ORIGINAL ARTICLE

Land use /land cover change and its implications on socioeconomic condition of farmers in Machakel Woreda, Ethiopia

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Abstract

Land use / land cover changes derived from the natural process and anthropogenic interference in ecosystem. Appropriate management of natural resources requires quick and up-to-date information for effective decision-making. The main objective of this research is to investigate the effects of land use / land cover (LULC) change on the socio-economic conditions of Machakel woreda. Remote sensing and geographic information system approaches are employed and socioeconomic survey was also conducted to see the impacts of land use / land cover change on socioeconomic condition of farmers. Results of the analysis indicated that farmland and settlements increased consistently every year with the rate of 7.59 km2 (1.02%) per year. The main driving forces of these changes are the population pressure and associated higher demand of land for farm and housing purpose. Shortage of clean water, higher rate of soil erosion, lower crop productivity, and land share related conflicts in the study area are also considered as main causes. Increasing number of animal population in contrast to the decreasing amount of grazing lands created the overgrazing of the area, which results loss of top soil through erosion. This fact calls for the need of taking measures like income diversification for agricultural families and a different way of rearing cattle than keeping them on the already over grazed lands.

Key words: *LULC change, Remote sensing, GIS, Controlled grazing, Alternative energy*

Introduction

Land use/land cover change has been believed to be the most ancient of all human induced environmental changes on the landscape. Starting from the domestication of plants

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and animals and control of fire, humans have been altering and modifying the landscape in an irreversible manner (Lambin *et al.*, 2003). Nonetheless, in the global history, an abrupt and massive land use change started in the 17th century associated with agricultural expansion and industrial revolution (Goldewijk & Ramankutty, 2004). Due to anthropogenic activities, the earth surface is being significantly altered in some manner, and humans' presence on the earth and their uses of land have a profound effect upon the natural environment, causing an observable pattern in the land use/land cover change over time (Opeyemi, 2006). One of the countries, where deforestation and land degradation are the underlying issues of land use /land cover change is Ethiopia. Though estimates vary about its extent and rate, no environmental problem is aggravated as deforestation especially in the northern parts of the Ethiopia. Empirically, deforestation rate is estimated to be between the range of 150,000 and 200,000 hectare per year. This makes the average annual rate of deforestation in the country 0.8 up to 1.05 % per year (Earths trend, 2003).

Machakel *woreda* is known for its surplus food production from East Gojjam zone. However, the recent high pressure from humans and livestock population has put a colossal pressure on the natural resources of the *woreda*. Recent studies done by Fekadu (2015) indicated that the land degradation in the region has become severe, needing immediate intervention. The livelihood of the community is based on agriculture and mixed farming systems that are exposed to rapid deforestation due to a reasonable agricultural potential that reflected in the diversity of crops and animal resources. In order to improve the environmental condition of the area without further deteriorating the bio environment, every bit of the available land has to be used in the most rational way. Very little, however, is known about the time and magnitude of the changes undertaken. This makes it difficult to predict the future and to prepare a possible mitigation plan. By identifying the socio-economic impacts of land-use change at a *woreda* level, this study intends to contribute to recent efforts to integrate land-use planning at the *woreda* and *Kebele* levels into sustainable resource development strategies by using GIS and Remote sensing techniques.

