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Effects of Land Use/Land Cover Change on Some Soil Physical and Chemical Properties in *Ameleke* micro-Watershed, Gedeo and Borena Zones, South Ethiopia

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Abstract
This study investigates effect of land use and land cover change (LUCC) on some soil physical and chemical properties at Ameleke micro-watershed, South Ethiopia. Satellite images of 1986, 2000 and 2006 were used to analyze LUCCs of the watershed. For the purpose of soil sampling, the watershed was divided in to three altitudinal belts, from each of which two sample sites were taken. From each sample site, composite soil samples were collected from agroforestry, crop land, grass land and shrub lands in three replications at 0-15cm and 15-30 cm depth and selected soil physical and chemical properties were analyzed. The result of the land use/cover analyses showed that agroforestry and crop lands occupy larger part of the upland while grass and shrub lands occupy larger part of the middle and lower altitude of the watershed. The change detection study revealed that from 1986 to 2006, crop land area increased from 23.3% to 31.0%; grass lands decreased from 25.9% to 14.96% and shrub lands decreased from 30.3% to 24.25%. Analyses of soil properties reveal that significant differences ($p < 0.05$) in soil available K, TN, OC, OM, available P and soil texture and insignificant differences in soil pH and CEC among land use and land cover types. The difference in soil properties among land use and land covers is highly significant at 0-15 cm depth than at 15-30 cm depth. This study recommends assessment of land use and land covers at homestead level and sharing experiences for expansion of agro forestry type of land use between Gedeo and Guji Oromo people are central for sustainable management of natural resources of the watershed.
Keywords:land use and land cover change, soil chemical properties, soil physical properties, Ameleke micro-watershed, South Ethiopia

1. Introduction

Land cover and land use change (LUCC) is a phenomenon starting from ancient time. However, the last three centuries witnessed rapid and extensive LUCC as part of global environmental changes (Lambin et al 2003; Gutman et al 2004; WRI 2005). Furthermore, global assessment of LUCC showed that cropland increased fivefold from 1770 up to 1990 and pasture land above six fold from 1700 to 1990 (WRI 2005). These increases of cropland and pasture land were at the expense of forest, natural grassland, steppe and savannas. In fact, the direction and speed of LUCC are not similar for all parts of the world.

Soil properties response to changes in LUCC was investigated at different points in time and spatial scale. In tropical region, for example, Hartemink et al (2008) have studied effects of land cover change on soil resources and the result showed that conversion of climax vegetation to human managed land use systems triggered to cause low soil structure stability, loss of organic matter, reduction in nutrient stock, and reduction in soil organic carbon. In addition, conversion of natural vegetation to other land uses exposes the land for erosion in sloping areas. In this region, Yang et al (2004) also explore that shifting cultivation and establishment of rubber tree plantations showed a decline in concentrations and stocks of soil organic carbon and total nitrogen than natural forest. Recently, Yifru and Taye (2011) have studied soil in different land cover and land use types in Bale, South East Ethiopia. In this study, soil organic carbon and total nitrogen were high in natural forest while these were low in cultivated fields. Several studies in Ethiopia reached at the same conclusion (e.g., Eyayu et al 2010; Nyssen et al 2008; Amare 2007; Fantaw 2007; Belay 2002; Kebrom and Hedlund 2000). Contrary to the above studies, Geissen et al (2009) in Mexico concluded that land-use change did not lead to change in some soil chemical properties rather to change in soil physical properties. From the above studies one can understand that it is hardly possible to draw uniform conclusion on the effect of land cover and land use change on properties of soil, which reveals the necessity to conduct studies at local spatial scale.

In Ameleke micro-watershed this study is attempted to map LUCC since 1980s and analyze its effect on some soil physical and chemical properties. General observation shows that the upper stream of Ameleke micro-watershed is under agroforestry and crop land while the lower and middle streams of the watershed are grass and shrub land use/ land cover types. In the upper part of the watershed natural forest and grass lands are changing into agroforestry and crop lands. In the middle and lower part of the watershed, there is overgrazing on grass and shrub lands and recently croplands are expanding. It is logical to hypothesize that more sustained removal of vegetation cover in this area can cause two fold effects on soil resources: firstly, change in soil properties and secondly, accelerated soil erosion. From these two hypotheses, this study examined the effect of land use and land cover change on some soil chemical and physical properties.

2 Materials and methods

2.1 Description of Study Area

Ameleke micro-watershed is located between 6°15_N to 6°26_N latitude and 38°10_E to 38°12_E longitude. It has an area of 69.69 km2 (Fig 1). The altitude ranges from 1200 m.a.s.l at the lower altitude and 2000 m.a.s.l at the water divide of the watershed. The mean monthly temperature ranges from 18.4 0C in the upland to >23 0 C in the lower altitude and the mean annual rainfall ranges from 1725 mm at the upper part of the watershed at 2000 m. a.s.l to 579 mm in the lower altitude of the watershed. The area experiences long rainy months from March to November with double maxima, the first being during April and May while the second in the months of September and October. The rainfall variability is very high, however. December to February is dry season (climate data was inferred from Dilla, Yirgachefe and Abaya Meteorological stations. They are the closest stations to the study area).

Nitisol and Solanchak are the major soil classes of this watershed (MoWR 2008). The upper part of the watershed is dominated by Nitisols with a colour of reddish brown and red. In this part the soil texture is mainly clay and relatively fertile and cultivated for agro forestry and annual crops. Solanchak soil class is found in the lower altitude of the watershed below 1500 m a.s.l. Soils at the lower altitude are less fertile, topsoil depth is very shallow, has grayish color and salinity is the major constraint for crop cultivation.

