Trends of Land Use/Cover Changes in Mandura District, Benshangul-Gumuz Regional State, Ethiopia

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Abstract: The main objective of this study is to investigate trends of land use/cover changes since the 1980s in Mandura district of Benshangul-Gumuz regional state. A total of 210 farm households from three kebeles: 105 from the local people and 105 from migrants were surveyed in May 2011 to acquire data on socioeconomic and land use. Aerial photographs of 1982 and SPOT-5 image of the 2006/07 were used to generate data on land use/cover changes. The results of this study indicate that respondents perceive that there were land use/cover changes in the study area since the 1990s. In view of this, respondents feel that bamboo trees, grazing land, grassland as well as wildlife have shown decline since the 1990s. The aerial photograph and spot-5 image analyses reveal the same result. Of the total 35, 386 ha of land that underwent conversion, farmland constituted 85.5%, riverine trees 12.4% and settlements 2.1%. The major drivers of land use/cover changes identified by respondents were population increase which in turn has triggered expansion of agriculture and deforestation. Consequently, the indigenous population has faced land shortage for practicing shifting cultivation. Furthermore, they were forced to change their livelihoods which in turn triggered natural environment degradation because of charcoal and wood selling practices. The study finally concludes that trends in land use/cover changes are evident and needs proper attention and appropriate interventions.

Keywords: Indigenous Population; Land Use/Cover Change; Migrants; Shifting Cultivation

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1. Introduction

Needless to say, Ethiopia is a country predominantly dependent upon agriculture for employment, foreign exchange as well as source of livelihoods for millions of smallholders. Agriculture in Ethiopia is mainly reliant upon natural resource stocks. In this case, good agricultural lands, fairly distributed rainfall throughout the year as well as other good biophysical factors are indispensable to carry out agricultural activities successfully. The reality on the ground reveals a different scenario where good biophysical conditions are rarely found in the country. Ethiopia can broadly be classified into three physiographic regions: the highlands, the lowlands and the rift valley. The highlands are favorable climatically, suitable for practicing agricultural activities and less infested with tropical diseases like malaria and trypanosomiasis, thus, attract millions for habitation (Kloos and Adugna, 1989). As a result, these areas, specifically the north, happen to be the most vulnerable and degraded physiographic regions in the country (Bruene, 1990; Woldemariam, 1990; Berisso, 1995; McCann, 1995; Nyssen *et al*., 2009). As a consequence of human and livestock population growth and heavy economic activities concentration, land suitable for cultivation is running short in much of the highland regions of the country (Tekle and Hedlund, 2000; Zeleke and Hurni, 2001; Tegene, 2002; Bewket, 2003; Amsalu, 2006; Garedew *et al*., 2009; Tsegaye *et al*., 2010). Furthermore, heavy concentration of both human and livestock population accentuated biophysical loss and eventually induced over grazing and soil erosion that in turn led to land degradation (Nyssen *et al*., 2009). The situation mentioned above with repeated famine and drought forced the government to initiate resettlement to the lowlands. Furthermore, individuals have also been forced to move to the lowlands in search of arable land. Consequently, a similar pattern of natural environment depilation has occurred in the lowlands as well. In the study area too, a similar situation has prevailed since the mid 1980s following massive government supported resettlement and self initiated in migration from the surrounding regions since the 1960s (Mekuria, 2008). Such movements have gradually resulted in demographic pressures to happen in the study district.

Land use/cover changes are one of the most important environmental concerns worldwide. This is so because it has direct link on the planet's climate change, ecology and human society (Campbell *et al*., 2005). Land use/cover changes are the outcomes of interplay of many factors. The simple assumption that land use/cover changes have caused by few factors do not hold true rather many interrelated complex factors best explain the processes (Lambin *et al*., 2001; Lambin *et al*., 2003). The same authors further contend that "Identifying the causes of land-use change requires an understanding of how people make land-use decisions and how various factors interact in specific contexts to influence decision making on land use" (Lambin *et al*., 2003). Decision making processes in turn are affected by different factors prevailing at local, regional and global levels.