Materials and Methods

Description of the Study Area

The study area is located between 10^0 19'75" to 10^0 41' 00" N latitude and 37^0 16' 46" to 37^0 45' 42" E longitude (Fig. 1). Administratively it is called Machakel woreda, in East Gojjam Zone, Amhara regional state, Ethiopia. The study area has spatial coverage of 735.7526 km^2 and the population of about135,527. The woreda is estimated to have rural population density 128.39 persons/km^2 (Machakel wereda, 2014). The study area is located about 328km northwest of Addis Ababa and forms the parts of the North West highlands of Ethiopia.
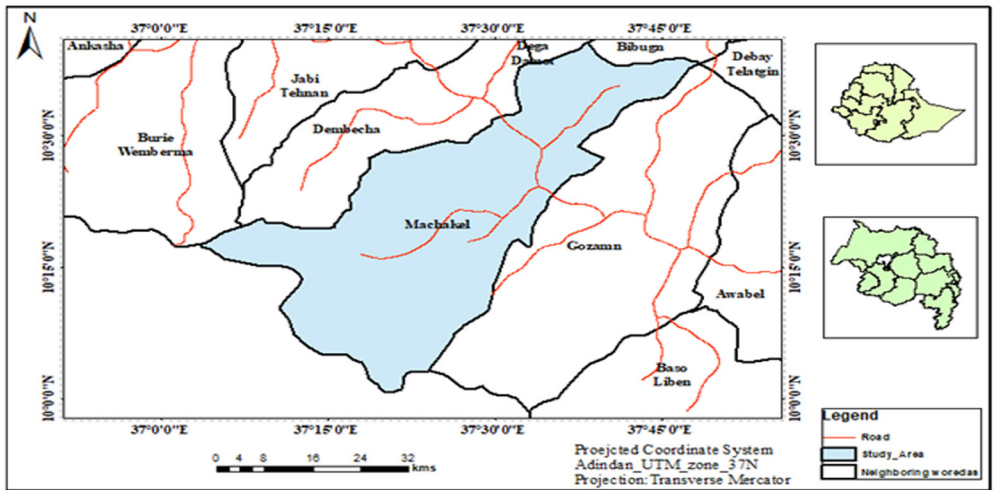
Fig. 1 Location map of the study area

Data sources and methods of collection

Satellite data

The data used to create the spatial data base in this study were obtained from United State Geological Survey (USGS) website which were taken in 1985 (MSS Landsat -5), 1994(TM landsat-5), 2004(ETM Landsat-7) and 2015 (OLI-TIRS landsat-8) in January (Table 1). This years and months were selected in order to have a clear difference with in each land use and land cover categories of the area. DEM (Digital Elevation Model) 30 m*30 m resolution was used for visualizing the three dimension of the study area which was used during image classification.

Acqui-sition Year	Data type	Time interval	Path/ Row	Obtained resolution	Used res-olution	Acquisition Date	Sensor type	Source	Purpose
1985	Land sat-5	Initial time	182/53	60m*60m	30m*30m	01 Jan 1985	MSS	USGS	classification
1994	Land sat-5	10 years	182/53	30m*30m	30m*30m	01 Jan.1994	TM	USGS	
2004	Land sat-7	10 years	182/53	30m*30m	30m*30m	12 Jan.2004	ETM+	USGS	
2015	Land sat-8 OLI-TIRS	10 years	182/53	30m*30m	30m*30m	01Jan.2015	OLI-TIRS	USGS	
2000	ASTER DEM	Initial	182/53	30m*30m	30m*30m	14Jan.2000		USGS	slope

Field data measurements and observations

The field data collections were done randomly to verify the classified image and to collect the necessary land use and land cover data for accuracy assessment. Total of 256 Ground control points were collected using Garmin Global Position System model 60 devices. The other field data were collected from focus group discussion (FGD) and interview. The FGD and Interview were done in kebele level and 16 FGD group and 16 interviewees were conduct. The respondents were elders, district leaders and administrative officials who are chosen for their concern to land and environmental protection where a significant land use and land cover changes are perceived within a given study time interval.

Land Use and Land cover Classification

The study area has been defined to have four LULC classes. These include farmland and settlements, forest, grassland and degraded land and woodlands. The cultivated land and settlements were merged into one category because it was difficult to recognize the scattered rural settlements as a separate land cover type from Land sat image. Also, cultivated land exists around homesteads. Hence, for practical reasons, the two land cover types were merged into one category. In addition, grassland and degraded land includes both open grazing lands and exposed lands. It was difficult to distinguish because the bare lands were identical with grazing lands, which were heavily degraded in the study area. As a result, they were classified together. The category and the description of these land cover classes were based on (IPCC, 2006). It provides general non perspective definitions for the six main land use categories as shown in table 2.

