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Full Length Research Paper

Assessing the Consequence of Land Use Change on Agricultural Productivity in Nadda Asendabo Watershed Gilgel Gibe Sub catchment of Ethiopia

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Abstract
Change in land use can negatively affect the potential use of an area and ultimately lead to soil and vegetation degradation that have an impact for loss of agricultural productivity. Hence, this study was conducted to examine land use change, its drivers and impacts in agricultural productivity in Gilgel Gibe Sub Catchment of Ethiopia. The impacts of land use change were investigated through socio-economic survey that involved 90 household interviews, key informants and 3 Focus Group Discussion. The result of socio-economic data analysis (the focus group participants and 96% of the sampled households) reported that agriculture, both crop and livestock productivity is declining. Clearance of vegetation has had an impact on the decline of agricultural productivity through soil fertility decline by the removal of vegetation cover and soil erosion. Among many factors, the major production constraints was directly associated mainly with land use change. Among others, the major reasons for the decline in vegetation cover include expansion of cropland, firewood collection for domestic consumption.

Key words: *land use, impacts agricultural productivity and watershed management*

Introduction

Land use activities, primarily for agricultural expansion and economic growth, have transformed one third to one-half of our planet's land surface in the form of forest clearance, agricultural practice and urban expansion, which made profound impacts on ecosystem service, food production and environment (Huimin Yan, 2009). The rapid increase in human population and strive for growth in the standard of living has put great pressure on natural resources such as vegetation, soil and water.

Through conversion and intensification of land use human have caused huge changes in the balance of natural ecosystems (Dale, 1997; Fenglei *et al.,* 2007). Land use change is driven by natural phenomena and anthropogenic activities, which in turn drives changes that would impact the ecosystem (Gol *et al.,* 2010; Rahdary *et al*., 2008). Crop land and pastures are now among the dominant ecosystems on the planet, occupying more than 35% of the world's ice-free land surface (Paul and Lisa, 2011). Likewise, agricultural land expansion and the ensuring land degradation and land use change. One of the negative impacts of land use change is the loss of fertile top soil that has multifaceted implication (Kahsay, 2004).

The agricultural sector in Ethiopia is increasingly being confronted with the pressure from a rapidly growing population and diminishing natural resources (Mulugeta, 2004). Ethiopian agriculture faces the challenge of providing food for a growing population (Abate, 2010). One of the immediate problems facing Ethiopia today is land degradation, particularly loss of vegetation cover and soil erosion contribute significantly to low agricultural productivity. In Ethiopia the highlands are the centre of economic activity of the country and are characterized by enormous ecological, environmental and agricultural diversity (Kahsay, 2004).

Generally, land use changes can affect the socio-economic status of the rural population (Lambin *et al.*, 2000). According to Muleta (2009), the most important human factors recognized as change agents of land use are the need to provide food for rapidly growing population this necessitates the expansion of agricultural land and the provision of land for the landless in order of self sufficiency. Consequently, agricultural productivity that determines rural income levels and wealth can be affected by the land use change. The land use change brings tremendous impacts in the agricultural productivity. Therefore, this particular study focused on the land use change and its impacts in southwestern highlands. Therefore, the objective of the study was to investigate the impacts of land use change on agricultural productivity in Nada Asendabo watershed, Gilge Gibe sub catchment of Ethiopia.

Materials and method

Description of the Study Area Location

The study area is located in Nada Asendabo watershed, is located close to Gilgel Gibe dam and about 260 km South West of Addis Ababa. The total study area covers 8,012ha. The site is located between 736' 00.87'' - 7^0 41' 05.72'' N latitude and 37^{00} 16' 55.88'' - 37 14' 40.73'' E longitude (Figure 1).

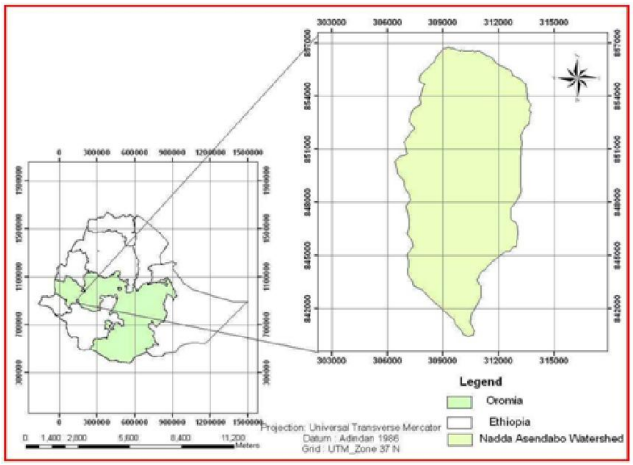

Figure 1. Location map of the study area.