Different researchers have put the reasons for land use/cover changes into two broad categories as proximate (direct) and underlying (indirect or root causes) (Geist and Lambin, 2002). The same source further contends that proximate factors occur at

local or household/farm level whereas underlying factors emanate from regional, country or even global level. As a consequence, proximate variables are context and region specific while the root causes on the other hand will be the result of complex political, economic and social conditions occurring at a distance (Lambin *et al*., 2003). Farm level analysis allows to address proximate causes and to interpret them in reference to underlying causes (Mottet *et al*., 2006). Long *et al*. (2007) identify industrialization, urbanization, population growth, and economic reforms as major factors of land use changes in Kunshan, China. Another study in Zimbabwe also recognized that pressure for agricultural land, building materials and fuel wood triggered land use/cover changes (Mapedza *et al*., 2003). Cropland expansion by stallholders in Africa is most prevalent whereby it intensifies and/ or the main cause of land use/cover change. Since the 1850s Africa and other regions like south and Southeast Asia, Latin America and Australia experience rapid land use/cover changes (Lambin *et al*., 2003). The degree of this change considerably varies from country to country. Land use/cove change is the manifestations of changing human demographics, natural resource uses, agricultural technologies, economic priorities, and land tenure systems" (Wolter *et al*., 2006).

A study conducted in Afar, identifies more than fifteen factors that cause land use/cover changes (Tsegaye *et al*., 2010). The driving forces documented in the study include migration from nearby highlands triggered by drought, land tenure and government policy changes (Tsegaye *et al*., 2010). Another study in the Central Rift Valley of Ethiopia reveals that population growth, decline in agricultural productivity, land tenure change and erratic rainfall have the major drivers of land use/cover in the area (Garedew *et al*., 2009). The land use/cover changes study in the northwestern Ethiopia comments that population dynamics, existing land tenure, institutional and socioeconomic conditions should be critically examined before experts devise any land related policy (Zeleke and Hurni, 2001).

In sum, the factors that affect land use/cover changes are complex and interrelated. The study of land use/cover changes demands a careful investigation of these complex and interrelated factors at local levels. Of the few available studies conducted in the study area, the method of data acquisitions were gravitated more towards the ethnographic and historical methods (Yntiso, 2003; Abute, 2004; Endalew, 2006; Mekuria, 2008). While those studies are important for acquisition of qualitative information on the ground, they fail to capture and quantify changes in the biophysical variables of the study area. This study attempts to fill this gap by employing a range of data acquisition methods, viz., aerial photographs, satellite imageries, field surveys, and group discussions. Furthermore, the previous studies in the study area did very little to unravel the complex factors and linkages between land use changes and associated environmental changes.

The general objective of this study was, therefore, to examine trends of land use/cover changes. Specifically the objectives were to: (a) asses views of different actors on land use/cover changes; (b) identify and categorize major drivers of land

use/cover as perceived by different actors; and (c) expound major problems encountered due to change in land use/cove at community level.

2. Research Methods

2.1. Description of the Study Area: Mandura District

The study was conducted in Mandura district, Metekel zone of Benshangul-Gumuz regional state. Mandura is situated between 10^0 50' 743 N and 11^0 10' 766'' N and 36^0 02' 48''E and 36^0 32' 42''E longitude, about 546 kilometers away from Addis Ababa, the capital of Ethiopia. The total area of the district is about 1,100 square kilometer. Physiologically it is part of the northwestern lowlands where many development endeavors are currently taking place.

