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Full Length Research Paper

Detecting and Quantifying Land Use/ Land Cover Dynamics in Nadda Asendabo Watershed, South Western Ethiopia

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Abstract
Understanding of the driving forces of land use/ land cover (LULC) change is essential for effective sustainable land resource management. Change in LULC can also negatively affect the potential use of an area and may ultimately lead to land degradation. Hence, this study was conducted to investigate LULC dynamics in Nada Asendabo watershed, South Western Ethiopia. It covers an area of 8,012 ha. Information is extracted from three period land sat images (1973 MSS, 1986 TM and 2004 ETM+). Six LULC classes namely forest land, agricultural land, grass land, built-up area, reverine forest and bush land were selected for the study. Results from LULC change analysis showed an increase in agriculture land and built-up area from 19.16% and 1.46% in 1973 to 52.11% and 3.40% in 1986, 65.60% and 8.88% in 2004 respectively. The increase in agricultural land and built-up area was mainly at the expense of forest land, grass land, reverine forest and bush land. Increasing population is the major contributing factors for the changes. Hence, Studies of land use/ land cover dynamics can be used for land use planner, natural resource managers and policy makers to provide a management and decision process.

Key words: GIS, Remote Sensing, LULC dynamics and watershed management

Introduction

The rapid increase in human population and strive for growth in the standard of living has put great pressure on natural resources. Through conversion and intensification of land use human have caused huge changes in the balance of natural ecosystems (Fenglei et al., 2007). According to (Rahdary et al., 2008), LULC change is dynamic, widespread and accelerating process, mainly driven by natural phenomena and anthropogenic activities. Geist and Lambin (2002) also stated as constantly changes in response to the dynamic interaction between underlying drivers and proximate causes. In general, LULC changes are affected by human-induced activities and growth, socio-economic factors, deterioration of vegetation cover, agricultural activities, government policies and environmental factors (Gol et al., 2010).

only few landscapes remain on the earth that are still in their intact natural state, the major causes of LULC dynamism being primarily associated with agricultural activities. According to (Khalid et al., 2010), the land degradation which appeared in the area particularly in agriculture is a result of rapid LULC changes. 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 ensuring land degradation introduces are serious environmental challenge in the highlands of Ethiopia.

The Ethiopian high lands, areas with elevation above 1500 m.a.s.l, cover about 500,000 km2 and represent 43% of the country (Mohamed, 1995). These highlands are the centre of economic activity of the country and are characterized by enormous ecological, environmental and agricultural diversity (Alemneh, 2003). The early development of agricultural systems and human settlement in this agro-ecological zone may have been due to the favorable climatic and ecological conditions in these areas. It may be for this reason that the highlands have been settled for millennia and known for a similar long-standing agricultural history (McCann, 1995).

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. The agricultural sector in Ethiopia is increasingly being confronted with the pressure from a rapidly growing population and diminishing natural resources (Mulugeta, 2004). The growing population and increasing socio-economic necessities creates a pressure on LULC chane (Fenglei et al., 2007).

In Ethiopia, limited number of studies has been conducted on LULC changes. Large areas, which were once under vegetation cover are now changed to cultivated land and expose to soil erosion resulting into environmental degradation and serious threat to the land (Amare, 2007). Generally, studies of LULC changes in Ethiopian highlands concentrate in the Northern Ethiopian highlands, areas early settled and where population pressure is relatively high (e.g. Belay, 2002). There have been very limited studies of similar topic in the southwestern regions of the country. Therefore, this particular study focused on the LULC dynamics in southwestern highlands. Available data on LULC change can provide critical input to decision making of environmental management and planning the future (Selcuk, 2008). Therefore, such a study will be used for land use planer and natural resource managers as a precursor to formulate and implement effective and appropriate strategies.

Accordingly the specific research question envisaged to be addressed in the study includes: What was the area of LULC during three different periods? The present study was, therefore, undertaken to investigate and quantify LULC dynamics in Nada Asendabo watershed, South Western Ethiopia.

