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Assessment of Soil Fertility Management Practices Employed by Farmers in Selected Villages of Jimma Zone, South Western Ethiopia

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Abstract
Soil fertility is one of the most important constraints of crop production in Ethiopia. There is a need to understand soil fertility management practices of farmers and the influence of socioeconomic factors on soil fertility management decisions. The study was conducted during 2014/2015 growing season. This study was conducted to document soil fertility management practices employed by farmers in Gera, Omo Nada and LimuSeka districts of Jimma zone, south western Ethiopia. Data was collected through questionnaire survey, focus group discussion and key informants at village level. Farmers' main strategies to maintain soil fertility include application of kosii (household refuse or waste) along with farm yard manure, mineral fertilizer applications and different agronomic practices. The rate of mineral fertilizer applied varied across households. The mean fertilizer application to maize is 88.2 kg DAP and 86.5kg urea per hectare in Gera, 91.1 kg DAP and 90.7 kg urea per hectare in Omo Nada, and 108 kg DAP and 105.7 kg urea per hectare in Limu Seka. Whereas, the mean fertilizer application to tef is 72.4 kg DAP and 17.4 kg urea per hectare in Gera, 70.5 kg of DAP and 13 in Omo Nada, and 75kg DAP and 13.4 urea per hectare in Limu Seka. The application rate to maize is roughly close to the nationally issued blanket recommendation rate of 100 kg DAP and 100 kg urea per hectare whereas to tef is far below it.
Keywords: Nutrient depletion, soil erosion, crop rotation, mineral fertilizers, soil fertility management practices

1. INTRODUCTION

Agriculture is the backbone of the Ethiopian economy and special attention is given by the government to spearhead the economic transformation of the country. The sector is the main economic pillar of the country's economy, and the overall economic growth is highly dependent on the success of the agriculture sector. It represents 42% of the GDP and 85% of the population gains their livelihood directly or indirectly from agriculture (CSA, 2015). About 64% of agricultural value addition comes from crops (Global Forum on Agriculture, 2010).

Soil is the most important resource required for agricultural production (Khanif, 2010). The most important constraint limiting crop yield in developing nations, and especially among resource-poor farmers, is declining soil fertility (Khosro and Yousef, 2012). Soil fertility is declining in many parts of Sub-Saharan Africa (Stoorvogel *et al*., 1993). Soil fertility is declining throughout the country primarily due to reduction in the length of fallow periods, lower levels of fertilizer application, complete removal of crop residues from fields, use of dung as a household fuel, and lack of adequate soil conservation practices (Eyasu, 2002). As a result, there is a growing concern that fertility depletion will seriously limit food security and sustainable agricultural production in Ethiopia (Shiferaw and Holden 2000; Bewket and Sterk, 2002).

Soil erosion still remains the major challenge that is adversely affecting the agricultural performance of the country; hence, the call for improved land management practices (Woldeamlak, 2003). In terms of soil nutrients and fertility, Ethiopia is one of the countries that experiences highest rates of nutrient depletion in Sub Sahara Africa (Stoorvogel *et al.*, 1993 and PIF, 2010). UNDP (2002a) reported loss of 30kg N /ha and 15-20 kg P /ha annually. A field level investigation in southern Ethiopia found even higher rate of nutrient depletion amounting -102 N and -26 kg K particularly in the distant out fields planted to cereals (Eyasu, 2000). In Jimm Zone, decreasing agricultural productivity per unit area due to soil fertility depletion is becoming a challenge for small holder farmers (Abebayehu *et al.*, 2011).

Several studies have been undertaken to assess local knowledge about soils. Research in this area has predominantly focused on documenting how farmers classify their soils (Talawar and Rhoades, 1997). Ethiopia is a large country with a wide diversity of socio-economic and agro-climatic conditions and farming systems. The reliable generalized analysis of soil fertility decline, soil fertility management practices and its picture at local level need to be identified (Eyasu, 1998).

The participation of local communities in decision making on soil fertility management is not well developed, rather decisions made at higher level have been implemented at grass root level. As a result, this top-down extension intervention approach has not been well absorbed by the farmers. Since farmers are the ultimate decision-makers and managers of their soils, understanding of farmers view and their soil fertility management practices is indispensable for exploring opportunities of improvement. Farmers' perceptions and their reaction as well as factors influencing investments in soil fertility management vary from place to place and from household to household due to variations in socio-cultural, economic and biophysical conditions (Payton *et al*., 2003; Amsalu and de Graaff, 2007).

In order to achieve food security in the country, it is time to shift research towards an approach based on soil fertility management that combines various existing soil fertility management practices that considers local realties. In order to design and implement efficient soil fertility management practices, assessment of existing soil fertility management practices is necessary. Against this background, the current study was carried out with the following objectives;

- To identify how farmers in different settings manage their soil comparing strategies employed by rich vis-à-vis medium and poor farmers, model *vis-a-vis* non-model
- To examine how wealth endowment and extension status at household level dictate farmers' decisions on soil fertility management.
- To identify areas for improvement in farmers' soil fertility management strategies that cause nutrient depletion and need to be rectified through research and extension intervention.

2. METHODS OF THE STUDY

2.1. Description of the Study Area

The study was carried out in Gera, Omo Nada and Limu Seka districts in Jimma zone of Oromia regional state, south western Ethiopia in the 2014/15 crop season. The study covered two Villages per district and 232 households. These were Ganji Chala and Wanja Kersa of Gera district, Doyo Yaya and Nada Bidaru of Omo Nada district, and Seka and Dora of Limu Seka district. The districts and the villages were purposively selected following the intervention sites of CASCAPE project under Jimma University. Figure 1 presents the location map of the districts within the Jimma zone. Gera district is bordered by Goma and Ginbo districts to the south, by the Sigmo district to the west, and Gumay district to the north (CASCAPE*,* 2014). Geographically, it is located 7^{0}40'N 36^{0} 15'E latitude and longitudes (Wikipedia, 2014). According to Gera district agriculture development office, the district covers an area of approximately 112,212 ha.

Limu Seka district is bordered by Yaanfa district to the west, Limu Genet to the north, Noono Benja district to the south and Choora Botori district to the east (CASCAPE*,* 2014). Geographically, it is located 8^{0}20'N 37^{0} 00'E latitude and longitudes (Wikipedia, 2014). Omo Nada is bordered by Gojeb River to the south which separates it from the Southern Nations, Nationalities and Peoples Region (SNNPR), by Dedo to the west, by Kersa to the northwest, by Tiro Afeta to the north, by Sokoru to the north, and by the Omo river to the east which separates it from the SNNPR. Geographically, it is located 30'N 37^{0} 15' latitude and longitudes. According to the district agricultural office, Omo Nada covers an area of 165,602.66 ha.

