Environmental Systems Research

Dynamics of land use and land cover changes in Huluka watershed of Oromia Regional State, Ethiopia

Gemechu Shale Ogato[1*] , Amare Bantider[2] and Davide Geneletti[3]

Abstract

Background: Land use and land cover changes in urbanized watersheds of developing countries like Ethiopia are underpinned by the complex interaction of different actors, driving forces, and the land itself. Land conversion due to residential development, economic growth, and transportation is identified as the most serious environmental pressure on urbanized landscapes of the world. It results in the degradation of natural vegetation and significant increases in impervious surfaces. The purpose of the study was to analyze spatio-teporal changes in land use and land cover in the Huluka watershed with implications to sustainable development in the watershed.

Results: Forest land, cultivated land, urban built-up, bush/shrub land, bare land, grassland, and water body were identified as the seven types of land use and land cover in the Huluka watershed. Forest land decreased by 59.3% at an average rate of 164.52 ha/year between 1979 and 2017. Bush/ shrub land decreased by 68.2% at an average rate of 318.71 ha/year between 1979 and 2017. Grassland decreased by 32.7% at an average rate of 228.65 ha/year between 1979 and 2017. Water body decreased by 5.1% at an average rate of 1.06 ha/year between 1979 and 2017. Urban built-up area increased by 351% at an average rate of 16.20 ha/year between 1979 and 2017. Cultivated land increased by 105.3% at an average rate of 692.76 ha/year between 1979 and 2017. Bare land increased by 41.9% at an average rate of 4.00 ha/year between 1979 and 2017. Infrastructural and agricultural expansion, increased demand for wood, local environmental and biophysical drivers, rapid human population growth, economic drivers, technological drivers, policy and institutional drivers, and local socio-cultural drivers were perceived by residents as drivers of land use and land cover changes. Increased flooding risk, increased soil erosion, increased sedimentation into water resources like lakes and rivers, decrease in soil fertility, loss of biodiversity, loss of springs, decrease in annual rainfall, and increase in heat during the dry season were perceived by residents as negative local effects of land use and land cover changes.

Conclusions: Changes in land use and land cover in the study water shade imply the need for integrating sustainable watershed planning and management into natural resources management strategies. In other words, practices of appropriate land use planning and management, family planning, participatory planning and management, appropriate environmental impact assessment (EIA), and proper planning and management of development projects and programmes are of paramount importance to promote sustainable development in the Huluka watershed and beyond.

Keywords: Drivers, Effect, Family planning, Land use and land cover, Management

*Correspondence: gemechushale2005@yahoo.com
[1] Environmental Planning Programme, Ethiopian Institute of Architecture, Building Construction, and City Development, Addis Ababa University, P.O.Box:518, Addis Ababa, Ethiopia
Full list of author information is available at the end of the article

Background

Land use and land cover changes in urbanized watersheds of developing countries like Ethiopia are underpinned by the complex interaction of different actors,

Ogato *et al. Environ Syst Res* (2021) 10:10

Page 2 of 20

driving forces, and the land itself (Zeleke 2000; Bewket 2003; Li et al. 2009; Claes et al. 2012; Fura 2013; Hall et al. 2014). In other words, it is mostly seen as the result of the complex interaction between changes in social and economic opportunities linked with the biophysical environment (Tucci 2007; Jha et al. 2012; Berggren et al. 2013; Dodman et al. 2013; Mngutyo & Ogwuche 2013).

Land conversion due to residential development, economic growth, and transportation is identified as the most serious environmental pressure on urbanized landscapes of the world (Nuissl et al. 2009; Wheater and Evans 2009; Adebayo et al. 2010; Santato et al. 2013; Zewdie et al. 2017). Individual ecosystem services that are affected by land-use transition include the production of food, regulation of energy and matter flows, water supply, the supply of recreational space, biodiversity or natural aesthetic values (Nuissl et al. 2009; Birkinshaw et al. 2010; Berggren et al. 2013; Santato et al. 2013). Development policies, strategies, and planning instruments are encouraged to address the problem of land-use transition as an ongoing process to get possible feedback dynamics which underpins their success (Ebi and Semenza 2008; Nuissl et al. 2009; Adebayo et al. 2010; Alfasi et al. 2012; Mngutyo and Ogwuche 2013).

Land use and land cover changes are affirmed to represent the most widely increasing and significant sources of contemporary changes in the earth's land surface (Balaban 2012; Claes et al. 2012; Mngutyo and Ogwuche 2013). They underpin the degradation of natural vegetation and significant increases in impervious surfaces (Parkinson 2003; Few et al. 2004; Birkinshaw et al. 2010; Berggren et al. 2013; Hao et al. 2015). High population growth rate and negative local impacts of climate change are confirmed to exacerbate the changes leading to modification or complete replacement of the land surface in rapidly urbanizing Ethiopian cities and towns with different environmental implications (Cordaid and IIRR 2011; Berggren et al. 2013; Fura 2013; Mngutyo and Ogwuche 2013; Ogato 2013; Hao et al. 2015; Ogato et al. 2017; Ogato et al. 2020).

Understanding the dynamics of land use and land cover changes in rapidly urbanizing local watersheds contributes immensely to promoting sustainable urban and rural local development in a watershed. Even though there were different studies on the dynamics of land use and land cover changes in the Northern part of Ethiopia, such studies are scant in Oromia Regional State and the study area (Huluka watershed). Hence, this study analyzed changes in land use and land cover, examined their drivers, and investigated their local effects in the Huluka watershed with environmental implications for sustainable watershed planning and management.
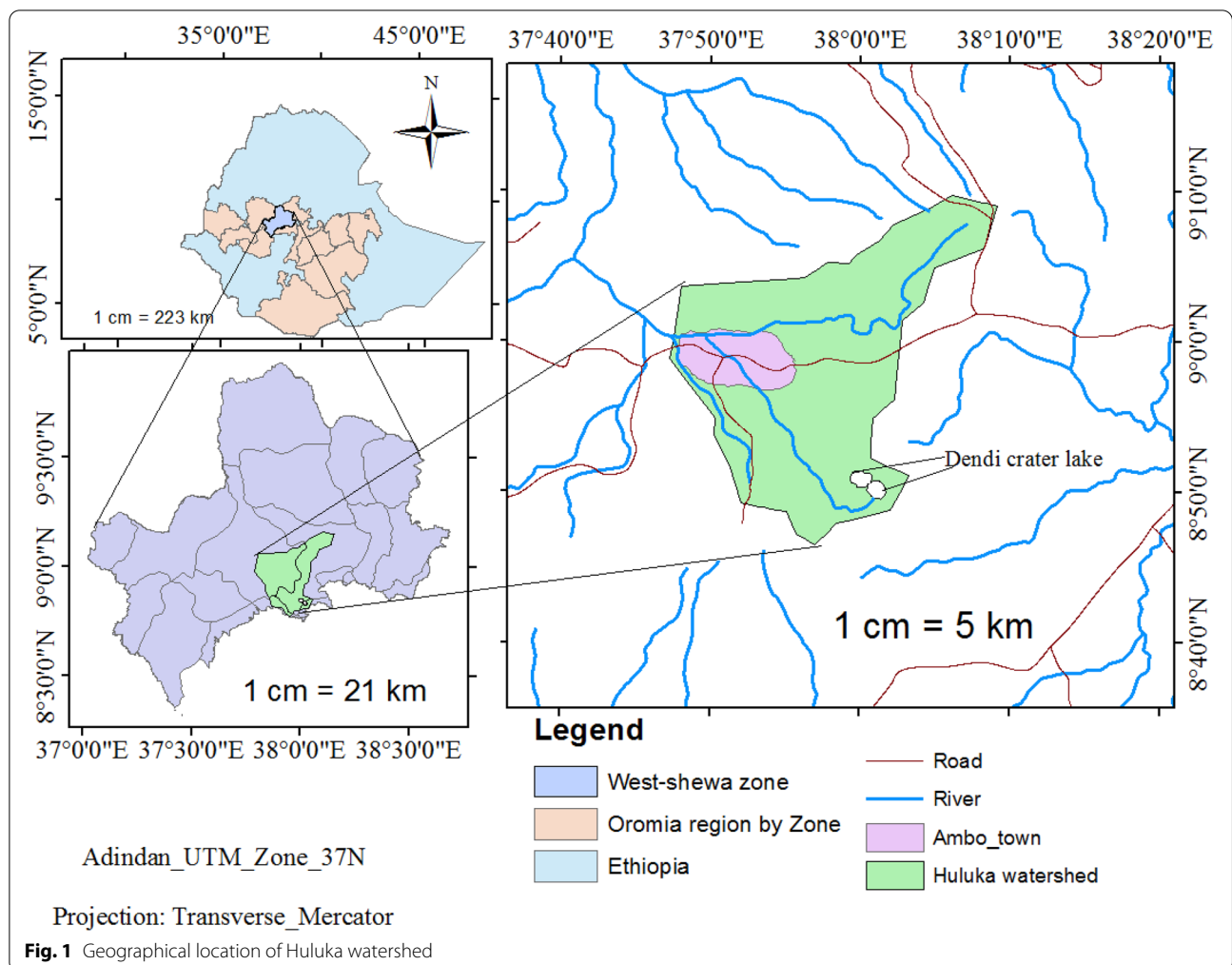
Methods

Description/Features of the Study Area

Huluka watershed is located in West Shoa Zone, Oromia Regional State, Ethiopia. The watershed is located between 8° 49′ 26″ to 8° 55′ 22″ N lat. and 37° 49′ 50″ to 38° 8′ 08″ E long (Fig. 1). The total land area of the Huluka watershed is 81237 ha and composed of villages mainly from Ambo, Dawo, Dendi, Elfeta, Jeldu, TokeKutaye, and Wonchi districts and Ambo town. The total human population of the watershed was reported to be about 303,416 in the year 2017 (CSA 2017). Forest, cultivated land, urban built-up, bush/shrub land, bare land, grassland, and water body were identified as the seven land use and land cover types in the watershed (Fig. 2). Forest land use and land cover in the watershed is characterized by areas covered with dense trees including Eucalyptus and Coniferous trees, and riverine trees. Bush/shrub land use and land cover is characterized by land with shrubs and bushes and scattered small trees mixed with grasses. Grassland land use and land cover is characterized by land predominately covered with grasses, forbs, and grassy areas used for communal grazing. Cultivated land use and land cover is characterized by areas used for rain-fed crop production and scattered rural settlements. Areas occupied by urban residential houses, buildings, and industrial uses. Urban Built-up land use and land cover is characterized by areas occupied by urban residential houses, buildings, and industrial uses. Water land use and land cover is characterized by areas covered by lake water in the watershed permanently. Bare land is characterized by areas with no or very little vegetation cover and characterized by shallow and rocky surface along the flooding area of the local stream valleys, over gentle and steep mountain slopes.

As the percentage change of transformation of urban built-up, and cultivated land use and land cover types in the watershed are high currently, environmental problems like flooding, soil erosion, biodiversity loss, climate change, decrease in soil fertility and agricultural production are typical features of Huluka watershed. Rapid human population growth in the watershed and lack of sustainable watershed management strategies has exacerbated the environmental problems in the watershed and beyond (Ogato et al. 2017, 2020).

