LAND USE TYPE AND LANDSCAPE POSITION EFFECTS ON SELECTED SOIL PHYSICO-CHEMICAL PROPERTIES:THE CASE OF OMANCHO WATER SHADE GURAGHE ZONE SOUTHERN ETHIOPIA

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STATEMENT OF AUTHOR

I here by declare that the thesis entitled ,"Land Use Type and Landscape Position Effects on Selected Soil physico-chemical Properties, the case of Omancho Watershed Gurage Zone, Southern Ethiopia," submitted for the partial fulfillment of the requirement for the Master of Science in Soil Science is my original work and has not been presented for a degree in any other university and all sources of material used for this thesis have been duly references are listed at the end of the main text.

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ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of Variance
Av.P	Available Phosphorus
CGS	Council of Graduate Studies
CV	Coefficient of Variance
DTPA	Diamine Tramine Penta Acetic Acid
DGS	Department of Graduate Committee
EC	Electrical Conductivity
EMA	Ethiopian Mapping Authority
EPRD	Ethiopian People's Revolutionary Democratic Front
FAO	Food and Agricultural Organization
FDRE	Federa Democratic Republic of Ethiopia
GPS	Global Positioning System
GZPEDD,	Gurage zone people Economies Development Department
LSD	Least significance difference
LSP	Landscape Positions
LUT	Land Use Type
SNNPRS	Southern Nations,Nationalities and Peoples Regional State
SAS	Statically Analysis Software
TN	Total Nitrogen
NGO	Non-Governmental Organization
PBS	Percent Base Saturation
SOC	Soil Organic Carbon
SOM	Soil organic matter
SWC	Soil and Water Conservation
GDP	Gross Domestic Product

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ABSTRACT

Understanding the effects of landscape positions and land use type on soil properties is crucial for improving the soil productivity and to ensure the environmental sustainability.The objective of this study was to assess land use type and landscape position effects on selected soil physico-chemical properties at Omancho watershed in Guraghe Zone of Southern Ethiopia. Accordingly, thirty six soil samples were collected from lower, middle and upper landscape positions and four land use types (woodland, grazing land, conserved and non-conserved land) at the depth of 0-15 cm in three replications.Data on selected soil physico-chemical properties were collected and statistically analysed.The result showed that most of measured soil properties were significantly ($p<0.05\%$)influenced by the interaction effects of topographic positions and land use types.The highest values of sand (46.67%) was recorded on non-conserved land of middle position, silt (33.67%) from grazing land at upper position and clay (57%) at lower position of grazing lands. The textural class in the study site was clay. The maximum (1.23gcm^{-3}) and minimum (0.94gcm^{-3}) soil bulk density (BD) values were recorded under upper position of non-conserved and lower position of conserved land respectively. The total porosity varied from 54 to 64.5 % which was recorded from the upper position of grazing land and the lower position of woodland respectively. The result showed that soil BD and sand fraction decreased from upper to lower position. In contrast, total soil porosity, clay and silt were increased from upper to lower position. Compared to conserved/woodlands, the non-conserved lands revealed the hightest BD and sand fraction. Soil pH was varied between 5.9 and 7.4% from the upper position of non-conserved land and lower position of conserved lands, respectively. The highest base saturation (73.13%) was recorded from the lower position on woodland uses, whereas the least value (46.4%) was recorded from the lower position of non-conserved land. The higher Av.P (1.04mg/kg soil) was recorded from the lower position of conserved land. The higher TN values (0.12%) was recorded from lower position of woodland,whereas the highest OC (1.20%) was recorded from lower positions of conserved land.The highest CEC (55meq/100gr soil) was recorded from the lower position of woodland whereas the least value (45meq/100gr soil) was recorded from the upper position of non-conserved land. Soil chemical parameters (pH, EC, Av.P, OC, TN, CEC) and exchangeable cations (K, Ca, and Mg) were significantly increased from upper to lower position. In general, the soil properties in all land use types were improved from upper to lower landscape positions. Thus, working soil and water conservation practices for all land use types, particularly in the upper land scape postions, are suggested.

Keywords:-Topography, Soil physico-chemical properties, Soil conservation, Landscape positions.

1.INTRODUCTION

Landscape position and land use types are vital factors affecting soil property variability (Wright *et al*., 2019). Topography is a significant factor controlling both hydrological and soil processes at the landscape scale, and its influence is also apparent in the soil catena concept (Seibert *et al.*,2007). Environmental factors such as slope aspect induced by microclimate differences, topography, parent materials, and vegetation communities are significantly influenced by the spatial variation of soil properties. Henceforth, under a small watershed scale, topography and land use types may be the dominant factors determining soil properties status (Mathewos, 2020; Yimer, 2017), particularly in areas of multiple land use and complex topography. Accordingly, quantifying the pattern and spatial distribution of basic soil indicators is fundamental to understanding many ecosystem processes. For example, determining the spatial distribution of soil organic carbon is an essential factor in land management decision making, climate change mitigation, and landscape planning (Aitkenhead *et al.*,2020). Therefore, landscape-based management, protection, and soil restoration are essential for several environmental and policy reasons.

Soil's physical and chemical properties are the result of the interaction among the soil- forming factors and processes, hence, making soil to be heterogeneous (Lawal *et al.*, 2014). One of the soils forming factors that influence the distribution of soil properties and water erosion is topography (Amuyou and Kotingo, 2015). As a factor of soil formation, topography an influence soil chemical and physical properties and also affect the pattern of soil distribution over landscape even when the soils are derived from the same parent material (Lawal *et al.*,2014). According to Musa and Gisilanbe (2017) differences in soil properties due to landscape positions result in detachment, transportation and accumulation of soil materials. The steepness of slope has great effect on soil properties particularly in soil distribution.

Soil is an invaluable natural resource, forming the basis for food and environmental, social, and economic security for the mankind. Its improper use and over use result in land degradation, causing many on- and off-site damages like decline in soil fertility and crop productivity, disruption in hydrological functioning of watersheds, increased incidence of droughts and floods, shrinking water supplies, increased sedimentation of water bodies and rivers, vulnerability to climate change, and deterioration in the socio-economic status of people (Hurni *et al*., 2010) and well-managed healthy soils, on the other hand, are least prone to either of these problems and ensure sustained ecosystem services (Keesstra *et al*., 2016) and are estimates that 75% of the land worldwide is degraded (Scholes *et al*., 2018) and 5 to 6 million hectares of arable land are being lost annually to severe degradation (Hamdy *et al*., 2014). Needless to say, the severely degraded areas bereft of natural capital, social capital, and economic capital are home to the most disadvantaged people, suffering from hunger, malnutrition, and poverty (Kirui *et al*., 2014).

Woodland is land spanning more than 0.5 hectares with trees higher than 5 m and a canopy cover of 5–10 percent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 percent (FAO, 2013). They provide a wide range of economic, social, and ecological benefits, ranging from cultural to tangible economic values (Hergarten *et al*., 2013). Under proper stewardship, this important capital asset can play a critical role in human livelihood, as well as in ecosystem functioning and health (Lindquist *et al*., 2012). They are also important for helping people adapt to the impacts of climate change (Locatelli *et al*., 2008). These wide-ranging roles of woodlands have received renewed recognition in recent times (Pramova *et al*., 2012). Woodlands are still under threat by various extractive human activities that result in degradation of habitat, land fragmentation, and land-use change (e.g., from forestry to agriculture) (Hergarten *et al*., 2013). Climate change can also exacerbate these pressures and exert significant negative impacts on the capacity of woodlands to provide vital ecosystem services (Seppala *et al*., 2009).

Common grazing lands are important sources of livestock feed in developing countries, although unrestricted access to such resources can result in overexploitation and degradation of the resource. Alternative ways of managing common resources, including state, collective and private management, have been suggested to arrest resource degradation. However, there is debate on the effectiveness of the various methods in improving use benefits as well as reducing degradation (Wade, 1986; Pearce and Turner, 1990; McCarthy *et al*., 2001).

Increasingly, however, collective (community) action is recognized as a viable and promising method of managing natural resources (McCarthy *et al*., 2001). For successful community natural resource management, it is necessary that management and use rights be vested in the community. In addition, the community must establish use regulations and enforce those regulations.

Aytenew (2015) reported that landscape position had direct and indirect effect on soil physico-chemical properties. It gives rise to toposequences of related soils from the same parent materials, about the same age and occupying under similar climatic conditions but have differences in their characteristics due to change in topography (Osuaku *et al.,* 2014). Besides topography, factors enhancing soil loss in Ethiopian highlands are cultivation of steep slopes, the tendency of soils to be affected; incomplete recycling of crop residue, deforestation, over grazing, and inadequate soil and water conservation measures (Hurni *et al.,* 2010). This indicates that the change in land use and landscape position could affect the physico-chemical properties of the soil (Getahun *et al.,* 2014). Similarly, Selassie *et al., (*2015) study in the Zikre watershed of northern Ethiopia and reported that the occurrence of variation in soil properties along landscape position. Wubie and Assen (2019) study in the Gumara watershed, Lake Tana basin of North-West Ethiopia reported that the forestland and gentle slopes have lowest bulk density and high total porosity.Hence, identifying the effect of landscape gradients on the physico-chemical properties of soil is fundamental, which has national significance.

1.1. Statement of the Problem

The well-being of present and future generations depends on the fertility status of soil in agrarian countries like Ethiopia. The natural phenomena and interference of human activities are aggravating soil degradation that needs immediate remedies to sustain cropland, livestock production and productivity. Soil is the only media, which supports the germination, growth and maturity of crops in association with other life supporting systems for better yield (Ministry of Agriculture, 2005).

In Ethiopia, the heavy dependence of people’s livelihoods on agriculture and inappropriate use of natural resources resulted in fast and vast land degradation (Tsegaye, 2006). Land resources degradation, resulting from different causes, was threatening long-term productivity.

Continuous cultivation and intensive grazing of land with out proper management resulted in decline in soil physical, chemical and biological properties that aggravate crop yield reduction and food shortage (Wasihun Mengiste *et al*., 2015). Evaluating land use induced changes and landscape positions on soil properties in the water shade is essential for understanding the impacts of agro-ecosystem transformation on soil productivity and to come up with appropriate and sustainable soil and land management options (Eyayu Molla and Mamo Yalew, 2018).

Increasing population pressure has historically resulted in land use change from natural forest to cultivated and grazing lands with subsequent changes.Land use changes from natural vegetation to cultivated lands brought about rapid nutrient depletion (Habtamu *et al.*,2014).

The study watershade is suitable for the production of different crops like teff *(Eragstistef)*, maize (Zea mays), pepper and sorghum (Sorghum bicolour). However, the ever increasing human population in the study area has dramatically reduced per capital land holding and created pressure on the available agricultural lands. Significant number of studies have been done on land management in different parts of the Ethiopia (Amsalu, 2006 and Heyi, 2012). Due to high population growth in the study area, land holding per household become low. Secondery data in the study area indicates there has been reducing land holding per capital and pressure on limited land for agriculture production. Forced the farmers to shift woodlands to cultivated lands. This might inevitably brought the disturbances of ecosystem and depletion of soil fertility and erosion. Consequently, in different land uses of the study area, there was a belief that the above-mentioned problems have brought a direct negative effect on soil fertility in general and crop production and productivity in cultivated lands in particular. However, the extent and rate of the problem in terms of physical and chemical soil degradations were not quantified properly.

Sustainable soil management technologies and practices, which have been supported by research finding, were not yet transferred to the farming communities in the study area. Thus, it is important to conduct a research to assess how cropland productivity has been improved through traditional biological and physical land management practices in relation to LUT and landscape positions in the study area.

However, land use type and landscape position effects on selected soil properties have not been scientifically studied and documented in the Abeshghae district. Therefore, this study was designed to analyses the land use type and landscape position effects on selected soil physico-chemical properties at omancho watershed, carried out in Abeshghe woreda, Ethiopia.

1.2. General Objective

- ☞ To assess land use type and landscape position effects on selected soil physico-chemical properties at Omancho watershed; Abeshgae Woreda, Guragae Zone, Southern Ethiopia.

1.2.1. Specific Objectives

- ☞ To evaluate the effects of landscape positions on selected soil physico-chemical properties at Omancho watershed.
- ☞ To evaluate the effects of different land use types on selected soil physico-chemical properties at Omancho watershed.
- ☞ To evaluate the interaction effects of landscape positions and land use types on selected soil physico-chemical properties at Omancho watershed.

1.3. Significance of the study

The economy of developing countries like Ethiopia, in general and a specific study area in particular primarily depends on agriculture and hence sustainable agricultural production depends on the appropriate soil fertility management. secondary data on the study area showed that some biological and physical land management practices were under taken in order to improve cropland productivity. Hence, it was crucial to identify a suitable and sustained land management practices to increase production of food grain for economic growth and development. This study was provided insight in to land use type and landscape position effects on selected soil physico-chemical properties at Omancho watershed, the results of the study have assumed to be significant for the land use type inorder to landscape positions, to make land resource management analyses. It is used as bench mark for other researchers who are interested to make another study around the topic. It is useful for the government body and interested sectors of this issue by providing over view of the current land use and management practices of the study area in order to take actions to solve land management related problem. As asource material for further studies, which could be a major input to formulate appropriate land use and fertility map policies. It is also contribute to the frontier of knowledge.