Materials and Methods

Description of the Study Area

The study area is located in Nada Asendabo watershed, Omo Nada Woreda, Jimma zone of Oromia Regional State. It is located close to Gilgel Gibe dam and about 260 km South West of Addis Ababa. The site is located between 70 36’ 00.87’’ - 70 41’ 05.72’’ N latitude and 370 16’ 55.88’’ - 370 14’ 40.73’’ E longitude (Figure 1). It covers an area of 8,012 ha.

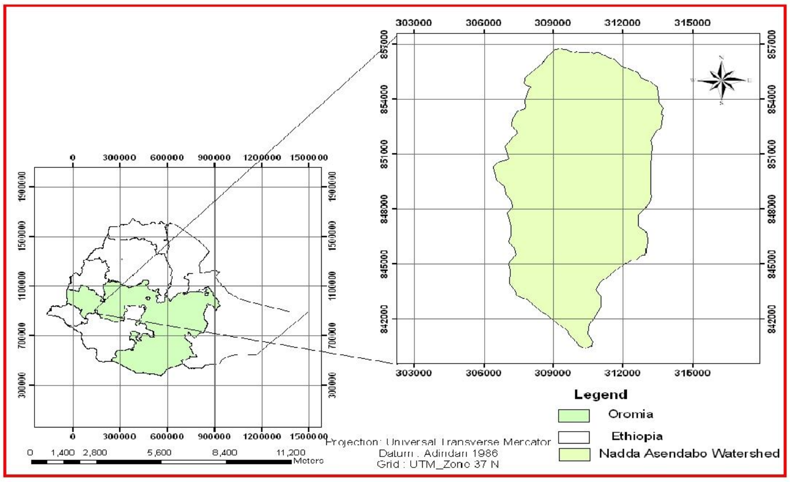

Fig 1. Location map of the study area.

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 Gilgel Gibe catchment are Nitisols, Acrisols, Ferralsols, Vertisols and Planosols. 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 18-25OC (SLMP, 2009).

50 years past most of area was covered with indigenous trees such as *Poducarpus falcatus* and *Juniperus procera* (personal communication). 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, and clearing vegetation.

Data collection procedures

Remote sensing, PRA tools and survey techniques were employed to quantify LULC change in the study area. Remote senesing data and topo map with the scale of 1:50,000 were used as supporting spatial data for delineating the boundary of the study watershed. GPS Germen was also available and used for ground verification. Multi-temporal land satellite images of three periods were obtained and used as data sources for LULC dynamic study (Table 1).

Table 1. Satellite images used for the study

Land sat Types	Date of Acquisition	Spatial Resolution (m)
Land sat-MSS	January 1973	56.75mX56.75m
Land sat-TM	March 1986	28mX28m
Land sat-ETM+	February 2004	28mx28m

A preliminary field survey had been conducted to get a general view on the physical condition of the area, such as the vegetation cover, LULC type and topography of the study area. GPS points during field work have been used as the support for the image classification. More than 155 sample training sites have been collected from all LULC class.

Analyzing land use/ land cover dynamics

Analysis of LULC dynamics was analyzed using Arc GIS 9.2 and ERDAS IMAGINE 9.2 soft ware. The acquired multi-temporal images were processed following standard image processing procedures that comprise image enhancement, rectification and classification. This has allowed the extraction of information on LULC condition and quantification of changes and its rate over the past 31 years using multi temporal analysis. The whole procedure followed is summarized in the chart below (Figure 2):