The highest elevation in the watershed is 3253 m above sea level while the lowest elevation of the watershed is 1834 m above sea level. The highest slope in the watershed is 32.5% while the lowest slope is 0%. Chromic Luvisols, Chromic Vertisols, Eutric Cambisols, Eutric Nitisols, Leptosols, Orthic Luvisols, and Pellic Vertisols are identified as the types of soils in the watershed. The highest mean total annual rainfall of the watershed over 32 years (1984–2015) is 1181 mm while the lowest is

Ogato *et al. Environ Syst Res*   (2021) 10:10

Page 3 of 20

Fig. 1 Geographical location of Huluka watershed

1036 mm (Fig. 3). The rainfall of the area was identified to be bimodal, with unpredictable short rains from March to April and, the main season ranging from June to September (Ogato et al. 2017).

Data types and sources of data

Satellite images were used as the data for the analysis of land use and land cover changes of the study periods. To this end, Landsat TM and ETM⁺ imagery for the periods 1979, 1984, 2009, and 2017 were used. These years were chosen to understand the changes in land use and land cover with their drivers and local effects in the watershed. Accordingly, 1979, 1984, and 2009 were chosen to understand the dynamics of land use and land cover changes over four decades. To this end, the year 1979 was chosen as a reference year representing the 1970s due to the availability of good quality Landsat image for the decade for the Huluka watershed. The year 1984 was considered as it was the census year in Ethiopia. 2009 was considered also as the year close to

the census year in Ethiopia (2007) with good quality land sat image for the study watershed. The year 2017 was chosen to represent the current year.

A Digital map on a shapefile with a scale of 1:50,000 from the Ethiopian Mapping Authority was used as supporting spatial data for delineating the boundary of the study watershed. Global positioning system (GPS) points collected during field observation were used to collect GCP (ground control point) to successfully undertake the image classification. To this end, 300 sample-training sites were used in each year from ancillary data like high-resolution Google Imagery while 300 sample training sites were used from field observation for the year 2017. Other sources of data included: Central Statistical Authority (CSA), Ethiopian Mapping Agency (EMA), Landsat website of www.glovis.USGS.gov, urban and rural communities in Huluka watershed, urban planners of Ambo town, and land use planners in Huluka watershed.

Fig. 2 Composition of land use and land cover in Huluka Watershed: **a** Forest, **b** Bush/Shrub land, **c** Grassland, **d** Waterbody, **e** Urban built-up, **f** Cultivated land, and **g** Bare land (Source: Participant Observation 2017)

Methods of data collection

To collect relevant data to analyze the dynamics of land use/land cover change in the watershed for the periods considered, online Satellite Imagery (Monkkonen 2008; Gondo and Zibabgwe 2010) was employed. Besides, participant observation (Kawulich, 2005) focus group discussion (Onwuegbuzie et al. 2009; Kassie 2017; Nyumba et al. 2018), and key informant interview (Strauss 1987; Burnard 1991; Kun et al. 2013; Gardner et al. 2019) were employed to collect qualitative data relevant for the study. Accordingly, six focus group discussions (three

men focus group discussions and three women focus group discussions), and fifteen key informant interviews (local men and women key informant interviews) were undertaken to collect qualitative data. The number of focus group discussions and key informant interviews was determined based on the saturation level of the information generated. Participants of focus group discussions and key informant interviews were selected purposively as they were expected to be experienced and knowledgeable about the issues under investigation. Accordingly, local men and women residents who have

Fig. 3 Elevation, slope, soil type, and rainfall distribution of Huluka watershed
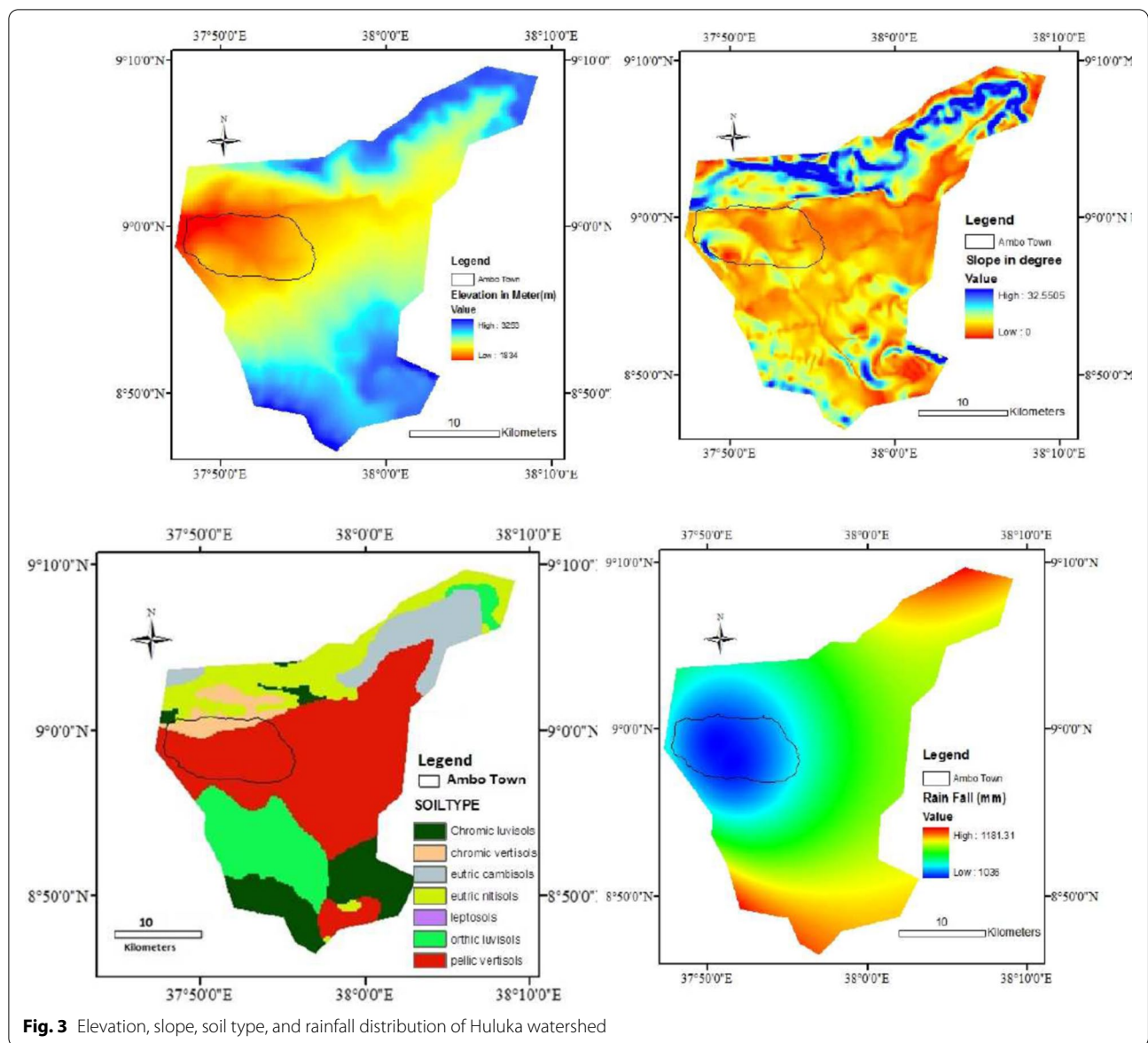
been living in the watershed for more than 50 years were included in the focus group discussions and key informant interviews.

Methods of data analysis
Geographic information system (GIS) and remote sensing technology-based analysis of land use and land cover changes
Based on prior knowledge of the study area, data collected from the local communities in the watershed, characteristics of Landsat images, ancillary data like Google Earth and field observation, seven land use and land cover classes (Table 1) were used for image classification and land use and land cover change analysis.

Arc GIS 10.1 software and ERDAS IMAGINE 9.1 software (Huang et al. 2007; Monkkonen 2008; Gondo and Zibabgwe 2010) were employed for the intended image classification, land use and land cover change detection and mapping. While ERDAS IMAGINE 9.1 software was employed to classify images and detect change over time, ArcGIS10.1 software was employed for geospatial analysis of the classified images and developing maps of land-use and land cover change.

The analysis of images involved the key steps of pre-processing; post-processing, overlaying and change detection, and creation of maps of land use/land cover change from Landsat TM imagery for the period, 1979–2017. The Pre-processing step involved geo-referencing

Ogato *et al. Environ Syst Res* (2021) 10:10

Page 6 of 20

Table 1 Description of land use and land cover categories considered in image classification

LULC	Description
Forest	Areas covered with dense trees including Eucalyptus and coniferous trees, and riverine trees
Cultivated land	Areas used for rain-fed crop production and scattered rural settlements
urban Built-up area	Areas occupied by urban residential houses, buildings, and industrial uses
Bush/shrub land	Land with shrubs and bushes, scattered small trees mixed with grasses
Bare land	Areas with no or very little vegetation cover and are characterized with the shallow and rocky surface along the flooding area of the local stream valleys, over gentle and steep mountain slopes
Grassland	Land predominately covered with grasses, forbs, grassy areas used for communal grazing
Water	Areas covered by Lake in the catchment permanently

the Landsat images, radiometric correction, layer stacking, resolution merge, image enhancement, and adding vector information from the administrative boundary of the study area.

The post-processing step involved image classification which was undertaken using hybrid classification methods involving both unsupervised and supervised techniques among different classification algorithms. To this end, the maximum likelihood was used for supervised classification by taking ground control points for the seven major land use and land cover classes. These land use and land cover (LULC) types were identified with the help of visual interpretation elements and the different reflection characteristics of the feature in the satellite images of 1979, 1984, 2009, and 2017. In other words, the supervised classification involved selecting pixels that represent land cover classes that were recognized by the researcher. Accuracy assessment was also undertaken in the post-processing step. Accordingly, an accuracy assessment was carried out to verify to what extent the produced classification is compatible with what exists on the ground (Anderson et al. 1976; Congalton 1991). All the output maps for the study period (1979, 1984, 2009, and 2017) fulfilled the required standard (which is a minimum of 85% accuracy).

The overlaying and change detection step involved: interpretation of changes in land use and land cover in various years and analysis of their environmental implications in the watershed. In other words, the post-classification method was employed for change detection. This technique helps to generate a change matrix where different transfers from one land use and land cover type to another can be visually observed. Accordingly, change metrics for detecting land use and land cover change were constructed between 1979 and 2017 through pixel-to-pixel comparisons. The classified data were then taken into the ArcGIS 9.1 environment to calculate the area for each land use and land cover type and produce the land use and land cover

maps of the area. These land cover maps were compared pixel by pixel with the final results showing both change-no-change information as well as 'from to' land cover change information. The land use and land cover change detection (percentage change) was made using the following formula (Fura 2013; Gashaw et al. 2017a, b; Miheretu and Yimer 2017):

$$\text{Percent of Change} = \frac{(A2 - A1)}{A1} \times 100 \qquad (1)$$

where, A1 = amount of land use and land cover type in year 1, A2 = amount of land use and land cover type in year 2.

The rate of change in land use and land cover (hectares/year) between two study periods was determined using the following formula (Gashaw et al. 2017a, b; Miheretu and Yimer 2017):

$$\text{Rate of Change} = \frac{(A2 - A1)}{Z} \qquad (2)$$

where, A1 = amount of land use and land cover type in year 1, A2 = amount of land use and land cover type in year 2, Z is the time interval between A1 and A2 in years.