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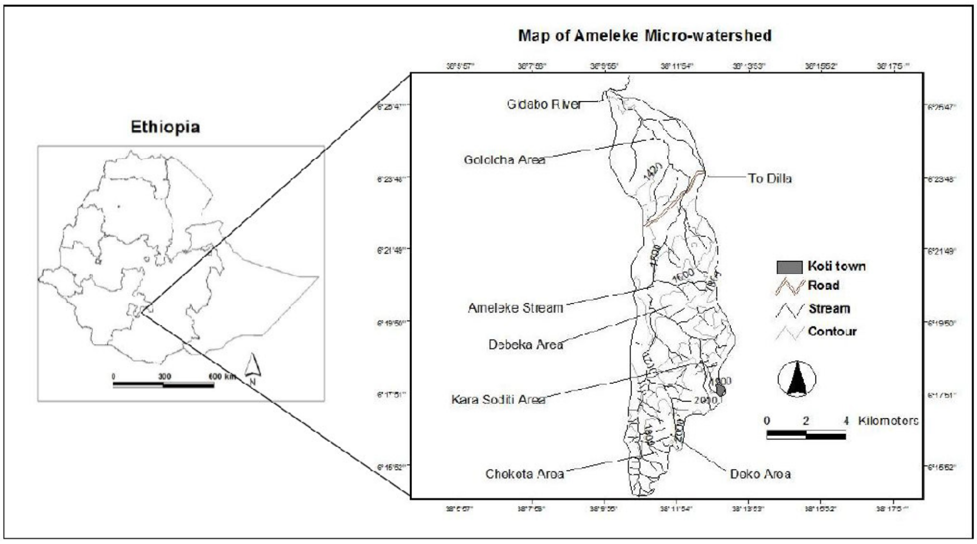
Agro-ecologically the upland (Cheketa Area, altitude ranging between 1800-2000 m a.s.l) of Ameleke micro-watershed is dominated by coffee, *enset*, maize and teff crops and characterized by typical traditional agroforestry type of land use. In the lower and middle altitude (Debeka and Gololcha Areas; 1500-1800 m a.s.l and < 1500 m a.s.l. respectively) of the watershed livestock production is the main stay of the community.

Fig 1 map of Ameleke micro watershed



2.2. Methods and Procedures

Methods and procedures for land use and land cover study

For the study, topographic map of 1:50,000 extracted from Dilla Sheet (EMA 1979) used as the base map. For LUCC analyses satellite images of Landsat TM for the date 21 January 1986, Landsat ETM+ for the date 5 February, 2000 and SPOT for the date 4 February, 2006 were acquired from Ethiopia Mapping Authority. Landsat TM 1986 and Landsat ETM+ 2000 images have 30m pixels resolution while SPOT 2006 image has 5m pixels resolution. These images were first rectified, geometrically corrected and geo-referenced to UTM 1984 projection. For land cover classification the supervised classification method of the ERDAS Imagine 8.6 software using the decision rule of maximum likelihood classifier algorithm. For this method, 14, 10, 12, 6 and 8 training areas were taken for classification and accuracy assessment of crop land, grazing land, shrubland, reverine forests and agroforestry respectively. Accuracy of land use and land cover classification was tested. Error matrices were produced for 1986, 2000 and 2006 land use and land cover maps with an accuracy assessment of 80 %, 85.0% and 85.71 % respectively. The overall accuracy and Kappa (K) statistics of 1986, 2000 and 2006 land use and land cover maps were 0.76, 0.82 and 0.83 respectively. Table 1 shows description of the land use/land cover types identified in the studied watershed.

Table 1. Description of Land use and land cover classes found in Ameleke watershed

Agroforestry	Those land uses where big trees like *Birbira(Milita ferruginea), Korch (Erythrina brucei), Wanza(Cordia africana), Warka (Ficus vasta), and sholla (Ficus sycomours*) and others are found with crops like maize, coffee, *(Ensete Ventricosum), Sicuardinich (Ipomea bapatase), Godera (Colocasia esculenta)* and *Boyna (Dioscorea abyssinica).*
Crop land	Areas of land that is ploughed and/or prepared for cultivation of annual crops.
Grazing land	Grass land refers to those land units that are used for livestock grazing, including privately and communally owned grazing areas. The land is basically covered by grass and herbaceous species.
Mixed cover	Lands on which trees, grass and herbaceous species, crops and shrubs are mixed at a place at different proportions.
Shrub land	Communities of vegetation dominated by short woody, self supporting, multi stemmed plants.
Riverine forests	Trees grown following the course of streams.

Adapted from Amare (2007)

Qualitative methods of the study

In each sub catchment, three focused group discussion, totally nine focused group discussion were conducted. The first focused group discussion was with households aged 55- 70 years and the second focused group discussion was with households aged 28- 47 years. The third focused group discussion was with the kebele watershed team. The size of group discussions was 6 households. Historical change in land use and land covers, soil erosion and color dynamics, economic activities of the households in different time and approaches and technologies of soil resources conservation were the main points of discussion. These participants are selected randomly and are Gedeo and Guji Oromo ethnic groups.

Interview of households was another method. Interview with 28 households was conducted. Similar to focused group discussion, land use/land cover changes, economic activities of the households and soil resources conservation were the main points of interview. Households for interview were selected randomly. Beside to these, households were also interviewed about the land use history of each sample plot and to select soil sample sites. Interview Participants were Gedeo and Guji Oromo ethnic groups those having different economic status, age and sex groups. Among the interviewees, 6 are women households.

2.3 Methods and procedures for soil sampling and analysis

Using bio-sequential soil sampling approach, soil samples were collected from six sample sites of three altitudinal belts of the watershed. In each sub catchment, there are two sub sample sites. Again in each sub catchment, samples were collected from cropland, grazing land and agroforestry/shrub lands. Before put down samples, land use history of plots were studied through households interview. A composite soil samples from five pits were taken from crop land, grass land, agroforestry and shrub land at 0-15 cm and 15cm-30 cm depth in three replications. From each sub catcment, 36 soil samples, totally 108 soil samples (3 replications ×6 sample sites ×3 land use/land covers × 2 soil depths) were collected.

Land use history of sample plots

Soil sample plots have different land use history. Crop lands in the upper sub catchment are plots where ploughing is started 30 years ago while croplands in the middle and lower subcatcments have recent land use history. In the middle sub catchment, croplands are since ten years ago where these plots were grazing lands before changed into crop lands. The croplands of lower catchments are since 8 years ago where these are changed from grazing and shrub lands. The agro forestry in the upper sub catchments is since long years ago.

