Research Article

Evaluation of the status of land use/land cover change using remote sensing and GIS in Jewha Watershed, Northeastern Ethiopia

Dereje Gebrie Habte[1] · Satishkumar Belliethathan[1] · Tenalem Ayenew[2]

Received: 10 November 2020 / Accepted: 10 March 2021 / Published online: 24 March 2021

Abstract

Evaluation of land use/land cover (LULC) status of watersheds is vital to environmental management. This study was carried out in Jewha watershed, which is found in the upper Awash River basin of central Ethiopia. The total catchment area is 502 km^2. All climatic zones of Ethiopia, including lowland arid ('Kola'), midland semi-arid ('Woinadega'), humid highland (Dega) and afro alpine ('Wurch') can be found in the watershed. The study focused on LULC classification and change detection using GIS and remote sensing techniques by analyzing satellite images. The data preprocessing and post-process was done using multi-temporal spectral satellite data. The images were used to evaluate the temporal trends of the LULC class by considering the years 1984, 1995, 2005 and 2015. Accuracy assessment and change detection of the classification were undertaken by accounting these four years images. The land use types in the study area were categorized into six classes: natural forest, plantation forest, cultivated land, shrub land, grass land and bare land. The result shows the cover classes which has high environmental role such as forest and shrub has decreased dramatically through time with cultivated land increasing during the same period in the watershed. The forest cover in 1984 was about 6.5% of the total catchment area, and it had decreased to 4.2% in 2015. In contrast, cultivated land increased from 38.7% in 1984 to 51% in 2015. Shrub land decreased from 28 to 18% in the same period. Bare land increased due to high gully formation in the catchment. In 1984, it was 1.8% which turned to 0.6% in 1995 then increased in 2015 to 2.7%. Plantation forest was not detected in 1984. In 1995, it covers 1.5% which turned to be the same in 2015. The study clearly demonstrated that there are significant changes of land use and land cover in the catchment. The findings will allow making informed decision which will allow better land use management and environmental conservation interventions.

Keywords Accuracy assessment · Change detection · Land use/cover change · Remote sensing and GIS

Abbreviations

DEM	Digital elevation model
ERDAS	Earth resources data analysis system
CSA	Central statistical agency
GIS	Geographical information system
LULC	Land use land cover change
SWAT	Soil and water assessment tool
USGS	United States Geological Survey

1 Background

Land use land cover (LULC) change is affected worldwide ecological processes, which results in major environmental challenges of global importance [14, 19]. It were estimated that the human footprint has affected 83% of the global terrestrial land surface. About 60% of the ecosystem services in the past 50 years alone were degraded by LULC change [15]. LULC change is arguably the most pervasive socioeconomic force driving change and degradation of

✉ Dereje Gebrie Habte, dereje.gebrie@aau.edu.et | [1]College of Natural and Computational Science, Center for Environmental Science, Addis Ababa University, P.O. Box 1176, Addis Ababa, Ethiopia. [2]College of Natural and Computational Science, Department of Earth Sciences, Addis Ababa University, P.O. Box 1176, Addis Ababa, Ethiopia.

SN Applied Sciences (2021) 3:501 | https://doi.org/10.1007/s42452-021-04498-4

ecosystem. Deforestation, urban development, agriculture and other human activities have substantially altered the Earth's landscape [23]. Nowadays, agriculture occupies 38% of the globe's ice-free terrestrial surface and is the largest land cover type by area [10]. The rate of agricultural expansion are decreasing globally. The impact is expected to be high in developing countries like Ethiopia [1].

1.1 Statement of the problems

While globally important, LULC change occurs locally [22]. LULC change is one of environmental challenges in Ethiopia [7, 18, 21].

Land use practices and topography determine the land cover change extent of the area [11]. For example, agricultural practices in the western and northern part of Ethiopia are different. Historical evidence shows that northern Ethiopia agriculture depends on slash and burning, whereas western part is depended on mixed farming system [9]. Such difference in farming practices significantly changes the land use land cover rates from place to place. Agricultural expansion is happening in the study area due to rapid population growth and usually it is encroaching forest, grass lands and other land use types. Because of this soil erosion, land degradation, loss of productivity and climate variability are exacerbated in the upper watershed areas. However, in the lower watershed areas drinking and irrigation water scarcity, floods, drought and loss of productivity is encountered. LULC change analysis, nowadays is the basic method to understand the dynamics of the land use/land cover status [5, 12]. The main goal of this study was to evaluate LULC change dynamics of the land use classes and vegetation cover changes starting from 1984 to 2015 using multi-temporal satellite data, in order to monitor the changes, so as to understand the extent of the problem that the study area is facing. The study is expected to pave the way for informed decision-making to implement land restoration and watershed conservation interventions.

2 Materials and methods

2.1 Methodological framework

The methodological framework included in this study was preprocessing and post-processing activities. The preprocessing activities included the land sat data preparation and watershed delineation. The cloud-free land sat images were downloaded from the United States Geological Survey (USGS). Atmospheric correction was performed in this process using Earth Resources Data Analysis System (ERDAS) software 2015 version. The post-processing activities (such as classification and accuracy assessment) were done to identify land use class. The ground truth verification points were automatically selected by using the random sampling method for accuracy assessment of the classification result. Based on this 256 points were verified by using Google Earth to investigate historical land sat images. The intensity analysis was performed by using analyzing error matrix at interval, category and transition levels.

2.2 Description of the study area

The Jewha watershed is characterized by diverse topographic conditions. It is located in the headwaters of the Awash River, which is Ethiopia's major inland drainage system. The watershed elevation of the study area ranges from 1200 to 3200 m above mean sea level. The topography is mountainous with dissected terrain and steep slopes characterized in most parts by scarce resource in the sub-watershed due to high population pressure and land degradation.

