Land Use/Cover Dynamics in Ribb River Watershed, North Western Ethiopia

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Abstract

Land use/cover change dynamics influences many aspects of the natural environment. Its shifting patterns as a component of many existing climate change problems has been gaining recognition as key cause and consequences of environmental problems and livelihood change. The Ribb River Watershed has been subjected to prolonged use for agriculture without conserving the natural resources. Forest degradation, biodiversity and habitat loss and soil degradation are the common problems in the area. Therefore, determining the land use and cover dynamics in the Ribb River Watershed was important to make decisions on resource conservation and executing sustainable development activities in the watershed areas. The main objectives of the study were to determine the land cover/use status of Ribb River Watershed in the years 1973, 1987, 1995, and 2011 by using landsat images and socio-economic data from the study area. The overall results of the analysis have shown that between the last 38 years in the Ribb River Watershed, about 57.4 % offorest, 52.3 % of bush lands 63.5 % of areas of water bodies were converted to cultivated and settlement lands, grazing lands and wetlands. The cultivated and settlement lands, grazing lands and wetlands increased in area by 36.2%, 50.9% and 66.3% respectively. Population pressure and land tenure policy were identified as the main causes for changes in land use/cover. The results of this study were significant indicators for planners and other stakeholders in the watershed to take measures that can help to bring long term solutions for resource conservation and bringing sustainable development and livelihood attaining mechanisms in the watershed.

Key Words*: Ribb River, watershed, land use/cover, Land Cover Change, GIS and remote sensing*

Introduction

Land cover refers to the bio-physical sate of the earth's land surface and immediate sub-surface (Turner *et al.,* 1995). Land use/cover plays an important role in affecting spatial patterns and shapes under the influence of forces of human needs and environmental features and processes (Briassoulis, 2000). It could involve changes in productivity, biomass, or phonology (Skole and Cochrane, 2004). Most of the land cover changes of the present and

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the recent past are due to human actions. Mankind's presence on the Earth and his modification of the landscape has had sound effect upon it (Aspinall and Hill, 2008). Land use/cover change involves either direct or indirect modification of the natural habitat and impact on the ecology of the area (Prakasam, 2010). These changes encompass climate change, including biodiversity loss and the pollution of water, soils and air which are the greatest environmental concerns of human beings today (Briassoulis, 2000). Different studies in the world revealed that Land use/cover dynamics and subsequent conversion lead to loss of biodiversity, deterioration in the physical and chemical properties of soil which causes degradation of the land (Emadodin *et al.,* 2009). According to Rientjes *et al.* (2011) changes in stream flow records were a result of changes in land cover observed in the area. Land use/cover (LUC) dynamics have attracted interest among a wide variety of researchers, ranging from those who favor modeling spatial and temporal patterns of land conversion to those who try to understand causes and consequences of land use change.

Population pressure has been found to have negative effect on LUC of an area (Sewnet and Rao, 2011; Shiferaw, 2011), riverine trees in Chemoga watershed (Woldeamlak, 2002). Spatial and demographic changes in Ethiopia have sharp impact on agricultural land and the supply and amount of fuel wood in the surrounding areas. Human activities including agriculture change the land use/cover and ecosystem use that together alter the amount of available photosynthetic production (Sewnet and Rao, 2011). There was mismanagement of land, including overgrazing and clearing of forests for different purposes. The rural poor people have been also degrading the natural resources to sustain their livelihoods (Amare and Kameswara, 2012). Because of small land holding size and shortage of land in the highlands of Ethiopia, plowing steep slopes with marginal output is common practice which has led to land and other natural resources degradation (Grepperud, 1996; Amare, 2013a). Thus, according to this study land tenure insecurity, poverty, lack of land and inaccessibility to market and road facilities are assumed to be the main drivers of natural resource degradation and the cause for extinction of fauna and flora from Ribb River Watershed.

Similarly, other different LUC change studies are made using GIS and remotely sensed data of different years, in some parts of Ethiopia. An important factor contributing to the decline in natural resources is the ever increasing human population, which resulted in an increase in cropland at the expense of traditional grazing areas such as bush lands, natural pasture and forests (Amare, 2013b). Particularly, ever-increasing unsustainable utilization of resources coupled with land use changes; agricultural intensification, rapid population growth, and poverty intensification are the major causes of natural resource degradation. Lack of integrated watershed/landscape management and lack of proper land use planning and clarity in the procedures for, and jurisdictions over, resource utilization of the watershed and its associated biodiversity have also been contributory causes.