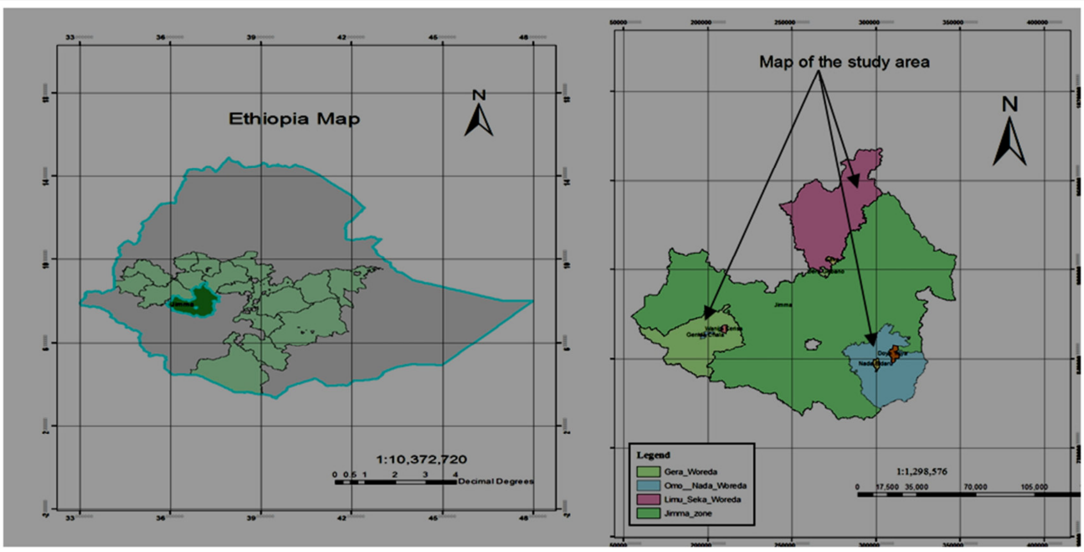

Figure 1.Location Map of the study area

3.1. Agro-ecology and Farming Systems of the Study Area

Most parts of Gera district fall within wet *dega* whereas most parts of Omo Nada and Limu Seka is wet *woyna* *dega*. The agro-ecology and some basic information of the study area is summarised in the (Table 1). The total area under coffee of the district is 80,830 ha and of this 2014 ha is forest coffee, while 21,733 ha are under other crops. In this district, livestock is a source of income, essential for crop production, and for food consumption (CASCAPE, 2014). Of the total land coverage of Omo Nada district about 48,984 hectares are currently covered by forest and grazing land, while 94,725 ha are used for crop production. About 19, 375 ha are swampy, degraded or otherwise unusable. The remaining 2518 ha is covered by homestead agroforestry, construction and others.

Table 1. Basic data and basic information of the study area

Back ground information	Gera	Omo Nada	Limu Seka
Agro ecology (%)			
-SM2	50.2	23	13
-H2	46.1	62	55
-SA1	3.7	15	32
Mean annual RF (mm)	1414-2256	1280 - 2584	800 - 1822
Mean annual temperature (C^o)	10.3-27	25-33	11.9-31.9
Altitude (masl)	1500 – 3200	880-3344	1400 – 2200
Population	132,238	248,173	189,463
Major crops grown			
-food crops	Maize, sorghum and *tef*	Maize, *tef,* sorghum, wheat and barley	Maize, sorghum and *tef*
-income generating crops	Coffee and *chat*	Pepper, maize and *chat*	Coffee, maize and sorghum

Source CASCAPE (2014); MOA, (2011) and computed data, (2015).

Where, SM2 = is tepid to cool sub moist mid highlands, H2 = tepid to cool humid mid highlands and SA1= hot to warm sub moist lowlands.

Limu Seka's potential for agriculture is estimated to be around 42,704 ha of land. In terms of cereal crops, sorghum covers 21,538 ha and maize covers 1,266 ha. About 10, 241 ha are currently covered by forest and bush, the rest land is covered by coffee, homestead agroforestry and other land use types.

2.2. Source of Data and Data Collection Method

Household survey, focus group discussions (FGD), key informant interviews, personal observation and semi-structured questionnaire (both open and closed ended) were the tools used to collect primary data. Secondary data were collected from the villages; districts agricultural development office and CASCAPE project working papers. The FGD were composed of 10-12 members at each village representing wealth, extension status and sex groups. The FGD covered perception of soil fertility and soil fertility status, soil fertility management practices and factors influencing the practices.

In order to explore how soil fertility management practices varied across different socioeconomic groups of farmers, a stratified random proportional sampling method was followed. Following this the total farmers of the study area were categorized as male and female, extension status (model and non-model), and wealth group (rich, medium and poor). Participatory wealth ranking using local criteria set by the community (Grandin, 1988) was followed to group the farmers in wealth group. In order to undertake the stratification effectively the list of all households (land holders) was obtained from each of the villages' administrative office and male and female households were identified. The total households of the study area were 4, 025, of this 3764 (93.52%) of them were male and the rest 261 (6.48%) were females.

The key informants who composed from 8-12 members are selected by the local elders and local leaders based on the assumption that they can categorize the farmers by wealth and extension status. The key informants set criteria of wealth group by using local wealth indicators to differentiate the households into rich, medium and poor wealth groups. Type of house, farm land, livestock, coffee farm and beehives were the indicators of wealth status.

The key informants who claim to know every household were grouped the farmers according to their wealth category following the above criteria. In response to this 676 (16.80%) of them were rich, 1926 (47.85%) and 1423 (35.35%) of them were medium and poor, respectively. Based on adoption of agricultural technologies, the extension status of the farmers was already categorized by the villages office of agriculture. According to this 1057 (26.26%) of them were models and the rest 2968 (73.74%) were non-models.

The questionnaire was focused mainly on the socio-economic aspects, physical and agronomic practices of soil fertility management practices employed by the sample households. The socio-economic aspect includes household wealth status, extension status, ownership of livestock, number of economically active family members, and area of cultivated land per household which are crucial on farmers' soil fertility management decisions. The physical and agronomic aspects essentially were focused on the current soil fertility management practices employed by the farmers of different social groups. These include the use of mineral fertilizers, farmyard manure, compost, crop residue management, crop rotation, physical and biological soil and water conservation measures and soil amendments. Preliminary test of the questionnaire was undertaken to check its validity and necessary corrections were taken place.

2.3. Sample Size

The sample size was determined by applying probability proportional formula (Cochran, 1977).

Sample size, $n_o = Z^2pq/e^2 = (1.96)^2(0.2)(0.8)/(0.05)^2 = 246$

$$n = \frac{n_o}{1+\frac{n_o-1}{N}} = \frac{246}{1+\frac{246-1}{4025}} = 232$$

Where;

n_o = desired sample size Cochran's (1977) when population greater than 10,000

n = finite population correction factors Cochran's (1977) formula less than 10,000

Z = standard normal deviation (1.96 for 95% confidence level)

P = 0.2 (proportion of population to be included in sample *i.e*., 20%)

q = is 1-P *i.e*., (0.8)

N = is total number of population

e = is degree of accuracy desired (0.05)

Based on Cochran (1977) population correction factors, 232 households were drawn from the stratum. The proportionate formula was used to draw sample sizes from the villages and from the stratum by applying (A/B) ×C and (A'/B') ×C' formula respectively (Hunt *et al*., 2001).