The grazing lands in the middle and lower sub catchments are the aboriginal land uses on which there is no change happened. In these plots, over grazing is increasing since parts of grazing plots are changed in to crop lands. Similarly shrub lands in the lower catchment are the aboriginal sample plots and over grazing is increasing on these plots.

Fig 2 Soil samples distribution

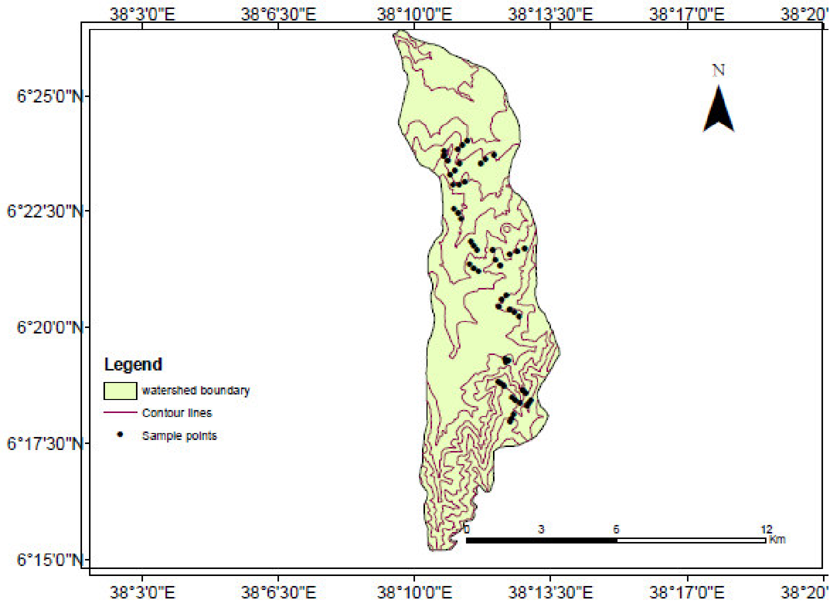


Table 2 Distribution of soil sampling areas

Sample area (Sub catchments)	Elevation range(masl)	Land use and land cover	Number of samples taken	Lati & longti	Slope (%)
Cheketa	1933- 1944	Cropland	6		11
		Agroforestry land	6		
		Grass land	6		
	1950-1962	Cropland	6		12 - 12.5
		Agroforestry land	6		
		Grass land	6		
		Total	**36**		
Debeka	1608-1613	Cropland	6		9.3-10.5
		Agroforestry land	6		
		Grass land	6		
	1617-1624	Cropland	6		9.3-10.5
		Agroforestry land	6		
		Grass land	6		
		Total	**36**		
Gololcha	1529-1535	Cropland	6		9.0
		Shrub land	6		
		Grass land	6		
	1507-1512	Cropland	6		7.5 - 8.4
		Grass land	6		
		Shrub land	6		
		Total	**36**		

Precautions were taken during sampling, which include samples were not taken from manure areas, litters were

removed by spatula before sampling, and samples were taken from more or less similar elevation, slope and micro topography for each sample sites. In the soil laboratory soil pH, texture, available Potassium (AK), Cation Exchange Capacity (CEC), Total Nitrogen (TN), Organic Carbon (OC), Organic Matter (OM) and available Phosphorus (AP) were analyzed. The samples were prepared and analyzed using the standard procedures in laboratory of Oromia Water Works Design & Supervision Enterprise. Texture was determined by Bouyoucos Hydrometer method, pH by using pH meter, OC by titration with ferrous ammonium sulphate using diphenylamine indicator (Schnitzer 1982). TN was determined by Kjeldahl method (Bremner and Mulvaney 1982), AP by Olsen extraction method (Olsen et al, 1954) and CEC (Chapman 1965) and AK were by ammonium acetate method and through K-reading using Atomic Absorption Spectrometer (Black et al 1965). Finally the soil properties under agroforestry, cropland, grass land and shrub land were compared. This enabled us to see the impact of spatial land use and land cover change on soil properties.
After having data of soil chemical and physical properties from different land use/cover, Analyses of Variance (ANOVA) was performed to test whether or not significant difference observed on the values of soil properties among the land use and land cover types. Besides, Least Significant Difference (LSD) post hoc multiple comparison tests were used to see the difference level of soil properties among the land use/land covers types.

3. Results and Discussion

3.1 Analysis of land use and land cover change

Cropland, grazing land, shrub land, mixed land cover, agroforestry and riverine forest were identified as the major land cover/use classes. These land use and land cover classes are found to have different spatial and temporal patterns (see Table 2).
The LUCC analyses have revealed that some land use and land cover types have gained an area while others have lost. Cropland area increased from 23.33% coverage in 1986 to 31.0% in 2006. Contrary to croplands, grass land area considerably declined from 25.9% in 1986 to 14.96% in 2006. Grass land in the upland has converted to cropland while in the lower altitude it has changed to shrub land. Overall, there is a net decrease on shrub land cover from 30.3% to 24.25% of the watershed in 1986 and 2006 respectively. There is also a change in riverine forest coverage but it is subtle. In the upland part of the watershed forest cover has modified into agroforestry land use type. From the analysis it is generally possible to conclude that in Ameleke woody vegetation cover is in the declining trend or modification phase.

Figure 3. Land use and land cover maps of Ameleke watershed in 1986, 2000 and 2006