The final step was the creation of maps of land use and land cover change. Accordingly, the analysis of images ended with the creation of maps of land-use and land cover change from Landsat TM imagery for the period, 1979–2017.

Qualitative analysis of socio-economic data

The qualitative data collected through focus group discussions, key informant interviews, and participant observation were analyzed by employing the thematic content analysis technique (Strauss 1987; Burnard 1991; Onwuegbuzie et al. 2009; Kassie 2017; Gardner et al. 2019). The responses from the focus group discussions and the key informant interviews were recorded by hand on the notebook as the participants preferred not to be recorded by any audiovisual tools. However, relevant

Ogato *et al. Environ Syst Res*   (2021) 10:10

Page 7 of 20

environmental events were recorded through audiovisual tools and hand during participant observation and transect walk sessions. As the number of focus group discussions (six) and key informant interviews (15) were manually manageable and the researcher is familiar with the data, no software was employed to analyze the qualitative data.

The major criteria underpinning the application of thematic content analysis were: transparency, maximizing validity, maximizing reliability, comparative analysis, and reflexive approach in the process of analysis (Kassie 2017; Asnake et al. 2019; Gardner et al. 2019). The application of thematic content analysis technique in this study to analyze the qualitative data involved the following steps:

Step one: Reading and Re-reading the recorded qualitative data to be familiar with the content;

Step two: Organizing the qualitative data by questions;

Step three: Coding the data into exhaustive, mutually exclusive, and specified categories or themes;

Step four: Reviewing and revising the coding system;

Step five: Looking for patterns across categories or themes; and.

Step six: Summarizing findings, and recognizing limitations of the data.

Results

This section presents results on the composition of land use and land cover in Huluka Watershed, analysis of land use and land cover change dynamics, and perceived drivers and local effects of land use and land cover changes.

Composition of land use and land cover in huluka watershed

Forest, cultivated land, urban built-up, bush/shrub land, bare land, grassland, and water body were identified as the seven types of land use and land cover in the watershed. Forest land use and land cover in the watershed is characterized by areas covered with dense trees including Eucalyptus and Coniferous trees, and riverine trees. Bush/shrub land use and land cover is characterized by land with shrubs and bushes, and scattered small trees mixed with grasses. Grassland land use and land cover is characterized by land predominately covered with grasses, forbs, and grassy areas used for communal grazing. Cultivated land use and land cover is characterized by areas used for rain-fed crop production and scattered rural settlements. Areas occupied by urban residential houses, buildings, and industrial uses. Urban Built-up land use and land cover is characterized by areas occupied by urban residential houses, buildings, and industrial uses. Water land use and land cover is characterized by areas covered by lake water in the watershed permanently. Bare land is characterized by areas with no or very

little vegetation cover and characterized by shallow and rocky surface along the flooding area of the local stream valleys, over gentle and steep mountain slopes.

Dynamics of land use and land cover changes in huluka watershed

The overall classification accuracy for the output maps was 92.28%, 92.67%, 93.27%, and 90.19% for the years 1979, 1984, 2009, and 2017 respectively. The overall kappa coefficient for the study period was 0.89, 0.90, 0.91, and 0.80 for the years 1979, 1984, 2009, and 2017 respectively (Table 2).

The spatio-temporal dynamics of land use and land cover changes in the watershed for forest land, cultivated land, urban built-up area, bush/shrub land, bare land, grassland, and waterbody between 1979 and 2017 are presented hereunder.

Forest land

Forest land was represented by areas covered with dense trees, which include both Eucalyptus and coniferous trees, and riverine trees. Forest land covered 10,550.52 ha (13%) in 1979, 8925.75 ha (10.9%) in 1984, 4232.253 ha (5.2%) in 2009 and 4298.85 ha (5.3)% in 2017. It decreased by 15.4% (324.95 ha/year) between 1979 and 1984 and 52.6% (187.74 ha/year) between 1984 and 2009. However, it increased by 1.6% (8.33 ha/year) between 2009 and 2017. It decreased by 59.3% (164.52 ha/year) between 1979 and 2017. The decrease of forest land in the watershed was attributable to its transformation to other land use and land cover types. It was largely transformed to cultivated land (4641.69 ha) and grassland (2221.13 ha) between 1979 and 2017 (Tables 3, 4, 5, and 6; Figs. 4 and 5).

Cultivated land

Cultivated land was represented by areas used for rain-fed crop production and scattered rural settlements usually associated with cultivated lands. Cultivated land covered 25,005.24 ha (30.8%) in 1979, 28,639.27 ha (35.3%) in 1984, 43,833.98 ha (54%) in 2009 and 51,329.96 ha (63.2)% in 2017. It increased by 14.5% (726.81 ha/year) between 1979 and 1984, 53.1% (607.79 ha/year) between 1984 and 2009, 17.1% (937.00 ha/year) between 2009 and 2017, and 105.3%

Table 2 Accuracy assessment of the land use/land cover classification for the study period

Accuracy	1979	1984	2009	2017
Overall classification accuracy (%)	92.28	92.67	93.27	90.19
Overall Kappa coefficient	0.89	0.90	0.91	0.80

Ogato *et al. Environ Syst Res*   (2021) 10:10

Page 8 of 20

Table 3 Proportion of land use/land cover change in Huluka/Ambo Town's Watershed (1979–2017)

No.	Land use/cover	Area of land use/cover class							
		1979		1984		2009		2017	
		Ha	%	Ha	%	Ha	%	Ha	%
1	Forest	10,550.52	13	8925.75	10.9	4232.253	5.2	4298.85	5.3
2	cultivated land	25,005.24	30.8	28,639.27	35.3	43,833.98	54	51,329.96	63.2
3	Urban built-up area	175.32	0.2	349.74	0.4	425.79	0.5	790.74	1
4	Bush and shrub land	17,746.11	21.8	12,767.1	15.7	7907.733	9.7	5635.09	6.9
5	Bare land	362.16	0.4	368.2	0.5	431.46	0.5	513.97	0.6
6	Water	789.48	1	811.98	1	748.44	0.9	749.07	0.9
7	Grassland	26,607.96	32.8	29,374.75	36.2	23,657.14	29.1	17,919.11	22
8	Total	81,236.79	100	81,236.79	100	81,236.79	100	81,236.79	100

Table 4 Changes of land use and land cover in Huluka Watershed (Percentage)

No.	Land use/cover class	Change of land use and land cover (%)			
		1979–1984	1984–2009	2009–2017	1979–2017
1	Forest	− 15.4	− 52.6	1.6	− 59.3
2	cultivated land	14.5	53.1	17.1	105.3
3	Urban built-up area	99.5	21.7	85.7	351
4	Bush and shrub land	− 28.1	− 38.1	− 28.7	− 68.2
5	Bare land	1.7	17.2	19.1	41.9
6	Water	2.9	− 7.8	0.1	− 5.1
7	Grassland	10.4	− 19.5	− 24.3	− 32.7

Table 5 Rate of changes of land use and land cover in Huluka Watershed (ha/year)

No.	Land use/cover class	Rate of change of land use and land cover (hectares/year)			
		1979–1984	1984–2009	2009–20,017	1979–2017
1	Forest	− 324.95	− 187.74	8.33	− 164.52
2	cultivated land	726.81	607.79	937.00	692.76
3	Urban built-up area	34.88	3.04	45.62	16.20
4	Bush and shrub land	− 995.80	− 194.38	− 284.08	− 318.71
5	Bare land	1.21	2.53	10.31	4.00
6	Water	4.5	− 2.54	0.08	− 1.06
7	Grassland	553.36	− 228.70	− 717.25	− 228.65

(692.76 ha/year) between 1979 and 2017. The increase of cultivated land in the watershed was attributable to the transformation of other land use and land cover types into cultivated land. A large proportion of grassland (17,552.41 ha), shrub/bush land (11,085.04 ha), and forest land (4641.69 ha) was transformed into cultivated land between 1979 and 2017 (Tables 3, 4, 5, and 6; Figs. 4, 5).
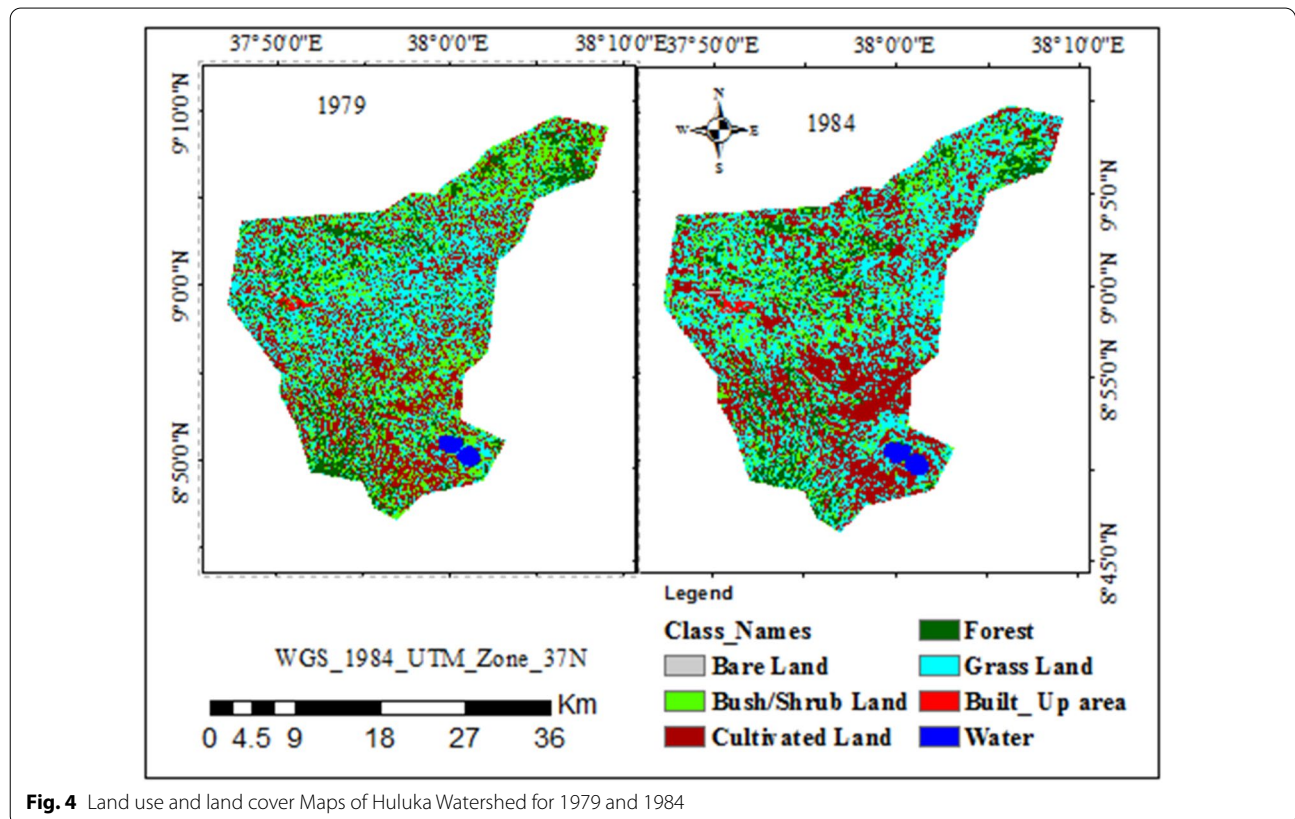
Urban built-up area

