Land use and land cover change and its driving forces in Endachewa catchment, Tigray, Ethiopia

Yonas kidane [a], Chen Hongbin (prof.)[a*], Teklwayne Tesfamicheal [b], Brhane Weldegebrial [c].Sebsibe Teka[a]

[a]Tongji University, UN Environment-Tongji Institute of Environment for Sustainable Development (IESD): College of Environmental Science and Engineering.Tongji University, Shanghai 200092, P.R. China.
Email:- hizyonas@gmail.com, hiyonas1yahoo.com, Tel +8619946255103, +251914788209
[* a] **Corresponding Author : Chen Hongbin, (prof.)Email : bhctxc@tongji.edu.cn Tel +8613002104405**
[b] Gondor University, Department of Sociology, Ethiopia
[c] Tigray regional state Bureau of construction,Road and Transport, Ethiopia

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Abstract

The aim of this study was assessing the land use and land cover (LULC) change and its driving forces analyzed for the last 42 years in Endachewa watershed, Tigray Northern Ethiopia. Major drivers of Land-use/Land-cover (LULC) dynamics and the observed environmental degradation as a response to these changes in the Endachewa watershed, Northern Ethiopia were studied. Data for this study were generated through analyzed of household heads' perceptions supplemented with interpretation of landsat images. The data were analyzed using descriptive statistics and Land sat-based image processing. The satellite image classification of the five periods (1976, 1988, 1998, 2009 and 2018) result and farmers' response indicated significant land use and land cover change of the study area. Over the 40 years, the aerial coverage of forest, Bare Land and bush land were decreased from the study beginning year 1976 LU coverage by 275.76 ha (100%), 622.53 ha (72.08%), and 451.62 ha (41.9%), respectively. On the other hand, farmland and water body has increased by an aerial coverage of 1334.7 ha (108 %) and 14.49 ha (100%). This shows that most of the previously covered by forest and bare lands are mostly shifted to the rapidly expanding farm land use classes. This was due to the conversion of forest, bush lands, and bare lands to farm lands. This shows an increase in the expansion of farm lands at the expense of all the other three land use and land cover change types, but mostly at the expense of forest and bare lands. With regard to the Proximate Driving Forces of LULC changes, it is revealed that Population Growth, Agricultural expansion, Infrastructure and Settlement Expansion were major driven force of land use and land cover change in the study area.

Key words: Ethiopia; Land Use and Land Cover Change; Endachewa watershed; Land sat images

1. Introduction

Throughout the course of human history, the land has been tightly attached to economic, social, infrastructure, and other human activities [1]. Land use and land cover (LULC) are distinct yet closely linked. While land cover refers to the ecological state and physical appearance of the land surface (such as closed forests, woodlands or grasslands) [2] . Land use/cover is a composite term, which includes both categories of land cover and land use [3]. The land use/cover pattern of a region is an outcome of natural and socioeconomic factors and their utilization by the man in time and space [4] . Land cover change occurs through conversion and intensification by human intervention, altering the balance of an ecosystem, generating a response expressed as system changes [5] . For centuries, humans have been altering the earth's surface to produce food through agricultural activities [6] . In the past few decades, conversion of grassland, woodland, and forest into cropland and pasture has risen dramatically, especially in developing countries where a large proportion of human population depends on natural resources for their livelihoods [7] . The increasing demand for land and related resources often results in changes in land use/cover [6] and it has local, national, regional, and global causes [8] . Land use/cover dynamics are widespread, accelerating, and significant process driven by human actions [9], but also producing changes that impact humans [10]. There are several important Factors influencing LULC, one of the key factors is human population growth [11].Increase in population and a continuous decline in the amount of agricultural land have led to an indiscriminate exploitation of natural forests and fragile lands for agriculture [12].Population growth is a major driving force in land cover change and contributes to resource degradation[13] .Deforestation and forest degradation have been influenced by a combination of underlying driving forces, including unclear land tenure, poor economic conditions, population growth, market (wood extraction), and sociopolitical factors [14] . On top of the rapid change in LULC of forestland, grazing land or bush lands to cultivated lands is becoming a common practice in most parts of Ethiopia [15] . Other important drivers of LULC change includes policies related to human settlement and land tenure [16] and agricultural [17]; changes in technology [18], culture [19] and political or socio-economic institutions [20] .

The size of Ethiopian population was 40 million in 1984, 53.4 million in 1994, 73.7 million in 2007, 84.2 million in 2012, 85.89 million in 2013 as projected by (CSA), this population become nearly 100 million in 2015 [20] and now in 2018 according CSA 109,224,414. Rain fed agriculture is the major economic activity of the country providing employment for over 85 percent of the population [21] . Ethiopia's forests have suffered owing to harsh deforestation and degradation from an increased demand for fuel wood, construction wood, and cropping and grazing land [22] .

Understanding the dynamics and driving forces behind LULC changes at the local level is fundamental to development planning, and the analysis of land-related policies [23] , and understanding of possible future choices [24] . LULC changes have increasingly become a key research priority for national and international research programs examining global environmental change and impact analysis of the changes, which is a standard requirement for land use planning and sustainable management of natural resources as highlighted by many researchers [25]. Determining the effects of LULC changes on the ecosystem requires knowledge of past land use practices, current LULC patterns, and future projections [13] . LULC change studies are proven essential for the qualification and quantification of central environmental processes and environmental change [26] . It is also vital for the influence of environmental management on biodiversity, water budget, radiation budget, trace gas emissions, carbon cycling, livelihood[26] , urban and rural agricultural land use [11] ,[27], and a wide range of socioeconomic and ecological processes [28]. Which in the aggregate affects global environmental change and the biosphere [20].

LULC changes can affect biodiversity, biogeochemical cycles, soil fertility, hydrological cycles, energy balance, land productivity, and the sustainability of environmental services [29]. Hence, there is a need for continuous monitoring of the changes and prediction [30]. It is a highly persistent that when the aggregated effects on environmental change globally. Consequently, it significantly affects the functioning of the earth's systems directly contributing to climate change [31] . LULC changes result in soil erosion and the formation of gullies, which are among the major cause of land degradation [32] . The highest average rates of soil loss are from previously cultivated lands, which are presently unproductive because of degradation and improper land use [33] .