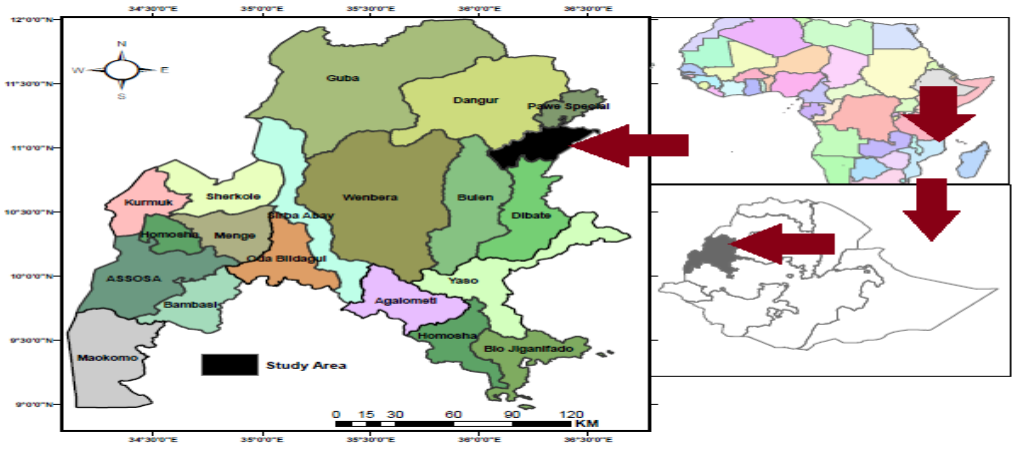

Figure 1. Location map of the study area

According to the third Ethiopian national census, Metekel zone has a total population of 276, 367 of which Mandura district constituted 14.74%, 40746 people (CSA, 2008). Rainfall and temperature records for the last twenty four years (1987-2011) are computed from the data obtained from Pawe metrological station. The mean annual amount of rainfall received by the study station amounts to 1579.8 mm. More than 65% of the total annual rainfall is mainly concentrated between June and August. In fact the six months from May to October account a little greater than 96% of the total annual rainfall and these months are also the months during which the main agricultural activities are carried out. The average annual temperature of the area is 24.5^0C. The corresponding amounts of maximum and minimum temperatures are 32.6^0C and 16.4^0C respectively. In general the study district is classified under the wet tropical (wet Kolla) agro-climatic region. With regard to altitude it ranges from 1015m to 1480m above mean sea level.

2.2. Data Collection and Analysis

This study attempts to figure out people's perception of the possible causes of land use/cover changes. Information has been generated through questionnaire surveys, in-

depth interviews and focus group discussions with indigenous people, migrants, local experts and policy makers at different jurisdictional levels. A total of 210 households selected through a stratified random sampling have been surveyed using structured and pre-tested questionnaire. A group containing 8-10 elderly people with deep knowledge of the study sites was selected for an in-depth interview and focus group discussions. The data were presented using figures and simple frequency tables.

Moreover, data pertaining to land use/cover changes were assessed by analyzing aerial photograph of 1982, remotely sensed image of the 2006/07 (Spot_5 image 2006/07), and toposheets with scale of 1:50,000 were scanned and used for geo-referencing the aerial photographs. Aerial photograph, satellite image (spot) as well as toposheets were acquired from the Ethiopian Mapping Agency (EMA). The digital aerial photograph was geo-referenced into a map coordinate system using the Universal Transverse Marketer (UTM) geographic projection using clearly observed and selected control points on 1:50,000 topographic map using ERDAS imagine 9.1 with 0.5 Root Mean Square (RMS) error. Then the VIRTUOZO software was used for removing all the errors in the aerial photographs and geo-referencing the images to UTM projection. Editing of the original image files was enhanced through sharpening with Adobe Photoshop Ver.5.0.

The aerial photograph was classified into different land use/cover types visually using a technique called onscreen digitization with the help of ArcGIS software. During interpretation of the photo those elements (tone, texture, shape, association, pattern and size) that aid for visual interpretation had been used.

Table 1. Sample size and profile of household respondents in Mandura

Characteristics	Sample Size
Number of Peasant Associations	3
Household heads interviewed	210
Percentage of total household heads	16.2 %
Age range (years)	22-80
Average age (years)	41.7
Average family size	6.2
Average land size(ha)	1.2
Male	161
Female	49

However, the satellite image was interpreted with aid of field collected ground truth using global positioning system (GPS) and ERDAS IMAGINE 9.1 software. The sample size and profile of household heads surveyed were presented as depicted in the Table above (Table 1).

3. Results and Discussion

3.1. Land Use/Cover Changes since the 1980s: Aerial Photograph and Spot Analysis

Attempt has been made to identify major land use/cover types using aerial photograph and satellite image of 1982 and 2006/07 respectively. The area coverage and spatial distribution of land-use and land cover types identified are presented in Table 2.