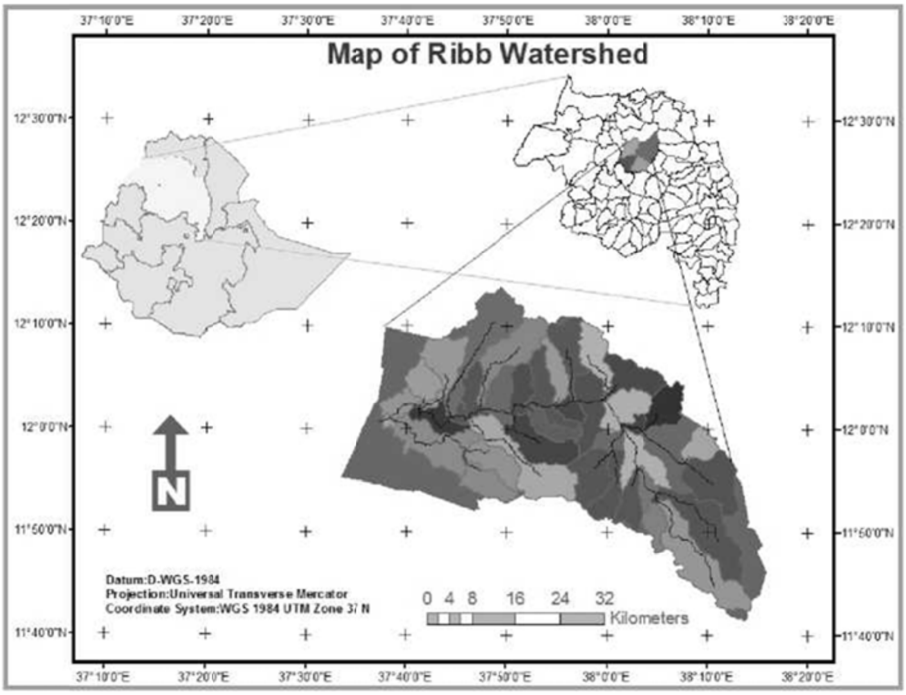
Accurate information on land-cover changes and the forces and processes behind is essential for designing sound environmental management policies. The land-cover analysis provides the baseline data required for proper understanding of how land was used in the past and the types of changes to be expected in the future. This research was therefore, aimed at analyzing the link between land cover changes and its causative factors in Ribb River Watershed. Identifying the driving forces behind land use changes, and developing appropriate measures to minimize their ecological effects have a great deal of importance for land use planning. Specifically, this study determines land cover and use status with special reference to its causes and evaluation of their consequences through time in Ribb River Watershed. Accordingly, one of the most densely populated areas of Ethiopia, the Ribb River Watershed, area of Lake Tana, was proposed for the study. Hence, the study was aimed at determining the land/cover changes between 1973 and 2011 and identifying the main causes of land cover/use in the Ribb River Watershed.

Study Area and Methodology

Description of the Study Area

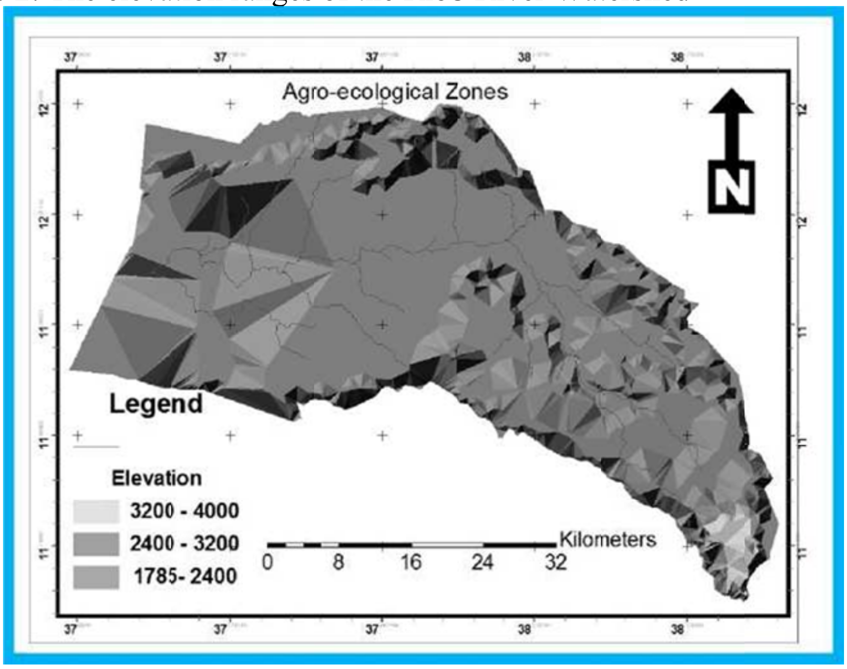
Ribb River Watershed is located mainly in Ebinat, Farta, Fogera and Libo Kemkem districts of South Gonder Zone, Amhara Region. It is situated at a distance of 625 km North-west of Addis Ababa, 60 km away from Bahir Dar Town, capital of the Amhara Region. Ribb River Watershed is part of Lake Tana Basin. The watershed is located between 10°43" north, and 11° 53" north latitude and 35^0 and 37° 47" east longitude (Figure1).