2. LITERATURE REVIEW

2.1. The concepts of land use types and landscape positions

Soil properties varied significantly among soil types and across locations reflecting differences in parent materials, climate, and land use types (Elias, 2019). The northern region and the most highland parts of Ethiopia are among the most seriously affected areas by land/soil degradation (Tamene *et al*.,2017). Factors are aggravating land/soil degradation resulting in low soil fertility manifested in lower yield and higher environmental problems (Asresie *et al.*,2015). Bekunda *et al.,* (2010) specially narrated this situation as the soil fertility decline is not out of the smallholder farmers violation, but rather the consequence of striving for household well being under difficult circumstances.

Land use type could determine the total production from the land and the status of the producer. The land use type could be determined by the need of producer, the environmental condition (soil, climate, rainfall, altitude), socioeconomic status (land lord,tiller,or peasant), and political (tenure, land policy, and ownership) and cultural manners (beliefs, norms, and by laws on the land) of the given area (Duguma *et al.*, 2010). The aforementioned factors could influence the owner to decide the type of land use on their land. Among the factors that could influence the user's preference is the soil condition of the field. The soil condition can be identified by analyzing the soil properties and comparing with the standards.

Rapid population growth is believed to influence the type of land use and the rate of expansion of specific land use type (Duguma *et al.,* 2010) could affect the soil properties of a given land when it is changed from natural to artificial land use system or vice versa. The intensified agricultural land expansion on the expense of the loss natural environment could also lead to severe land degradation. In the central highlands of Ethiopia, there is significant land use change from natural ecosystem to artificial ecosystem with in five decades. Recently, Jaleta *et al.,* (2016) Eucalyptus woodlot has joined the artificial ecosystem with rapidly expanding on grassland, woodland, riverside wetlands, cultivated land, and degraded land in the central highlands of Ethiopia (Chanie et al., 2013).

2.2. Indigenous land management practices

Indigenous land management practices are simple structures of a short-term nature that could be reshuffled each year to make use of the soil captured above the structure and avoid rodent production Tsegaye and Bekele (2010). They are built upon farmers' indigenous knowledge as part of their farming practices that have evolved through the course of time without any outside institutional interventions. These technologies are one of the inherited and transferred from generation to generation (Tollera, 2011).

This type of knowledge includes the complex of practices and decisions made by local people. It is based on experience passed from one generation to the next, but nevertheless, it changes, adapts and assimilates new ideas Oudwater and Martin (2003). (Failing *et al*.,2007), define local knowledge as the full variety of insights, observations and beliefs related to a particular decision that do not stem from conventional scientific expertise.

The most perceived and preferred indigenous land management practices include zero-grazing, agro-forestry (woodlot), trash lines, grass strips, minimum tillage, contour ploughing, animal manures, fallowing and biological or agronomic methods such as cereal-legume intercropping, crop rotation and mulching, residues of crop production (Ayalew *et al.*, 2009).

2.3. Improved /Introduced / land management practices

The introduced type of land management technologies refers to the recommended type of structures, which have standard length, width and height. These structures have specific design requirements and need major investments of labor in construction, often during a single period. In most areas of Ethiopia, new land management technologies were introduced more than two decades ago. During such span of time, the introduced technologies have been under continuous modification, which make it very difficult to trace them back to their origins to compare them with recent development (Tadesse, 2011).

This type of land management technologies in Ethiopia includes soil/stone bunds, bench terrace, inorganic fertilize, check dam, waterways, cut off drains, area closure and closed gullies, hillside terrace, fanyajuu, organic fertilizer (Blata, 2010). These technologies are comparatively had long run benefits and importance. However, the hope and desire of the farmers was to get immediate benefits and to increase production from treated lands in order to continue the practical application of the new technology (Amsalu, 2006). Study conducted by Adane (2007) pointed out that farmers have blamed the new technology because of different reason. The complains of the farmers are associated with the following drawbacks: its narrowness for ploughing, losses of the substantial lands out of use, the breeding conditions of rodents and weeds with in structure, its difficulty in designing, demands of much labor, encourage for formation of water logging at flat land, solidness at steep slope and artificial water way to form gullies.

Recognizing land degradation as a major environmental and socio-economic problem, the government of Ethiopia has made several interventions on soil and water conservation measures in the early 1970's to improve land management (Demena, 2012). However, the achievements have fallen far below expectations. The country still loses a tremendous amount of topsoil and the threat of land degradation is broadening alarmingly.

Proper use and management of agricultural land implies improving land productivity through encouraging different conservation and rehabilitation mechanisms and rational utilization of the country's land resource. This strategy is targeted mainly to chronically food-insecure, moisture deficient and pastoral areas. The focus is on environmental rehabilitation to reverse the current trend in land degradation, and as a source of income generation for food insecure households. Watershed- based water harvesting and introduction of high value crops, livestock, and agro-forestry development are new elements in the revised strategy (Demana, 2012).

2.4. Land management challenges in Ethiopia

2.4.1. Policy related and Technical challenges

Agricultural production sustainability can be challenged not only by long-term insecurity of land, water, and forest resource bases, but also challenged by specific policies formulated to protect these resource bases to enhance agricultural productivity and improve the livelihood of rural dwellers (Rozanov, 1998). In particular the challenge in this regard relates to developing the necessary capacity in terms of educational, professional, and institutional standards for the agriculture sector (Enemark, 2005).

According to (Regassa *et, al.,*2013) making the extension services systematic, effective and demand driven is critical challenge in the development of agricultural sector in general and to manage agricultural land in particular. The national agricultural extension system also requires care full analysis of national policy and policy makers directly or indirectly give emphasize to resolve and fulfills facilities needed for extension. Example, limited development agent and application of information technology tools to facilitate the work of extension service in agricultural land management are one of the challenges related with national policy (Qamar, 2016).

According to (Rahman, *et, al*.,2009) resource availability like animal manure is also agreat challenge to practice effective land management practices in line with technical challenges.

2.5. Effects of Land Management practices on Soil Properties

Ethiopia is considered to be one of the least developed countries where agriculture had always played a central role in the country's economy. The rapidly increasing population has led to a declining availability of cultivable land and a very high rate of soil erosion were done (Abera, 2003). Soil is the foundation resource for nearly all land uses, and the most important component of sustainable agriculture Mulugeta and Karl (2010). Therefore, assessment of soil quality indicators with respect to land use types, management practices and slope classes is useful and primary indicator for sustainable agricultural land management.Generally, a sound understanding of land use and management effects on soil properties provides an opportunity to evaluate sustainability of land use systems(Woldeamlak, 2003).

Recent interest in evaluation the quality of our land resource has been therefore simulated by increasing awareness that soil is critically important component of the earth's biosphere, functioning not only in the production of food and fiber but also in the maintenance of local, regional, and worldwide environmental quality Wakene and Heluf (2004**).**In response to the increasing demands for food production, agricultural lands are expanding at the expense of natural vegetation and grasslands (Lambin *et al.*,2000); (Hartemink *et al*.,2008).

The land management in agricultural areas has an important influence in microbial soil properties (García-Orenes *et al*.,2013). Unsuitable land management can lead to aloss in soil fertility and a reduction in the abundance and diversity of soil micro organisms. However,ecological practices and some organic amendments can promote theactivities of soil microbial communities and increase biodiversity (García-Orenes *et al*.,2010).

2.6. Effects of Land Use Types on Soil Properties

Land use is an integrator of several environmental attributes which influence nutrients export Land use and land management practice influence the soil nutrients related soil processes, such as erosion, oxidation, mineralization, and leaching, etc. (Fu *et al*.,1999); (Hontoria *et al*.,1999), and consequently modify the processes of transport and redistribution of nutrients. Moreover, soils through land use change also produce considerable alterations (Fu *et al*.,2000), and usually diminish soil quality after the cultivation of previously untilled soils. Hypothesized that a wide array of soil nutrients may vary among land uses and landscape positions. (Guadie*et al.*,2020) highlighted that raising awareness andconvincing farmers toward SWC practice is essential for futuresustainable land management.

Various studies have been conducted to assess the effect of land use changes on soil physical and chemical properties in Ethiopia e.g. (Yimer *et al*.,2007, 2008); (Lemma *et al*.,2006); (Lemenih et al.,2005). (Lemma et al.,2006) showed that afforestation of farmland with exotic trees increased total N, exchangeable K^{+}, and exchangeable Ca^{2+} in surface soils while it had little effect on available P in Belete forest, which is part of government afforestation programme. Another study conducted by (Lemenih *et al*.,2005) in Munessa Shashamene state forest area showed that soils under Eucalyptus saligna Sm. deteriorated more than those in traditional farming. (Yimer *et al*.,2007) also compared croplands, forestlands and grazing lands and found that soil organic C and total N decreased in croplands as compared to forestlands..

Another study by Alemayheu and Sheleme(2013) also found comparable higher organic carbon (OC), total nitrogen (TN) under grassland as compared to cultivated land use types. Similarly, according to Yihenew and Getachew (2002), human managed land uses like cultivated and grazing land use types had more deleterious effects on soil electric conductivity (EC), pH, soil organic carbon (SOC), TN and on the overall activities of soil macro faunal in the soil. The highest clay content observed in soils of the cultivated land could be attributed to the mixing of soil during tillage activities as was also reported by Heluf and Wakene (2014), (Tematio *et al*.,2011) and (Aminu *et al*.,2013).Sustainable use of land resource has been an increasing concern to decision and policy makers (Tesfahunegn, 2014).

2.7. Effect of Topography on Soil properties

Topography influences soil properties through its effects on geomorphologic, hydrological and biogeochemical processes (Webster *et al.*,2011). It determines both the vertical redistribution of elements within soil profiles through leaching and laterally along slope gradients (Laekemariam *et al.*,2016).

2.8. Effects of Landscape positions and Land Use type on Soil Physical Properties

2.8.1. Soil Texture

Soil texture determines a number of physical and chemical properties of soils. It affects the infiltration and retention of water, soil aeration, absorption of nutrients, microbial activities, tillage and irrigation practices (Gupta, 2004). This results are in agreement with the findings of (Ayele *et al.,*2013), and Tsehaye and Mohammed (2013), who explained that cultivated and grazing lands are susceptible to erosion, because they have less vegetation cover. It is also an indicator of some other related soil features such as type of parent material, homogeneity and heterogeneity with in the profile, migration of clay and intensity of weathering of soil material or age of soil (Lilienfein *et al*.,2000). Soil texture is one of the inherent soil physical properties less affected by management. Over a very long period of time, pathogenic processes such as erosion, deposition, eluviations and weathering can change the textures of various soil horizons Brady and Weil (2002).

The mean value of sand fraction was highest in cultivation areas followed by grazing and forest, it means the cultivated area was eroded by soil erosion, low water holding capacity,and others. On the other hand, soil structural composition fo rforest land use has the highest. High mean value for silt on conserved and clay on forest land (Terefe*et al.,*2020). It may be high water holding capacity.

2.8.2. Bulk Densities

Bulk density is the dry mass (weight) of soil per bulk volume Michael and Donald (1996).It was determination of compactness or loosenes of soil structure. Higher clay fraction at the upper landscape in the treated land could be due to the establishment of conservation structures in the sub watershed that protected soil particles from erosive runoff and trapped them for in situ deposition (Wolka *et al.,* 2011; Adimassu *et al.,* 2014).It was highly significantly affected by the interaction effect of land use and slop class where the highest value was observed on the surface layer of grazing land and lowest on the surface layer of forest land, which might be due to the effects of high compaction by grazing animals in grazing and cultivated lands and high OM content in forest land (Habtamu*et al*.,2014). Bulk density also provides information on the environment available to soil microorganisms.

According to (Selassie *et al*.,2015) reported that progressive increase in soil bulk density due to continuous cultivationin the top plow layers might have resulted from a declinein the soil organic matter content and compaction from the tillage.Higher bulk density in the cultivated and grazing land unitswas the product of continuous shallow depth cultivation and dryseason livestock trampling. Variation in soil bulk density couldalso result from the absence of soil conservation practices thatremoves soil organic matter. Soil bulk density of the forest, grazing,and cultivated land with soil conservation had lower bulkdensity than land uses with out soil conservation.

Bulk density normally decreases as mineral soils become finer in texture. Soils having high bulk density exhibit favorable and poor physical conditions, respectively. Bulk densities of soil horizons are inversely related to the amount of pore space and soil OM Brady and Weil (2002); (Gupta, 2004). Any factor that influences soil pore space was also affect the bulk density. For instance, intensive cultivation increases bulk density resulting in reduction of total porosity. The study results of Woldeamlak and Stroosnijder (2003) and (Mulugeta,2004) revealed that the bulk density of cultivated soils was higher than the bulk density of forest soils. Similarly, (Ahmed,2002) reported that soil bulk density under both cultivated and grazing lands increased with increasing soil depth. On the other hand, (Wakene,2001) reported that bulk density was higher at the surface than the subsurface horizons in the abandoned and lands left fallow for twelve years. The changes in the physical soil attributes on the farm fields can be attributed to the impacts of frequent tillage and the decline in OM content of the soils.

