Dynamics of Land Use/Land Cover Change and its Implications for Land Degradation in Mida Woremo Watershed, North Central Ethiopia

Abrham Atile[1]*, Solomon Asfaw*[2*] *and Solomon Tekalign*[2]

Abstract

Land use/land cover change has been the most widely observed phenomenon in Ethiopian highlands over many decades. This study analyzed dynamics of LULCC and its implication for land degradation measures over a period of 45 years (1972 to 2017) in Mida Woremo watershed in the north central Ethiopian highlands. The study used remote sensing data including Land sat MSS (1972), Land sat TM (1986), Land sat ETM+ (2000) and Land sat OLI (2017). In addition, a total of 175 sample households residing in the watershed were selected from three kebeles namely Behera, Ketemana Dere, and Dengora using a systematic random sampling technique for questionnaire surveying, and supported it with the qualitative data gathered using focus group discussion and key informant interview. A supervised classification approach based on maximum likelihood classifier was employed to classify 1972, 1986, 2000 and 2017 images based on 238 ground truth points, and identified five major land use/land cover classes. These include cultivated land, settlement land, bare land, forest cover and bush land. A weighted average index (WAI) was used to assess farmers' perceptions of causes of LULC changes and impacts on the biophysical environment. The results indicated that the watershed has undergone significant land use/land cover from 1972 to 2017. Over the last 45 years, the areas of cultivated, settlement and bare land were increased by an average growth rate of 5.98%, 97.06%, and 0.48% per year, respectively. These changes were at the expense of the forest and bush land covers that decreased at an average rate of 1.9% and 1.41% per year, respectively. The observed land use/land cover changes were driven by a combination of proximate and underlying driving forces. These include expansion of agriculture and settlement areas, which increased the demand for woody vegetation. This resulted in a decline in soil fertility and native vegetation, which led to land degradation. Therefore, proper land use and land management practices should be in place that take the biophysical and socio-economic set-up of the area into consideration and that ensure the livelihood of the people and maintain the ecosystem in the watershed.

Keywords: Ecosystem, highlands, land degradation, land use/land cover, watershed

[1] Department of Geography and Environmental Studies, Kebridhar University, Ethiopia

2 School of Geography and Environmental Studies, Haramaya University, P. O. Box 138, Addis Ababa, Ethiopia

1. Introduction

Land use/land cover (LULC) change has been a great concern over decades due to its profound effect both on natural and human systems. It is one of the major indicators of global environmental change through changing ecosystem processes, hydrological cycle and surface energy balance (Zhou *et al.,* 2008; Terefe *et al.,* 2017; Liu *et al.,* 2017). At a local level, LULC changes have varying effects including soil degradation and loss in biodiversity, which lead to the risk of land degradation (Falcucci *et al*., 2007; Birhan and Assefa, 2017). The circumstances of these changes, however, vary in spatial and temporal dimensions as a result of multiple processes evident in specific human-environment conditions. Given the profound impact that LULC change has on biophysical environment and human livelihoods, its future management and sustainability would require proper understanding at a local level.

Soil degradation through water erosion which is the manifestation of land degradation has been one of the global environmental issues that threaten both developing and developed countries. Though it is a natural phenomenon and has persisted on earth for a long period, the problem has become very serious in recent decades. Human activities primarily from forest clearing for agricultural use are a key factor for excessive soil erosion worldwide. According to the Food and Agriculture Organization's (FAO, 2016) report, the decline in global forests is estimated to be around 129 million ha between 1990 and 2015, representing an annual rate of loss of 1.3%. LULC change inducing soil erosion contributes about 83% of the global degraded land and affects a total land area estimated to be around 1094 million ha (Kachouri *et al.,* 2013). Agricultural land is the primary source of soil erosion at global level though the rate varies from region to region. For example, average soil erosion from agricultural land is estimated 5-70 t ha^{-1} yr^{-1} in the United State, 0.3-40 t ha^{-1} yr^{-1} in India and 150-200 t ha^{-1} yr^{-1} in China (Panagos *et al.,* 2015; Li *et al.,* 2016). In Ethiopia, on average 42 t ha^{-1} of land is eroded annually from cultivated lands (Bishaw, 2001).

The Ethiopian highlands (elevation >1500 m above sea level) generally accommodate more than 85% of the population, about 95% of the total cultivated land and generate the bulk of the crop production of the country (Daniel *et al.,* 2016; Terefe *et al.,* 2017). In addition to its favorable climatic conditions for settlement and agriculture, it is one of biodiversity hot spots representing ecological space for mountain ecosystem. For example, the highlands of Ethiopia alone contribute more than 50% of the tropical Afromontane vegetation in Africa (Lemenih, 2005). This plays an important role in balancing the ecology of the catchment and in maintaining the downstream biodiversity, in addition to its numerous economic, social and cultural benefits provided to the society at the local scale (Derege *et al.,* 2014). However, greater proportions of these forest covers and their biodiversity have changed or are lost completely due to human activities. Reports suggest that over 50% of the Ethiopian highlands have been severely degraded due to factors related to LULC changes (Bishaw, 2001; Hurni *et al.*, 2010).

Land use/land cover changes are the result of both human and natural factors though human-induced factors have increased through time. Human-induced LULC change factors such as expansion of agricultural land and urban development at the cost of vegetation cover have increased through time on a global scale (Hanssen *et al.,* 2014; Liu *et al.,* 2017; Wakijira *et al.,* 2020). In Ethiopia, deforestation for intensive farming is a major driver for LULC changes, and is exacerbated by population growth. Several studies conducted in Ethiopia (Belay, 2002; Asmamaw *et al*., 2012; Amare, 2015; Wubie *et al.*, 2016; Tesfa and Triphati, 2016; Birhan and Asefa, 2017) indicated that deforestation has resulted from traditional intensive farming and population pressure has been a major cause for existing LULC changes. For example, Wubie *et al.* (2016) showed a massive decline in forest cover between 1957 and 2005 in the Gumara watershed, northwestern Ethiopia. Recently, urbanization and urban land expansion in Ethiopia (Eleni *et al*., 2013) due to government policy has been implemented at the cost of urban vegetation and has a great implication for local climate change and deterioration of soil and surface water quality. Despite a large number of LULC related studies in Ethiopia particularly in the highlands of Ethiopia, the rates and magnitude of change vary from place to place and time to time as a result of multiple processes shown to be working in specific human-environment conditions (Garedew *et al*., 2009).

However, there is still a lack of reliable information about spatial and temporal dynamics of LULC changes, causes and impacts at a local level. Spatially, explicit information that shows environmental changes at a watershed level may help to take appropriate management measures and understand the future scenarios of the changes at a regional level. The objective of this study, therefore, was to investigate the dynamics of land use/land cover changes between 1972 and

2017 period and examine its implications for land degradation in Mida Woremo watershed in the north central Ethiopian highlands.