Urban built-up area was represented by areas occupied by urban residential houses, buildings, and industrial uses. Urban built-up area covered 175.32 ha (0.2%) in 1979, 349.74 ha (0.4%) in 1984, 425.79 ha (0.5%) in 2009 and 790.74 ha (1%) in 2017. It increased by 99.5% (34.88 ha/year) between 1979 and 1984, 21.7% (3.04 ha/year) between 1984 and 2009, 85.7% (45.62 ha/year)

Table 6 Matrix for land use and land cover changes for 1979 to 2017 in Hectares (ha)

|		To 2017							
		Forest	Cultivated	Built-up	Bush/shrub	Bare	Water	Gras,	Total
From 1979	Forest	2355.048	4641.698	91.98	1207.098	30.6	2.97	2221.126	10,550.52
	Cultivated	389.592	17,788.73	177.57	1245.042	246.69	4.14	5153.472	25,005.24
	Built-up	20.52	0	127.89	4.86	0.45	0	21.6	175.32
	Bushishrab	782.388	11,085.04	118.53	1377.676	111.15	2.43	4268.898	17,746.11
	Bare land	2.43	257.58	0	17.37	9.88	0	74.9	362.16
	water	0	4.5	0	0.36	0	736.02	48.6	789.48
	Grass	748.872	17,552.41	274.77	1782.684	115.2	3.51	6130.51:	26,607.96
	Total	4298.85	51,329.96	790.74	5635.09	513.97	749.07	17,919.11	81,236.79

Fig. 4 Land use and land cover Maps of Huluka Watershed for 1979 and 1984

between 2009 2017, and 351% (16.20 ha/year) between 1979 and 2017. The increase of urban built-up areas in the watershed was attributable to the transformation of other land use and land cover types into urban built-up areas. A large proportion of grassland (274.77 ha), cultivated land (177.57 ha), shrub/bush land (118.53 ha), and forest land (91.98 ha) was transformed into urban built-up area between 1979 and 2017 (Tables 3, 4, 5, and 6; Figs. 4, 5).

Bush/Shrub land

Bush/shrub land was represented by land covered by shrubs and bushes and sometimes with scattered small trees mixed with grasses. Bush/Shrub land covered 17,746.11 ha (21.8%) in 1979, 12,767.1 ha (15.7%) in 1984, 7907.733 ha (9.7%) in 2009 and 5635.09 ha (6.9%) in 2017. It decreased by 28.1% (995.80 ha/year) between 1979 and 1984, 38.1% (194.38 ha/year) between 1984 and 2009, 28.7% (284.08 ha/year) between 2009 and 2017,
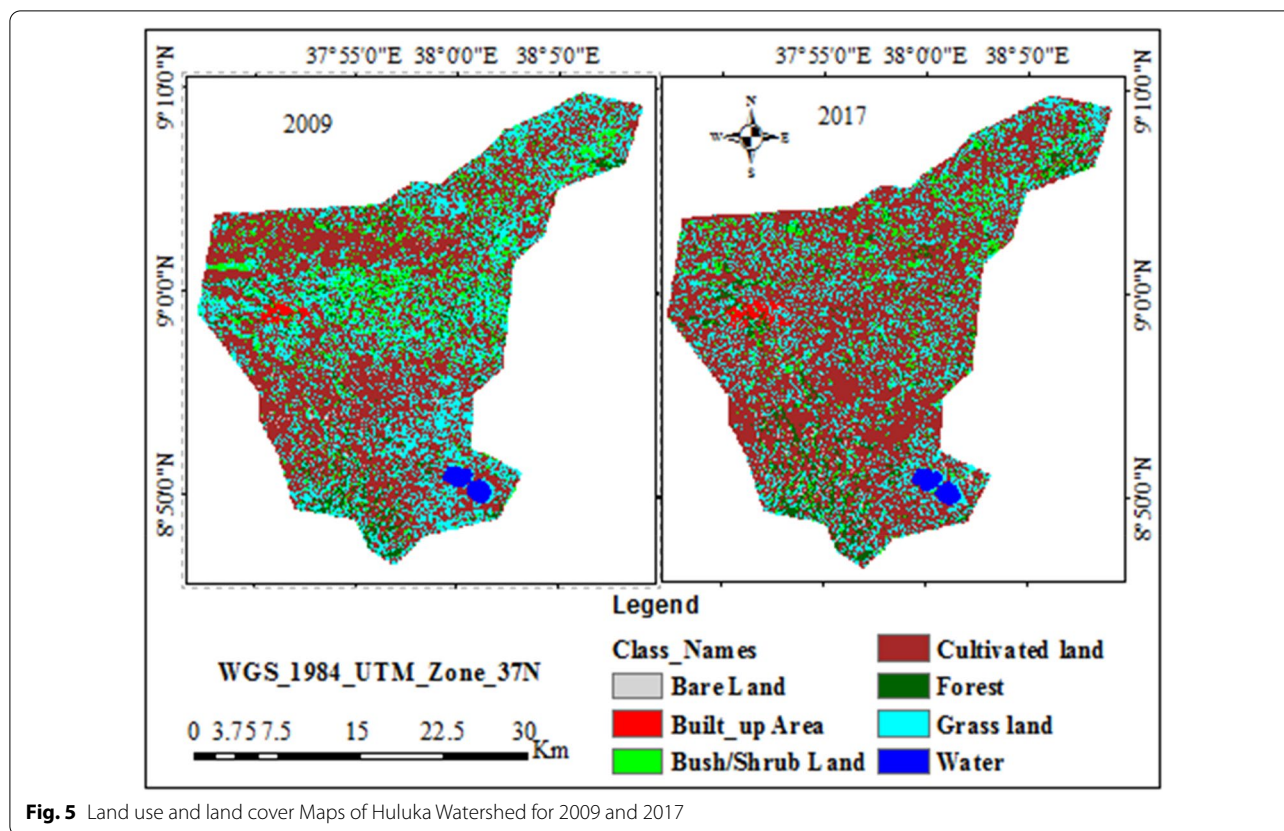
Fig. 5 Land use and land cover Maps of Huluka Watershed for 2009 and 2017

and 68.2% (318.71 ha/year) between 1979 and 2017. The decrease of bush/shrub land in the watershed was attributable to its transformation to other land use and land cover types. Its large proportion was transformed into cultivated land (11,085.04 ha) and grassland (4268.89 ha) between 1979 and 2017 (Tables 3, 4, 5, and 6; Figs. 4, 5).

Bare land

Bare land was represented by areas with no or very little vegetation cover and characterized by shallow, and rocky surface along the flooding area of the local stream valleys, over gentle and steep mountain slopes. Bare land covered 362.16 ha (0.4%) in 1979, 368.2 ha (0.5%) in 1984, 431.46 ha (0.5%) in 2009 and 513.97 ha (0.6%) in 2017. It increased by 1.7 (1.21 ha/year)% between 1979 and 1984, 17.2% (2.53 ha/year) between 1984 and 2009, 19.1% (10.31 ha/year) between 2009 2017, and 41.9% (4.00 ha/year) between 1979 and 2017. The increase of bare land cover in the watershed was attributable to the transformation of other land use and land cover types into bare land. A large proportion of cultivated land (246.69 ha), grassland (115.20 ha), and shrub/bush land (111.15 ha) was transformed into bare land between 1979 and 2017 (Table 3, 4, 5, and 6; Figs. 4 and 5).

Waterbody

Waterbody was represented by areas covered by lake water in the catchment permanently. Waterbody covered 789.48 ha (1%) in 1979, 811.98 ha (1%) in 1984, 748.44 ha (0.9%) in 2009 and 749.07 ha (0.9%) in 2017. It increased by 2.9% (4.5 ha/year) between 1979 and 1984. However, it decreased by 7.8% (2.54 ha/year) between 1984 and 2009. It increased by 0.1% (0.08 ha/year) between 2009 and 2017. It decreased by 5.1% (1.06 ha/year) between 1979 and 2017. The decrease of the waterbody in the watershed was attributable to its transformation to other land use and land cover types. Its large proportion was transformed into grassland (48.6 ha) and cultivated land (4.5 ha) between 1979 and 2017 (Table 3, 4, 5, and 6; Figs. 4, 5).

Grassland

Grassland was represented by land predominately covered with grasses, forbs, grassy areas used for communal grazing. Grassland covered 26,607.96 ha (32.8%) in 1979, 29,374.75 ha (36.2%) in 1984, 23,657.14 ha (29.1%) in 2009 and 17,919.11 ha (22%) in 2017. It increased by 10.4%(553.36 ha/year) between 1979 and 1984. It decreased by 19.5% (228.70 ha/year) between 1984 and

Ogato *et al. Environ Syst Res*   (2021) 10:10

Page 11 of 20

2009, 24.3% (717.25 ha/year) between 2009 and 2017, and 32.7% (228.65 ha/year) between 1979 and 2017. The decrease of grassland in the watershed was attributable to its transformation to other land use and land cover types. It was largely transformed into cultivated land between 1979 and 2017 (Tables 3, 4, 5, and 6; Figs. 4, 5).

Drivers and local effects of land use and land cover changes in Huluka watershed

Drivers of land use and land cover changes in Huluka watershed

The major themes of the thematic content analysis of qualitative data were drivers of land use and land cover changes and the relationship between the drivers and land use and land cover changes in the Huluka watershed. The summary of findings from focus group discussions indicates that the local communities in the watershed felt that the land use and land cover changes in their watershed are visible and underpinned by infrastructural and agricultural expansions, increased demand for wood, local environmental and biophysical drivers, rapid human population growth, economic drivers, technological drivers, policy and institutional drivers, and local socio-cultural drivers. The entire key informants also felt that the aforementioned drivers underpin land use and land cover changes in their watershed. The perceived causal relationship between land use and land cover changes and the drivers are summarized hereunder.

Infrastructural and agricultural expansion All the focus groups confirmed that unplanned expansion of infrastructure and agriculture are among the major drivers of land use and land cover changes in the Huluka watershed. This finding was further confirmed by the entire key informants who felt that many of the infrastructural and agricultural expansions are not planned and land use and land cover changes in the watershed are underpinned by unplanned expansions. Many of the key informants emphasized that they appreciate the planned expansion of relevant infrastructures like roads, electrification, and telecommunication. However, they suggested that appropriate environmental impact assessment must precede any infrastructural expansion in their watershed. It was also possible to observe the unplanned infrastructural and agricultural expansions in the watershed through participant observation.

Increased demand for wood All the focus groups affirmed that there is currently an increased demand for wood (fuelwood and wood for construction) in the Huluka watershed. The women focus groups emphasized that the challenge of fuelwood is visible in their environment as they do not find easily trees in their environment despite their increased demand for it. This affirmation was further supported by the assertion of the entire key informants who felt that trees in the watershed are at big risk as humans need them for fuelwood and construction purposes without thinking to plant or replace them for future sustainable use. Key informants from the down-stream of Huluka watershed where Ambo town is situated further attest that there is increased demand for wood for construction purposes in the watershed especially in the urbanized part of the watershed. It was also possible to observe the increased demand for fuelwood and wood for construction through participant observation.

