PATTERNS OF CHANGE IN POPULATION, FARMLAND SIZE AND FOREST COVER IN SIGMO DISTRICT OF OROMIA REGION, ETHIOPIA

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Abstract

The world population is exceeding seven billion at the same time when resource limits and environmental degradation are becoming more apparent every day. This paper analyzes the nexus between population dynamics and forest degradation. The study quantified the effect of human population growth on rates of deforestation using GIS based information taken for 30 years (1985-2015) in Sigmo district, South Western Ethiopia. A mixed approach, comprising of both quantitative and qualitative methods, is used for the study. Descriptive statistical techniques such as frequencies and percentages are employed and presented in tables, graphs, charts, and satellite image maps. Inferential statistics such as, Pearson correlation coefficient are implemented to demonstrate the degree of association between the dependent (forest area and farmland size) and independent variables (population growth). The findings of the study revealed that the population of the study area has grown very rapidly (2.9% /year). The rapidly growing population adversely impacted the forest resource of the area in a way of agricultural land expansion, fuel wood

consumption, settlement expansion, timber harvest for construction and commercial logging. Thus, between 1985 and 2015, forest cover of the study area got reduced nearly by half (48.8%) while farm lands expanded by about 124%. These, in turn, have resulted in soil erosion and loss of soil fertility, depletion of biodiversity, interruption of water flows, and the spread of desertification

Introduction

The world is experiencing unprecedented demographic change. The most obvious example of this change is the huge increase of human population. Four billion people have been added since 1950. Projections for the next half century are expected in a highly divergent world, with stagnation or potential decline in parts of the developed world and continued rapid growth in the least developed regions (Bongaarts, 2015). According to the Central Statistical Authority of Ethiopia (CSA, 2007), the total number of persons enumerated in the third Population and Housing Census were 73,918,505. Of these, 37,296,657 (50.5%) were males and 36,621,848 (49.5%) were females. The population of the country in the previous censuses of 1984 and 1994 were 39,868,572 and 53,477,265, respectively. Currently the national population is estimated nearly 104 million and projected to be over 188 million by the year 2050 (United Nations, 2015).

It has become increasingly evident that human population growth has an impact on natural resources. However, the interplay between population growth and environmental degradation has been a matter of debate for decades (Abayneh and Simane, 2015; Amare, 2000; Gete, 2010). Rapid population growth and economic development in many countries are degrading the environment through uncontrolled growth of urbanization and industrialization, expansion of agriculture, and the destruction of natural habitats (Nagdeve, 2007). The causes of environmental degradation can be grouped into proximate and underlying causes (Adugnaw, 2014). The proximate causes are the indicator of inappropriate resource management practices and the underlying causes of environmental degradation include a complex of social, political, economic, technological, and cultural variables

that constitute initial conditions in the human-environment interaction. In Ethiopia both causes are the reason for agricultural land and forest degradation.

Before a century, forests, either coniferous or broad-leaved vegetation, covered nearly 35-40% of Ethiopia. Rapid population growth, extensive forest clearing for cultivation, overgrazing, movement of political centers, and exploitation of forests for fuel wood and construction materials without replanting reduced Ethiopia's forest area to 16% in the 1950s and to 3.1% by 1982 (UNEP, as cited in Badege, 2009).

Deforestation is a key problem in Ethiopia. Historical evidences indicate that high forests might have once covered about 35-40 % of the total land area of the country (EFAP, 1994). Tree cutting is a common occurrence which has been taking place over the centuries because of the need for more land for cultivation, for use as source of fuel and for construction purposes (Shibru & Kifle, 1998). The underlying causes of deforestation are, however, closely linked with the vicious cycle of mutually reinforcing factors, i.e. poverty, population growth, poor economic growth and the state of the environment. The impacts of population growth on the natural resources in general and on forest resources in particular vary depending on socio-economic and other factors. In view of the above facts, an attempt is made in this study to explore the impacts of rapid population growth on forest resources of Sigmo district in Oromia Regional State.

