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Trends and Driving Factors of Land Use and Land Cover Change in Kewot District, Northern Ethiopia

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Abstract: This study examines the Trends and driving factors of land use land cover change in Kewot District, Amhara Region, Ethiopia from 1972 to 2014. To achieve this objective, both primary and secondary sources of data were used. The primary data were collected from 124 sample respondents through questionnaires, key informants, Development agents and field observation. Secondary data for the study includes Landsat satellite images of three periods (1972, 1994 and 2014) which were taken in the dry season have been collected from the USGS Website. The results of this study showed that the highest conversion was occurred to farm land followed by shrub land throughout the study period from 1972 to 2014 within the last 42 years. This was because of mainly population pressure, land tenure system, natural hazards like (flood, land slide and drought) and other immediate factors like crop and grazing land expansion, deforestation and so on. Moreover, small streams and some wet land areas were dried up and converted either into irrigation land or to grazing (grass land) implying global climate change is also another factor for the reduction of such LULC types in the study area.
Key words: Land Use and Land Cover, population pressure, land tenure, deforestation, and NDVI

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I. INTRODUCTION

Ethiopia is currently faced with sever deforestations and environmental degradation leading to low agricultural productivity which in turn resulted in decreasing income and food security problems. Rate of land cover dynamics and fragmentation of land recently becomes a cause for degradation of the environment and climate variability (Asaye, 2008). The increase in population increases the demand for these natural resources, worsening the environmental degradation and poverty in the country. Precipitation variability negatively affects vegetation and agricultural productivity (Amare, 2007). In the country, rapid population increment is a major drive force for climate variability and land use land cover dynamics (Assenand Nigussie, 2009).

On the other hand, the request for 'what factors drive land-use and land-cover change?' remains largely unanswered (Turner and Meyer, 1994). Even though natural processes may also contribute to changes in land cover, the major driving force is human induced land uses (Allen and Barnes, 1985). These human induced causes of land cover change, which are critical and currently increasing in alarming rate; and can be categorized into two broad divisions: proximate and driving causes. Proximate causes are immediate actions of local people in order to fulfill their needs from the use of the land and at the proximate level, land-use and land-cover change may be explained by multiple factors rather than a single variable (Geist and Lambin, 2002). These causes include agricultural expansion, wood extraction, infrastructure expansion and others that change the physical state of land cover (Turner and Meyer, 1994).

On the other hand, underlying (indirect or root) driving forces are fundamental socio-economic and political processes that push proximate causes into immediate action on land use and land cover (Geist and Lambin, 2002). Underlying driving forces including demographic pressure, economic status, cultural, technological and institutional factors, influence the LULC of a given area in combination rather than as single causations (Turner and Meyer, 1994). However, these two major categories of causes operate at different levels. Proximate causes are endogenous and operate at the local level (individual farms, households, or communities) and thus under the control of the local people.

The need to understand the relationships between human population dynamics and natural resources have been of interest at least as far back as Malthus, who argued that human population growth, could outstrip the ability of the earth to provide food. However, more recent scholars have noted that population-environment relationships are much more complex and are influenced by many more human activities than just procreation (Kellenberg, 2012).

Whatever debates are made between scholars, still studies indicate that population pressure, mainly in developing countries, is one of the underlying cause for LULCC. For example, it is estimated that 427 million in the year 1500, world population increased to 1,650 million in 1900, 3,600 million in 1970, and 5.2 billion in

1990. Recent projections point to a figure of around 10 billion by the year 2050. This corresponds to a growth rate of approximately 85 million per year, and the doubling of the present population within the next half century. Almost all of this increase has occurred, and will continue to occur, in the developing world. Thus, the combination of population growth, limited expansion of arable land, and more and more land being used for both agricultural and non-agricultural purposes, increases the pressure on, and competition for, the available land (Verheye, 1997).

There are various factors affecting the land use land cover change depending on the circumstances. One factor for land use land cover change in one area may not be a factor for the same change in other areas. Therefore, this study is aimed at investigation of the driving forces of Land Use Land Cover Change in Kewot District.