Where,

A = Total households in a given village

B = Total households of the study area (*i.e.,* 4025)

C = Total determined sample households (232) at village level

and

A' = Determined sample size in a given village

B' = Total households in that village

C' = Total number of households in that strata

Accordingly, 63 of them were drawn from Gera (Ganja Chala = 25and Wanja Kersa= 38), 95 from Omo Nada (Nada Bidaru = 35 and DoyoYaya = 60) and 74 from Limu Seka (Seka = 32 and Dora = 42).

2.4. Socioeconomic Profile and Strata of the Respondents

Out of the total respondents, 218 (93.97%) of them were male headed households and the remaining 14 (6.03%) were female headed households. Among the respondents, 111 (47.85%) of them were medium, and the rest 82 (35.35%) and 39 (16.81%) of them were poor and rich respectively. Concerning the extension status of the farmers 171 (73.71%) and 61 (26.29%) of them were non-model and model households respectively. Sample size drawn from the villages and the strata are illustrated in (Table 2).

Out of 63 respondents from Gera district 60 (95.24%) of them were male and the remaining 3 (4.76%) of them were female. In terms of their wealth group, about 10 (15.87%) of them were rich, 27 (42.86%) and 26 (41.27%) of them were medium and poor, respectively. Among the respondents of this district 18 (28.57%) of them were model and 45 (71.43%) of them were non-model farmers. Of the 95 respondents of Omo Nada district 90 (94.44 %) of them were male and 5 (5.56 %) of them were female headed households. Of the total respondents of this district 11 (11.58 %) of them were rich, 51(53.68 %) of them were medium and 33 (34.74 %) of them were poor. In terms of their extension status, 20 (21.05 %) of them were model and 75 (78.95 %) of them were non-model farmers.

Table 2. Summary strata of the sampled households

District	Villages	Number of sampled households in the all strata									
		Sex			Wealth status				Extension status		
		M	F	Tot	R	Med	P	Tot	Mod	NM	Tot
Gere	GCh	24	1	25	6	10	9	25	9	16	25
	WK	36	2	38	4	17	17	38	9	29	38
Omo Nada	NB	33	2	35	5	14	16	35	7	28	35
	DY	57	3	60	6	37	17	60	13	47	60
Limu Seka	Seka	30	2	32	6	16	10	32	9	23	32
	Dora	38	4	42	12	17	13	42	14	28	42
Total		218	14	232	39	111	82	232	61	171	232

Where, GCh = Ganji Chala, WK = Wanja Kersa, NB = Nada Bidaru, DY = Doyo Yaya, M = male, F = female, R = rich, Med = medium, P = poor, Mod = model and NM = non-model and Tot = total.

Out of the 74 respondents from Limu Seka District 68 (91.89 %) of them were male and 6 (8.11) of them were female headed households. With regard to the wealth group, 18 (24.32 %) of them were rich, 33 (44.59 %) and 23 (31.08 %) of them were medium and poor, respectively. Among the respondents of this district 23 (31.08 %) of them were models and the rest 51(69.92 %) were non-model farmers.

2.5. Statistical Analysis

The data were subjected to SPSS version 20 and descriptive statistics, mean and frequency were used to present the out puts of the analysis. Chi square test was used to determine the significance differences among wealth groups and extension status of the soil fertility management practices. Gap analysis for the amount of mineral fertilizers was performed by subtracting the blanket recommendation (100 kg/ha DAP plus 100 kg/ha urea) from the amount of fertilizer applied by the farmers.

3. RESULTS AND DISCUSSIONS

3.1. Demographic characteristics of the households

The mean age of the respondents of Gera was 48.3, whereas that of Omo Nada and Limu Seka was 46.5 and 45.5 years respectively. Comparatively Gera district respondents' average age was the greatest whereas that of Limu Seka was the least.

Table 3. Demographic characteristics of households by wealth group and district

District	Wealth status	Age of HH head	Family Size	
			Total	Adults
Gera	Rich (N = 10)	43.4	7.3	3.2
	Medium (N = 27)	48.6	6.8	2.0
	Poor (N = 26)	46.9	5.6	1.5
	Mean	48.3	6.4	2.0
Omo Nada	Rich (N = 11)	41.2	7.7	3.0
	Medium (N = 51)	48.4	6.9	1.9
	Poor (N = 33)	47.2	5.8	1.4
	Mean	46.5	6.6	1.8
Limu Seka	Rich (N = 18)	42.2	7.4	2.9
	Medium (N = 33)	49.6	6.0	1.5
	Poor (N = 23)	47.1	6.5	1.6
	Mean	45.5	6.2	1.9

Where, N= number of respondents, HH=household

The average age of Gera's rich, medium and poor respondents was 43.4, 48.6, and 46.9 years, respectively whereas that of Omo Nada respondents was 41.2, 48.4 and 47.2 years, respectively. The mean age of rich, medium and poor respondents was 42.2, 49.6 and 47.1 years, respectively. The mean family size of Gera, Omo Nada and Limu Seka district was 6.4, 6.6 and 6.2 respectively. As shown in (Table 3), except in Limu Seka's medium and poor wealth group, the total average family members and adult family members increased as wealth status of the respondents increased. This could be due to the fact that in the study area better wealth group had large family size and in most cases, rich wealth group has more than one wife.

3.2. Land holding and livestock ownership

In all of the study districts farm land and total livestock units (TLU) are increased as the wealth group rise up from poor to rich, since they are indicators of wealth status of the respondents (Table 4). The mean farm land of Gera, Omo Nada and Limu Seka districts respondents was 0.935 ha, 1 ha and 0.835 ha.

Table 4.Farm land, livestock ownership – disaggregated by districts and wealth groups

Districts	Wealth status	Farm land size (ha)	TLU	Cattle (#)	Oxen (#)	Equine (#)	Small ruminants (#)
Gera	Rich (N = 10)	2.367	6.8	6.8	2.3	0.5	1.4
	Medium (N = 27)	0.760	5.0	4.6	1.6	0.1	1.5
	Poor (N = 26)	0.570	1.5	1.0	0.0	0	0.5
	Mean	0.935	3.8	3.4	1.4	0.1	1.1
Omo Nada	Rich (N = 11)	3.031	10.0	7.2	3.3	1.6	3.2
	Medium (N = 51)	0.840	4.7	2.9	1.7	0.5	1.8
	Poor (N = 33)	0.513	2.1	1.0	0.8	0	1.3
	Mean	1.00	4.4	2.7	1.6	0.5	1.8
Limu Seka	Rich (N = 18)	1.626	5.5	4.2	2.1	1.1	1.1
	Medium (N = 33)	0.721	4.0	3.0	1.4	0.5	1.2
	Poor (N = 23)	0.379	2.0	1.0	0.7	0	1.1
	Mean	0.835	3.7	2.5	1.2	0.5	1.1

Where, N = number of respondents, TLU = Tropical Livestock Unit

There are little differences in the mean farm land among the districts but, great differences among wealth group of the districts and among rich respondents of the districts. On average TLU of the respondents of Gera, Omo Nada and Limu Seka districts was 3.8, 4.4 and 3.7 respectively. Averagely the respondents of Gera, Omo Nada and Limu Seka owned 3.4, 2.7 and 2.5 cattle excluding oxen respectively. The mean oxen for plough of the respondents of Gera, Omo Nada and Limu Seka districts were 1.4, 1.6 and 1.2, respectively.