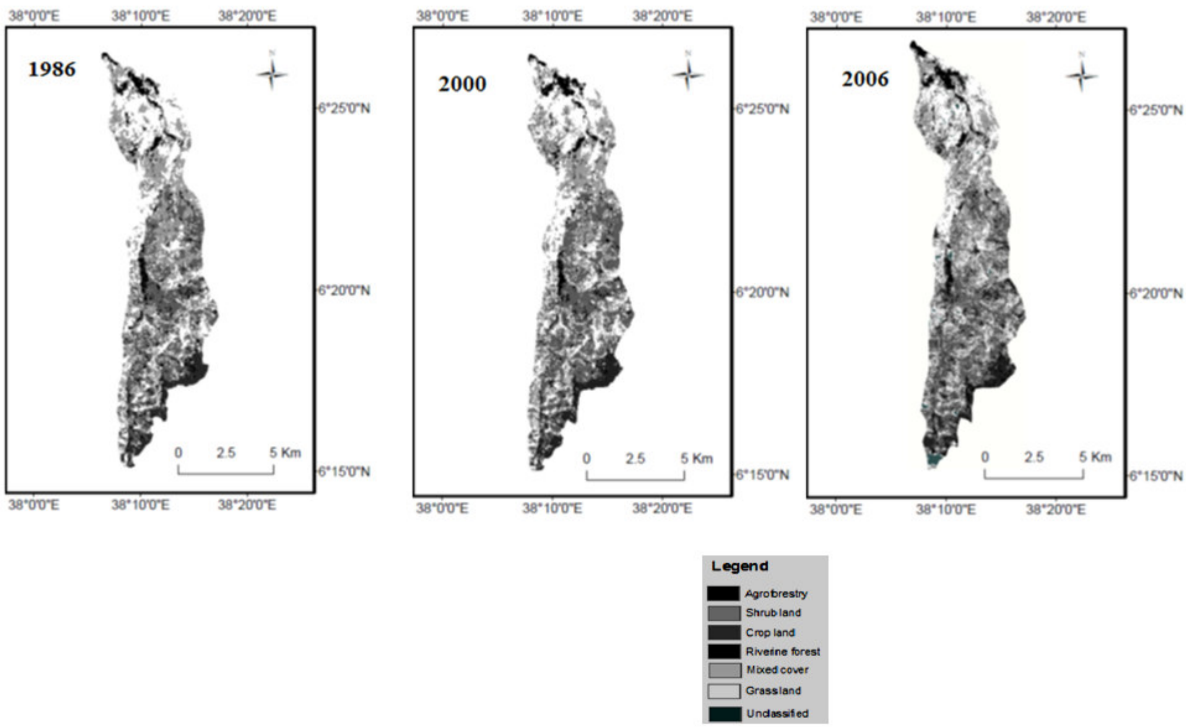


Table 3 Change in area of land uses and land covers from 1986-2006

Land use and land cover types	Area in ha			Area in percentage			Land use and land cover change in ha		
	1986	2000	2006	1986	2000	2006	1986 to 2000	2000 to 2006	1986 to 2006
Agroforestry	433	492	529	6.2	7.0	7.6	+59	+37	+97
Crop land	1626	2052	2156	23.33	29.4	31.0	+426	+104	+530
Grazing land	1807	1601	1043	25.9	22.97	14.96	-206	-558	-764
Mixed cover	506	829	1093	7.26	11.89	15.68	+323	+264	+587
Riverine forests	485	399	377	6.95	5.72	5.4	-86	-22	-108
Shrub land	2112	1596	1690	30.3	22.9	24.25	-516	+94	-422
Unclassified	--	--	81	--	--	1.16	--	--	--
Total area	**6969**	**6969**	**6969**	**100**	**100**	**100**			

The result of the satellite image analyses described above is also confirmed by the elders who are residing in the study site. During interview and FGD in Deko and Karasoditi kebeles (the middle land of the study watershed), participants were requested to appraise the trend of LUCC. They replied that grass lands are changing in to cultivated land (cropland and coffee cultivation) and agroforestry land. The change to cropland is more evident since 1970s. They further explained that after *Derg* came to power in the early 1970s, every plot of land, which were under communal ownership, came under the hands of individual farmers. Proclamation of _Land to the tiller_ resulted in land fragmentation and lands which were grass cover are started to plough. One elder from Oromo ethnic group who has a seat in *kallu* system (*Kallu* is a traditional institute in the area), for example, narrated the change in the middle altitude of the watershed lucidly as below.

Formerly there was domestication of large number of livestock on large communal grazing land area. However, since the 1970s grass lands were converted into coffee cultivation. Grass lands were also changed into cropland mainly during Derg regime. So, today croplands and coffee cultivation are the major land uses. On grass lands and croplands there was also planting of trees. Through gradually, trees, coffee and crops become interspersed. Within this cultivation, legumes, and root crops like Boleke [Fasiolus bulagavulagarese], Boyna [*Dioscorea abyssinica*] and Sweet potato (*Ipomea bapatase*) are expanding. There are also mixed type of land uses around homesteads in the area.

The FGD also revealed that there was forest cover in Cheketa and Alemo areas in Dako and Karasoditi kebeles (upland part of the study watershed). Later, the forest was cleared and thinned (modified) by the settlers found outside this watershed. In their words:

People from Tumata Chericha, Mekonessa and other upstream settlers were transporting trees from Alemo and Cheketa Areas for traditional wood products and for fuel. The farmers of Deko and Kara Soditi kebele themselves modified natural forest in to agroforestry type of land use. Adjacent to forest lands there was coffee cultivation mainly on grass lands. In between coffee trees, trees like Birbira [Milita ferruginea], Wanza [Cordia africana], Warka [Ficus vasta], and sholla [Ficus sycomours], started to be grown to serve as shade tree for coffee seedlings, resulted another land use system, agroforestry.

LUCC pattern in Debeka, Debobesa and Gololcha Areas (the middle and lower altitude part of the study site) is quite different from Deko and karasoditi areas. In group discussion and interviews of Debeka and Gololcha kebeles, participants were also requested to explain the trend of land use and land cover change. Their reply was: _before 50 and 60 years ago the area was covered by grass land and shrub land. During this time most of grass lands were communal lands. Currently former communal grass lands are distributed to farmers (private ownership) and changed in to croplands. The change into cropland is hastier since the last 10 years_. Participants pointed out the rationale for this cropland increase. According to them, some NGOs and the current government policy were to be blamed. For instance, Luteran World Federation educated farmers to change their living style and type of economic activity from livestock rearing to farming. They explain:

This organization distributes different seeds like Maize to the farmers during rainy seasons, in turn, this pushes farmers to plough more land. On the same way government forced farmers to plough more grass lands. Model farmers participated in conferences under the agenda of __development and transformation__. From the conferences farmers learnt how to change their living and how to increase productivity. After farmers returned from meetings and conferences, they decided to plough the remaining grass lands for crop cultivation.

