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Integrated Soil Management Practices in Rehablitating Degraded Lands in Ofute Catchment, Southern Ethiopia

Abera Abiyo [1] Teshome Yirgu[2] Alemu Lailago[3]
1.Abera Abiyo, Lecturer, College of Agricultural Science, Wachemo University, Ethiopia
2.Assistant professor, School of Graduate Studies, Arbaminch University, Ethiopia
3.Assistant professor, College of Natural Science, Wolayta Sodo University, Ethiopia

Abstract
Soil degradation in the form of soil erosion and soil fertility decline is the main problem of the study area which had influenced the environmental quality and productivity of land. Loss of vegetation cover, drought and climatic change were another recently prevailed environmental problem which further affects the livelihoods of rural people and the production potential of the area. The socio-economic as well as the demographic data that have relevance to the study was collected and both the indigenous and modern soil management practices are explored using questionnaire surveys, focus group discussions and key informant interview. A number of indigenous soil management practices were practiced in the catchment such as fallowing, crop rotation, contour farming, traditional stone bunds, traditional ditches, plantations and traditional cut-off drains. On the other hand, currently introduced modern soil management practices like fanaya juu, soil bunds, improved cut-off drains, grass strips, check dams and basins are practiced by households in the study catchment. The survey results showed that age, gender, family size, educational status, annual income, farm size, farm land distance, soil fertility, slope and severity of soil erosion were among the major factors that influence the implementation of soil management practices. Formulating appropriate plan and strategies for controlling deforestation, applying area closure method of land management practices in steep slope areas, encouraging locally perceived indigenous knowledge of farmers on soil management, and appropriate design and maintenance of modern soil management practices are critically recommended to recover rapid destruction of resources and soil degradation in the study area. Assessing the impact of climatic variability on crop production and loss of crop species and analyzing the slope factors for measuring rate of soil degradation by researchers for the future became the suggested research gaps in the study area.
Keywords: Integrated soil management practices, soil erosion, degraded lands and rehabilitation

INTRODUCTION

Land degradation can be remaining an important global problem concern because of its adverse impact on agricultural productivity, food security and the quality of the environment. Due to land degradation in most developing countries, agricultural productivity reached the level beyond the subsistence requirement of a household (Antenah, 2010). Producing more food to feed the rapidly rising world population, while maintaining and conserving the environment, has become a global challenge (Ambler, 2000).

The principal environmental problem in Ethiopia is land degradation in the form of soil erosion, gully formation, fertility loss, desertification and deforestation (Melaku, 2000). Land degradation had created serious limitations to economic development and food security in several developing countries, particularly in areas where population densities are high like Ethiopia (Amsalu and de Graaff, 2006). Ethiopian highlands in general and South Central highlands in particular is suffering from rapid population growth and wide variety of excessive land degradations mostly soil degradation, deforestation, drought and ground and surface water impoverishment. This environmental situation not only undermines the agricultural production capacity but also threaten the sustainability of many regions in the country (Ibid).

The study was taken place in southern region of south central high lands of Kambata Tambaro Zone in Ofute Catchment. Soil degradation in the form of soil erosion and soil fertility decline had influenced the environmental quality and productivity of the area which further affects the livelihoods of rural communities and the production potential of land. Loss of vegetation cover, drought and climatic change were recently prevailed environmental problem in south central high land including Kambata Tambaro zone. Furthermore, due to long historic agricultural practices and lack of appropriate soil management practices, a number of agricultural lands, forest area, range lands, sloppy areas and grazing lands are seriously damaged. Thus over cultivation, overgrazing, deforestation, rapid expansions of settlement and over exploitation of resources are the major problems which have direct influence on excessive soil losses in the area. So soil erosion is the serious problem in the study area. Moreover, the spread of drought due to insufficient distribution of rainfall and increase of temperature from time to time influence the crop production and loss of some plant species in the study area. The soil degradation problem also increases farmers' vulnerability to food shortages and becomes a threat to the mere survival of the people. Most of the farmers of the areas held small land size who practice subsistence cropping system which further result with excessive loss of soil and other resources.

Even though introduced soil conservation structures are applied in most places, still land degradation is ongoing process which needs further research and investigations. The conventional western approach to land conservation is a recent phenomenon in the region, though farmers use traditional measures. The soil and water conservation measures which had been practiced even in Ethiopia did not help to mitigate the problem of soil erosion and environmental degradation (Habtamu, 2006). There are several possible reasons for the failure of past conservation intervention to meet users' expectations. First, the introduction of the measures did not consider local conservation and farming practices and in many cases did not fit with local conditions. Second, since interventions normally include such activities as reforestation, terrace construction, etc., they are generally characterized by high initial costs that poor farmers could not afford and by benefits that only become apparent in the long run (Ambler, 2000).

To alleviate the problem, a number of policy measures have been undertaken by current government, although their success is highly questioned. More recently, Ministry of Agriculture and Rural Development of Ethiopia has planned a program to involve rural communities living in highly degraded and drought prone highland areas in soil conservation and afforestation practices in the form of Food- For-Work (FFW) under the Productive Safety Net Program (PSNP) (MoARD, 2003). These practices were also carried out in Ofute catchment, Southern Nations and Nationalities Regional State. Farmers were initially obligated to participate in the construction of conservation structures because the construction is undertaken through group labor in the form of Food- For- Work. The implementation rate of the soil conservation practices were, however, very low because farmers prefer to remove the structures from their farmland instead of maintaining and replicating them after they constructed. On the other hand, most of farmers of the study area were not involved in the implementation of soil management practices rather only selected farmers has been participated in the conservation program. These further created a problem on the uniform distribution of structures among the farmers.

Hence it is very important to study the real factors and problems related with widespread application of soil management practices in the study area. Further, it seems significant to examine and identify soil degradation problems and to have dealt with integrated soil management practices which became as a remedy to rehabilitate the degraded lands in the study areas. Therefore, this paper is designed to explore the possible ways of integrating the indigenous with the modern soil management measures for achieving sustainable land management and rehabilitating degraded lands in the study catchment.

Materials and Methods

Description of the study area

The study was conducted in the Ofute river catchment which is located in southern Ethiopia, in Kambata Tambaro zone Kecha Bira Woreda. The study area has a total area of about 7,895 hectares and inhabited by 34,282 people out of which 17,186 are female while the remaining 17,096 are male. It is bordered by Doyogana Woreda to the Norh, Boloso Sore woreda of Wolaita Zone to the South, Kadida Gamela woreda to the East and Hadera Tunto Zuria woreda to the West. Astronomically, the study area is located between 7º09' 15"N -7º16' 45"N latitude and 37º 42' 20"E - 37º 47'10"E longitude (fig. 1). It is found at 327 Km away from Addis Ababa and 117 km away from Hawassa.

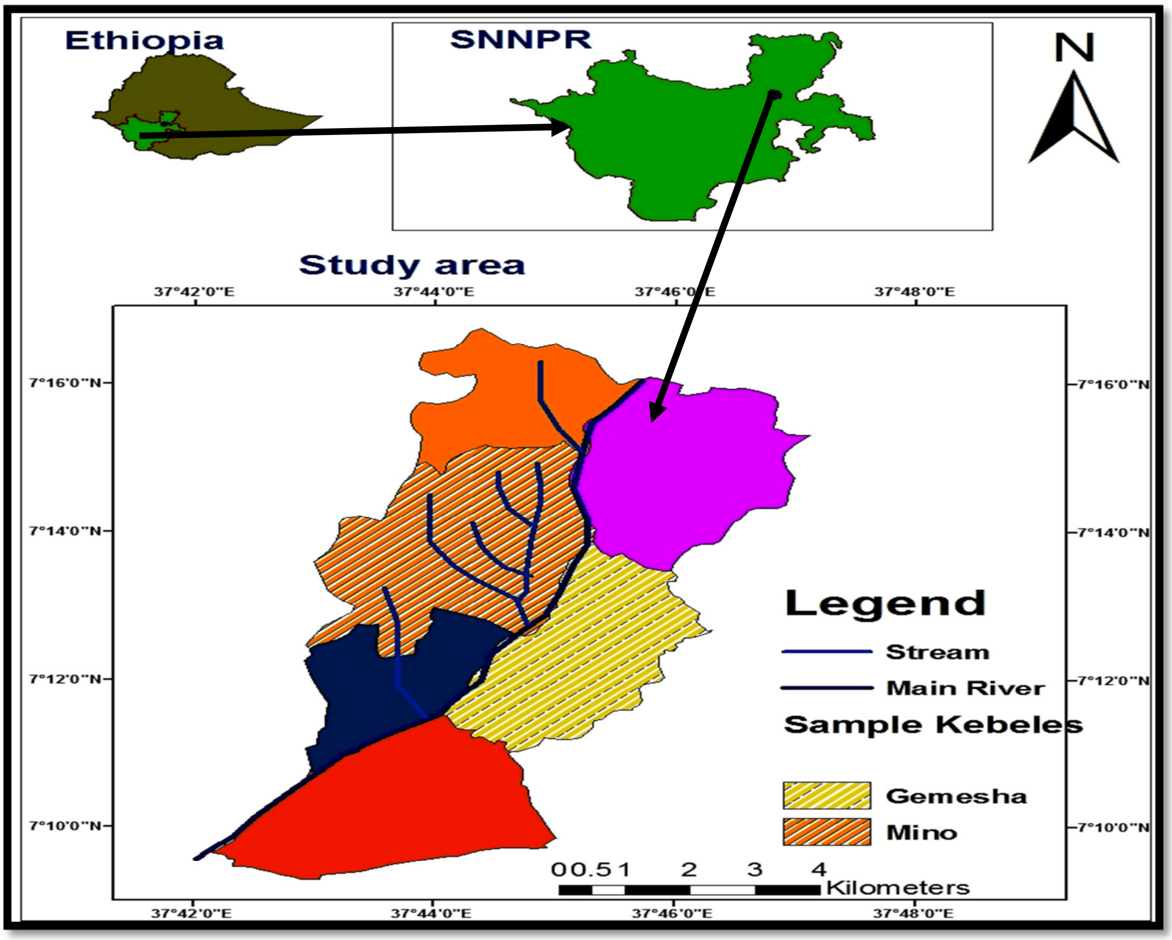

Figure 1: Location Map of the study area Source: Ethio- Gis (1994)

Study Design

The study was based on field based survey of selected households in different villages of the catchment. The main research approach followed in the study was descriptive and both qualitative and quantitative data were analyzed. The sample household heads and their fields were selected especially to identify the role of soil management structures and their status of application in the area.