2.8.3.Total Porosity

The total porosity of soils usually lies between 30% and 70%. In soils with the same particle density, the lower the bulk density, the higher is the percent total porosity. As soil particles vary in size and shape, pore spaces also vary in size, shape and direction (Foth,1990). Coarse textured soils tend to be less porous than fine texture soils, although the mean size of individual pores is larger in the former than in the latter. There is close relationship between relative compaction and the larger (macro pores) of soils Ike and Aremu (1992). According to the same authors, tillage reduces the macro pore spaces and produces a discontinuity in pore space between the cultivated surface and the subsurface soils. It is also shown that TP is highest in the woodland followed by grazing land use accounting. Soil physical properties were considerably influenced by changesin land use and the implementation of conservation practices (Terefe*et al.*,2020).

Total pore space (%) = 1-(BD/PD) x 100 ; the constant value of PD have 2.65gm/cm^3

Generally, intensive cultivation causes soil compaction and degradation of soil properties including porosity. Macro pores can occur as the spaces between individual sand grains in coarse textural soils. Thus, although a sand soil has relatively low total porosity, the movement of air and water through such soil is surprisingly rapid because of the dominance of macro pores. Fertile soils with ideal conditions for most agricultural crops have sufficient pore space, more or less equally divided between large (macro) and small (micro) pores. The decreasing OM and increasing in clay that occur with depth in many soil profiles are associated with a shift from macro-pores to micro-pores Brady and Weil (2002). Micro pores are water field; and they are too small to permit much air movement. Water movement in micro pores is slow, and much of the water retained in these pores is not available to plants. Considering the surface soils, (Wakene,2001) stated that the lowest total porosity was observed on the abandoned research field, followed by under the land left fallow for twelve years and the highest was recorded on the farmer’s field. According to (Mulugeta,2004),The lowest total porosity was the reflections of the low OM content.

2.9. Effects of Landscape positions and Land Use types on Soil Chemical Properties

Soil chemical properties are the most important among the factors that determine the nutrient supplying power of the soil to the plants and microbes.The occurrence of higher concentration of organic matter at top soil is due to the redistributive effect of slope (Esu *et al.*,2008). Organic matter is also known to decrease with depth in pedon Idoga and Azagaku (2005). Nutrient supplying power of the soil to the plants and microbes is determined by the soil chemical properties. The chemical reactions that occur in the soil affect processes leading to soil fertility build up. Soil minerals inherited from the parent materials over time release chemical elements that undergo various changes and transformations within the soil. Takele *et al*., (2014) reported was significantly varies across forest, grazing and cultivated land use on soil chemical properties**.** Rodrigo-Comino *et al*., (2016) highlighted the effect of slope positions on selected soil physical properties and existence of mean variations in soilphysical and chemical properties at varying slope positions. (Bezabih *et al*.,2016) The lowest value of soil pH in the cultivatedland might result from higher microbial oxidation that creates organic acid and reduction in basic cations.

They also highlightedthat soil chemical properties such as pH, OC, TN, C:N ratio and AP have showed an improvement under SWCpractice than without. Other studies have also shown land use– soil–slope interactions in assessing the effect of land management practices on soil physical and chemical properties in the other part of Gojeb river, Southwest Ethiopia.(Sileshi*et al.*,2019) and (Bezabih *et al*.,2016). According to Guadie *et al.,* (2020) indicated that SWC practicestended to increase soil fertility and most of the soil chemical properties showed relative change with landscapepositions. Other studies conducted to assess variations in soil properties under different LUTs insouthern Ethiopia (Negasa*et al*.,2017).

2.9.1. Soil Reaction (pH)

Soil pH is the measure of the acidity or alkalinity of a soil, numerically equal to 7 for soils with a neutral pH, increasing with rising alkalinity and falling with increasing acidity.Soil reaction affects nutrient availability and toxicity, microbial activity, and root growth. Thus, it is one of the most important chemical characteristics of the soil solution because both higher plants and microorganisms respond so markedly to their chemical environment.Fertilizer application in cultivation land units might reduce the pH value. Habtamu *et al*., (2014), reason out that lowering of pH value in cultivated land areas results from nitrification of $NH4^+$ from chemical fertilizer, which releases. The woodland in lowerpositions showed constant value. This finding is in line with (Wolka *et al.*, 2011) and (Tufa *et al.*,2019). (Wolka *et al*., 2011) found a higher pH at the treated sub-watershed than the untreated one. In the study of (Tufa *et al.*,2019), pH was not affected by land use but a lower mean value was observed in the subsurface soil. However, Demelash and Karl (2010), (Ademe *et al.*, 2017), and Alemayehu and Fisseha (2018) found higher pH values on conserved land than the non-conserved land**.**Generally, the soils in the study area were slightly acidic and neutral; yet, it is in the preferred range for most of the agricultural practices agree with (Alemayehu and Fisseha 2018).

Descriptive terms commonly associated with certain ranges in pH are extremely acidic (pH < 4.5), very strongly acidic (pH 4.5-5.0), strongly acidic (pH 5.1-5.5), moderately acidic (pH 5.6-6.0), slightly acid (pH 6.1-6.5), neutral (pH 6.6-7.3), slightly alkaline (pH 7.4-7.8), moderately alkaline (pH 7.9-8.4), strongly alkaline (pH 8.5-9.0), and very strongly alkaline (pH > 9.1) Foth and Ellis (1997).

The degree and nature of soil reaction is influenced by different anthropogenic and natural activities including leaching of exchangeable bases, acid rains, decomposition of organic materials**,** application of commercial fertilizers and other farming practices. Brady and Weil (2002). Fertilizer application in cultivation land units might reduce the pH value. Researchers(Habtamu*et al*.,2014) reason that lowering of pH value in cultivated land areas results from nitrification of $NH4^+$from chemical fertilizer, which releases.

Electrical conductivity is an important indicator of soil health (USDA NRCS (United States Department of Agriculture Natural Resource Conservation Services) 2012). It is a measure of the ability of the solution to carry electric current; the more dissolved ionic solutes present in the soil, the greater is its electrical conductivity Provin and Pitt (2012). EC is the sum total of anions and cations, and roughly equivalent to the total dissolved solids (Rhoades and Corwin 1990). Thus, the source of higher dissolved solutes for the higher EC in the woodland of sub-watershed might be from cations and anions in the higher TN, available P, exchangeable K, and OC. Furthermore, the relatively higher clay particles in the conserved land could have contributed to the increase of the EC of the soil, because soil particles affect the EC of the soil.

From the result EC constant value at non-conserved land, increasing treande from lower to upper position at conserved land and variation on grazing and wood land.

2.9.2. Soil Organic Carbon

Soil organic carbon (SOC) is one of the most important chemical properties which is greatly influenced by land use type on a long-term bases. The highest organic carbon content resulted in higher organic matter content for soils of forest land while other land uses only rated medium levels (Mesfin,2013). Mishra *et al*.,(2015) reported that SOC is comparatively higher (>0.5 g kg-1) in surface horizons of upper land than lower land. Kiflu and Beyene (2013) observed significant differences in SOC content of soils among the different land use systems. Soil organic carbon (Rezaei *et al*., 2005) and total nitrogen (Zewdie *et al*., 2015)are found to be significantly affected by changes in conservation practice. Alijani and Sarmadian (2014) explained that soil carboncontent could be affected by topographic features, climatic conditions, and the extent of soil conservation practice.

The mean values of soil organic carbon across the different land use types and slope zones were different from cultivated, grazing and woodland area (Bezabih *et al*.,2014). Using of N fertilizer and animal manure in corn fields togather more products, increases SOC in cultivated soils (Gol, 2009). According to (Sharma *et al*.,2014) found that agricultural and degraded lands had up to 25% lower SOC stocks than forest soils, to the top half a meter layer of soil. The typical decrease of carbon content with depth was the sharpest for agricultural soils. The surface layer is most relevant to assess the impact of management practices on soil OM, because surface soils are easily modified directly by cultivation.

2.9.3. Soil Organic Matter

Soil OM is defined as any living or dead plant and animal materials in the soil and it comprises a wide range of organic species such as humic substances, carbohydrates, proteins, and plant residues In most tropical environments, the conversion of forest vegetation to agricultural land results in a decline of the soil OM content to a newer, lower equilibrium Woldeamlak and Stroosnijder (2003).

Most cultivated soils of Ethiopia are poor in OM contents due to low amount of organic materials applied to the soil and complete removal of the biomass from the field (Yihenew,2002), and due to severe deforestation, steep relief condition, intensive cultivation and excessive erosion hazards. Biological degradation is frequently equated with the depletion of vegetation cover and OM in the soil, but also denotes the reduction of beneficial soil organisms that is an important indicator of soil fertility. Uncultivated soils have higher in soil OM (both on surface and in soil) than those soils cultivated years Miller and Gardiner (2001).

Thus, water and oxygen holding capacity is increased, even beyond the absorptive capacity of OM, increases exchange and buffering capacity since well decomposed OM or humus has a very high CEC that adds to the buffering capacity of the soil, minimizes leaching loss because organic substances have the ability of holding substances other than cations against leaching, sources of nutrients (N, P, S and most micronutrients) and growth promoting substances, that is, hormones or growth -promoting and regulating substances valuable to plants may be produced by organisms that decompose soil OM, stabilizes soil structure, and provides energy for microbial activity .

Gregorich *et al.,(*1995) reported that the concentration of organic carbon (OC) in the forest soil decreased with depth by more than 10-fold in the surface 30 cm, from 139 g/kg soil in the 0-15 cm layer to 12 g/kg soil in the 15-30 cm layer. In contrast, the OC concentration under corn was similar for soil layers within the plow layer, ranging between 19 and 21 gram carbon per kg of soil. However, the mass of OC in the surface 10 cm of the forest soil was about three times greater than the soil under corn, but below 10 cm, the quantity of OC in the forest was similar to that of the soils cultivated for corn (Gregorich *et al*.,1995). Thus, the surface layer is most relevant to assess the impact of management practices on soil OM, because surface soils are easily modified directly by cultivation. The total amount of OC in the soil can be considered as a measure of stored OM.In a sense, stored OM is a mean OM store or standing stock of OM because it reflects the net product or balance between ongoing accumulation and decomposition processes and it is thus greatly influenced by crop management and productivity. Over the past few years, various attempts have been made to obtain both global and regional inventories of soil OM storage based on soil map units.

3.9.4.Cation Exchange Capacity

Generally, the chemical activity of the soil depends on its Cation exchange capacity (CEC) of soils is defined as the capacity of soils to adsorb and exchange cations Brady and Weil (2002). Cation exchange capacity is an important parameter of soil because it gives an indication of the type of clay minerals present in the soil, its capacity to retain nutrients against leaching and assessing their fertility and environmental behavior. High clay and organic matter contents in lower landscapes contributed to the high amount of CEC. Similarly, Selassie *et al.,(*2015) reported that the occurrence of variation in soil properties along with landscape position. Ahigher mean value of cation exchange capacity was found on woodland followed by conserved land. Lower mean value was found in non-conservedland .

Soils with large amounts of clay and OM have higher CEC than sandy soils low in OM. In surface horizons of mineral soils, higher OM and clay contents significantly contribute to the CEC, while in the subsoil particularly where Bt horizon exist, more CEC is contributed by the clay fractions than by OM due to the decline of OM with profile depth (Foth,1990; Brady and Weil, 2002). Soil solutions contain dissolved chemicals, and many of these chemicals carry positive charges (cations) or negative charges (anions) Fisher and Binkley (2000).

Generally, processes that affect texture (such as clay) and OM due to land use changes also affect CEC of soils.Woldeamlak and Stroosnijder (2003) reported that CEC value was highest in soils under forest land and lowest under cultivated land. Besides, due to the intensity of human action, there was a drastic loss of CEC in the surface than in the subsurface layers in soils of Senbat watershed, western Ethiopia (Nega, 2006).Therefore, it is necessary to study and evaluate soil chemical properties to avoid soil nutrient depletion and degradation, and to sustain production.

2.9.5.Total Nitrogen

Nitrogen (N) is the essential plant element taken up by plants in the greatest quantity next to carbon, oxygen and hydrogen; It is one of the most deficient elements in the tropics for crop production (Mesfin, 1998). This finding is also in agreement with the findings of (Berhanu ,2016), who reported variation of total nitrogen paralleled with that of the change in organic carbon content in soils of Girar Jarso of North Shoa Zone, Oromia, Ethiopia. (Malo *et al.*,2005).

Another study by Alemayheu and Sheleme (2013) also found comparably higher organic carbon (OC), total nitrogen (TN) under forest land as compared to cultivated land use types. The total N content of a soil is directly associated with its OC content and its amount on cultivated soils is between 0.03% and 0.04% by weight Tisdale *et al*.,1995). Soil organic carbon (Rezaei*et al*., 2005) and total nitrogen (Zewdie*et al*.,2015) are found to be significantly affected by changes in conservation practice. The N content is lower in continuously and intensively cultivated and highly weathered soils of the humid and sub humid tropics due to leaching and in highly saline and sodic soils of semi arid and arid regions due to low OM content (Wakene, 2001) reported that there was a 30% and 76% depletion of total N from agricultural fields cultivated for 40 years and abandoned land, respectively, compared to the virgin land in Bako area, Ethiopia.