Unlike to Deko and Karasoditi areas, forests of Debeka and Golocha areas were used as sources of domestic energy (fire wood and charcoal). Respondents also have indicated that charcoal production is a day to day activity of most farmers. They further reported that it is more serious problem when there is rainfall scarcity. Rainfall scarcity resulted in low dairy farm and crop production. To escape from hunger, farmers forced to sell charcoal. As a result farmers were very reluctant to stop cutting of trees for charcoal even in front of development agents and kebele administrators. In general, the FGD and interview disclosed that communal grass lands and natural forest cover were changed to cultivated land. The participants repeatedly mentioned that this land cover change is the phenomenon mainly since the 1970s.

In this watershed the Gedeo and Guji people have different land use practices and the change is also different among these ethnic groups. In the upper part of the watershed the people are mostly Gedeos. Gedeos modify the natural forest cover then plant *enset* (*Ensete Ventricosum)* and coffee in between sparse natural trees. On the other hand, Gedeos grow indigenous trees like *Birbira* (*Milita ferruginea*)*, Warka* (*Ficus vasta*)*, Shola* (*Ficus sycomours*)*, Wanza* (*Cordia africana*) *and* other trees on previously non-forested land and coffee and enset followed. In the lower stratum of coffee and *enset* they grow several crops such as *Boleke* (*Fasiolus bulagavulagarese*)*, Sicuardinich* (*Ipomea bapatase*)*, Godere* (*Colocasia esculenta*)*,* and *Boyna* (*Dioscorea abyssinica*). Furthermore, a gradual downslope expansion of agroforestry is observed from the upland areas of the watershed to the middle altitude.

In the low elevated areas of this watershed (1200-1625 m a.s.l), the people are Guji Oromos. Unlike Gedeo people, agroforestry land use type is not the tradition of them. The people are largely agro pastoralist. In the past, there were large communal grass lands. But owing to population pressure and change in land tenure system, communal grass lands are changing in to semi-private and private grazing fields. Even grass lands are changing in to croplands and people are becoming agro-pastoralist. In this area, charcoal production is contributing to the reduction of tree density.

The result of LUCC study of Ameleke micro-watershed is in agreement with several micro level studies in Ethiopia (for example, Berhan 2010; Nyssen et al 2008; Gessesse and Kleman 2007;Gete and Hurni 2001;; Belay 2002) and different from others (e.g., Amare 2007; Woldeamlak, 2002; Kebrom and Hedlund 2000;).

3.2 Soil properties in relation to land use/land cover types and altitudinal belt

After the collection of soil samples from different land use and land cover types at 0-15 cm and 15-30 cm depths, soils texture, pH, CEC, available K, TN, OC, OM and total available P content were tested. Tables 3 and 4 present mean values of major soil properties on different land use/land cover types and altitudinal belts of the studied watershed. Table 5 also presents the ANOVA result, which tests whether or not significant differences exist on values of soil parameters among the land use/land cover types.

Table 4 Soil properties in relation to Land use and land covers in Ameleke watershed (mean ± Sd)

LULC	Depth in cm	Number of samples	pH	AV. K (Cmol(+)/kg)	CEC (Cmol (+)/kg)	TN (%)	OC (%)	OM (%)	Av. P(ppm)	SAND (%)	SILT (%)	CLAY (%)
Crop land	0-15	18	6.34± 0.7	1.41±1.1	36.82±8.7	0.150±.06	1.780±.7	3.081±.3	6.044±.8	40.55±.5	27.05±5.3	32.381±1.5
	15-30	18	6.20±.70	0.96± 0.8	36.951±.02	0.100±.04	1.190±.5	2.05±0.9	3.83±4.9	39.11±1.07	22.61±2.7	38.28 ±1.1
	Over all	36	6.30±0.7	1.18±0.99	36.89 ±9.38	0.12±.06	1.49±0.73	2.57±1.26	4.93± 4.95	39.831.29	24.83-4.74	35.33±1.33
Grazing land	0-15	18	6.29±.5	1.03 ±0.2	42.35 ±1.1	0.170±.07	2.000±.9	3.461±.57	2.242±.06	39.505±.86	23.77 ±7.6	36.72 ±9.7
	15-30	18	6.37±0.6	0.74±0.26	43.07 ±1.16	0.12 ±0.5	1.420±.6	2.44 ±1.0	0.92 ±0.5	37.39 ±5.9	22.22± 7.8	40.39 ±1.0
	Over all	36	6.34 ±0.5	0.88±0.27	42.71±1.12	0.15±0.07	1.71±0.81	2.95±1.40	1.58 ±1.63	38.44±5.92	23.00±7.70	38.55±1.01
Agro forestry	0-15	12	6.61 ±0.5	3.66 ±1.9	44.07 ±7.9	0.28±0.06	3.25±0.73	5.60±1.27	33.2 ±1.72	49.66 ±.83	30.92±4.66	19.42±1.54
	15-30	12	6.66 ±0.6	1.92±1.14	38.005±.2	0.13±0.03	1.54± 0.4	2.67±0.69	17.37± 1.9	42.33±1.02	25.58±4.29	32.08 ±9.2
	Over all	24	6.66 ±0.5	2.79±1.87	41.03-7.25	0.20±0.09	2.40 ±1.0	4.13 ±1.8	23.66±2.01	52.91±8.83	28.25±5.16	25.75±1.40
Shrub land	0-15	6	6.32 ±0.3	2.78±1.6	36.30 ±1.3	.20 ±005	2.34 ±0.6	4.04±1.13	22.15±1.13	54.50±9.89	35.33±8.52	10.16±7.02
	15-30	6	6.45 ±0.5	1.57 ±0.8	40.16 ±8.6	0.15±0.45	1.79± 0.5	3.08±0.88	12.01±1.34	51.33±8.23	32.83±9.55	15.83±4.85
	Over all	12	6.38 ±0.4	2.17±1.3	38.23 ±1.06	0.18±0.05	2.06±0.63	3.56±1.08	17.08±1.36	42.0 ±1.20	34.00±8.73	13.00±6.48
Over all	**0-15**	**54**	**6.38 ±0.57**	**1.94±.16**	**40.21 ±1.01**	**0.19±0.83**	**2.24±0.9**	**3.87±1.67**	**12.61±1.56**	**43.78±1.4**	**27.74±7.29**	**28.48±1.55**
	15-30	**54**	**6.410±.63**	**1.17±0.97**	**39.58 ±9.89**	**.12 ±0.64**	**1.41±0.54**	**2.43±0.93**	**6.78 ±1.21**	**40.61±9.74**	**24.28±6.80**	**35.11±1.23**