Land use through inappropriate agricultural practices, high human and livestock population pressure have led to severe land cover change. In Ethiopia, also most people lives in rural areas and depends directly on land for their livelihood [34], futhermore, the woody biomass fuel of households [35]. As a result, soil erosion, biodiversity loss, and land degradation occur in the study area. Soil erosion will again lead to loss of groundwater due to poor infiltration capacity and washed away of the soil nutrient and desertification will occur. These all evidences will contribute to low productivity leading to poverty. Therefore, a systematic analysis of LULC change is so crucial to exactly comprehend the extent of the change. Studies of LULC changes in the Ethiopian highlands concentrates in the Northern Ethiopian highland areas early settled and where population pressure is relatively high [36]. There have been very limited studies LULC change and driving force in the study area northern regions of the country. Even if there are a few studies conducted in Northern Ethiopia, there is no study on land use and land cover change in Endachewa watershed. LULC change is basic data on the extent and trend in the study area that would help for planning and the adoption of sustainable land management practices. In addition, it helps to understand the extent and the trend of LULC changes

and its impact on communities' livelihood. Such studies are scanty in the present study area. Therefore, this study is mainly aimed to analyze the trend and driving forces of land use and land cover change in the watershed.

The general objective of the research was to assess land use and land cover change and its driving forces analyzed for the last 40 years in Endachewa watershed, Tigray Northern Ethiopia**.**

2. Materials and Methods

2.1. Background of the study area

Endachewa watershed is located in Tigray Regional State W/Leke woreda of Northern Ethiopia. The study area is located about 160 km west of Mekelle city, the capital of the Tigray Regional State. The watershed is located within 14^0 02'12'' N -14005'42'' North latitude and 38059'26'' E- 39004' 17'' East longitudes, at an elevation range between 1941 m and 2406 m above sea level. It has a mid-latitude type of agro-ecology. The total area of the study area is **3452.47** ha.

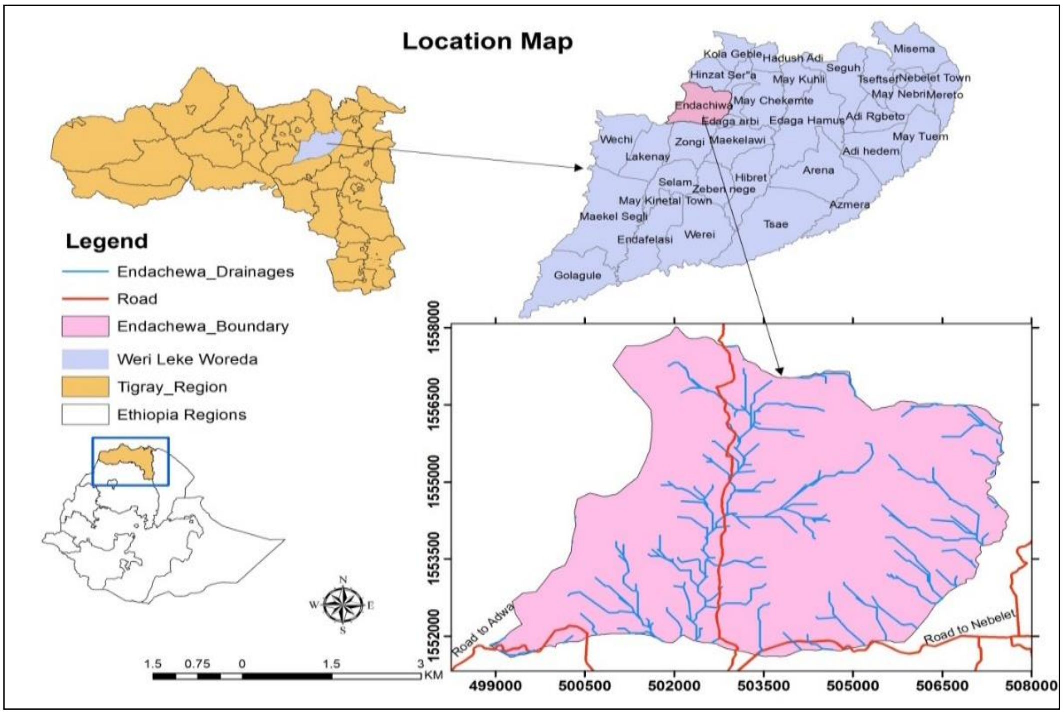


Fig 1: Location map of the study area

The topography of the study sites is varied and includes some flat and gentle slopes as well as steep escarpments. The altitude of the area ranges from 1,941 m.a.s.l. At the lower limit to 2406 m.a.s.l at the plateau. Considering FAO's (2010) slope classification scheme, more than half of the study area is sloppy type topography [37]. Very flat and steep land surface covers very little coverage (3%).

The rainfall in the study area was disproportionately distributed throughout the growing months. The annual rainfall is influenced by the planetary wind pattern and topography, the yearly rainfall trend is real and its peak time during the summer months, and low values during the winter months. The rainfall taken from meteorological data was used to assess seasonal and annual variability. The rainfall patterns in the study area for the period's between1990-1995 showed that there slightly decreases in rainfall pattern. Results revealed that a cyclic pattern of variations with alternating drier and wetter years is suggested. The decrease in annual rainfall trend over the past almost 40 years. The linear fit rainfall trend showed that variability observed in the three decades. However, between 2000 -2005 owed a slight increase and drastically this area are characterized by erratic rainfall and frequent droughts. The negative slope shows decrease in rainfall trend. The rainy season is between June and September.

2.2. Data acquisition and pre-processing

This research was dependent on primary and secondary data source. Field surveys were carried out by distributing a questionnaire to collect primary data, and understand the real ground and their impact. The field survey was supported by key informant interviews to gather information about the issues land use/ land cover change and to prepare the base map for analysis purpose and applying the different methods to achieve the researching objectives. GIS images (1976- 2018) of the study area was collected from the official map producer/owner called USGS.

The major data collection instruments were questionnaires, and key informant interviews to investigate the land use/land cover change and its driving forces in the study area. Both open and close-ended questioners were prepared in English and translated to local language 'Tigringa,' and The study was used purpusive sampling technique. Hence,the study was involving 184 respondents for questionnaire. Besides, 39 participants for key informant interview and focus group discussion were involved .