Local environmental and biophysical drivers All the focus groups attested that vulnerable soil quality, hilly topography, and lands without forest, bushes/shrubs, and grass cover are the local environmental drivers exacerbating the land use and land cover changes in the Huluka watershed. They affirmed also that flooding is one of the contributing local bio-physical drivers for land use and land cover changes. The entire key informants also agreed with the aforementioned attestation as they felt that these local environmental and bio-physical factors contribute much to land use and land cover changes in the watershed. The key informants from the urbanized part of the watershed emphasized that vulnerable soil types in their locality and hilly topography contribute to land use and land cover changes in the watershed. They also felt that flooding exacerbate the aforementioned undesirable environmental situation. It was also possible to observe some local environmental, and biophysical drivers through participant observation (Fig. 6).

Rapid growth of human population All the focus groups asserted that the rapidly growing human population in the watershed is one of the major drivers of land use and land cover changes in the Huluka watershed. The entire key informants agreed with the above assertion as they further emphasized that the rapidly growing human population in the watershed demands much resources from the natural environment which threatens the natural environment resulting in the degradation of natural resources. The key informants from the urbanized part of the watershed felt that the demand for shelter and food certainly hasten the transformation of land use and land cover to urban built-up areas and cultivated land. This threatens forest land, grassland, and bush/shrub land as they attested. It was also possible to observe the detrimental effect of human unplanned settlement in the watershed exacerbating the land use and land cover changes (Fig. 6).

Economic drivers All the focus groups confirmed that market growth and commercialization, urban expansion, and price increase are among the major economic drivers contributing to land use and land cover changes in the watershed. The entire key informants agreed with

Fig. 6 Partial view of drivers of land use and land cover changes in Huluka watershed: **a** vulnerable local soil, **b** Vulnerable hilly topography, **c** Water erosion induced gully, **d** Flooded urban environment, **e** Human settlement around the lake, and **f** Disturbed lake water (Source: Participant Observation 2017)

the above confirmation as they further emphasized that the economic needs of different stakeholders in the watershed significantly drive the land use and land cover changes in the watershed. It was also possible to observe some economic drivers through participant observation.

Technological Drivers All the focus groups affirmed that agro technical change and agricultural production factors are among the major technological drivers contributing to land use and land cover changes in the watershed. The entire key informants agreed with the above affirmation

as they further emphasized that land use and land cover changes in the watershed are much affected by access to technologies by different stakeholders in the watershed. It was also possible to observe some technological drivers through participant observation.

Policy and institutional drivers All the focus groups confirmed that formal land policy, property rights, and the absence of relevant institutions are among the major drivers of land use and land cover changes in the Huluka watershed. The entire key informants agreed with the

Ogato *et al. Environ Syst Res* (2021) 10:10

Page 13 of 20

above confirmation. For instance, key informants from the urbanized part of the watershed felt that urban development policy and land use policy contribute much to land use and land cover changes that threaten their livelihoods. Most of the key informants felt that the absence of strong and stringent environmental protection policies and strategies underpins the degradation of natural resources in the Huluka watershed. They also felt that the property rights issue affects their attitude towards the conservation of natural resources. It was also possible to observe some of the policy and institutional drivers through participant observation.

Local socio-cultural drivers All the focus groups asserted that religious institutions, public attitudes, and beliefs, and individual and household behavior are among the socio-cultural drivers contributing to land use and land cover changes in the Huluka watershed. The entire key informants agreed with the above confirmation. For instance, many key informants felt that forest land cover is more conserved in religious institutions as they promote living in peace with nature. They also affirm that the conservation or degradation of natural resources in the watershed is determined by public attitudes and beliefs, and individual and household behavior. It was also possible to observe some of the socio-cultural drivers through participant observation.

Local effects of land use and land cover changes in Huluka watershed

The major themes of the thematic content analysis of qualitative data were local negative effects of land use and land cover changes on farmers' livelihoods, the reciprocal cause-effect relationship between flooding risk and land use and land cover changes, strengths, and weaknesses of the current community-based soil and water conservation measures practiced, and effective adaptation measures to land use and land cover changes. A summary of the findings for the aforementioned themes is presented hereunder.

Local negative effects of land use and land cover changes on farmers' livelihoods All the focus groups attest that land use and land cover changes in the Huluka watershed have negative local effects on their livelihoods. Accordingly, they identified increased flooding risk, increased soil erosion, increased sedimentation into water resources like lakes and rivers, decrease in soil fertility, loss of biodiversity, loss of springs, decrease in annual rainfall and increase in heat during the dry season. The entire key informants also felt that the negative local effects of land use and land cover changes on their livelihoods are current realities and affirmed that many of the environmental disasters in the watershed are highly attributable to the land use and land cover changes. It

was also possible to observe some of the negative local effects.

Reciprocal cause-effect relationship between flooding risk and land use and land cover changes All the focus groups affirmed that flooding risk in their watershed is highly linked to land use and land cover changes as the transformation of land use and land cover from forest land, grassland, and bush/shrub land to cultivated land, and urban built-up areas exacerbate flooding risk caused by other factors. They also asserted that flooding risk in the watershed also exacerbated land use and land cover changes as it hastens the transformation of productive land use and land cover into degraded land use and land covers. The entire key informants also felt that a reciprocal cause-effect relationship exists between land use and land cover change and flooding risk. They attest that land areas without forest, grass, bush/shrub, and water are much vulnerable to flooding risk. They also confirmed that flooding risk in their watershed is highly underpinned by the changes in land use and land cover in the watershed. Hence, the existence of the reciprocal cause-effect relationship between flooding risk and change in land use and land cover was attested by the focus groups and the key informants. It was also possible to observe the negative effects of flooding risk on different land use and land cover types.

Strengths and weaknesses of the current community-based soil and water conservation measures All the focus groups affirmed that the current community-based soil and water conservation measures practiced in the watershed have contributed to increased soil fertility, healing of degraded land areas, conservation of soil and water resources, local adaptation to the flooding risk, improvement in yield from crop production, and improvement in social capital among local farmers, and between farmers and agricultural development professionals. However, they identified weaknesses that require careful attention in future interventions for sustainable watershed management. Accordingly, they identified poorly supervised and managed soil and water conservation measures in some places, lack of planting appropriate tree species on the established soil and water conservation structures, lack of considering rehabilitation of degraded lands in the soil and water conservation measures practiced, negative downstream impacts of some practiced measures, interference of livestock in the established structures, and lack of mainstreaming non-structural measures. The entire key informants also felt that the aforementioned strengths and weaknesses properly characterize the current community-based soil and water conservation measures practiced in the Huluka watershed. It was also possible to observe some of the strengths and weaknesses.

Effective adaptation measures to land use and land cover changes All the focus groups suggested compost preparation and use, the practice of crop rotation, effective planning to rehabilitate degraded lands through structural and non-structural soil and water conservation measures, strengthening the ongoing community-based soil and water conservation practices, institutionalizing appropriate environmental impact assessment into any local development projects, planting appropriate tree species and management on established soil and conservation structures, and establishing an appropriate institutional framework for forest and other natural resources' management as effective adaptation measures to land use and land cover changes. The entire key informants also felt that the aforementioned suggestions by local communities for sustainable watershed development are vital.

Discussion

Dynamics of land use and land cover changes and implications

The increase in urban built-up area land use and land cover by 351% at an average rate of 16.20 ha/year over 38 years (1979–2017) was confirmed in the Huluka watershed. This is similar to the previous study by Oluwayemisi et al. (2020) who confirmed the drastic increase in built-up area coverage over 20 years (1999–2019). Abebe et al. (2019) assert that rapid population growth and economic development underpin expansions of built-up areas in Ethiopia. Gashaw et al. (2017a, b) reported increased coverage of built-up areas over 30 years (1985–2015) with similar predicted trends for 2030 and 2045.

The increase in urban built-up areas has grave implications for promoting sustainable development in the Huluka watershed and beyond. Scholars in the field assert that land use is closely related to the urban development process of rapid urbanization that takes place in most developing countries (Miheretu and Yimer 2017; Abebe et al. 2019). In other words, how land has to be allocated to a variety of functions such as roads, utilities, housing industrial estates, shopping centers, offices, schools, hospitals and other elements of the physical organization of a city are attested to have far-reaching socio-economic, cultural, political, technical and ecological implications (Andjelkovic 2001; Parkinson 2003; Tucci 2007; Claes et al. 2012; Santato et al. 2013).

The continued high rate of urbanization, in general, is affirmed to lead to problems such as urban poverty, a lack of urban services, especially to the urban poor, poor provision of urban services, considerable strain on existing urban infrastructural facilities, street children, urban unemployment, urban transportation problems, displaced persons, urban crime, a proliferation of slums and squatter settlements, and urban environmental degradation (Balzerek et al. 2003; Ujoh et al. 2010; Hao et al. 2015; Abebe et al. 2019). These urban challenges were also confirmed to affect the urban development process in the Huluka watershed where Ambo town is situated. As the aforementioned challenges are underpinned by unplanned urban expansion, only sustainable land use planning and management and sustainable urban development are feasible solutions (Gashu and Gebre-Egziabher 2018). In other words, protecting land from the urban expansion is affirmed to be imperative for countries whose economic viability and environmental sustainability are increasingly threatened by growing population pressures on a limited natural resource base, the agricultural expansion of marginal lands, deforestation to meet growing demands for food, energy, and construction, and climate change (Brown 2011; FDRE-MUDHC 2014; Miheretu and Yimer 2017; Worku et al. 2017; Abera et al. 2020).

The increase in cultivated land use and land cover by 105.3% at an average rate of 692.76 over 38 years (1979–2017) was confirmed in the Huluka watershed. This is similar to a previous study by Abera et al. (2020) who reported that cultivated land use and land cover increased at an average rate of 1515.7 ha/year between 2000 and 2018. Wubie et al. (2016) reported a consistent expansion of cultivated land use and land cover over the four decades analyzed (1957–2005). Hassen and Assen (2017) reported the expansion of cultivated land by about 57.68% (91.5 ha/year). Miheretu and Yimer (2017) reported an increase in cultivated land by 7.13% over 50 years (1964–2014). Woldesenbet et al. (2020) reported an increase in area coverage for the cultivated land-use system over 30 years. Deribew and Dalacho (2019) reported an increase in cultivated land cover by 36.70% over 60 years (1957–2017). Gashaw et al. (2017a, b) reported increased coverage of cultivated land cover over 30 years (1985–2015) with similar predicted trends for 2030 and 2045.

The increase in cultivated land use and land cover has grave environmental implications for the Huluka watershed and beyond. For instance, the increase in cultivated land was at the expense of forest land, grassland, and bush/shrub land use and land cover and this affects the livelihoods of the human population and other members of the ecosystem in the watershed. In other words, elements of the ecosystem in the watershed are much vulnerable to disaster risks like flooding and soil erosion. Scholars of sustainable development recommend integrated watershed management to address diverse water-related issues in the watershed. In other words, sustainable land management (SLM) is attested to have a vital contribution. The main objective of SLM is affirmed

Ogato *et al. Environ Syst Res*   (2021) 10:10

Page 15 of 20

to be integrating people's coexistence with nature over the long-term, so that the provisioning, regulating, cultural, and supporting services of ecosystems are ensured (Ali et al. 2011; Liniger et al. 2011; FDRE-MUDHC 2014).