Average total N increased from cultivated to grazing and forest land soils, which again declined with increasing depth from surface to subsurface soils (Nega, 2006). The considerable reduction of total N in the continuously cultivated fields could be attributed to the rapid turnover (mineralization) of the organic substrates derived from crop residue (root biomass) whenever added following intensive cultivation (Mc Donagh *et al*.,2001).Moreover, the decline in soil OC and total N, although commonly expected following deforestation and conversion to farm fields, might have been exacerbated by the insufficient inputs of organic substrates from the farming system (Mulugeta, 2004). The same author also stated that the levels of soil OC and total N in the surface soil (0-10 cm) were significantly lower, and declined increasingly with cultivation time in the farm fields, compared to the soil under the natural forest.

2.9.6. Available Phosphorus

Phosphorus (P) is known as the master key to agriculture because lack of available P in the soils limits the growth of both cultivated and uncultivated plants and Following N, P has more wide spread influence on both natural and agricultural ecosystems than any other essential elements,because of the removal of available phosphorus from higher slope gradient. In similar way, Asmamaw and Mohammed (2013) and Wolde *et al*., (2007) reported that high amount of available phosphorus was recorded in lower slope positions.This finding is in agreement with other researchers (Ademe et al. 2017; Aytenew and Kibret 2016; Tufa *et al.*, (2019). Ademe *et al.*,(2017) found higher P at conserved landscape than other land uses. In most natural ecosystems, such as forests and grasslands, P uptake by plants is constrained by both the low total quantity of the element in the soil and by very low solubility of the scarce quantity that is present Brady and Weil (2002). It is the most commonly plant growth-limiting nutrient in the tropical soils next to water and N. Erosion tends to transport predominantly the clay and OM fractions of the soil, which are relatively rich in P fractions. Thus, compared to the original soil, eroded sediments are often enriched in P by a ratio of two or more Brady and Weil (2002).

2.9.7. Exchangeable Bases

Potassium is the third most important essential element next to N and P that limit plant productivity. Its behavior in the soil is influenced primarily by soil cation exchange properties and mineral weathering rather than by microbiological processes. Unlike N and P, K^+ causes no off-site environmental problems when it leaves the soil system. It is not toxic and does not cause eutrophication in aquatic systems Brady and Weil (2002). According to Foth and Ellis (1997) soil parent materials contain potassium (K^+) mainly in feldspars and micas. As these minerals weather, and the K ions released become either exchangeable or exist as adsorbed or as soluble in the solution.

Available potassium present in soil solution which is easily available to the plant. Wakene, (2001) reported that the variation in the distribution of K^+ depends on the mineral present, particles size distribution, degree of weathering, soil management practices, climatic conditions, degree of soil development, the intensity of cultivation and the parent material from which the soil is formed.

Exchangeable sodium (Na^+) is alters soil physical and chemical properties mainly by inducing swelling and dispersion of clay and organic particles resulting in restricting water permeability and air movement and crust formation and nutritional disorders (decrease solubility and availability of calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions Sposito, (1989).Moreover, it also adversely affects the population, composition and activity of beneficial soil microorganisms directly through its toxicity effects and indirectly by adversely affecting soil physical and as well as chemical properties. In general, high exchangeable Na^+ in soils causes soil sodicity which affects soil fertility and productivity.

Exchangeable calcium and magnesium soils under continuous cultivation, application of acid forming inorganic fertilizers, high exchangeable and extractable Al^{3+} and low pH^- are characterized by low contents of Ca^{2+} and Mg^{2+} mineral nutrients resulting in Ca^{2+} and Mg^{2+} deficiency due to excessive leaching Dudal and Decaers (1993). Exchangeable Mg^{2+} commonly saturates only 5 to 20% of the effective CEC, as compared to the60 to 90% typical for Ca in neutral to somewhat acid soils Brady and Weil (2002).Research works conducted on Ethiopian soils indicated that exchangeable Ca^+ and Mg^+ cations dominate the exchange sites of most soils and contributed higher to the total percent base saturation particularly in Vertisols (Eyelachew, 2001).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location

The study was conducted at Omancho watershed, located in Jejeba and Gasore Kebele Abeshge woreda Gurage zone, in Southern Nations, Nationalities, and Peoples' Region of Ethiopia (SNNPRS). It is bordered on the south by the Wabe River, which separates it from Cheha district, on the west and north by the Oromia Region, and on the east by Kebena district. Which is found 4 km far from AbeshgaeWoreda (Wolkite Town) and 159 km far fromAddis Ababa (CASCAPE, 2015).

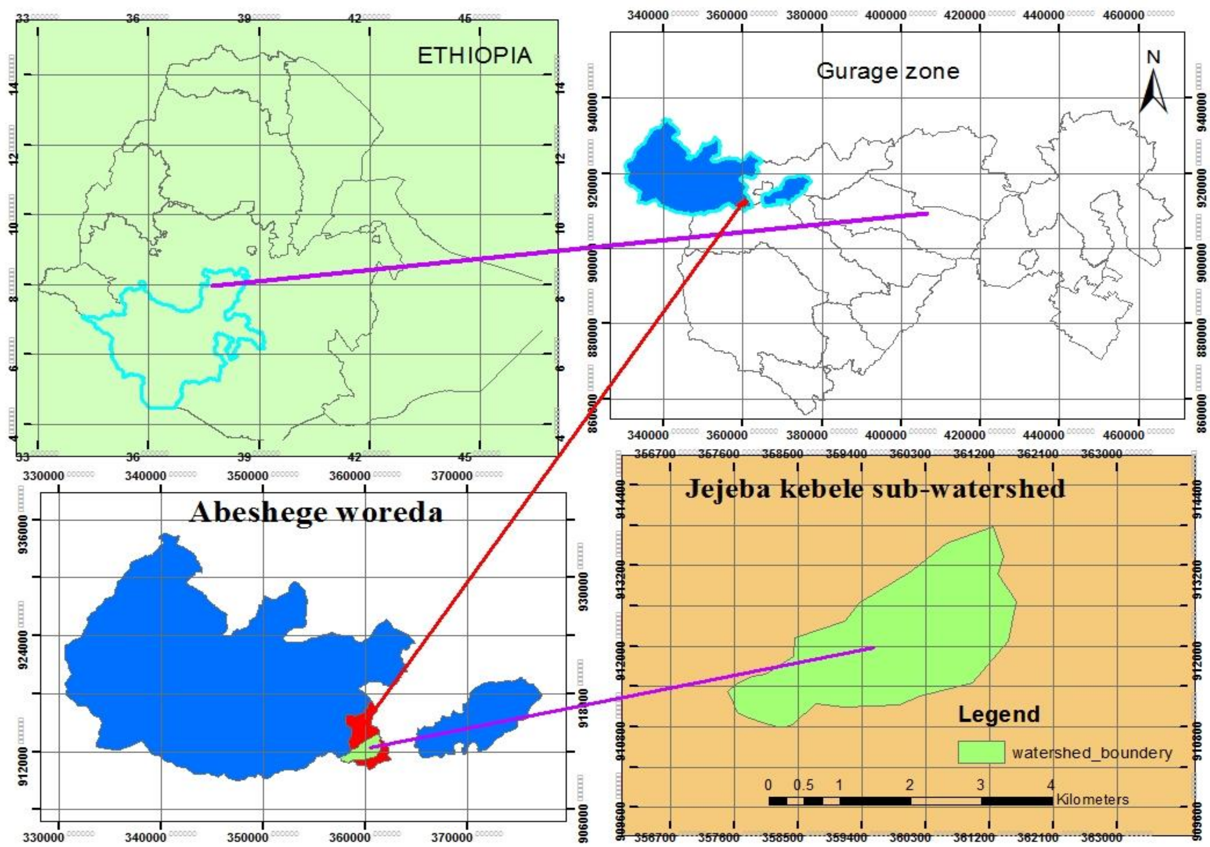

Figure 1. Map showing the study area of Omancho Watershed, Abeshgae Woreda, Gurage Zone, SNNP and Ethiopia.

3.1.2. Climate and Topography

Topography of Abeshgae Wereda is characterized as flat, gentle slope and steep slope,(GZPEDD. 2018).The main rainy season of the study area which accounts for around 75-90% of the total annual rainfall occurs from June to September. Two main distinct seasons, dry and wet seasons are recognized in the area. The dry season starts from November to May, while the wet season covers the remaining part of the year, when most of the precipitation takes place. According to the Ministry of Agriculture (MOA, 1998), the agro-ecology of the area was classified into two agro-ecological zones (midland and lowland areas).

The study area (Omancho Water shade) lies at a latitude and longitude of 07°56′N to 08°19′N and 37°28′ E to 37°37′ E, respectively.The mean annual rain fall data being around 1183.8mm.The district has generally a midland climate at annual rainfall is low.The average annual temperature is 21°C.The information obtained from Gurage Zone Planning and Economic Development Department (GZPEDD, 2012). It has the altitude maximum 1813 m.a.s.l at highest area and minimum of 1691 m.a.s.l at lowland area**.** Particularly in Jejeba and Gasore kebele Omacho sub-watershed is midland climatic zone.

3.1.3. Population of the study area

The population size of Abeshgae Worda and their distribution vary from the history of early human settlements. High population pressure existed in the middle and high altitude and relatively low population pressure at low land areas. Based on 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), total populations of AbeshgaeWoreda 101,834 of whom 53,814 are men and 48,020 are women. Specifically Jejeba and Gasore Keble has male 1,353 and female 1,362 total 2,715. The study area of Omancho Watershed covers an area of about 330 hectares and characterized by nearly level to sloping. Number of population male 502 female 560 total 1,062, number of house hold male 182 female 20 total 202 and average farmland perfarmers is 1.5 hectares.

3.1.4. Farming System

Mixed farming is the dominant economic activity of people in the study area. The area is suitable for different crop production. The main crops grown in the area are teff (Eragrostistef), maize (Zea mays), Pepper and sorghum (Sorghum bicolour). Agriculture in the area is predominantly rain-fed subsistence peasant farming on individual holding and traditional grazing on communal lands and the amount, reliability and distribution of rainfall are important determinants for crop yield.The majority of the farmers are depending on cereals and spices. The cultivated land accounts for an average of about 71.5% and the grazing and woodland account for about 26.35% of the Omancho sub-watershed area (AWADO, 2018). The remaining of the total area coverage of the watershed constitute settlement areas and others. Livestock production was an essential part of the farming system. Most farm households in the areas keep cattle, sheep, goat poultry and donkey. Oxen were used to plough croplands, Cows for milk and some model farmers used mechanized farming system. The high livestock number have led to over grazing. This was mainly due to graze freely on farm plot after crops harvest. As to animal forage, communal grazing areas, private pastures and crop residues were the principal source of feed for their livestock in the study area. It have been responsible for land degradation in Ethiopia and the study area. As well as have contribution for soil erosion process and for removing conservation structures.

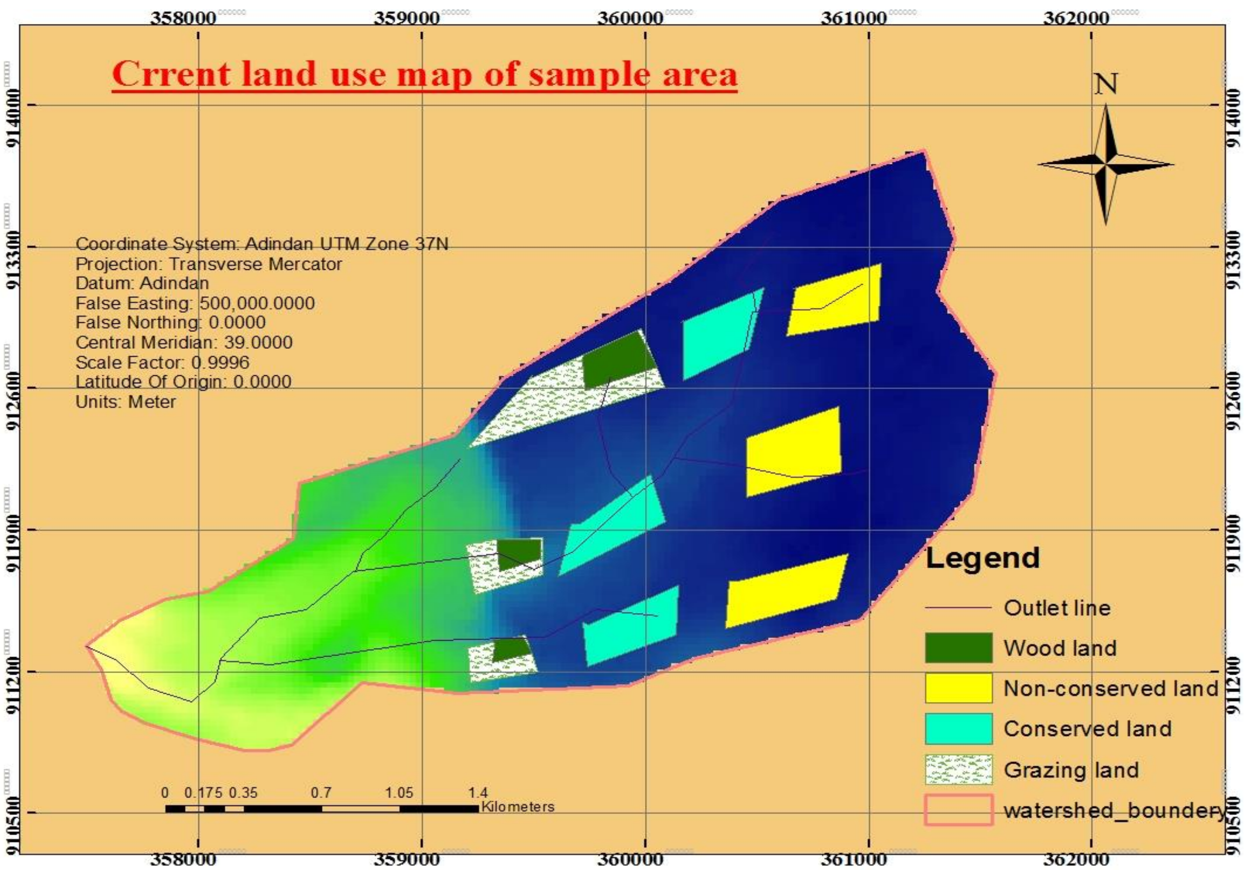

Figure 2. Map showing the current land use in study area of Omanch Watershed, Abeshgae Woreda, Gurage Zone, SNNP and Ethiopia.