For data processing visual image interpretation and digital image interpretation techniques were used. Signatures of the classes were identified from satellite imageries and verified in the field. Five classes of the land cover were created. Image pre-processing techniques were carried out including Geo-referencing, resampling, and image enhancement before initiation of the analysis. Enhancement techniques were applied to satellite image in order to increase visual distinctions between features and increase the amount of information that can be visually interpreted from the data. For accurate image classification, band selection also crucial since one feature which is not discriminated apparently may be clearly differentiated on another band. For this purposes false color composite (False color composite = 4:3:2) and true color composite (True color composite =3:2:1) were utilized. The Landsat MSS 1976, Landsat TM 1988, Landsat TM 1998, Landsat TM 2009 and Landsat OLI 2018 images have four, seven and twelve bands respectively with a spatial resolution of 60 meter and 30 meters.

Image correction compensates for distortion, errors, and noise during data acquisition and recording. In order to prepare the land cover of the years 1976, 1988, 1998, 2009 and 2018, the Landsat images have been pre-processed using standard procedures including Geo-referencing and geometric correction (Image rectification). Image rectification is an important procedure for many image processing applications. Simply, it is the process of converting a raw image into a specified map projection.

All images were spectrally enhanced on the rectified image to improve or increases the visual appearance and interpretability of imagery. Enhancements like principal components analysis, the **tasseled** cap transformation, etc. were utilized.

The final step of the processing portion is to layer stacking the different bands which would then be classified. Therefore, layer stacking was applied to extract the images of the study site (Endachewa). This had been done in ERDAS Imagine using the "Layer Stack" algorithm. unsupervised classification with ISODATA classification algorithm has been applied to identify the locations and directions of the individual land cover of the site. This is useful for generating a basic set of classes, and subsequently, supervised classification were applied to further definition of classes.

The satellite imageries for this study were Land sat MSS1-4, L5 TM & OLI L8 (1976, 1988, 1998, 2009 and 2018). These satellites were taken at different months and datesbecause of the cloud cover. Therefore, for the sake of clarity, the study was used at different times. The Digital elevation model (DEM) of the study area with 30 m by 30 m resolution, from Aster Global DEM was obtained. These data were used to examine the land use, land cover, and the topography of the study area in general by using ERDAS Imagine 2014 and Arc GIS 10.6 software.

The types of satellites with their acquisition of dates, path and row, as well as resolutions used in this study are summarized in Table 1.

Table 1.- Details of satellite data acquisition

No	Satellite Sensor	Acquisition date in day/months/year (G.C)	Path	Row	Resolution

1	Landsat 1-5 MSS	25/01/1976	169	050	60m*60m
2	Landsat 5 TM	02/01/1988	169	050	30m*30m
3	Landsat 5 TM	29/01/1998	169	050	30m*30m
4	Landsat 5 TM	13/12/2009	169	050	30m*30m
5	Landsat 8 OLI TIRS	20/01/2018	169	050	30m*30m

As we have used Landsat images with 60 and 30 m resolution, our land cover classes become depending on pixel based image classification. This pixel based image classification better classifies five classes within the study area. These are defined or described as follows (***Table-2)***:

Table-2. The Land Cover Classification Scheme utilized in this study

No	**Class Name**	**Description of the Land Cover Class**
1	Forest Land	Total canopy cover ≥20% [(typically areas encompassed with Woody plants, a mix of more trees of enrichment planting and natural re-vegetation, on average ≥2m height & an area of > 0.5 hectare (MEFCC, 2015).
2	Farm Land	Refers to land surface covered with Cropland, irrigated land, agro-forestry and other heterogeneous agricultural areas. (MEFCC, 2015).
3	Bare Land	Refers to those land surface features little or devoid of any type of vegetation cover which includes degraded areas, rocky areas, gullies, bare soil, etc. (FAO, 2010)
4	Bush Land	Refers to those areas covered with more bushes and any tree, shrub, grasses. (FAO, 2010)
5	Water Body	Refers to land areas covered by surface water (Dams, rivers, Lakes, etc.). (FAO, 2010)
6	Degraded Land	Refers to land surface which is not vegetated, cultivated & settled. This includes big gullies, bare soils, degraded areas; and excludes rocky areas. (FAO, 2010)

3. Result and Discussion

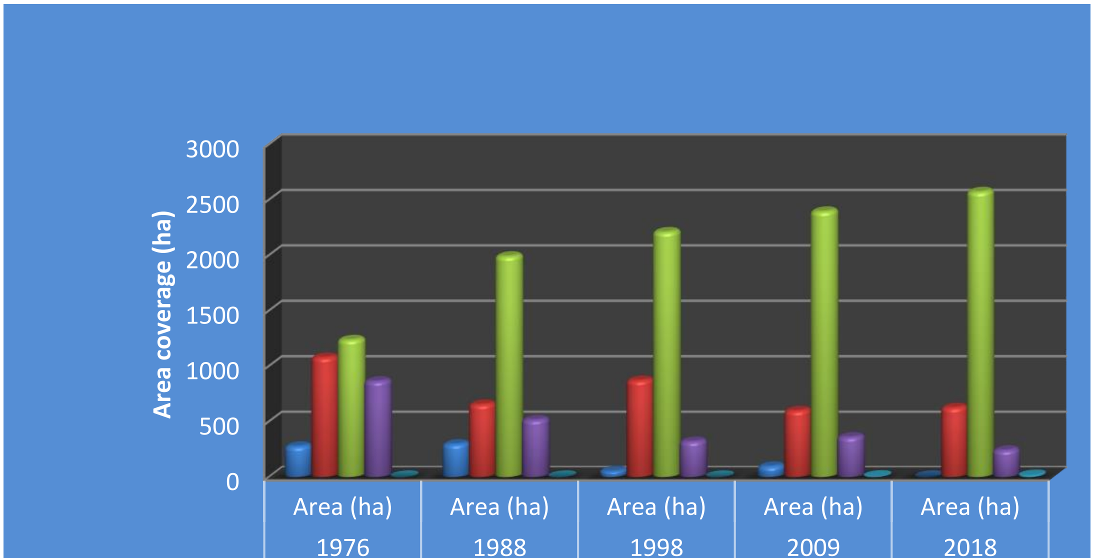
3.1. Socio-demographic characteristics of sample households