Sources of Data

The sources of data for this study were from primary and secondary data sources. The primary data was collected from villages, zonal and Woreda agricultural experts and household heads.The primary data obtained from the fieldwork were supplemented by secondary data in order to bridge information gap from primary sources. Secondary sources include published materials such as reports, plans, official records, census records, project reports and research papers.

Data gathering instrument

Detailed information on household demographic and socio-economic condition, data on soil management practices, agricultural production, farming practices and land degradation were collected by questionnaire, field observations, and focus group discussion. At the beginning stage of the survey, informal meetings were undertaken with village elders and community representatives in order to elaborate soil, agricultural, social and economic condition of the study area.

In addition to the informal meeting, transect walk across the village were conducted in order to obtain all the necessary physical information and determine the questionnaire that need to be included in the survey.

Questionnaire had been the most important tool of data collection in the study. Research questionnaires were developed based on the problem assessed and objectives set. The survey questionnaire included both open and close ended questions. Subsequently, on the basis of the results obtained from the pretest, necessary arrangements were made on questionnaire and its reliability and clarity was also tested.

Field observation had been conducted throughout the whole process of the research in order to ensure the validity of information obtained. On the other hand, informal interview and focus group discussion were conducted to know the general information and problems of the study area. Focus group discussions were held in each of the kebeles. The discussion was carried out with group of farmers comprising 5-10 members that consists of Kebele leaders, youth and female representatives, elders, teachers and development agents.

The sample size and sampling procedures

In order to draw valid inferences from the sample and to ascertain the degree of accuracy of the result, the sample had needed to be drawn following the law of probability. Therefore, this study employed the following sampling procedure. Accordingly, two-stage sampling design was used to determine sample villages and household heads. In the first stage, the sample peasant associations (kebeles) from the study area were selected. Ofute catchment contains six Kebeles. From the total six kebeles of the catchment, two peasant associations namely Mino and Gemasha were selected randomly. The selected Kebeles accounted about 33.3% of the total peasant association in the catchment.

The second stage involves preparation of a list of household heads from each selected Kebeles. Out of the total 5207 household heads in the catchment, the size of household heads in sampled Kebeles (Mino and Gemesha) was 2075. That is 1245 household heads in Mino and 830 in Gemesha Kebele. Out of total population in sample Kebeles about 11% were female headed households. Thus, 5% of the total household heads from selected sample Kebeles were considered using systematic random sampling techniques, which makes up 104 sample household heads for this study.

Table1: Sample size of the study area

	Total Household heads			Sample size		
Name of the sample Kebeles	Male	Female	Total	Male	Female	Total
Mino	1090	155	1245	57	5	62
Gemesha	762	68	830	41	1	42
Total	1852	223	2075	98	6	104

Data analysis Techniques

Combinations of both qualitative and quantitative methods were employed to analysis the data. The household survey data were coded and entered into computer environment for analysis. Then using Statistical Package for Social Scientists (SPSS), data tabulation, computation of frequencies, descriptive statistics (mean and percentage) were used. Moreover, cross tabulation, Pearson Correlation coefficient, Spearman and coefficient of contingency correlation methods were used to analyze and examine the statistical relationship between the variables. Pearson product moment correlation coefficient was used for ratio and interval scale data whereas Spearman correlation coefficient was used for ordinal data in the study. But for nominal data cross tabulation and coefficient of contingency method of correlation were used. The analysis was taken place by considering two groups of variables (dependent and independent). The dependent variable was the implementation of soil management practices whereas the independent variables analyzed in the study were age, sex, family size, educational status, and farm land distance, fertility of soil, slope of land and severity of soil erosion.

In addition, Likert scale and MS-Excel were used to generate tables, charts and graphs for summarizing and categorizing data. Furthermore, interviews with local people, DAs, soil conservation experts and supervisors as well as field observation notes were analyzed qualitatively.

Results and Discussion

Demographic characteristics of study area

Population size and density

Interviewed households have total population of 770, out of which 407 (53%) are males and 363 (47%) females. Out of the total population in study sample 61% are found in *Mino* and 39% in *Gemasha* Kebele (table 2). The overall population density of sample population in the study area is about 6 persons per hectare of land.

From the sample of 104 household heads, the result indicates that 94% of the respondents are male. These household heads include a wide range of people: village elders, decision makers or local administrators, younger people, older people, poor farmers and rich farmers. The remaining 6% of the household heads are females, they can be either widowed or divorced (table 2).

Table 2: Population size by sex

Name of Kebeles	No. of household heads			Population			Average family size
	Male	Female	Total	Male	Female	Total	
Mino	57	5	62	238	234	472	8
Gemesha	41	1	42	169	129	298	7
Total	98	6	104	407	363	770	7.5

The ethnical composition of population in the study catchmentcomprises Kambata 84%, Hadiya 9%, Wolayta 5% and the rest comprises Tambaro and others 2%. Religious composition of the area is Protestants 55%, Orthodoxies 38%, and Roman Catholics 7% of the population. Kembatissa language is, well known and is spoken by 89% of population that is followed by Hadiyissa (7%) and Wolaita (4%) in the study area (table 3).

Table 3: Ethnical and religious composition of the study area

Variables	Category	Frequency	Percentage
Ethnicity	Kambata	648	84
	Hadiya	67	9
	Wolayta	35	5
	Other	20	2
Language	Kembatissa	683	89
	Hadiyissa	56	7
	Wolaita	31	4
Religion	Orthodox	293	38
	Protestant	423	55
	Catholic	54	7

Marital status and family size

Majority of household heads in the study are married (96%). And the remaining households are single (1 %), divorced (1%) and widow (2%) (table 4). The family sizes of the household heads are discussed by categorizing into three groups. Out of sampled household heads interviewed in the survey from the selected two kebeles, 78% of household heads have family size of 5-8. The remaining 4% and 18% of the household heads have family size of 1-4 and greater than 8 respectively (table 3.7). The result shows that majority of household heads (96%) have family size greater than 5 who are heavy burden to the economic capability of household heads.Minimum and maximum family sizes of households are 2 and 13 respectively, while the average being 7. The result is much greater than regional average family size of households i.e. 4.7 person per household.

Table 4: Marital status and family size of household heads

Variable	Category	Mino %	Gemesha %	Over all Total Freq.	%
Marital status	Single	0	2.4	1	1
	Married	95.2	97.6	100	96
	Divorced	1.6	0	1	1
	Widow	3.2	0	2	2
	Total	100	100	104	100
Family size	1-4	3	5	4	4
	5-8	74	76	81	78
	>8	23	19	19	18
	Total	100	100	104	100

Age – sex structure

Age- sex compositions of family members of the survey household heads are summarized in to four age groups including the age groups of household heads (table 5). Out of the total household population, 12% of the family members are under 5 years age groups, 24% are between 6-14 years old and 61.5% are 15-64 years old. Household family members aging above 64 years account for only 2.5% of the total population of sample households. The result shows that majority of populations are at middle age or working age group (61.5%). This implies that productive age groups of population are dominant in the study area. These populations are active power for the application of soil conservation technologies. There are also large numbers of young age population (0-14 years) in the study area which are indicators of rapid population growth in the future and low number of old-age persons (> 64 years). Generally, there are more young people than older people; because of poor health care and lack of balanced nutrition people die at a relatively young age.

Table 5: Age - Sex structure of sample population

Age group	Frequency by gender per Kebeles				Total Frequency		Over all total percentage
	Mino		Gemesha				
	Male	Female	Male	Female	Male	Female	
0-5	25	26	22	19	47	45	12
6-14	57	45	46	37	103	82	24
15-64	145	161	98	70	243	231	61.5
>64	11	2	3	3	14	5	2.5
Total	238	234	169	129	407	363	100

Out of 104 household heads interviewed for the study, 30% are 20-40 years old and 47% are between 41-60 years age group. The remaining 23% of household heads are greater than 60 years old (table 6). Minimum and maximum ages of the interviewed household heads are 25 and 90 respectively and the average age is 49.5 years. Most of the farmers in the study area (77%) belong to the young and the middle aged groups. Out of total old age percentage, large proportion of old farmers are living in *Mino* Kebele (32%) compared with 9% from *Gemesha*. The informal discussion with key informants indicated that old age, economically poor, and female household heads perceived the soil conservation practices as the only role of the government. Therefore, they assume that the access of the soil conservation work would be activated with income provision i.e. money or food aid.

Table 6: Age groups of household heads

Variables	Category	Kebeles		Over all Total		Mean
		Mino (%)	Gemesha (%)	Freq.	%	
Age group	20-40	21	43	31	30	
	41-60	47	48	49	47	
	>60	32	9	24	23	49.5
	Total	100	100	104	100	

Dependency ratio

The average age dependency ratio of population in the study area is 0.62 or 62% which means one worker (someone in the farming household aging 15-64) has to support 0.6 persons aging under 15 or above 64 in the households (table 7). The young and old age dependency ratios are 58 and 4 persons per 100 economically active age groups respectively. Young age dependency ratio is higher in Gemesha compared with Mino Kebele. The age dependency ratio of the sample survey is lower compared with zonal (0.84), regional (0.89) and national (0.85) age dependency ratios as it was reported by World Bank (2010).

Table 7: Dependency ratio of the population

Kebeles	young age dependency ratio (per 100 active persons)	old age dependency ratio (per 100 active persons)	Overall age dependency ratio
Mino	50.0	4.0	54.0
Gemesha	74.0	4.0	77.0
Total	58.0	4.0	62.0
Ethiopia	79.3	6.0	85.2

Socio economic characteristics of study area

Educational status of households

Educational characteristics of households were identified by dividing into two major groups such as illiterates and literates. Out of total household heads covered in the survey, 23 household heads (22%) of respondents are illiterates. The remaining 78% of household heads are literate. The literate household heads are further discussed by categorizing into three groups. Out of total literacy level of household heads 60% of respondents completed grade level 1-6, 17% completed grade 7-12 and 1% attended grade level above 12 (table 8). The result shows that majority of household heads attended grade 1-6. Thus, they have more access to information about soil and water conservation practice. Educational attainment of household heads of the sample found to commensurate with what was reported for the zone. Generally, better-educated households have a more realistic perception about soil erosion problems and have more knowledge related to soil management.