The study area is located in northeastern part of Ethiopia. It has an average annual rainfall of 1007 mm, with short rain, March–April and long rain June–September. The mean annual minimum and maximum temperatures are 16.5 and 31 °C. The community relies on subsistence agricultural system. The region has gone through substantial changes in settlement and land use over the years. However, research has not been conducted in the area, in regard to LULC.

The watershed is in the rift valley escarpments of Eastern Amhara region, which encompasses the lowlands of North Shewa zone. Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), Kewot District has a total population of 118,381, an increase of 9.97% over the 1994 census. About 29,058 households were counted in this district, resulting in an average of 4.07 persons to a household, and 28,104 housing units (Fig. 1).

2.3 Data source

The input data for land sat image were obtained from USGS. Cloud-free images of years 1984, 1995, 2005 and 2015 were used. The digital elevation model (DEM) with the resolution of 30 m used from the same sources. Observational data for ground truth verification were collected from field observation in addition to Google Earth map.

2.4 Methodology

2.4.1 Land use/land cover (LULC) classification

Landsat images with path (168) and row (53) were obtained from the USGS (see Table 1). Cloud-free images in

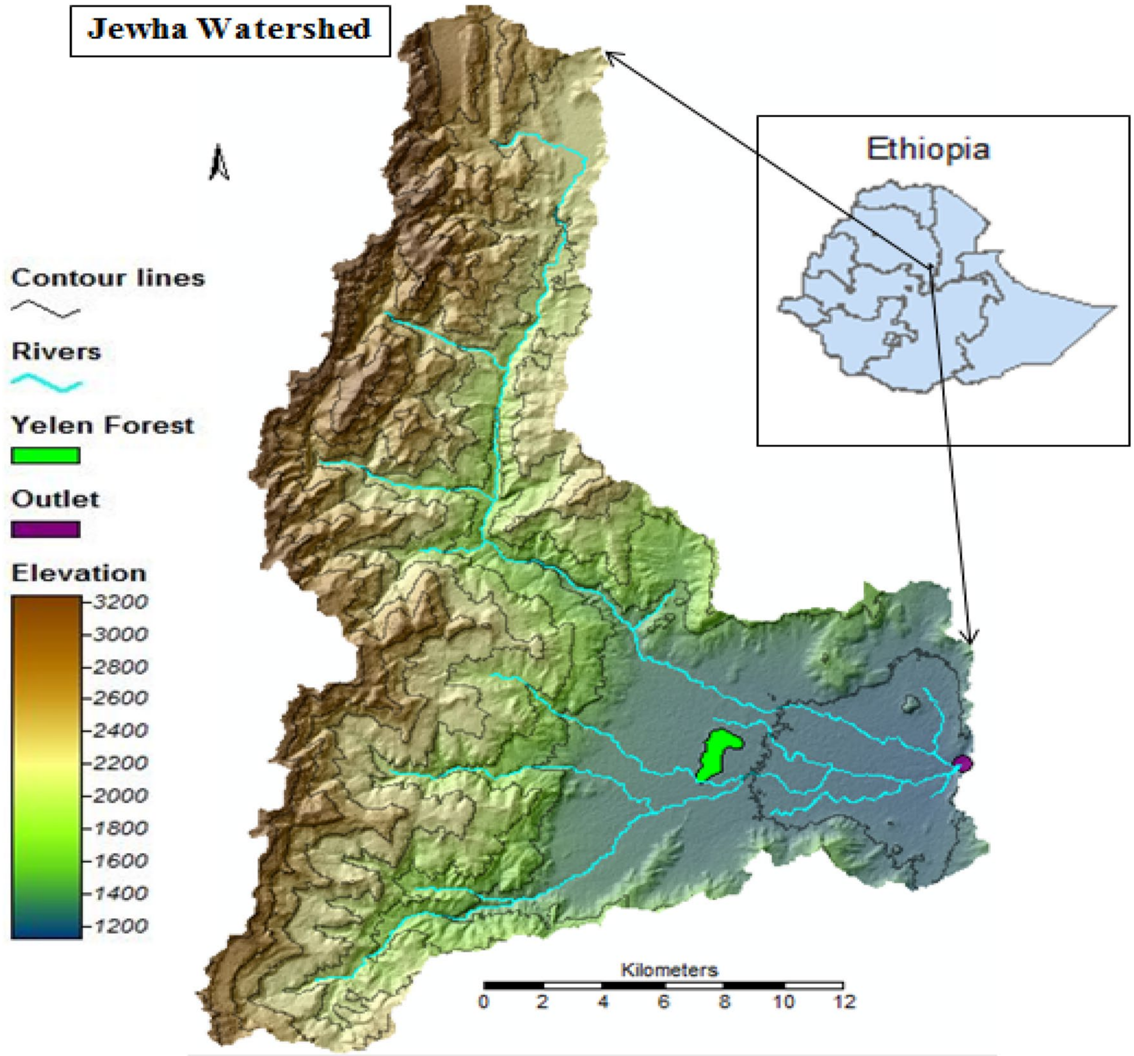

Fig. 1 Map of the study area

Table 1 Types of Landsat used in the study

Image and sensor	Path	Row	Resolution	Acquisition date	Source
Landsat 5 (TM)	168	53	30×30	11/02/1984	USGS
Landsat 5 (TM)	168	53	30×30	04/03/1995	USGS
Landsat 7 (ETM^+)	168	53	30×30	9/04/2005	USGS
Landsat 8 (OLI)	168	53	30×30	7/03/2015	USGS

the years 1984, 1995, 2005 and 2015 were taken for LULC classification.

