people (chapter 4).

The variation in community participation in different stages of watershed management practices attributed to various physical, socio economic and institutional factors. Frequency of extension contact, land tenure security and group membership explained positively and significantly community participation in all stages of watershed management program practices. Specifically, result of the study also indicated that community participation at planning stage was affected positively and significantly by access to off/non farm income sources, frequency of extension contact, land ownership security, group membership and topographic setting. Number of total livestock owned, frequency of extension contact, land ownership security, group membership and topographic setting affected positively and significantly community participation at implementation stage. But, farmland size owned affected the participation negatively and significantly at the same stage. Community participation at monitoring and evaluation stage of watershed management practices affected positively and significantly by family size, frequency of extension contact, landownership security and group membership. This indicated that, a community context in which local biophysical, socio-economic, and institutional attributes are embedded determines the actions taken by the participants in watershed management adoption.

There were wide ranges of watershed management practices implemented in the study watershed. Among others, the major practices include: soil and water conservation practices such as, soil bund, stone faced soil bund, grass strip cultivation with mostly soil bund, gully rehabilitation through check dam and grass; soil fertility management practices such as, compost application and mixed approach such as agro forestry practices, and most of them are interdependent. The result of the study indicated that there were variation in the adoption of watershed management of the practices in different topographic setting and across watershed management program participants and non participants (chapter 5). For example, mostly soil and water erosion controlling practices( stone faced soil bund, gully rehabilitation practices, soil bund) were implemented more in the upper topographic settings than soil fertility management practices( compost, agro forestry practices). Watershed program participants implemented the practices better than the non participants. There is also variation with regards to the intensity of adoption of watershed management practices. In addition, the result revealed that the specific adoption rates of over all respondents for many of the practices and the intensity of adoption were low. Factors such as access to extension services, access to training on watershed management practices, topographic settings, family size and perception on soil erosion had positive significant relationship with both adoption rate and intensity of adoption of most of the practices.

The variation in the rate of adoption and intensity adoption of watershed management practices across different type of practices and farmers implied that, there is still an important potential to upscale the adoption of watershed management practices. Policy makers, experts and planners needs to consider heterogeneity in households' socio economic and topographic specific characteristics and target practices with lower adoption rates and provide farmers with further incentives (extension services outreach, training) towards the intensification of their use.

Local communities not only recognize the extent, severity, causes and indicators of soil erosion and soil fertility decline but also the socio economic and ecological impacts of watershed management practices (chapter 6). According to the farmers, the ecological impacts of watershed management practices include; runoff decreased, soil loss decreased, down slope/plot flood reduced, an improvement in the availability of grass and trees for food supplement of livestock and soil fertility and moisture improvements increased. They also indicated socio economic

effects of watershed management practice namely; improved land productivity and improvement in livelihood strategies, an improvement in strengthening of community institutions such as watershed committee, self help groups and community involvement in watershed management practices.

However, there is spatial variation in the perception of the socio economic and ecological benefits of watershed management practice by farmers in different topographic settings and across watershed program participants and non participants. As indicated by farmers more ecological benefits were perceived in the upper topographic setting, while the socio economic benefits were more perceived in the middle and lower topographic settings implying that participatory and integrated approach is required for the sustainable improvements in both natural resources management and socio-economic characteristics. The program participants were better perceived the benefits. The variations were associated to physical factor like topographic and /or socioeconomic factors such as farm land size, access to off/nonfarm income sources, frequency of extension contact, access to training on watershed management practices , access to credit services and group membership.

The findings of the study indicated that the implementation of watershed management practices have positive impacts on the various livelihood assets-natural, physical, human, financial and social of households in the study area( chapter 7). Generally, the difference was better for watershed program participants in all dimension of livelihood assets value but, both belong to the average category of livelihood asset measurement scale. Estimates of propensity score matching model using the kernel matching estimator result indicated the existence of a positive significant livelihood assets value of 24.8 % for program participants compared to non-participants. This indicates an encouraging sign for watershed management program designers and implementers to address the sustainable development goals such as, among others, poverty reduction, improving ecosystem services and improving households' sustainable livelihoods. There is also a need to upscale the program to areas not covered by the intervention program.