Figure 1: Map of the study area (Ribb River Watershed)



Ribb River Watershed receives mean annual rainfall of 1488 mm. The watershed receives maximum rainfall during the months of June, July, August and September. The mean annual maximum temperature is about 2^0C. The mean minimum temperature is 10^0C. Peak flow in the River occurs in August with average monthly flow of $52m^3s"^{\ 1}$ when rainfall is at its maximum. The Watershed's topographic feature extends from a place where Ribb River originates, fringes of Guna Mountain to where finally it joins Lake Tana. This downstream part of the Watershed is part of the wide flat floodplain called Fogera Flood Plain, with a total area of 490 km^2 (Abera, 2011). The upper part of the Watershed is highly rugged with high Guna Mountain ranges. The elevation in the Watershed ranges from 1785 meter above sea level around Lake Tana to 4000 meter above sea level around source of the Watershed (Figure 2). The Watershed is dominated by a huge volcano system named Guna Mountain Shield Volcano (Getnet, 2011; Abera, 2011). It corresponds to the eruptive events that occurred during the early Miocene to Pliocene Period and classified in the shield group basalt (Getnet, 2011). At the end of the Ribb River, the area is completely overlain by recent flood materials, which are mainly covered by silt to clayey deposits (Genet, 2011).

Figure 2: The elevation ranges of the Ribb River Watershed



According to CSA (2007) the total number of population that shares the watershed was 878,261 from which 447,795 were male and 430,466 were females. Mixed farming is the common practice in the Watershed. From the total of 857,018 were Orthodox Christians and 19324 people were Muslims. The remaining are followers of other religions.

Data Sources and Methods of Analysis

The principal data used in this research was landsat images of 30 meter resolution, climate data, socio-economic and census and other population reports from different sources. The major data source for land cover/use analysis was http://glovis.usgs.gov where free landsat image was available (Table 1). Four multi-temporal remotely sensed images were acquired for change detection for this study, including (Landsat MSS 1973, Landsat TM 1987, Landsat TM 1995, and Landsat TM 2011). The process of detecting LUC from the satellite images were prepared using image processing techniques, and classification of images into different LUC classes were determined based on the information acquired from unsupervised classification, field observation of the LUC of the sample areas. Images chosen from the same season can also reduce the misclassification error related to spectral analysis of different land use/cover types. In addition, contour map of the study area, the topographic maps assisted to digitize some features and in field investigations and accuracy assessment of the image classification. Each image was enhanced by using linear contrast stretching and histogram equalization to improve the image to help identify ground control points for rectification. These data were resampled by using the nearest neighbor algorithm, so that the original brightness values of pixels kept unchanged. The MSS and Landsat images were geo-referenced by using ground control points. To make the classified land cover images comparable in terms of landscape metrics, the images must have the same spatial resolution. Our approach is to resample the classified images to 30 m, which is close to the lowest spatial resolution of all images using the majority rule aggregation, the method that Petit and Lambin (2001) proposed. After resampling, a majority filter (3^3) was applied to the classified images for the removal of isolated pixels to minimize potential analytical errors.

Table 1: Description of Image Data and Sources

Image	Path	Row	Spatial Resolution	Acquisition Date	Source
Landsat MSS	181	52	57x 57	01 - 02 - 1973	USGS
Landsat TM	169	52	28.5 x 28.5	31-01 - 1987	USGS
Landsat TM	169	52	28.5 x 28.5	21 - 01 - 1995	USGS
Landsat TM	169	52	28.5 x 28.5	01-01 - 2011	USGS

The supervised classification is the most common method in obtaining land use/cover information. In this research, after data preprocessing, a training

$$\begin{bmatrix} A_{11} & A_{12} & \cdots & A_{1n} \\ A_{21} & A_{22} & \cdots & A_{2n} \\ A_{n1} & A_{n2} & \cdots & A_{nn} \end{bmatrix}$$

Where: Aij is the area of conversion from i type of land use in k time to j type of land use in k+1 time.

sample was selected according to spectrum features. Unlike the conventional classifications of land use/cover, the maximum likelihood classification was used to map the land use/cover of watershed. When finishing supervision classification, manual-work interpretation was done on the image classified, and the precision of classification result was assessed. *Using classification result of the two-time remote sensing images and conversion matrix model, (formula) land use conversion matrix can be obtained through cover analysis. Conversion direction of certain type of land and resources of newly increased area of certain type can be seen clearly by matrix like below.*

Accuracy assessment was conducted following the image classification. Accuracy assessment was very important for understanding the developed results and employing these results for decision making (Congalton and Green, 1998). One hundred and eighty randomly collected independent points were used for assessing the accuracy of the classification. Finally, the accuracy of the classification result for 2011 images was obtained. Therefore, the error matrix and other statistics, which includes overall accuracy and kappa statistics, were used to determine the accuracy of classes obtained from the image classification process.