The area is characterized by gentle, flat and undulating topography with the altitude ranging from 1650 – 2200 m.a.s.l. The upper part of the area is generally gentle slope. The lower part is with plain or flat. The drainage from this sub-watershed flow in to Gilgel Gibe dam.

According to Van Ranst *et al.,* (2011), the major reference soil groups in the Glgel Gibe catchment are Nitisols, Acrisols, Ferralsols, Vertisols and Planosols. Texture range from clay to loam clay or sandy clay. The middle and high altitude soils are less rich in nutrients due to the fact that they have been under human land use for long (SLMP, 2009).

The area is characterized mostly by hot moist tropical agro-climatic zone. The rainfall of the area is bimodal, with unpredictable short rains from March to April and the main season ranging over June to September. The minimum and maximum annual rainfall is ranging from 1066 to 1200mm with a mean annual temperature of 18-25^{O}C (SLMP, 2009).
The most important social and economic problems are low level income and the high population growth rate with declining agricultural production. The economic bases of the community in the area are rain fed farming practices, some irrigation and free livestock rearing. Mixed agriculture remains to be the main livelihood activity. The major cultivated crops include maize, teff and sorghum. Average land holding size is less than 2ha per household (SLMP, 2009). In general, activities other than agriculture seem to be very limited. In the area agriculture is an important household resource that played significant role to household food security, income generation, food supply and transportation for supply of manure and fuel. Cattle, sheep, goat, donkey and mules are the most common domestic animals raised in the area. Rangeland is common grazing system in the area (SLMP, 2009).

The elders of the surrounding have stated that 50 years past most of area was covered with indigenous trees such as *Poducarpus* and *Juniperus*. Later agricultural land expansions have resulted in destruction of forest trees and treat to even wildlife (SLMP, 2009). At the present, unsustainable management of the natural resource is manifested by cultivation of hillsides and steep slopes, clearing trees, changing grassland into cropland, soil erosion and less water infiltration due to devotion of vegetation, and organic matter deterioration are resulting in overall loss of land productivity.

Data Collection

Remote sensing, PRA tools and socio-economic survey techniques were employed to quantify land use change and to assess the impact of this change in the study area. Multi-temporal land satellite images of three periods: 1973, 1986 and 2004 were used. A structured questionnaire, focus group discussions and key informant interviews were used. In addition, transect walks involved direct observation was carried.

After getting the total number of household heads in the watershed it was determining total sample size of the survey. A total of 126 households were sub -sampled for the household questionnaire, however only 90 heads of household were interviewed for technical reasons. The number of sample household farmers selected for the questionnaire was determined using the Formula developed by (Cochran, 1977 as cited in Bartlett *et al*., 2001). The formula developed by (Cochran, 1977 as cited in Bartlett *et al*., 2001).

$$no = \frac{z^2 pq}{d^2} \rightarrow n = \frac{no}{1 + \frac{no - 1}{N}}$$

Where;

n_o = the desired sample size Cochran's (1977), when population is greater than 10000
n = number of sample size when population is less than10, 000
Z = 95% confidence limit i.e. 1.96
P = 0.1 (proportion of population to be included in the sample i.e. 10%)
q = 1-P i.e. (0.9)
N = total number of population
d = Precision or degree of accuracy desired (0.05)

Data Analysis

Land use change data was analyzed using Arc GIS 9.2 and to analyze the socio-economic data, descriptive statistics were utilized with the help of Statistical Package for Social Sciences (SPSS) version 16. There were parameters that required ranking. Hence, Indices were calculated to provide ranking of reasons of production constraints and also other causes of deforestation in the study area. The indices were calculated as follows; first sum up for the number of household ranked for each individual value, secondly multiply each of the rank by the overall reasons. Finally, the sum of each individual value divided by the overall reason will give the index value.
Index = Sum of (8 X number of household ranked first + 7 X number of household ranked second + 6 X number of household ranked third + 5 X number of household ranked fourth + 4 X number of household ranked fifth + 3 X number of household ranked six + 2 X number of household ranked seven + 1 X number of household ranked eight) given for an individual reason, criteria or preference divided by the sum of (8 X number of household ranked first + 7 X number of household ranked second + 6 X number of household ranked third + 5 X number of household ranked fourth + 4 X number of household ranked fifth + 3 X number of household ranked six + 2 X number of household ranked seven + 1 X number of household ranked eight for overall reasons, criteria or preferences.

Results and Discussion

Land use class change

For a clear and informative comparison of the land use change area value for the periods of 1973, 1986 and 2004 summarized in table below. More of forest land, grass land and reverine forest cover and bush land existed in 1973 and 1986 maps but were reduced in the 2004 map. The latter map showed a predominance of agricultural land and built up area instead.