2. Materials and Methods

2.1. Description of the Study Area

This study was conducted in the Mida Woremo watershed of North Central Highlands of Ethiopia. Specifically, it lies between $10^{0}10'00''$ to $10^{0}30'00''$N latitude and 38^{0} $50'$ $00''$ to 39^{0} 20' 43'' E longitude (Fig. 1), and covers an area of about 68,280 ha. The area is situated about 225km away from the capital city, Addis Ababa, and about 785km from Bahir Dar, the capital city of the Amhara Regional State. The elevation of the watershed ranges from 1261 to 275m.a.s.l. The watershed is characterized by sloppy and rugged topography where the upper part of the watershed is characterized by steep slope and dissected mountains whereas the lower part of the watershed is dominated by gentle slope and plain surface. The Mida Woremo watershed is the origin of the Jemma River which is one of the tributaries of the Abay (Blue Nile) River.

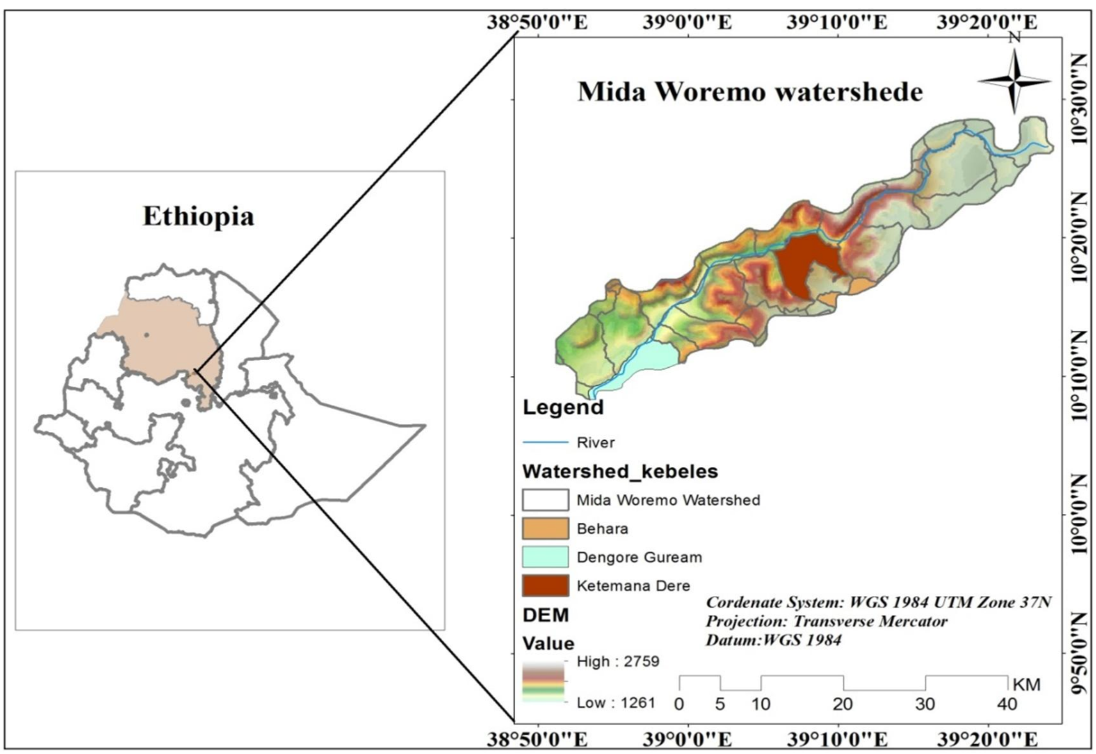

Figure 1: Location map of the study area

Based on agro-climatic zonal classifications, the study area is described as a tropical sub-humid, and semi-arid climatic zone (Daniel, 1977). According to the data from the National Metrological Services Agency (NMSA) recorded for thirty years at Degollo station, the mean maximum temperature of the three hottest months, and mean minimum temperature of the three coldest months are 6^0C and 24^0C, respectively (Fig. 2). The study area is characterized by mono-modal rainfall pattern where it receives higher amount of rainfall during July to August.

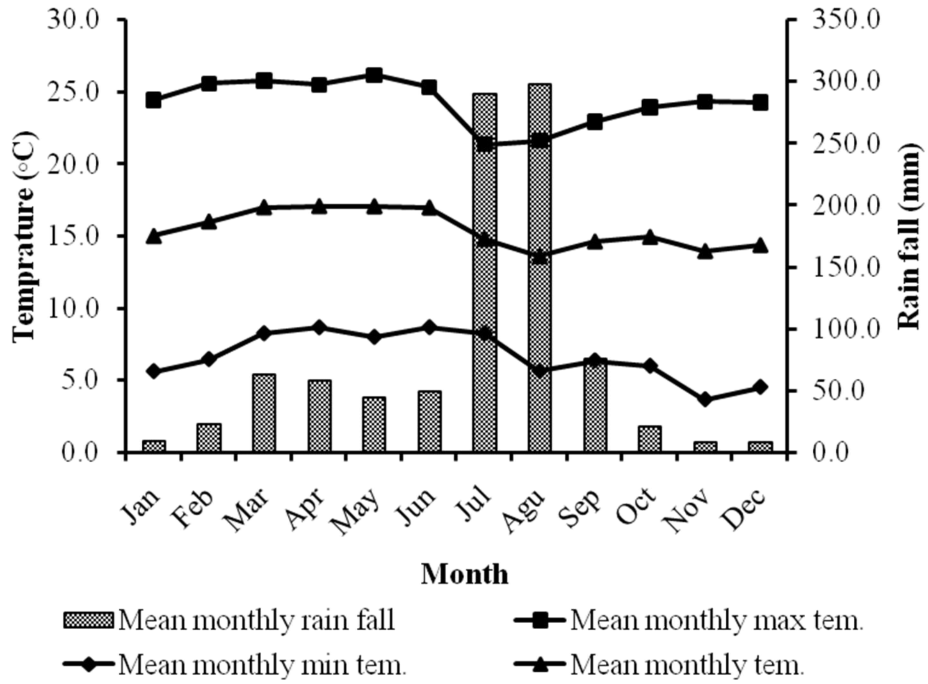

Figure 1: Mean monthly maximum and minimum temperature and mean monthly rainfall records from Degollo Meteorological Station from 1985 to 2017

According to the Central Statistical Agency (CSA, 2007), the total population of the watershed was 220,608, of which 110,240 were men and 110,368 were women. Among the total population, it was reported that about 207,511 (94%) were rural inhabitants and the remaining 13097(6%) were urban dwellers. Agriculture is the main economic activity and a source of livelihood in the study watershed. The farming system is mixed crop-livestock production on a subsistence level. The major crops grown in the area are cereals including sorghum, maize, *teff*, wheat, and barley.

2.2. Research Methodology

This study was primarily dependent on remote sensing data to see the trajectory of LULC change, and triangulated the result with the data obtained through socio-economic surveying. Therefore, the study employed mixed methods research design where both quantitative and qualitative data were used concurrently in the research procedure. Mixed methods research represents more of an approach to examining a research problem than a methodology (Mardy *et al.,* 2018), and enhances the synergy and strength that exists between quantitative and qualitative data, and helps to understand a phenomenon more fully than independently using quantitative or qualitative methods alone. According to Creswell (2007), the mixed design encompasses more than simply combining qualitative and quantitative methods but, rather, reflects a new epistemological paradigm that occupies the conceptual space between positivism and interpretivism.