Though, the watershed management program has a good impact on rural livelihood; the sustainability of this has been a pressing question. There were differences in the improvements of various indicators of all livelihood assets and have showed an imbalance in the five principal assets for respondent households in the study area for both program participants and non

participants. This suggested that there are gaps in the improvement of the five dimensions of livelihood asset in the study area, so that it needs emphasis to enhance the household asset for sustainable livelihood improvement of households. Factors such as age of household head, livestock ownership, distance of the farmers' training center from the home, distance of farm land from home of framers, topographic location and training on watershed management program were major factors of group (program participants and non participants) differences. Hence, though there were promising improvements in the livelihood asset of households, still there is space to enhance the livelihood assets of households while ensuring the sustainable management of natural resources. For instance, many efforts needed to enhances the financial, physical and social assets to support livelihood benefits and long-term sustainability of natural resources.

Local perception, participation and adoption and livelihood perspectives of the watershed management practices by the farmers are the decisive element for the success of watershed management intervention strategies. The findings of the study indicated that there was a significant positive association between intensity of adoption of watershed management practices and perception of watershed degradation; perceived ecological and socioeconomic benefits of watershed practices; level of participation in watershed management practices and livelihood assets value (chapter 8). However, the sustainability of watershed management strategies has been a pressing question. For example, the participation of community in different activities at planning stage of watershed management practices was relatively better for some activities such as, meeting and training, while less in other activities like watershed resources management planning and formulation and enforcement of watershed management rules/bylaws implying that there is prior setting of plans and problem identifications without the involvement households (chapter 4). The variation in the rate of adoption (less than fifty percent for the majority of watershed management practices) and intensity adoption of watershed management practices across different type of practices and farmers implied that, there is still an important potential to upscale the adoption of watershed management practices( chapter 5). The study also indicated that there were differences in the improvements of various indicators of all livelihood assets and have showed an imbalance in the five principal assets for respondent households in the study area for both program participants and non participants suggesting that there are gaps in the improvement of the five dimensions of livelihood asset in the study area which in turn affect the

sustainability of watershed management practices (chapter 7). This suggested more participatory and integrated approaches need to be encouraged to upscale the program to areas not covered and sustaining of watershed management practices.

## *9.2. Contributions*

### *9.2.1. Research contribution*

This empirical study contributes the following significances. This study provides the interface of physical aspects of a catchment with social aspects of people within the different settings of the catchment. Farmers' awareness, knowledge and experiences combined with other variables on magnitude, causes and dynamics of soil degradation and conservation measures could provide information that helps to determine level of watershed management intervention practices.

This study also brings to the fore the appreciation of community participation in watershed management. The work has potential to make an important contribution to raising awareness of community participation in river basin management and the need for engagement from the outset. The findings offer important reflections for future participatory schemes.

This paper also carries important significance for understanding the "how and why" farmers adopt watershed management practices in the study basin. The paper also addresses an important research question assessing the impact of watershed management intervention program on household livelihood assets and the nexus of principal components of watershed management adoption-perception, community participation, adoption decisions and livelihood implications.

### *9.2.2. Socioeconomic contributions*

Farmers' evaluation of socio economic and ecological impacts of watershed management practices provides opportunity to have watershed intervention strategies that have technically feasible, adapted to the local environment, ecologically sound, economically viable and socially accepted practices. This remains a critical input to increase the effectiveness and sustainability of watershed intervention strategies and to have promising conservation measures.

Understanding of community participation in different stages-planning, implementation, and monitoring and evaluation provide valuable social-cultural, ecological, economic and local knowledge ensuring sustainable development in agricultural sector and livelihood improvement

of people. It also provides support to how rural communities deal with watershed management issues and promote the sustainable development of the rural communities. It also gives support for building relationships between rural communities and ways to enhance interactional capacity in order to reduce adverse impacts of watershed problems and to improve adaptability.

An understanding of households' watershed technology adoption behaviors would lead to more conscious perception of the complex link between agricultural practices, environmental impacts and socioeconomic effects. Furthermore, an improved knowledge of factors leading to a higher adoption of farmers to watershed management activities may contribute to improve the effectiveness and sustainability of watershed management conservation measures.

An understanding of the sustainability of farmers' livelihood aspects is important to be aware of the livelihood condition of households undertaking watershed management program; enables to build the strong base to farmers whether offered watershed management practices are worthwhile undertaking or not. It also contributes for decision makers and planners to decide on especially the magnitude of intervention and up scaling planning of watershed management intervention strategies.