3.3. Farmers Perception of Soil Fertility Decline

Low crop yield, stunted growth and color changes of crops, changes in soil color and soil thickness, shift in weed biomass and weed species were the most important indicators of soil fertility status in the study area. According to focal group discussions, farmers of the study area were perceived fertile soil as good crop yielding, *sondi* (black colored), *furda* (good thickness) and good for working. If grasses such as *chookorsa (Cynodon dactylon), mujjaa (Snowdina polysatarch), asangra (Datura stramonium)* are grown up on the land the soil is fertile. Yellowed and stunted growth of crops, red soil color, reduced soil thickness, growing of plants such as *Hiddi adii (Solanumsp) and Qorxobbii (Plantagolanceolata. L,)* on the land are indicators of infertile soil. The present study is in agreement with Eyasu (2002); Taye and Yifru (2010) and Abush *et a*l. (2011).

3.4. Soil Fertility Management Practices

Soil fertility is the most important asset worldwide and especially in developing countries like Ethiopia where most of the nation economy is dependent on agriculture. Many farm crops and their residues are removed from the land and the supply of essential elements becomes depleted. Under continuous cultivation soils are losing organic matter and mineral nutrients faster than they can be replaced. Regular loss of nutrients from the soil results in the loss of soil fertility. So, for the maintenance of soil fertility, replacement of the organic matter and mineral nutrients removed from the soils is necessary. The farmers of the study area have been maintaining fertility of their soils by applying organic manures, mineral fertilizers and other agronomic practices. Only very few respondents applied compost; whereas none of the respondents applied lime for soil amendments.

3.4.1. Application of Organic Manures

Application of *kosii*, farm yard manure and inorganic fertilizers are the major practices of soil fertility management in the study area. Due to its immediate effects on crop production, inorganic fertilizers are a good option for improving soil fertility.

Kosii- is a practice of spreading households' wastes to the field located around home to maintain soil fertility. '*Kosii",* which literally means waste, consists all kinds of human and livestock residues/leftovers in and around the residence and applied (thrown) over the land almost on daily basis (Tekilu and Gezehagn, 2003).

Farm yard manure (FYM) - application of manure is another important means of soil fertility management. Some of the farmers constructed house for their animals and the animals stay in the house during night time. The manure of the cattle cleaned from the house and spread over the land. While others construct fence near their home for keeping their cattle during night and morning time, so that manures accumulated will be spread over the land to maintain fertility of the soil. Unlike other areas, kraaling (keeping cattle at night in the barn and rotating the position of the barn regularly in order to uniformly distribute manure to crop fields) is not a common practice in the study area except in Wanja Kersa village in which some respondents practiced it.

"Kosii" is the common practice and almost all of the respondents of the study area applied to their farm land. As shown in (Table 5) most of the respondents in the entire districts, wealth group and extension status applied *kosii,* farm yard manure (FYM) and mineral fertilizers (MF).

Table 5. Soil fertility management practices employed by the respondents

District	WS/ES	Apply *Kosii* and FYM		Apply *Kosii,* FYM and MF		Apply *Kosii,* FYM, MF and C		χ^2 value	P-value
		N	%	N	%	N	%		
Gera	Rich	-	-	10	100%	-	-		
	Medium	1	3.7	24	88.9	2	7.4		
	Poor	6	23.1	19	73.1	1	3.8	7.122^{ns}	0.121
	Model	-	-	16	88.9	2	11.1		
	NM	7	15.6	37	82.2	1	2.2	4.279^{ns}	0.117
Omo Nada	Rich	-	-	10	90.9	1	9.1		
	Medium	1	2.0	50	98.0	-	-		
	Poor	3	9.1	30	90.9	-	-	20.429***	0.001
	Model	-	-	20	100	-	-		
	NM	4	5.3	70	93.3	1	1.3	2.980^{ns}	0.366
Limu Seka	Rich	-	-	18	100	-	-		
	Medium	-	-	32	97	1	3		
	Poor	1	4.3	22	95.7	-	-	17.238***	0.000
	Model	-	-	23	100	-	-		
	NM	1	2	49	96.1	1	2	4.645*	0.064

Where, WS = wealth status, ES = extension status, N = number of respondents, FYM = farm yard manure, MF = mineral fertilizer, C = compost, ns = non-significance *** and * represent level of significant at 1% and 10%.

Almost all of the rich respondents, about 24 (88.9%) of the medium and 19 (73.1%) of poor respondents of Gera applied *kosii,* FYM and MF and the Pearson chi-square test revealed that there was no statically significance difference among wealth group and extension status. Similarly, about 10 (90.9%) of the rich, 50 (98%) of the medium and 30 (90.9%) of the poor respondents of Omo Nada applied *kosii*, FYM and MF and statically there was significant difference among wealth group of the district ($\chi^2 = 20.429$, df = 4, P = 0.001).

In Limu Seka district almost all of the rich respondents, about 32 (97%) of medium and 22 (95.7%) of the poor respondents applied *kosii*, FYM and MF and statically there was significant difference among wealth group ($\chi^2 = 17.238$, df = 4, P < 0.001). None of the rich respondents of the study area and a single medium respondent of Gera and Omo Nada applied only *kosii* and FYM. Whereas about 6 (23.1%) of poor wealth group of Gera, 3 (9.1%) of Omo Nada and a single respondent of Limu Seka applied only *kosii* and FYM. Compost (C) application is not common practice in the study area.

In Gera district about 2 (7.4%) of medium and 1 (3.8%) of the poor wealth group applied *kosii*, FYM, MF and Compost (C). In the case of their extension status, most of the model respondents of the study area applied *kosii*, FYM and MF. More specifically about 16 (88.9%) model respondents of Gera, all model respondents of Omo Nada and Limu Seka applied *kosii*, FYM and MF. Likewise, most of the non-model respondents of the districts applied *kosii*, FYM and MF. About 7 (15.6%) of non-model respondents of Gera, 4 (5.3%) of Omo Nada and 1 (2%) of LimuSeka applied only *kosii* and FYM. Statistically there was a significant difference among model and non-model respondents only in LimuSeka ($\chi^2 = 4.645$, df = 2, P = 0.064).

Application rate of FYM- most of the respondents applied FYM to their farm land but the application is limited mainly to home-garden and parcel of land around their home used either for the production of vegetables or local maize variety. Averagely the respondents of Gera, Omo Nada and Limu Seka applied 690.1, 798.8, and 670.2 *gundo (sefed)*/ha of fresh FYM respectively. One *gundo/sefed* is estimated to be 4 kg.