2.2.1. Data sources and methods of collection

Remote sensing and acquisition techniques

The study used both multi-date and multi-scale satellite imageries including Landsat MSS (Multispectral Scanner), Landsat TM (Thematic Mapper), LandsatETM+ (Enhanced Thematic Mapper Plus) and Landsat8 OLI (Operational Land Imager) taken for the years 1972, 1986, 2000 and 2017, respectively. These dates were selected on the basis of major historical events, state policy reforms, and availability of satellite imageries. All theremote sensing data were freely downloaded from the United States Geological Survey (USGS) web-pages (http://earthexplore.usgs.gov.com).

As part of the image pre-processing, the Landsat images used for this study were processed for geometric and radiometric corrections to reduce the effects of atmospheric and terrain factors. Accordingly, each image was geometrically corrected based on well-distributed Ground Control Points (GCPs) identified in the field and 1: 50,000 topographic maps, and validated the accuracy within 0.5 Root Mean Square Error (RMSE). To reduce radiometric errors, images were calibrated using the radiometric correction technique based on the method used by Liu et al. (2017). Following this, the study area was selected from each period of the satellite images using the shape file of the watershad boundary. False colour composition (band 4, band 3, and band

2) was applied for each image to improve the visibility and interpretability of the images. To ensure consistency between datasets, all the satellite images were projected to the similar spatial reference system and applied Universal Transverse Mercator (UTM), WGS84 Spheroid and Datum with Zone 37N for projection.

In this study, ground truth was carried out in January, 2017, and this almost coincided with the season where the majority of the satellite images were taken for the area. A total of 340 ground truth sample points was collected in the field stratified proportional to the LULC classes. The sample points were expanded using Google Earth and the remote sensing image where 238 (70%) of the total samples were used as reference data to classify the images, and the remaining 30% (102) sample points were randomly selected for accuracy assessment. Table1. Description of major LULC types used in this study

No.	LULC Types	Description
1	Bare land	Area with very little or no vegetation cover on the surface of the land. It consists of vulnerable soil to erosion and degradation. It also includes bedrock which is unable to support cultivation.
2	Forest cover	Areas covered with dense natural and plantation forest. It includes eucalyptus trees, junipers procera, and mixed indigenous tree species.
3	Bush land	Areas covered with small trees mixed with shrubs, grasses; less dense than forest.
4	Cultivated land	Areas used for crop cultivation both annually and perennially. This category includes areas covered with crop, and land under preparation.
5	Settlement	Areas covered with residential houses both rural and urban. This category includes small and large buildings, roads, administrative buildings, and small industrial areas.

A supervised classification approach based on maximum likelihood classifier was employed to classify 1972, 1986, 2000 and 2017 images. Image classification for 2017 satellite image was conducted based on the ground truth points collected from field surveys and Google Earth whereas ancillary data such as historical maps, aerial photographs,and information gathered from local communities in the field helped to classify the 1972, 1986 and 2000 satellite images. Finally, the study identified five major LULC categories (Table 1) for Mida Woremo watershed.

Accuracy assessments for classified images were made in this study due to the fact that LULC maps derived from remote sensing imagery always contain some sort of errors associated with the classification techniques or error inherited from the satellite itself (Zhou *et al.,* 2008). In this study, accuracy assessment was carried out based on randomly selected 102 sample points. However, constraints in reference data to crosscheck all multi-temporal data, the study validated the accuracy exclusively for classified images of 1986 and 2017. While the study used the ground truth data collected from the field and other supplementary data such as Google Earth as a reference to validate the classified image of 2017, aerial photograph and topography sheets (1:50,000 scale) were used as a reference for 1986 classified images. Finally, four statistical parameters including user accuracy, producer accuracy, overall accuracy and *kappa* coefficient were reported to validate the accuracy of 1986 and 2017 classified images.

2.2.2. Sampling and socio-economic data collection methods

The target population of this study was smallholder farming households who resided in Mida Woremo watershed, which is part of the Weremo Wajituna *woreda*. The *woreda* is represented by 30 *kebeles* (2 urban and 28 rural) and three agro-ecological zones (*Dega*, *Woyina Dega* and *Kolla*). The sampling method employed for this study was a multi-stage sampling technique in such a way three *kebeles* were first selected purposely since they were found within the watershed and represented three agro-ecological zones. These *kebeles* were Behera*,* Ketemana Dere, and Dengorafrom Dega, Woyina Dega and Kollaagro ecological zones, respectively. A total of 1750 households were identified from three *kebeles* from a list provided by *woredas*. A 10 percent sample size was determined for this study with 95 percent confidence level and 10 percent level of precision (sampling error = 0.07). The sample size was determined based on Mardy et al. (2018) suggesting that the ideal sample size for a population more than 1000. Accordingly, a total of 175 sample households were selected from the list using a systematic random sampling technique (taking n^{th} household from the sampling frame at k interval) for questionnaire surveying.

The items in the questionnaire focused on four themes: (1) Socioeconomic characteristics, (2) Farmers' perceptions of causes of LULC changes, and (3) Farmers' perceptions of impacts of LULC changes on soil degradation. In addition, focus group discussions (FGDs) and face-to-face interviews were conducted to triangulate the data from the questionnaires. Three focus group discussions were conducted, one per *kebele*, each comprising eight persons, and a total of six key informant interviews; two key informant interviews per *kebele* were conducted. The focus group discussions were composed of community leaders, elders, women and youth groups; and the participants were selected purposively for the FGDs to provide information related to LULC changes and the present and past social and economic status of the area to strengthen the reliability of the questionnaire.

2.2.3. Method of data analysis

Analysis of LULC change dynamics

This study was primarily based on remote sensing data take nat different periods. The study produced LULC map for four separate periods (1972, 1986, 2000, and 2017) and calculated the area cover in terms of hectare for each LULC category. The rate of LULC change between the two successive periods was also calculated to show the trend in LULC changes according to Peng *et al.* (2008) procedures:

$$P = \frac{A_f - A_i}{A_i} \times 100\% \qquad [1]$$

Where, *P* is the percentage of LULC changes between two consecutive years, and A_i and A_f are the areas of one LULC type at the initial year (*i*) and at the final year (*f*) of the study period, respectively.

Similarly, the study used the single land use dynamicity model to evaluate the dynamic in LULC change, and analyze the annual changing rate based on the following formula used in Sun *et al*. (2016):

$$R = \frac{A_f - A_i}{A_i} \times \frac{1}{T} \times 100\% \qquad [2]$$

Where, *R* stands for the dynamic degree of LULC in a certain study time, and *T* stands for the length of the considered period.