Based on FAO standard and the ground truth surveys using GPS systems and unsupervised classification techniques of the land sat images, the land cover was classified. The major land classes were: forest, agriculture and settlement area, wood and bush lands, grass and bare lands, water bodies and wet lands. Only major land cover types were considered, the dispersed rural settlement for example is included in the classification of agricultural areas, because settlement in the rural areas are near their farmlands and the swamps, ponds, riparian vegetation and marsh areas were categorized under wetlands (Table 2).

Table 2: Land use/cover classes and their description

Code	Land class	Description
1	Water Bodies	Areas with surface water in the form of ponds, lakes, streams, rivers, and reservoirs.
2	Wetlands	Areas covered by marsh, playas, ox-bow lakes, cut-off meanders which are seasonal as well as permanent in nature
3	Cultivated and Settlement Lands	Areas with standing crop, tree crops, and crop lands where the crops were harvested and rural and urban settlement areas.
4	Forest Cover	Areas with tree cover of more than 10% and more than 0.5ha, with minimum tree height of 5m.
5	Bush Lands	Scrub vegetation at the fringes of forest cover and areas dominated by scattered tree less than 5m height
6	Grazing Lands	Areas of natural/semi-natural grass land with other grazing-like plants and non-grazing-like plants.

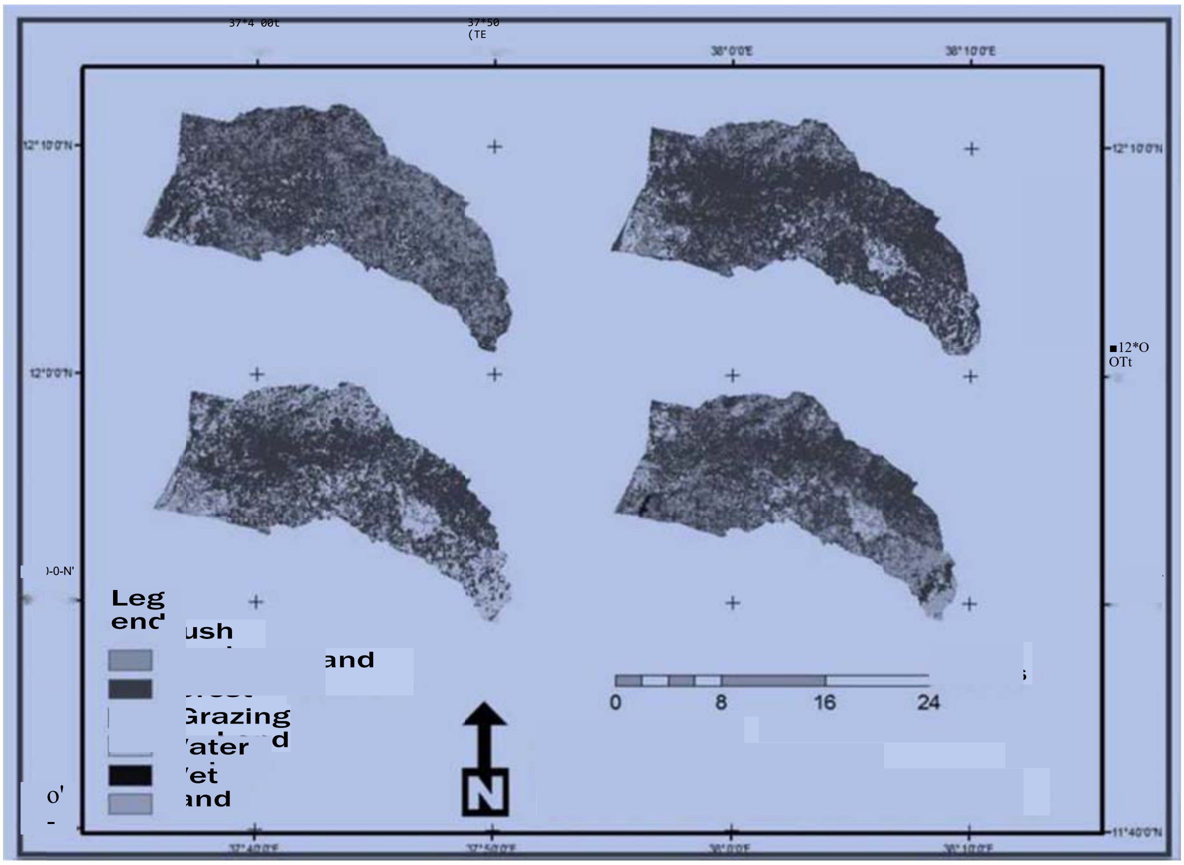
Source: FAO, Africover (1997)

The socio economic data obtained from different census of population and the household survey were analyzed using Statistical Package for Social Sciences (SPSS). Data collected through focus group discussion, interviews and field observation were summarized using qualitative techniques and supplement the qualitative results. Population growth, size and doubling time were calculated by using different techniques.