Table 2. Land use/cover changes in Mandura district between 1982 and 2006/07

Land use/cover classes	Land use/cover Changes				Area changes of Land use/cover
	1982		2006/07		1982-2006
	ha	%	ha	%	Ha
Forests	2598	2.59	0	0	-2598
Woodlands	15712	15.63	232	0.23	-15480
Shrublands	33649	33.48	24100	23.98	-9549
Grassland with scattered trees	5858	5.83	45	0.04	-5813
Bare land	5466	5.44	3520	3.50	-1946
Riverine trees	2502	2.49	6882	6.85	+4380
Farmland	34534	34.36	64800	64.48	+30266
Settlement	181	0.18	921	0.92	+740
Total	100500	100	100500	100	

3.1.1. Forests

As elsewhere in Ethiopia, the forest cover of the study area shows a gradual decline during 1982-2006/07. Forest cover decreased from 2.59% in 1982 to zero in 2006/07. In terms of land area the district lost 2,598 ha of forest cover between 1982 and 2006.

3.1.2. Woodlands and shrublands

In terms of area woodland is one of the largest land use/cover types in the study district. The proportion of woodland cover at different periods also shows change. In 1982 it constitutes 15.63%. The change was dramatic in 2006 where the proportion dropped to a mere 0.23%. Woodland loss in the district totaled 15,480 ha between 1982 and 2006.

Shrublands were one of the largest in terms of area in 1982 constituting a little more than 33% of the total area in the district. The proportion declined to 23.98% between 1982 and 1982, the second largest changes in the land use/cover category under consideration. Thus, a total of 9, 549 ha of shrublands have been converted to different land use/cover types over a period of 25 years.

3.1.3. Grasslands with scattered trees and bare land

Like land use/cover categories mentioned above, grassland with scattered trees follow similar pattern of decline. The grassland in the area has declined from 5.83% in 1982 to 0.04% in 2006. Overall, 5,813 ha of grassland with scattered trees have been converted into farmland between 1982 and 2006.

Bare lands have also been transformed into other land use types. Their proportion declined from 5.44% in 1982 to 3.50% in 2006. The conversion totaled 1,946 ha over a period of 25 years.

3.1.4. Riverine trees

In the study district, it is common to see trees growing along river banks. In fact, most tall trees in the district are found along the banks of rivers and streams. The information generated from land use land cover maps for different years reveals that this class of land cover constitutes 2.49% and 6.85% of the total area in 1982 and 2006 respectively. The trend shows a gain of 4,380 ha of land between 1982 and 2006 (Figure 2).

3.1.5. Farmland and settlement

Farmland expansion was huge and it is the largest land use type that gained the largest proportion of land from other land use/cover types. In 1982, farmlands constituted 34.36% of the total land area in the district but the proportion increased dramatically to 64.5% in 2006. Between 1982 and 2006, a total of 30, 266 ha of land have been converted to farmland. Of the total 35, 386 ha of land that underwent conversion, farmland constituted 85.5%, riverine trees 12.4% and settlements 2.1%.

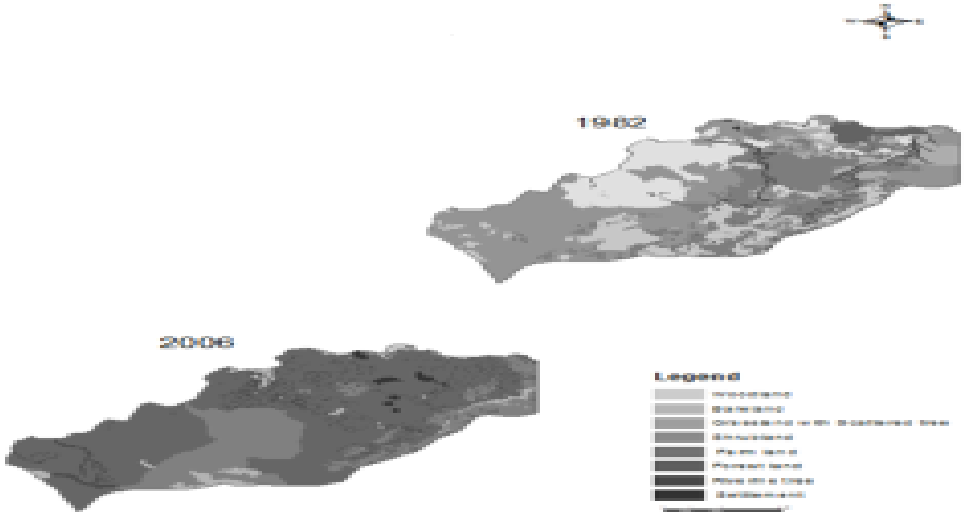

Figure 2. Land use/cover types in Mandura district in 1982 and 2006/07

Though a small increase, settlements have expanded between the study periods. The proportion of land under settlements constituted 0.18% and 0.92% between1982 and