It is found that rapid population growth is diminishing the biodiversity and the forest size of the area. Sigmo district is one of the few pockets having dense forest cover in Oromia Region, Ethiopia. However, empirical evidences reveal that nearly 50% of it vanished within three decades, leaving behind either bare lands or lands converted to farmlands and settlements. However, in the district, no study has been conducted so far on issues dealing with the impacts of population growth on the environment in general and forest resources in particular. Therefore, the principal objective of this research is to assess the impact of population dynamics on forest resource and farm land size change in the district.

Materials and Methods

The Study Area

Sigmo district is one of the districts in Jimma administrative Zone. Astronomically it is located between 7^0 45' 00" North to 8^0 00' 00" North latitudes and 35^0 45' 00" East to 36^0 25' 00" East longitudes in Oromia Regional State (see figure 1). It is 457 km southwest of Addis Ababa, the capital city of Ethiopia.

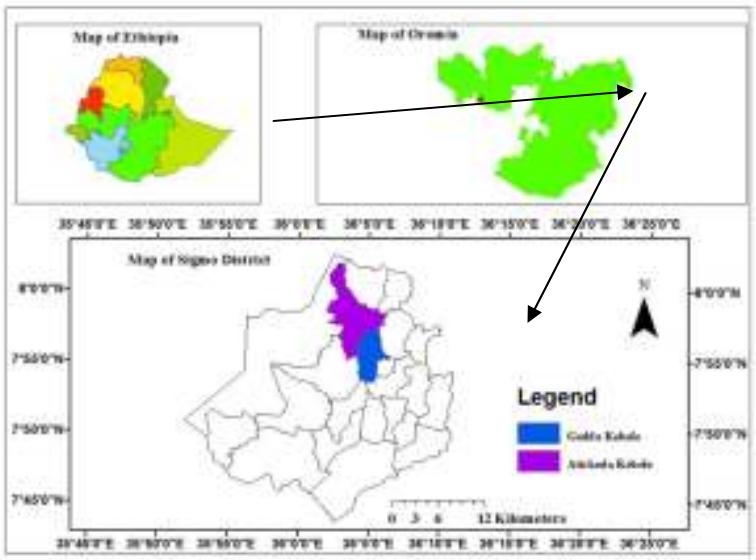

Figure 1. Administration Map of Sigmo District (Source: Arc GIS 9.3)

Research Methodology

To obtain the necessary data, both primary and secondary sources were used. The primary data was attained through satellite image and GPS data. The secondary data sources were collected from published and unpublished documents, archives, journals, articles and internet web sites. The land sat images downloaded from the USGIS were extracted by mask

with the study area Digital Elevation Model (DEM). Following the preprocessing activities, supervised image classification systems were done in ERDAS IMAGINE 9.2. In addition to this the land sat images were classified with respect to the land use land cover types. When classifying imageries both supervised and unsupervised methods of classification were used with a false color composite (FCC) of 5, 4, 3 for Land sat TM images and a false color composite (FCC) of 6, 5, 4 for land sat 8 images of 2015.

After the supervised classification took place on the land sat image, accuracy assessment was undertaken to validate and compare the classified image with geographical data that are assumed to be true. The accuracy assessment of the land use land cover map has been undertaken by comparing the field data collected by GPS with the classified images in ERDAS IMAGINE 9.2 software. The purpose of taking accuracy assessment was to make proof whether the supervised classification was similar with the land use land cover classes on the ground.

Results and Discussion

Trends of Population Growth

The population of Sigmo district in 1994 was about 72,190; of which 70,238 were rural and 1,952 were urban dwellers (CSA, 1996). The total number of population of the district had increased to 85,074 in around seven years by the year 2001; of which 49.5% were female and about 50.5% were males (CSA, 2001/02).