Analysis of LULC conversion

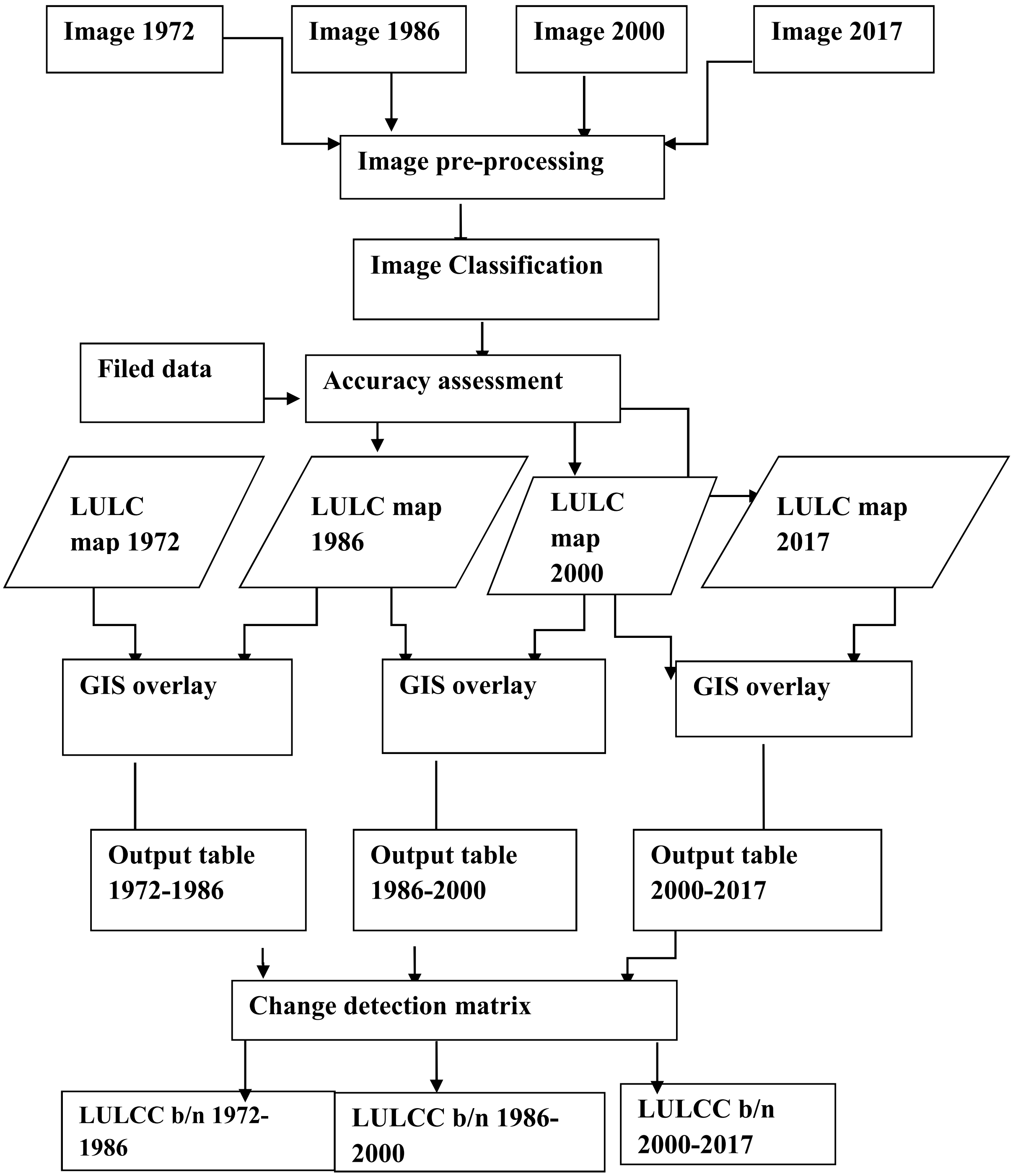

Figure 3: A flow chart showing data and methods employed in this study

The analysis of the LULC change detection was based on post-classification comparison of independently classified LULC maps of 1972, 1986, 2000 and 2017. To this end, a cross-tabulation method was conducted using a spatial overlay of the two LULC maps to show change detection (Figure 3). The output table was further processed in Excel to quantify the LULC change matrix, and statistical analysis was applied that described loss, gain, net change and net persistence.

Analysis of socio-economic data

In addition, socio-economic data collected through household survey was analyzed. In this study, a weighted average index (WAI) was used to assess farmers' perception of the causes of LULC changes and impacts on the biophysical environment and human livelihoods in the watershed. Weighted average index was previously applied to assess household perception levels issues related to environmental changes (Ndamani and Watanabe, 2016; Mardy *et al.,* 2018). In this study, a four-point rating scale (Likert scale) was used and asked the households to score using 0-3, i.e. (high, medium, low, or none with a corresponding score of 3, 2, 1, and 0, respectively). A weighted average index (WAI) was computed for each cause and effect based on the following formula (Eq. 3):

$$WAI = \frac{\sum F_i W_i}{\sum F_i} \quad [3]$$

Where: F= Frequency; *W*= Weight of each scale; *i*= weight (3= high effect; 2= medium effect; 1= low effect and 0=no effect)

On the other hand, the qualitative data gathered using key informant interviews and FGDs were analyzed and interpreted using qualitative techniques in the form of thematic narrations.

3. Results and Discussion

3.1 LULC Proportions for the Study Periods

The study identified five major LULC types for each period *(*1972, 1986, 2000 and 2017) in Mida Woremo watershed. These included bare land, bush land, cultivated land, forest cover, settlement and built-up areas. The LULC maps were produced for different periods, and the extent of each LULC categories is presented in Figure 4 and Table 2. The spatio-temporal variation in the distribution of LULC generally resulted in the formation of typical patterns of LULC in the study watershed. Between 1972 and 1986, the area of bush land was the largest, cultivated land was second and settlement/built up was the least. However, the area of cultivated land was the largest, followed by bush land and bare land; and the least was forest cover in the 2017 LULC map.

The results further indicated that between 1972 and 2017, cultivated land and settlement/built-up areas increased progressively in their sizes whereas the sizes of bush land and forest cover decreased during the same period in the watershed. As a result, the proportion of cultivated land and settlement covers increased respectively from 17% and 0.07% in 1972 to 62.84% and 2.98% in 2017. The finding agrees with Temesegn and Tesfahun (2014), who reported an increase of cultivated land by 72.7% between 1985 and 2011 in the east of Lake Tana, northern Ethiopia. Similarly, in their studies Eleni *et al*. (2013) reported continuous increases of settlement areas over 40 years in the Koga Catchment, northwestern Ethiopia.

Table 2. Areas of LULC categories for Mida Woremo Watershed (a total of 68,280 ha)

Year	Bare land ha (%)	Bush land ha (%)	Cultivated land ha (%)	Forest Cover ha (%)	Settlement ha (%
1972	5,560 (8.14)	42,128 (61.70)	11,622 (17.02)	8,923 (13.07)	45.5 (0.07)
1986	6,558 (9.61)	31,811 (46.60)	22,221 (32.54)	7,507 (11.01)	182.3 (0.28)
2000	7,289 (10.67)	15,637(22.91)	41,592 (60.91)	2,826 (4.14)	936.6(1.37)
2017	6,765(9.91)	15,220(22.19)	42,908 (62.84)	1,353 (1,98)	2,032.5(2.98)

On the other hand, bush land and forest covers decreased, respectively, from 61.7% and 13.07% to 22% and 1.98% during the same period. The size of bare land showed slight increase during the study period though the trend was not consistent. This finding was in line with Wubie et al. (2016), who indicated the decline in bush land, and was in contrast to the work of Birhan and Asefa (2017), who reported increases of bush land cover between 1964 and 2014 in the Gelana sub-watershed, Northern Highlands of Ethiopia.