### *9.2.3. Extension and policy recommendations*

Since one of the main aims for watershed management practices is to restore ecosystem services and improve livelihoods of people, it is essential to understand how local livelihoods interact with land they are cultivating and surrounding landscapes as well as different watershed management measures to ensure sustainable ecological balance and peoples' livelihoods enhancements. Future policy and planners for watershed management program will, therefore, need to carefully consider the variation in local-level perceptions, priorities and contextual factors, including social dynamics, economic, physical and institutional factors influencing the acceptability of restoration options and aims to match measures to needs of communities.

The study indicated that conservation alternatives can be adopted or not by farmers' perceived ecological and socio economic benefits of watershed management practices. Hence, it is apparent that the knowledge and efforts of local farmers' need to be encouraged and appreciated as they are crucial for sustainable watershed management planning and implementation. Experts need to evolve a mechanism that let farmers involve assessing the bio-physical and socio-economic

impacts of program that make them involve in implementation watershed management practices. It is also vital to take in to account those determinants of farmers' perceptions for design and effective implementation of sustainable watershed management intervention strategies.

The variation in involvement of the people in different activities of watershed development program at different stages is a matter of serious concern to policy makers and planners. More effort is needed for raising farmers' awareness through delivering information on the importance of watershed management programs to involve fully in watershed activities at all stages. Hence, the watershed management planners and policy makers should also give due consideration to socio economic and institutional factors for future sustainable watershed development planning. Thus, empowering the community in a way that they assume the responsibilities of planning and set bylaws providing for proper implementation of the plans and the protection of assets created is of paramount importance

An important implication of the results was that, extension workers and planners need to target practices with lower adoption rates and provide farmers with further incentives (extension services outreach, training) towards the intensification of their use. In addition, results implied that local administrators and planners should recognize heterogeneity in households' socio economic and topographic specific characteristics in the up scaling and implementation of watershed management practices in the study area. Furthermore, policymakers and planners need to consider these determining factors such as access to extension and training services and capital intensive nature of practices to augment the adoption of watershed management practices. The interdependency of practices also suggested the need of promoting each practice as a package that contribute to upscale watershed management practices adoption and broaden farmer options while harnessing the synergies between them.

The results of the study indicated that, though there were promising improvements in the livelihood asset of households, still there is space to enhance the livelihood assets of program participant group while ensuring the sustainable management of natural resources. For instance, many efforts needed to enhances the financial, physical and social assets to support livelihood benefits and long-term sustainability of natural resources. Secondly, the program could be extended and up scaled to all areas, so that the program non participants have got opportunity to improve their livelihood assets.

### *9.3. Future direction of research*

Further research relevant to the effects of watershed management intervention measures will be needed to evaluate physical and biochemical soil properties of the watershed at different spatial scales.

Watershed resources management play crucial role in ecosystem services and in determining food, social, and economical security of people living in the watershed. Hence, researches pertinent to the interface between watershed management interventions and ecosystem services will be needed to evaluate the ecosystem services of the watershed at different spatial scales.

Smallholder farmers in Ethiopia generally face with increasing weather variability and climate change, requiring urgent action. However, current understating of different location-specific watershed management practices in terms of their capacity to develop adaptation to actual and potential weather variability and climate change has been required. Hence an empirical research is needed on the sustainable adaptation to climate change and variability through watershed management practices for sustained livelihoods and watershed management practices.

Integrated watershed management cuts across many sectors and institutions within a watershed. Hence, a close and effective coordination for pooling resources to achieve clearly identified mutual objectives and goals is better than everything being done by the watershed program itself. Hence, research with regards to institutional arrangements that dealing with land and water resources through co-operation and co-ordination are vital research area for sustainable development and up scaling planning of watershed management intervention strategies.

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## Appendixes

### Section I

Chapter 3: Appendix Table 3 A1, Reliability Statistics for watershed degradation indicators

<b>Reliability Statistics</b>	
Cronbach's Alpha	N of Items
.872	20

Source: model out put

Chapter 3: Appendix Table A2 , Multicollinearity test for variables in the binary logistic regression model

Variable	VIF	1/VIF
Land size	1.60	0.623689
Off/nonfarm activities	1.58	0.634395
Livestock(TLU)	1.45	0.687879
Extension contact	1.37	0.728082
Farm distance	1.21	0.829610
Topographic settings	1.20	0.830324
Group membership	1.20	0.830769
Credit services	1.18	0.850034
Training services	1.17	0.852931
Sex	1.12	0.892744
Age	1.10	0.911989
Family size	1.08	0.927422
Land tenure security	1.06	0.944311
Literacy status	1.05	0.954270
Mean VIF	1.24	