Table 5- **Soil properties in relation to Land use and land covers in different sub –watersheds of Ameleke watershed (mean ± Sd)**

Sub-watersheds	Land covers	Depth in cm	pH	AV. K (Cmol(+)/kg)	CEC (Cmol(+)/kg)	TN (%)	OC (%)	OM (%)	Av. P(ppm)	(Silt%)	Clay(%)	Sand(%)
Cheketa (1933-1944 & 1950-1962 masl)	Cropland	0-15	5.56±.21	.84±15	29.20±4.85	.15±0.26	1.73±.31	2.98±.53	5.36±3.07	25.33±3.72	27.00±2.15	47.66±8.91
		15-30	5.56±.21	.59±.22	29.33±5.31	.10±.02	1.15±.26	1.99±.45	3.53±2.5	22.66±3.88	48.66±5.42	28.66±4.5
	Grazing Land	0-15	5.96±.33	.91±.19	33.46±6.72	.20±.07	2.38±.91	4.10±1.58	1.82±1.02	38.16±5.34	27.00±7.15	34.83±1.19
		15-30	5.96±.33	.50±.12	33.36±8.28	.13±.06	1.49±.69	2.57±1.19	.63±.43	22.66.±5.85	37.33±1.04	39.83±5.63
	Agroforestry	0-15	6.15±.18	3.17±1.74	40.13±3.13	.24±.03	2.81±.36	4.85±.63	43.72±1.69	34.00±2.53	33.33±2.34	32.66±4.08
		15-30	6.15±.18	1.85±1.24	38.88±3.72	.11±.01	1.32±.17	2.28±.29	30.49±2.05	25.00±5.21	39.33±5.57	35.66±8.61
Gololcha (1529-1535 & 1507-1552 masl)	Cropland	0-15	6.96±.35	2.26±.55	47.03±5.22	.08. ±01	.95±.20	1.65±.35	6.30±7.07	26.83±9.57	27.00±3.57	46.16±9.66
		15-30	6.90±.54	0.78±1.65	48.13±7.31	.06±.01	.77±.10	1.33±.17	6.357.81	32.50±1.07	32.50±1.07	22.33±1.03
	Grazing land	0-15	6.96±.30	1.03±.27	50.28±1.09	.09±.04	1.11±.54	1.91±.93	1.99±1.26	20.00±1.00	42.16±7.83	37.83±7.25
		15-30	6.96±.48	.93±.23	55.53±5.66	.10±.05	1.14±.66	1.97±1.15	1.07±.56	23.00±1.29	45.50±1.40	31.50±2.73
	Shrub land	0-15	6.31±.25	2.78±1.65	36.30±1.29	.20±.05	2.34±.65	4.03±1.13	22.15±1.29	35.33±8.52	10.16±7.02	54.50±9.89
		15-30	6.45±.47	1.57±.812	40.16±8.66	.15±.04	1.79±.50	3.08±.88	12.01±1.34	32.83±9.55	15.83±4.87	51.33±8.23
Debeka (1608-1613 & 1617-1624	Cropland	0-15	6.48±.55	2.26±1.65	34.23±2.54	.23±.040	2.67±.45	4.61±.78	6.44±4.60	27.16±5.70	22.66±1.26	50.16±1.53
		15-30	6.35±.67	.78±.41	33.40±6.35	.14±.05	1.61±.83	2.82±1.12	1.63±.65	22.83±3.06	33.66±9.15	43.50±8.01
	Grazing Land	0-15	5.93±.15	1.14±.08	43.30±8.71	.21±.04	2.53±.49	4.36±.86	2.91±3.32	24.33±3.72	33.16±7.88	42.50±4.41
		15-30	7.06±.20	.31±.06	3.68±.78	6.35±1.34	22.78±1.01	4.15±2.31	48.00±9.54	65.33±1.20	28.50±5.31	6.16±9.36
	Agrofrestry	0-15	7.06±.20	4.15±2.31	48.00±9.54	.31±.06	3.68±.78	6.35±1.34	22.78±1.01	28.50±5.31	6.16±9.36	65.33±1.20
		15-30	7.16±.38	1.99±1.68	37.11±6.66	.15±.039	1.77±.45	3.05±.78	4.25±3.43	26.16±3.54	24.83±5.70	49.00 ±7.12