The study results show key demographic and socioeconomic characteristics of the surveyed households. A large percentage of household heads (85.1%) were males, whereas females constituted the remaining proportion (14.9%). Large proportions (52%) of respondents were between the ages of 60 and 65 years, while 28.4% and 19.6% of them were between 66 and 71 years, and 59 or 58, respectively. Family sizes ranged from 1 to 9 persons, with an average family size of 5.9 persons. About 47.2% of respondents had between one and five household members, while a majority (52.8%) of them had six or more members in the family. Households with productive labor force of 2, 3-4, and 5 categories accounted for 45.5%, 33.9%, and 20.7% of the sample households, respectively. Economically dependent age groups (0-14) and elderly (65 and above) varied from family to family. In this regard, 56.6% of respondents had household dependency ratios of between 0.0 and 0.5, while 33.9% of households had dependency ratios of between 0.5 and 3. 23% of the respondents were illiterate. Relatively a greater proportion (38.8%) of the respondents could read and write whereas the educational achievements of 28.1% of respondents ranged from grade 1 to grade 8. A small proportion of the household heads (9.9%) had attended grade 9 and above level of formal education. Most of the surveyed, households were engaged in mixed farming activities (70.3%), and some of them (2.5%) were engaged in some form of off-farm activities like petty trading, informal labor and selling charcoal and wood. The land holdings of households in the study area varied from 0.5 ha to 1.8 ha with an average holding size of 0.6 ha per household. A large majority of the surveyed households (63%) had planted and keep natural trees for reversing land degradation and ecological reasons of sustainable land management. A large number of households were aware of land degradation, particularly soil erosion, soil nutrient depletion, and development of gullies as major problems in their localities.

3.2. Land use/Land covers of the study area

The dynamics of LULC were analyzed using household heads' perceptions supplemented with interpretation of remote sensing images. The key findings of change detection results are presented from 1976 to 1988 (in Figure 2), and this can be compared with the perceived LULC changes. Analysis of the 1976 image classification reveals that the Farm Land covered 35.8% of the study area. The classification result shows around half of the watershed (40%) of the area was covered by both forest and bush lands. Bush land and farm land were almost proportional around 31% and 35%, respectively, bare land is 25.01% and the less cover is 8%.

As in the 1988 image classification analysis, reveals that the Farmland and forest land were increased significantly. But, bush land was decreased by almost half of the area. It can be seen in Figure 2, that Farm Land comprised the dominant portion (57.63%) of the land area followed by Bush Land 18.92%, Bare Land 14.90%. Forest Land occupied only 8.55% of the watershed area in 1988.



	Area (ha) 1976	Area (ha) 1988	Area (ha) 1998	Area (ha) 2009	Area (ha) 2018
Forest Land	275.76	295.2	52.92	95.04	0
Bush Land	1076.76	653.4	870.3	597.06	625.14
Farm Land	1236.6	1989.72	2208.7	2394.3	2571.3
Bare Land	863.64	514.44	320.13	360	241.11
Water Body	0	0	0	5.67	14.49

Figure 2: Land use Land cover of the study area from 1976 - 2018 G.C

Analysis of the 1998 image revealed that Farm Land constituted the largest proportion of land in the watershed with a value of 63.98%, followed by Bush Land which accounts for 25.21% (Figure 2). Bare Land and Forest Land constituted 9.27% and 1.53%, respectively.

The 2009 image analysis result indicated that one new land cover created, which is a water body (5.7 hectare). The water body was formerly farmed and bare area as compared with 1998 G.C. The farm Land size increased and expanded to 70%, which was 64% in 1998. The other land use/cover is decreased in these current times as compared to the past 11 years. This is also due to different human activities like Farm Land expansion and population increase (Figure 2).

The 2018 image analysis result indicated that Forest land is completely removed due to agricultural expansion and deforestation. Water body increased to (15 hectare). The farm Land size increased and expanded to 75%, which was 69% in 2009. Bush land is slightly decreased due to agricultural expansion. The other land use/cover is decreased in these current times as compared to the past 9 years. (Figure 2)

3.2.1. Land Use and Land Cover changes in Endachewa watershed from 1976-2018

The satellite image classification of the five periods (1976, 1988, 1998, 2009, and 2018) results indicated significant land use and land cover change of the study area. The 1976 –2018 period change detection analysis also shows a significant increment and decrement in spatial extent of different land use land covers.