Table 8: Educational characteristics of the household heads

		Mino			Gemesha			Total		
Level of literacy		M	F	T	M	F	T	M	F	T
Illiterate	No	14	3	17	6	0	6	19	3	23
	%	23	5	28	14	0	14	18	3	22
Grade completed 1-6	No	32	2	34	28	0	28	60	2	62
	%	52	3	55	67	0	67	59	2	60
Grade completed 7-12	No	11	0	11	7	0	7	18	0	18
	%	18	0	18	17	0	17	17	0	17
Above 12	No	0	0	0	0	1	1	0	1	1
	%	0	0	0	0	2	2	0	1	1
Total	No	57	5	62	41	1	42	98	6	104
	%	92	8	100	98	2	100	94	6	100

Farm size and fragmentation

As in most of the highlands of the country, the landholding of farmers in the study area is very small. There is significant variation in the size of landholding among households. Minimum and maximum sizes of landholding are 0.25 and 2.2ha, the average being 1.2ha. As shown in table 9, majority of farmers (70%) cultivate less than 1 ha of land. On the other hand, 18% of households cultivate 1.1-1.5ha. Households who are cultivating more than 1.5ha account for only 12%. From the discussion one can conclude that farmers of the area have very low farm size which affects livelihood of households since majority of people in the area depends on subsistence agriculture. Reports for Zonal level landholding size indicted that 68% of households cultivate 0.1 - 1ha (CSA, 2010). Majority of farmers in the study area have farm lands away from homestead area.

Table 9: Land holding size of sample household heads

Size of land holding	Mino		Gemesha		Total	
	No. of HHH	%	No. of HHH	%	No. of HHH	%
<0.25 ha	3	5	1	3	4	4
0.26-0.50 ha	15	24	7	17	22	21
0.60-1.00	25	40	22	52	47	45
1.1-1.5	10	16	9	21	19	18
1.6-2.0	5	8	2	5	7	7
>2.0	4	7	1	2	5	5

Cropping pattern

Agricultural practices in the catchment are characterized by small-scale subsistence mixed farming-system, with livestock production as an integral part. Out of the total 104 sampled household heads, 60% of household heads practice of commercial and household subsistence cropping. The remaining 40% of household heads are involved in practice of only household subsistence agriculture without producing commercial crops (table 10). Commercial crops produced in the study area include cash crops such as coffee and Ginger.

Table 10: Agricultural practices of the household heads

Agricultural practices	Frequency	Percentage
Subsistence agriculture	42	40
Commercial agriculture	0	0
Commercial and subsistence agriculture	62	60
Nomadic way of life	0	0

Crop production

Crop production is mainly rain-fed. Almost all of the croplands are planted to annual food crops, including cereals (Maize, Wheat, Teff, Barely and Sorghum), pulses (Haricot beans, Beans and Peas), root crop and cash crops. Perennial crops such as Enset, Banana, coffee and Timber (eucalyptus) are also grown in the study areas. Majority of household heads produce Teff (86.5%), Maize (92%), Ensat (97%) and Yam (81%) which account 24.85ha, 22.17ha, 9.53ha and 12.13ha of cultivated farm lands respectively. On the other hand smaller numbers of respondents produce Wheat (16%), Potato (34%), Ginger (53%) and other crops (34%) such as Coffee, Haricot bean as well as vegetables and fruits (table 11).

Enset is staple food in the area and almost always grown for consumption but the amount of farm land occupied by the crop is too low (9.53 ha) and it is planted around homesteads. Discussion with key informants indicate that crops such as Enset and sweet potato which had been widely produced in the area now become extremely decreasing in their volume of production. This is occurred because of rapid loss of soil by erosion and frequent occurrences of drought due to rainfall and temperature variability.

Table 11: Land allocations among different crop type

Crop type	Mino (ha)	Gemesha (ha)	Total ha	% of respondents produce
Wheat	4.01	0	4.01	16
Teff	16.44	8.41	24.85	86.5
Maize	12.12	10.05	22.17	92
Potato	1.9	2.27	4.17	34
Enset	4.81	4.72	9.53	97
Ginger	4.1	6.52	10.62	53
Yam	5.7	6.43	12.13	81
Others	4.2	1.69	5.89	34

Livestock production

Farmers in the study area practice mixed agriculture in which livestock production is an important economic activity. The livestock populations in the study area are cattle (cows, calves, heifer, young bulls and oxen), goats, sheep, donkeys, mules, horses and chickens. The total livestock population of sample kebeles was 4,244.7 TLU of which cattle accounts 94.6%, goats and sheep 2.3%, and horses, mules and donkeys account 3.1 % of total livestock units (table 12). Majority of farmers in the study area have cattle which become an important source of income. Sample farmers rear livestock for various purposes, including draught power, milk, meat, transport and other purposes. Oxen are an important animal for ploughing the farms, and donkeys and mules are the most common pack animal.

The availability of feed and water are serious constraints to livestock production in the study area. The principal sources of animal feed in the study area are private grazing land, crop residue and Communal grazing lands. Key informants replied that majority of farmers in the study area use private grazing land for feeding their animals. Due to high density of population, there are little communal lands for grazing. Farmers also use crop residue as animal food instead of leaving on the farm field. This indirectly affects soil fertility in the study area. According to focus group discussion, the number of livestock population is decreasing from time to time due to lack of pasture lands for grazing and shortage of feed.

Table 12: Livestock population in sample kebeles

Livestock Type	Mino		Gemesha		Total Livestock holding		
	No.	TLU	No.	TLU	No.	TLU	%
Cows	680	476	453	317.1	1133	793.1	18.7
Oxen	846	592.2	564	394.8	1410	987	23.3
Heifer	499	349.3	387	270.9	886	620.2	14.6
Young bulls	542	379.4	361	252.7	903	632.1	15
Calves	832	582.4	565	395.5	1397	977.9	23
Donkeys	139	69.5	113	56.5	252	126	2.9
Mules	3	2.4	2	1.6	5	4	0.09
Horses	4	3.2	3	2.4	7	5.6	0.13
Goats	370	37	193	19.3	563	56.3	1.3
Sheep	255	25.5	170	17	425	42.5	1

"Conversion factors into TLU are 0.1 for Sheep and goats; 0.8 for Horse and Mules; 0.5 for Donkeys and 0.7 for all cattle (Jahnke, 1982)."

Land uses

The current share of different land use in the study area can be categorized into crop lands covering the largest proportion of the study area which is used by 98% of sample household heads and accounts 64.39 ha of land, fallow land account 3.49ha (16%) and grazing land which accounts 7.76ha (72%) (fig. 2). Furthermore homestead land was occupied by 80% of respondents. Forest land accounts only 5.73 ha of land use which implies low forest coverage of study area. The discussion with key informants show that the land use or cover change is mainly observed in changing from forest and grazing land to crop land and settlement area. The discussion also revealed that the formerly available forest and grazing land now become occupied by settlements and crop production.

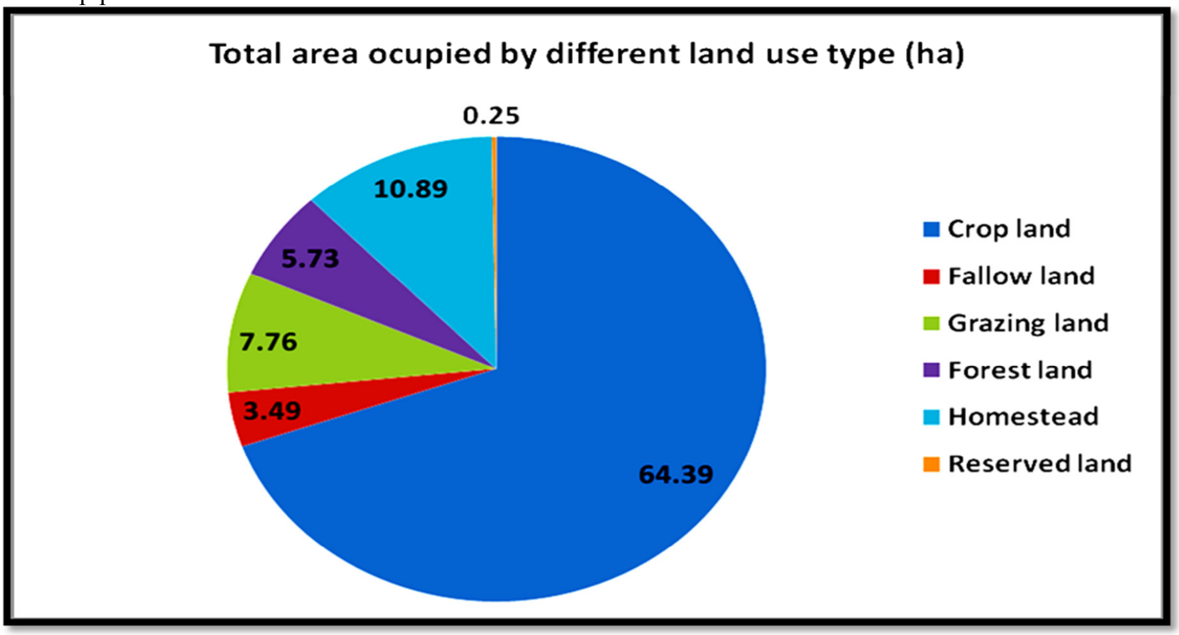

Figure 2: Land use/cover types Source: Household survey, June 2012

Sources of income of respondents

The main sources of incomes for household in the study area are sales of crop production and animals. As indicated in table 13, 73% of respondents answered that sales of crops and animal production together were major source of income for farmers in the study area. But only 5% and 4% of the respondents get income only from sales of crop production and animals alone respectively. Majority of farmers in study area have annual income ranges between 3,000-6,000 Ethiopian Birr from the above mentioned sources.