Table2: Description of land covers classes

No.	Land cover types	Description
1	Farmland and settlement	A land use category that includes areas used for the production of adapted crops for harvest, this category includes both cultivated and non-cultivated lands
2	Forest	A land use category that includes areas at least 36.6 m wide and 0.4 hectare in size with at least 10 percent cover by live trees of any size.
3	Grass land and Degraded lands	A land use category on which the plant cover is composed principally of grasses, grass like plants, forbs, or shrubs suitable for grazing and browsing.
4	Woodlands	Areas with sparse trees mixed with short bushes, grasses and open areas; less dense than the forest

Land use and land cover detection

A combination of information collected from field, local people knowledge, elders and natural resource experts through informal interviews and focus group discussions with satellite images used in the analysis of land use and land cover change detection. The land cover maps for the four-period series of images were analyzed based on land use and land cover types area comparison. The changes over 30 years were analyzed and rate of change for each land use land cover type is calculated. In the meantime, the rates of land use and land cover changes for the three periods from 1985- 1994, 1994 - 2004 and 2004-2015 were computed using the following formula:

$$R = \frac{Q2 - Q1}{T},$$

Where R= Rate of change, Q1=initial year land use/ land cover in km2, Q2 = recent year land use/ land cover in km2, T= time interval between initial and recent years (Geist and Lambin, 2002).

Finally, few informal interviews and focus group discussions were also conducted in the woreda to obtain additional information to know the causes and impacts of land use and land cover the changes on socio economic conditions of the woreda to fully strengthen the information already collected through formal ways.
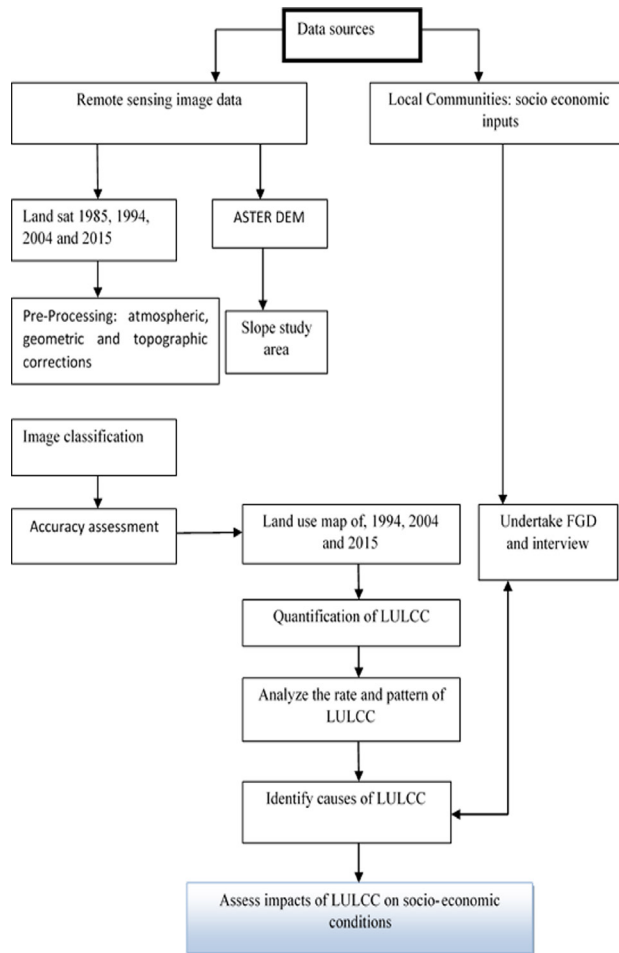

Fig. 2 Flow chart of the overall methodology

Results and discussions

Land use and land cover change detection

Land use land covers change detection between1985 and 1994

In the period between1985 and 1994, there was an increment of farmland /settlements and wood-lands but a decrease in the rest of land use and land cover classes (Table 4). In 1985, the farmland and settlements covered an area of 363.3 km2 and it increased to 463.3 km2 in1994. In the first period of analysis FS cover expands by 100.3_km2 as a result of, additional area gained largely from forests by about 167.5 km2 (52.2 %). On the other hand, forest cover was diminished by 119 km2 due to the conversion of the original forest cover mainly into farmland/settlements, grass land and wood lands. This possibly reflected the expansion of farmland and settlement at the expenses of natural forest covers. Similarly, wood lands expanded by 27.6 km2 in the first period of analysis due to additional area gain largely from farmland/settlement covers, and forests by about 17.6km2 (4.8%) and 24 km2 (7.5%) respectively.

In contrast, the grassland initially covered 33.2 km2 (4.5%) and decreased by 8.2 km2 due to loss of its original cover largely into farmlands by about 13.9 km2 (3.8%) and 8.8 km2 (2.7%) between 1985 and 1994 (Table 4). This shows the increasing in usage of grass lands for farm and settlements.