Currently the total population of the district is 117,945. Using arithmetic projection method, on average annual rate of population growth between 1994 and 2016 is nearly about 2.9% in the district. The national population grew annually by 2.6% between 1994 and 2007. Thus, from this one can conclude that the population in the study area was growing faster than the county's average (2.6%)

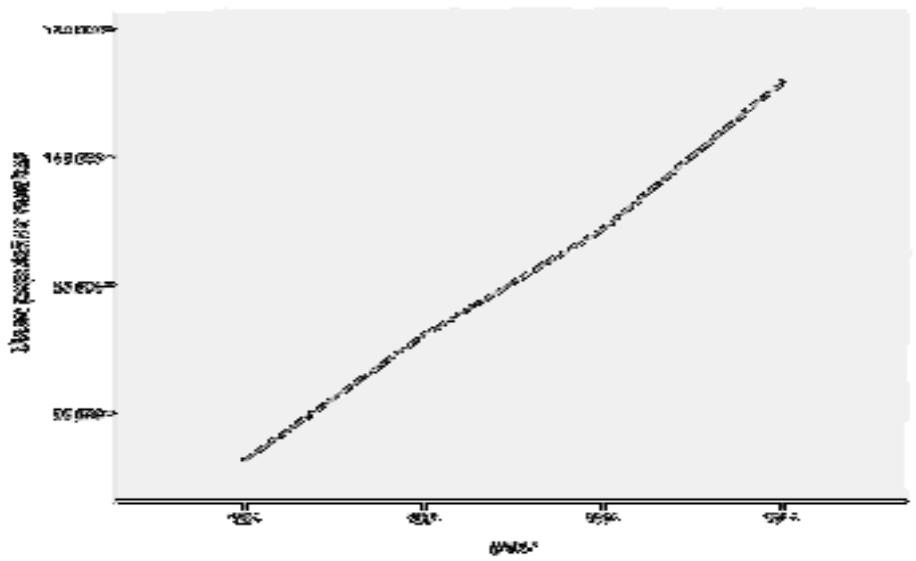

Figure 2. Trends of Population growth of the Study Area
Source: Own construction based on the above CSA sources, 2016)

Patterns of Population Growth and Forest Resources

The world has experienced a rapid population growth throughout the last century. A growing population consequently implies a growing demand for agricultural products and forest products such as food, construction materials and energy supply (Rademaekers, *et al*., 2010).

The high population growth rate and the subsequent rising demands for farm and grazing land, for construction material, fuel wood, charcoal, resettlement, and low public awareness are the main factors responsible for the decline of forest areas (EPA, 2008). A Pearson correlation analysis was employed to examine whether there is a relationship between population growth and forest cover. The results revealed negative relationship. The Pearson correlation coefficient (r) was -0.997 with p-value of 0.003. As it is provided in table 2 below, the correlation coefficient (-0.997) implies that relationship was strong negative correlation. The percentage increase in population size was negatively associated with the extent of forest cover overtime; and this might imply that the decline in forest cover within the last

three decades was due to the increase in population at a persistently high growth rate in the study area. Similarly, studies conducted in different parts of Ethiopia have confirmed that population growth has been found to have negative effect on forest cover (Kebrom and Hedlund, 2000; Gete and Hurni, 2001).

Table 1**:** *Correlation between Population growth and Forest Cover of the Study Area*

Year	Population number	Forest cover (km^2) *	p- value	Pearson Correlation coefficient (r)
1984	52,685	407		
1994	72,190	328	0.003***	-0.997
2004	92,313	269**		
2014	111,755	210		

Source: Authors' computation

Note: * The forest cover of the study area in 1985, 1995, 2005 and 2015
** Estimation result of forest cover of the study area in 2004
***Correlation is significant at the 0.01 level (2- tailed)

Extent and Rate of Deforestation: Land Use/Land Cover Change of the Study Area

To investigate the spatial and temporal change of forest cover in the study area, understanding the land use and land cover changes about the past is crucial and it is also essential to understand the current changes and to predict for future. As figure 3, figure 4 and figure 5 clearly show, there was a continuous land use / land cover change for most parts of the district in the three decades (1985 to 2015). Therefore, the analysis of the maps shows that there was a significant reduction in forest cover of the study area.