Source: model output

Chapter 4: Appendix Table A1, Reliability Statistics for community participation indicators

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.915	0.918	27

Source: model out put

Chapter 4: Appendix Table A2, value of VIF in binary logistic regression model

Variables	VIF	1/VIF
Off/non farm income sources	1.53	0.655646
Farm land size	1.49	0.672965
Total livestock owned (TLU)	1.37	0.728207
Frequency of extension contact	1.34	0.744288
Access to credit services	1.17	0.851357
Group membership	1.17	0.852882
Topographic setting	1.17	0.855359
Sex	1.12	0.896184
Age	1.10	0.912142
Family size	1.08	0.928275
Land tenure security	1.05	0.951252
Literacy status	1.04	0.962218
Mean VIF	1.22	-

Source: model out put

Chapter 5: Appendix Table A, Multicollinearity test in Multivariate probit model

Variable	VIF	1/VIF
Perception of soil erosion	1.98	0.504254
Land size	1.79	0.559552
Off/nonfarm activities	1.58	0.632868
Extension contact	1.49	0.670246
Livestock (TLU)	1.47	0.680851
Topographic settings	1.43	0.699709

Group membership	1.23	0.813292
Farmland distance	1.22	0.819725
Credit services	1.20	0.834304
Training services	1.19	0.843701
Sex	1.12	0.892223
Age	1.10	0.911986
Family size	1.08	0.926118
Land tenure security	1.06	0.939271
Literacy status	1.05	0.953189
Mean VIF	1.33	

Source: model out put

Chapter 6: Appendix table A, Reliability Statistics for socio economic and ecological benefit indicators

Cronbach's Alpha	N of Items
.878	13

Source: model out put

Chapter7: Appendix Table A, Multicollinearity test for variables in the Propensity score matching (PSM)

Variables	VIF	1/VIF
Topographic location	1.26	0.791662
Distances of FTC from home	1.25	0.798747
Training on the watershed management pro	1.23	0.814589
Age of the household head	1.11	0.898642
Distances of farm land from home	1.10	0.909745
Number of livestock (TLU) owned	1.10	0.911211
Number of family size	1.07	0.938907
Sex of the household head	1.03	0.968232
Literacy status of the household head	1.03	0.973925
Mean VIF	1.16	-

Source: model out put

## Section II

### 1. Conversion factor of tropical livestock unit (TLU)

Livestock type	TLU	Livestock type	TLU
OX	1	Horse	1.1
Cow	1	Sheep(adult)	0.13
Woyfen	0.34	Sheep(young)	0.06
Heifer	0.75	Goat(adult)	0.13
Calf	0.25	Goat(young)	0.06
Donkey(Adult)	0.7	Hen	0.013
Donkey(young)	0.35	-	

Source: Storck et al., 1991

### 2. Concept and definition of terms

**Community** is defined as a group of individuals, such as the people with common socioeconomic characteristics and interests living in a particular area. Since the main unit of analysis in this study is households, the term community and households are used interchangeably.

**Livelihood assets:** are distinguished into five different capitals such as human, social, natural, physical and the financial capital

**Livelihood outcomes:** are the achievements of livelihood strategies, such as more income, increased well-being, and reduced vulnerability, improved food security and a more sustainable use of natural resources and sustained livelihood assets

**Livelihood strategies:** are defined as the range and combination of activities and choices that people make in order to achieve their livelihood goals, including productive activities, investment strategies, and reproductive choices.

**Soil and Water Conservation (SWC):** activities at the local level, which maintain or enhance the productive capacity of the land in areas affected by, or prone to, degradation.

**Sustainable Land Management (SLM):** the use of land resources, including soils, water, animals, and plants, for the production of goods to meet changing human needs while

simultaneously ensuring the long-term productive potential of these resources and ensuring their environmental functions.

**Sustainable livelihood:** A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base.

**Watershed management Approaches:** ways and means of support that help introduce, implement, adapt, and apply SWC technologies on the ground.

**Watershed:** a topographically delineated area in which all water flowing into it goes to a common outlet

**Watershed degradation:** the loss of value over time in terms of quantity and quality of land and water resources in a watershed

**Watershed management Technologies:** agronomic, vegetative, structural and management measures that prevent and control land degradation and enhance productivity in the field.

**Watershed management:** a process of organizing or wise use of land and other resources used in the watershed to provide the desired goal without adversely affecting environmental resources

**Vulnerability context:** refers to the seasonality, trends, and shocks that affect people's livelihoods.