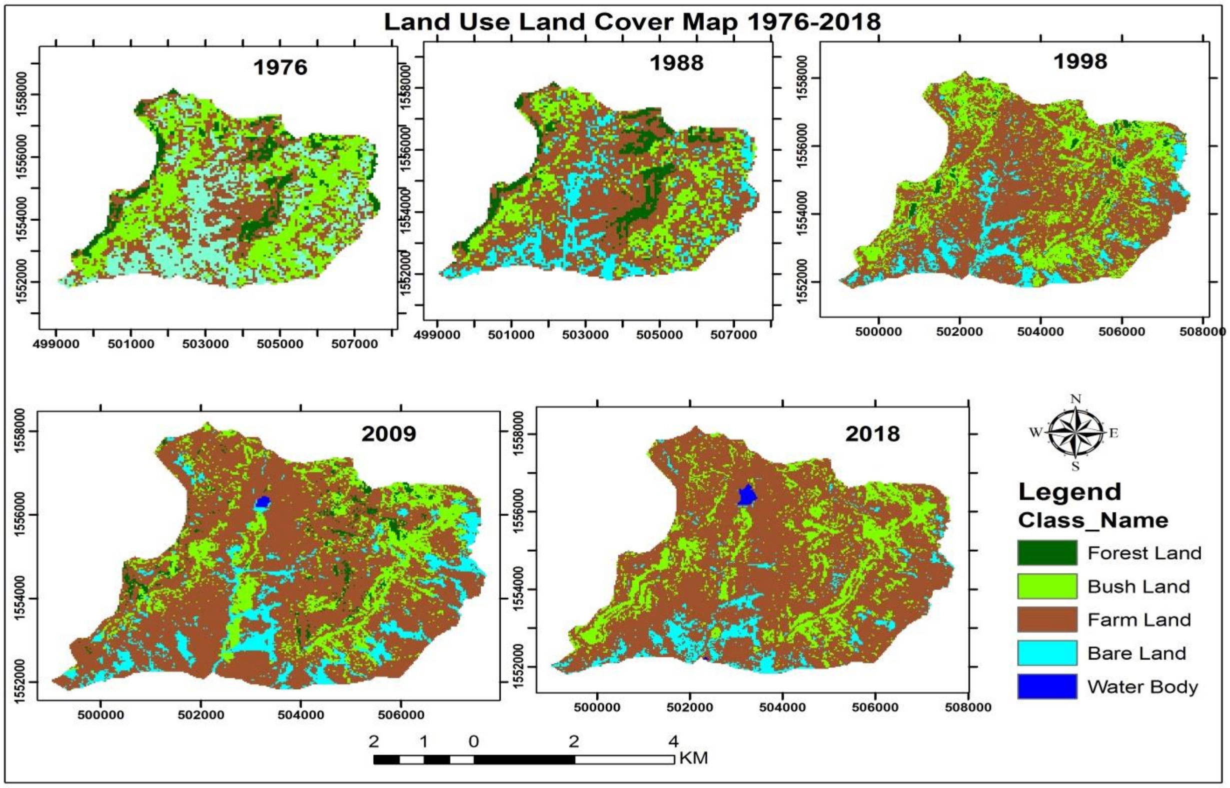


Figure 3: Land use Land cover change Endachewa watershed from 1976-2018

During this period, the areal coverage of forest, Bush lands and Bare Lands were decreased by 276.76 ha (100%), 451.62 ha (13.08%), 622.23 ha (18.03%), respectively. On the other hand, both farm and water body have increased by an aerial coverage of 1334.7 ha (138.68%) and 8.82 ha (0.26%), respectively. This was due to the conversion of forest, bush lands and bare lands into farm lands. As evident from table 3, farm lands were consistently increased during this period. This shows an increase in the expansion of farm lands at the expense of all the other three land use and land cover change types, but mostly at the expense of forest and bare lands.

Table 3: Land use, land covers change image classification in Ha 1976-2018

No.	**Land Cover Type**	**1976**		**1988**		**1998**		**2009**		**2018**	
		Area (ha)	**Area (%)**	**Area (ha)**	**Area (%)**	**Area (ha)**	**Area (%)**	**Area (ha)**	**Area (%)**	**Area (ha)**	**Area (%)**
1	Forest Land	275.76	7.99	295.2	8.55	52.92	1.53	95.04	2.75	0	0
2	Bush Land	1076.76	31.19	653.4	18.92	870.3	25.21	597.06	17.30	625.14	18.11
3	Farm Land	1236.6	35.81	1989.72	57.63	2208.69	63.98	2394.27	69.36	2571.3	74.49
4	Bare Land	863.64	25.01	514.44	14.90	320.13	9.27	360	10.43	241.11	6.98
5	Water Body	0	0.00	0	0.00	0	0.00	5.67	0.16	14.49	0.42
	Total	**3452.76**	**100.00**	**3452.76**	**100.00**	**3452.04**	**100.00**	**3452.04**	**100.00**	**3452.04**	**100**

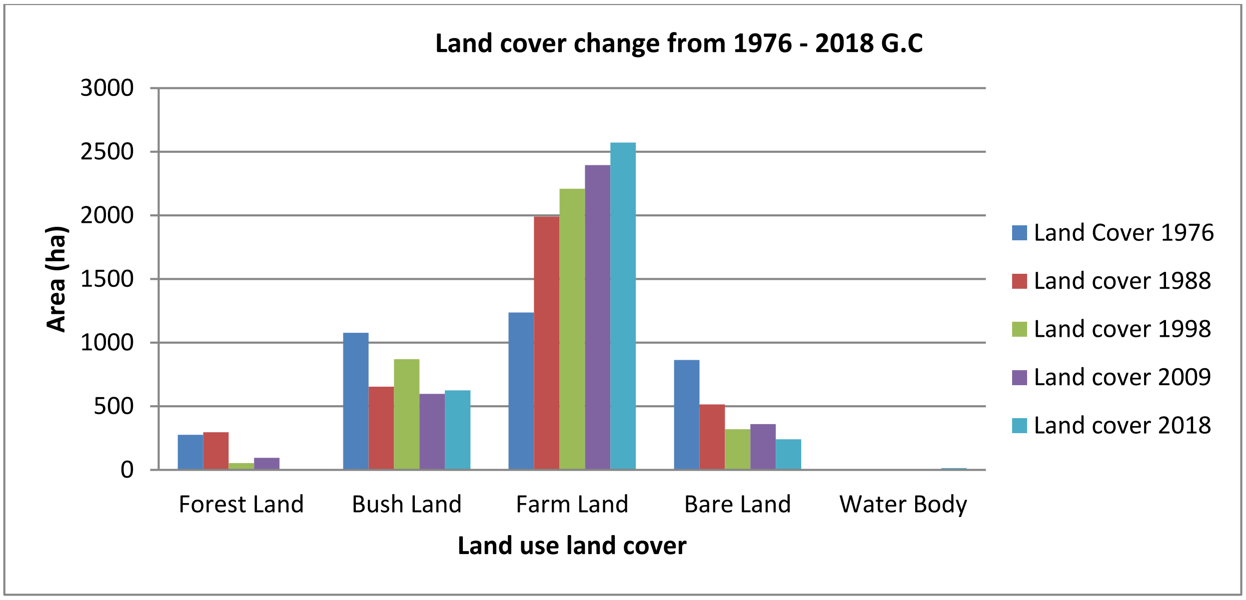


Figure 4: Land use land cover change from 1976 to 2018

3.2.2. The rate of land uses land cover changes:

The rate of change was calculated for each land use, land cover using the following formula:

Rate of change (ha/year) = (A-B)/C

Where A = Recent area of land use/ cover in ha.

B = Previous area of land use/ cover in ha.

C = interval between A and B in years

The result is presented using table and graph

Table4 : Land use land covers class in ha and rate of change in ha/year (1976 – 2018)

		Land use land cover (1976-2018 G.C)					Rate of change			
no.	**Land Cover Type**	**1976 Area (ha)**	**1988 Area (ha)**	**1998 Area (ha)**	**2009 Area (ha)**	**2018 Area (ha)**	**1976-1988**	**1988-1998**	**1998-2009**	**2009-2018**
1	Forest Land	275.76	295.2	52.92	95.04	0	1.62	-24.23	3.83	-10.56
2	Bush Land	1076.76	653.4	870.3	597.06	625.14	-35.28	21.69	-24.84	3.12
3	Farm Land	1236.6	1989.72	2208.69	2394.27	2571.3	62.76	21.90	16.87	19.67
4	Bare Land	863.64	514.44	320.13	360	241.11	-29.10	-19.43	3.62	-13.21
5	Water Body	0	0	0	5.67	14.49	0.00	0.00	0.52	0.98
	Total	**3452.76**	**3452.76**	**3452.04**	**3452.04**	**3452.04**				