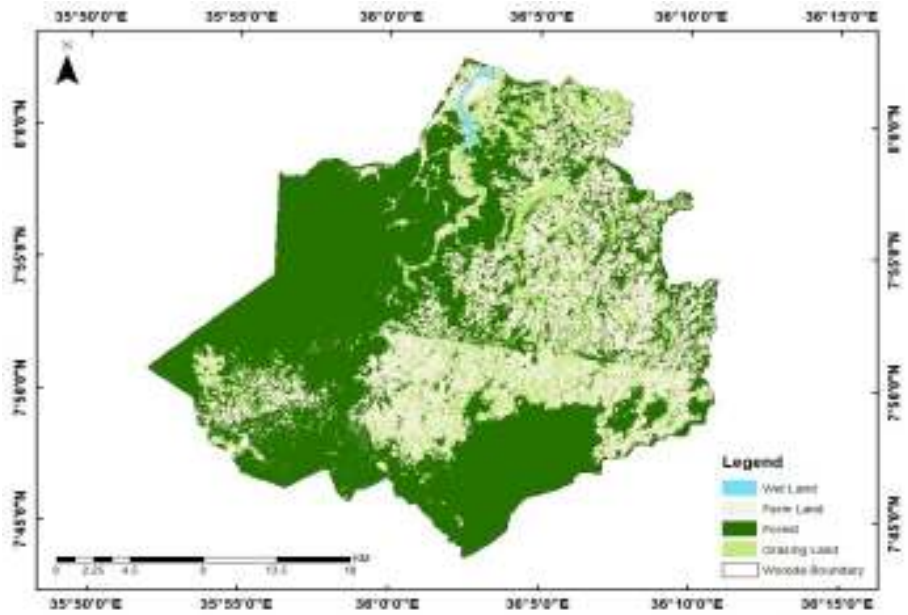

Figure 3. Land Sat Image TM of 1985 Showing LU/LCC of the Study Area
Source: Own work, 2016

As shown in Figure 3, the study area has been defined to have four land use and land cover types: farmland, forest, grazing land and wetland. The description of these land cover categories were presented in Table 2. The land use and land cover classification for 1985 from Land sat TM image showed that majority of the study area was under forestland which accounted for about 57.9% of the land area of the district followed by farmland with a percentage value of 26.1%. Grazing land and wetland had coverage of 15% and 0.4% of the total area of the district, respectively. Most western, north western and southern parts of the study area were covered by forest while farmlands and grazing lands were dominantly found in the central and eastern parts of the study area.

The land cover classification for 1995 Land sat TM image showed that most parts of the study area were covered by forestland and farmland. Farmland and grazing lands showed increase in their land cover.

Table 2*: Land Use / Land Cover Status of the Study Area in 1985, 1995 and 2015*

Land use / cover type	1985		1995		2015	
	Area (km^2)	P (%)	Area (km^2)	P (%)	Area (km^2)	P (%)
Farmland	183	26.0	230	32.7	410	58.3
Forest	407	57.9	328	46.7	210	29.9
Grazing land	110	15.7	144	20.5	82.4	11.7
Wetland	3	0.4	1	0.1	0.6	0.09
Total	703	100.0	703	100.0	703	100.0

Source: Analysis result using Arc GIS 9.3

But, the forestland and wetlands showed decrease in their land coverage. As it is shown in figure 4, in 1995 Land sat TM image below, forestland and farmland accounted for 46.7% and 32.7% of the study area, respectively, while both grazing land and wetland accounted 20.5% and 0.1%, respectively.