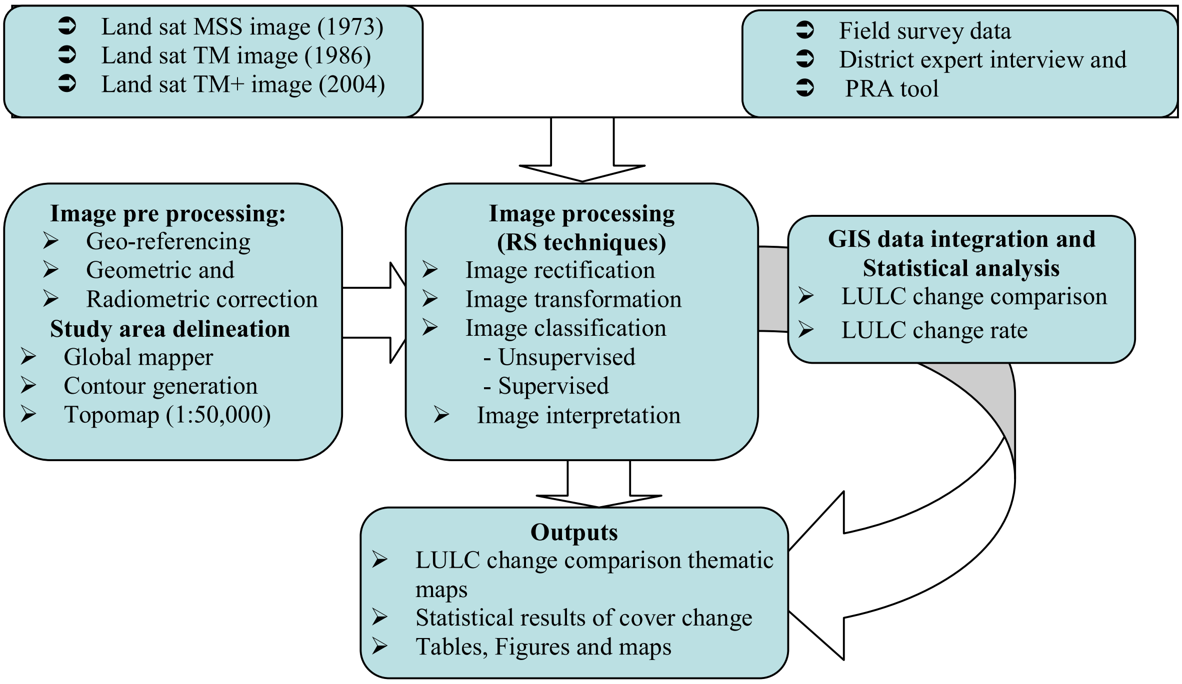

Fig 2. Flow chart showing methods for land use/ land cover classification

A combination of information collected from the field, topographic map and local people knowledge and satellite images was used in the analysis of LULC change.The land cover map for the three period series of images was analyzed based on LULC types area comparison. The changes over 31 years were analyzed and rate of change for each LULC type is calculated. In the mean time, the rate of LULC change for the two periods from 1973 - 1986 and 1986 - 2004 can be computed using the following simple formula:

$$r=(Q2-Q1)/t \quad \text{------equation1}$$

Where, r = rate of change
Q2 = recent year land use/ land cover in ha
Q1 = initial year land use/ land cover in ha and
t = interval year between initial and recent year

Results and Discussion

Land use/ land cover class change for 1973, 1986 and 2004

For a clear and informative comparison of the land use/ land cover change area value for the periods of 1973, 1986 and 2004 summarized in Table 2 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 (Table 2). The latter map showed a predominance of agricultural land and built up area instead. Generally, there was a continuous change taking place for most LULC types over the whole study period.

Table 2. Comparison of area under different land use/ land cover types during 1973, 1986 and 2004.

Land use/ land cover 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**

Figure 3, below show that LULC class distribution by the respective years (1973, 1986 and 2004) for the study area. In 1973, the dominant LULC classes were grass land and bush land that are found in all parts of the watershed part.

On the map of the 1986 agricultural land predominates and followed by grass land, bush land, forest land and built-up area of the total area coverage. In 2004 agricultural land still dominated covering followed by built-up area.

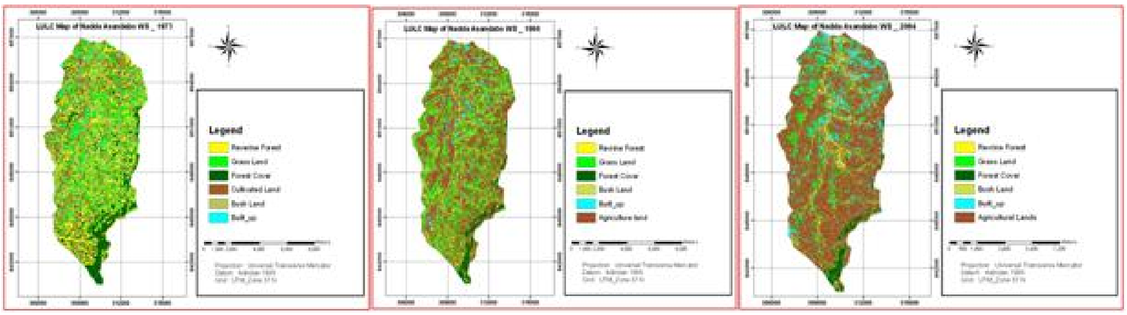

Fig 3. Land use/ land cover map of the study area in 1973, 1986 and 2004 respectively.