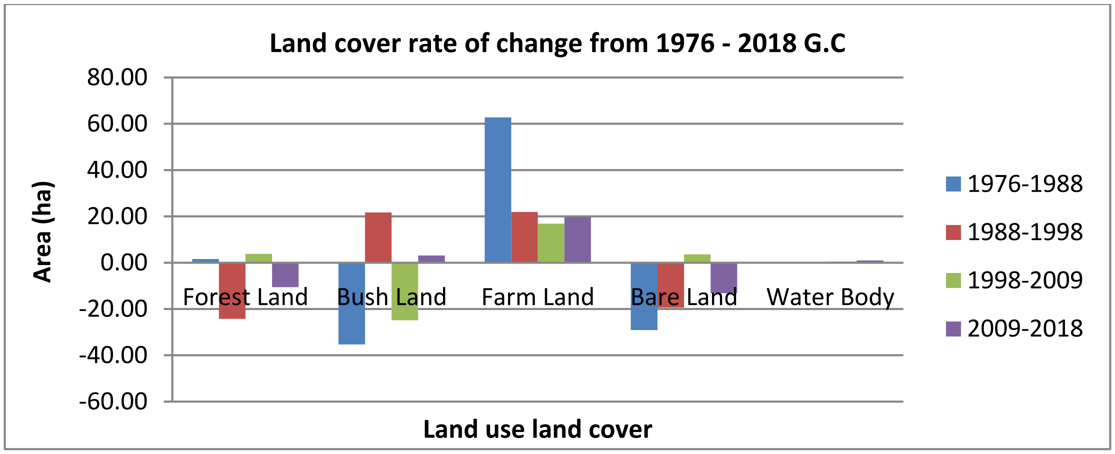


Figure 5: Land use land covers class in ha and rate of change in ha/year (1976 – 2018)

3.2.3. Land Use/Land Cover Change Matrix 1976 to 2018

An important aspect of change detection is to determine what is actually changing to what i.e., which land use class is changing to the other. This information will also serve as a vital tool in management decisions. This process involves a pixel to pixel comparison of the study year images through overlay analysis. The land use land cover change matrix depicts the direction of change and the land use type that remains as it is at the end of the day. For the land use land cover change matrix shown in (Table 5) the rows represents the older land cover categories and the columns represent the newer categories.

3.2.4. Land Use and Land Cover Change Detection from 1986 To 2000

The results of land use and land cover map as shown in (Table 5, Figure 3and 6) between 1976 and 2018, there was a dramatic increment of cultivated land to some extent followed by water body, but due to the conversion of forest and bush land to grassland the areal coverage of the forest is covered by now is zero and bush land and bare land show a reduction. This is just the general impression of land cover dynamics based on comparison of individual land cover maps.

Table 5: Transition matrix between the years 1976-2018 G.C (ha)

	To final state (2018)						
From initial state (1976)	**Forest Land**	**Bush Land**	**Farm Land**	**Bare Land**	**Water Body**	**Total in 1976(byha)**	**Loss (ha)**
Forest Land (ha)	**0**	79.38	192.78	3.24	0.18	275.58	275.58
Bush Land (ha)	0	**374.58**	691.47	8.73	1.98	1076.76	702.18
Farm Land (ha)	0	114.75	**1066.68**	48.87	6.3	1236.6	169.92
Bare Land (ha)	0	56.43	621	**180.18**	6.03	863.64	683.46
Water Body (ha)	0	0	0	0	**0**	0	0
						3452.76	1831.14
Total in 2018	0	625.14	2571.93	241.02	14.49	**3452.76**	

Gain	0	250.56	1505.25	60.84	14.49	**1831.14**	
Net change	-275.58	-451.62	1335.33	-622.62	14.49	0	0

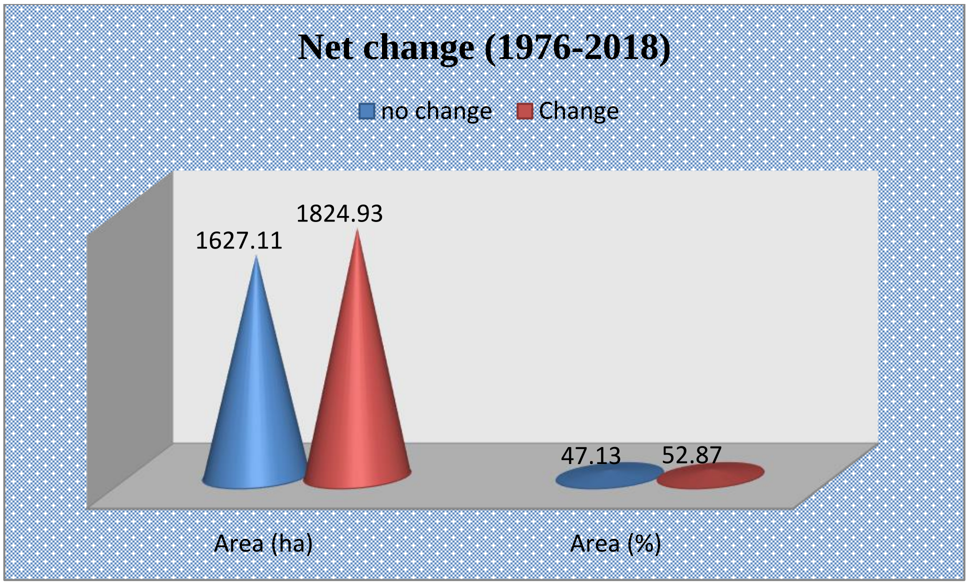


***Figure 6*: Transition matrix result between the years 1976-2018 G.C**

3.3. Proximate Driving Forces of LULC changes in Endachewa watershed

During the period of 1976-2018, there was a number substantial change in population growth (9,689) and the farmland (1334.7 ha), but the productivity per hectare in ton (0.68) enhanced slightly due to the uses agricultural inputs such as fertilizer and water harvesting systems for farming purpose (table 6). These data expressly stated that a high population growth increases the demand for land for agricultural activities and biomass as the source of fuel and construction materials. Due to the increase in food and fuel wood demands resulting from population pressure, local farmers are forced to push farm lands at the expense of forest in the most marginal and fragile landscapes. There may be a similar change expected in the future, which can be a major cause of land degradation in the watershed, leading to a decline in crop production unless there is due considerations for natural resources conservation practices.