The LULC map for 'Jewha' watershed was delineated using Soil and Water Assessment Tool (SWAT) software. An intensive preprocessing such as geo-referencing, layer stacking was carried out in order to Orto-rectify the satellite images [17]. The classification then was processed using ERDAS Imagine 2015 software after the satellite image bands correction was carried out using radiometric algorithm. Then, from the stacked satellite image the study area subset was extracted. Further, the gap in Landsat 7 image was filled by using the interpolation method.

2.4.2 Accuracy assessment of classification

To check the classification accuracy, assessment of error matrix was done for all images of the study periods. According to [12], maximum likelihood algorithm produced acceptable LULC classification. Each of the land use/cover class of the study area was compared to the reference points to assess the accuracy of the classification. For this purpose, 256 reference points were collected (Fig. 2). The reference data were prepared by using distribution parameters of equalized random points from the topographic map and verified by using historical data of Google Earth [3].

2.4.3 Intensity analysis

Intensity analysis is a mathematical framework that compares a uniform intensity to observed intensities of temporal changes among categories [16]. In this study intensity analysis used at three levels: interval, category and transition.

Interval level shows the results of change area between two periods. The study periods have three intervals: these are 1984–1995, 1995–2005 and 2005–2015. The duration of the intervals was 11, 10 and 10 years respectively. The temporal intensity change for each time interval was calculated as stated by [16].

At the category level, each category to measure how the size and intensity of both gross losses and gross gains varies across space were examined. After the intensity analysis of gross losses and gross gains, calculated for each category, the observed intensities and uniform intensity of annual change were compared.

At the transition level, the size and intensity of the transition variation among categories were examined. When a category losses or gains, this level of analysis can identify which other categories are intensively avoided versus targeted for transition by comparing the observed intensity of each transition with a uniform intensity that would exist if the transition were distributed uniformly among the categories available for the transition [4].

The land cover class defined as follow (Table 2) in the study area. The researcher verified the land cover classes on ground by using observation and historical images of Google Earth.

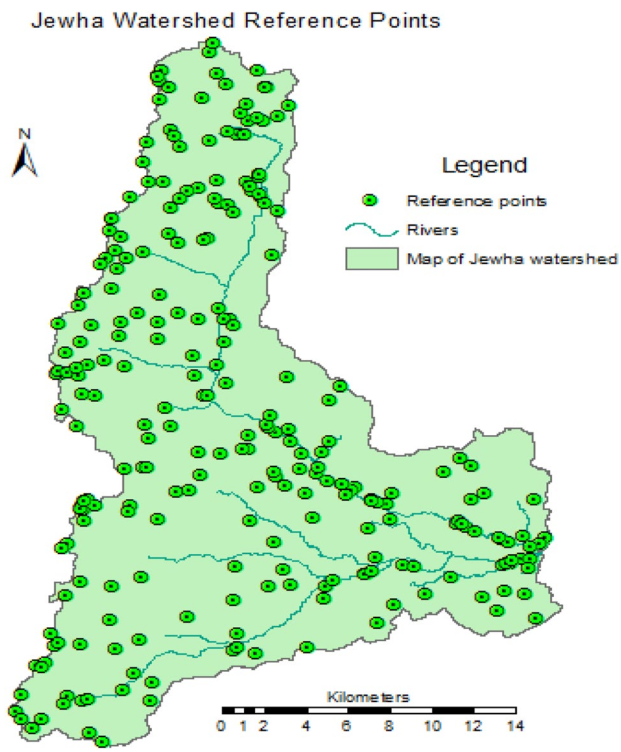

Fig. 2 Reference points used for accuracy assessment

3 Result and discussion

3.1 Land use/land cover change analysis and intensity analysis

The result shows that there is significant land cover change from the forest to cultivated land for the years 1984–1995 but the change is not significant from the year 2005–2015 (Table 6). The forest cover status of 'Yelen' forest, which found in the study watershed, was analyzed by I-tree canopy and Google Earth software. This natural forest is decreased from 268 ha in 1987 to 168 ha in 2015 (Fig. 4). From field observation it was understood that this was due to human interference and livestock population growth (Figs. 3, 4).

Workflow of multi-temporal land use/land cover change detection proved to be efficient. The accuracy assessment done from intensity analysis at interval, category and transition levels presented as follow:

Table 2 Land cover classification scheme

Land cover class	Description
Natural forest	Deciduous, evergreen and mixed forest
Plantation forest	Eucalyptuses and pines species
Cultivated lands	Arable land, permanent crops and heterogeneous agricultural areas
Shrub land	Areas covered with small trees, bushes and shrubs. In some areas, grasses are found within them. These are areas less dense than forests
Grass land	Natural grasslands, pasture areas and sparsely vegetated
Bare land	Without natural cover (either grass or shrub) mainly river beds

3.1.1 Interval level

From the figure below, the transition matrix 1984–1995 in percent of landscape change occurs on 4.36%. The transition matrix in the intervals 1995–2005 and 2005–2015 are 4.60 and 5.21%, respectively. The annual change is fast in the interval of 2005–2015. The change was slow between 1984–1995 and 1995–2005 (Fig. 5).

3.1.2 Category level

Categorical change in the interval of 1995–2005 (Fig. 6) is active in grass land, shrub land, natural forest plantation forest and bare land which are above uniform intensity of 4.60. Plantation forest emerged due to the intervention in the highlands of the watershed.

Changes of 2005–2015 interval active (Fig. 7) in categories of grass land, shrub land, cultivated land, natural forest and bare land which are above uniform intensity of 5.21. Natural forest and bare land are highly active in this case. From observation the bare land is increased due to loss of productivity in the sloppy area and gully formation in the lowland transition from cultivated land. Plantation forest is dormant during this time and it may be due to the protection it receives.