The increase in bare land use and land cover by 41.9% at an average rate of 4.00 ha/year over 38 years (1979–2017) was confirmed in the Huluka watershed. This is similar to the previous study by Hassen and Assen (2017) who reported an exceptional expansion of bare land by 11.37 ha/year underpinned by the presence of unsustainable land management practices. Contrary to our finding, the decrease in bare land use and land cover by 46.8% at an average rate of 27 ha/year (2000–2018) was confirmed by a previous study conducted in Ethiopia by Abera and his colleagues. They identified the expansion of built-up areas at the expense of bare land as the underpinning reason (Abera et al. 2020).

The decrease in the forest land use and land cover by 59.3% at an average rate of 164.52 ha/year over 38 years (1979- 2017) was confirmed in the Huluka watershed. This is similar to some previous studies in Ethiopia which confirmed the decrease in forest land use and land cover. For instance, Negassa et al. (2020) confirmed a reduction in dense and open forest cover in the Komto forest priority area of East Wollega Zone, Ethiopia. A reduction in forest land use and land cover by 59.9% at an average rate of 745.2 ha/year was also confirmed by the current similar study conducted in the Chewaka district of Ethiopia (Abera et al. 2020). Woldesenbet et.al. (2020) also confirmed a decrease in area coverage for forest land-use systems over 30 years. Oluwayemisi et al. (2020) also confirmed a drastic decrease in forest land coverage over 20 years (1999–2019). Deribew and Dalacho (2019) also reported a decrease in forest land cover by 39.79% over 60 years (1957–2017). Gashaw et al. (2017a, b) reported decreased coverage of forest land use and land cover over 30 years (1985–2015) with similar predicted trends for 2030 and 2045.

The reduction in forest land use and land cover has serious implications for exacerbating environmental problems in the watershed and beyond. For instance, deforestation and logging are regularly affirmed for exacerbating the disastrous effects of floods generated by extreme rainfall (Gebresamuel et al. 2015). In other words, deforestation tends to generate higher flows, net erosion, and nutrient losses. To avert this undesired human impact on the natural environment, afforestation is recommended as it tends to reduce groundwater recharge and net water availability. In other words, trees are attested to have the capacity to intercept part of the precipitation and, owing to their deeper root systems, transpire more water than grasses during the drier periods (Birkinshaw et al. 2010; Santato et al. 2013).

The urban areas, which are growing rapidly, are attested to need forests to improve the human well-being of the urban population by creating green spaces. Besides this, forests are asserted to provide multiple ecosystem services for people living in rural areas (Dessie & Tadesse 2013; Gashu and Gebre-Egziabher 2018). Furthermore, the importance of forests for sustainable development is increasingly being recognized, not only as a source of wood and timber, but also for carbon sequestration, as a source of renewable energy, for cultural and spiritual values, and recreation, among others (Muller and Reinstorf 2011; Dessie and Tadesse 2013; Abera et al. 2020). Abera et al. (2020) attest that developing a proper land-use plan and limiting population growth through family planning are of paramount importance to conserve and protect forest land use and land cover. Hence, conservation and wise use of forest land resources in the Huluka watershed is of paramount importance to promote sustainable watershed development.

The decrease in shrub/bush land use and land cover by 68.2% at an average rate of 318.71 ha/year over 38 years (1979- 2017) was confirmed in the Huluka watershed. This is similar to the finding of Gashaw et al. (2017a, b) who reported decreased coverage of shrub/bush land use and land cover over 30 years (1985–2015) with similar predicted trends for 2030 and 2045. The decrease in shrub/bush land use and land cover implies that land without shrub/bush cover is vulnerable to soil erosion, flooding, and climate change. Moreover, the livelihoods of local communities are affected since feed shortage and fuelwood shortage are exacerbated in the watershed and beyond.

The decrease in grassland use and land cover by 32.7% at an average rate of 228.65 ha/year over 38 years (1979–2017) was confirmed in the Huluka watershed. This is similar to the study by Woldesenbet et.al. (2020) who reported a decrease in area coverage for grassland use systems over 30 years. Oluwayemisi et al. (2020) reported a drastic decrease in grassland coverage over 20 years (1999–2019). Gashaw et al. (2017a, b) reported decreased coverage of grassland use and land cover over 30 years (1985–2015) with similar predicted trends for 2030 and 2045. The decrease in grassland use and land cover has grave environmental implications for the Huluka watershed and beyond. For instance, the reduction in grassland use and cover implies a shortage of grazing land and feed shortage for livestock affecting the mixed crop-livestock farming system in the watershed and beyond. Reduction in grassland use and land cover also mean increased risk of land to flooding and soil erosion.

The decrease in waterbody by 5.1% at an average rate of 1.06 ha/year over 38 years (1979–2017) was confirmed in the Huluka watershed. This is similar to a previous study

conducted by Oluwayemisi et al. (2020) who confirmed a drastic decrease in water body coverage over 20 years (1999–2019).

The decrease in water body has serious environmental implications for the watershed and beyond, as ecosystem services from the water body (Dendi lake) are detrimentally affected by human-induced and natural factors. Some of the ecosystem services provided by lake include Habitat for aquatic birds, other animals and plants; fish and shellfish production; biodiversity; food production; water storage, including mitigating the effects of floods, and droughts; groundwater recharge; shoreline stabilization, and storm protection; water purification; nutrient cycling; sediment retention and export; recreation and tourism; climate change mitigation; timber production; education and research; and aesthetic, and cultural value (Ozesmi and Baur 2002; Abunie 2003; Galbraith et al. 2005; Millennium Ecosystem Assessment 2005; Wetlands International 2010). Hence, **s**ustainable wetland conservation and restoration policies and strategies should be integrated into sustainable local development and poverty alleviation policies and strategies as environmentally sound economic development underpin sustainable development that creates livelihood options and employment opportunities for current as well as future generations (Ogato 2013; Yohannes et al. 2020).

Drivers of land use and land cover changes and implications

The finding of the study indicates that infrastructural and agricultural expansions, increased demand for wood, local environmental and bio-physical drivers, the rapid growth of human population, economic drivers, technological drivers, policy and institutional drivers, and local socio-cultural drivers were the perceived drivers of land use and land cover changes in Huluka watershed. While technological drivers, local environmental and biophysical drivers, and socio-cultural drivers were not well confirmed by previous studies in Ethiopia, drivers like rapid growth of human population, increased demand for wood, policy, and institutional drivers were well confirmed as discussed hereunder.

Scholars in the field affirm that the main drivers of land use and land cover changes are the combination of biophysical processes, demographic dynamics, urbanization, and successive government policies (Jember 2014; Gashaw et al. 2017a, b; Karki et al. 2018; Deribew and Dalacho 2019; Megersa et al. 2019; Yesuph and Dagnew 2019). An increase in the human population is confirmed to be the major driver for land use and land cover changes in Ethiopia (Kindu et al. 2013; Gashaw et al. 2017a, b; Abebe et al. 2019; Hassan et al. 2016; Wubie et al. 2016; Miheretu and Yimer 2017; Worku et al. 2017; Abera et al.

2020). For instance, Worku et al. (2017) and Wubie et al. (2016) assert that Population growth increases demands of more cultivated land, fuelwood, charcoal, and infrastructural development. Abera et al. (2020) assert that rapid population growth and high population density induce increased demand for resources and exacerbate the rate of resource depletion in the area. Local environmental and biophysical drivers are affirmed to underpin land use and land cover changes in Ethiopia (Kindu et al. 2013; Gashaw et al. 2017a, b; Yesuph and Dagnew 2019). For Gashaw et al. (2017a, b), the reduction of land productivity underpinning the intension of the people for getting new fertile cultivable lands is one of the biophysical drivers.

Policy and institutional drivers are also attested to contribute to land use and land cover changes in Ethiopia (Kindu et al. 2013; Hassen and Assen 2017; Zewdie et al. 2017; Gashu and Gebre-Egziabher 2018; Yesuph and Dagnew 2019; Abera et al. 2020). For instance, Gashu and Gebre-Egziabher (2018) assert that policy and institutional drivers underpin the dynamics of land use and land cover changes in Ethiopia. Economic drivers are also affirmed to contribute to land use and land cover changes in Ethiopia (Kindu et al. 2013; Minale 2013; Gebresamuel et al. 2015; Hassan et al. 2016; Hassen and Assen 2017; Yesuph and Dagnew 2019; Abera et al. 2020). For instance, Hassan et al. (2016) identified economic development, climate change, population growth, rapid urbanization, and deforestation as drivers of land use and land cover changes.

The above discussions imply that diverse drivers of land use and land cover changes in the Huluka watershed should be considered in planning and managing sustainable development projects and programmes in the watershed and beyond. This requires the participation of stakeholders, coordination of different activities, and collaboration of all development partners to ensure the sustainability of development initiatives in the watershed and beyond.

Local effects of land use and land cover changes and implications

The finding of the study indicates that increased flooding risk, increased soil erosion, increased sedimentation into water resources(lake and rivers), decrease in soil fertility, loss of biodiversity, loss of springs, decrease in annual rainfall, and increase in heat during the dry season were the perceived local negative effects of land use and land cover changes in Huluka watershed. While there are limited empirical pieces of evidence linking annual rainfall and environmental heat to changes in land use and land cover in Ethiopia, other local effects were well documented as discussed hereunder.

Increased flooding risk was one of the perceived negative local effects of land use and land cover changes in the Huluka watershed. This perception is similar to the attestations by previous studies in Ethiopia which attested that flooding risk in Ethiopia is underpinned by land use and land cover changes. For instance, scholars in the field affirm that the hydrology of a watershed is much affected by land use and land cover changes resulting in flooding risk (Assen 2011; Gebresamuel et al. 2015; Gashaw et al. 2017a, b; Megersa et.al. 2019 Yesuph and Dagnew 2019). Scholars also assert that urban built-up area is characterized by urban runoff which is defined as streamflow or the sum of surface runoff and subsurface runoff from an urban area (Zhiyu et al. 2013; Gashu and Gebre-Egziabher 2018). Increased soil erosion was one of the perceived negative local effects of land use and land cover changes in the Huluka watershed. This perception is similar to the confirmations by previous studies in Ethiopia which confirmed that soil erosion is the result of land use and land cover transformation. For instance, scholars in the field attest that cultivated land use and land cover, and bare land use and land cover are vulnerable to soil erosion (Assen 2011; Wubie et al. 2016; Miheretu and Yimer 2017; Tellen and Yerima 2018; Megersa et.al. 2019; Yesuph and Dagnew 2019; Girma and Gebre 2020).

Increased sedimentation into water resources was one of the perceived negative local effects of land use and land cover changes in the Huluka watershed. This perception is similar to the assertions of scholars in the field who assert that land use and land cover changes underpin water pollution and threaten the lives of globally important species dependent on wetlands like lakes and rivers (Esa et al. 2018; Karki et al. 2018). The decrease in soil fertility was one of the perceived negative local effects of land use and land cover changes in the Huluka watershed. This perception is similar to the assertion of scholars who assert that decline in soil fertility is underpinned by the transformation of land use and land cover (Wubie et al. 2016; Bekele et al. 2018; Karki et al. 2018).