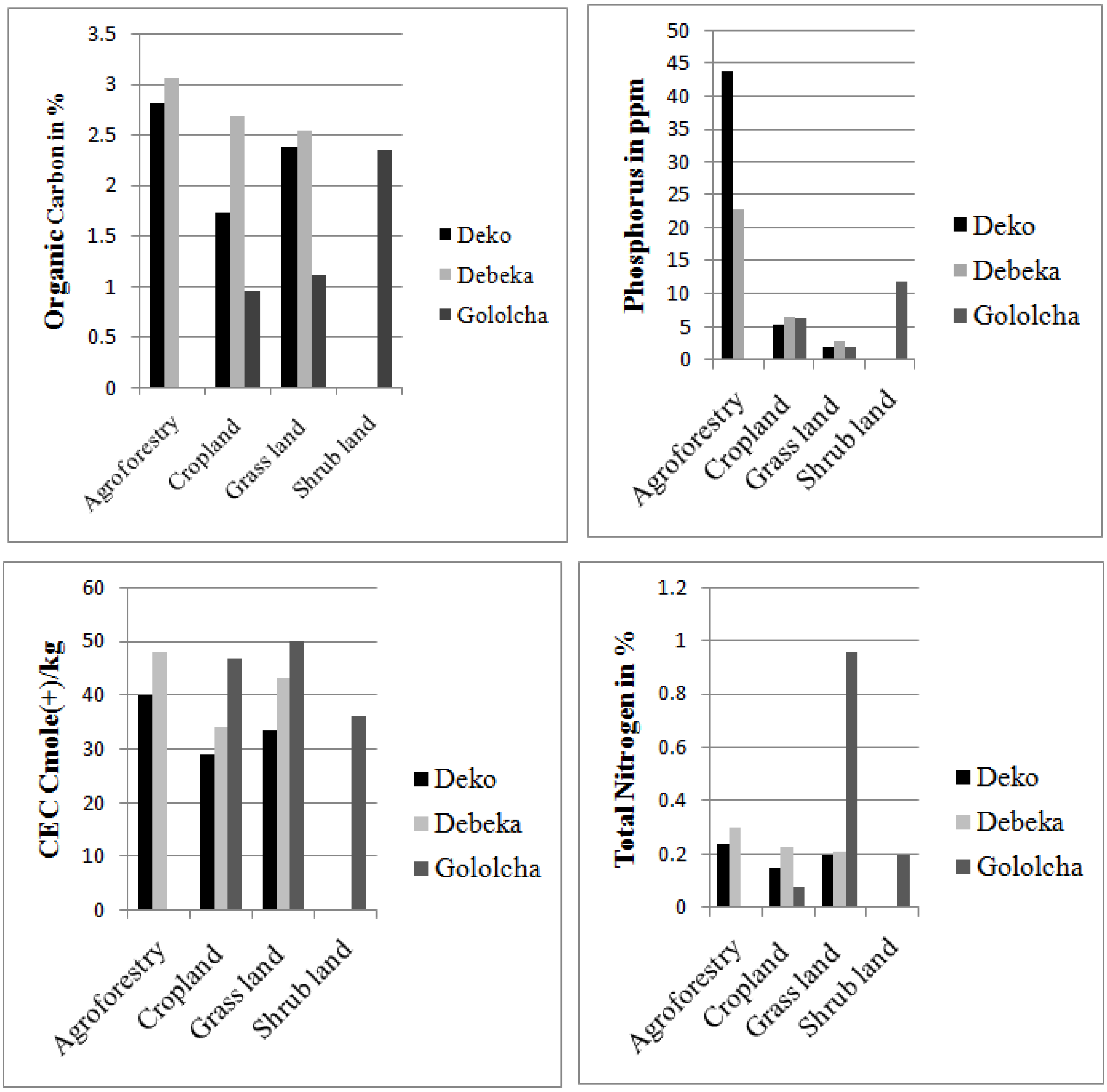
Table 6 ANOVA Between Land Use and Land Covers and Soil Properties at 0-15cm depth

		Sum of Squares	Df	Mean Square	F	Sig.
PH	Between Groups	2.138	3	.713	2.009	.117
	Within Groups	36.900	104	.355		
	Total	39.039	107			
TN	Between Groups	.096	3	.032	6.328	.001*
	Within Groups	.525	104	.005		
	Total	.621	107			
OC	Between Groups	13.141	3	4.380	6.379	.001*
	Within Groups	71.412	104	.687		
	Total	84.553	107			
OM	Between Groups	39.030	3	13.010	6.375	.001*
	Within Groups	212.231	104	2.041		
	Total	251.261	107			
AVP	Between Groups	8506.657	3	2835.552	23.857	.000*
	Within Groups	12360.958	104	118.855		
	Total	20867.615	107			
AVK	Between Groups	62.551	3	20.850	15.547	.000*
	Within Groups	139.479	104	1.341		
	Total	202.030	107			
CEC	Between Groups	675.049	3	225.016	2.346	.077
	Within Groups	9975.211	104	95.915		
	Total	10650.260	107			
SAND	Between Groups	2434.111	3	811.370	6.437	.000*
	Within Groups	13108.806	104	126.046		
	Total	15542.917	107			
SILT	Between Groups	1278.574	3	426.191	10.259	.000*
	Within Groups	4320.417	104	41.542		
	Total	5598.991	107			
CLAY	Between Groups	7212.130	3	2404.043	16.830	.000*
	Within Groups	14855.389	104	142.840		
	Total	22067.519	107			

*. The mean difference is significant at the 0.05 level.

From the data presented on tables 3-5 we deduce that there is a significant difference in soil properties except in soil pH and CEC on different land use and land cover classes. The difference is more pronounced on the top soil (0-15cm depth) than 15-30 cm depth. It indicates LUCC is active determinant of soil properties. If geology, climate and soil type are significant factors for change in soil properties, we could not have found this much difference in soil properties within this small difference of depth. Detailed analysis about each of the properties is given below.

Fig 4 Comparison of some soil properties under different land use and land cover types of Deko, Debeka and Gololocha areas at 0-15 cm soil depth.



Soil organic carbon (OC) and organic matter (OM)

ANOVA and *post hoc* multiple comparisons firmly show that there is a significant difference (P<0.01) of soil OC and OM content in different land use/land cover types. The difference is very strong between agroforestry and cropland. They are relatively highest on soils of agroforestry (the overall mean being 2.4±1.0 for OC and 4.3±1.8 for OM) and shrub lands (the overall mean being 2.06±0.63 for OC and 3.56±1.08 for OM) than soils in cropland (1.49±0.73 for OC and 2.57±1.26 for OM) and grazing lands (1.71±0.81 for OC and 2.95±1.48 for OM). It implies there is more supply of litters and return of OM to the soils under agroforestry and shrub land system and low OC on crop lands is due to removal of biomass from the field. In agreement to this, in Southern Ethiopia, OC content of soils in _*Birbira*_ (*Millettia ferruginea*) dominated agroforestry was higher than the carbon content of soils of open fields (Hailu et al 2000). In Ameleke micro-watershed, a soil on the agroforestry and shrub lands seems good terrestrial sequesters, though carbon content is declining with depth. This might be because it is on the top soil where more biological processes take place. By scientific community, it is frequently cited that clay soil has high organic carbon. But croplands of Cheketa Area in Ameleke micro-watershed have clay soil and in parallel low organic carbon. This might be due to relatively more tillage practices on cropland. Tillage practice is responsible for reduction in organic matter of the soil (FAO 2005).