II. OBJECTIVES OF THE STUDY

The main objective of this study is to examine the trends and factors of Land Use and Land Cover change in Kewot District, North Shoa Zone, Ethiopia

1. Location Of The Study Area

The study area is located in Amhara National Regional State, Ethiopia. The District is characterized by rugged topography where 26% of the land is plain, and 38% is mountainous, 17% gorge and 19% undulating. Plain and gently sloping lands are used for cultivation; whereas grazing lands only found on the hillsides and marginal lands consisting of the least share of land surface in the study area.

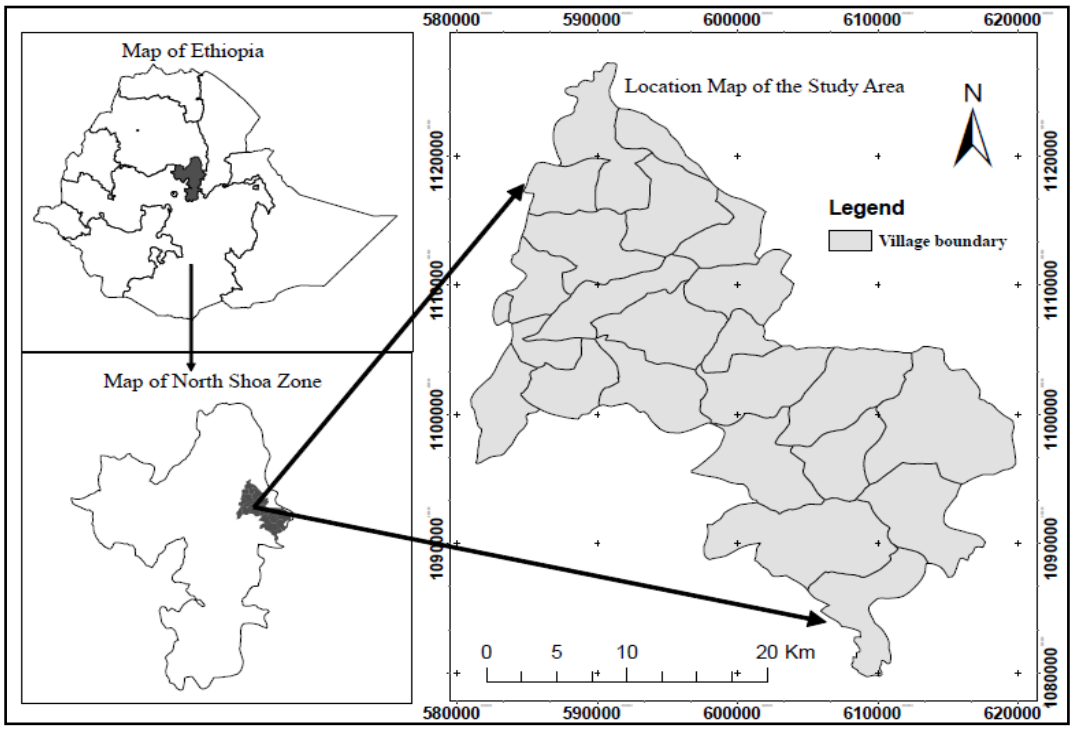

Figure 1: Location map of the study area

III. MATERIALS AND METHODS

1.1. Methods of Data Collection

For this study both primary and secondary sources of data were employed. The primary data sources were obtained through field observation, key informants interview and questionnaires. Likewise the training sample points that were used to classify the satellite images of the study area have been collected using GPS. Questionnaires were distributed for about 124 households. The key informants selected for an in-depth interview were elderly peoples, kebele leaders, and development agents (DAs). Secondary Datawere used for land use and land cover change analysis. For the study the data in the last four decades (1972 to 2014), Landsat satellite images of three periods (1972, 1994 and 2014) which were taken in the dry season has been collected. Satellite images were downloaded from the United States Geological Survey (USGS) website.