The land use / land cover classification for 2015 from Land sat 8 satellite image showed that most parts of the study area were covered by farmland and forestland. Farmland accounted for about 58.3% of the study area, followed by forest land (29.9%). Grazing land and wetland accounted about 11.7% and 0.09% of the study area, respectively. The land cover of farmland in the study area had shown increase over the past 30 years in the time period between 1985 and 2015. On the other hand, the cover of forestland, grazing land, and wetlands had shown significant decrease over the same period of time.

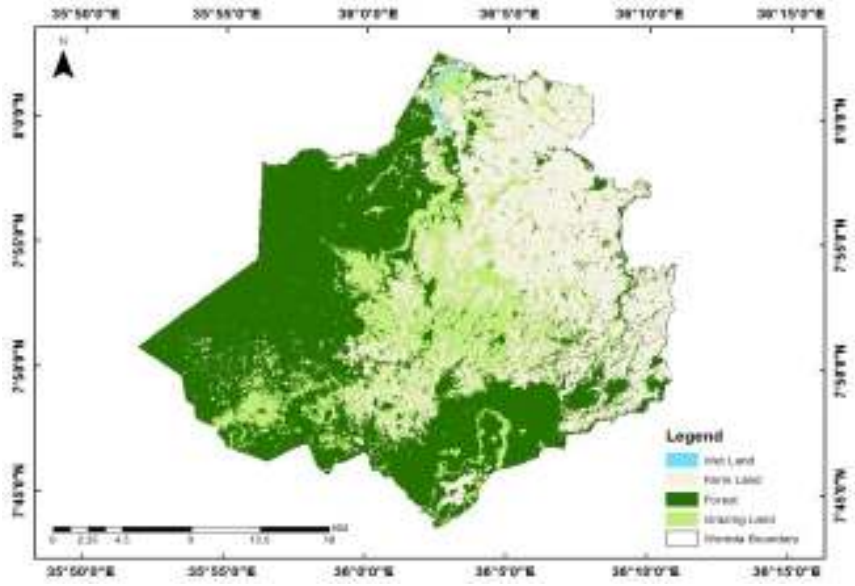

Figure 4. Land Sat Image TM of 1995 Showing LU/LCC of the Study Area
Source: Own work, 2016

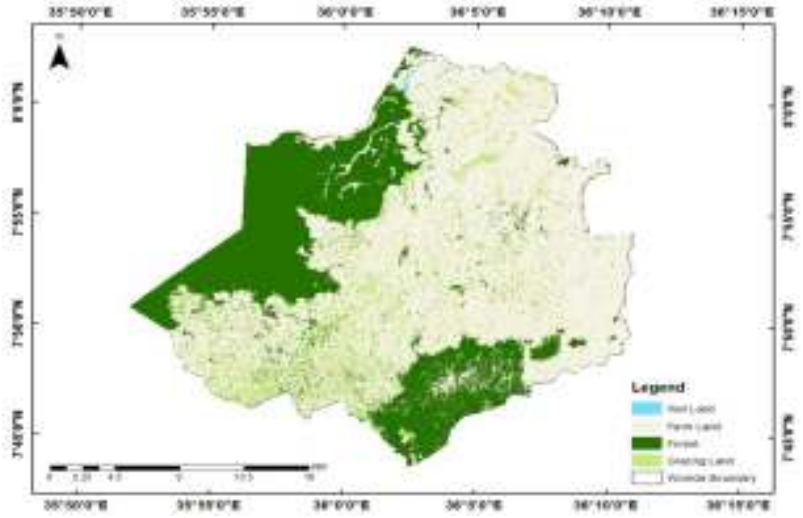

Figure 5. Land Sat Image 8 of 2015 Showing LU/LCC of the Study Area
Source: Own work, 2016

Level of Land Use / Land Cover Change within 1985-2015

When the change analysis for the last 30 years is observed, farm land showed an increase of 124.0% followed by a decrease in wetland (80.0%), whereas forestland and grazing land decreased by 48.4% and 25.1%, respectively. The forest cover of the study area in 1985 was about 407 km^2; and after ten years, in 1995, it had diminished in its cover to about 328 km^2. It also further declined to 210 km^2 in 2015. In general, in the period between 1985 and 2015, the forest cover of the study area had declined by 197 km^2 (48.4%). Hence, it is possible to generalize that agricultural land expansion is the primary cause of decline in forest cover or forest loss and other land use / land cover types in the study area.