Table 6.Amount of FYM applied across the study districts

District	WS/ES	Do you apply FYM				Rate of application (*Gundo*/ha)
		Yes		No		
		N	%	N	%	
Gera	Rich (N=10)	10	100	-	-	1275.6
	Medium (N=27)	27	100	-	-	908.2
	Poor (N=26)	26	100	-	-	260.8
	Model (N=18)	18	100	-	-	1315.5
	Non-model (N=45)	45	100	-		713.3
	Mean	63	100	-	-	690.1
Omo Nada	Rich (N=11)	11	100	-	-	1825
	Medium (N=51)	51	100	-	-	857.8
	Poor (N=33)	32	97.0	1	3.0	360.7
	Model (N=20)	20	100	-	-	1894.3
	Non-model (N=75)	75	100	-	-	885.5
	Mean	94	98.9	1	1.1	798.8
Limu Seka	Rich (N=18)	18	100	-	-	821.4
	Medium (N=33)	33	100	-	-	730
	Poor (N=23)	23	100	-	-	368
	Model (N=23)	23	100	-	-	904.8
	Non-model (N=51)	51	100	-	-	702.3
	Mean	74	100	-	-	670.2

Where, WS = wealth status, ES = extension status, N = number of respondents, SD = standard deviation

On average Gera's rich, medium and poor respondents apply 1275.6, 908.2, and 260.8 *gundo*/ha of fresh FYM respectively. In average model respondents of the district applied 1315.5*gundo*/ha whereas the non-model applied 713.25*gundo*/ha Omo Nada's rich, medium and poor respondents applied 1825, 857.8, 360.7 *gundo*/ha of fresh FYM respectively. Model respondents of Gera district applied 1894.3 *gundo*/ha while non-model of the district applied 885.5*gundo*/ha. Limu Seka's rich, medium and poor respondents applied 821.4, 730, and 368 *gundo*/ha of fresh FYM respectively. Model and non-model of this district applied 904.8 and 702.3 *gundo*/ha.

As indicated in the table (6) the amount of FYM applied per hectare is increased as the wealth status of the respondents gets better in the entire district. Similarly, model farmers are applied more than non-model respondents. This is due to the fact that number of livestock was one of the criteria to indicate wealth status of the farmers that can determine the amount of manure that can be obtained from the animals. Among wealth groups of the districts, great differences in the amount of FYM applied per hectare were observed.

3.4.2.Application of mineral fertilizers

Most of the farmers applied mineral fertilizers only to maize improved variety and *tef* but, the farmers also cultivate maize local variety. If the amount of total applied fertilizes is divided by total cultivated land the average amount of applied fertilizers/ha would be very small. Even though some of the farmers started to use NPS fertilizer, DAP and Urea were the common fertilizers used for production. The farmers applied band application form to maize and broadcast application form to *tef*.

On average rich respondents of Gera applied 105.3 kg/ha of DAP and105.3 kg/ha of urea to maize whereas, 88.3 kg/ha of DAP and 25 kg/ha of urea to *tef*. The medium respondents of this district applied 100.7 kg/ha of DAP and 97.3 kg/ha of urea to maize, and 86 kg/ha of DAP and 26.2 kg/ha urea *to tef* (Table 7). The poor wealth group applied 72.1 kg/ha of DAP and 64.4 kg/ha of urea to maize and, 52.1 kg/ha of DAP and 5.2 kg/ha of urea to *tef*. In the case of their extension status the model respondents of the district applied 110.3 kg/ha of DAP plus 110.3 kg/ha of urea to maize, and 100 kg/ha of DAP plus 25 kg/ha of urea to *tef*. Whereas the non-model applied 79.3 kg/ha of DAP plus 77 kg/ha of urea to maize, and 65 kg/ha of DAP plus 14.4 kg/ha urea to *tef*.

Table 7. Application of mineral fertilizers by wealth group and extension status

District	Wealth/Extension status	Do you apply mineral fertilizer				Rate of application (kg/ha)			
		Yes		No		Maize		*Tef*	
		N	%	N	%	DAP	Urea	DAP	Urea
Gera	Rich (N=10)	10	100	-	-	105.3	105.3	88.3	25.0
	Medium (N=27)	26	96.3	1	3.7	100.7	97.3	86.0	26.2
	Poor (N=26)	20	76.9	6	23.1	72.1	64.4	52.1	5.2
	Model (N=18)	18	100	-	-	110.3	110.3	100	25.0
	Non-model (N=45)	38	84.4	7	15.6	79.3	77.0	65.0	14.4
	Mean	56	88.9	7	11.1	88.2	86.5	72.4	17.4
Omo Nada	Rich (N=11)	11	100	-	-	111.5	102.4	89.4	27.3
	Medium (N=51)	50	98	1	2	93.4	92.2	72.2	16.5
	Poor (N=33)	30	90.9	3	9.1	85.6	79.5	61.7	3.0
	Model (N=20)	20	100	-	-	113.8	113.8	85.4	25.0
	Non-model (N=75)	71	94.7	4	5.3	85.7	84.5	66.5	10.0
	Mean	91	95.8	4	4.2	91.1	90.7	70.5	13.0
Limu Seka	Rich (N=18)	18	100	-	-	127.3	127.3	91.1	19.4
	Medium (N=33)	33	100	-	-	109.3	104.3	79.4	15.6
	Poor (N=23)	22	95.7	1	4.3	90.8	89.7	60.0	5.5
	Model (N=23)	23	100	-	-	126.6	125.0	87.6	17.4
	Non-model (N=51)	50	98	1	2	100.0	96.5	69.2	11.5
	Mean	73	98.6	1	1.4	108.0	105.4	75.0	13.4

Where N = number of respondents, SD = standard deviation

The mean fertilizer application of the district's respondents to maize was 88.2 kg/ha of DAP and 86.5 kg/ha of urea with standard deviation of 45.5 and 40.5 kg/ha for DAP and urea respectively. Whereas the mean to *tef* was 72.4 kg/ha of DAP and 17.4 kg/ha of urea with the standard deviation of 39.8 and 32 kg/ha of DAP and urea respectively. There were variations in the amount of fertilizers applied to the major crops among the respondents.

The rich respondents of Omo Nada applied 111.5 kg/ha of DAP and 102.4 kg/ha of urea to maize crop. The amount of fertilizers applied to *tef* by this wealth group was 89.4 kg/ha of DAP and 27.3 kg/ha of urea. Whereas the medium respondents of this district applied 93.4 kg/ha of DAP and 92.2 kg/ha of urea to maize, and 72.2 kg/ha of DAP and 16.5 kg/ha of urea to *tef*. Poor respondents of the district applied 85.6 kg/ha of DAP and 79.5 kg/ha of urea to maize, and 61.7 and 3 kg/ha of DAP and urea respectively. Model respondents of Omo Nada applied 113.8 kg/ha of DAP plus 113.8 kg/ha urea maize, and 85.4 kg/ha DAP plus 25 kg/ha urea to *tef*.

The non-model respondents applied 85.7 kg/ha DAP plus 84.5 kg/ha urea to maize, and 66.5 kg/ha DAP and 10 kg/ha urea to *tef*. The mean fertilizer application of the district's respondents to maize was 91.1 kg/ha of DAP and 90.7 kg/ha of urea with standard deviation of 35 and 35.6 kg/ha for DAP and urea respectively. Whereas the mean to *tef* was 70.5 kg/ha of DAP and 13 kg/ha of urea with the standard deviation of 35.4 kg/ha and 29.5 kg/ha of DAP and urea respectively (Table 14). As the SD indicates there is a great variation in the amount of fertilizers used among the respondents.