Table1. Comparison of area under different land use during three different years

Land use types	Years					
	Area for 1973(ha)	Area in (%)	Area for 1986(ha)	Area in (%)	Area for 2004(ha)	Area in (%)
Bush land	1901	23.73	991	12.37	634	7.91
Reverine forest	1456	18.17	505	6.30	349	4.36
Agricultural land	1535	19.16	4,175	52.11	5255	65.60
Grass land	1920	23.96	1,646	20.54	681	8.50
Built - up area	117	1.46	272	3.40	712	8.88
Forest land	1083	13.52	423	5.28	381	4.75
Total	8,012	100.00	8,012	100.00	8,012	100.00

Table 1 above show that land use class distribution by the respective years (1973, 1986 and 2004) for the study area. In 1973, (Figure 3) the dominant land use classes were grass land and bush land that are found in all parts of the watershed part covering 1920ha (23.96%) and 1901ha (23.73%) respectively.

Land Use Change and Its Impacts: The Interplay

Crop productivity and production constraints

Major crops grown in the study area include maize, sorghum and teff. Maize was the dominant crop. According to the focus group participants and 96% of the sampled households respondents the current crop productivity is low as compared to levels some years ago. There was an increasing trend of productivity for some years past that could be due to high fertility of the soil and the new land best for agricultural production due to high agricultural expansion and new technological adoption. Meaning, there was agricultural expansion into previously uncultivated areas, which usually takes place at an extensive and constant technological level; and agricultural intensification on already cultivated land. According to the interviewed household and data on crop yield average production varies among different landscapes and between crops. As the respondents stated, the main reasons for the declining in agricultural productivity mentioned the production preference, the production constraints was directly associated mainly with land use change. Constraint preference rank in the area was presented. Among many factors, low fertility, improved seed scarcity and unaffordable price of fertilizer were the first, second and third main reasons with an index values of 0.214, 0.195 and 0.172, respectively.

Table 2. Ranking of major constraints for decline in crop production of the study area (%)

Production constraints	Ranking							
	1st	2nd	3rd	4th	5th	6th	7th	Index
Land degradation/low fertility	53.33	10.00	21.11	10.00	3.33	1.11	1.11	0.214
Improved seed scarcity	20.00	36.66	22.22	13.33	5.55	1.11	1.11	0.195
Unaffordable price of fertilizer	15.55	22.22	22.22	14.44	22.22	0.00	3.33	0.172
Minimum farm land	2.22	1.11	3.33	13.33	24.44	36.66	18.88	0.092
Pest/ diseases/ weeds	1.11	14.44	24.44	33.33	14.44	5.55	6.66	0.147
Lack of extension service	3.33	4.44	3.33	2.22	6.66	44.44	35.55	0.078
Erratic rain fall	4.44	11.11	3.33	13.33	23.33	11.11	33.33	0.105

Index = sum of [7 for rank 1 + 6 for rank 2 + 5 for rank 3+ 4 for rank 4 + 3 for rank 5 + 2 for rank 6 + 1 for rank 7] for a particular production constraint divided by sum of [7 for rank 1+ 6 for rank 2 + 5 for rank 3 + 4 for rank 4+ 3 for rank 5 + 2 for rank 6 + 1 for rank 7] for the overall production constraints for decline in crop production of the study area.

According to group discussions with the sampled households, high population pressure in the area contributed to reduction for agricultural production. Similarly, the results of remote sensing data on land use change also show an increasing trend of agricultural land during the study periods. This increase in an area of agricultural land was mainly at the expense of bush land, grass land and other vegetated area clearance. The decline in the average land holding, together with the disproportion between population growth and agricultural land further aggravated soil erosion later decline in soil fertility and impact on agricultural productivity.

Livestock production and production constraints

In the study area, according to interview with respondents the source of livestock feed were private land, common land and both the private and common land. The land use change data shows that, highly declining of grazing land that affects the availability of feed resources for the livestock. According to the socio-economic survey data, the trends of the number of livestock show the declining manner as shown below Figure 2.