Results and Discussion

The LUC maps of the Ribb River Watershed for four reference years, and statistical summaries of the different LUC types are presented (Figure 3 and Table 2). Land use/ cover change results were obtained by using combined methods of analysis of remote sensing and GIS techniques from Landsat MSS images of 1973, Landsat TM images of 1987, 1995 and 2011.

Figure 3: Land use/cover dynamics map, 1973-2011



Water bodies (WB): The water bodies covered about 0.5% of the total area of the watershed in 1973. The cover share of WB has been continuously declining to 0.3%, in 1987 and1995 and 0.2 %, in 2011 (Table 3). This scarce natural resource in the Watershed has lost 63.5 % of its cover between 1973 and 2011. This result also agrees with Ellis (2010) and Amare (2013b). These studies confirmed that there was land cover change in Gilgel Abbay Watershed at the same time. These studies have indicated the declining of water cover in the Watershed.

Wetlands (WL): The wetlands in the Ribb River Watershed have shown dynamic changes. In 1973, it was about1.69% and increased to 1.87% in 1987, but declined to 1.85% in 1995, and increased to 2.81% in 2011 (Table 3 and Fig. 3). Studies on flood hazard (Legesse and Gashaw, 2008) in the area revealed that downstream part of the Ribb River Watershed and the different land uses in these areas were within high to very high flood hazard and risk level. Specially, flood hazard was severe in the years 1996, 1998, 1999, 2000, 2001, 2003 and 2006 may be one reason for the wetlands increase in the Ribb Watershed (Legesse and Gashaw, 2008).

Cultivated and Settlement Lands (CSL): Cultivated and settlement areas have shown increasing trends between 1973 and 2011. In 1973 it was about 51.7% and it increased to 67.97% in 1987, 70.67% in 1995, but slightly decreased to 70.43% in 2011, respectively (Table3 and Fig.3). It was one showed the largest expansion and share than other land use types. This implies agriculture and settlement has expanded by converting other covers such as grass, forest, bush lands and water bodies. This could have resulted in degradation of land and water resources in the watershed. Similar studies in other parts of the world have shown that population growth was a major driving force for LUC dynamics (Turner, 2009). This implies that the existence of little or no possibility of earning livelihood from off-farm employment has made no alternatives and made people to participate on cutting trees and expanding agricultural areas (Shiferaw, 2011; Amare, 2013a).

Forest Cover (FC): Forest cover constituted 11.74% of the total area of Ribb River Watershed in 1973 and showed rapid decrease during the next period of the study. The land cover share of forest has declined to 2.40% in 1987

(Table 3 and Fig. 3). However, it slightly increased in the remaining study years because of conservation practice in the area. But this scarce resource in the watershed has lost its 57.42% of the cover from 1973 to 2011. This has shown that deforestation rate in the Watershed was rapid and the majority of available forests have changed into other land use units. This implies that because of deforestation, there may be rapid run off and less infiltration and other related effects on the Watershed (UNEP, 1983; Kassa, 2003).

Bush land (BL): The change in bush land cover was not similar throughout the study time. Bush land showed a decreasing trend during the two study periods. But it declined in the third point of time and again increased during the last period from 29.34 % in 1973 to 16.29%, 8.15 % and 14% respectively from 1973-2011 (Table 3 and Fig. 3). The result had shown two fold decrease of bush lands in the watershed. However, in 2011 bush lands increased to 14% because of recent conservation activities in the study area. Generally, in the years between 1973 and 2011 bush land cover decreased by 52.3%. This indicates that there was extensive clearing of bush lands for human settlement, farming and other household activities (uses) (Kassa, 2003; Muluneh, 2010).

Grazing Lands (GL): This study encompasses the land covers that include areas of natural grazing along with other vegetation, predominantly grazing like plants (monocots) and browsing like plants (FAO, 1997). Within the stated years grazing lands have shown continuous increase, i.e., from 5.02% in 1973 to 11.12%, 15.45% in 1987 and 1995 respectively (Table 3 and Fig. 3). However, in 2011 the coverage declined to 7.58 %. For the last 38 years, about 50.77 % of grassland was converted from other land covers. This was related to the land ownership of librated tenants from the then landlords as per the 1975 Proclamation which might have led to clearing of forest and bush lands for wood consumption and increasing of grazing lands.