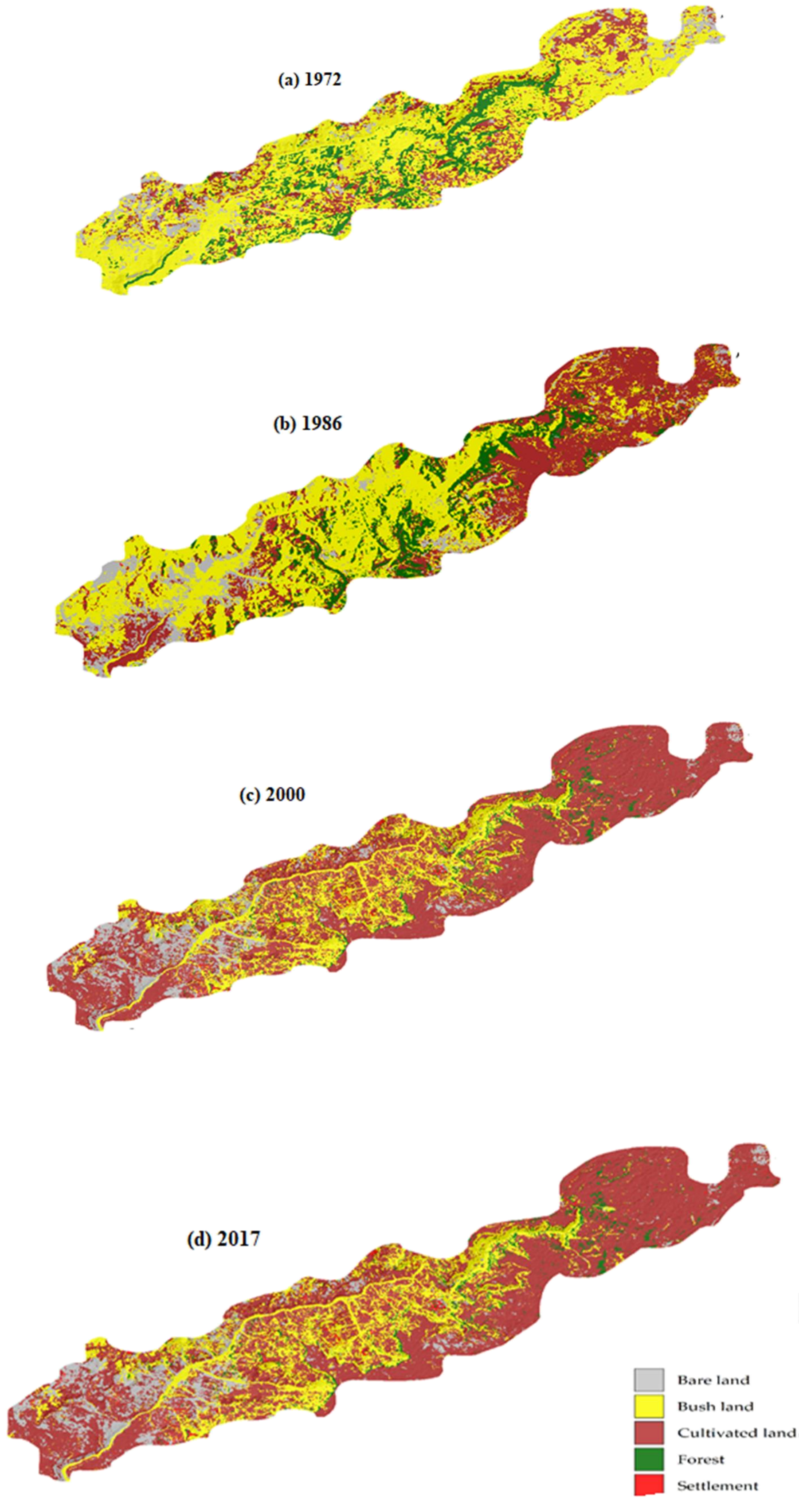
(a) 1972
(b) 1986
(c) 2000
(d) 2017
Bare land
Bush land
Cultivated land
Forest
Settlement

Figure 4: LULC map for 1972, 1986, 2000, and 2017 in Mida Woremo Watershed

3.2. Accuracy Assessment

The user's and producer's accuracy for classified images of 1986 and 2017 are presented in Table 3. The overall accuracy for 1986 and 2017 classified images was 84.5% and 87.3%, respectively. The Kappa statistic was 0.83 for 1986 classified image and 0.86 for 2017.

Table 3. Accuracy assessment results for classified images of 1986 and 2017

LULC Types	TM (1986)		OLI (2017)	
	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy
Bare land	84.47	77.91	87.84	79.57
Forest Cover	94.47	77.91	100	97.81
Bush land	91. 26	88.67	95. 08	90.37
Cultivated land	85.39	80.65	82.03	80.15
Settlement/Built-up area	73.55	79.5	89.58	86.65
Overall accuracy	**84.5**		**87.3**	

3.3. Rate of LULC Change (1972-2017)

The findings indicated that LULC changes occurred at different scale. Overall, during the whole study period (1972–2017), cultivated land increased by 31285.3 ha (269.2 %), settlement area by 1986.98 ha (4367.9%), forest cover decreased by 7570.2 ha (84.83%), bare land increased by 1204.81 ha (21.7%) and bush land dereased by 26906.86 ha (63.84%) in the study watershed. Based on the annual rate change results (Table 4), the total area of forest cover decreased at an annual rate of 1.13% per year between 1972 and 1986, 4.5% per year between 1986 and 2000 and 3.1% per year between 2000 and 2017. The results suggest that on average the extent of forest cover has decreased at an annual rate of 1.9% from 1972 to 2017. The finding was in line with the study of Amare (2013), who reported about 73.3% (an annual rate of 2.1%) of forest cover loss from 1973 to 2008 in Gilgel Abbay watershed, northwestern Ethiopia. Similarly, bush land cover was reduced at a rate of 1.74% per year, 3.7% per year and 0.16% per year in the periods 1972-1986, 1986-2000 and 2000-2017, respectively. Generally, bush land cover decreased on average 1.4% per year between 1972 and 2017. However, the annual rate of change in bush cover identified in this study was slightly lower compared to the study of Wubie et al.

(2016), who reported 91.39% (an annual rate of 1.9 %) between 1957 and 2005 in the Gumara watershed of Lake Tana basin, northwestern Ethiopia.