Table 13: Sources of household income

Sources of income	Frequency	Percentage
Sale of crop	5	5
Sale of animals	4	4
Sale of crop and animals	76	73
Others	19	18

Bio-physical characteristics of study area

Topography

The nature of topography of a particular geographic entity has multi-dimensional implications up on the development of physical infrastructure, human way of life, the type of production of crops, the land use conditions and the type of flora and fauna exists. The relief of the study area is generally characterized by high lands and ridges which are the extension of the Ambaricho Mountain. The Ambaricho Mountain is the highest mountain in the Kambata Tambaro Zone. The altitude of the study catchment lies between 1800m – 2400m above sea level (fig. 3). The highest place in the study area is Songacho hill which is approximately 2400m peak.

The slopes of the study area were categorized as flat, gentle, moderately sloping and steep slope. Out of total sample plots 26% and 47% are gentle and moderately sloping respectively. The others are flat 9%, and steep slopping 18% of the land area. Therefore, majority of land in study kebeles are moderately sloping.

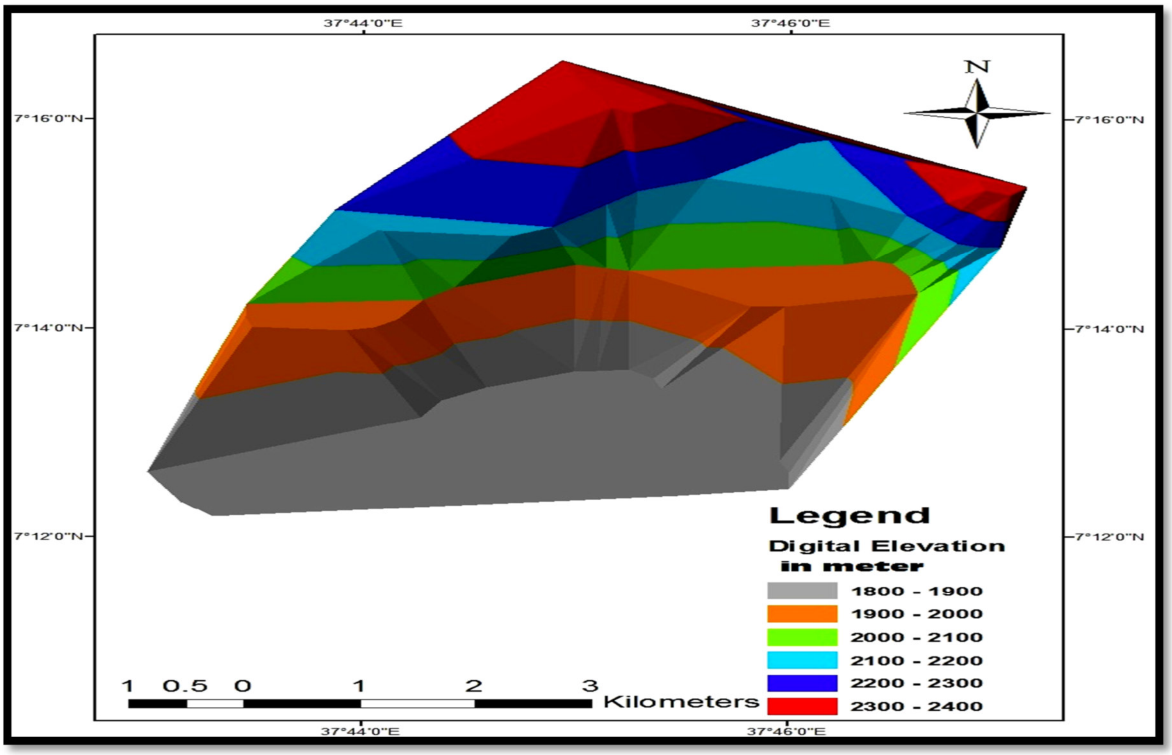

Figure 3: Relief Map of the study area. **Source:** *(Ethio- Gis data base, 1994)*

Climate

Climate is one of the elements of the physical environment which has a pronounced impact on settlement pattern, human way of life, the type of soil, economic activities, flora and fauna existed and developed so forth (Habtamu, 2006). Among different climatic elements temperature and rainfall have a considerable impact in such an agrarian country like Ethiopia and in the study area. The climate of the study catchment is characterized by moderate temperature and rain fall and it is categorized under *Woina Dega* Ethiopian agro ecology zone. According to the Kecha Bira woreda meteorological data, the annual average maximum and minimum temperature of the study area is 31ºc and 18ºc respectively. Its mean annual temperature is about 25ºc. The total annual rainfall of the study area ranges between 950-1200 mm. The rainfall pattern generally is bimodal, with over 70 percent falling between April and August. The main rainy season in the area is summer (Kiremt) that ranges from the June to August with maximum rainfall and two minimum rainy seasons such as the Spring (Tsedy) and Autumn (Meher) with little rain fall. The dry season (Bega) in the area is mostly from October to February. The dry season limits the water availability in the study area. The months with maximum rainfall and temperature are July and February respectively (fig. 4).

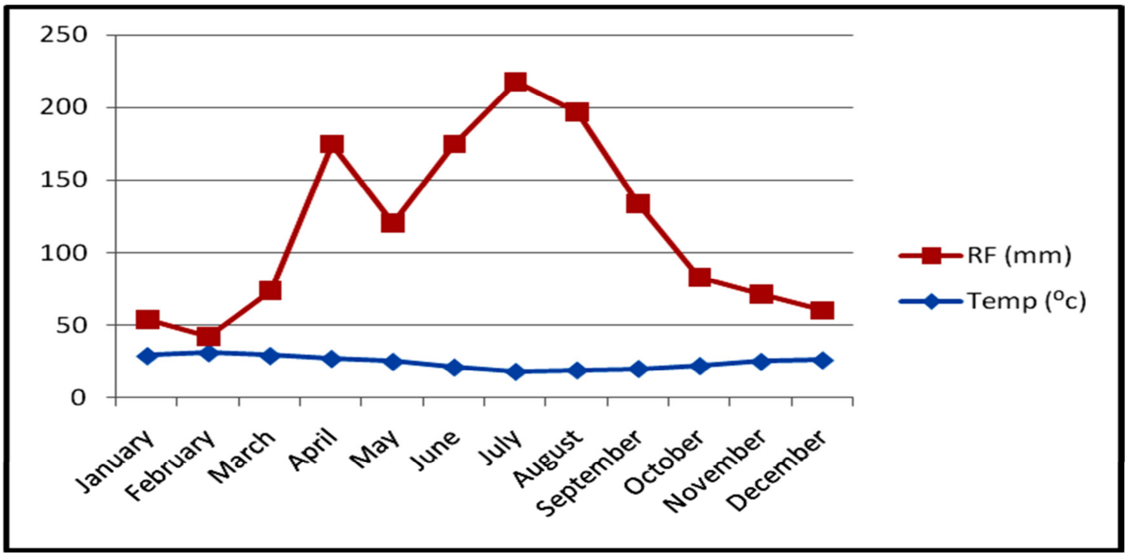

Figure 4: Temperature and Rainfall of study area

Geology and Soil

Most of geomorphologic features of the study area are disturbed by exogenesis forces such as weathering and erosion. Rapid rate of erosion by the river and runoff have been created large gullies and gorges in upper part of the catchment which become inaccessible for agriculture and livestock production. The relief of the study area is generally characterized by some plain, plateau, ridges and rugged terrain (fig. 5). The study area is dominated by relatively soft weathered rocks particularly susceptible to erosion. Major type of rock in the area is sedimentary followed by some volcanic rocks. The soil on soft and deeply weathered rock is deep and free from stones (Habtamu, 2006).

Soil can be characterized by its structure, color, consistence, texture, and abundance of roots, rocks and carbonates (Abay, 2012). Most soils have a distinct profile, which is a vertical section of soil through all its horizons and extends up to the parent materials or it is sequence of horizontal layers (Pidwirny, 2007). Generally, these horizons result from the processes of chemical weathering, eluviations, illuviation, and organic decomposition. The profile is important both from the standpoint of soil formation and soil development (pedology) and crop husbandry since it reveals the surface and the subsurface characteristics and qualities, namely depth, texture, structure, drainage conditions and soil-moisture relationships (WRB, 2006). Soil of the study site is derived from highly weathered rocks, mainly sedimentary rocks and basalts. The soil forming factors in the study area are climate, parent material, relief/topography and flora/fauna. The two dominant types of soils covering the present study area are Nitosols and Vertisols (Abay, 2012). Nitosols are the dominate soil in the catchment. The soil types of the area comprise 50% silt, 20% clay and 30% sandy (Ibid). Farmers also identified soil color of the study area as black 19 %, reddish 63 %, gray 2% and brown 16% (table 14). Generally soil color in the study area is dominated by red followed by black.

Table 14: Color of Soil in the study catchment

	Percentage of plots per Kebeles		
Soil color	Mino	Gemesha	Total percentage
Gray	2	5	2
Reddish	64	59	63
Brown	10	26	16
Black	24	10	19

Drainage

In the catchment, there are two intermittent springs and three perennial rivers. The entire area drains towards the Omo valley via Omo River. The Ofute River starts from the high lands of Kechabira Woreda. The river at its upper course is joined by the two small rivers and other minor springs. Finally, it flows towards the Ajora fall. Ajora fall is the most tremendous twin water fall in Ethiopia. The twin is formed by two major rivers Ajacho and Soke. Therefore, Ofute River forms the tributary of Soke River which enters to the fall in western side of the fall (fig. 7). In the upper course, the river passes steep slope and form some gorges and rapids which accelerate rapid loss of soil in hill sides of the area. Generally, the river at its middle course flows towards to Boloso Sore woreda in Wolaita zone and formed a boundary between Wolaita and Kambata Tambaro zones.