2006 respectively. A total of 740 ha of land have been converted to settlements between 1982 and 2006.

3.2. Farmers' Perception on Land Use/Cover Changes

Subsistence farmers in many parts of the developing world have kept on changing the natural environment in an effort to feed themselves. Basically this change is closely associated with the changing situations prevailing in the area as well as at national and global levels. Anthropogenic influences on the natural environment can be expressed in terms of gradual conversion or complete change of the natural environment. In the study area too, complete change as well as conversion of the natural environment has been evident since the 1980s and before. An attempt has been made to understand how the local population perceives the changes that have taken place some years back. Consequently, four land use/cover categories were identified and farmers were asked to give their views on how these changes occurred. As a result, the survey result yields the information depicted in the subsequent Figures.

The proportion of land under bamboo tree cover has been in a good condition in the 1980s. A little more than 57% of respondents reply favoring bamboo cover was high (Figure 3).

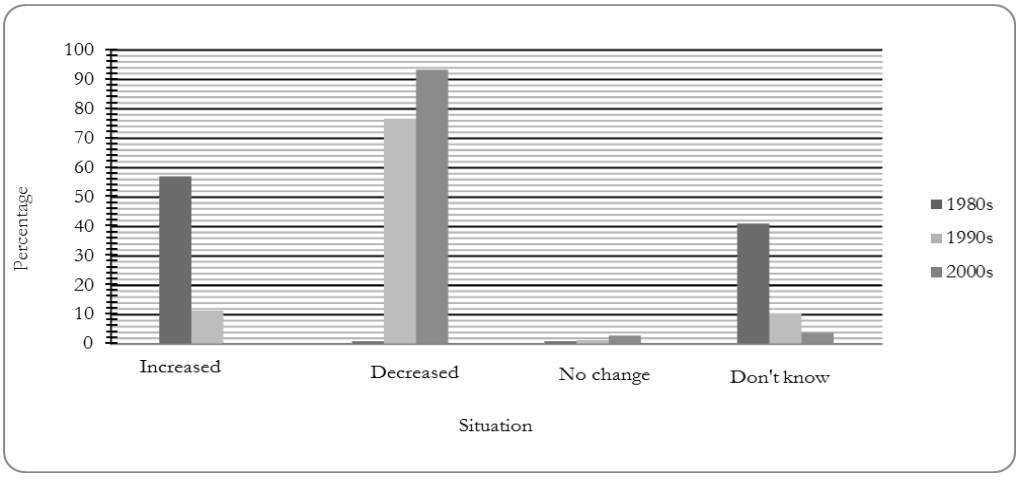

Figure 3. Distribution of farmers' view on bamboo cover changes, 1980s-2011

The figure further reveals that 76.7% of respondents state that bamboo tree cover has declined since the 1990s. In the same way in the 2000s bamboo cover has significantly declined as 93.3% of respondents have ascertained the situation. By the time this study was conducted (2011) many areas which were once covered with bamboo trees are devoid of this vegetation. The study by Embaye (2006) also indicates that bamboo can only be found in the protected spots and has totally disappeared from the rest of the area. The same author further pointed out the major drivers to be conversion to agricultural land, unsustainable cut for sale which eventually put the bamboo forest spectacular deterioration in the district.

Contrary to this, the proportion of arable land devoted for cultivation was small during the 1980s and increased since the 1990s (Figure 4). Partly the explanation is there was land redistribution in the nearby region (Amara region) which forced significant proportion of farmers to move to the study area. More than 92.4% of the respondents reaffirm that the proportion of cultivated land at present is significantly high.