Table 4. Percentage of annual rate of LULC change (%/year)[b]

Period	Bare land	Bush land	Cultivated land	Forest Cover	Settlements
1972-1986	1.28	-1.74	6.52	-1.13	21.5
1986-2000	0.8	--3.7	6.3	-4.5	29.6
2000-2017	-0.42	-0.16	0.18	-3.1	6.9
1972-2017	0.48	-1.41	5.98	--1.9.	97.1

[b] Annual rate of change was calculated as [a] divided by the time duration (year) between initial and final year where [a] is percentage of LULC change between periods was calculated as $\mathbf{100}\times(\mathbf{A}_{\text{final year}} - \mathbf{A}_{\text{initial year}})/\mathbf{A}$ initial year, where **A** = area of the LULC type

In contrast, the sizes of cultivated land and settlement area had increased during the period 1972-2017 (Table 4). On average, cultivated land and settlement area have increased at a rate of 5.98% per year and 97% per year during this period. These findings agreed with many of the previous studies conducted in the highland regions of Ethiopia despite the fact that there was variation in the rate of change among those studies. For example, Gete and Hurni (2001) found a 95% increase in the area of the cultivated land in the period between 1957 and 1995 in Dembecha area, Northwestern Highlands of Ethiopia. Similarly, Temsegen and Tesfahun (2014) indicated that the area of cultivated land increased by 72.7% between 1985 and 2011 in the east of Lake Tana, Ethiopia.

3.4. Changes in LULC Conversions

3.4.1. LULC change in the period 1972-1986

From 1972 to 1986, cultivated land showed the highest net increase followed by bare land and settlement land. The bush land cover was the most unchanged LULC category, whereas settlement area was persistently the least unchanged LULC category. The net change to persistence ratio was relatively higher for cultivated land (positive), bare land (positive), bush land (negative) and forest area (negative) indicating the most dominant trends in changing watershed. Overall, 53.86% of the total area of the watershed occupied in 1972 was changed in 1986 (Table 5).

Table 5. LULC change matrix in Mida Woremo watershed (68,280ha), 1972-1986

From 1972	Bare land	Bush land	Cultivated land	Forest	Settlement	Total 1972	**Loss**
To 1986							
Bare land	***2.91***	3.43	1.74	0.05	0.01	8.14	5.23
Bush land	4.29	***31.40***	21.20	4.65	0.15	61.69	30.29
Cultivated	2.28	8.32	***5.99***	0.39	0.04	17.02	11.03
Forest land	0.13	3.46	3.60	***5.83***	0.06	13.08	7.25
Settlement	0	0.04	0.01	0.01	***0.01***	0.07	0.06
Unchanged						***46.14***	
Total 1986	9.61	46.65	32.54	10.93	0.27		
Gain	6.7	15.25	26.55	5.1	0.26		
Net change	1.47	-15.04	15.52	-2.15	0.2		
Net persistence	0.5	-0.48	2.59	-0.37	0.2		

3.4.2. LULC change between 1986 and 2000

Table 6 shows the conversion matrix of the LULC change from 1986 to 2000. Accordingly, the cultivated land showed the highest net increase, followed by settlement area. While cultivated land, bush land and bare land were relatively the most persistent LULC categories, forest cover and settlement land were the least persistent LULC categories. The net change to persistence ratio was higher for cultivated land (positive), bush land (negative), forest land (negative) and settlement land (positive) indicating the most dominant trends in changing watershed. Generally, almost half (50%) of the total watershed occupied in 1986 remained unchanged between 1986 and 2000.

Table 6: LULC change matrix in Mida Woremo watershed (68, 280 ha), 1986-2000

From 1986	Bare land	Bush land	Cultivated land	Forest	Settlement	Total 1986	**Loss**
To 2000							
Bare land	***5.04***	0.26	4.12	0.07	0.12	9.61	4.57
Bush land	4.35	***15.31***	25.17	0.75	1.02	46.60	31.29
Cultivated	1.17	2.82	***26.96***	1.39	0.20	32.54	5.58
Forest land	0.10	4.53	4.42	***1.92***	0.02	10.99	9.07
Settlement	0.03	0.02	0.18	0.02	***0.01***	0.27	0.25
Unchanged						***49.24***	
Total 2000	10.69	22.94	60.85	4.15	1.37		
Gain	5.65	7.63	33.89	2.23	1.36		
Net change	1.08	-23.66	28.31	-6.84	1.11		
Net Persistence	0.21	-1.54	1.05	-3.56	1.11		

3.4.2. LULC change between 2000 and 2017

Table 7 indicates the conversion matrix of the LULC change during 2000-2017. During this period, cultivated land showed the highest net increase, followed by settlement land. Cultivated land, bush land and bare land were relatively the most persistent LULC categories, whereas forest cover and settlement area were the least persistent LULC categories. The net change to persistence ratio was higher for cultivated land (positive), settlement land (positive), forest cover (negative) and bare land (negative) indicating the most dominant LULC categories in changing watershed. Overall, 37.68%, of the total area of the watershed has undergone LULCC, whereas the remaining 62.32 % of the total watershed remained unchanged between 2000 and 2017.

Table 7: LULC change matrix in Mida Woremo watershed (68,280 ha), 2000-2017

From 2000	Bare land	Bush land	Cultivated land	Forest	Settlement	Total 2000	**Loss**
To 2017							
Bare land	***4.40***	2.02	4.09	0.00	0.18	10.69	6.29
Bush land	0.46	***11.34***	9.47	1.12	0.55	22.94	11.6
Cultivated	4.77	8.14	***45.84***	0.12	1.96	60.83	14.99
Forest land	0.16	0.60	2.47	***0.74***	0.17	4.14	3.40
Settlement	0.12	0.19	0.96	0.02	***0.00***	1.37	1.29
Unchanged						***62.32***	
Total 2017	9.91	22.29	62.84	1.98	2.98		
Gain	5.51	10.95	16.99	1.26	2.86		
Net change	-0.78	-0.65	2.00	-2.14	1.57		
Net Persistence	-0.17	-0.06	0.04	-2.89	1.57		

Where, bolded diagonal elements in italics (Table 5, 6, and 7) represent proportions of each LULC category that was unchanged (persistent). The loss column and gain row indicate the proportion of the LULC that experienced gross loss and gain in each categories, respectively. All the figures in the table are presented in percentage except *net persistence*, which is a ratio.

3.5. Driving Forces of LULC change

The driving forces of LULC in the watershed are basically associated with human-induced factors. The results indicated that between 1972 and 2017, cultivated land and settlement/built-up areas progressively increased, whereas there was a decrease in the sizes of bush land and forest cover. It is believed that the influence of human activities such forest clearing for agriculture and demand for firewood and house construction had a greater contribution to LULC changes in the socio-economic context of Ethiopia.

According to the results obtained from sample respondents in the household surveying (Table 7), urbanization ranked first for being the cause of LULC changes with a WAI of 2.71, followed by expansion of agricultural land (WAI=2.63), increasing demand for firewood and construction (WAI=2.59), and insecure land tenure rights (WAI=2.25). The influence of human activities on LULC changes has accelerated with population growth. This is because population pressure and environmental changes have direct relationship and immediate implications for local livelihood by changing the land cover into different land use units.

