Spatio-temporal Dynamics, Drivers, Effects and Environmental Implications of Land use/land Cover Changes in Ambo Town and Its Watershed, West Shoa Zone, Oromia Regional State, Ethiopia

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Research

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Abstract

Background: Land use/land cover change in urban watersheds of developing countries like Ethiopia is claimed to be a consequence of complex interaction of different actors, driving forces, and land itself. It is asserted to result in the degradation of natural vegetation and significant increases in impervious surfaces. The purpose of the study was to analyze spatio-temporal changes in land use/land cover in Huluka watershed where Ambo town is situated and examine their drivers and effects with environmental implications.

Results: The overall increase of urban built-up area, cultivated land, and bare land use/land cover type with 351%, 105%, and 41.9% respectively between the year 1979 and 2017 implies the increase in flooding disaster risk in the watershed as such land use/land cover types exacerbate the run-off conditions in the watershed. Infrastructural expansion, agricultural expansion, increased demand for fuel wood and wood for construction, local environmental factors, local biophysical drivers, and local Social events were identified as proximate drivers of land use/land cover changes in the study area. Demographic factors, economic factors, technological factors, policy and institutional factors and cultural factors were confirmed as the underlying drivers of land use/land cover change in the watershed. Increased flooding risk, increased soil erosion; increased sedimentation into the lake (Dendi lake) and rivers (Huluka, Awaro, Debis, Boji, Bolo, Aleltu, Karkaro, and Korke), decrease in soil fertility resulting from flooding risk, and change in climatic parameters (decrease in annual rainfall and increase in heat during dry season) were claimed as the negative effects of land use/land cover change in the study area.

Conclusions: Practice of appropriate land use planning and management in the watershed, appropriate environmental impact assessment (EIA), and proper planning and management of socio-cultural, economic, and environmental development are of paramount importance to promote sustainable development in the watershed.

1. Background

Land use/land cover change in developing countries like Ethiopia is claimed to be a consequence of complex interaction of different actors, 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 (due to the interaction of decision making at different levels) 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 belongs to the most serious environmental pressures on landscapes worldwide, in particular in urbanized areas (Nuissl et al., 2009; Wheater & Evans, 2009; Adebayo et al., 2010; Santato et al., 2013). Individual ecosystem services that are affected by land use transition include the production of food, regulation of energy and matter flows, water supply, 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). Unless policy strategies and planning instruments attempt to address the problem of land use transition as an ongoing process (rather than defining fixed land use patterns as their ultimate goal), they will neglect possible feedback dynamics and thus can hardly be successful (Ebi & Semenza, 2008; Nuissl et al., 2009; Adebayo et al., 2010; Alfasi et al., 2012; Mngutyo & Ogwuche, 2013).

Land use/land cover change is amongst the most widely increasing and significant sources of today's change in the earth's land surface (Balaban, 2009; Claes et al., 2012; Mngutyo & Ogwuche, 2013). It results in 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). This particularly creates several problems and become an issue in rapidly urbanizing Ethiopian towns like Ambo. This coupled with the high population growth rate and negative local impacts of climate change lead to modification or complete replacement of the land surface contributing to urban flooding risk (Cordaid & IIRR, 2011; Berggren et al., 2013; Fura, 2013; Mngutyo & Ogwuche, 2013; Ogato, 2013; Hao et al., 2015).

Understanding the dynamics of land use/land cover changes with their drivers and effects contributes immensely for promoting sustainable urban and rural development in the watershed and its basin. Hence, this study analyzed change in land use/land cover in Huluka watershed where Ambo town is situated and explore local perceptions on its causes and effects. To adress these objectives, four research questions were answered: 1) What is the composition of the land use/land cover types in Ambo town's watershed for the study period? 2) What are the proportions of these land use/land cover over the study period? 3) What is the rate of change for land use/land cover in Ambo town's watershed for the study period? 4) What are the drivers and effects of land use/land cover changes in the study area?

2. Methodology

2.1. Description of the Study Area

Huluka Watershed is affirmed to be located in West Shoa Zone, Oromia Regional State, Ethiopia. Geographically, it is confirmed to be 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 Huluka watershed is confirmed to be about 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 303416 in the year 2017 (CSA, 2017).