Table 6 : Population ,farmland covering and Agriculture productivities data during last 40 years(Source: werielek woreda Rural and Agricultural office)

Year	Population number	Farm land Area in ha	Productivity (ton) per ha	Average ton per person per year
1976	2,598.00	1,236.60	0.9	0.42
1988	3,919.00	1,675.92	0.11	0.504
1998	5,289.00	2,164.92	0.15	0.61
2009	7107.00	2,343.65	0.145	0.47
2018	12,287.00	2,571.30	0.158	0.33

The focus group discussion (FGD) participants and key informants in the study area indicated that four major proximate (direct) driving forces appears to explain a large part of the LULC change in Endachewa watershed. These are: (i) population pressure, (ii) agricultural expansion (iii), Infrastructure and Settlement expansion, (iv) wood extraction (Table 7). Nearly 4.1% of the respondents also argued that the expansion of built-up areas and other infrastructure was a cause of LULC change in the Endachewa watershed. Previous studies also highlighted that expansion of infrastructures was driving forces of LULC changes [38] .

The land cover conditions of the Ethiopian highlands have also been modified or significantly transformed by the rapidly increasing population pressure and growing livestock population. Human population in the highlands has grown fast on the limited land area; and almost every piece of land is converted into cultivated land to produce food [13] . Like elsewhere in the country, the study area watershed has experienced fast population growth. Over 79.5% of the surveyed farmers indicated that the rapidly growing population pressure is one of the major driving forces of LULC change and related (Table 7) and CSA report the population number indicate in the study area in 1976 and 2018 (study year) is 2598 and 12287, respectively ,they increase by 400% and above. Key informants also asserted that land holding per capita had declined due to the increasing population pressure. This situation has created pressure on the limited land for agricultural production. This is a clear evidence in favor of the Malthusian and Neo-Malthusian theoretical premise and the standards of political ecologist school of thought regarding population dynamics, land system change and resource degradation [39].

Agricultural Activities: Subsistence rain-fed farming and livestock husbandry are the major livelihoods of the rural community in the Endachewa watershed. As the study area is a typical rain-fed farming system, smallholder agricultural land expansion at the expense of other land covers is by far the most widespread proximate driver of land use dynamics and related land cover changes as reported by 13.6% of respondent's table (7)

A large number of respondents (2.8%) also suggested that wood cutting for the fulfillment of domestic uses was the most prevalent driving force of vegetation destruction. The majority of the surveyed farmers also noted that some households that are very poor were engaged in cutting and selling of trees for income generation. Discussion with key informants such as local natural resource conservation experts also confirmed that the increasing demand of tree products such as fuel wood, construction materials and charcoal for domestic uses in and around the Endachewa watershed was one of the major driving forces of land cover change.

Table 7: Proximate Driving Forces

No.	Proximate Driving Forces	%	Rank
1	Population Growth	79.5	1
2	Agricultural expansion,	13.6	2
3	Infrastructure and Settlement Expansion ,	4.1	3
4	Wood Extraction	2.8	4
	Total	100.00	

4. Conclusion and Recommendation

Long term watershed level LULC change detection analysis is mostly done using remotely sensed images, however, this study verified that household level survey data provide an equally important source of information and even additional details can be extracted regarding the magnitude, driving forces and environmental and socioeconomic impacts of LULC changes.

The objective of this study was to assess the land use and land cover change and its driving forces in the Endachewa watershed, Tigray regional state, northern Ethiopia and the study found that significant LULC change has occurred in the study area, with associated land resource degradation. The major changes observed include expansion farm and water body, and loss of forest, bush lands and bare lands in the study area for the last 40 year (1976- 2018). The study identified population pressure, agricultural expansion, infrastructure and settlement expansion, wood extraction for fire wood and charcoal as the Proximate factors of LULC change in the watershed.

In the view of the conclusions drawn, the following suggetsions are made to government, Households and Community managers

- The government shall provide and implementing strong family planning policy. To minimize the problems of landless youths, it would imperative to create and strengthen off-farm income generating activities due to limited capacity of land to accommodate the additional population. Together with this, the policy to drive modern farming is a step towards improving productivity and yield per hectare.

- The local and regional government should prepare strategic planning to monitor abrupt urban expansions and infrastructures and avoiding deforestation, wood land degradation through awareness creation and stringent enforcement of forest regulation. Additionally, provision of alternative energy from renewable sources such as wind, geothermal, solar, biomass at reasonable price to rural and urban residents.

- The Households should be applying modern methods of sowing, maturing and irrigating the new high-yielding varieties of seeds. Besides, using improved seed, pesticide, latest technologies and best practices for farm management could help to vastly increase yields. As a result, the households would enable them to produce enough food to carry over the entire consumption year. Thus, the farmland expansion would be minimized.

- The Community managers would participate the community in the protection of communally owned forest areas. Hence, rehabilitation, closure and distribution of degraded hills or other conservation practices has to be launched to minimize land degradation and to counteract the deteriorating of forest, Bush lands and Bare Land and avoid further extinction of important tree species.