Table 7: Farmers' perceptions of causes of LULC changes in the watershed ***(N=175)***

Variables	**Causes**					Rank
	High	Moderate	Low	None	WAI	
Expansion of agriculture	134	22	15	4	2.63	2
Demand for firewood and construction	127	30	12	6	2.59	3
Urbanization	145	18	9	3	2.74	1
Insecure land tenure rights	121	32	20	2	2.25	4

Code: High =3, Moderate=2, Low=1, None=0.

Source: Households Survey, 2017

According to the Central Statistical Agency census reports of 1994 and 2007, the size of the population in the study *woreda* was projected to grow at an annual rate of 3.51 and is expected to double in 2040. This may lead to further increases in the demand for natural resources in the area. According to the information obtained from key informant interviews and FGDs, it is anticipated that the number of the population will increase from time to time and has already exerted pressure on the existing land resources due to increasing demand for food, firewood, house construction and other essentials. For example, as the demand for food and shelter increases, it leads to the expansion of cultivated land and house construction by encroaching on uncultivated areas including forest cover, bush and bare land.

Many studies conducted in Ethiopia have supported the fact that population growth will be one of the major driving forces for land use/cover change. For example, in his study Woldamlak (2002) found the decline in woody vegetation cover due to increasing demand for cultivation, settlement, and fuel and construction in Chemoga Watershed, Blue Nile Basin, Ethiopia. Similar studies (Mohamme and Tassew, 2009; Amare, 2013; Woldeamlak and Solomon, 2013; Wubie *et* *al*., 2016) discovered that LULC change particularly the decline of forest covers has been associated with population pressure in many parts of the Ethiopian highlands. Land use/land cover change has also resulted from insecure land tenure rights mediated by institutional reforms and policy change. As the information obtained from key informants and FGDs indicated, land reform policies that the government implemented in 1974 and 1991 also contributed to the expansion of agriculture and land degradation in the watershed. For example, distribution of land following the 1975 land to tiller policy and the 1991 EPRDF land redistribution policy resulted in insecure land ownership and poor resource management among smallholder farmers.

3.6. Implications of the LULC change for land degradation

One of the manifestations of LULC change is soil degradation which in turn accelerates the risk of land degradation. The farmers ranked highest the perceived effects of soil degradation that resulted from LULC change. As shown in Table 8, farmers perceived that soil degradation had the highest effect on soil fertility decline with a WAI of 2.96, followed by decline in crop production (WAI= 2.85). These findings have coincided with the findings of Karl *et al*. (2009) which stated that decline in crop production resulted from soil degradation because of its negative impacts on plant growth. On the other hand, this result differs from the finding reported in Mardy *et al*. (2018), where the farmers responded that crop decline was the least severe effect of soil degradation. Increased cost of conservation (WAI = 2.17) was perceived as the last effect; this may suggest poor soil conservation practices at the household level.

Table 8: Farmers' perceptions of LULC induced soil degradation effects on the watershed ***(N=175)***

Variables	Effects					Rank
	High	Moderate	Low	None	WAI	
Decline in soil fertility	168	7	-	-	2.96	1
Decline in crop production	141	16	18	-	2.85	2
Increased cost of production	152	19	4	-	2.71	3
Food shortage	118	55	2	-	2.65	4
Decline in income	120	37	17	1	2.56	5
Expansion of unproductive land	88	35	49	3	2.17	7
Increased cost of conservation	105	42	23	5	2.39	6

Code: High =3, Moderate=2, Low=1, None=0.

Source: Households Survey, 2017

The current study identified major environmental and socio-economic problems attributed to LULC changes. The findings indicated that the extent of forest cover and bush land have been significantly reduced over time in the study watershed. The removal of natural vegetation cover such as bushes and forests in the study watershed and their conversion to cultivated, bare land and settlement area without effective land management practices has resulted in the prevalence of soil erosion. Asmamaw *et al*. (2012) warned that poor land use/cover management at the catchment could cause the occurrence of high soil erosion and gullies. Changes in vegetation cover not only cause the physical removal of soil but also accelerate the degradation of basic soil properties, which lead to a decline in soil fertility (Warra *et al*., 2013).

The other manifestation of land degradation resulting from LULC change is the loss of biodiversity. The findings show that the area under natural vegetation cover has declined over the past four and half decades in Mida Woremo watershed. In addition to soil erosion risks and decline in soil quality, decline in vegetation cover may change the native ecosystem leading to the loss of biodiversity. According to key informant interviews, there were many indigenous tree species such as *Acacia abysssinica (locally called girar), Dodonea angustifolia (kitekita) ,Carissaspinarum (agame), Olea Africana (woyera), Cordia Africana (wanza), podocarpusfalctus (zigeba), Juniperouspodocarpus (tid), Eucleaschimpera (Dedeho), Ficus sur (shola) and Ficus vasta (warka)* in the Mida Woremo watershed**.** The Mida Woremo watershed was also home to many wild animals like apes *(locally tota),* tigers *(nebir),* lions *(anbesa),* foxes *(kebero),* hyenas *(jib) and monkeys (zenjero)*. However, most of the indigenous tree species and animals disappeared and the remaining few plant and animal species are on the way to disappear due to deforestation. For instance, tree species like *Olea Africana (woyera), Cordia Africana (wanza), podocarpusfalctus (zigeba), Juniperouspodocarpus (tid), Ficus sur (shola) and Ficus vasta (warka)* have already *disappeared* and are only found in protected areas like churches, monasteries and inaccessible areas of the watershed. As explained by key informants, some animal species like tigers *(nebir),* lions *(anbesa) and* hyenas *(jib)* which were previously found in the catchment are not currently there. Though the results of this study coincide with the findings of many previous studies (e.g., Wubie *et al*., 2016; Birhan and Asefa, 2017) conducted in the highlands of Ethiopia, the causes and impacts of LULC changes on biodiversity vary from place to place.

4. Conclusion

The findings revealed that the study's watershed has experienced significant LULC changes over the last 45 years. These changes are attributed mainly to human-induced activities such as expansion of agricultural lands, increasing demand for firewood and urbanization, which are exacerbated by population growth. The risks of land degradation have manifested themselves mainly in the forms of soil degradation through soil erosion and loss of biodiversity. These resulted in the decline in soil fertility and crop production, increased cost of production, expansion of unproductive land, a decline in native vegetation and many others. Therefore, proper land use and land management practices should be in place that consider the biophysical and socio-economic set-up of the area, and ensure the livelihood of the people and maintain the ecosystem in the watershed. Proper intervention should be implemented to reduce population pressure and to apply proper land management practices. This also requires making use of energy efficient utilities and rural electrification to minimize encroachment upon the land for firewood and charcoal.

References

Amare, S. 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 Geosciences4*: 1003-1008.

Amare, S. 2015. Land Use/Cover Change at Infraz Watershed, North western Ethiopia. *Journal of Landscape Ecology*8 : 70-83.

Asmamaw, L.B., Mohammed, A.A. and Lulseged, T.D. 2012. Land use/cover dynamics and their effects in the Gerado catchment, northeastern Ethiopia. *International Journal of Environmental Studies*, 1-18.