Rate of land use/ land cover change

The dynamics in land use/ land cover change from 1973 to 2004 is discussed by separating them into different periods. The results showed that in all period's agriculture and built-up areas showed an increment, while the rest showed a decrement in area coverage.

Table 3. Rate of land use/ land cover change in the study period

Land use/ land cover types	1973 to 1986		1986 to 2004		1973 to 2004	
	Area Change (ha)	Rate of Change (ha/yr)	Area Change (ha)	Rate of Change (ha/yr)	Area Change (ha)	Rate of Change (ha/yr)
Forest land	-660	-50.77	-42	-2.33	-702	-22.64
Agricultural land	2,640	203.08	1080	60.00	3,720	120.00
Grass land	-274	-21.07	-965	-53.61	-1,239	-39.97
Built-up area	155	11.92	440	24.44	595	19.19
Reverine forest	-951	-73.15	-156	-8.66	-1107	-35.71
Bush land	-910	-70.00	-357	-19.83	-1267	-40.87

Generally, grassland, forest land, bush land and reverine forest showed a continuous decline. This is believed that the agricultural and built-up areas expanded at the expense of grass land, forest land, bush land and reverine forest.

The observed trends of increasing agricultural land and built-up areas and decreasing grass land in the area could be explained by: First, the population growth forced the farmers to till and expand their lands in greater extent than before to cope up with the conditions and to sustain their life Second, infrastructure expansion on the expense of grass land, forest land, and bush land has contributed to the reduction of those land use/ land cover types in the area. However, this change also alters to cultivated land.

Some earlier studies in some area indicated that many households were abandoning unproductive grazing land and the increasing population pressures have an impact on natural resources degradation. The study revealed that most of the potential grazing areas have been mostly affected by human factors. Even though it has continuous gain in total bush land overtime its high loss of bush land and grass land latter changed to cultivation land signifies a negative outcome of combined long-term efforts of grass land conservation.

The expansion of agricultural land during the first study period at the expense of other lands indicated increased pressure on agricultural land latter reduces the productivity due to its resources exploitation, unsustainable cultivation and soil fertility decline. These days cultivation through conversion of grazing land or bush lands to cultivated lands is becoming a must to the area due to high population pressure. In this condition, the expected livestock death is high and the area could be productive up to some certain period of time while its productivity will reduced after repeated cultivation.

Conclusion

Land use/ land cover change analysis are the major information required for planning and decision making. This study used an integrated approach to understand past and the present conditions of the study area. The study comes up with the following major findings; generate thematic LULC maps for change comparison and dynamics using land sat images. Six LULC classes were identified. Based on the findings of the study LULC classification change analysis for the study periods revealed that dynamism and it was found that there is rapid increase in cultivated land and built up area, while there is a decreasing trend in grass land, forest land and bush land. Generally, the results also show that the extent of agricultural and built up area has increased the whole periods at the expense of mainly grass land, forest land, reverine forest land and bush land.

This is prevalent phenomena and the resource degradation due to unsustainable land resources management, removal of vegetation cover, population growth and the associated expansion of farming and increasing demand for resources are imposing threat on the productivity. The high population pressure contributed to the clearance of vegetation for the expansion of new agricultural land, homestead, fuel wood consumption and other livelihood needs which further exacerbated the degradation of natural resources latter aggravated low agricultural productivity.

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 depends for both subsistence and income generation. Therefore, the current trends in land use/cover must be improved, towards the resources management and conserving of the existing vegetation and other natural resources in the study area. There should be well organized, strong and effective policy intervention to protect the remaining vegetation and avoid further extinction. These should actively involve and be done in collaboration with all concerned stakeholders (such as local communities, government and NGOs) for effective management of natural resources.

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