Total Nitrogen (TN)

In Ameleke micro-watershed, TN content of the surface soil is mostly greater than 0.1% and of course, there is a variation of it among different land uses and land cover types. ANOVA showed there is significant difference ($P < 0.01$) in TN among land use/ land cover types. Low TN is observed on croplands. This is due to more tillage and no addition of fertilizer that replaced the removed TN by continuous tillage. The result of this study agrees with several studies conducted in Ethiopia and elsewhere (e.g., Yifru and Taye 2010; Eyayu et al 2009).

Available Phosphorus (AP)

Among the properties of soil subject to laboratory analysis, AP content of the soil in Ameleke micro-watershed showed a large deviation among land use/land cover types. For instance at 0-15 cm soil depth, it appeared 1.83ppm on grazing land and 43.72ppm on agroforestry land of Cheketa Area. AP is highest on agroforestry and shrub lands while it is lowest on grass lands of all case study areas, which is similar to organic carbon and organic matter. This is in agreement with studies such as Tornquist et al (1999) and Hailu et al (2000). In Costa Rica, Phosphorus content of the surface- 25cm depth of soil of agroforestry was higher than soil in pasture land (Tornquist et al, 1999). In Southern Ethiopia, phosphorus content of soils in *Birbira* (*Millettia ferruginea*) dominated agroforestry was higher than the phosphorus content of open fields (Hailu et al 2000). In contrast to this study, there was no difference on the phosphorus content of the soil under primary and secondary forest, seasonal agricultural land, pasture land and fruit plantation on tropical soils, southeast Mexico (Geissen et al 2009).

Available Potassium (AK)

Potassium content of soils in Ameleke micro-watershed have slightly higher available potassium with the average value of 1.94 Cmole/kg than Potassium content of tropical soils with the average value of 1.65Cmole/kg (Hartemink, 2006). The ANOVA analysis revealed that there is significant difference ($P<0.01$) of AK among land use/ land cover types. It is highest on agroforestry and lowest on cropland. Similar to this study, potassium content was among the soil properties showed a significant difference on the top soils of _*Bisana*_ (*Croton macrostachyus*) trees dominated agroforestry land and lands away from _*Bisana*_ (*Croton macrostachyus*) trees in north-western Ethiopia (Yeshanew et al 1999).

Soil pH

The overall pH value of the studied watershed ranges from moderately acidic (pH 5.56 on cropland of Cheketa Area) to neutral (pH 7.16 on agroforestry land of Debeka Area). ANOVA and LSD post hoc multiple comparisons revealed that there is insignificant difference (at 0.01 probability level) in pH value of soils found on different land use and land cover classes.

Cation Exchange Capacity (CEC)

The soils of Ameleke micro-watershed have good CEC than tropical soils. In tropical region, soils of bush vegetation and permanent cropping have CEC of 12.5 Cmole/kg and 8.8 Cmole/kg respectively on the top 15cm depth (Hartemink 2006). But CEC of soil of Ameleke micro- watershed ranges from 29.2 in croplands at Cheketa Area and 55.6 on the grass lands of Gololcha Area. The ANOVA test did not yield significant difference at 0.01 probability levels among land use/ land cover types. This result is different from several studies (e.g., Nega and Heluf 2009).

Soil Texture

In the croplands of Cheketa Area, the soil constitute on the average 48% clay, 27% sand and 24 % silt. While in the croplands of Gololcha Area the soil constitute on the average 46 % sand, 27 % s clay and 27% silt. ANOVA further ensures soil texture is significantly changing within land uses of in the study areas within the watersheds. This finding is different from the general accepted knowledge that 'soil texture is the property of soil which is not subject to easy modification' (Brady 2002). Similar studies, for example, Agoumé and Birang (2009) concluded that LUCC significantly determine soil texture on their study in Cameron. But in Bako area of western Oromia, Ethiopia, soil texture did not show any change between '*Zigba'* (*Cordia africana*) dominated agroforestry and open fields (Abebe et al 2001).

Soil Color

Soil color helps to indicate OM content, water content, and oxidation states of iron and manganese oxides in the soil. In Ameleke, there is a difference in soil colour between different land uses. 2.5YR2.5/4 and 10YR3/3 from crop lands, 10YR2/1 and 2.5Y3/2 from agroforestry land and 5YR4/3 from grass lands were identified. On agroforestry land the soil has relatively black color and at the same time the soil has high organic matter content. On crop land soil has dark reddish brown color. It seems that there is oxidation of iron on cropland use. The soil has reddish black and grayish color on shrub land. In agreement to this Study, Maranon et al (1997) have found that vegetation cover type was among the principal factors of soil color change and soil color is strongly correlated with texture, organic carbon content, Cation Exchange in the Mediterranean region.

4. Conclusion

The study revealed considerable land use change in the Ameleke micro-watershed in the last three decades. In the upland (> 1800 m.a.s.l), agroforestry and cropland are the major types of land use/land cover types. While grass and shrub lands are found the dominant land cover types in the middle (~1500-1800 m.a.s.l) and lower altitude (~1200- 1500 m.a.s.l) of the watershed. The LUCC study showed an increase on crop land, mixed cover and agroforestry land use types, while decreases on grass land, shrub land and riverine forest for the period 1980s to 2006. An increase on mixed cover is a way for a change of shrub and grass lands in to crop land. The analysis of the pattern of change discloses that agroforestry is moving downslope from the upland to the middle altitude. Generally, the increasing trend of cropland in Ameleke in recent decades is a little different from other parts of Ethiopia, particularly from the Northern part whereby expansion of crop land reached its upper limit and started to slowed down since 1980s.

In Ameleke micro-watershed, there is a significant difference in soil properties among land use/ land cover types (LULCs). Soil AK, TN, OC, OM, texture and color are significantly different when compared to (i) the LULCs of the entire watershed and (ii) within the LULCs of different altitudinal belts of the watershed. The differences are mostly found between (i) agroforestry land and cropland, (ii) agroforestry and grass land, (iii) shrub land and crop land and (iv) shrub land and grass land. But there is no significant difference in soil CEC and pH among land use/ land cover types. The difference in soil properties among LULCs is more significant on 0-15 soil depth than on 15- 30cm soil depth. Generally, it is fair to conclude that (a) LUCC causes change in soil physical and chemical properties and (b) agroforestry type of land use is in line withsustainable land management practices at least from soil resources perspective in the Ameleke micro-watershed.

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