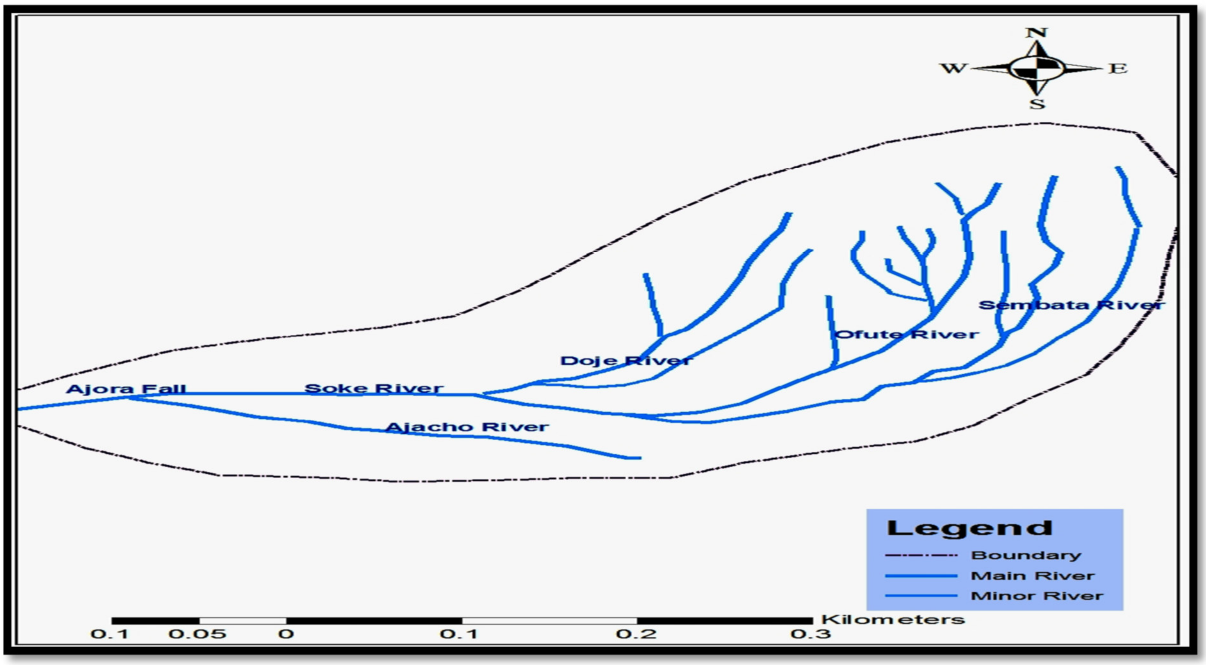

Figure 5: Drainage Map of the study area.Source: *(Ethio- Gis data base, 1994)*

Vegetation cover

The area has been covered by forests in hillsides, rivers and uncultivated rocky lands. Currently, vegetation cover is removed, and replaced by settlement, cultivation and grazing lands. This is due to the fact that rapidly growing population result with the removal of available forests cover of the area for the need of more land for settlement and agricultural purposes as well as grazing with large livestock population. Generally, the vegetation coverage of the study area was categorized into modern and indigenous tree varieties. The major modern introduced tree species observed in the study area are *Eucalyptus globules, Eucalyptus camaldulensus,Juniperus procera, Gravilearobusta,Sesbania sesban* and *Casuarina cunninghmiana (*Table 15).

Table 15: Major types of imported tree varieties in the catchment

Local Name	Botanical Name	Locality Observed
Nach bahir zafi	*Eucalyptus globules*	Communal lands
Kay bahir zafi	*Eucalyptus camaldulensus*	Communal lands
Faranji tid	*Juniperus procera,*	Homestead area
Gravilea	*Gravilearobusta*	Farm fields
Sesbania	*Sesbania sesban*	Farm fields
Shiwashiwe	*Casuarina cunninghmiana*	Homestead area

Major indigenous tree species which were observed in the study area include *Cordia africana, Hagenia abyssinica, Podocurpus gracilior, Olea Africana, Aningeria altissima, Croton machrostachus, Ficus vusta, Ficus sur, Vernonia amygdolinica, Phytyolaa lodicandera, Commiphora Africana, Ehretia abyssinica, Euphorbia ampliphyla, Euphorbia tirucalli, Arundo donax, Prunus Africana* and others (table 16). Informal discussion with key informants revealed that the forest cover in the study area is declining through time due to deforestation, increment of population settlement and over grazing. The interference of human population in terms of rapid spread of settlement due to high population growth seriously destructs the vegetation cover and distribution in the study area. Hence, the effect of deforestation to the removal of vegetation cover is very great.

Table 16: Types of indigenous tree varieties in the catchment

Local Name	Botanical Name	Locality Observed
Wanza	*Cordia Africana,*	Farm and communal lands
Koso	*Hagenia abyssinica*	Hill side area
Zigiba	*Podocurpus gracilior*	Homestead area
Weyera	*Olea Africana*	Homestead and communal lands
Kerero	*Aningeria altissima*	Hill sides
Bisana	*Croton machrostachus*	Farm and communal lands
Warka	*Ficus vusta*	River courses
Sholla	*Ficus sur*	River courses
Grawa	*Vernonia amygdolinica*	Scattered in all areas
Endod	*Phytyolaa lodicandera*	River courses
Dokima	*Commiphora Africana*	Scattered in all areas
Korch	*Ehretia abyssinica*	Farm field and farm boundaries
Kulkual	*Euphorbia ampliphyla*	Farm boundaries
Kinchib	*Euphorbia tirucalli*	Farm boundaries
Shimboko	*Arundo donax*	Hill side areas
Habasha tid	*Prunus Africana*	Homestead areas

Soil Erosion and its constraints

Farmers in the study area are well aware of the soil erosion problem. The households are asked whether soil erosion was a problem in their plot of land or not. About 96% of respondents acknowledged soil erosion as a problem at least in one of their plots (table 17). This result is comparable to the findings of Habtamu (2006) and Michael (2002) which were carried out in other part of the country. For instance, the study made at Anna watershed in Hadya Zone, SNNPR indicated that about 92% of interviewed farmers perceived soil erosion as a problem on their farm plots (Habtamu, 2006). A study conducted in the high lands of Ethiopia, East Gojam indicated that about 96.7% of the surveyed farmers perceived soil erosion as a major problem on their farm (Michael, 2002). Moreover, during focus group discussion the informants described indicators of soil erosion on their farm. Accordingly, the indicators of soil erosion include decrease in the capacity of soils to grow a variety of crops, decrease in the depth of top-soil, decline in water holding capacity of soils, decline in yield from the farm, etc.

In addition, households were also interviewed about the degree of severity of soil erosion in their farm plots. Thus, about 38% and 34% of the respondents acknowledged that severity of soil erosion in the farm field is moderate and severe respectively (table 17). The remaining (24%) of farmers rated the problem to be minor on their farm plot. Farmers that rated the problem to be severe are lower compared to that identified by Michael (2002) which was about 71.7%. Therefore, severity of soil erosion in the study area is lower as compared to findings by Michael (2002).

Table 17: Respondents view on Severity of soil erosion.

Variable	Category	Kebeles Mino (%)	Gemesha (%)	Overall total Freq.	%
The degree of soil erosion in farmlands	Severe risk	32	36	35	34
	Moderate risk	37	38	39	38
	Minor risk	24	24	25	24
	No risk	7	2	5	4

Regarding the causes of soil erosion, 52% of the sample farmers believed that deforestation is the most important cause of soil erosion and ranked first by respondents (table 18). The second most important causes of soil erosion in catchment is cultivation of steep slopes as responded by 35% of interviewers compared with other causes listed in second rank. Generally the main causes of soil erosion in their rank order from the most to least factor include deforestation, cultivation of steep slopes,over cultivation,poor agricultural practices,over grazing and excess rainfall. Due to an increasing prevalence of the above listed causes, soil erosion can affect the production potential of the area, livelihood of households and environmental quality.

Table 18: Perceived causes of soil erosion in the study area

Causes of soil Erosion	Ranks and percentage of respondents 1st	2nd	3rd	4th	5th	6th
Deforestation	52	8	11	9	8	16
Over grazing	2	19	24	26	30	11
Over cultivation	27	16	39	18	5	4
Poor agricultural practices	17	13	8	32	18	14
Cultivation of steep slopes	9	35	6	7	19	13
Excess rain fall	6	11	14	8	22	40

Soil management practices employed in the study area

Soil is the most important resource on which agriculture is based. Soil management practices are tools that farmers can use to prevent soil degradation and build organic matter and fertility. Before the introduction of modern soil management practices, most farmers in the area were practicing indigenous methods of soil conservation. Thus, soil management practices in the study area are discussed in view of indigenous, modern and integrated methods. They were implemented by community of the study villages, the agricultural department in *Kechabira* Woreda, *Catholic mission* and office of *World Vision* in the study area.

Indigenous soil management practices

Indigenous soil management measures are broadly grouped as physical, vegetative, and agronomic methods of soil management practices. These practices also emerge from a detailed understanding of local conditions, and are modified in response to changing socio-economic, political and ecological conditions. As it is indicated in table 19, almost all indigenous soil management practices were implemented by farmers in the study area. But the application status varied from one type to another according to their role of controlling soil from erosion and rehabilitation of degraded lands. In order to reduce the magnitude of soil erosion in the study area, farmers used a number of indigenous soil conservation technologies. Among these tree planting, contour farming, cut- off - drains, traditional stone bunds, Crop rotation, traditional ditches, fallowing, organic manure and mixed cropping are top mentioned aspects.

Local tree planting is categorized under indigenous vegetative measures which can prevent soil erosion by slowing down water flowing over the land and this allows much of the rain water to infiltrate into the ground and thus prevent it from being washed away. Moreover, plants break the impact of a raindrop before it hits the soil, thus reducing its ability to erode soil. The loss of protective vegetation through deforestation, over-grazing, ploughing, and fire makes soil vulnerable to being swept away by wind and water.