Belay, T. 2002. Land-cover/land-use changes in the Derekolli catchment of the South Welo Zone of Amhara Region, Ethiopia. *Journal of Eastern Africa Social Science Research Review*, 18: 1-20.

Birhan, A. and Assefa A. 2017. Land use/land Cover changes and their environmental implications in the Gelana sub-watershed of Northern highlands of Ethiopia. *Journal of Environmental System Research,* 6: 1-12.

Bishaw, B. 2001. Deforestation and Land Degradation in the Ethiopian Highlands: A Strategy for Physical Recovery. *Northeast African Studies*, 8; 7-25.

Daniel, G. 1977. Aspects of climate and water budget in Ethiopia. Addis Ababa University printing press, Addis Ababa, Ethiopia.

Daniel, M. Woldeamlak B., and R, Lal. 2016. Conservation effects on soil quality and climate change adaptability of Ethiopian watersheds land degradation and development. *Land Degradation Development*. 27: 1603–1621 DOI: 10.1002/ldr.2376.

Derege, T.,Tsunekawa, A., Tsubo, M., Syed, A., Nigussie, H. .2014. Land-use change and its socio-environmental impact in Eastern Ethiopia's highland. *Regional Environmental Change 14*,757-768.

Eleni, Y.Wolfgang W., Michael, E.K., Dagnachew, L., and G. Bloschl. 2013. Identifying Land Use/Cover Dynamics in the Koga Catchment, Ethiopia, from Multi-Scale Data and Implications for Environmental Change. *International Journal Geo-Information*, 2: 302-323.

Falcucci, A., Maiorano, L. and Boitani, L. 2007.Changes in land-use/land-cover patterns in Italy and their implications for biodiversity conservation. *Landscape Ecology*, 22: 17-631.

FAO.2016. Global Forest Resources Assessment 2015: How are the World's Forests Changing? 2nd ed.; Food and Agriculture Organization of the United Nations: Rome, Italy, 2016.

Garedew, E., Sandewall, M., Soderberg, U., and Campbell, B.M. 2009.Land-use and land cover dynamics in the Central Rift Valley of Ethiopia. *Environment and Management, 44,* 683–694.

Hurni, H., Solomon A., Amare, B.,, Berhanu, D., Eva, L., Brigitte, P., Birru, Y, and Gete Z. 2010. Land degradation and sustainable land management in the highlands of Ethiopia. *Global Change and Sustainable Development,* 5: 187-207.

Kachouri, S., Achour, H., Abida, H., Bouaziz, S. 2014.Soil erosion hazard mapping using Analytic Hierarchy Process and logistic regression: a case study of Haffouz watershed, central Tunisia. *Arab Journal of Geosciences* : DOI 10.1007/s12517-014-1464-1.

Karl, T.R., J.M. Melillo, and T.C. Peterson, editors. 2009. Global Climate Change Impacts in the United States. Cambridge University. Press, Cambridge, UK.

Li, Z., Fang, H. 2016. Impacts of climate change on water erosion: *A review. Earth Sci.* 163, 94–117.

Lemenih, M., Karltun, E., Olsson, M. 2005. Soil organic matter dynamics after deforestation along a farm field chronosequence in southern highlands of Ethiopia. *Agriculture, Ecosystems and Environment, 109,* 9-19.

Liu, C., Xu, Y., Sun, P., Huang, A., Zheng, W. 2017. Land use change and its driving forces toward mutual conversion in Zhangjiakou City, a farming-pastoral ecotone in Northern China. *Journal of Environmental Monitoring and Assessements*,189; DOI 10.1007/s10661-017-6218-6.

Mardy, T., Uddin, M.N.,Sarker, M.A., Roy, D., Dunn, E.S.2018. Assessing Coping Strategies in Response to Drought: A Micro Level Study in the North-West Region of Bangladesh. *Climate.6*, 23(https://www.mdpi.com/2225-1154/6/2/23

Mohammed, A., and Tassew N. 2009. Land use/cover changes between 1966 and 1996 in Chirokella micro watershed, Southern Ethiopia. *East African Journal of Sciences,* 3: 1-8.

Ndamani, F., Watanabe, T. 2016. Determinants of Farmers' Adaptation to Climate Change: A Micro Level Analysis in Ghana. *Sci. agric. (Piracicaba, Braz.)* [online]. 2016, vol.73, n.3, pp.201-208. ISSN 1678-992X. (http://dx.doi.org/10.1590/0103-9016-2015-0163).

Panagos, P., Borrelli, P., Poesen, J., Ballabio, C., Lugato,, E., Meusburger, K., Montanarella, L., Alewell, C. 2015. The new assessment of soil loss by water erosion in Europe. *Environ. Sci. Policy* 54, 438-447.

Peng, J., Wu, J., Yin, H., Li, Z., Chang, Q. and Mu, T. 2008. Rural Land Use Change during 1986-2002 in Lijiang, China, Based on Remote Sensing and GIS Data. *Journal ofSensors,* 8:8201-8223.

Sun, Q., Zhang, C., Liu, M. and Zhang, Y. 2016. Land use and land cover change based on historical space–time model. *Solid Earth*, 7: 1395-1403.

Terefe, T., Feyera, S., Moges, K. 2017. The impact of land use/land cover change on ecosystem services in the central highlands of Ethiopia. *Ecosystem Services,* 23*; 47-54.*

Temesgen, G., and Tesfahun, F. 2014. Evaluation of Land Use/ Land Cover Changes in East of Lake Tana, Ethiopia. *Journal of Environment and Earth Science*, 4: 49-53.

Tesfa, W., and Tripathi, D. 2016. Analyses of land use and land cover change dynamics using GIS and remote sensing during 1984 and 2015 in the Beressa Watershed Northern Central Highland of Ethiopia. *Modeling Earth System and Environment*, *2*: 1-12.

Wakjira, T., Tamene, A., Miegel, K. 2010. Drivers and Implications of Land Use/Land Cover Dynamics in Finchaa Catchment, North western Ethiopia. *Land* 9, 113; doi:10.3390/land9040113.

Warra, H., Mohammed, A. and Nicolau, M. 2013. Spatio-temporal impact of Socio-economic practices on land use/land cover in the kasso catchment, Bale Mountains, Ethiopia. *Scientific Annals of "AlexandruIoan Cuza" University of IAŞI*, 1: 96-120.

Woldeamlak, B., and Solomon A. 2013. Land-use and land-cover change and its environmental implications in a tropical highland watershed, Ethiopia. *International Journal of Environmental Studies*, 70: 126-139.

Woldeamlak, B. 2002. Land covers dynamics since the 1950s in Chemoga Watershed, Blue Nile Basin, Ethiopia. *Mountain Research and Development*, 22: 263-269.

Wubie, M., Mohammed, A., Melanie D.N .2016. Patterns, causes and consequences of land use/cover dynamics in the Gumara watershed of lake Tana basin, Northwestern Ethiopia, *Environmental System Research, 5: 1-12.*

Zhou, Q., Li, B., and Kurban, A. 2008.Trajectory analysis of land cover change in arid environment of China.*International Journal of Remote Sensing, 29,* 1093–1107.