3.2. METHODOLOGY

3.2.1. Site Selection

Prior to field work, a preliminary interpretation of topographic map obtained from the Ethiopian Mapping Authority (EMA) and google earth image was done.Then the map units was delineated on the basis of landscape positions and land use/land cover pattern. Reconnaissance survey of the area was conducted to determine representative sampling site of the area.

3.2.2. Treatments and Soil Sampling

The study considered two factors: landscape position (upper, middle and lower slope) and four land-use types cultivated land (conserved and non-conserved), grazing and woodland. Factorial sampling procedure were adopted for research design. A total of thirty six soil samples with in

0-15cm depth were taken from each adjacent land use type and with in each landscape position in three replication. The composite soil samples were collected by thorourhly mixing fifteen randomly collected sub-samples from each adjascent land use type and with in each landscape position by taking about one kilogram composite soil sample with quartering method.Global positioning system (GPS) and clinometers were used to recorded the geographical locations and slopes of the sampling sites of selected land uses, respectively.

3.2.3. Soil sample preparation and analysis

The samples collected by ouger were air dried, mixed well and passed through a 0.5mm for total N and OC, 2 mm sieve for other selected soil physico-chemical analyses.The soil physico-chemical analyses was carried out at Wolkite Soil Testing and Soil Fertility Improvement Laboratory Centers using standard laboratory procedures and Phosphorus reading was carried out at Wolkite University. For disturbed soil sample fifteen composite soil sample one kilogram were taken.

Undisturbed core samples collected by core sampler from each land use types were used for soil physical parameters such as soil bulk density and total porosity. Soil bulk density was determined as the ratio of oven dry soil samples mass to its volume in an oven at 105 ^{O}C to constant weights, while Percentage total pore space was computed from the value of bulk density and particle density (1-BD/PD x 100) as described in Hao *etal., (*2008). Texture was estimated using Hydrometer method Gee and Bauder (1986) after destroying organic matter by adding hydrogen peroxide (H_2O_2) and dispersing the soil through adding sodium hexametaphosphate (NaPo3)6. Soil pH and electrical conductivity (EC) these parameters were measured from soil suspension solution prepared with 1:2.5 soil water ratios using digital pH meter and EC meter respectively (Van-Reeuwijk, 1993). Organic matter content was determined following the Walkey and Black (1934), conversion method (% OM=1.724 x % OC). Total nitrogen was determined following the Kjeldahl Procedure as described by, (1992) conversion method (% OM/20). Available phosphorous were determined by the Olsen method Olsen *et al.*, (1954). Cation exchange capacity (CEC) of the soil was determined with the ammonium acetate saturated method and exchangeable bases (Ca, Mg, K and Na**)** were determined after leaching soil by 1.0M ammonium acetate at pH 7.0. Exchangeable Ca and Mg in the extracts were measured using atomic absorption spectrophotometer. Na and K these were analyzed by flame photometer (Chapman, 1965). Percent base saturation (PBS) was calculated as the ratio of sum of the base forming cations (Ca, Mg, K and Na) to CEC of the soil and multiplied by 100.

3.2.4. Statistical data analyses

The soil data were subjected to analyses of variance with factorial method using SAS software(latest version). A two-ways analyses of variance were performed to assess the significance of differences in soil parameters between landscape position and land use types.Treatment means were compared using least significant differences (LSD). Correlation analyses were also conducted among soil parameters and the research design is quartering method.

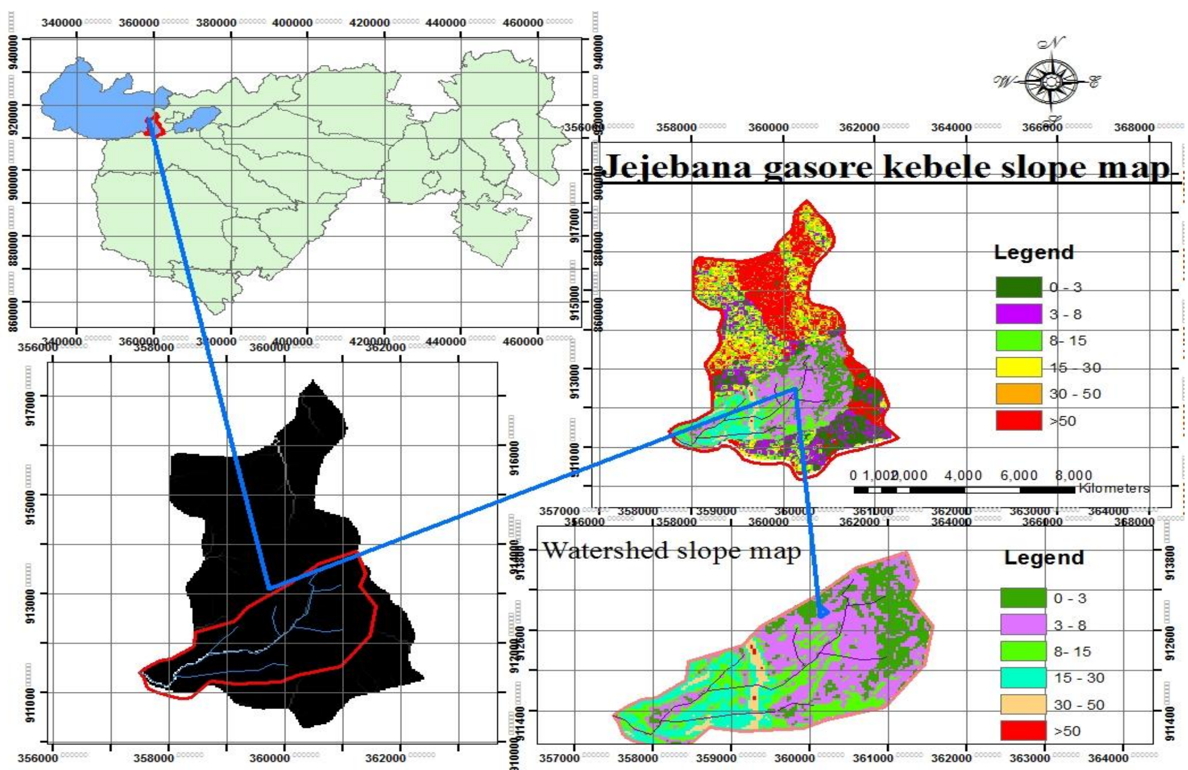

Fig 3. Map showing the slop of Omancho Watershed, Abeshgae Woreda, Gurage zone, SNNP and Ethiopia.

4. RESULTS AND DISCUSSION

4.1. Effects of Landscape positions and Land Use type on Soil physical Properties

4.1.1. Soil Particle size distribution

Sand, silt and clay contents revealed significant variation by the interaction effects of landscape positions and land use types (P <0.05) (Table 1). Sand content varied from 19% at grazing land of lower position to 46.67% non-conserved land at the middle position. The higher sand proportion at the middle positions under non-conserved lands might be due to the removal of the fine particles (silt and clay) by soil erosion, and left over accumulation of sand. These results are in agreement with the findings of Tsehaye and Mohammed (2013), who explained that non-conserved and grazing lands are susceptible to erosion, because they have less vegetation cover.These results are also in agreement with the findings of Ayele *et al.*, *(*2013), who reported a high mean value of sand under soils of middle and upper landscape positions. Silt ranged from 22.00% on the middle position of non-conserved land and 33.67% upper position of grazing land and the amount of clay was between 28% and 57% which was recorded from the upper position of grazing land and lower position of grazing land, respectively (Table 1). It was also noted that the clay content of land use types was increasing towards the lower landscape postion of the watershed except woodlands. Higher clay fraction at the lower landscape positions in the grazing land could be due to erosive runoff in the watershed that protected soil particles from erosive runoff and trapped them for in situ deposition (Wolka *et al.*, 2011; Adimassu *et al.*, 2014). And also, due to the mixing of soil during tillage activities (Heluf and Wakene 2014, Tematio *et al*., 2011 and Aminu *et al*.,2013). Overall, landscape positions and land use types were dominated by clay textural class. According to Bezabih *et al*. (2016).

Sand content of grazing land units increased from lower to upper position where as in woodland is the reverse. Silt fraction generally showed a decreasing trend from lower to upper positions in all land use types except grazinglands.

Table.1.Interaction effects of landscape Positions and Land Use Type on soil particle size distribution at omancho water shade in 2022.

Land-use type	Sand (%)			Silt (%)			Clay (%)		
	Landscape Positions			Landscape Positions			Landscape Positions		
	LS	MS	US	LS	MS	US	LS	MS	US
N.Conserved	19.33^{g}	46.67^{a}	31.00^{e}	28.00^{d}	22.00^{g}	24..00^{f}	52.67^{c}	31.33^{j}	45.00^{f}
Conserved	19.33^{g}	31.00^{e}	28.67^{f}	29.67^{c}	32.00^{b}	24.00^{f}	51.00^{d}	37.00^{h}	47.33^{e}
Grazing	19.00^{g}	34.67^{d}	38.33^{b}	24.00^{f}	24.00^{f}	33.67^{a}	57.00^{a}	41.33^{g}	28.00^{l}
Woodland	39.00^{b}	36.67^{c}	19.05^{g}	31.00^{b}	30.00^{c}	26.00^{e}	30.00^{f}	33.33^{i}	55.00^{b}
LSD(0.05)		1.12			0.67			1.05	
CV (%)		2.20			1.49			1.47	

Means in the same column followed by the same letter(s) are not significantly different at 5% level of significance**;** LSD=least significant difference; CV= coefficient of variation.

Table. 2. Soil textural class as affected by landscape postion and land -use types

LUT	Lower	Middle	Upper
N.conserved	Clay	Sandy Clay Loam	Clay
Conserved	Caly	Clay Loam	Clay
Graizing	Clay	Clay	Clay Loam
Woodland	Clay loam	Clay Loam	Clay

4.1.2. Soil Bulk Density and Total Porosity

The analysis of variance table showed that the soil BD was highly significantly influenced by the interaction effects of landscape positions and land use types ($P < 0.05$), (Table 1).The lowest 0.94 gm/cm^3 and maximum 1.23 gm/cm^3 soil BD values were recorded from the lower position of conserved land and upper position of non-conserved land, respectively (Table

3).This result is in agreement with the findings of Safadoust *et al., (*2015) who reported that low and high bulk density values were observed in lower position and upper position, respectively, caused by variation in contents of clay fraction and organic matter. It is also similar with the findings of Kakaire *et al.,(*2015), who reported significantly higher bulk density under the soils of upper landscape position and non-conserved land. Woodland and non-conserved land uses in most landscape positions were found statistically non significant at LUT and landscape positions. Bezabih *et al*., (2016) reported that soil bunds play a vital role in controlling the variation of soil BD by collecting the soil organic matter. This might have subsequently contributed to lower BD values of conserved land uses. Soil BD in the present study were below 1.4 gm/cm^3 implying that suitable for root growth (Hillel, 2004).

Total porosity was significantly influenced by the interaction effects of landscape positions and land use types ($P < 0.05$) (Table 3). Accordingly, the highest 64.5% total porosity was observed on the lower position of the woodland.While the lowest 54.00% was recorded on the upper position of the grazing land (Table 3). This was due to high organic matter contents, high clay fraction and lowest bulk density content of wood and conserved land, on the other hand, the low clay content and compaction with bulk density of soils under grazing and non-conserved land. Soil physical properties were considerably influenced by changes in land use type and the implementation of conservation practices (Terefe *et al.,*2020). FAO (2006) rated total porosity as very low (< 2%), low (5-10%), medium (10-15%), high (15-40%) and very high (> 40%). Accordingly, all land use types under all topographic postions were categorized under very high categories. Higher total porosity observed in the study area implies that the soil has a better aggregation and indicates better conditions for crop production and to provide good aeration for micro-organisms, (FAO 2006).

Table.3 Interaction effects of landscape positions and land use type on soils Bulk density (gcm^{-3}) and Total porosity (%) in the Omancho watershed, in 2022.