About 81% of the sample households used planting indigenous trees as a remedy to reduce soil erosion in the study area (table 19). During the transect walks, it was found that trees planted on farm lands for the purpose of reducing soil erosion include banana, *Enset ventricosum*, Coffee tree, *Cordia african, Croton machrostachus*, local grass strip (Sembelet, Dasho) and others which have a great role in protecting soil moisture, controlling rapid run-off and flood, breaking wind as well as enhancing soil fertility with their decomposing broad leaves. Tree species such as *Ehretia abyssinica,Euphorbia ampliphyla*, *Euphorbia tirucalli* and other small trees were planted in degraded communal lands and areas affected by gully. This result reveals that local plantation of trees are the most frequently used indigenous soil management practices in the study area.

Contour farming is an indigenous physical soil conservation technique. It is used alone or in combination with other conservation practices such as cut-off drains and plantation of different trees. Of the sampled household heads, 52% of respondents had implemented contour farming as soil management practices (table 19). Contour farming have implemented during land preparation period for crop production before planting season because it is part of the plough of land for appropriate seedbed. While the farmer ploughs the land along the contour for preparation of an appropriate seedbed for production, it serves the purpose of conserving the soil from erosion. When the land is ploughed horizontally, the contour furrow serves to hold rainwater until it infiltrates, and by doing so it is very important to moderate the eroding effects of surface run-off. Thus, its function is multiple, i.e., it conserves soils by holding water until it infiltrates and control rapid run-off from the cultivating fields.

Table 19: Indigenous soil conservation measures implemented by households

Indigenous soil management practices	Kebeles				Total	
	Mino		Gemesha			
	No	% of sample HHH	No	% of sample HHH	No	% of sample HHH
Traditional stone bunds	1	2	9	15	10	10
Traditional ditches	36	58	20	48	56	54
Crop rotation	34	55	28	62	60	58
Fallowing	12	19	17	40	29	28
Cut-off drains	22	36	13	31	35	33.6
Tree planting	47	75	37	88	84	81
Contour farming	27	44	27	64	54	52
Terraces	5	8	2	5	7	8
Application of manure	52	84	34	81	86	73
Mixed cropping	31	50	28	67	59	56
Inter cropping	17	27	11	26	28	27

Traditional cut-off drains are one of the physical indigenous soil management structures commonly constructed by digging the soil deep by family labor and neighborhood and enforced by wood blocks of soils with grass, stones and some small trees. The survey results show that 33.6% of the farmers in the catchment used cut-off drains (table 19). The discussion with key informants examined that cut-off drains are constructed mostly in sloppy land where there is rapid run-off and soil erosion. As observed during transact walks, cut-off drains which were constructed at one place for long period of time directly causes big gullies and accelerate soil degradation. Traditional cut-off drains are important to prevent loss of seeds, fertilizers and soil due to excessive run-off coming from uplands of the terrain and dispose the excess surface run-off from higher ground and protect the downstream cultivation land by diverting run-off to waterway or rivers.

Traditional stone bundsare an indigenous physical soil management structures which are constructed on steep eroded barelands and hill sides (Mushir *et al*., 2012). In the study area only 10% of the respondents had constructed traditional stone bunds (Table 19). The survey result shows that most farmers in the study area did not use traditional stone bunds for soil management. This is because of that most farm lands were stone less for construction of bunds, need of more human power for construction and flat sloppiness of some agricultural lands at lower course of river. During focus group discussion, key informants stated that stone terraces are considered effective in erosion control especially in steeply sloping hill areas. Stone bunds are useful to reduce the velocity of run-off, control soil erosion, and increase soil moisture retention capacity and water availability to plant.

Traditional ditchesare one of the widely used indigenous physical soil management practices in the study area and also locally known as '*Zofaro*'. These are micro channels constructed on cultivated farms to drain-off excess water from the field via to cut-off drains. The structures are constructed and maintained mainly by oxen drawn plough and family labor. Out of total respondents, 54% of household heads applied indigenous drainage ditches for managing soil and controlling erosion. These are low cost measures in which construction is part of the normal ploughing activity. However, unlike the plough furrows, the ditches are made wider and deeper in dimension and usually run diagonally across the field. According to focus group discussion traditional ditches are constructed during farming period and destructed after the harvesting of crops for preparation of new ditches on farm fields annually.

Fallowingis a traditional agronomic soil management practices which involves the practice of leaving the land out of production for 3-5 years for the purpose of restoring soil fertility and minimizing soil loss. But in the area most of the land under this treatment is highly degraded to the extent of almost reaching a point of no return or not easy to recover within a short period of time. Out of total respondents, 28% of farmers practiced fallowing as an indigenous soil conservation measure (table 19). During discussions with key informants, it was learnt that through time traditional fallow periods have become very short and rare in the area as a result of high population pressure and associated over cultivation. Hence, the application of fallowing is impossible with increasing population and the need of extra farm lands for the future in study area. During a transect walk in the study area, it was observed that farmers applied fallowing in the formerly degraded farm and grazing lands. The survey result is similar to the study conducted at Digil watershed in East Gojam indicated that fallowing was used to be the most important way for improving soil fertility (Michael, 2002). Therefore, fallowing is effective measure in restoring degraded farm and grazing lands in the study area.

Crop rotation is one of the most important means of improving soil fertility as well as conserving soil in the study catchment. Out of total interviewed households 58% of them used crop rotation in their farm fields for improving soil productivity and conserving soil (table 19). Farmer's choices of crops to grow in rotation are largely based on their personal preference, agro climatic condition and suitability of the soil type of farm plot for the chosen crops. According to the key informant discussion, major crop rotation system practiced by farmers in the study area are from cereals to cereals (Maize - Teff - Maize or Maize - Wheat or Wheat - Teff - Wheat), from legumes to cereals (Haricot bean - Teff or Maize - Beans - Maize) or from cereals to root crops (Maize - Sweet potato or Wheat - Sugar potato or Teff - Yam). Planting of different crops on the field in rotation can increase soil nutrients and crop yields. On the other hand, if the same crop is grown on the same land frequently, the planted crop develop the root at the same depth of soil profile and thus the propagation of the root systems in the same depth results in strong competition for moisture and nutrients.

Application of organic manure is an agronomic indigenous soil fertility management practices used to be an important input for maintaining and enhancing soil fertility. Manure made of animal dung and urine is the best part of organic fertilizer. In the study area 73% of households applied organic manuring on their farm plots in order to improve fertility of the soil (table 19). Farmers used manure mainly on the homestead farm rather than the distance plot probably to reduce transport cost or unnecessary labor cost. During focus group discussions with key informant and Development Agents and farmers (especially, those who are poor) have increased the use of manure application in their field due to currently prevailing high price of the inorganic fertilizer.

Mixed cropping is traditionally practiced ways of growing two or more crops in the same field in one season. In most cases grains and leguminous crops are mixed together in order to improve soil fertility and control surface run-off from the farm fields Mushir *et al*., 2012). Out of total respondents, 56% of households practiced mixed cropping in the study area (table 19). According to key informants, the fast growing legumes such as haricot beans, peas and beans are mixed with late matured crops like maize and sorghum to fix nitrogen and control soil detachment. It is significant for protecting the soil against erosive forces and increasing crop production.

Inter croppingis the systems of planting different kinds of annual crops in alternate rows, so that it can provide better canopy for loose of soil particle which are exposed to rill erosion. Such a technique can reduce a risk of soil erosion than covering the farm with sole crop. Thus, the increased coverage of soil surface with crops, enhances the stability of soil aggregates thereby reduce the erosive capacity of rain and also erodibilty of the soil (Lal, 2008). In the study catchment about 27% of respondents used intercropping to manage soil (table 19). The household data further revealed that the main crops used in intercropping system include Haricot bean with Maize or Yam, Sugar potato with Wheat or Barley and Yam with Ginger and Maize. Key informants also acknowledged the significance of intercropping to avoid sheet or rill erosion and thereby to improve the productivity of soil.

Terraces are traditional physical indigenous soil management structures constructed along the contours in steep degraded slopes. They are common in most part of Ethiopia, especially in dry area to support area closure, plantation and protect downstream fields (Shibru, 2010). Very few numbers of farmers (8%) used terraces in the study area along hill sides (table 19). This is due to the fact that terraces were formerly the most important soil conservation methods but now days it is replaced by modern structures like soil bund and *fanaya juu* terraces. They are effective in controlling run-off and erosion especially hill side area.

Farmers are asked about the role of indigenous soil management practices in controlling soil erosion and rehabilitating degraded lands in the study area. Accordingly, about 63% of respondents replied that indigenous soil conservation practices play an active role in conserving soil if used together with modern methods of soil management practices (table 20). While 10% of respondents explained that indigenous soil conservation practices are very active for controlling soil erosion even if used alone without integrating it with modern methods. On the other hand, 22% of respondents replied that indigenous soil conservation methods are not preferable as compared to introduced modern practices. During transect walks; it was observed that almost all farmers applied both traditional and modern soil management practices on the same fields simultaneously. Similarly, research conducted by Michael (2002) found that combing the indigenous methods with modern measures were an effective strategy to ensure sustainable land management among the farmers in the North-western highlands of Ethiopia.

Table 20: Use of indigenous soil management practice by the study households

The role of indigenous soil management practices	Kebeles		Total	
	Mino (%)	Gemesha (%)	No	%
Very active	17	2	11	10
Less important	3	7	5	5
It is good if used together with modern methods	48	84	65	63
Not preferred method compared to modern methods	32	7	23	22
Total	100	100	104	100

Modern soil management practices

Modern soil management practices are newly introduced methods of soil conservation which were widely applied in the study area. The non-indigenous soil conservation practices were introduced with the objectives of conserving, developing and rehabilitating degraded lands and increasing food security through increased food production (MoARD, 2003). Sample households were asked whether they have been using modern soil management practices in their farm lands or not. Out of total sampled household heads 93% of interviewers replied that they have applied modern soil management practices in the study catchment. Widely applied modern soil management practices in catchment include *fanaya juu,* soil bunds, grass strip*,* improved cut-off drains, introduced tree planting andbasins.