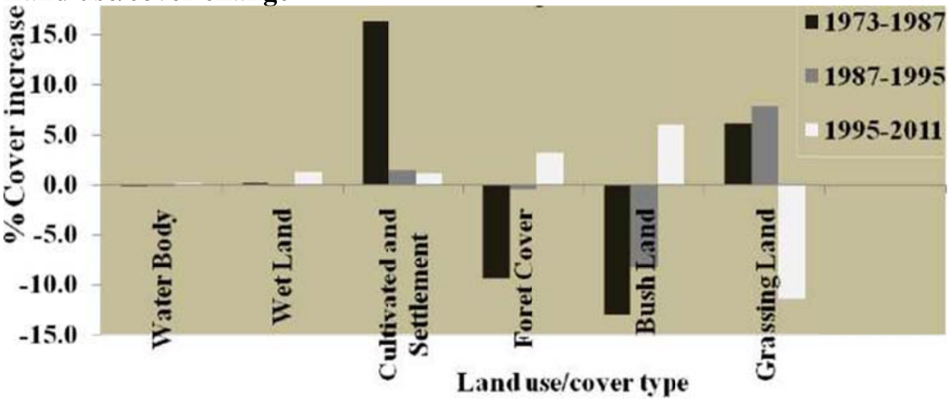
Table 3: Land Use/Cover Classes in the Study Area from 1973-2011

Class	1973		1987		1995		2011		**1973-2011**
	Area(ha)	%	Area(ha)	%	Area(ha)	%	Area(ha)	%	**Total loss or gain**
WB	972	0.48	685	0.34	684	0.34	355	0.18	-617
WL	3367	1.69	3729	1.87	3704	1.85	5599	2.81	+2232
C&S	102986	51.71	135365	67.97	140737	70.67	140275	70.43	+37289
FC	23394	11.74	4782	2.40	7035	3.53	9962	5.00	-13432
BL	58440	29.34	32449	16.29	16232	8.15	27882	14.00	-30558
GL	10001	5.02	22150	11.12	30768	15.45	15087	7.58	+5086
Total	199160	100	199160	100	199160	100	199160	100	

WB=Water Bodies; WL=Wetland; C & S=cultivated &settlement; FC=forest cover; BL=bush land GL=grazing land

Figure 4: Land Use/Cover in Ribb River Watershed, between1973 and 2011

Land use/cover change



Accuracy Assessment

The accuracy assessment was made and it was 100% for water bodies and 80% for bush lands (Table 4). The users' accuracy that was the percentage of correctly classified coverage from total classified was 100 % for water bodies LUC and 85% for the grazing LUC. The overall classification accuracy was 89.75% and the overall kappa statistics was 0.85. According to Amare (2012) the scientifically accepted result for kappa statistics was defined as poor when kappa coefficient is less than 0.4; good when it was between 0.4 and 0.7 and it will be taken as excellent when kappa coefficient is greater than 0.75. Thus, based on this expression the LUC classification for 2011 image in this study was excellent.

Table 4: Confusion Matrixes of the Classification of 2011 Landsat TM Image

Classified Classes	WB	WL	C&S	FC	BL	GL	Total	Producers Accuracy (%)	Users Accuracy	Kappa for Each Category
WB	10	0	0	0	0	0	10	100.00	100.0	1.00
WL	0	18	0	0	1	0	19	94.74	94.7	0.95
C and S	0	0	179	1	21	1	202	95.21	88.6	0.79
FC	0	0	1	26	0	0	27	83.87	96.3	0.96
BL	0	0	6	4	96	1	107	80.00	89.7	0.85
GL	0	1	2	0	2	30	35	93.75	85.7	0.85
Total	10	19	188	31	120	32	400	-	-	-

Demographic Factors: The population of watershed districts has shown a rapid increase. The population of watershed districts has doubled itself in less than 20 years. According to Amare (2013b), the driving force for most land use changes was population growth. Other similar studies at the local level in Ethiopia have found that in the Ethiopian highlands population pressure has led to land cover change (Grepperud, 1996). In Ribb River Watershed, selected land cover units and population increase were correlated. There was strong positive correlation between population and farm and settlement lands, with increase of population there was parallel expansion of agriculture and settlement areas. But the correlation between population and forest has shown strong negative relationship; that is, when population size increased, there was decline of forest and bush land covers (Figure 4). The population change (in Figure 4) and land cover change (Table 5) were correlated and the result showed negative relationship. In all districts population and farm and settlement have been increasing while forest and bush land covers were declining. This implies that population growth in Ribb River Watershed was one of the causes of conversion of forest, water and bush lands into farm and settlement lands.