The mean fertilizers application of Limu Seka's rich respondents was 127.3 kg/ha of DAP and 127.3 kg/ha of urea to maize, and 91.1 kg/ha of DAP and 19.4 kg/ha of urea to *tef*. Whereas the medium respondents of this district applied 109.3 kg/ha of DAP and 104.3 kg/ha of urea to maize while 79.4 kg/ha of DAP and 15.6 kg/ha of urea to *tef* respectively. The poor wealth group of the district applied 90.8 kg/ha of DAP and 89.7 kg/ha of urea to maize crop, and 60 kg/ha of DAP and 5.5 kg/ha of urea to *tef* respectively. Model respondents of this district applied 126.6 kg/ha DAP plus 125 kg/ha urea to maize, and 87.6 kg/ha DAP plus 17.4 kg/ha urea to *tef*. Non-model respondents of Limu Seka applied 100 kg/ha of DAP plus 96.5 kg/ha urea to maize, and 69.2 kg/ha DAP and 11.5 kg/ha urea to *tef*.

The mean fertilizer application of the respondents of this district to maize was 108 kg/ha of DAP and 105.4 kg/ha of urea with standard deviation of 26.6 and 29.1 kg/ha for DAP and urea respectively. Whereas the mean fertilizer applied to *tef*was 75 kg/ha of DAP and 13.4 kg/ha of urea with the standard deviation of 30.7 kg/ha and 30.4 kg/ha of DAP and urea respectively.

Gap analysis of mineral fertilizers - the amount of DAP and urea fertilizers applied to maize by rich respondents of Omo Nada is greater than the blanket recommendation; i.e. 100kg/ha urea plus 100kg/ha DAP (Mulat *et al.,* 1998) by 5.3%. Similarity the amount of DAP and urea applied to maize by the medium respondents is better than the blanket recommendation by 0.7 and 2.75 respectively. The application rate was also better for model respondents by 10.3%. Whereas the amount of fertilizers applied to maize by poor and non-model respondents was negative (Table 8). The mean fertilizer applied to maize crop in the district was below the blanket recommendation for both DAP and urea by -11.8% and -14.5% respectively.

The amount of DAP and urea fertilizers applied to maize were also positive for rich respondents of Omo Nada by 11.5% and 2.4% respectively. Similarity, the amount of DAP and urea were positive for the model respondents by 13.8%, whereas, the mean was negative by 8.9% and 9.3% respectively. Similar to Gera district, the application rate of DAP and urea to maize was positive for rich, medium and model respondents by 27.3%, 9.3% and 4.3%, and 26.6% and 25.0%, respectively. The mean rate to the crop was also positive by 8.0% and 5.4% for DAP and urea respectively.

Table 8. Gap analysis of mineral fertilizer application on the basis of blanket recommendation

District	Wealth/Extension status	Gap with respect to blanket recommendation %			
		Maize		*Tef*	
		DAP	Urea	DAP	Urea
Gera	Rich (N=10)	5.3	5.3	-11.7	-75
	Medium (N=27)	0.7	2.7	-14	-75.8
	Poor (N=26)	-27.9	-35.6	-57.9	-94.8
	Model (N=18)	10.3	10.3	-	-75
	Non-model (N=45)	-19.7	77.0	-35	-85.61
	Mean	-11.8	-14.5	-27.6	-82.6
Omo Nada	Rich (N=11)	11.5	2.4	-10.6	-72.7
	Medium (N=51)	-6.6	-7.8	-27.8	-83.5
	Poor (N=33)	-14.4	-20.5	-38.3	-93.0
	Model (N=20)	13.8	13.8	-14.6	-75.0
	Non-model (N=75)	-14.3	-14.5	-33.5	-90.0
	Mean	-9.9	-9.3	-29.5	-87.0
Limu Seka	Rich (N=18)	27.3	27.3	-9.9	-80.6
	Medium (N=33)	9.3	4.3	-19.6	-84.4
	Poor (N=23)	-9.2	-10.3	-40	-94.5
	Model (N=23)	26.6	25.0	-12.4	-82.6
	Non-model (N=51)	-	-3.5	-30.8	-88.5
	Mean	8.0	5.4	-25	-86.6

Where the negative sign (-) before the numbers indicates below the blanket recommendation rate

The amounts of both DAP and urea fertilizers applied to *tef* crop was far below the blanket recommendation for all wealth status and extension status. According to Mesfin (2009) the average rate of applied fertilizer is about 40 kg/ha (total fertilizer in kg used divided by total cultivated land in ha). Even though both DAP and urea application rate is far below the blanket recommendation, the application rate of urea to *tef* is too small than DAP. The farmers were not applying sufficient amount of mineral fertilizers to all crops due to high cost of fertilizers and lack of credit without interest. Application of *kosii* and farm yard manure is limited to home-garden and/ or small size farm land near to home due to limited number of livestock. This calls for intervention action that is based on site specific, soil and cultivar testing to identify nutrient efficiency crops and other alternative solutions.

3.4.3. Crop rotation

Crop rotation entails the growing of different crops in a well-defined sequence on the same piece of land each season. Rotations allow crops with different rooting patterns to use the soil sequentially reduce pests and diseases and sustain the productivity of the cropping system (James *et al*., 2012). Legume based crop rotation is important way of soil fertility maintenance. In order to investigate rotational practice of the study area, the respondents were interviewed for crops they grew for the last three consecutive years on the same plot of land. Accordingly, most of the rotational patterns were cereal followed by cereal which was not legume based crop rotation. Even there were some farmers that were interchanging maize varieties of BH-660 followed by BH-140 for consecutive crop calendar. They perceived that BH-140 cannot deplete soil nutrients compared with BH-660. According to their perception rather than cropping BH-660 for two consecutive years, cropping BH-140 in the next year is advantageous. Of the total respondents, only 9 (3.9%) of them practiced legume based crop rotation (maize followed by common bean).

Generally, without considering wealth group and extension status the most frequently rotated crops in the study areas were:

- Maize followed by *tef*, followed by sorghum by 35 (15.1%) respondents
- Maize followed by *tef,* followed by maize by 24 (10.3%) respondents
- Maize followed by sorghum, followed by *tef* by 16 (6.9%) respondents

This implies that there is a great soil fertility loss due to mono-cropping that exercised either mono-cropping or rotation of cereals that aggravates declining of soil fertility (e.g maize followed by sorghum and *tef*).

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In Gera district about 8 (80%) of rich, 20 (74%) of medium and 17 (65%) of the poor respondents practiced crop rotation (Table 9). The remaining 2 (20%), 7 (25.9%) and 9 (34.6%) of the rich, medium and poor respondents do not practiced crop rotation respectively. In this district, about 16 (88.9 %) of the model and 29 (64.4 %) of non-model respondents had practiced crop rotation. About 2 (11.1%) of model and 16 (35.6%) of non-model respondents did not practiced crop rotation. In this district, the chi-square test did not show significant differences among wealth group in practicing intercropping, whereas significant difference was observed among the model and non-model farmers (χ^2 = 3.764, df = 1, P = 0.067).