Fanya juuis an introduced physical soil management structures constructed by digging a trench and throwing the soil uphill to form an embankment. *Fanya juu* terraces are sometimes called converse terraces and applied on cultivated lands, grazing lands and sloppy homestead farm land. It is suitable mostly in moist mid lands or medium rainfall areas with deep drained soils (Habtamu, 2006). Out of the total sample households, 63% of respondents replied that they applied *fanaya juu* terraces in their farm plots (table 21)The construction of *fanaya juu* varies from village to village based on slope category of farm land. Accordingly, the recommended farm land slope gradient category for construction of *fanaya juu* is in between 3-15% slopes (MOARD, 2003). Therefore, the amount of farmers who had constructed *fanaya juu* at *Mino* Kebele is 39% but it is 98% at *Gemesha* Kebele (table 21). This is because of that slopes of farm lands at *Mino* Kebele are steeper than *Gemesha*. Majority of farm lands at *Gemesha* are categorized between low to moderate slope. Thus, large number of households applied *fanaya juu* terraces here.

Table 21: Modern soil management techniques practiced by households

Types of modern soil management practices	kebeles				Over all total	
	Mino		Gemesha			
	No of HHH	%	No of HHH	%	No of HHH	%
Fanaya juu terraces	24	39	41	98	65	63
Improved cut-off drains	37	60	23	55	60	58
Check dames	3	5	4	10	7	7
Soil bunds	47	76	26	62	73	70
Basins	8	13	4	10	12	12
Plantation of trees	21	34	11	26	32	31
Grass strip	60	97	38	90	98	94

As it had been observed during transact walk, *fanaya juu* was used together with other modern vegetative measures such as planting elephant grass and *Sesbania sesban,* whichwere grown as soil conservation structures in order to stabilize the structures (fig. 6). Key informant discussion revealed that stabilizing grass can reduce soil losses, improve the availability of organic matter in the soil and thereby used as a source of fodder for animals.

Figure 6: Stabilization of Fanaya juu terraces by elephant grasses in Gemesha

Soil bunds are physical structures constructed from soil along the contour**s** where the soil is thrown downwards across the slope in moderate to steep slope areas (fig.7). They are suitable mostly in semi-arid and arid parts of the country along mountainous and hill side areas (Michael, 2002). In the study area, 70% of the respondents have constructed soil bunds on their farm fields (table 21). In mountainous part of the study area, farmers are constructing bunds to secure financial support from productive Safety Net program. Unlike the findings of Mushir *et al*, (2012), soil bunds in the study area are built in both moderate and steep slope terrains. But, the survey work undertaken by Mushir *et al*, (2012) found out that soil bunds were constructed only in moderate slope areas. Soil bunds are very much important to control run-off from farm fields by reducing the slope length which ultimately reduces soil loss, stop velocity of run-off and store water with in the ties to be infiltrated by soil.

Figure 7: Soil bund terraces on degraded lands in Mino locality

Check dames are structures constructed by woods and rock fragments across the gully to reduce the velocity of run-off and prevent deepening and widening of the gully. Gully encroachment or gully erosion is one of the serious problems in the study catchment (fig. 8). In order to mitigate the problem, different gully rehabilitation or stabilization measures were currently taken place in the study area. As can be observed during transect walks, most gullies are formed along the border and outsides of the farm plots. Thus, about 7% of the respondents constructed check dames around farm fields and communal lands (table 21). But the official records from sample Kebeles showed that a total of 1650 meters check dames were constructed in the study area.

Figure 8: Partial view of degraded gully in Gemesha village

Plantations of introduced trees such as *Sesbania sesban*, *Gravillea robusta*, *Juniperus procera,Eucalyptus* *globules*, Sisal and Euphorbia are important soil management methods in the study area which are planted along the contour and sometimes used together with other conservation techniques. *Gravillea robusta, Eucalyptus globules* and *Juniperus procera* are widely planted trees on degraded hillsides, gully areas and communal lands which are mostly planted by government for the purposes of rehabilitating the degraded lands and maintaining the biodiversity of the area. Other newly introduced trees such as *Sesbania sesban,* Sisal and Euphorbia are planted on severely eroded farm lands and overgrazed lands to regain fertility of the soil (fig. 9). This type of conservation method was practiced by 31% of the respondents in order to reduce erosion problem and conserve the soil round the root of the plants (table 21). During transact walks across the field it was observed that highly degraded lands are closed up and covered by different types of modern plants in order to rehabilitate the area and to protect livestock from grazing.

Figure 9: Rehabilitation of Degraded gullies using plantation of trees at Mino

Grass strips are grasses and shrubs which have been planted in narrow strips along the contour at intervals across the slope on eroded and overgrazed lands. Grass strips are the least cost and least labor-demanding soil conservation structures. About 94% of respondents practiced grass strips on their farm fields for controlling soil erosion in catchment (table 21). The main types of modern grasses planted by study households include elephant grasses and bushes (fig. 10). The key informants reported that there are different types of strips used together with grass strips like Banana strips, Enset strips, *Gravillea* and Coffee tree strips together with other soil management structures like soil bunds and *fanaya juu* terraces. These are effective methods in controlling erosion and provide valuable biomass which is used for animal feed.

Figure 10: Grass strips used in Mino Kebele

Basins are normally small, circular or semi-circular shaped micro-catchments or holes constructed to capture and hold rainwater and soil (fig. 11). They are constructed along the contours on the eroded bare lands and communal lands which are used to trap rapid run-off and flow of rain water. The constructed basins enhance the infiltration capacity of water and nutrients in the ground. Basins are categorized as micro basins, half-moon basins and eyebrow basins. About 12% of respondents had practiced basins for soil management in the study area (table 21). According to natural resource management experts from *Kecha Bira district,* basins are mostly constructed by government under productive safety Net program.

Figure 11: Half Moon Basins on degraded communal land in Mino village

Improved cut-off drains are modern conservation measures that are currently practiced in the study catchment. They are graded channels with a supporting ridge or bank on the lower side. They are constructed across a slope and are designed to intercept the run-off and convey it safely to an outlet such as waterways. The survey results showed that 58% of respondents constructed modern cut-off drains on their farm lands (table 21). Discussion with key informants showed that cut-off drains are very important to protect cultivated land from run-off by diverting water away from fields. According to natural resource experts in the study Kebeles, improved cut-off drains are similar to the traditional cut-off drain in terms of function but it differ in manner of construction and maintenance.

Factors affecting implementation of soil management practices

Age of households

The influence of farmer's age in the implementation of soil management practices is positive, but it is not statistically significant. As stated in table 22, younger age group (20-40) farmers are less likely to participate in the implementation of integrated soil management practices than intermediate and aged households. This was due to the fact that younger age group farmers have engaged in different types of off-farm activities such as small business, daily labor and other sources of income to maximize their capitals instead of investing in farm conservation practices. The survey result is concomitant with the findings of Chomba (2004) which reported that younger households are less likely to participate in soil management practices.

Gender was the other influencing factor investigated in the analysis**.** As can be seen in table 22, there was a positive relation between gender and implementation of integrated soil management practices. Though there existed weak relationship between the two variables, male households are more actively participated in the implementation of indigenous soil management practices than female house hold heads. Hence, male headed households spent much more time and labor in engaging on indigenous soil management practices than their female counter part.

On the other hand, female head households are active participants in the adoption of modern soil conservation practices in the study area. According to key informants and experts' view from Woreda agricultural department, in most cases modern soil management practices were constructed by active participation of local government through Productive Safety Net Program and this program provide financial support mostly to female household heads those from low income groups to be more involved in introduced soil management practices than male households.

Table 22: Relationship between age and sex of household heads and implementation of integrated soil management practices

Variables		Soil management practices Indigenous methods of SMP	Modern methods of SMP	Integrating indigenous with modern	Total		Correlation result
		% of HHH	% of HHH	% of HHH	Count	%	
Age group	20 - 40	33	36.8	27.8	31	29.8	
	41 - 60	67	31.6	49.4	49	47.1	0.068
	Age >60	0	31.6	22.8	24	23.1	
Gender	Male	100	89.5	93.5	97	93.3	0.09
	Female	0	10.5	6.3	7	6.7	

'Cross tabulation and correlation'

Family size

The family sizeof households plays an important role in the investment and implementation of soil management practices in the study area. The size of family member can positively affect the implementation of integrated soil management practices. Although the relation was not statistically significant, the result showed that farmers with large families are more involved in the implementation of soil management practices. Among the 79 household heads who have implemented integrated soil management practices, 61 household heads (72.2%) have a family size of 5-7 (table 23). This implies that the presence of sufficient size of labor force in a household is an important requirement for the application of soil management structures. This finding confirms the survey result by Eleni (2008) that was conducted at Tulla District, Ethiopia which stated that family size could have a positive and significant relation with implementation of soil conservation structures.

Table 23: Relationship between family size and the implementation of integrated soil management practices

Variable		Soil management practices			Total		Correlation
		Indigenous methods of SMP	Modern methods of SMP	Integrating indigenous with modern			
		% of HHH	% of HHH	% of HHH	Count	%	
Family Size	< 5	16.7	0	8.8	4	4	
	5 - 8	66.7	84.2	72.2	81	78	0.055
	> 8	16.7	15.8	19.0	19	18	
Total		100	100	100	104	100	

'Cross tabulation and correlation' Educational status

There is a negative correlation between the educational leveland the implementation of integrated soil management practices. Out of total 23 illiterate households participated in implementation of soil management practices, 17 illiterate households (21.5%) were involved in the application of integrated soil management practices (table 24). Although the relationship between variables are statistically not significant, the result showed that households with lower educational level are more involved in the application of integrated soil management practices than the educated counterpart. This was due to the fact that better educated households have a wide chance to be involved in other source of income. Hence, the effect of educational background of householdis not the hindrance to the involvement in the integrated soil management practices. The similar study conducted in Northern Ethiopia by Berhanu and Swinton (2003) identified that low level of educational background is not an important factors in influencing the use of integrated soil management practices. Another study carried out by Krishna *et al,* (2008) found different results: education of the household head was found to have a positive and significant influence on the application of soil management strategies.