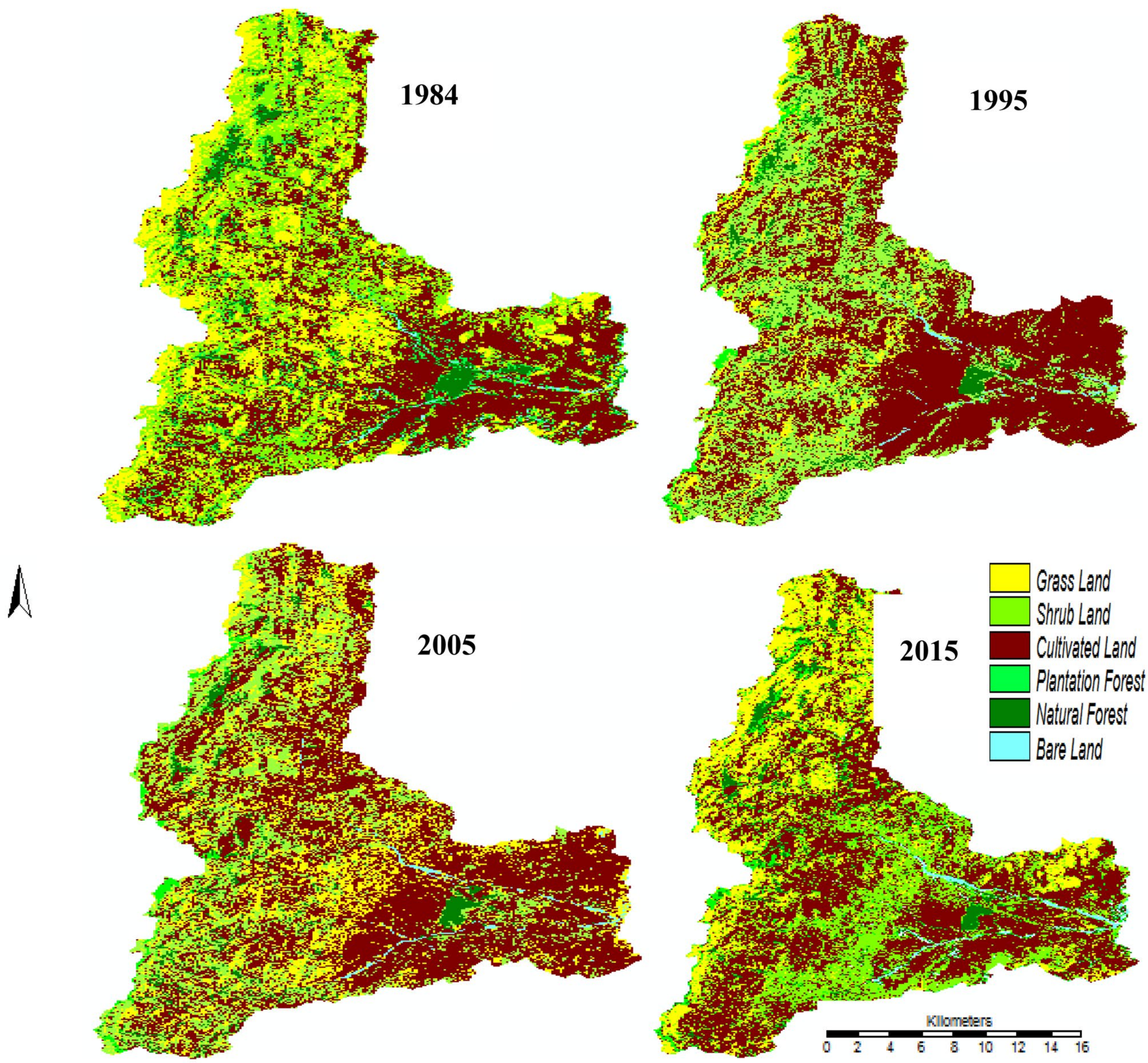

Fig. 3 Classified images of Jewha watershed for the years 1984, 1995, 2005 and 2015