The above discussed negative local effects of land use and land cover changes have critical implications for sustainable watershed management in the study area. Scholars attest that appropriate strategic measures should be practiced to reduce the negative local effects of land use and land cover changes (Gashaw et al. 2017a, b; Hassen & Assen 2017; Hishe et al. 2017; Kassie 2017; Mekuriaw 2017; Worku et al.2017; Zewdie et al. 2017; Gella 2018). Many of them strongly affirm that it is vital to institutionalize sustainable biological and physical soil conservation measures to mitigate land degradation and improve the livelihood of the local community in the watershed (Amdihun et al. 2014; Wolancho 2015; Wolka et al. 2015; Yimer et al. 2015; Tadesse et al. 2017; Deribew

and Dalacho 2019; Kidane et al. 2019). Others assert that integrated water resources planning and management is vital as one of the elements of natural resources management (Laekemariam et al. 2016; Qayum et al. 2016; Seyoum 2016; Teshome 2016; Miheretu and Yimer 2017; Meshesha and Khare 2019). Others attest that payments for ecological services are vital for the sustainable management of natural resources (Tolessa et al. 2017; Bogale 2020; Hasan et al. 2020).

Conclusions

Forest land, cultivated land, urban built-up area, bush/shrub land, bare land, grassland, and water body were identified as the seven land use and land cover types in the Huluka watershed. There were dynamic Spatio-temporal changes in land use and land cover in the study watershed and the study periods. Urban built-up area increased by 351% at an average rate of 16.20 ha/year over 38 years (1979–2017). Cultivated land increased by 105.3% at an average rate of 692.76 ha/year. Bare land increased by 41.9% at an average rate of 4.00 ha/year. Forest land decreased by 59.3% at an average rate of 164.52 ha/year over 38 years (1979- 2017). Shrub/bush land decreased by 68.2% at an average rate of 318.71 ha/year. Grassland decreased by 32.7% at an average rate of 228.65 ha/year. Waterbody decreased by 5.1% at an average rate of 1.06 ha/year.

Drivers and local effects of land use and land cover changes were identified. Infrastructural and agricultural expansions, increased demand for wood, local environmental and bio-physical drivers, the rapid growth of human population, economic drivers, technological drivers, policy and institutional drivers, and local socio-cultural drivers were identified as the perceived drivers of land use and land cover changes in Huluka watershed. Increased flooding risk, increased soil erosion, increased sedimentation into water resources(lake and rivers), decrease in soil fertility, loss of biodiversity, loss of springs, decrease in annual rainfall, and increase in heat during the dry season were identified as the perceived local negative effects of land use and land cover changes in Huluka watershed.

To promote sustainable local development in the watershed and beyond, the following recommendations are forwarded:

- Appropriate land use planning and management in the watershed should be practiced to reduce the negative local effects of land use and land cover change in the watershed;
- Family planning should be encouraged in the study area since rapid human population growth under-

pins land use and land cover changes and their negative effects in the Huluka watershed and beyond;

- Appropriate environmental impact assessment (EIA) should be conducted before initiating any local development projects;
- Appropriate institutional framework for integrated watershed management should be established for proper planning and management of the watershed development activities;
- Compost preparation and use, and crop rotation should be encouraged to improve the productivity of soil resources in the watershed;
- Rehabilitation of degraded lands through structural and non-structural soil and water conservation measures should be properly planned and managed;
- The ongoing community-based integrated watershed management should be strengthened;
- Appropriate tree species should be planted and managed on the established soil and water conservation structures;
- Local socio-cultural development in the watershed should be properly planned and managed to promote sustainable socio-cultural development in the watershed; and
- Local economic development in the watershed should be properly planned and managed to promote sustainable economic development in the watershed.

Availability of data and materials
Not applicable.

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors have no competing interests in publishing the manuscript.

Author details
[1] Environmental Planning Programme, Ethiopian Institute of Architecture, Building Construction, and City Development, Addis Ababa University, P.O.Box:518, Addis Ababa, Ethiopia. [2] Center for Food Security Studies, College of Development Studies, Addis Abeba University, Addis Ababa, Ethiopia. [3] Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy.

References
Abebe MS, Derebew KS, Gemeda DO (2019) Exploiting temporal-spatial patterns of informal settlements using GIS and remote sensing technique: a case study of Jimma city Southwestern Ethiopia. Environ Syst Res 8(6):1–11

Abera A, Yirgu T, Uncha A (2020) Impact of resettlement scheme on vegetation cover and its implications on conservation in Chewaka district of Ethiopia. Environ Syst Res 9(2):1–17

Abunie L (2003) The distribution and status of Ethiopian wetlands: an overview. In: Abebe YD, Geheb K (Eds), 2003. Wetlands of Ethiopia. Proceedings of a seminar on the resources and status of Ethiopia's Wetlands.

Adebayo WO, Jegede OA (2010) The environmental impact of flooding on transportation land use in Benin City Nigeria. Afr Res Rev 4(1):390–400

Andjelkovic I (2001) Guidelines on non-structural measures in urban flood management. IHP-V, Technical Documents in Hydrology, No. 50. Paris: International hydrological programme, UNESCO.

Alfasi N, Almagor J, Benenson I (2012) The actual impact of comprehensive land-use plans: Insights from high-resolution observations. Land Use Policy 29:862–877

Ali M, Khan SJ, Aslam I, Khan Z (2011) Simulation of the impacts of land-use change on surface runoff of Lai Nullah Basin in Islamabad, Pakistan. Landscape Urban Plan 102:271–279

Amdihun A, Gebremariam E, Rebelo L-M, Zeleke G (2014) Suitability and scenario modeling to support soil and water conservation interventions in the Blue Nile Basin Ethiopia. Environ Syst Res 3(23):1–13

Anderson JR, Hardy EE, Roach JT, Witmer RE (1976) Land use and land cover classification system for use with remote sensor data. Washington, DC: Government Printing Office (US Geological Survey, Professional Paper 964).

Assen M (2011) Land use/cover dynamics and its implications in the Dried Lake Alemaya Watershed, Eastern Ethiopia. J Sust Dev Afr 13(4):267–284

Asnake DT, Hirpha DD, Ogato GS (2019) Practices and challenges of corporate social responsibility in Ethiopia: the case of dangote cement factory, Ada Berga District, West Shoa Zone, Oromia Regional State. Ethiop J Sci Sustain Dev 6(2):72–79

Balaban O (2012) The negative effects of the construction boom on urban planning and environment in Turkey: unraveling the role of the public sector. Habitat Int 36:26–35

Balzerek H, Fricke W, Heinrich J, Moldenhauer K, Rosenberge M (2003) Man-made flood disaster in the savanna town of Gombe / Ne Nigeria: the natural hazard of gully erosion caused by urbanization dynamics and their peri-urban footprints. Erdkunde 57:94–109

Bekele A, Aticho A, Kissi E (2018) Assessment of community-based watershed management practices: emphasis on technical fitness of physical structures and its effect on soil properties in Lemo district Southern Ethiopia. Environ Syst Res 7(20):1–11

Bewket W (2003) Towards integrated watershed management in highland Ethiopia: The Chemoga Watershed Case Study. Ph.D. Thesis. Wageningen: Wageningen University and Research Center.

Berggren K, Moghadas S, Gustafsson A-M, Ashley R, Viklander M (2013) The sensitivity of urban stormwater systems to runoff from green/pervious areas in a changing climate. Novatech 2:1–10

Birkinshaw SJ, James C, Bathurst JC, Iroume A, Palacios H (2010) The effect of forest cover on peak flow and sediment discharge—an integrated field and modeling study in central-southern Chile. Hydrol Process 5:1–14

Ogato *et al. Environ Syst Res* (2021) 10:10

Page 19 of 20

Bogale A (2020) Review, the impact of land use/cover change on soil erosion in the Lake Tana Basin, Upper Blue Nile Ethiopia. Appl Water Sci 10(235):1–6

Brown D (2011) Making the linkages between climate change adaptation and spatial planning in Malawi. Environ Sci Policy 14:940–949

Burnard P (1991) A method of analyzing interview transcripts in qualitative research. Nurse Educ Today 11:461–466

Claes K, Vandenbussche L, Versele A, Klein R, Verbist B (2012) Sustainable urban planning and construction in the South. KLIMOS working paper 7. Leuven: KLIMOS.

Congalton RG (1991) A review of assessing the accuracy of classifications of remotely sensed data. Remote Sens Environ 37:35–46

Deribew KT, Dalacho DW (2019) Land use and forest cover dynamics in the North-eastern Addis Ababa, central highlands of Ethiopia. Environ Syst Res 8(8):1–18

Dessie G, Tadesse M (2013) Rethinking forestry and natural resources higher education in Ethiopia: an education for sustainable development perspective. S Afr J Environ Educ 29:216–244

Dodman D, Brown D, Francis K, HardoyJ, Johnson C, Satterthwaite (2013) Understanding the nature and scale of urban risk in low- and middle-income countries and its implications for humanitarian preparedness, planning, and response. London: International Institute for Environment and Development (IIED).

Ebi KL, Semenza JC (2008) Community-based adaptation to the health impacts of climate change. Am J Prev Med 35(5):501–507

Esa E, Assen M, Legass A (2018) Implications of land use/cover dynamics on soil erosion potential of the agricultural watershed, northwestern highlands of Ethiopia. Environ Syst Res 7(21):1–14

Federal Democratic Republic of Ethiopia-Ministry of Urban Development, Housing, and Construction (FDRE-MUDHC) (2014) National Report on Housing and Sustainable Urban Development. FDRE-MUDHC, Addis Ababa

Few R, Ahern M, Matthies F, Kovats S (2004) *Floods, health, and climate change: a strategic review.* Tyndall Centre Working Paper No. 63. Norwich: Tyndall Centre for Climate Change Research.

Fura GD (2013) Analyzing and Modeling Urban Land Cover Change for Run-off Modeling in Kampala, Uganda. The thesis of Master of Science. Enschede: University of Twente.

Galbraith H, Amerasinghe P, Huber-Lee A (2005) *The effects of agricultural irrigation on wetland ecosystems in developing countries: A literature review.* CA Discussion Paper 1. Colombo, Sri Lanka: Comprehensive Assessment Secretariat.