1.2. Sampling Techniques and sample size determination

This study has been conducted in Kewot District, which has a total number of 22 rural Kebeles. Among the 22 Kebeles of the District, totally 8 Kebeles namely; AbayAtir, Ayaber, BirbiranaGelgelo, DebirnaJegol, Kure beret, Medina, Wokfelie and Yelen were selected using purposive sampling techniques. The following sample size determination formula of Kothari (2004) was used to determine the sample size for the study.

$$n = \frac{Z^2.P.Q.N}{E^2(N-1) + Z^2.P.Q}$$

Where, n = sample size; Z= values of standard variation at 95% confidence interval (1.96); P = sample proportion (0.03). Q= 1-p; E = the estimate should be within 3% of the true value; N = the total house hold population.

Hence, $n = \frac{(1.96)2(0.03)(1-0.03)(36827)}{(0.03)2(36827-1)+(1.96)2(0.03)(1-0.03)}$

n =124

After the determination of the sample size, proportionate sample size allocation technique was employed for each kebele using the formula: n/ N, and using a common multiplying factor k.

Where, N is Total number of population at the 8 Kebeles; n is the total sample size and k is a common multiplying factor determined by the above formula; Therefore, k = 124 /36827= 0.0034. Then multiplying each sample Kebeles population by 0.0034 has given the results 24, 11, 13, 8, 15, 9, 19 and 25 for AbayAtir, Ayaber, BirbiranaGelgelo, DebirnaJegol, Kureberet , Medina, Wokfelie and Yelenkebeles respectively. Finally, the simple random sampling method was used to select the sample respondents at each respective kebele.

1.3. . Methods of Data Analysis

The data collected through questionnaire were analyzed and interpreted using tables in the form of percentages and frequencies with the data acquired through interview and field observations. For the secondary sources, the two types of image processing stages (pre-processing and post processing) were employed. In the pre-processing stage image mosaic and tinning, geometric and radiometric correction, image sub setting (masking) and unsupervised classification were carried out over the original land sat images of the study area acquired in three periods of (1972, 1994 and 2014). On the other hand, the post processing stages of image processing includes: collection of ground control points and reclassification (supervised classification), accuracy assessment, change matrix calculation and change detection.

IV. RESULTS AND DISCUSSION

1.4. .Demographic Composition of Respondents

The sample population is dominated by the age group of (30-39) that accounts 39% followed by the age group of (20-29) which is about 22%. Generally, the study area is mainly inhabited by the adults implying the need of land for different purposes is high since population pressure is one of the causes of LULC change in the study area. The existence of adult age group population in the study area is a driving factor for LULC changes in Kewot District which needs high degree of government attention. About 39.5% of the respondents have acquired primary school education whereas 25.8% were remaining illiterate and the remaining 34.7% were able to read and write. Finally, it can be concluded that despite the participation of relatively high number of individuals in primary school, there is also existence of individuals who terminate their education because of many reasons and joined into the illiterate groups, thereby increasing the demand of land for cultivation, settlement, grazing etc. and resulted LULC change in the study area. On the other hand, about 39.5% of the respondents have family size of 1 to 3 children followed by those families who have size of 4 to 6 children accounted 34.7%. The rest those who have greater than 7 and less than 1 family size accounted about 14.5% and 11.3% respectively.

1.5. Trends of LULC Change in Kewot District

According to the analysis of Landsat images of the study area that vary in temporal information of the different LULC types across different periods, it was possible to extract valuable information about the trend of changes as shown below.