Table 3: LULCC matrix between 1985 and 1994

1985		1994					
		FS	F	GD	W	Total	
	Class Name	km²	km²	km²	km² %	km²	%
	FS	267.67	63.93	13.86	17.5563	363.0231	49.37
	F	167.53	117.57	8.8	23.9229	317.8269	43.22
	GD	13.29	13.088	1.12	5.6511	33.1533	4.5
	W	14.77	3.70	1.05	1.8009	21.3363	2.9
	Total	463.2696	198.2934	24.8454	48.9312	48.9312	735.3369
	Class Change	+100.2456	-1195335	-8.2979	+27.5949	+27.5949	

FS= farmlands and settlements, F=forest, GD= grasslands and degraded land and W= woodlands.

Land use land covers change detection between1994 and 2004

In the period between 1994 and 2004, there was an increment of farm land /settlements while the other classes decrease (Table 5). In 1994, the farmland and settlements covered an area of 464.2038 km2 (63%) and it increased to 666.2 km2 (90.4%) in (2004) on this period of analysis FS cover expands by 201.95 km2 as a result of, additional area gained largely from forests by about 158.54 km2 (79.8 %). On the other hand, forest cover was diminished by 163 km2 due to the rapidly conversion of the forest cover into farmland/settlements. This result shows the rapid expansion of farmland and settlement at the expenses of natural forest covers. Likewise, wood lands and Grass lands diminished by 33.6 km2 and 5.3 km2 respectively during this period of analysis due to additional area gain largely from farmland/settlement covers.

Table 4: LULCC matrix between 1994 and 2004

		2004					
		FS	F	GD	W	Total	
	Class Name	km^2	km^2	km^2	km^2 %	km^2	%
	FS	444.8673	8.5743	5.0607	5.7015	464.2038	63
	F	158.5431	26.2188	9.288	4.5972	198.6471	26.96
1994	GD	23.1633	0.4041	0.6705	0.6543	24.8922	3.37
	W	39.5757	0.4437	4.5423	4.4478	49.0095	6.65
	Total	666.1494	35.6409	19.5615	15.4080	736.7526	
	Class Change	+201.9456	-163.0062	-5.3307	-33.6015		

FS= farmlands and settlements, F=forest, GD= grasslands and degraded land and W= woodlands.

Land use land covers change detection between 2004 and 2015

In the period between 2004 and 2015, there was an increment of farm land /settlements, forest and grass lands on the expense of wood lands which shows a decrease in total area (Table5). In 2004, the farmland and settlements covered an area of 666.14 km2 (90.41) and it increased to 667.20 km2 (90.56) in 2015. In this last period of analysis FS cover expands by 1.05km2 as a result of, additional area gained from forests by about 4.923 km2 (0.07 %). Similarly, forest cover increased by 7.9 km2 due to the conversion of farm/settlement in to forest by 16.08km2 (36.94%), grass land by 0.567km2(1.3%) and wood land by 0.77km2(1.7. This possibly reflects the expansion of forest in the last analysis year.

In contrast, wood lands decreased by 11.5542 km2   in the last period of analysis due to additional area lose to farmland/settlement covers, and wood lands by about 0.3798km2 (9.8%) and 0.3717 km2 (9.66%) respectively. In comparison, the grassland in 2004 covered 19.57 km2 (2.65%) and increase by 2.6 km2   due to a gain of cover from farmlands/ settlement   by about 5.6025 km2 (25.8 %) and 1.4391 km2 (6.5%) between 2004 and 2015 (Table 6).