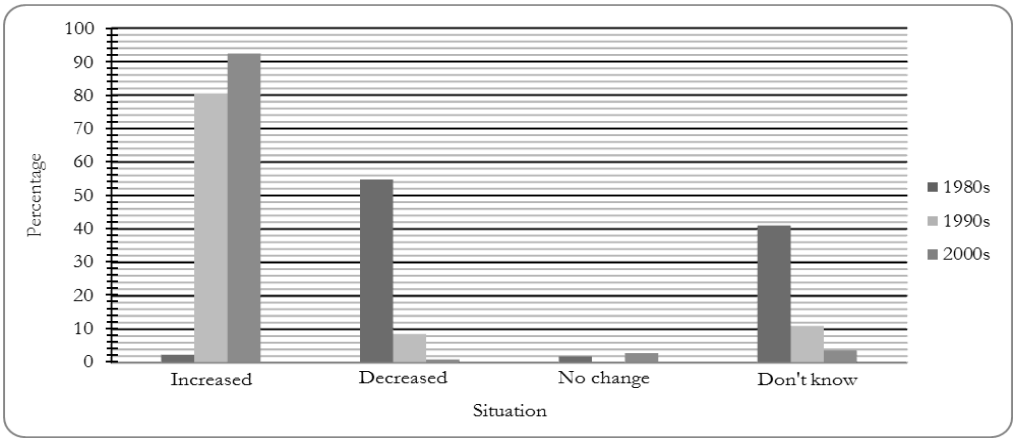

Figure 4. Distribution of farmers' view on cultivated land changes, 1980s-2011

As elsewhere in Ethiopia, grasses have versatile importance to the rural population. They are used for thatch on houses, granaries or outbuildings. Like other land use/cover, grasses have also been in a good status during the 1980s. Respondents support this assertion by 55.2% (Figure 5). The situation has changed since the 1990s where deterioration of grass has significantly high.

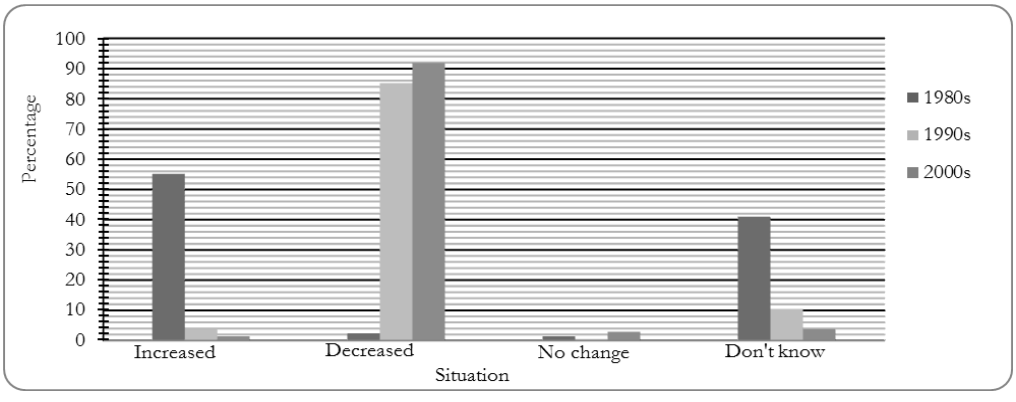

Figure 5. Distribution of farmers' view on grassland changes, 1980s-2010

As it is indicated in Figure 5, 85.2% and 91.9% of respondents respectively confirm that grasses are seriously deteriorated in the study district in the 1990s and 2000s. In the focus group discussions that were performed, the farmers described the difficulty

they have faced to get grasses for purposes indicated above. They express that to get good quality grass they are forced to travel up to 30 to 40 km.

In the 1980s and before, significant proportion of the study area was covered with low land bamboo. These important and other vegetations have been cleared. Consequently, the wildlife once common in the district has been dwindling from time to time. In response to this, during the survey farm households stated that wildlife was commonly available during the 1980s, confirmed by more than 56 percent. But the situation since the 1990s has a different picture where there exists a significant decline of wildlife (Figure 6). This is also confirmed by Yntiso (2004) who stated that the deforestation process contributed to the tragic disappearance of wild animals and edible wild plants in Metekel zone.