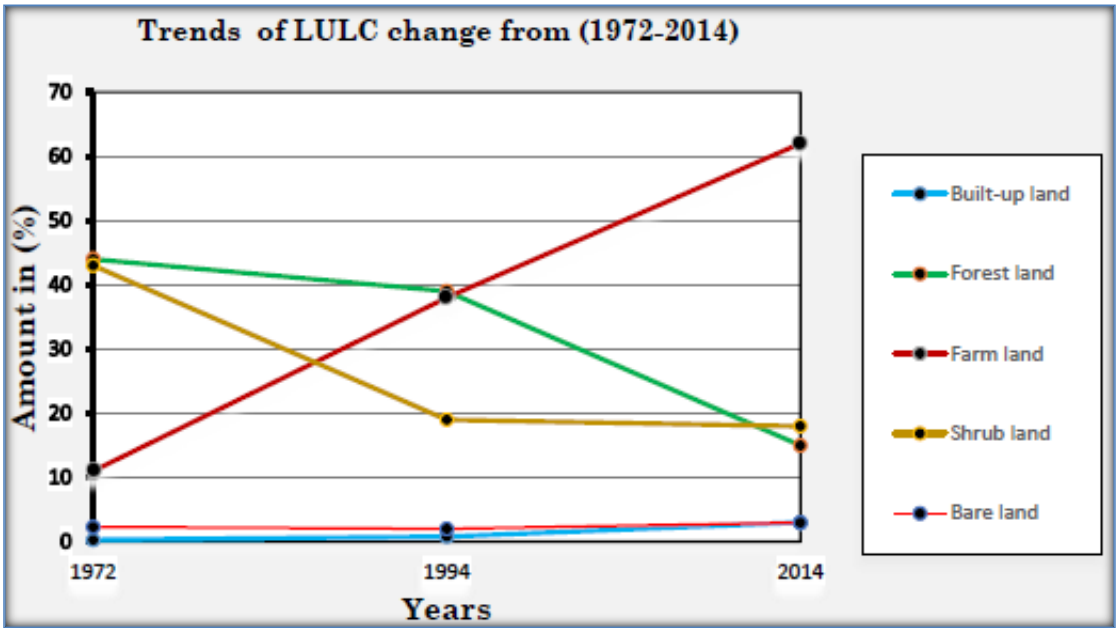

Figure 1: Trends of LULC change from 1972 to 2014

As shown from the figure above, the trend of forest and shrub lands showed continuous decrement while other classes mainly farmland showed continuous increment throughout the study period in the last four decades in the study area. From 1972 to 1994, especially farm land was expanded at the expense of mainly shrub and forest lands with a share of about >60% in 2011 implying, it is a dominant LULC type over the study area. On the other hand, the reason behind the increment of both built-up and bare lands in the study area was that of population pressure and unwise use of resources respectively in the last 42 years. Even though, the researchers have been observed recovery of bare lands (degraded areas) through area closure, reforestation (conversion to forest land) and cultivation of crops in some areas through soil conservation under the guidance of Development Agents, still there is expansion of bare lands since the rate of conservation is less than the rate of misuse of the resources.

1.6. The NDVIResults

The Normalized Differencing Vegetation index (NDVI) is one of the most commonly used vegetation indices analysis technique developed for identifying health and vigor of vegetation and for estimating green biomass (Leica, 2003). In this research the NDVI map was created in the three respective periods of (1972, 1994 and 2014) to get an overview of the location and presence of vegetation biomass for visual comparison to aid the image classification process. The NDVI was calculated using the formula NDVI= (NIR- RED)/ (NIR+RED) in ERDAS Imagine 10 software and the result is presented in the maps below.

Table 1: Statistical Values of NDVI Results

Period	Maximum	Minimum
1972	0.73	0.57
1994	-0.17	-0.29
2014	0.54	-0.41

Source: Satellite image interpretation

The statistical and visual observation of the three respective images of the study area shows a decrement in the maximum value of NDVI from 1 to -0.17 which implies the reduction of high forest areas. According to the respective maps shown below, there is a decrement in the general trend of vegetation biomass from 1972 to 2014. For instance, in 1972 there was high vegetation biomass mainly in the north western and western part of the study area. However, the vegetation index shows decrement on wards after 1994 and this is due to deforestation and agricultural expansion. According to the data obtained from questionnaire, interviewing of elders and field observation there is high population pressure in the study area that triggers high demand of land for cultivation and this is the main factor responsible for the expansion of farm land at the expense other LULC types mainly forest cover in the study area.