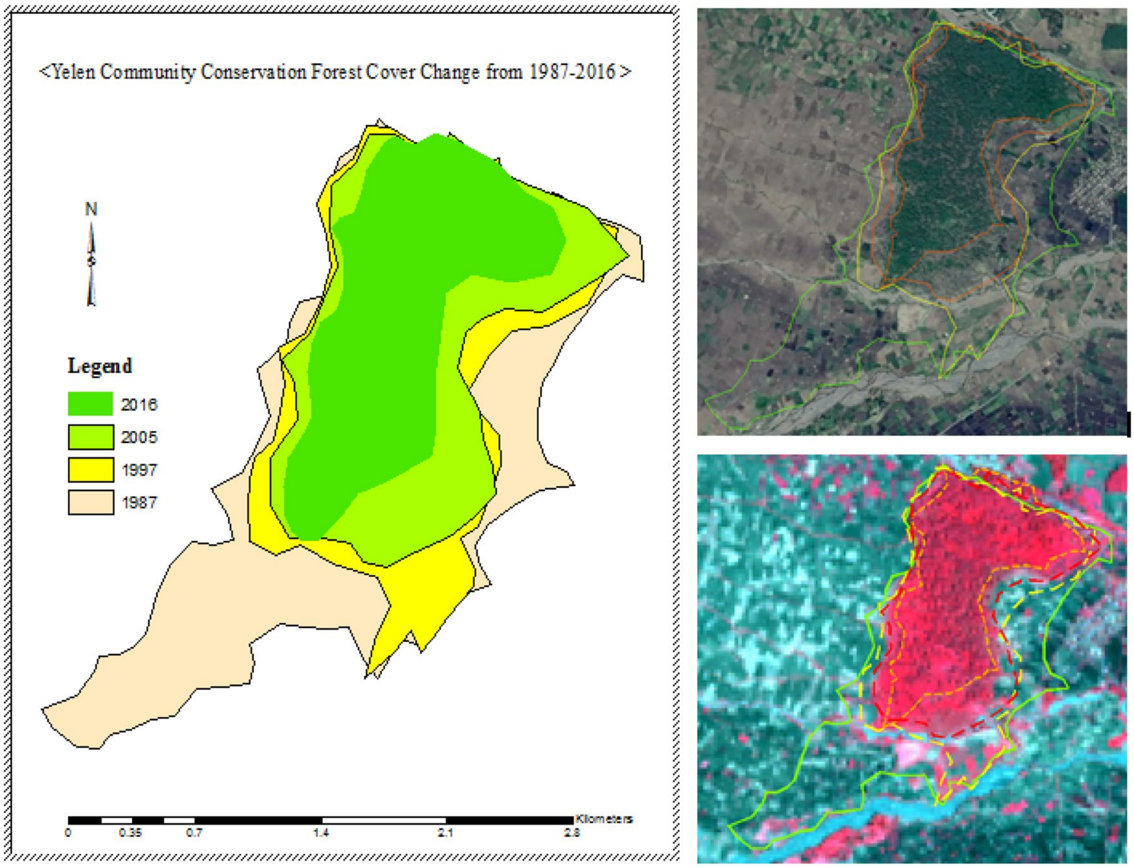

Fig. 4 'Yelen' forest cover trend from 1987 to 2016 in the watershed

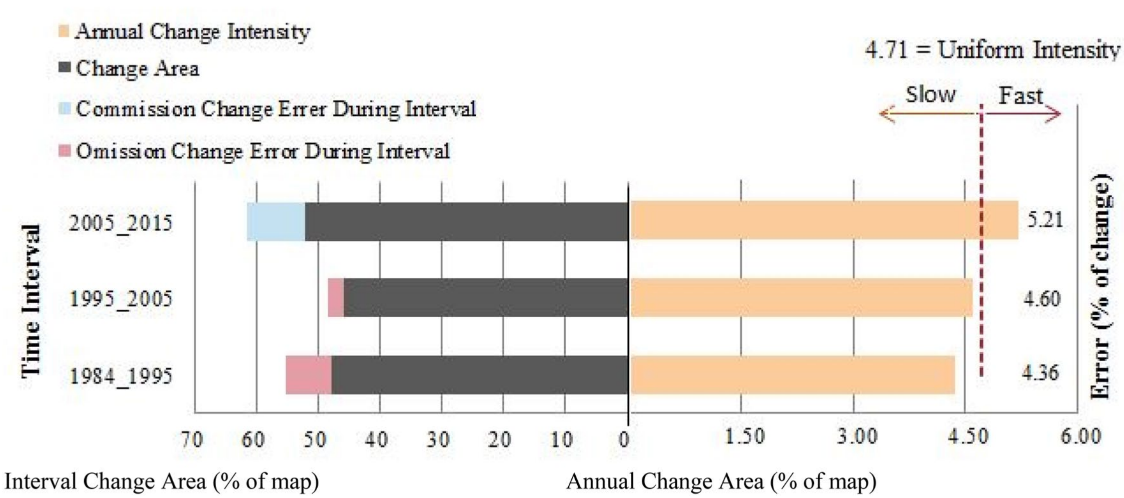

Fig. 5 Calculation of hypothetical errors of interval level

3.1.3 Land use/cover change detection at transition level

Cross-tabulation is a means to determine amounts of conversions from a particular land cover to the other land cover categories at later date. The LULC change detection of each consecutive year was calculated, that is, the years between 1984–1995, 1995–2005 and 2005–2015. In the table below, the column indicates

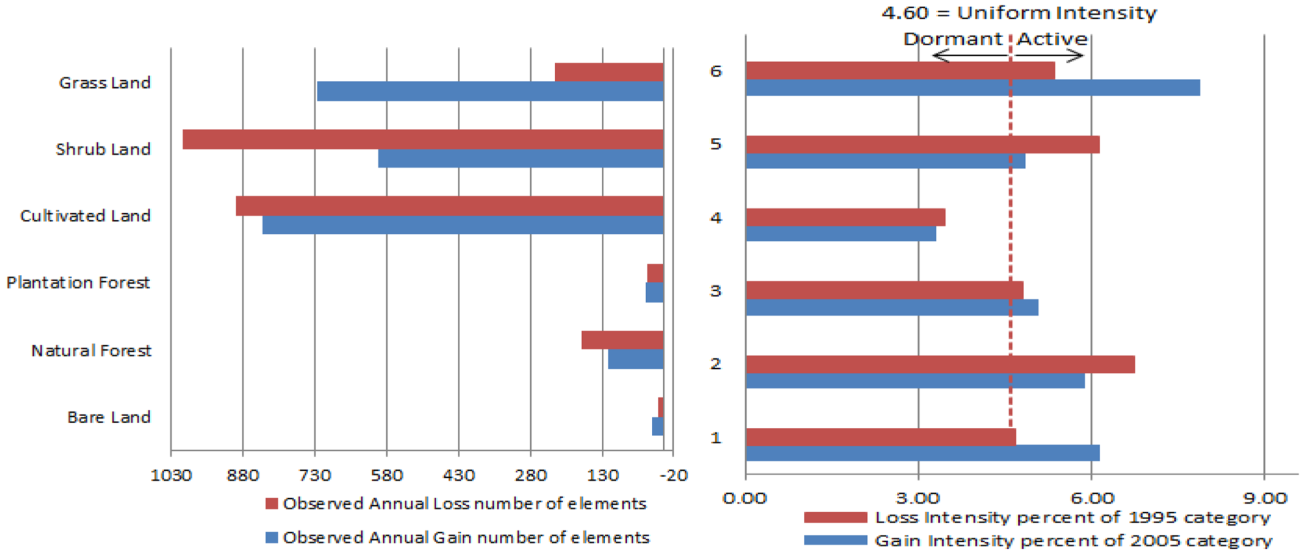

Fig. 6 Categorical level annual change area and annual change intensity on 1995–2005