Land-use type	Bulk Density (gcm^{-3})			Total Porosity (%)		
	Landscape Positions			Landscape Positions		
	LS	MS	US	LS	MS	US
N.Conserved	1.03^{bcd}	1.12^{bc}	1.23^{a}	61.33^{abc}	58.00^{c}	62.00^{ab}
Conserved	0.94^{d}	1.03^{bcd}	1.02^{cd}	63.33^{a}	58.00^{c}	63.40^{a}
Grazing	0.97^{d}	1.12^{bc}	1.11^{bc}	61.13^{abc}	57.40^{cd}	54.00^{d}
Woodland	1.03^{bcd}	1.12^{bc}	1.10^{bc}	64.50^{a}	58.00^{c}	58.50^{bc}
LSD(0.05)		0.10			3.98	
CV (%)		5.90			3.94	

Means in the same column followed by the same letter(s) are not significantly different at 5% level of significance**;** LSD=least significant difference; CV= coefficient of variation.

4.2. Effects of landscape positions and Land Use type on Soil Chemical Properties

Soil chemical properties are the most important factors that affect soil quality and determine the nutrient supplying power of soil to the plants and microbes. In this study, the most important soil chemical properties were analyzed and presented below.

4.2.1. Soil pH and Electrical Conductivity

The soil pH value was significantly influenced by interaction effects of landscape position and land use types (Table 4). Soil pH in the watershed ranged between 5.9% and 7.4% which were recorded from upper positions of non-conserved and lower positions of conserved lands respectively. Soil pH on non-conserved and conserved lands decreased towards the upper position and showed an increasing trend towards lower landscape positions. For grazing land use, pH value decreased towards upper position and then declined though the values were statistically not significant. The woodland in all positions showed constant value. The lowest pH value in non-conserved soils of the upper landscape position might be due to the loss of exchangeable bases caused by runoff and erosion and reduction in basic cations. Habtamu *et* *al*., (2014), reason out that lowering of pH value in non-conserved land areas results from nitrification of NH^{4+} from chemical fertilizer. These conditions increase the activity of H^+ ion in the soil and reduce the soil pH. The result of this study in lines with the finding of Emiru and Gebrekidan, (2013), who reported that loss of basic cations by means of runoff generated from erosion reduces soil pH in non-conserved land which in turn increases soil acidity. This finding isalso in line with Ademe *et al.*,(2017), who reported higher pH values on conserved land than the non-conserved land**.**

According to Foth and Ellis (1997), soil pH level (< 4.5) is rated as very strong acid (4.5-5.2) strong acid, (5.3-5.9) moderate acidic,(6.0-6.6) slightly acidic, (6.7-7.3) is rated as neutral and (7.4-8.0) medium alkaline. Based on the above ratings, the soil pH values in the watershed ranged between 5.9% (moderate acid) to 7.4% (medium alkaline). It is in the preferred range for most of the agricultural practices (Alemayehu and Fisseha, 2018).

The soil EC value was significantly influenced by the interaction effect of landscape position and land use types (Table 4). Soil EC in the watershed was between 30.00ms/cm and 136.43ms/cm which were recorded from upper positions of non-conserved and middle position of woodland respectively. For all land use types, except non-conserved land, EC decreased from lower to upper position. This is due to soluble cations and anions always move downward with surface runoff and accumulated down at lower positions. This might have caused an increase in EC at the lower position than upper position. The results is in lined with Selassie *et al*., (2015) who observed that washing away of solutes and basic cations lowers the value of EC in the watershed.

Table.4. Interaction effects of landscape positions and land use type on soils pH (H_2O) and EC (ms/cm) in the Omancho watershed, in 2022.

Land-use type	pH(H_2O)			EC(ms/cm)		
	Landscape Positions			Landscape Positions		
	LS	MS	US	LS	MS	US
N.Conserved	7.20^{a}	6.40^{bc}	5.90^{d}	30.43^{e}	31.30^{e}	30.00^{e}
Conserved	7.40^{a}	7.30^{a}	6.50^{b}	59.20^{cd}	35.50^{e}	36.56^{b}
Grazing	7.20^{a}	6.10^{cd}	7.10^{a}	66.30^{c}	58.96^{cd}	46.00^{de}
Woodland	6.70^{b}	6.70^{b}	6.70^{b}	136.43^{a}	96.33^{b}	36.5^{e}
LSD(0.05)		0.36			17.67	
CV (%)		3.13			10.88	

Means in the same column followed by the same letter(s) are not significantly different at 5% level of significance**;** LSD=least significant difference; CV= coefficient of variation.

4.2.2. Soil Organic Carbon and Organic Matter

Soil organic carbon was significantly affected by the interaction effects of landscape positions and land use types ($P < 0.05$) (Table 5). Soil organic carbon in the watershed was between 0.20% and 1.20% which were recorded from the upper position of grazing land and lower position of conserved land respectively. Additionally, the same value 1.20% was recorded on the lower position of woodland. Soil organic carbon content increases down landscape positions. This might be due to high surface soil materials taken from the upper landscape positions and deposition down to lower landscape positions. On the other hand, the lower mean value of SOC in non-conserved land is due to high oxidation of organic matter and total removal of crop residues Worku *et al*.,(2014). This could be due to soil erosion processes and different anthropogenic activities like land fragmentation and grazing intensity in the non-conserved land. According to Foth and Ellis (1997) when the value OC has between 0.5-1.5 the rating became low. Khan *et al.*, (2013) also observed low soil organic matter in the non-conserved land. Soil erosion and the addition of low organic matter contents could reduce soil clay content in the non-conserved land. From the result, good nutrient management in the woodland and conserved land while the lowest value in the grazing and non-conserved land might be due to low addition of organic matter and rapid mineralization coupled with poor nutrient management. Similar results were recorded by Jamala and Oke, (2013); Birhanu and Enyew, (2014) who noted low status organic matter and total nitrogen in the cultivated land is due to poor nutrient management. From the result, soil organic carbon is directly proportional to soil organic matter, total nitrogen and CEC of the soil.

Alemayheu and Sheleme (2013) also found comparably higher organic carbon (OC), under woodland and conserved land as compared to non-conserved and grazing land use types. In this study, organic matter was positively highly correlated with OC (r= 0.99^{***}), total nitrogen with OC (r=0.99^{***}) and C;N ratio with OC (0.86^{***}), OM (r=0.81^{***}), and TN (r=0.80^{***}) with OC.

Soil organic matter value was significantly affected by the interaction effects of landscape positions and land use types (Table 5). Soil organic matter in the watershed was between 0.30% and 2.1% which were recorded from non-conserved land of the upper position and grazing land of the lower positions respectively. The lowest mean value of soil OM in the non-conserved land might be due to low addition of organic materials, crop residual removal, lack of SWC structure and rapid mineralization and due to frequent cultivation on non-conserved lands. The result was in agreement with that of Yihenew and Getachew (2013) who reported that lowest organic matter in grazing and non-conserved land and highest in the conserved land.Similar results were found by Jamala and Oke, (2013); Birhanu and Enyey, (2014) who noted poor organic matter and total nitrogen in the non-conserved land is due to poor nutrient management. This is also in agreement with Bezabh *et al.,(*2016).

Table.5. Interaction eeffects of landscape positions and land use type on soils OC and OM in the Omancho watershed, in 2022.

Land-use type	OC (%)			OM (%)		
	Landscape Positions			Landscape Positions		
	LS	MS	US	LS	MS	US
N.Conserved	0.65^{cd}	0.95^{abc}	0.22^{e}	1.08^{cd}	1.61^{abc}	0.30^{e}
Conserved	1.20^{a}	0.80^{bc}	0.94^{abc}	2.0^{a}	1.37^{bc}	1.76^{ab}
Grazing	0.78^{bc}	1.10^{ab}	0.20^{e}	2.10^{a}	1.32^{bc}	1.90^{ab}
Woodland	1.20^{a}	0.33^{de}	0.22^{e}	0.31^{e}	0.56^{de}	0.31^{e}
LSD(0.05)	0.32				0.59	
CV (%)	9.6				12	

Means in the same column followed by the same letter(s) are not significantly different at 5% level of significance**;** LSD=least significant difference; CV= coefficient of variation.

4.2.3. Soil Total Nitrogen and Available Phosphorus

The soil TN value was significantly influenced by the interaction effects of landscape position and land use types ($P < 0.05$) (Table 6). Soil TN was between 0.019% and 0.12% which were recorded from the upper position of non-conserved land and the lower position of woodland respectively. High TN deposition at the lower position was connected to the displacing of TN from upper positions. The possible reason for low status of TN in the case of upper position of non-conserved land might be due to loss of TN by erosion, regular harvesting in which case the crops continuously remove the nutrients from the soil became low. This result agrees with Alemayehu and Sheleme (2013), who reported that TN under woodland was higher than non-conserved land and grazing lands.The possible reason might be due to leaching and high organic matter content in woodland and relatively low organic matter in non-conserved and grazing lands. The current findings were in agreement with that of Tiejun *et al.,(*2007), who reported that changes in soil organic matter could lead to changes in TN and long term cultivation in non-conserved land with out organic fertilizers usually leads to a decrease in soil total nitrogen contents. More over, the findings of Berhanu (2016), demonstrated variation of TN paralleled with that of the change in organic carbon content in soils of Girar Jarso of North Shoa Zone, Oromia, Ethiopia. According to Foth and Ellis (1997) TN < 0.1% very low, 0.1-0.3 low, 0.3-0.5 medium,0.5-1 high and >1 very high. Thus, the value in watershed rated under low category.

Available phosphorus varied substantially with landscape positions and land use types at ($p < 0.05$) (Table 6). Soil available phosphorus in the watershed was between 0.01mg/kg soil and 1.04 mg/kg soil which were recorded from upper positions of non-conserved land and lower position of conserved land respectively. Relatively the higher soil Av.P at the conserved land could be attributed to the release of phosphorus from the decomposition of organic materials and also could be associated to the adequate aeration brought about by tillage as P release is faster in good aerated soils, due to the removal of available phosphorus from higher slope gradient by errosion. Similarly, Asmamaw and Mohammed (2013) and Wolde*et al*., (2007) reported a high amount of available phosphorus at lower positions. This finding is also in agreement with Ademe *et al*,. (2017); Aytenew and Kibret (2016); Ademe *et al.*, (2017) who recorded higher Av.P at conserved landscape position than other landscape positions. Generally, the soils in the study area have very low available phosphores contents (Tekaligh, 1991).

Table.6. Interaction effects of landscape positions and land use type on soils Total Nitrogen and Available Phosphorus in the Omancho watershed, in 2022.

Land-use type	TN (%)			Av.P (mg/kg soil)		
	Landscape Positions			Landscape Positions		
	LS	MS	US	LS	MS	US
N.Conserved	0.05^{cd}	0.08^{abc}	0.019^{a}	0.66^{ab}	0.04^{c}	0.01^{c}
Conserved	0.06^{bc}	0.10^{a}	0.08^{ab}	1.04^{a}	0.04^{c}	0.32^{b}
Grazing	0.06^{bc}	0.02^{e}	0.09^{ab}	0.86^{a}	0.94^{a}	0.83^{a}
Woodland	0.12^{e}	0.03^{de}	0.02^{e}	0.20^{c}	0.90^{a}	0.86^{a}
LSD(0.05)	0.02			0.43		
CV (%)	8.4			10		

Means in the same column followed by the same letter(s) are not significantly different at 5% level of significance**;** LSD=least significant difference; CV= coefficient of variation.

4.2.4. Effects of Landscape positions and Land Use type on CEC, PBS, and exchangeable Base

4.2.4.1. Cation Exchange Capacity and Percent Base Saturation

The Cation Exchange Capacity (CEC) value was significantly influenced by the interaction effects of landscape position and land use types ($P < 0.05$) (Table 7). Cation Exchange Capacity was between 45.02 meq/100gr soil) and 55.02 meq/100gr soil) which were recorded from upper positions of non-conserved land and lower position of woodland respectively. High clay and organic matter contents in lower landscapes contributed to the high amount of CEC. Non-conserved land had less organic matter, continuous cultivation, removal of crop residue, where as vegetation cover in the woodland and prolonged fallow period assisted with soil conservation practice might have reduced soil erosion and leaching of exchangeable cations. Similarly, Selassie *et al.,*(2015) reported that the occurrence of variation in soil properties along landscape position. This result agree with the findings of Bezabih *et al.(*,2016) indicated that soil physico-chemical properties variations among land uses in association with and with out soil bund under different landscape positions, but disagrees with the findings of Tellen and Yerima (2018), who reported that CEC did not show a clear picture of the variation under soils of different land use/land cover systems. According to the ratings recommended by Hazelton and Murphy (2007) the soil is ranged very high in all land use types in its exchangeable CEC content at different landscape positions. Since the value of CEC has > 40. As the same time CEC was significantly increased from non-conserved land to grazing and woodland (Sileshi *et al.*,2019).