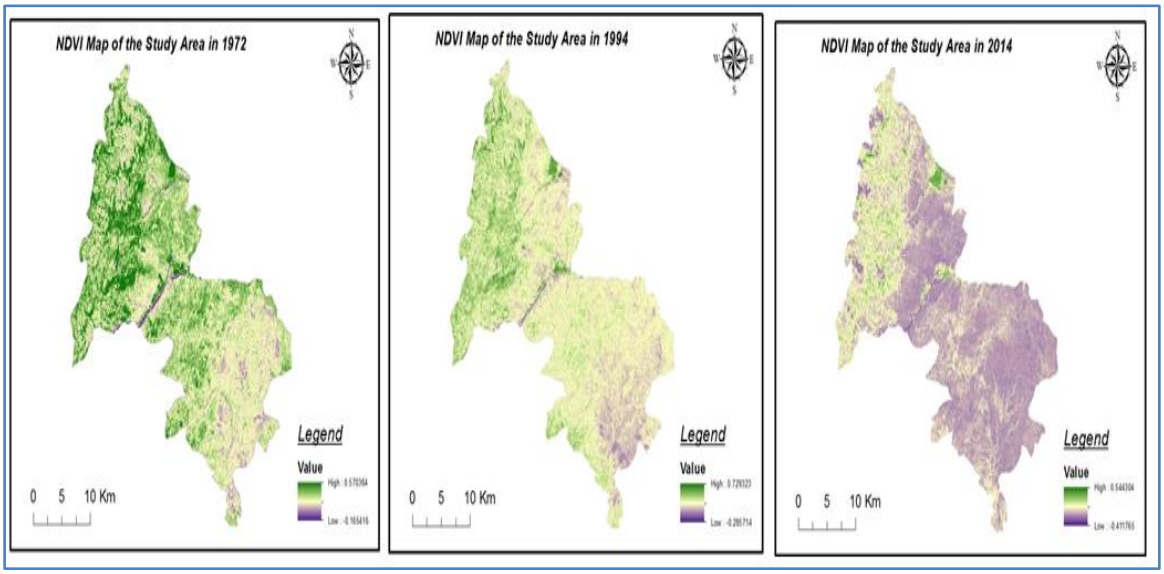

Figure 2: NDVI map of the study area (1972, 1994, and 2014)

1.7. Causes of LULC Change in the Study Area

The causes of LULC change are different and may vary in time and space. For instance, driving causes identified at the national level might be different from those drivers at the local level. Therefore, it is crucial to identify such changing factors at the local level so as to set development plans and environmental protection measures of specific areas.

The causes of LULC change can be under stood in two ways one is using the indirect method which is based on the remote sensing data (Landsat image) analysis and the second one is the direct method which was based on the analysis of household survey data. In the first case the causes of LULC change can be inferred indirectly from the (from-to-change) analysis of one cover type to another cover type indirectly using satellite images of the same area but taken at different times (i.e. temporally varying images).

However, understanding of causal factors in such a way is to some extent difficult since making firm decision is impossible due to the fact that the spectral information contained in each pixels of the image is only about the type of cover rather than the type of cause. Therefore, devising another mechanism to understand the real cause of the change is very essential and this is based on the analysis of house hold survey data. In this study both of the above methods were employed and it is time for the second type to discuss in detail as presented below.

Regarding land holding in the study area, About 67.74% of respondents ensured that their land size is not enough. The reason for those who have not enough farm land is due to high population pressure and the society in the study area are trying to get additional farm land through different mechanisms like clearing of forests, invading communal lands which in turn results LULC change. Moreover, the researchers also observed from field observation that there are many youths and landless groups who are ready to invade the remaining small left marginal and communal lands in the study area and there would be further expansion of cropland at the expense of others like grass land, bare land and shrub land in the future in order to secure their lively hoods. Based on the 1997 land reform proclamation guideline that set 3 hectares of land as the highest threshold size to be given for individuals.

Most of the respondents (40.34%) have lived in the study area in a period of more than 31 years followed by 25% that lived from 21-30 years. The rest 18.53% and 16.13% are those who lived from 1-10 years and 11-20 years respectively. This implies that the study area is inhibited by those communities who have lived for a long period of time and that might be a causal factor for the expansion of farm land at the expense of other LULC types in order to get additional farm land for cultivation to feed their family. And also there would be a high probability of farm land expansion at the expense of other LULC types in the future since there would be so many landless groups in the study area.