Figure 5: Population change over time in districts in Ribb River Watershed

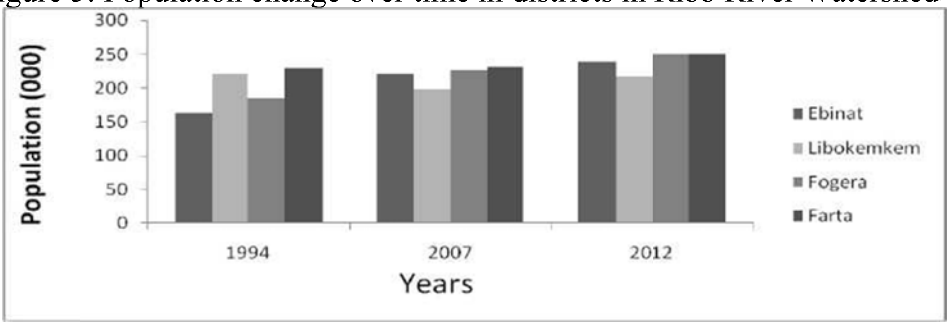


Table 5: Trends of Populaton of Rural Districts and Changes in Land Use

	1973-1987	1987-1995	1995-2011	1973-2011
Population ('000')	+107	+62	+151	+320
Cultivated and Settlement (ha)	+32379	+5372	-462	+37289
Forest Cover (ha)	-18612	2253	2927	-13432
Bush Land (ha)	-25991	-16217	11650	-30558

Land Tenure Factors: Prior to 1975 in Ethiopia land was in the hands of land lords. Since 1976, after a dramatic land reform in the wake of the overthrow of the Emperor Haile Selassie I regime, the state has owned all land, and only use rights to cultivation are handed over to rural households. The respondents in the selected sample area were interviewed about management efficiency of the land holding systems. About 74.5% of the respondents were found aware of tenure security and land management relationship. They believed that if land was individually owned, it would be better managed. In addition, about 95.8% of respondents believed that private land holding was more manageable and protected than other land holding systems. Thus, for the land to be secured and used for long and sustainable manner the land holding system should be private. The land cover change is directly related to land ownership that is those lands owned privately were better managed than the government and communal owned lands. Hence, one of the reasons for the land cover and use change in Ribb River Watershed was the land security problem.

Shiferaw and Holden (2011) have shown that in the Ethiopian highlands with the absence of appropriate policies and technological assistance, and increasing population, rural poor households can be caught in poverty - population - environment trap that might be triggered and lead to increased poverty and land degradation. They believed that land cover change can be resulted from the existing poverty. As a result of this, many people in the watershed have to get income for living from other sources such as selling fire wood, cow dung and others which could have caused deforestation and deterioration of other environmental resources. These activities in turn degrade the land and expand the land cover and use change in the watershed. This implies poverty was one of the causes of land conversion in the GAC, especially in the upper part of the Watershed (Figure 6).

Figure 6: Transporting cow dung to and selling firewood in market place

Because of small land holding size and shortage of land in the highlands of Ethiopia, plowing steep slopes and lack of knowledge of managing the land also contributed to land conversion. People in highlands practiced mixed farming, producing crops and rearing animals because animals are both the sources of food/farm power used in farm activities. Own observation and discussion with the communities in the area showed that farmers did not have enough land and they could not apply chemical fertilizers because of its high price. Instead they tried to expand their plot by clearing forests and using communal grazing areas found near their farm lands. They also use the communal grazing land to graze their livestock. Because of land scarcity, they plowed marginal and steep slope areas. Their farming method is traditional (the most ancient type) and it is not capable of managing soil loss.

Conclusion

The results of the study indicated that the LUC was changing in the Watershed. This was related to the continued expansion of cultivated land and settlement over the years in the Ribb River Watershed. This has brought significant decrease in the water bodies, forest and bush land covers. On the whole in the Ribb River Watershed, increased population pressure brought changes in the land use pattern. In the absence of taking urgent measures, the lands of the Ribb River Watershed may lose the remaining natural landscapes. This might have implication to crop productivity and causes more degradation of natural resources and intensify poverty. Thus, the study recommended that the Ribb River Watershed should adopt an ecological management plan combined with good population control policy linked to land distribution and poverty alleviation strategies.

References

Abebe, S. 2005..*Land Use and Land Cover Change in Headstream of Abbay Watershed, Blue Nile Basin, Ethiopia* (Unpublished Master's Thesis). Addis Ababa University, Addis Ababa, Ethiopia.

Abera, Z. 2011. *Flood mapping and modeling on Fogera flood plain: A case study on Ribb River* (Unpublished master's thesis).Institute of

Technology, Addis Ababa, Ethiopia.

Amare Sewnet. 2013. Retrospective Analysis of Land Cover and Use Dynamics in Gilgel Abbay Watershed by Using GIS and Remote Sensing Techniques. Northwestern Ethiopia. International Journal of Geosciences, 4(7): 1003-1008.