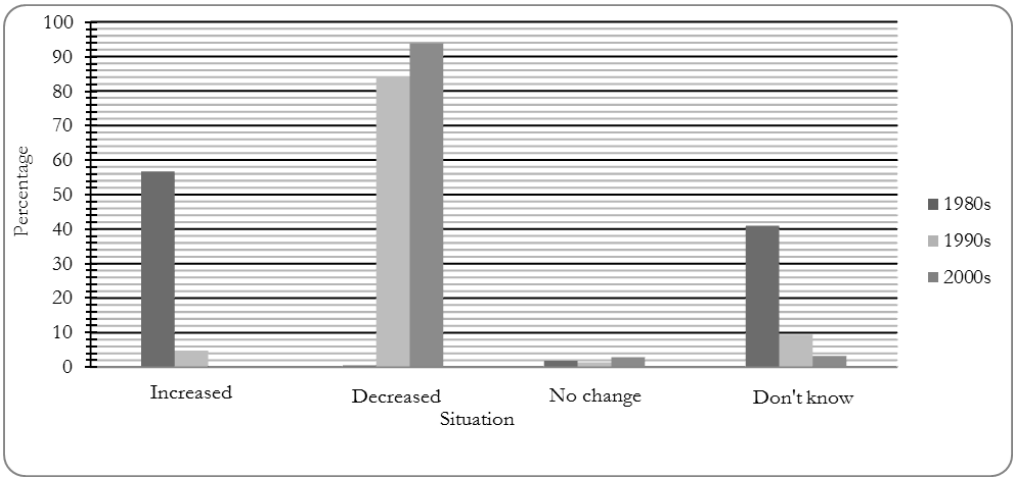

Figure 6. Distribution of farmers' view wildlife Changes, 1980s-2011

3.3. Drivers of land Use/Cover Changes and Associated Problems

Land use/cover change in the study area was high since the 1990s as perceived by farm households and further confirmed from aerial photograph and Spot-5 analysis. Respondents were asked to reason out possible causes of land use/cover changes. In this respect, a little greater than 30 percent of responses and 100 percent of cases associate land use/cover changes with population increase in the area. The share of deforestation, on the other hand, is 29.7 percent of responses and 96.7 percent of cases. Likewise, expansion of agricultural land accounts 29 percent of responses and 94.3% of cases. The corresponding share of the introduction of development projects is 10.5 percent of responses and 34.3 percent of cases (Figure 7).

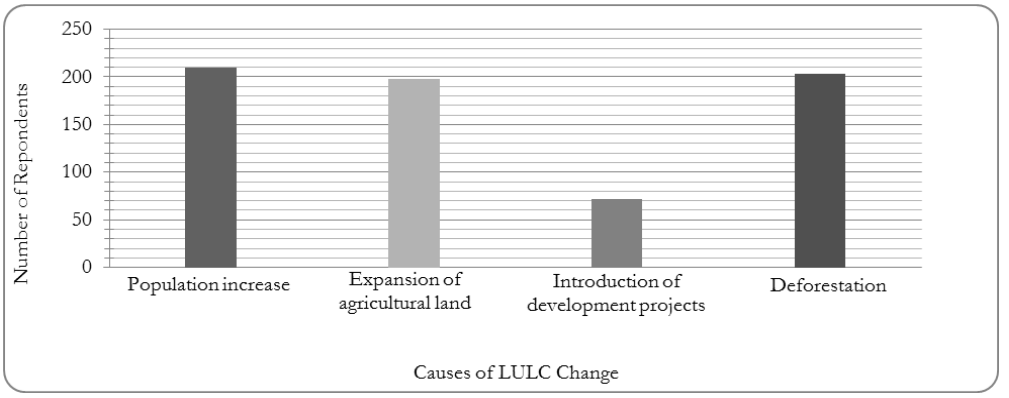

Figure 7. Distribution of farmers' view on causes of land use/cover changes

The overall assessment is that population increase triggers deforestation and expansion of agricultural activities which eventually result in land use/cover changes. The principal reason for population increase was flow of population from the nearby regions in search of land for cultivation and other related agricultural activities. This inflow of population in turn is triggered by drought and fine, demographic pressure, land re-distribution and shortage of arable land in the area of origin. This consequently has increased rural population size in the area of destination. As a result, this has created land shortage for shifting cultivators (the Gumuz) and pressure and deterioration of the natural environment. During field investigation, one of the residents stated that "twenty years ago it was possible to harvest bamboo trees for different purposes from around the homesteads but now we are forced to travel long distances outside of our peasant association, where at times we may not succeed in finding a bamboo tree". This assertion clearly indicates that natural environmental change is well recognized and understood by residents.