The soil Percent Base Saturation (PBS) value was significantly influenced by the interaction effects of landscape position and land use types ($P < 0.05$) (Table 7).The highest PBS value 73.13 % was recorded in the lowe position of woodland, where as lower position of non-conserved land had the lowest value 46.40 %. This shows that the value increases from lower to upper landscape positions except woodlands. Percent base saturation was also significantly increased from conserved to woodland and decrease from conserved land to non- conserved lands. According to (Habitum 2014) the high percent base saturation in the surface layers of woodlands might be due to relatively high organic matter and clay contents (soil colloidal sites and storehouse of exchangeable bases) compared to the surface layers of non-conserved and grazing lands. Apparently, (Kedir,2015), suggested that variation in percentage base saturation could also be due to variation in pH, soil organic carbon content, soil texture, parent materials, and intensity of cultivation, leaching, topography and land management practices. Based on the above table, the soil PBS values in the watershed was between 46.40% to 73.13% it is high and weakly leached. It is in the preferred range for most of agricultural practices. According to Hazelton *et al.* (2007), the PBS value of 46.40% and 73.13% indicated high and weakly leached soils respectively.

Table.7. Interaction effects of landscape positions and land use type on soils Cation Exchange Capacity(meq/100gr soil) and Percent Base Saturation (%)in the Omancho watershed, in 2022.

Land-use type	PBS			CEC		
	Landscape Positions			Landscape Positions		
	LS	MS	US	LS	MS	US
N.Conserved	46.40[e]	50.10[de]	52.10[cde]	50.40[ab]	49.01[d]	45.20[e]
Conserved	49.0[e]	57.50[cde]	61.50[ab]	49.93[e]	51.20[cd]	49.33[d]
Grazing	51.76[cde]	52.30[cde]	55.90[cde]	50.60[cd]	52.40[bc]	54.40[ab]
Woodland	73.13[a]	71.10[ab]	63.16[abc]	55.02[a]	51.33[cd]	49.20[d]
LSD(0.05)		11.59			2.56	
CV (%)		12.06			2.99	

Means in the same column followed by the same letter(s) are not significantly different at 5% level of significance**;** LSD=least significant difference; CV= coefficient of variation.

4.2.6. Exchangeable Bases (Ca2+ and Mg2+)

The value of Exchangeable calcium was significantly influenced by the interaction effects of landscape position and land use types (P< 0.05) (Table 8). The highest 28 cmol$_{(+)}$kg^{-1}) ca^{+} were recorded under the lower position of woodland where as the lowest 2.66 cmol$_{(+)}$kg^{-1}) were recorded under the upper position of non-conserved land. The lower value could be related to the influence of intensity of cultivation and abundant crop harvest with little or no use of input in non-conserved land. The contents of exchangeable calcium decreased with landscape positions under woodland and non-conserved land. These indicate that there was higher leaching of basic cations in the non-conserved land than in the other land- use practices and high content of exchangeable calcium in lower landscape position, might be due to the washing down of cations by erosion from the upper positions and deposited in lower positions. This result is supported by previous findings of (Tadele *et al.,* 2013) and (Wolde et al., 2007), who reported that an increasing tendency of the content of exchangeable bases, as the slope of landscape decreases, there could lower erosion and higher accumulation at lower landscape position. Asimilar observation was also reported by (Mamo, 2011). According to Hazelton and Murphy (2007), when the value of Ca^{+} < 2 became very low and when the value of Ca^{+} >20 cmol($_{+)}$kg^{-1}), the rating becomes very high, so the study area of the watershed have a very high value of exchangeable calcium. In this study, exchangeable calcium showed significant ($P < 0.05$) and negatively correlation ($r = -0.80^{**}$) with Mg, **(**Table10).

The value of exchangeable magnesium was significantly influenced by the interaction effects of landscape position and land use types ($P< 0.05$) (Table 8). Exchangeable magnesium was between 1.00(cmol$_{(+)}$kg^{-1}) and 29 (cmol$_{(+)}$kg^{-1}) that was recorded from upper positions of non-conserved land and lower position of woodland respectively. The lower values of Mg in the upper positions of non-conserved lands might be due to low organic matter content and high leaching of exchangeable Mg. According to (FAO, 2006), when the value of Mg^{+} < 0.3 became very low and when the value > 8 cmol($_{+)}$kg^{-1}), the rating becomes very high. From the rating, the study area of the watershad have a very high value of exchangeable magnesium.The value of exchangeable magnesium in the study area was significantly ($P < 0.01$) and strongly positively correlated (r=0.50***) with pH and ($r=0.49^{*}$) with CEC and negatively ($r=-0.29^{*}$) with OM and ($r=-0.30^{*}$) with OC.

Table .8. Interaction effects of landscape positions and land use type on Exchangeable Bases (Ca^{2+} and Mg^{2+}) on Omancho watershed, in 2022.

Land-use type	Ca^{2+}(cmol/kg)			Mg^{2+}(cmol/kg)		
	Landscape Positions			Landscape Positions		
	LS	MS	US	LS	MS	US
N.Conserved	21.00^{bc}	17.00^{cd}	2.66^{e}	6.00^{cde}	8.00^{bcde}	1.00^{e}
Conserved	18.00^{bcd}	14.00^{d}	21^{bc}	2.66^{de}	4.00^{cde}	11.00^{bc}
Grazing	16.33^{cd}	3.00^{e}	21.00^{bc}	25.00^{a}	14.00^{b}	9.00^{bcd}
Woodland	28.00^{a}	24.00^{ab}	24.00^{ab}	29.00^{a}	6.66^{bcde}	2.00^{cde}
LSD(0.05)		6.61			7.48	
CV (%)		14			17	

Means in the same column followed by the same letter(s) are not significantly different at 5% level of significance**;** LSD=least significant difference; CV= coefficient of variation.

4.2.7. Exchangeable Bases (K+ and Na+)

The value of exchangeable K and Na was significantly influenced by the interaction effects of landscape position and land use types ($P< 0.05$) (Table 9). The highest K value 1.22 ($cmol_{(+)}$ kg^{-1}) was recorded under the lower position of woodland and while the lowest 0.57 ($cmol_{(+)}kg^{-1}$) was recorded in the upper positions of grazing land. According to Hazelton and Murphy (2007), exchangeable K of the soil is rated as very low (< 0.2 $cmol_{(+)}kg^{-1}$), low (0.2-0.3 $cmol_{(+)}kg^{-1}$),medium(0.3-0.6$cmol_{(+)}kg^{-1}$),high(0.6-1.2$cmol_{(+)}kg^{-1}$)and very high(>1.2$cmol_{(+)}kg^{-1}$). Thus, exchangeable K was rated under medium and higher cagtegories. The higher value of exchangeable sodium 0.37($cmol_{(+)}kg^{-1}$) was recorded on the lower positions of non-conserved land and the lowest value 0.09 ($cmol_{(+}$ kg^{-1}) was recorded on the upper position of conserved land which might be due to low erosion and leaching in conserved land. This result was in agreement with Mamo (2011) who reported that deforestation, leaching, limited recycling of dung and crop residues, declining fallow periods and soil erosion have contributed to the depletion of basic cations and reduction of CEC in non-conserved and grazing land as compared to adjacent land use types. According to FAO (2006), exchangeable Na^+ is rated as very low (< 0.1 $cmol_{(+)}kg^{-1}$), low (0.1-0.3 $cmol_{(+)}kg^{-1}$), medium (0.3-0.7$cmol_{(+)}kg^{-1}$), high (0.7-2 $cmol_{(+)}kg^{-1}$) and very high (> 2$cmol_{(+)}kg^{-1}$). The study area of the soil was qualified as high in non-conserved land and very low in conserved land for their exchangeableNa^+ contents.

Table 9. Interaction effects of land use type and topographic positionson Exchangeable Bases (Na^+ and K^+) on Omancho watershed, in 2022.

Land-use type	Na^+(cmol/kg)			K^+(cmol/kg)		
	Landscape Positions			Landscape Positions		
	LS	MS	US	LS	MS	US
N.Conserved	0.37^{a}	0.60^{a}	0.23^{bcd}	1.05^{bcd}	1.09^{bc}	0.69^{ef}
Conserved	0.26^{bc}	0.60^{a}	0.09^{d}	0.97^{d}	0.79^{e}	1.00^{cd}
Grazing	0.30^{b}	0.13^{cd}	0.63^{a}	1.13^{ab}	0.79^{e}	0.57^{g}
Woodland	0.15^{cd}	0.15^{cd}	0.15^{cd}	1.22^{a}	0.67^{fg}	0.67^{fg}
LSD(0.05)		0.14			0.10	
CV (%)		13			6.94	

Means in the same column followed by the same letter(s) are not significantly different at 5% level of significance**;** LSD=least significant difference; CV= coefficient of variation.

Table 10. Pearson's correlation(r) matrix for various soil physico-chemical parameters.

	PH	OC	OM	TN	C:N	CEC	Na^+	K^+	Mg^+	Ca^+	Sand	Silt	Clay	BD	PBS	EC	Av.p	TP
PH	1																	
OC	-0.28	1																
OM	-0.2	0.99^{***}	1															
TN	-0.28	0.99^{***}	0.99^{***}	1														
C:N	-0.31	0.86^{***}	0.81^{***}	0.80^{***}	1													
CEC	0.53^{***}	-0.06	-0.07	-0.07	-0.18	1												
Na^+	-0.78^{**}	0.55^{*}	0.56^{**}	0.56^{**}	0.56^{**}	0.56^{*}	1											
K^+	0.09	0.68^{***}	0.68***	0.67^{***}	0.70^{***}	-0.06	0.36	1										
Mg^+	0.50^{**}	-0.29^{*}	-0.30^{*}	-0.31	-0.29	0.49^{*}	-0.43^{*}	-0.06	1									
Ca^+	-0.22	-0.05	-0.04	-0.04	-0.03	-0.37	0.01	-0.04	-0.80^{**}	1								
Sand	-0.05	0.06	0.06	0.06	0.00	0.50^{*}	0.04	0.04	0.05	0.02	1							
Silt	-0.27	0.02	0.01	-0.00	0.06	-0.09	0.03	-0.16	-0.45^{*}	0.50	0.06	1						
Clay	0.14	-0.06	-0.06	-0.06	-0.02	-0.42^{*}	-0.05	0.02	0.11	-0.21	-0.92	-0.43	1					
BD	-0.03	-0.16	-0.18	-0.19	-0.14	0.35	-0.11	-0.18	0.29	-0.12	0.34	0.15	-0.36	1				
PBS	0.28	-0.51^{**}	-0.51^{*}	-0.52*	-0.44^{*}	-0.03	-0.54^{**}	-0.15	0.33	0.23	0.00	0.07	-0.02	0.25	1			
EC	0.14	0.13	0.11	0.12	0.18	0.26	0.11	0.39	0.16	-0.21	0.29	-0.50	-0.07	0.19	-0.14	1		
Av.p	0.79^{***}	-0.42^{*}	-0.44^{*}	-0.45^{*}	-0.38	0.28	-0.86^{***}	-0.16	0.37	-0.00	-0.17	-0.00	0.16	0.30	0.51^{*}	0.07	1	
TP	0.04	0.18	0.02	0.21	0.16	-0.36	0.10	0.02	-0.28	0.11	-0.34	-0.16	0.37	-0.99	-0.24	0.18	0.29	1

**Significant at P = 0.001; ** significant at P = 0.01; * significant at P = 0.05 levels; TN = total nitrogen;Av.P=availablephosphorus,EC=electrical conductivity

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The effects of three landscape positions and four land-use types on soil properties were evaluated in Omancho water Shade Guraghe Zone Southern Ethiopia. Thirty six soil samples were taken.The result confirmed that soil properties were influenced by the interaction effects of landscape position and land use types. The highest values of the sand fraction was recorded on non-conserved land of middle position, silt and clay from grazing land of upper position and lower position ofgrazing lands. The textural class in the study site was clay. The maximum and minimum soil bulk density (BD) values were recorded under the upper position of the non-conserved and lower position of conserved land. The highest value of total porosity was recorded under the lower position of woodland and the least value was recorded from the upper position of grazing land. The higher value of soil pH was recorded under the lower position of conserved land and the least value was recorded from the upper position of non-conserved land, respectively. The highest base saturation was recorded under the lower position of woodland uses, whereas the least values was recorded from the lower position of non-conserved land. The highest CEC was recorde from the lower position of woodland and the least values was recorded from the upper position of non-conserved land. Higher Av.P was recorded from the lower position of conserved land. The higher TN values was recorded from the lower position of woodland, the higher OC was recorded from the lower positions of conserved land. The result showed that soil BD and sand fraction decreased from upper to lower position. In contrast, total soil porosity, clay and silt were increased from upper to lower position. Compared to conserved/woodlands, the non-conserved lands revealed the hightest BD and sand fraction, whereas total soil porosity, clay and silt fraction increased from upper to lower slope position. Most of soil chemical parameters such as pH, EC, Av.P, OC, TN, CEC and exchangeable cations (K, Ca, and Mg) also increased from upper to lower position. Among land-use types woodland and conserved lands were better than non-conserved and grazing land. In general, the soil properties in all land use types were improved from upper to lower landscape positions.