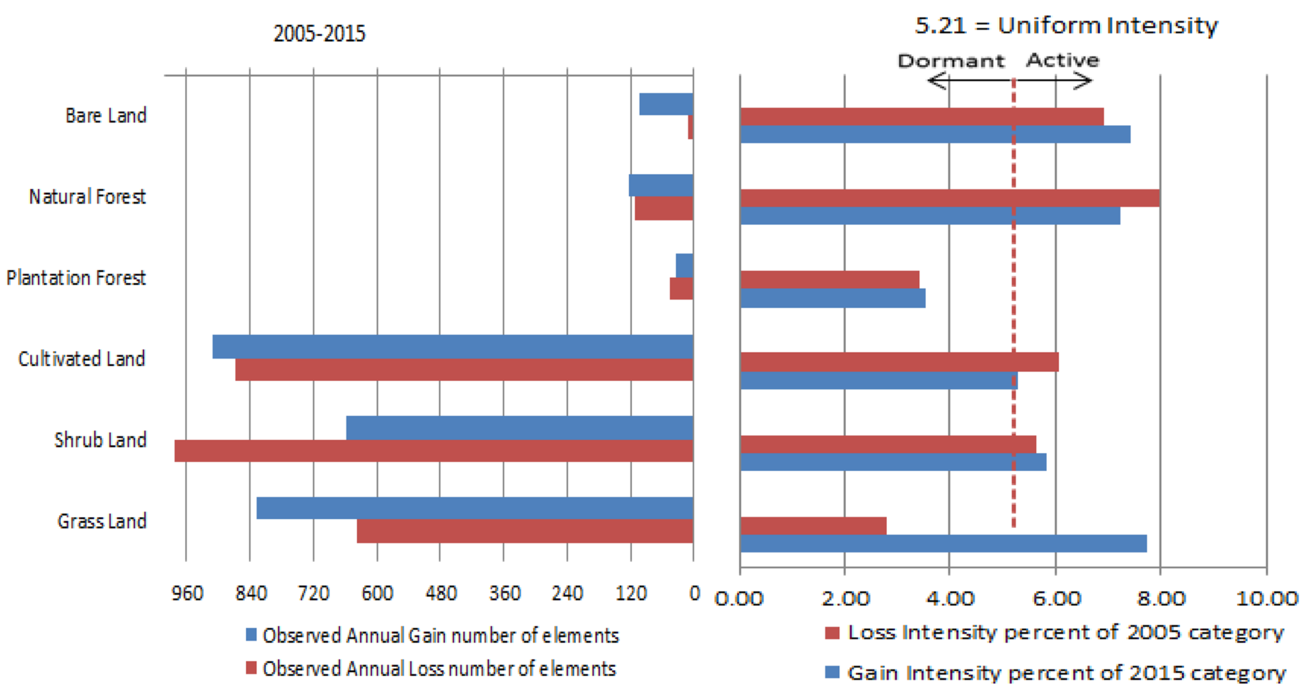

Fig. 7 Annual change area and annual change intensity on 2005–2015

initial year (1984) and the row indicate the final year (1995).

The transition matrix (Table 3) shows that the highest probability of change (7049 ha), grass land were changed to cultivated land and the second were cultivated land that were changed to shrub land, this may be due to loss of productivity in the sloppy area, whereas the lowest probability of change were that natural forest to bare land. In this period, there was no plantation forest detected, this is because the plantation activities were started only around 1977 E.C. Finally, agriculture has led to rapid land use change contributed to increase of cultivated land from 9046 in 1984 to 12,042 ha in 1995, whereas forest land, which has high environmental protection value, decreased from 1519 ha in 1984 to 1185 ha in 1995.

In the years between 1995 and 2005 (Table 4) the change of probability were high from shrub land to cultivated land (6680 ha) the lowest were from bare land

Table 3 LULC change detection between 1984 and 1995 in hectare (ha)

Cross-tabulation	1995						1984	
	Bare land	Natural forest	Plantation forest	Cultivated land	Shrub land	Grass land	Total	Gross loss
1984								
Bare land	175.76	2.79	0	527.63	189.28	2.52	897.98	722.22
Natural forest	1.89	1119.44	92.2	448.14	1570.55	33.53	3265.75	2146.31
Plantation forest	0	0	0	0	0	0	0	0
Cultivated	75.44	219.83	5.86	14,415.79	4272.07	391.53	19,380.52	4964.73
Shrub land	17.58	1092.58	321.14	3459.89	8177.49	1991.45	15,060.13	6882.64
Grass	30.19	108.97	315.55	7049.31	2260.42	2620.04	12,384.48	9764.44
1995								
Total	300.86	2543.61	734.75	25,900.76	16,469.81	5039.07	50,988.86	24,480.34
Gross gain	125.1	1424.17	734.75	11,484.97	8292.32	2419.03	24,480.34	48.01%

to plantation forest. In this case, cultivated land has decreased from 25,769 in 1995 to 25,224 ha in 2005. This may be because of loss of productivity that 4789 and 3745 ha of cultivated land changed to grass and shrub lands, respectively.