Table 9. Frequency, percept and chi square test of crop rotation

WS/ES	Gera (N = 63)				Omo Nada (N = 95)				Limu Seka (N = 74)			
	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Rich	8	80	2	20	11	100	-	-	7	38.9	11	61.1
Medium	20	74.1	7	25.9	45	88.2	6	11.8	13	39.4	20	60.6
Poor	17	65.4	9	34.6	23	69.7	10	30.3	8	34.8	15	65.2
χ^2 value	0.918 ^{ns}				7.436**				0.074 ^{ns}			
P-value	0.657				0.025				1.000			
Model	16	88.9	2	11.1	20	100	-	-	10	43.5	13	56.5
Non-model	29	64.4	16	35.6	59	78.7	16	21.3	18	35.3	33	64.7
χ^2 value	3.764*				5.131**				3.091 ^{ns}			
P-value	0.067				0.038				0.179			

Where WS = wealth status, ES = extension status, N = number of respondents, ** and * represent level of significant at 1%, 5% and 10% respectively

Almost all of the rich respondents of Omo Nada, about 45 (88.2%) of the medium and 23 (69.7%) of the poor respondents had practiced crop rotation whereas, about 6 (11.8%) of the medium and 10 (10.3 %) of the poor respondents did not. Almost all of the model respondents of the district and about 59 (78.7%) of the non-model respondents had practiced crop rotation whereas, about 16 (21.3%) of the non-model respondents did not practiced. Significant differences in chi-square test were observed between both wealth group and extension status (χ^2 = 7.436, P = 0.025, df = 2 and χ^2 =5.131, P = 0.038, df = 1) respectively.

Of the 18 rich respondents of Limu Seka district, about 7 (38.9%) of them had practiced crop rotation whereas, about 11 (61.1%) did not. About 13 (39.4%) of the medium and 8 (34.8%) of the poor respondents of the district did not practice crop rotation. Similarly, about 20 (60.6%) of the medium and 15 (65.2%) of poor respondents did not practiced crop rotation. In terms of their extension status about 10 (43.5%) of the model and 18 (35.3%) of the non-model farmers had practiced this agronomic practices. There were no significant differences between wealth group and extension status in this district.

4.2.1. Intercropping

Maize and common bean were the main intercropped cereal and legume crops. Those farmers who had practiced intercropping understood well the advantages of intercropping. They used intercropping to respond to land shortage and to improve soil fertility. The farmers are well familiar as the leaves and roots of haricot bean have advantageous to improve soil fertility. All of the rich respondents of Gera district practiced intercropping of legumes with cereals. Most of the medium and poor respondents do not practiced intercropping, only about 8 (29.6%) of the medium and 7 (26.9%) of the poor respondents practiced it (Table 10). In the case of their extension status, about 17 (94.4%) of the model and 8 (17.8%) of the non-model respondents of this district practiced intercropping. Statistically significant difference between wealth group and extension status were observed (χ^2 = 18.108, p = 0.000, df = 2 and χ^2 = 31.573, P = 0.000, df = 1) respectively.

About 9 (90.9%) of rich respondents of Omo Nada, 13 (25.5%) of the medium and 11 (33.3 %) of the poor respondents exercised intercropping of legumes with cereals. Of the 20 model respondents about 14 (70%) of them and 20 (26.7%) of the non-model respondents exercised intercropping. Whereas about 6 (30%) of the model and 55 (73.3%) of the non-model respondents do not practiced intercropping. Statistically significant differences among wealth group and extension status was observed (χ^2 = 16.983, P = 0.000, df = 2 and χ^2 = 12.902, P= 0.000, df = 1) respectively.

Table 10. Frequency, percentage and chi-square test of regarding intercropping

WS/ES	Gera (N= 63)				Omo Nada (N= 95)				LimuSeka (N= 74)			
	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Rich	10	100	-	-	10	90.9	1	9.1	17	94.4	1	5.6
Medium	8	29.6	19	70.4	13	25.5	38	74.5	6	18.2	27	81.8
Poor	7	26.9	19	73.1	11	33.3	22	66.7	3	13	20	87
χ^2 value	18. 108***				16.983***				36.869***			
P-value	0.000				0.000				0.000			
Model	17	94.4	1	5.6	14	70	6	30	17	73.9	6	26.1
Non-model	8	17.8	37	82.2	20	26.7	55	73.3	9	17.6	42	82.4
χ^2 value	31.573***				12.902***				22.091***			
P-value	0.000				0.000				0.000			

Where WS = wealth status, ES = extension status, N = number of respondents, ***, ** and * represent level of significant at 1%, 5% and 10% respectively

In the case of Limu Seka district about 17 (94.4%) of the rich, 6 (18.2%) of the medium and 3 (13%) of the poor respondents exercised intercropping. In the case of the extension status of the farmers, about 17 (73.9%) of the model respondents and 9 (17.6%) of the non-model respondents exercised intercropping. Similarly, statistically significant differences among wealth group and extension status were observed (χ^2 = 36.869, P = 0.000, df = 2 and χ^2 = 22.091, P = 0.000, df = 1) respectively.

3.4.4. Crop residue management

Almost all of the rich respondents of Gera and Omo Nada, about 17 (94.4%) of Limu Seka retained crop residue partially on the farm land. About 9 (33.3%) of Gera's, 7 (13.7%) of Omo Nada's and 4 (12.1%) of Limu Seka's medium respondents partially removed crop residue. All of the poor respondents of the study area totally removed crop residues. Statistically significant differences between wealth groups were observed in all the districts (χ^2 = 34.514, P = 0.000, df = 2 in Gera, χ^2 = 55.675, P = 0.000, df = 2 in Omo Nada and χ^2 =52.059, P = 0.000, df = 2 in Limu Seka (Table 11).

Regarding the extension status of the farmers, almost all model farmers of Gera district and a single (2.2%) of the non-model respondents reported that they partially remove crop residues. Statistically significant difference among model and non-model respondents were observed ($\chi^{2=}$ 58.358, P = 0.000, df = 1). In Omo Nada, about 15 (75%) of the model and 3 (4%) of the non-model respondents were partially remove crop residues from their farm land. Statically significance difference among model and non-model respondents were observed (χ^2 = 51.828, P = 0.000, df = 1). In Limu Seka district about 18 (78.3%) of the model and 3 (5.9%) of the non-model respondents partially removed crop residues and statistically significant differences among model and non-model respondents were observed (χ^2 = 40.856, P = 0.000, df = 1).

As indicated in the Table 11, out of the total respondents most of them removed crop residues from their land. There was competing uses for *tef* straw for mud house construction and mattress making. Due to this *tef* straw was completely removed from the farm land (Figure 3). Maize and millet straw were used for animal feeding, whereas sorghum straw was used for fence construction especially in Omo Nada district and for animal feeding in other districts (Figure 2). Using crop straw as household fuel is not common in the study area but, some farmers burn the remaining residues to clean farm land during land preparation for sawing.