____. 2013b. Population and Environment Interaction: The Case of Gilgel Abbay Catchment, Northwestern Ethiopia. E3 Journal of Environmental Research and Management, 4(1): 153-162.

Amare Sewnet and K.K. Rao. 2012. Impacts of Land Cover/Use Dynamics of Gilgel Ababay Catchment of Lake Tana on Cliate Variability, Applied Geomatics, 4(3): 155-163.

Amare Sewnet and K. Kameswara Rao. 2011. Hydrological Dynamics and Human Impact on Ecosystems of Lake Tana, Northwestern Ethiopia. Ethiopian Journal of Environmental Studies and Management, 4:56-63

Aspinall, R. J., & Hill, M. J. 2008. Land Use Change: Science Policy and Management. New York: CRC Press, Taylor and Fransis Group.

Brassoulis, H. 2000. Analysis of Land Use Change: Theoretical and Modeling Approaches. URL: http://www.rri.wvu.edu/Briassoulis/.htm, Retrieved, on January 26, 2012.

Congalton, R. G., & Green, K. 1999.. Assessing accuracy of remotely sensed data: Priniciples and practices. Florida: Lewis Publishers, Boca Raton.

Ellis, E. 2010. Land to Use and Land to Cover Change. In: Encyclopedia of Earth (Eds). Environmental Information Coalition, National Council for Science and the Environment. Washington D.C.: Cutler J. Cleveland.

Emadodin, L., Reiss, S., & Bork, H.R.2009. A Study of the Relationship between Land Management and Soil Aggregate Stability: Case Study near Albersdorf, Northern Germany. *J. Agri. Biol. Sci., 4,* 48-53.

FAO. 1997. FAO's Land Cover and Land Use Activities.

Getnet, T. 2011. . Sedimentation Modeling for Ribb Dam (Unpublished Master's Thesis). Institute of Technology, Addis Ababa University, Ethiopia.

Grepperud, S. 1996. Population Pressure and Land Degradation: The Case of Ethiopia. *Journal of Environmental Economics and Management,* 30: 18-33.

Kassa, G. 2003. GIS Based Analysis of Land Use/Land Cover, Land Degradation and Population Changes: A Study of Boru Metero area of South Wello, Amhara Region (Unpublished Master's Thesis), Addis Ababa University, Ethiopia.

Legesse, D., and Gashaw, W. 2008. Flood Hazard and Risk Assessment in Fogera Woreda Using GIS & Remote Sensing (Unpublished Master's Thesis). Addis Ababa University, Ethiopia.

Muluneh, A. 2010. Synthesis of Research on LUC Dynamics in the Ethiopian Highlands. UNU-Land Restoration Training Programme, Keldnaholt, 112 Reykjavik, Iceland.

Petit C. C., Lambin E. F. 2001. Integration of Multi-Source Remote Sensing Data for Land Cover Change Detection. *International Journal of Remote Sensing,* 15: 785-803.

Prakasam. C. 2010. Land Use and Land Cover Change Detection through Remote Sensing Approach: A Case Study of Kodaikanal Taluk, *Tamil Nadu International Journal of Geomatics and Geosciences,* 1(2).

Rientjes, T. H. M., Haile, A. T., Kebede, E., Mannaerts, C. M. M., Habib, E., and Steenhuis, T. S. 2011. Changes in Land Cover, Rainfall and Stream Flow in Upper Gilgel Abbay Catchment, Blue Nile Basin, Ethiopia. *Hydrology and Earth System Sciences,* 15: 1979-1989.

Shiferaw, A. 2011. Evaluating the Land Use/ Cover Dynamics in Borena Woreda of South Wollo Highlands, Ethiopia. *Journal of Sustainable Development in Africa,* 13(1), 87-107.

Skole, D. L., & Cochrane, M. A. 2004. Observations of Land Use/ Cover Change in Regional Case Studies. In: Gutman *et al.* (Eds.). Land Change Science: Observing, Monitoring and Understanding Trajectories of Change on the Earth's Surface. Kluwer Academic Publishers, pp. 461.

Turner, A. 2009. Population Priorities: the Challenge of Continued Rapid Population Growth. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 364 (1532), 297-2984.

Turner, B. L., David S., Steven S., Gunther F., and Rik, L. 1995. Land Use and Land Cover Change Science/Research Plan. *The International Geosphere and Biosphere.* Sweden, Stockholm.

UNEP (United Nations Environment Programme). 1983. Ecology and Environment : What We Know About Desertification? Desertification control 3, 2-9.

Woldeamlak Bewket. 2002. Land Cover Dynamics since the 1950s in Chemoga Watershed, Blue Nile Basin, Ethiopia. *Mountain Research and Development, 22* (3), 263 - 269.