Table 5 indicates transition matrix which represented the replacement of one type of land use to another. In the years between 2005 and 2015, the highest probabilities of change, at (4581 ha), are that shrub land was changed to cultivated land, while the lowest, zero probabilities were presented from bare land to plantation forest, this is because of most of bare land are rivers bed. Shrub land has been replaced by other land uses such as grass land (4496 ha) and natural forests (620 ha). Natural forest was replaced by shrub and cultivated lands. This may be due to forest degradation and agricultural expansion. The results of the study are in conformity with researches undertaken in highland watershed as seen in [8, 20].

The table below (Table 6) shows the cumulative change of each land use in the specified year; those were natural forest and shrub land which decreased from 1518 and 6638 ha in 1984 to 975 and 4219 ha in 2015, respectively. Cultivated land and bare land show increasing manner. This led to high land degradation in the watershed and gulley formation in the riverbeds.

In the transition between low and mid-land, grass land is changed to shrub land in 2015 (Fig. 3). This may be due to recovering process [6, 13], since the area is not suitable due to steepness of the slope for grazing vegetation to grow easily. However, the total percentage of grassland is increased. In the upper watershed, the cultivated land is changed to grass land, this may be due to loss of productivity in the sloppy area. According to Agidew and Singh [2], a mountainous and highly dissected terrain with steep slopes will be susceptible for land degradation due to high population pressure. Bare land in the second and third study periods decreased; this is may be due to restoration to grass and shrub land. However, it increased in 2015 because of gully formation in the rivers bed.

Table 4 LULC change detection between 1995 and 2005 in hectare (ha)

Cross-tabulation	2005						1995	
	Bare land	Natural forest	Plantation forest	Cultivated land	Shrub land	Grass land	Total	Gross loss
1995								
Bare	160.11	3.51	0	93.51	4.59	38.61	300.33	140.22
Natural forest	3.51	821.88	105.75	789.66	672.93	141.84	2535.57	1713.69
Plantation forest	0	83.61	377.73	30.24	185.13	51.84	728.55	298.98
Cultivated	187.92	190.53	24.03	16,832.79	3744.72	4788.81	25,768.8	8936.01
Shrub	64.71	859.95	208.8	6680.34	6346.89	2234.34	16,395.03	10,048.14
Grass	0.36	45.99	50.13	797.04	1374.75	1954.17	4222.44	2268.27
2005								
Total	416.61	2005.47	766.44	25,223.58	12,329.01	9209.61	49,950.72	23,405.31
Gross gain	256.5	1183.59	388.71	8390.79	5982.12	6975.27	23,176.98	46.86%

Table 5 LULC change detection between 2005 and 2015 in hectare (ha)

Cross-tabulation	2015						2005	
	Bare land	Natural forest	Plantation forest	Cultivated land	Shrub land	Grass land	Total	Gross loss
2005								
Bare	300.69	0.63	0	67.59	42.84	4.5	416.25	115.56
Natural forest	10.17	876.33	34.11	554.85	425.52	104.85	2005.83	1129.5
Plantation forest	1.26	170.1	302.4	80.01	38.97	177.39	770.13	290.34
Cultivated	590.31	374.94	232.11	16,616.85	3971.61	3497.4	25,283.22	8666.37
Shrub	61.83	620.1	59.31	4580.64	2507.58	4495.68	12,325.14	9817.56
Grass	374.4	55.71	13.05	3815.1	2110.86	2851.38	9220.5	6369.12
2015								
Total	1338.66	2097.81	640.98	25,715.04	9097.38	11,131.2	50,021.07	26,388.45
Gross Gain	1037.97	1221.48	338.58	9098.19	6589.8	6975.27	25,261.29	52.75

Table 6 Summary of area statistics for the maps of 1984, 1995, 2005 and 2015

Land cover type	Area (ha)							
	1984		1995	%	2005	%	2015	%
Bare land	897.98	1.76	300.33	0.59	416.25	0.82	1338.66	2.63
Natural forest	3265.75	6.40	2535.57	4.97	2005.83	3.93	2097.81	4.11
Plantation	0	0.00	728.55	1.46	770.13	1.51	640.98	1.26
Cultivated	19,380.52	38.01	25,768.8	50.54	25,283.22	49.59	25,715.04	50.43
Shrub land	15,060.13	29.54	16,395.03	32.15	12,325.14	24.17	9097.38	17.84
Grass land	12,384.48	24.29	4222.44	8.28	9220.5	18.44	11,131.2	21.83
Unclassified	0	0.00	1038.14	2.04	967.79	0.61	967.79	1.90
Total	50,988.86	100	50,988.86	100	50,988.86	100	50,988.86	100

4 Conclusions and recommendations

The study clearly demonstrates that there is visible land use/land cover change over the last twenty years in the study area. This change has adverse environmental implications, which would be exacerbated if the same trend continues. The extent of the cultivated land had increased by 12% between 1984 and 2015. The results have clearly shown that this change has come at the expense of the vegetation cover which has decreased by 11.3% during the same period. The cultivated land had increased from 38.7% in 1984 to 51.4% in 2015. Even if the natural forest is increased in 2015 as it compared with 2005, natural forest decreased when it compared with 1984. And shrub land had decreased throughout the study periods.

The natural forest of 'Yelen' decreased not only by area coverage but also by the canopy cover as observed in the field as well as from i-tree canopy. This shows that the quality of forest being degraded and total change to other land use class. Furthermore, the depletion of the vegetation cover as well as the increment of bare land from 1.8% in 1984 to 2.7% in 2015 has immense impact on the area resulting in gully formation in the riverbeds as observed on the ground from field visits. The trend of the whole study periods shows there is degradation of forest and soil. The increment of bare land was from 1.8% in 1984 to 2.7% in 2015, from observation this is due to gully formation.