Table 11. Frequency, percept and chi square test of crop residue management

WS/ES	Gera (N= 63)				Omo Nada (N= 95)				Limu Seka (N= 74)			
	Yes, partially		Yes, totally		Yes, partially		Yes, totally		Yes, partially		Yes, totally	
	N	%	N	%	N	%	N	%	N	%	N	%
Rich	10	100	-	-	11	100	-	-	17	94.4	1	1.6
Medium	9	33.3	18	66.7	7	13.7	44	86.3	4	12.1	29	87.9
Poor	-	-	26	100	-	-	33	100	-	-	23	100
χ^2 value	34.514***				55.675***				52.059***			
P-value	0.000				0.000				0.000			
Model	18	100	-	-	15	75	5	25	18	78.3	5	21.7
Non-model	1	2.2	44	97.8	3	4	72	96	3	5.9	48	94.1
χ^2 value	58.358***				51.828***				40.856***			
P-value	0.000				0.000				0.000			

Where WS = wealth status, ES = extension status N= number of respondents, ***represent level of significant at 1%

In addition to this, grazing of animals on farm land was other means of removing the remaining crop residues (Figure 4). Out of the total respondents of the study area about 217 (93.5%) of the respondents practiced control grazing on grazing land during production season and free grazing both on grazing land and on farm land during off season that could aggravates soil erosion. Of the total respondents, only about 15 (6.5%) of them practiced control grazing on grazing land in all season.

That means there was free grazing on the farm land after the crops were harvested. This result indicates that the crop residues left on the farm land were grazed by the animals and nothing were left on the ground. In addition to this, the animals trampled on the farm land so that, soil erosion could be aggravated.

Figure 2. Totally removed maize residues from the field in Gera district

Figure3. Totally removed *tef* residue from the field in Limu Seka district

Figure 4. Free grazing on farm land during off season in Omo Nada district

3.4.5. Physical soil and water conservation measures

Physical measures are structures built for soil and water conservation by considering some principles that aimed to increase the time of concentration of runoff, thereby allowing more of it to infiltrate into the soil; divide a long slope into several short ones and thereby reducing amount and velocity of surface runoff; reduce the velocity of the surface runoff and protect against damage caused due to excessive runoff (Tidemann, 1996).

In Gera district, almost all of the rich respondents, about 9 (33.3%) of medium and 3 (11.5%) of poor respondents had exercised soil bund on their farm land and statistically there was significant differences among wealth group ($\chi^2 = 24.921$, df = 2, $P < 0.001$) (Table 13). Similarly, all rich respondents of Omo Nada, about 13 (25.3%) of the medium and none of the poor respondents had exercised this measure and statistically there was significant difference among the wealth group in applying physical soil and water conservation measures (soil bund) (χ^2 = 43.698, df = 2, P < 0.001). About 17 (94.4%) of the rich, 5 (15.2%) of the medium and 2 (8.7%) of the poor respondents of Limu Seka had practiced soil bund and statistically there was significance different among the wealth group in applying physical soil and water conservation measures (χ^2 = 41.998, df = 2, P < 0.001).

In the case of the extension status of the farmers most of the model farmers constructed bunds. Almost all model respondents of Gera, about 75% of Omo Nada and 78.3% of Limu Seka constructed bunds. About 8.9% of non-model respondents of Gera, 12% of Omo Nada and 11.8 % of Limu Seka had exercised bunds. Statistically there were significant differences among model and non-model respondents in all the study districts (χ^2 = 46.964, df = 1, P < 0.001 in Gera, χ^2 = 33.191, df = 1, P < 0.001 in Omo Nada and χ^2 = 31.985, df = 1, P < 0.001 in Limu Seka). The common physical SWC measures in the study area were soil bund, and both stone and soil bund were practiced only by very few (about 0.9% respondents).

Most of the farmers of the study area had developed several indigenous technologies since antiquity to overcome the problem of soil erosion by water. These are cut-off-drains locally called *"Boraatii lolaa",* drainage furrows called *"Bo'oo"* and ridges are other important structures used for soil and water conservation measures. *"Boraatii"* and *"Bo'oo"* are constructed mainly by oxen drawn plough in which *"Boraatii"* are deeper, wider and reinforced by hoeing and other materials than *"Bo'oo"* depending on the amount of slope length and gradient, amount of runoff produced from the field.

"Boraatii" is constructed at the upper end of the field and is used to divert runoff before entering to the crop field. *"Bo'oo"* (semi-parallel drainage furrows) is common in the field of small seeded crops like *tef* and wheat and constructed at relatively closer interval depending on the slope. Ridges are constructed across the slope from the accumulation of weeding over time and makes bund that can serve for soil and water conservation purposes. The practice is similar to the report of Tekilu and Gezahegn (2003) from East Wollega.

Table 12. Frequency, percent and chi square test for PSWC (soil bund) practices

Wealth /Extension status	Gera (N = 63)				Omo Nada (N = 95)				Limu Seka (N = 74)			
	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Rich	10	100	-	-	11	100	-	-	17	94.4	1	5.6
Medium	9	33.3	18	66.7	13	25.3	38	74.5	5	15.2	28	84.8
Poor	3	11.5	23	8.5	-	-	33	100	2	8.7	21	91.3
χ^2value	24.921***				43.698***				41.998***			
P-value	0.000				0.000				0.000			
Model	18	100	-	-	15	75	5	25	18	78.3	5	21.7
Non-model	4	8.9	41	91.1	9	12	66	88	6	11.8	45	88.2
χ^2value	46.964***				33.191***				31.985***			
P-value	0.000				0.000				0.000			

Where, PSWC = physical soil and water conservation *** represent level of significant at 1%

4. SUMMARY, CONCLUSION AND RECOMMENDATIONS

4.1. Summary and Conclusion

Agriculture is the pillar of Ethiopian economy and Ethiopians life, which is highly threatened by soil fertility. The study was carried out to reveal how farmers are currently maintaining soil. The farmers of the study area had been maintaining soil fertility by application of *kosii*, farm yard manures, mineral fertilizers, agronomic and physical soil and water conservation measures. Application of *kosii*, farm yard manure and *boraatii lolaa* (cut off drain) were the important indigenous soil fertility management practices applied by all of the respondents of the study area. However, *kosii* and farm yard manure is limited to home-garden and/ or small size farm land near to home. The farmers were not applying sufficient amount of mineral fertilizers to all crops due to high cost of fertilizers and lack of credit without interest. The farmers applied about 100kg DAP and 100 kg/ha urea with one to one ratio to maize crop whereas to *tef* is far below the blanket recommendation rate. Limited number of cattle and farm land size limited the application of manures and fallowing respectively in the study area. Time and labour consuming and misunderstandings of compost discontinued compost preparation.

4.2. Recommendations

- The farmers must be involved in the planning process of soil fertility management practices through considering local knowledge and capacity of the farmers.
- Scaling-up of multipurpose trees and improved fodders on marginal and other lands can reduce the competition on crop residues through providing fodders for livestock and at the same time can restore soil fertility.
- Training of the farmers on the expansion of inter cropping (mixed cropping) and legume based crop

rotation that supported with demonstration.
- Giving training for the farmers on compost preparation aided with demonstration can change the idea of farmers towards compost preparation.
- Regulating cost of fertilizers and facilitating credit with little or no interest can reduce the problem of mineral fertilizes. So, those, smallholder farmers may get access to use mineral fertilizers.
- Initiating the farmers to apply physical soil and water conservation practices on own farm.
- Introduction of conservation tillage and training the farmers on contour plough is necessary to reduce the amount of soil lost during repeated cultivation and *yafaro* plough respectively.
- Introducing of lime for acidic soil amendments by soil testing is necessary.

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