About 75.8% of respondents evaluated the LULC change of their local area as moderately changed. However, about 16.94% and 7.26% of them evaluated the LULC change ashigh and low respectively. Here, even though, the judgment of the respondents about LULC change is depending mainly on their perception, it must be noted that there is LULC change in the study area, although the degree of change varies in time and place due to many factors like deforestation, cropland land expansion, and natural disasters etc.and this indirectly ensures the findings of the researchers about the real existence of LULC change which was discussed earlier.

Nearly50% of respondents replied that cropland expansion was the dominant cause of LULC change in the study area followed by deforestation, Natural hazards and other factors that accounted about 35.48%, 15.32% and 5.65% respectively. In this study, farm land was expanded at the expense of others (mainly forest and shrub lands) throughout the study period (1972 to 2014). Moreover, farm land expansion is also aggravated by other factors like population pressure through fuel wood and charcoal production together with house and fence construction is also played an important role in the destruction of both natural and manmade forests that results another LULC change or deforestation.

While observing the NDVI value of the three respective images of the study area in (1972, 1994 and 2014), it was mentioned that the densely populated forest of the study area was reduced and this might be due to the aforementioned reasons. In addition to this, the existence of abruptly changed topography and the effect of global climate change are also triggering agents for LULC changes in the study area through natural hazards like flood, drought and so on.

However, there are some studies that show the relative increment of forest cover in some parts of Amhara Region like North Achefer District (Getahun, 2011) and Mecha District (Tenaw, 2007), mainly due to plantation and area closure activities. Likewise, from the satellite images and actual field observation, there is an area closure activity in few parts of the study area. However, there is still reduction of forest coverage because of the existence of high rate of deforestation than reforestation and afforestation activities.

Most of the respondents (64.52%) ensured that there is reduction of natural forests in their local area as compared to the past whereas the rest about 16.13% replied the opposite, as being increased, and the other 19.35% replied as no change observed in the status of forests in their local area. However, based on the image analysis (mainly NDVI result) and the majority of respondents from the above table, the level of natural forests in the study area has shown reduction because of many factors as discussed before.

More than 57% of the respondents replied flooding is responsible factor that change the surface of the land, followed by land slide and drought that accounted nearly 20% and 22.6% respectively. During field survey the researchers have observed the formation of gully and valley erosion in some parts of the study area (particularly in the western side) and this implies that flooding among natural hazards was a modifying agent that brought LULC change over the study area. For instance, Yelen kebele is a prominent example of the study area that is affected by almost every year by flood. Land and rock slide along the slope of the mountain is also observed in the western part of the study area. The study area is also victim of droughts due to global climate change and such natural events are sometimes resulting reduction of agricultural outputs. Generally, LULC change in the study area have been mainly caused by proximate or direct causes like crop land expansion, need for fuel wood and charcoal, population pressure and natural hazards like (flood, drought and land or rock slide etc.)

V. CONCLUSION

Generally the highest conversion was occurred to farm land followed by shrub land throughout the study period from 1972 to 2014 within the last 42 years. This was because of mainly population pressure, which results in high demand of land for cultivation, land distribution for landless people which took place at the expense of other LULC classes like bare lands, bush and shrub lands and grass lands was the main factor for the increment of farm lands in the study area.

On the other hand, the major factors which are found responsible for the change of LULC in the study area include population pressure, land tenure system, natural hazards like(flood, land slide and drought) and other immediate factors like crop and grazing land expansion, deforestation and so on. Moreover,small streams and some wet land areas were dried up and converted either into irrigation (crop land) or to grazing (grass land) implying global climate change is also another factor for the reduction of such LULC types in the study area. Additionally, according to the interview made with elders, there is always increasing demand of agricultural land which in turn causes addition of cultivated land from communal lands such as forests, bare lands, grazing areas etc. and others from time to time. Because of this, in different parts of the study area, there was an observation of a remarkable LULC change toward farm land mainly in the eastern and southern parts. The reason behind the increment of both built-up and bare lands in the study area was that of population pressure and unwise use of resources respectively in the last 42 years. Even though, there have been observed recovery of bare lands (degraded areas) through area closure, reforestationand cultivation of crops in some areas through soil conservation under the guidance of DA's, still there is expansion of bare lands since the rate of conservation is less than the rate of misuse of resources.

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