Based on the conclusions drawn from the results of the study, it is imperative that a robust local level natural resource management program should be put in place to mitigate the deleterious impact resulting from the degradation of natural resources. Special emphasis should be given to enhance the quality and quantity of the existing forest cover as well as concerted attempts should be made to add appropriate additional area under forest cover. The authors also recommend that a research program to understand the impact of LULC change on the water resources in tandem with the climate variability should be undertaken.

Acknowledgements First of all I thanks to God helped me for everything in my life. Then following this, organizations and persons should be acknowledged; the first is Addis Ababa University for financial support. The second is Debremarkos University (researchers' hosted university) for additional financial support. The following persons should be also acknowledged: Prof. Tafa Tulu for his Guidance and supervision, Prof. Tenalem Ayenew for his guidance and supervision and Dr. Satishkumar Belliethathan for his critical review and supervision. I will also thank my families for their support to be finalized this work.

Author's contribution DG wrote the initial draft of the manuscript with comments from TA and SB. All authors together developed the ideas and frameworks for the manuscript. All authors read and approved the final version of the manuscript.

Data availability All data generated or analyzed during this study are included in the manuscript.

Declaration

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics approval and consent to participate Not applicable. This is an original research.

References

1. Abeselom K (2018) The impact of foreign aid in sustainable development in Africa: a case study of Ethiopia. Open J Polit Sci 8(04):365
2. Agidew AMA, Singh KN (2017) The implications of land use and land cover changes for rural household food insecurity in the Northeastern highlands of Ethiopia: the case of the Teleyayen sub-watershed. Agric Food Secur 6(1):1–14
3. Al-Ahmadi FS, Hames AS (2009) Comparison of four classification methods to extract land use and land cover from raw satellite images for some remote arid areas. Kingd Saudi Arab Earth 20(1):167–191
4. Aldwaik SZ, Pontius RG Jr (2012) Intensity analysis to unify measurements of size and stationarity of land changes by interval, category, and transition. Landsc Urban Plan 106(1):103–114
5. Anil NC, Sankar GJ, Rao MJ, Prasad IVRKV, Sailaja U (2011) Studies on land use/land cover and change detection from parts of South West Godavari District, AP–using remote sensing and GIS techniques. J Ind Geophys Union 15(4):187–194
6. Archer SR, Andersen EM, Predick KI, Schwinning S, Steidl RJ, Woods SR (2017) Woody plant encroachment: causes and consequences. In: Rangeland systems, pp 25–84
7. Awoke BG (2010) The role of geo information technology for predicting and mapping of forest cover spatio-temporal variability: Dendi district case study, Ethiopia. J Sustain Dev Afr 12(6):9–33
8. Ayele GT, Tebeje AK, Demissie SS, Belete MA, Jemberrie MA, Teshome WM, Mengistu DT, Teshale EZ (2018) Time series land cover mapping and change detection analysis using geographic information system and remote sensing, Northern Ethiopia. Air Soil Water Res 11:1178622117751603
9. Bard KA, Coltorti M, DiBlasi MC, Dramis F, Fattovich R (2000) The environmental history of Tigray (Northern Ethiopia) in the Middle and Late Holocene: a preliminary outline. Afr Archaeol Rev 17(2):65–86
10. FAO F (2011) The state of the world's land and water resources for food and agriculture (SOLAW)-Managing systems at risk. Food and Agriculture Organization of the United Nations
11. Fan F, Wang Y, Wang Z (2008) Temporal and spatial change detecting (1998–2003) and predicting of land use and land cover in Core corridor of Pearl River Delta (China) by using TM and ETM+ images. Environ Monit Assess 137(1):127–147
12. Hyandye C, Mandara CG, Safari J (2015) GIS and logit regression model applications in land use/land cover change and distribution in Usangu catchment. Am J Remote Sens 3(1):6–16
13. Kimaro HS (2019) Encroachment dynamics of *Acacia drepanolobium* in Maswa game reserve. Doctoral dissertation, NM-AIST
14. Klimanova O, Naumov A, Greenfieldt Y, Prado RB, Tretyachenko D (2018) Regional trends of land use and land cover transformation in Brazil in 2001–2012. Geogr Environ Sustain 10(4):98–116
15. Nkonya E, Karsenty A, Msangi S, Souza C Jr, Shah M, Von Braun J, Park S (2012) Sustainable land use for the 21st century
16. Pontius RG, Gao Y, Giner NM, Kohyama T, Osaki M, Hirose K (2013) Design and interpretation of intensity analysis illustrated by land change in Kalimantan. Indonesia Land 2(3):351–369
17. Rwanga SS, Ndambuki JM (2017) Accuracy assessment of land use/land cover classification using remote sensing and GIS. Int J Geosci 8(04):611
18. Shiferaw A, Singh KL (2011) Evaluating the land use and land cover dynamics in Borena Woreda South Wollo Highlands, Ethiopia. Ethiop J Bus Econ (The), 2(1)
19. Sleeter BM, Sohl TL, Bouchard MA, Reker RR, Soulard CE, Acevedo W, Zhu Z (2012) Scenarios of land use and land cover change in the conterminous United States: utilizing the special report on emission scenarios at Eco regional scales. Glob Environ Chang 22(4):896–914
20. Taye M, Simane B, Zaitchik F, B., G Selassie, Y., & Setegn, S. (2019) Land use evaluation over the Jema Watershed, in the Upper Blue Nile River Basin. Northwest Highl Ethiop Land 8(3):50
21. Tefera MM (2011) Land-use/land-cover dynamics in Nonno district, central Ethiopia. J Sustain Dev Africa 13(1):123–141
22. Wilbanks TJ, Kates RW (1999) Global change in local places: how scale matters. Clim Change 43(3):601–628
23. Wu J (2008) Land use changes: Economic, social, and environmental impacts. Choices 23(316):6–10