Table 24: Relationship between educational status of household head and the implementation of integrated soil management practices

Variable		Soil management practices			Total		Correlation
		Indigenous methods of SMP	Modern methods of SMP	Integrating indigenous with modern			
		% of HHH	% of HHH	% of HHH	Count	%	
Educational status	Illiterate	33	21.1	21.5	23	21.1	
	Learned grade 1-6	50	47.4	63.3	62	59.6	
	Learned grade 7-12	17	26.3	15.2	18	17.3	-0.067
	Learned above 12	0	5.3	0	1	1.0	
Total		100	100	100	104	100	

'Cross tabulation and correlation'

Soil fertility and location of crop lands

The condition of soil fertilityon cultivated plots is an important factor that affects farmers' decision on the application of soil conservation practices. The level of soil fertility has a negative correlation with the degree of involvement in the integrated soil management practices (table 25). Farmers with infertile farm land are more involved (89.4%) in conservation work than those who have fertile land. This is due to the reason that farmers with infertile soils have an interest to improve the level of soil fertility and productivity of land by using varying soil management methods. The survey result is similar to findings of Eleni (2008) which stated that fertility status of soil is negatively and significantly correlated to continuous use of soil management practices.

The other interesting factor which determines the implementation of integrated soil management practices is the distance of farm land from the residence. The farm land distance was negatively and significantly correlated at 1% level of significance to the implementation of integrated soil management practices (table 25). As distance of farm land increases from the homesteads, the rate of application of integrated soil management practices decreases. This implies that distant farms are not well managed compared to farm lands close to the homesteads.

Table 25: Relationship between distance of farm land and soil fertility with integrated soil management practices

Variables		Soil management practices: Indigenous methods of SMP	Modern methods of SMP	Integrating indigenous with modern	Total		Correlation
		% of HHH	% of HHH	% of HHH	Count	%	
Location of farm plots	Near	66.7	94.7	97.5	99	95.2	-0.277**
	Far	33.3	5.3	2.5	5	4.8	
Total		100	100	100	104	100	
Fertility of Soil	Fertile	0	0	6.3	5	4.8	
	Medium	0	0	7.6	6	5.8	-0.192
	Low	100	100	86.1	93	89.4	
Total		100	100	100	104	100	

Source: Household survey, June 2012 'cross tabulation and correlation'
**. Correlation is significant at the 0.01 level (2-tailed)

4.3.5 Slope and severity of soil erosion

A positive relationship was observed between slope gradient and integrated management of soil. But the correlation was not statistically significant (table 26). The result showed that as the gradient of slope increases, farmer's participation in integrated soil management practices also increases. On the other hand, gradient of slope is positively and significantly related with indigenous soil management practices such as fallowing, contour ploughing and stone bund terraces at 5% significance level. A similar conclusion was found by Amsalu (2006) that stated effect of slope on construction of traditional Stone terraces was found to be positively correlated. But gradient of steep slope is negatively and significantly correlated with modern soil management practices such as *fanaya juu*, soil bunds and grass strips at 5% level of significance. This implies that most farmers in steep slope area are encouraged to apply indigenous soil management practices alone or integrating it with modern methods.

Table 26: Correlation of slope with indigenous and modern soil management practices.

Variables	Relation of Slope of land
Indigenous soil management	0.213*
Modern soil management practices	-0.195*
Integrated soil management practices	0.086

*.Correlation is significant at the 0.05 level (2-tailed).

There was a positive relationship between severity of soil erosion and implementation of integrated soil management practices. Although the correlation was not statistically significant, the result shows that the severity of the risk of soil erosion increases even if the soil management practices were implemented by households in the study area (table 27). This is due to length of implementation period of soil management practices, landholding size of farmers and types of agricultural practices experienced by households as well as un appropriate design and unfit of some introduced soil management practices to the biophysical and socioeconomic conditions of the environment.

Table 27: Relationship between severity of soil erosion and implementation of soil management practices

Variables		Soil management practices: Indigenous methods of SMP	Modern methods of SMP	Integrating indigenous with modern	Total		Correlation
		% of HHH	% of HHH	% of HHH	Count	%	
Severity of soil erosion	Severe	17	21	15	17	16.3	
	Moderate	66	21	29	31	29.8	0.10
	Minor risk	0	53	39	41	39.4	
	No risk	17	5	17	15	14.4	
Total		100	100	100	104	100	

Source: Household survey, June 2012 'Cross tabulation and correlation'

The result further showed that severity of soil erosion was negatively and significantly correlated with implementation times and agricultural practices like household subsistence agriculture (table 28). There was a negative and significant correlation between agricultural practices and severity of soil erosion at 1% level significance. Severity of soil erosion was also negatively correlated with land holding size and implementation time of integrated soil management practices at 5% significance level. Thus, unless improving agricultural practices and appropriate management measures are applied by small holder farmers, application of integrated soil management practices alone could not reduce the severity and risk of soil erosion.

Table 28: Correlation between severities of soil erosion with different variables

Variable	Correlation with Severity of soil erosion
Agricultural practices	-0.427**
Landholding size	-0.237*
Implementation times of SMP	-0.237*

**. Correlation is significant at the 0.01 level *. Correlation is significant at the 0.05 level

Economic factors in relation to integrated soil management practices

The major economic factors considered in this study are annual income and landholding size of household heads. Annual incomewas positively correlated with application of integrated soil management practices (table 29). Although the relationship was not statistically significant, correlation result clearly showed the influence of household capital on application of soil management practices. Positive correlation indicates that rich farmers are more involved in the maintenance and construction of soil conservation structures such as *Fanaya juu* and *Soil bunds* than farmers with low income. This is in line to the findings of Kessler (2006), which report that farmers with a higher income became interested to invest more in conservation measures than farmers from low income group.

Landholding size is the other important variable in relation to implementation of soil management practices. The effect of landholding size in the implementation of soil management practice was found to be negative relationship but it is not significant factor. Negative relationship showed that farmers who own large farm size are found to be less involved in the application of soil management practices. This is because of that those with large sized land need more time to manage enormous labor and capital. As shown in table 29 out of 19 household heads with holding size between 1.1–1.5 ha, about 68% of the household heads had participated in applying integrated soil management practices compared to 100% application to those with farm size less than 0.25ha. The finding is similar with that of Habtamu (2006) that was undertaken in Anna watershed, Hadiya Zone Ethiopia, who identified that farmers with large farm size were less likely to retain conservation structures. On the contrary, survey result by Eleni (2008) reported that farmers with larger farm size are more likely to invest in soil conservation measures.

Table 29: Relationship between economic factors and the implementation of integrated soil management practices

Variables		Soil management practices			Total		Correlation
		Indigenous methods of SMP	Modern methods of SMP	Integrating indigenous with modern			
		% of HHH	% of HHH	% of HHH	Count	%	
Annual income	< 3,000	33.3	0	12.7	12	11.5	
	3000 -6000	66.7	84.2	75.9	80	76.9	0.035
	> 6,000	0	15.8	11.4	12	11.5	
Total		100	100	100	104	100	
Landholding size	<0.25 ha	0	0	5.1	4	3.8	
	0.26-0.50 ha	16.7	15.8	22.8	22	21.2	
	0.6-1 ha	33.3	52.6	44.3	47	45.2	-0.086
	1.1-1.5 ha	33.3	21.1	16.5	19	18.3	
	1.6-2 ha	16.7	10.5	5.1	7	6.7	
	>2 ha	0	0	6.3	5	4.8	
Total		100	100	100	104	100	

Source: Household survey, June 2012 'Cross tabulation and correlation'

CONCLUSION AND RECOMMENDATION

The farming system in the catchment was characterized by small-scale subsistence mixed farming-system, with livestock production as an integral part. Crop production was mainly rain-feed. Almost all croplands are planted to annual food crops, including cereals pulses and cash crops. About 70% of households cultivate less than 1ha of land which indicates the serious scarcity of land. The average farm size has been declining because of increasing population density. Moreover, the productivity of cropland has declined over time due to over cultivation, drought and soil erosion.

Farmers of the study area were very well aware of the soil erosion problem. Majority of farmers acknowledged the problem of soil erosion in their farm plots. On the other hand, severity of soil erosion in the farm field was described as moderate to severe risk to the agricultural production. The perceived main causes of soil erosion in the study area were deforestation, cultivation of steep slopes and over cultivation.

Before the introduction of modern soil management practices, most farmers in the area were practicing indigenous methods of soil conservation. Almost all farmers implemented indigenous soil management practices on their farm field in the study area. The major types of indigenous soil management practices applied by households in the study area are plantations, contour farming, and traditional cut- of -drains, Crop rotation, traditional ditches and fallowing.

Fallowing is not frequently used indigenous soil management practices in the study area due to over population and shortage of cultivated lands. Indigenous practices of soil management play a great role for conserving soil if they were used in combing with modern methods of soil management practices. It was also observed that almost all farmers applied both traditional and modern soil management practices on the same fields simultaneously which refers to integrated soil management practices.

The majority of farmers (60%) perceived that all soil management measures increased crop yield, rehabilitate degraded lands, brought livelihood change, prevent soil erosion, increase soil fertility and improve soil-water retention capacity of the soils in the catchment. Integrated soil management practices were positively influenced by age, family size, gender of household heads, annual income, severity of soil erosion, and slope. While integrated soil management practices were negatively influenced by educational status, landholding size, cultivation land distance and fertility of Soil.

The severity of the risk of soil erosion increases even if the soil management practices were implemented by households in the study area. To minimize such problem, the concerned implementing organs should be recommended to maintain appropriate design and assess the fitness of introduced soil management practices to the biophysical and socioeconomic realities of the environment before implementation. And they have to make the farmers to stay their land with appropriate soil managing measures longer period and provide technical supports for construction of the structures.

Most of modern soil management structures were more likely to be implemented on infertile and moderately sloping farm lands. But a number of steeply sloping degraded farm and grazing lands as well as degraded communal lands and some fertile farm lands were not well conserved by using soil management practices which need further active conservation and rehabilitation program. Therefore, the Woreda and Zonal agricultural office experts, farmers and other concerned NGOs should were recommended to apply soil management measures in all types of degraded lands and fertile lands uniformly for reducing soil degradation and advancing land productivity.

The prevalence of drought due to shortage of rainfall and an increase of temperature in recent decades result with decline of production and loss of formerly available root crops like sweat potato, yam and Ensat. Therefore, the impact of climatic variability on crop production and loss of crop species should be assessed by researchers for the future is recommended in the study area.

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