During focus group discussions it was stated that small urban centers have been flourishing and, as a result, demand for natural resources for source of fuel and construction also simultaneously increased. Specifically the indigenous population widely cut trees and prepares charcoal for sale which was not formerly the tradition. They were forced to practice this activity following the inflow of migrants from the surrounding region. This has increased the demographic pressure and shortage of agricultural land for shifting cultivators. To derive their livelihoods they keep on clearing natural vegetation and grab as much land as they can and the routine continues in the same way. Consequently, this has resulted in natural resources depletion and change of livelihoods of the indigenous population which formerly used to be friendly with the environment.

Attempts were made to assess the current land use in the study district. As elsewhere in Ethiopia, the majority of rural residents of the district derive their livelihoods from agricultural activities. As a result, agriculture dominates the land use than any other activities.

Table 3. District level land under cultivation and amount of yield (2005-2011)

Year	Cultivated land (hectare)	Percentage change	Yield obtained(Quintals)
2005	10636	-	110604
2006	12460	14.7	228834
2007	14156	12.9	269479
2008	17340	18.4	302914
2009	18556	6.6	352943
2010	23195	20	228154
2011	31147	25.5	731978

As can be seen from Table 3, the land that has been brought under cultivation is significantly high each year. It is also evident that the yield increase each year was obtained at the expense of bringing more land under cultivation. In subsistence agriculture, where the use of modern agricultural input is little or non-existent, yield increases are achieved by bringing more land under cultivation. Subsistence agriculture is inherently ineffective and, therefore, large areas of land are needed to meet the needs of rural households (Worku, 2007). As previous studies have indicated, much of the agricultural expansion targets marginal and ecologically fragile environments such as forests, woodlands, and steep slopes (Aredo, 1990; Mamo, 1994; Abute, 2002; Yntiso, 2003), which are not in most cases occupied and put under cultivation. Such expansion may eventually result in several land degradation. Based on data obtained from the district Agriculture and Rural Development Office, it is apparent that on average 2,930 ha of land has been brought under cultivation each year between 2005 and 2011, and the percentage change of cultivated land shows a remarkable increase each year (Figure 8).

Figure 8. An area which once covered with thick bamboo and other trees but now converted to farmland

4. Conclusion

Farm households' knowledge on the changing natural environment has a paramount importance to devise appropriate natural resources conservation and utilization strategy. This awareness enables farm households and policy makers at different jurisdictions level to make appropriate and timely interventions whenever there is resource related problems. Cognizant of this fact, this study unveiled views on trends and drivers of land use/cover changes. In relation to this, the study revealed that respondents were well aware of the existence of land use/cover changes. Moreover, natural environment deterioration was the result of land shortage which consequently forced the indigenous population to shift from friendly way of utilizing the natural environment to unsustainable way of natural resource utilization including wood and charcoal selling. Equally important is urban population increase which triggered the wider use of products from the natural resource stocks like wood, bamboo, charcoal for different purposes. This means that drivers identified by farm households were diverse and interrelated with each other.

The study further identifies time and rate of natural resources decline. It was since the 1990s that decline of the natural environment accentuated and reached its peak in 2000s. Likewise, the 1982 aerial photograph as well as the spot-5 image of the 2006/07 reveals the same result. In this regard, Bekele (2008) has stated that the shift from unitary to federal state in 1991 had created a power vacuum during which time destruction of natural resources took place on a large scale. There is no clearly stated responsibility between the federal and regional governments pertaining to utilization and management of natural resources. Thus, other options of livelihood sources should be put in place to reduce and eventually reverse the problem and enhance sustainable resource management practices in the district.

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