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References

1. Lambin, E.F., *Global land-use and land-cover change: what have we learned so far?* Global Change News, 2001. **46**: p. 27-30.
2. Mwavu, E. and E. Witkowski, *Land-use and cover changes (1988–2002) around Budongo forest reserve, NW Uganda: Implications for forest and woodland sustainability.* Land degradation & development, 2008. **19**(6): p. 606-622.
3. Ioannis, M. and M. Meliadis, *Multi-temporal Landsat image classification and change analysis of land cover/use in the Prefecture of Thessaloiniki, Greece.* Proceedings of the International Academy of Ecology and Environmental Sciences, 2011. **1**(1): p. 15.
4. Zubair, M. and C. Garforth, *Farm level tree planting in Pakistan: the role of farmers' perceptions and attitudes.* Agroforestry systems, 2006. **66**(3): p. 217-229.
5. Dale, V.H., *The relationship between land-use change and climate change.* Ecological applications, 1997. **7**(3): p. 753-769.
6. Assefa, E., *Landscape dynamics and sustainable land management in southern Ethiopia*. 2012, Christian-Albrechts Universität Kiel.
7. Baishya, R., S.K. Barik, and K. Upadhaya, *Distribution pattern of aboveground biomass in natural and plantation forests of humid tropics in northeast India.* Tropical Ecology, 2009. **50**(2): p. 295.
8. Olson, J.M., et al., *The spatial patterns and root causes of land use change in East Africa.* 2004.
9. Leh, M., S. Bajwa, and I. Chaubey, *Impact of land use change on erosion risk: an integrated remote sensing, geographic information system and modeling methodology.* Land Degradation & Development, 2013. **24**(5): p. 409-421.
10. Agarwal, C., et al., *A review and assessment of land-use change models: dynamics of space, time, and human choice.* Gen. Tech. Rep. NE-297. Newton Square, PA: US Department of Agriculture, Forest Service, Northeastern Research Station. 61 p., 2002. **297**.
11. Lambin, E.F., et al., *The causes of land-use and land-cover change: moving beyond the myths.* Global environmental change, 2001. **11**(4): p. 261-269.
12. Gobeze, T., et al., *Participatory forest management and its impacts on livelihoods and forest status: the case of Bonga forest in Ethiopia.* International forestry review, 2009. **11**(3): p. 346-358.
13. Bewket, W., *Land cover dynamics since the 1950s in Chemoga watershed, Blue Nile basin, Ethiopia.* Mountain Research and Development, 2002. **22**(3): p. 263-270.
14. Nyssen, J., et al., *Human impact on the environment in the Ethiopian and Eritrean highlands—a state of the art.* Earth-science reviews, 2004. **64**(3-4): p. 273-320.
15. Abate, A. and M. Lemenih, *Detecting and quantifying land use/land cover dynamics in Nadda Asendabo Watershed, South Western Ethiopia.* International Journal of Environmental Sciences, 2014. **3**(1): p. 45-50.
16. Meyer, W.B., W.B. Meyer, and I. BL Turner, *Changes in land use and land cover: a global perspective*. Vol. 4. 1994: Cambridge University Press.
17. Reed, K., *Improving the adaptation of perennial ryegrass, tall fescue, phalaris, and cocksfoot for Australia.* New Zealand Journal of Agricultural Research, 1996. **39**(4): p. 457-464.
18. Hasselmann, F., et al., *Technological driving forces of LUCC: Conceptualization, quantification, and the example of urban power distribution networks.* Land Use Policy, 2010. **27**(2): p. 628-637.
19. Rockwell, J., *The new colossus: American culture as power export.* New York Times, 1994. **30**: p. 1-30.
20. Alemayehu, F., M. Tolera, and G. Tesfaye, *Land Use Land Cover Change Trend and Its Drivers in Somodo Watershed South Western, Ethiopia.* African Journal of Agricultural Research, 2019. **14**(2): p. 102-117.
21. Devereux, S. and I. Sussex, *Food insecurity in Ethiopia*. 2000: Institute for Development Studies.
22. Birhanu, A., *Environmental degradation and management in Ethiopian highlands: Review of lessons learned.* International Journal of Environmental Protection and Policy, 2014. **2**(1): p. 24-34.
23. Tekle, K. and L. Hedlund, *Land cover changes between 1958 and 1986 in Kalu District, southern Wello, Ethiopia.* Mountain research and development, 2000. **20**(1): p. 42-52.
24. de Sherbinin, A., et al., *A CIESIN thematic guide to social science applications of remote sensing.* New York: Center for International Earth Science Information Network (CIESIN) of Columbia University, 2002.
25. Petit, C., T. Scudder, and E. Lambin, *Quantifying processes of land-cover change by remote sensing: resettlement and rapid land-cover changes in south-eastern Zambia.* International Journal of Remote Sensing, 2001. **22**(17): p. 3435-3456.
26. Verburg, P.H., et al., *Modeling the spatial dynamics of regional land use: the CLUE-S model.* Environmental management, 2002. **30**(3): p. 391-405.
27. Ayele, G.T., et al., *Multitemporal land use/land cover change detection for the Batena Watershed, Rift Valley Lakes Basin, Ethiopia*, in *Landscape Dynamics, Soils and Hydrological Processes in Varied Climates*. 2016, Springer. p. 51-72.
28. Kurt, S., *Land use changes in Istanbul's Black Sea coastal regions between 1987 and 2007.* Journal of Geographical Sciences, 2013. **23**(2): p. 271-279.
29. Fasona, M.J. and A. Omojola. *Climate change, human security and communal clashes in Nigeria*. in *International Workshop on Human Security and Climate Change, Oslo, Norway. June*. 2005.
30. Kindu, M., et al., *Land use/land cover change analysis using object-based classification approach in Munessa-Shashemene landscape of the Ethiopian highlands.* Remote Sensing, 2013. **5**(5): p. 2411-2435.

31. Lewis, S.L., *Tropical forests and the changing earth system.* Philosophical Transactions of the Royal Society B: Biological Sciences, 2005. **361**(1465): p. 195-210.
32. Kidanu, S., *Using Eucalyptus for soil & water conservation on the highland vertisols of Ethiopia*. 2004: Wageningen University and Research Centre.
33. Pimentel, D. and M. Burgess, *Soil erosion threatens food production.* Agriculture, 2013. **3**(3): p. 443-463.
34. Tesfaye, S., et al., *Land use and land cover change, and woody vegetation diversity in human driven landscape of Gilgel Tekeze Catchment, Northern Ethiopia.* International Journal of Forestry Research, 2014. **2014**.
35. Tesfaye, K.F.Y.D.G., *Assessment of Woody and Non-Woody Fuel Biomass Resource Availability and Rate of Consumption in the Somodo Model Watershed South-Western Ethiopia.* Assessment, 2017. **7**(4).
36. Tegene, B., *Land-cover/land-use changes in the derekolli catchment of the South Welo Zone of Amhara Region, Ethiopia.* Eastern Africa Social Science Research Review, 2002. **18**(1): p. 1-20.
37. Badía, D., et al., *Influence of slope and parent rock on soil genesis and classification in semiarid mountainous environments.* Geoderma, 2013. **193**: p. 13-21.
38. Wu, K.-y. and H. Zhang, *Land use dynamics, built-up land expansion patterns, and driving forces analysis of the fast-growing Hangzhou metropolitan area, eastern China (1978–2008).* Applied geography, 2012. **34**: p. 137-145.
39. Rudel, T.K., J.T. Roberts, and J. Carmin, *Political economy of the environment.* Annual Review of Sociology, 2011. **37**: p. 221-238.