Table 3 : *Magnitude of Change (MC) of LU / LC Types within 1985-1995, 1995-2015 and 1985-2015*

LU/LC Type	1985 (Km²)	1995 (Km²)	2015 (Km²)	1985-1995		1995-2015		1985-2015	
				MC	P (%)	MC	P (%)	MC	P (%)
Farm land	183	230	410	+47	+25.7	+180	+78.3	+227.0	+124.0
Forest	407	328	210	-87	-19.4	-118	-36.0	-197.0	-48.4
Grazing land	110	144	82.4	+34	+30.9	-61.6	-42.8	-27.6	-25.1
Wetland	3	1	0.6	-2	-66.7	-0.4	-40.0	-2.4	-80.0
Total	703	703	703	_	_	_	_	_	_

Source: Analysis result using Arc GIS 9.3
Note: On MC and P '-' indicates decrease and '+' indicates increase

Analysis of the magnitude and direction of relation between population growth, deforestation and farm expansions reveal that these three

variables are strongly correlated. As population number increases forest size is declining whereas farm area for all purposes is expanding over time.

Table 4: *Correlation matrix between population growth, farmland and forest cover (1985-2015)*

Items	Population	Farmland	Forest cover
Population	1	0.991	-0.997
Farmland	0.991	1	-0.983
Forest cover	-0.997	-0.983	1

Source: Authors' computation, 2016

The per capita share of forest land in the study area also declined over time. As it is indicated in table 5, in 1985 the per capita share of forest land was about 0.8 ha/person which has dramatically declined to 0.45, 0.29 and 0.19 ha/person in 1995, 2005 and 2015 respectively.

Table 5: *Percapita Forest Area share (ha/person) in Sigmo District (1985-2015)*

Year	Population	Forestland (ha)	Percapita share of forest (ha/person)
1985	52,685	40700	0.772
1995	72,190	32800	0.454
2005	92,313	26900	0.29
2015	111,755	21000	0.188

Source: Authors' computation, 2016

Conclusion and Recommendations

The findings of the study revealed that the total population of Sigmo district has increased from 72,190 to 117,645 between 1994 and 2016. Using arithmetic assumption, the average annual rate of population growth between 1994 and 2016 is nearly about 2.9%.

Analysis of land sat TM image of 1985 and 1995, and land sat 8 images of 2015 result show that the forest cover of the study area has decreased alarmingly. In 1985 about 57.9% of the total area of the study area was covered by forest. After ten years, in 1995, the total forest cover of the area was reduced to 46.7%. In 2015, the forest cover diminished to only 29.9% of the total area of the district. In the time between 1985 and 2015, the forest cover of the study area has been lost by -48.4%. Farm land expansion was the main cause for the loss of forest in the time period between 1985 and 2015. Between 1985 and 2015, farm land had increased by 124% at the expense of other land uses mainly forests.

Nevertheless, the reason for forest degradation is more complex than this paper addressed. The implications drawn from the previous studies conducted in different local areas of the world witness that population growth is not the only factor affecting the rate of resource degradation. Other factors such as land tenure system, and weak agricultural extension services that will help intensification would be a huge array of obstacles for better resource management. The policy implication drawn from this study is to formulate policies enhancing sustainable intensification of land resources that would lessen the need for agricultural expansion that latter reduce pressure on environmental resources. In the short-run, increase access to family planning services that could reduce fertility rate and population growth in the study area

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