Table 5: LULCC matrix between 2004 and 2015

		2015					
		FS	F	GD	W	Total	
	Class Name	km^2	km^2	km^2	km^2 %	km^2	%
	FS	644.0823	16.0848	5.6025	0.3798	666.1494	90.41
	F	4.923	26.1189	4.599	-	35.6401	4.83
2004	GD	8.0983	0.567	10.5246	0.3717	19.5623	2.65
	W	10.0998	0.7668	1.4391	3.0951	15.4008	2.09
	Total	667.2033	43.5375	22.1652	3.8466	736.7526	
	Class Change	+1.0539	+7.8974	+2.6029	-11.5542		

Farmland and settlements: The area of land that was occupied by farmland and settlements in all four Landsat images took the first rank in terms of area coverage in the study

area. The farmland and settlements have converted mainly from forest areas and also from grass /degraded lands and woodlands. According to the information gained from the FGD (focus group discussion) and interviews the farmland and settlements increased between 1985 and 1994 mainly due to the 1975 national land reform which is made following the coming to power of the Derg regime in 1974. Similar studies by (Woldeamlak, 2002) and (Yigremew, 1997) showed that the land reforms distributed much of the communal lands, such as grass land, forests, wood lands and marsh areas to landless peasants for the purpose of cultivation and thus increased farmland and settlements between 1985 and 1994.

Moreover, the farmland and settlements showed increasing pattern of change during the second period compared (1994 to 2004). Farmland and settlements have converted mainly from forest areas, and also from grass land /degraded lands and woodlands. According to the FGD and interview, the farmland and settlements increased between 1994 and 2004 due to the most recent land redistribution of 1997 in the Amhara Regional state. This justification of the FGD is consistent with (Yigremew, 1997), which distributed much of the woodland to landless young peasants for cultivation. Due to the above stated reasons the farmland and settlements were increased during the period that this comparison had made.

Similarly, the farmland and settlements showed increasing pattern of change during the third period of comparisons (2004 and 2015). The farmlands and settlements were converted mainly from woodlands and grasslands. Based on FGD and interviews, the reason that the farmland and settlements increased between 2004 and 2015 was purely due to the population pressure and associated increased demand of land for farming by the new generation. This assertion was similar to the study conducted by Haile, (2004).

Forest: The area of land that was occupied by forest depicted decreasing in the periods between 1985and 1994. The forest has mainly converted to farm lands and settlements and grasslands. According to FGD and interviews, the forests decreased between 1985 and 1994 because of the 1975 national land reform of the military regime. This justification has matched with (Yigremew, 1997), which indicated that the reform has helped the people to open the road to clear out the natural indigenous forests for the purpose of widening up their agricultural area to get higher agricultural fields that can meet the higher demand of families for food. Due to these reasons, the forest has decreased during this period. Furthermore, the forest showed decreasing pattern of change during the second periods of 1994 to 2004. The forest was changed mainly to farmland/settlements and grasslands. Based on FGD and interviews, forest lands decreased during this period due to the most recent land redistribution of 1997 in the Amhara Regional state. This reason is also mentioned in (Yigremew 1997), which proved that it distributed much of the forested areas to landless young peasants. In addition, the landless young peasants had deforested illegally more than the area given by the administrators so as to cultivate virgin lands. Due to this reason the forest areas were decreased during the period.

However, the forest showed increasing pattern of change during the third period of comparison (2004 and 2015). It has gained some parts mainly from farmlands. According to FGD and interviews, the forest coverage increased between 2004 and 2015 as the government engaged in training professional natural resource protectors in the rural region so as to keep and preserve the natural forests free from any adverse interventions and destructions. In addition, the other important factor for the increased area coverage of forests was the house hold level planting of trees in the farmlands, grazing and degraded lands as a response to the increasing shortage of natural forests thus increased the forest. This justification agreed with (the ideas of Woldeamlak, 2002) which supported the gov-

ernment's afforestation and reforestation programs that has promoted the areal increase of forests.

Grassland and degraded lands: Grassland and degraded land included both open grazing lands and degradation exposed lands. This is because, it was difficult to distinguish open bare lands from grazing lands as they were heavily degraded in the study area. As a result, they were classified together. The area under the grassland and degraded land showed decreasing pattern of change during the first period comparison in between 1985 and 1994.The grassland and degraded land have converted in to farmland and settlements and forests. According to FGD and interviews, the grassland decreased mainly due to 1975 national level land reforms, which distributed much of the grazing land to landless peasants for the purpose of cultivation. Also, the grasslands portrayed decreasing pattern of change during the second period comparisons between 1994 and 2004. The grasslands are converted into forests and farmlands/settlements. According to FGD and interviews, the grassland and degraded lands decreased in between 1994 and 2004 due to the illegal owning of grasslands for the purpose of farming and tree planting and even for settlement activities.