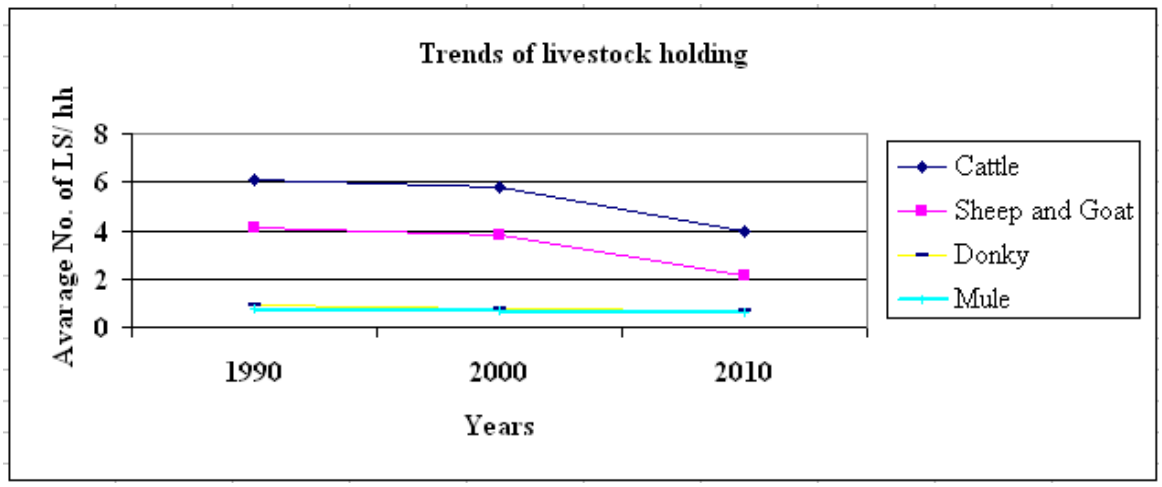

Figure 2. Trends of livestock holding of sampled households (n=90)

The reasons for the declining of livestock number are many. Among this the major reasons are shown in Table 3. Generally, most of the respondents recognized that grazing area had declined, due to the conversion to cultivated land, decrease productivity of grazing land, conversion of bush land to cultivated land, expansion of settlements and inadequate rainfall as the 1st, 2nd , 3rd, 4th and 5th Rank respectively, according to their major reasons.

Table 3. Reasons for shortage of livestock feed as the respondent's perceived (%)

Reasons for shortage of livestock feed	Ranking					
	1st	2nd	3rd	4th	5th	Index
Grass land changed to cultivated land	87.8	8.88	1.11	1.11	1.11	0.320
Decrease in productivity grazing land	3.33	33.33	31.1	22.22	10.0	0.198
Conversion of bush land to cultivated	0	34.44	34.4	18.88	12.2	0.194
Expansion of settlements	4.44	16.66	16.7	18.88	43.3	0.148
Inadequate rainfall	4.44	6.66	16.7	38.88	33.3	0.146

Index = sum of [5 for rank 1+ 4 for rank 2 + 3 for rank 3 + 2 for rank 4 + 1 for rank 5] for a reasons for shortage of particular livestock feed divided by sum of [5 for rank 1+ 4 for rank 2 + 3 for rank 3 + 2 for rank 4 + 1 for rank 5] for the overall Reasons for shortage of livestock feed as the respondent's perceived.

According to the study, 96% of interviewed households depend on agriculture (both crop production and livestock production). However, results of socioeconomic survey showed that soil fertility loss, soil erosion, crop yield decline and the reduction in livestock numbers have occurred. These were mainly due to removal of vegetation cover and increasing demand of agricultural land and forest products induced by population pressure in the study area. Since the demand for cropland has come into increasing competition with that of grazing land, the availability of grazing area and livestock feed shows a declining trend. The expansion of settlement and grass land degradation has also contributed to this problem. Hoekstra *et al*. (1990) also reported that the decline in fodder resources is due to the ever-increasing human population which resulted in an increase in crop land at the expense of traditional grazing areas such as bush land, natural pasture and forest, which has recently been aggravated.

Summary and Conclusion

This study used an integrated approach to understand past and the present conditions of the study area. Remote Sensing data indicates that there are land use changes that have an impact on agricultural productivity. In the study area, the vegetation cover was converted to cultivated land and builtup area. As a result, land degradation occurs and productivity is decreasing; consequently, the current crop yield per unit area is gradually declining. Similarly, the number of livestock per household also declined due to the low availability of livestock feed, caused by the conversion of grazing area to other land uses, decrease productivity of grazing land, conversion of bush land to cultivated land, expansion of settlements. In contrast, the absence of such proper natural resources management has led to the further degradation of the natural resources latter treats to the land degradation and productivity decline. The main conclusion of this study is that, among other factors, the cover change in the study area may affect natural resources and reduce agricultural productivity on which the livelihood of the local community. Therefore, the current trends in land use must be improved, towards the resources

management and conserving of the existing natural resources in the study area through community participation and using sustainable land resources management plan so that agricultural productivity can be improved. The change in land use in the study area have negative impacts in agricultural productivity therefore, to mitigate the impacts there should be an introduction and dissemination of other technologies, in order to reduce pressure on natural resource. Strong and effective policy interventions such as forest policy and land ownership have to be implemented to protect any remnant vegetation so as to sustain the productivity of the land.

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