Gardner H, Green K, Gardner A, Geddes D (2019) Maternal and Infant Health in Abu Dhabi: Insights from Key Informant Interviews. Int J Environ Res Public Health 16(3053):1–12

Gashaw T, Tulu T, Argaw M, Worqlul AW (2017a) Evaluation and prediction of land use/ land cover changes in the Andassa watershed, Blue Nile Basin Ethiopia. Environ Syst Res 6(17):1–15

Gashaw T, Tulu T, Argaw M (2017b) Erosion risk assessment for prioritization of conservation measures in Geleda watershed, Blue Nile basin Ethiopia. Environ Syst Res 6(1):1–14

Gashu K, Gebre-Egziabher T (2018) Spatiotemporal trends of urban land use/ land cover and green infrastructure change in two Ethiopian cities: Bahir Dar and Hawassa. Environ Syst Res 7(8):1–11

Gebresamuel G, Singh BR, Dick O (2015) Land use changes and their impacts on soil degradation and surface runoff of two catchments of Northern Ethiopia. Acta Agric Scand Sect B Soil Plant Sci 60(3):211–226

Gella GW (2018) Impacts of integrated soil and water conservation programs on vegetation regeneration and productivity as an indicator of ecosystem health in Guna-Tana watershed: pieces of evidence from satellite imagery. Environ Syst Res 7(2):1–14

Girma R, Gebre E (2020) Spatial modeling of erosion hotspots using GIS-RUSLE interface in Omo-Gibe river basin, Southern Ethiopia: implication for soil and water conservation planning. Environ Syst Res 9(19):1–14

Gondo T, Zibabgwe S (2010) GIs solutions and land management in urban Ethiopia: Perspectives on capacity, utilization, and transformative possibilities. Manag Res Pract 2(2):200–216

Hall J, Arheimer B, Borga M, Brázdil R, Claps P, Kiss A, Kjeldsen TR, Kriauciuniene J, Kundzewicz ZW, Lang M, Llasat MC, Macdonald N, McIntyre N, Mediero L, Merz B, Merz R, Molnar P, Montanari A, Neuhold C, Parajka J, Perdigão RAP, Plavcová L, RoggerM SalinasJL, Sauquet E, Schär C, SzolgayJ VA,

Blöschl G (2014) Understanding flood regime changes in Europe: a state-of-the-art assessment. Hydrol Earth Syst Sci 18:2735–2772

Hao L, Sun G, Liu Y, Wan J, Qin M, Qian H, Liu C, John R, Fan P, Chen J (2015) Urbanization dramatically altered the water balances of a paddy field dominated basin in Southern China. Hydrol Earth Syst Sci Discuss 12:1941–1972

Hassen EE, Assen M (2017) Land use/cover dynamics and its drivers in Gelda catchment, Lake Tana watershed Ethiopia. Environ Syst Res 6(4):1–13

Hassan Z, Shabbir R, Ahmad SS, Malik AH, Aziz N, Butt A, Erum S (2016) Dynamics of land use and land cover change (LULCC) using geospatial techniques: a case study of Islamabad Pakistan. Springer Plus 5(812):1–11

Hasan S, Shi W, Zhu X (2020) Impact of land use land cover changes on ecosystem service value—a case study of Guangdong, Hong Kong, and Macao in South China. PLoS ONE 15(4):1–20

Hishe S, Lyimo J, Bewket W (2017) Effects of soil and water conservation on vegetation cover: a remote sensing-based study in the Middle Suluh River Basin, northern Ethiopia. Environ Syst Res 6(26):1–16

Huang J, Lu XX, Sellers JM (2007) A global comparative analysis of urban form: applying spatial metrics and remote sensing. Landscape Urban Plan 82:184–197

Jha AK, Bloch R, Lamond J (2012) Cities and flooding: a guide to integrated urban flood risk management for the 21st Century. The World Bank, Washington DC

Karki S, Thandar AM, Uddin K, Tun S, Aye WM, Aryal K, Kandel P, Chettri N (2018) Impact of land use land cover change on ecosystem services: a comparative analysis on observed data and people's perception in Inle Lake Myanmar. Environ Syst Res 8(5):1–15

Kassie GW (2017) Agroforestry and farm income diversification: synergy or trade-off? The case of Ethiopia. Environ Syst Res 6(8):1–14

Kawulich BB (2005) Participant observation as a data collection method. Forum Qualitative Sozialforschung 6(2):1–28

Kidane M, Bezie A, Kesete N, Tolessa T (2019) The impact of land use and land cover (LULC) dynamics on soil erosion and sediment yield in Ethiopia. Heliyon 5:1–13

Kindu M, Schneider T, Teketay D, Knoke T (2013) Land use/land cover change analysis using object-based classification approach in munessa-shashemene landscape of the Ethiopian Highlands. Remote Sens 5:2411–2435

Kun KE, Kassim A, Howze E, MacDonald G (2013) Interviewing key informants: strategic planning for a global public health management program. Qualitat Rep 18(18):1–17

Laekemariam F, Kibret K, Mamo T, Karltun E, Gebrekidan H (2016) Physiographic characteristics of agricultural lands and farmers' soil fertility management practices in Wolaita zone Southern Ethiopia. Environ Syst Res 5(24):1–15

Li Z, Liu W, Zhang X, Zheng F (2009) Impacts of land-use change and climate variability on hydrology in an agricultural catchment on the Loess Plateau of China. J Hydrol 377:35–42

Liniger H, Studer RM, Hauert C, Gurtner M (2011) Sustainable land management in practice: guidelines and best practices for Sub-Saharan Africa. FAO, Rome

Mekuriaw A (2017) Assessing the effectiveness of land resource management practices on erosion and vegetative cover using GIS and remote sensing techniques in Melaka watershed Ethiopia. Environ Syst Res 6(16):1–10

Meshesha TW, Khare D (2019) Towards integrated water resources management considering hydro-climatological scenarios: an option for sustainable development. Environ Syst Res 8(5):1–11

Millennium Ecosystem Assessment (2005) Ecosystems and human well-being: Wetlands and water synthesis. World resources institute, Washington, DC

Miheretu BA, Yimer AA (2017) Land use/land cover changes and their environmental implications in the Gelana sub-watershed of Northern highlands of Ethiopia. Environ Syst Res 6(7):1–12

Minale AS (2013) Retrospective analysis of land cover and use dynamics in gilgel abbay watershed by using gis and remote sensing techniques, North Western Ethiopia. Int J Geosci 4:1003–1008

Mngutyo ID, Ogwuche JA (2013) Urban development, flood, and disaster management: challenges of contemporary urban planning perspectives. Int J Innov Environ Studies Res 1(1):1–6

Muller A, Reinstorf F (2011) Exploration of land-use scenarios for flood hazard modeling—the case of Santiago de Chile. Hydrol Earth Syst Sci Discuss 8:3993–4024

Ogato *et al. Environ Syst Res*   (2021) 10:10

Page 20 of 20

Negassa MD, Mallie DT, Gemeda DO (2020) Forest cover change detection using geographic information systems and remote sensing techniques: a spatio-temporal study on komto protected forest priority area, East Wollega Zone Ethiopia. Environ Syst Res 9(1):1–14

Nuissl H, Haaseb D, Lanzendorfc M, Wittmer H (2009) Environmental impact assessment of urban land use transitions. A context-sensitive approach. Land Use Policy 26:414–424

Nyumba TO, Wilson K, Derrick CJ, Mukherjee N (2018) The use of focus group discussion methodology: Insights from two decades of application in conservation. Methods Ecol Evol 9:20–32

Ogato GS (2013) The human ecology of wetlands in least developed countries (LDCs) in time of climate change: policy implications for wise use and conservation of Wetlands. Am J Hum Ecol 2(4):127–138

Ogato GS, Abebe K, Bantider A, Geneletti D (2017) Towards Mainstreaming Climate Change Adaptation into Urban Land Use Planning and Management: The Case of Ambo Town, Ethiopia. In: Filho WL, Kalangu J, Musiyiwa K, Munishi P, Simane B, Menas WM (eds) Climate Change Adaptation in an African Context: fostering resilience and capacity to adapt. Springer, Berlin

Ogato GS, Bantider A, Abebe K, Genelati D (2020) Geographic information system (GIS)-Based multicriteria analysis of flooding hazard and risk in Ambo Town and its watershed, West shoa zone, Oromia Regional State, Ethiopia. J Hydrol Reg Stud 27:1–18

Onwuegbuzie AJ, Dickinson WB, Leech NL, Zoran AG (2009) A qualitative framework for collecting and analyzing data in focus group research. Int J Qualitat Methods 8(3):1–21

Oluwayemisi S, Olokeogun OS, Ayanlade A, Popoola OO (2020) Assessment of riparian zone dynamics and its food-related implications in Eleyele area of Ibadan Nigeria. Environ Syst Res 9(6):1–11

Ozesmi SL, Baur ME (2002) Satellite remote sensing of wetlands. Wetlands Ecol Manage 10:381–402

Parkinson J (2003) Drainage and stormwater management strategies for low-income urban Communities. Environ Urban 15(2):115–126

Qayum A, Gupta A, Arya R (2016) Environmental taxation based integrated modeling towards sustainable environmental conservation approach. Environ Syst Res 5(23):1–10

Santato S, Bender S, Schaller M (2013) *The European Floods Directive and opportunities offered by land-use planning*. CSC Report 12. Germany: Climate Service Center.

Seyoum B (2016) Assessment of soil fertility status of Vertisols under selected three land uses in Girar Jarso District of North Shoa Zone, Oromia National Regional State Ethiopia. Environ Syst Res 5(18):1–16

Strauss AL (1987) Qualitative analysis for social scientists. Cambridge University Press, Cambridge

Tadesse L, Suryabhagavan KV, Sridhar G, Legesse G (2017) Land use and land cover changes and Soil erosion in Yezat Watershed, North Western Ethiopia. Int Soil Water Conserv Res 5:85–94

Tellen VA, Yerima BPK (2018) Effects of land-use change on soil physicochemical properties in selected areas in the North West region of Cameroon. Environ Syst Res 7(3):1–29

Teshome M (2016) Rural households' agricultural land vulnerability to climate change in Dembia woreda Northwest Ethiopia. Environ Syst Res 5(14):1–18

Tolessa T, Senbeta F, Kidane M (2017) The impact of land use/land cover change on ecosystem services in the central highlands of Ethiopia. Ecosyst Serv 23:47–54

Tucci CEM (2007) Urban flood management. World Meteorological Organization, Geneva

Ujoh F, Kwabe ID, Ifatimehin OO (2010) Understanding urban sprawl in the Federal Capital City, Abuja: Towards sustainable urbanization in Nigeria. J Geogr Reg Plan 3(5):106–113

Wetlands International (2010) Wetlands & Water, Sanitation and Hygiene (WASH)—understanding the linkages. Wetlands International, Ede, The Netherlands

Wheater H, Evans E (2009) Land use, water management, and future flood risk. Land Use Policy 26S:S251–S264

Wolka K, Tadesse H, Garedew E, Yimer F (2015) Soil erosion risk assessment in the Chaleleka wetland watershed, Central Rift Valley of Ethiopia. Environ Syst Res 4(5):1–12

Wolancho KW (2015) Evaluating watershed management activities of campaign work in Southern nations, nationalities and peoples' regional state of Ethiopia. Environ Syst Res 4(6):1–13

Worku T, Tripathi SK, Khare D (2017) Household-level tree planting and its implication for environmental conservation in the Beressa Watershed of Ethiopia. Environ Syst Res 6(10):1–10

Wubie MA, Assen M, Nicolau MD (2016) Patterns, causes, and consequences of land use/cover dynamics in the Gumara watershed of Lake Tana basin Northwestern Ethiopia. Environ Syst Res 5(8):1–12

Yesuph AY, Dagnew AB (2019) Land use/cover spatiotemporal dynamics, driving forces, and implications at the Beshillo catchment of the Blue Nile Basin, North Eastern Highlands of Ethiopia.

Yimer F, Alemu G, Abdelkadir A (2015) Soil property variations in relation to exclosure and open grazing land use types in the Central Rift Valley area of Ethiopia. Environ Syst Res 4(17):1–10

Yohannes H, Soromessa T, Argaw M, Dewan A (2020) Changes in landscape composition and configuration in the Beressa watershed, Blue Nile basin of Ethiopian Highlands: historical and future exploration. Heliyon 6:1–17

Zeleke G (2000) *Landscape dynamics and soil erosion process modeling in the North-Western Highlands*. Ph.D. dissertation. Berene: University of Berne.

Zewdie M, Worku H, Bantider A (2017) Temporal dynamics of the driving factors of urban landscape change of Addis Ababa During the Past Three Decades. Environ Manag 25:1–17

Publisher's Note