In contrast, grass lands and degraded areas showed increasing pattern during the third period of comparisons between 2004 and 2015. The grasslands have converted mainly from farmland/settlements and forests. According to FGD and interviews conducted with the local people in the study area, the major reason for the increase in the area extent of grassland and degraded land was due to the illegal deforestation during the national land reforms of 1975 which opened the way to the community to change the forest into woodland then gradually the woodland again changed to grassland. Farm lands and settlements were also converted into degraded lands due to the obligatory villagization program of 1985 and 1986.during the resettlement, the early residential areas mostly remained degraded lands.

Woodlands: This type of vegetation have covered the fringes of forested areas and sprawled towards the grassland and degraded land. They showed increasing pattern of change during the first period of comparison (1985 and 1994). Based on the FGD and interviews conducted with the local people in the woreda, the woodland increased between 1985 and 1994 owing to the proclamation of 1975 national land reforms which made the landless peasants' owners of cultivation area in the different parts of the woreda mainly on the edge of virgin forest and grasslands. As a result, most landless peasants scrambled the surrounding forest and grasslands so as to alter them to private agriculture areas and thus the peasants planted trees on grassland areas, transforming them into woodland.

However, the woodlands portrayed decreasing pattern of change in the last two periods of comparisons (1994-2004 and 2004-2015). In these periods, woodlands converted mainly to farmland, settlements and grassland that eventually became degraded land. Based on FGD and interviews conducted with the local people, "the woodland decreased following 1997 land redistribution pledged in Amhara Regional State." This idea agreed with the findings of (Yigremew, 1997), which sated the landless peasants totally controlled and scrambled surrounding woodlands and changed in to crop and grass lands. The FGD and interviews reports also indicated that the woodland converted to farmlands due to population pressure, which distributed much of the open communal property of woodlands to the small-scale youngsters' associations by government for the purpose of increasing agricultural production in the rural areas.
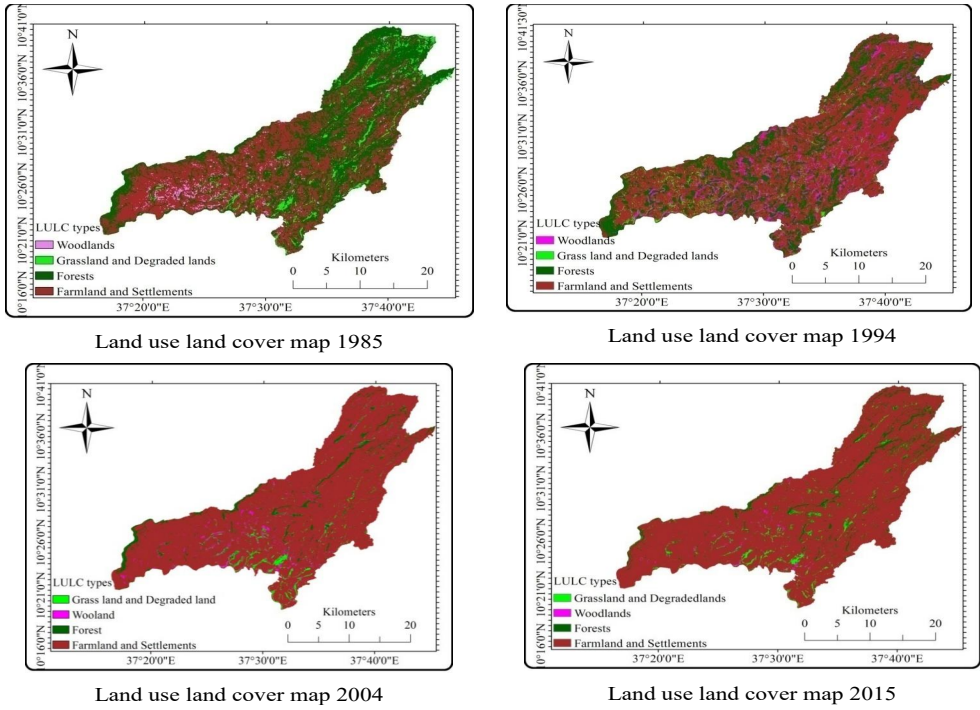
Land use land cover map 1985