5.2. Recommendation

The following recommendations are forwarded from the results :- Integrated land and soil fertility management are required in all landscape positions to maintain soil Physico-chemical properties because the interaction effects of land uses with landscape position showed negative effects especially on non-conserved and grazing lands. Since the study site is shortage of water, water conservation structures must be practices. Soil/ land management options should focus on scenarios that could improve the soil conditions to enhance crop production on a sustainable basis. Appropriate soil and water conservation practices, livestock management practice like cutting and carrying systems and expansion of improved forage need attention to decrease the land degradation and pressure of livestock on land resources. In addition, overgrazing, inappropriate use of land and conversion of woodland to cultivated land should be reduced. It should be also conserved as making area closure, game reserves to make an area ecologically conducive. In general, the soil properties in all land use types were improved from upper to lower landscape positions. Thus, working soil and water conservation practices for all land use types, particularly in the upper land scape postions, are suggested. Increase the soil fertility techniques, reducing the intensity of cultivation and adopting integrated soil management could maintain the existing soil condition, replenish the degraded soil properties and strategies should be flexible in responding to the various agro-ecological zones ,soil and water conservation practices, local resource endowment and farmers capacity to invest in affordable integrated land management techniques. Additionally, to improve the land management practices (combined used of organic and commercial fertilizer) along side of the land.

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7. APPENDICES

Appendixes 1. Mean square estimates for a two-way analysis of variance of soil Physico-chemical properties under four land use types and three landscape positions in the Omancho watershed area.

Source variation	Mean square of source of variation					
	LandUses(LUT)(3))	Replication(2)	Landscape positions(LP)(2)	LUTx LP(6)	Error	CV (%)
Sand	64.66***	0.19ns	522.02***	277***	0.46	2.20
Silt	35.29***	0.44ns	6.69***	62.87***	0.14	1.49
Clay	49.58***	0.33ns	444.08***	416***	0.39	1.47
Bulk Density (BD)	0.01**	0.01ns	0.00ns	0.03***	0.00	5.90
TP (*f*)	15.05**	7.21ns	3.00ns	44.96***	5.44	3.94
pH	1.86ns	0.04ns	0.28*	0.26***	0.04	3.13
OC	1.02***	0.00ns	0.20*	0.26***	0.04	9.6
OM	3.31***	0.00ns	0.79*	0.79***	0.13	12
(TN)	0.01***	0.00ns	0.00*	0.00***	0.00	8.4
E.Condactivity(EC)	8093***	177.65ns	1686.25***	1087***	10.3	10.88
Av.p (mg kg^{-1})	1.35 ***	0.08ns	0.41*	0.15ns	0.06	10
CEC($cmol_{(+)}kg^{-1}$)	42.7***	6.99ns	23.40**	4.79ns	1.88	2.99
ExCa ($cmol_{(+)}$ kg^{-1})	146***	45.58ns	89.33*	234***	6.64	14
ExMg ($cmol_{(+)}$ kg^{-1})	217***	17.86ns	66.36ns	304.1***	9.98	17
Exc.Na($cmol_{(+)}kg^{-1}$)	0.48***	0.01ns	0.01ns	0.05***	0.00	13
Ex.K($cmol_{(+)}$ kg^{-1})	0.34***	0.00ns	0.15***	0.02***	0.00	6.94
PBS (%)	660***	42.40ns	169.81ns	21.28ns	7.77	12.06
C:N ratio	5.05 ***	0.05ns	0.26ns	1.58*	0.37	5.51

* = Significant at (P = 0.05); ** = high Significant at P = 0.01;***= very highly significant ,Ns = Non-significant; EC=Electrical conductivity CEC= Cation exchange capacity ;LS =Landscapes , LUT= Land Uses Types.

Appendixes 2.Variance Analyses of Soil Properties in Different landscape Positions.

LU*SP	DF	SS	MS	F	P
Sand	6	1663.50	277.25	593.46	0.0000
Silt	6	377.28	62.88	444.65	0.0000
Clay	6	2498.50	416.42	1057.06	0.0000
pH(H^2O)	6	1.60	0.27	5.87	0.0009
EC	6	6225.60	1037.60	9.99	0.0000
OC	6	1.58	0.26	6.34	0.0006
BD	6	4.78	0.79	5.85	0.0009
OM	6	269.77	44.96	8.26	0.0001
TN	6	0.009	0.001	5.50	0.0013
C;N	6	8.68	1.44	3.63	0.0118
K^+	6	0.17	0.03	8.02	0.0001
Na^+	6	0.33	0.05	7.94	0.0001
TP	6	1409.78	234.96	18.58	0.0000
Mg^+	6	1825.06	304.18	15.29	0.0000
Ca^{2+}	6	0.19	0.03	8.55	0.0001

Significant at 5% level.

Appendix 3.Average monthly distribution of rainfall (mm) of Abeshgae Districtfor the years from 2008 to 2017.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2008	4.2	0	0	21.6	72.5	224.7	267.2	124.8	201.4	198.4	0	0	1114.8
2009	0	0	0	38.4	98.7	169.2	310.1	229.4	138.6	54.1	26.8	4.2	1069.5
2010	6.2	10.9	67.1	37.4	105.4	154.6	400.8	273.2	116.8	97.8	3.4	5.5	1279.1
2011	47	6	76.8	58.3	168	278.1	254.4	232.2	90.1	0	0	37.8	1248.7
2012	17.6	63.5	76.4	122.9	0	196.9	369.4	218.1	202.7	25.3	10.1	9.3	1312.2
2013	46.3	9.9	30.1	97.7	88	207.5	82.3	204.3	160	3.3	6.3	10.3	946.00
2014	44.7	4.4	93.9	97.4	10.3	173.9	240.5	211.6	239.1	38.6	34.2	0	1188.6
2015	42.3	58.3	34.9	52.8	122.5	189.3	220.6	216.6	137.4	30.4	0	0	1105.1
2016	0	8.4	7.9	95.4	248.8	189.9	287.8	239.9	83.5	52	67.5	0	1281.1
2017	37.7	76.1	40.8	103.8	157.8	266.5	196.8	226.3	121.8	43.4	5.1	36.5	1312.6
Mean	24.6	23.8	42.8	72.6	107.2	205.1	263	217.6	149.1	54.3	15.4	10.3	1183.8

Source: National Meteorology Service Agency, Hawassa Branch office, (2012).

Appendix 4.Average monthly temperature (^{0}C) of Abeshgae District for the years from 2008 to 2017

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	mean
2008	20.5	20.4	20.9	20.4	20.4	20.2	20.2	20.2	19.8	20.0	20.4	21.2	20.4
2009	21.3	21.2	23.7	22.2	21.8	20.5	19.7	19.5	20.2	21.2	21.1	21.7	21.2
2010	20.9	21.2	20.4	22.0	21.6	21.4	21.0	22.2	21.7	21.5	20.5	20.9	21.3
2011	20.9	23.1	22.8	21.4	22.8	20.3	20.1	19.5	19.9	20.6	21.0	21.3	21.1
2012	22.3	23.3	23.2	NA	22.9	22.6	NA	19.5	20.3	21.2	20.7	21.1	18.1
2013	21.4	21.9	23.0	22.5	24.0	21.8	21.1	21.0	20.4	20.7	21.2	21.1	21.6
2014	21.8	22.1	23.8	22.7	20.9	20.1	18.8	19.1	19.7	20.4	21.8	21.0	21.0
2015	21.9	22.0	23.5	23.5	23.7	23.9	20.1	19.7	21.1	22.4	21.3	21.9	22.0
2016	22.4	22.9	23.2	22.9	22.6	21.6	19.7	19.6	20.5	22.3	22.6	21.8	21.8
2017	21.8	22.2	22.4	23.1	21.8	20.6	19.8	19.5	20.7	23.8	22.5	22.0	21.7
Mean	21.5	22.0	22.7	20.0	22.2	21.3	18.0	19.9	20.4	21.4	21.3	21.3	21.0

Source: National Meteorology Service Agency, Hawassa Branch office, (2012).

Appendixes 5. The major land use/Land use Cover types in Omancho watershed area are cultivated, Conserved, woodland, grazing land, and other land uses

Land use type	Land Size Per Hectare	
	Coverage (ha)	Percentage(%)
Cultivated land	236	71.51
wood Land cover	35	10.60
Grazing land cover (winter season)	52	15.75
Eucalyptus tree cover	5	1.54
Miscellaneous land cover	2	0.6
Total	330	100

Source : secondary data

Appendixes 6. Slope category of Omancho Watershed

Slop (%)	Slope description	Class
2-5	Gently sloping	01
5-10	Sloping	02
10-15	Strongly sloping	03
15-30	Moderatelysteep	04

Source, (author)

Appendixes 7. Description of land use/cover classes identified in Abeshgae Worda, Omancho Water Shed Gurage Zone Southern Ethiopia

Land use	Description
Wood land	This category of land consisted indigenous tree and shrub species.
Grazing land	Allocated for cattle grazing, which is dominated by small grasswith some scattered trees and bushes.
Conserved land	Allocated for annual soil and water conservation for annual crop production.
N.conserved land	Allocated for annual no soil and water conservation practices.

Appendixes 8. Ratings of PH,OC, AV P and, TN in the soil

pH(H2O)		OC (%)		AV.P(mg/kg soil)		TN (%)	
Rating		Rating		Rating		Rating	
<4.5	V/ SAc.	< 0.5	V/ Low	< 5	V/low	< 0.1	V/low
4.5-5.2	Sac	0.5-1.5	Low	5-9	low	0.1-0.3	Low
5.3 -5.9	Mac	1.5-3.0	Medium	10-17	Medium	0.3-0.5	Medium
6.0-6.6	Sli/ Ac	> 3.0	High	18-25	High	0.5-1	High
6.7.7.3	Neutral			>25	V/High	> 1	V/High
7.4-8.0	MAK						
>8.0	SAK						

V/SA=very Strong Acid, SA =strong Acid, Sli/Ac Slightly Acid, MAK =medium Alkaline, SAK = strong Alkaline, source "Tekalign (1991),Landon, (1991),"Mohamed Mekonnen *et al.*, *(*2016*)*,Foth and Ellis (1997)

Appendixes 9. Ratings of Soil Texture ,BD and Porosity in the soil

Soil Texture		Bulk Density (gcm^3%)		Porosity	
	Rating			Rating	
< 10	Silt Loam	< 0.9	Granular	< 2	V/low
10-25	sandy Loam	0.9-1.2	single grain granular	5-10	Low
20-35	Sand Clay Loamy	1.2-1.4	Sub granular ,Angular, blocky	10-15	Medium
35-55	Sandy Clay	1.4-1.6	Prismatic, Platy	15-40	High
25-40	Clay Loamy			>40	V/High
4.-60	Silt Loam				
25-40	silt Clay Loam				
25-40	Clay loam				
40-60	Silt Clay				
40-60	Clay				

Source: (FAO, 2006)

Appendixes 10. Ratings of exchangeable Ca, Mg, K and CEC in the soil.

CEC(meq/100gr soil) Rating		Ca(cmolkg^{-1}) Rating	Mg(cmolkg-^{1}) Rating	Na(cmolkg-^{1}) Rating	K(cmolkg$^{1)}$ Rating	PBS(%) Rating
V/ Low	> 13	< 2	< 0.3	< 0.1	<0.2	0-20
Low	13-15	2-5	0.3-1	0.1-0.3	0.2-0.3	20-40
Medium	15-25	5-10	1-3	0.3-0.5	0.3-0.6	40-60
High	25-40	10-20	3-8	0.5-1	0.6-1.2	60-80
V/High	>40	>20	>8	> 1	>1.2	> 80

Source Beernaert (1990), Tekalign (1991), FAO (2006), Hazelton and Murphy (2007)

WOLKITE UNIVERSITY

SCHOOL OF GRADUATE STUDIES

APPROVAL SHEET-I

This is to certify that the thesis entitled,"Land Use Type and Landscape Position Effects on Selected Soil physico-chemical Properties, the case of Omancho Watershed Gurage Zone, Southern Ethiopia," Submitted to Wolkite University Department of Natural Resource and Management School of Graduate Studies. It is a record of original research carried out by Zemecha Sahile.We recommend that it have been accepted as fulfilling the thesis requirements.

1. Fanual Laekemariam (PhD)	___________________	9/2022E.C
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Co Advisor	Signature	Date

APPROVAL SHEET-II

As a member of the Board of Examiners of the MSc Thesis Open Defense by Zemecha Sahile have read and evaluated his thesis entitled,“Land Use Type and Landscape Position Effects on Selected Soil physico-chemical Properties, the case of Omancho Watershed Gurage Zone, Southern Ethiopia.”We recommend that the thesis has been accepted as fulfilling the requirements for the Degree of Master of Science in Soil Science.

1 Asrat Fikre (……)	__________________	-------------------
Chairperson	Signature	Date
2. Teshome Yitbarek (PhD)	__________________	-------------------
Internal Examiner	Signature	Date
3. Israel Zewde (PhD)	__________________	--------------
External Examiner	Signature	Date

Final approval and acceptance of the thesis is contingent up on the submission of its final copy to the Council of Graduate Studies (CGS) through the Candidate’s Department Graduate Committee (DGS).

BIOGRAFICAL SKETCH

The author was born in Edja, Guraghe Zone SNNP regional State, in June 1978 E.C. He attended his Primary School at Yesray and Secondary School at Agena and Emdiber in Guraghe Zone. He completed his Secondary School education in June 1996.

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