Land use land cover map 1994

Land use land cover map 2004

Land use land cover map 2015

Fig. 3 Land use land cover map of the Study area

Table 6: Rate of land use land cover change

Class Name	1985 (Area in km^2)		1994 (Area in km^2)		2004 (Area in km^2)		2015 (Area in km^2)	
FS	363.0231	49.37%	464.2038	63%	666.1494	90.41%	667.2033	90.56%
F	318.8269	43.22%	198.6471	26.96%	35.6401	4.83%	43.5375	5.9%
GD	33.1533	4.5%	24.8922	3.37%	19.5623	2.65%	22.1652	3.0%
W	21.3363	2.9%	49.0095	6.65%	15.4008	2.09%	3.8466	0.52%

FS= farmlands and settlements, F=forest, GD= grasslands and degraded land and W= woodlands.

Socio-economic effects of the LULCC

Substantial changes in LULC have been witnessed by the time series Landsat images analysis over the entire study period. However, these changes were not only on the land but they also had a direct impact on the socio-economic conditions of the study area. From the FGD and interviews done with people of the study area who know better about the land use changes because of their long-time residence in the area under study. The researcher has identified negative impacts that are observed in the study area.

Water sources dried. Water sources for household use have been excess and can be found easily in many places in the study area in the form of springs, streams and water-holes. According to the information gained from the FGD and interviews, water sources are drying faster and easy access to water has become increasingly difficult. Traditionally women are given the responsibility of fetching and fulfilling the water needs of families but they are currently facing challenges of accessing clean water than ever before. The cattle and other domestic animals are also in danger of totally losing the water sources like springs and streams that are drying every day. Boys who look after the animals have witnessed the problem of finding water for the animals as indicated by the interviewees.

Forests services gone. There are regulatory ecosystem services that forests provide to the society. However, the study area has lost much of its forest resources in a very short time. So, this area has encountered environmental problems like temperature increase and fluctuation of rainy seasons. From the FDG and interviews it can be understood that forests of the study area were sources of grass for animals as they were shelters for many wild animals. Firewood for most households has also been mainly gained from the forests. However, the regulatory services and other importance of the forest cover are proved to be lost in the study area following the misuse and conversion of the forestland into other land use types.

Grazing lands limited. There have not been problems of grazing lands for home animals in the study area as the residents interviewed witnessed. But following the conversion of grasslands into other land use types, feeding animals has become an issue for rural families. Keeping them at home and feeding them as much as needed is not something that the farmers cannot easily afford. The number of animals has decreased considerably as the grazing land is almost inadequate to support as much animals as needed.

Decrease in crop production of farmlands. Farmlands which are used without artificial fertilizers have shown significant decline in the amount of yield obtained. All the farmers are not equally interested and capable of applying fertilizers on their farms even if they know that the soil fertility of farmlands has declined and they do not produce as much as they expect. Farmers that are interviewed indicated that there are some farmers who are economically weaker and do not afford to pay for fertilizers. And, the amount of crop produced in these farms is lower than the average expected.

Land related Conflicts. The rapidly increasing population number and illegal land controls for farming by young peasants has caused conflicts among the society. As the information gained from FGD and interviews these conflicts are becoming common even in a family member who share the same parenthood.

Conclusion

By applying GIS techniques for remotely sensed Landsat images and conducting socio economic surveys, this study is aimed at investigating the effects of LULCC on the socio-economic conditions of the study area. The spatiotemporal land cover dynamics are analyzed and detected by using ERDAS IMAGINE and the results are integrated with information gained from FGD and interviews. Based on the results obtained from the analysis, the study area has shown consistent land use and land cover changes. This can be seen from the land use types classified and their proportion within study time. Farm lands and settlements are increasing at the expense of the other land use types specially forest. Grasslands and woodlands have also decreased their proportions and become limited to smaller areas. Socio-economic effects of the land use land cover change are investigated

from the information collected through interviews and focus group discussions. The main effects are shortage of water sources for household use and animals, higher soil erosion and associated loss of soil fertility, absence of the regulatory and provisional services to be gained from forests, and occurrence of conflicts even within families on share of land. This study advocates that the multitemporal satellite data is very useful to detect the change in land use and land cover and to see its impact on socioeconomic comprehensively.

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