Forest area, cultivated land area, urban built-up area, bush/shrub land area, bare land area, grassland area, and water area were identified as the seven land use/land cover types in the watershed. The highest elevation in the watershed is 3253 meters above sea level while the lowest elevation of the watershed is 1834 meters above sea level. The slope of the watershed was confirmed to range between 0% and 32.5%. Chromic Luvisols, Chromic Vertisols, Eutric Cambisols, Eutric Nitisols, Leptosols, Orthic Luvisols, and
Pellic Vertisos were identified as the types of soils in the watershed. The rainfall of the area is confirmed to be bimodal, with unpredictable short rains from March to April and the main season ranging over June to September. The highest mean total annual rainfall of the watershed over 32 years (1984–2015) was affirmed to be 1181 mm while the lowest was 1036 mm (Fig. 2).

2.2. Data Types and sources of Data

Four period of satellite images were used to conduct this study. To this end, Landsat TM and ETM* imagery for the periods 1979, 1984, 2009, and 2017 were used. These years were chosen based on the purpose of the study and the purpose of the study was to understand the changes in land use/land cover and local residents’ perceptions on its cause and negative effects in the watershed. 1979, 1984, and 2009 were chosen to see the dynamics of land use/land cover change over four decades. To this end, year 1979 was chosen as a reference year representing 1970s due to the availability of good quality Landsat image for the decade for Huluka watershed. Year 1984 was considered as it was the census year in Ethiopia. 2009 was considered also as year close to the census year in Ethiopia (2007) with good quality land sat image for the study watershed. Year 2017 was chosen to represent current year.

Digital map on shape file with the scale of 1:50,000 from 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 for secondary data types and perception related primary data types.

2.3. 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 & Zibabgwe, 2010) was employed. In addition, personal field observation, focus group discussion, and key informant interviews were employed to get additional primary data. Accordingly, six focus group discussions, and fifteen key informant interviews were undertaken to collect qualitative data from the local communities in the watershed based on the purpose of the study.

2.4. Methods of Data analysis

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/land cover classes (Table 1) were used for image classification and land use/land cover change analysis. Arc GIS 10.1 software and ERDAS IMAGINE 9.1 software (Huang et al., 2007; Monkkonen, 2008; Gondo & Zibabgwe, 2010) were employed for the intended image classification, land use/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/land cover change.

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

| LULCC          | 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 characterized with 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 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 the landsat images, radiometric correction, layer stacking, resolution merge, image enhancement, and adding vector information from 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, maximum likelihood was used for supervised classification by taking ground control points for seven major land use land cover classes. These land use/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 represents land cover classes that were recognized by the researcher. Accuracy assessment was also undertaken in the post-processing step. Accordingly, accuracy assessment was carried out to verify to what extent the produced classification is compatible with what actually 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 change in land use and land cover change in various years and analysis of its implication for environmental and management issues like flooding risk in Ambo town and its watershed. In other words, post-classification method was employed for the change detection. This technique helps to generate change matrix where different transfers from one land use/land cover types to another can be visually observed. Accordingly, change metrics for detecting land use and land cover change were constructed between 1979 and 1984, between 1984 and 2009, between 2009 and 2017, and between 1979 and 2017 through pixel-to-pixel comparisons. The classified data were then taken in to ArcGIS 9.1 environment to calculate area for each land use/land cover type and produce the land use/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 was made using the following formula (Fura, 2013):

\[
\Delta = \frac{(A_2 - A_1)}{A_1} \times 100
\]

Where: \(\Delta\) = land use and land cover change (%), \(A_1\) = amount of land use/land cover type in year 1, \(A_2\) = amount of land use and land cover type in year 2.

The final step was creation of maps of land use/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.

To examine the drivers and effects of land use/land cover changes, qualitative data collected through document review, key informant interview, focus group discussion, and personal observation were analyzed with the help of thematic analysis, content analysis and narrations. The major criteria underpinning the combined application of the aforementioned qualitative methods of data analysis were: transparency, maximizing validity, maximizing reliability, comparative analysis, and reflexive approach in the process of analysis. The major steps involved in the process included: 1. Reading and annotating transcripts; 2. Identify themes; Developing a coding scheme; and 4. Coding the data.

3. Results

This section presents results on the composition of land use/land cover in Huluka Watershed, analysis of land use change dynamics, and local residents’ perceptions on the causes and negative effects of land use/land cover change in their area.

3.1. Composition of Land Use/Land Cover in Huluka Watershed for the Study Period
Forest area, cultivated land area, urban built-up area, bush/shrub land area, bare land area, grassland area, and water area were identified as the seven types of land use/land cover in the watershed.

### 3.2. Spatio-temporal Dynamics of Land Use/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 year 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 year 1979, 1984, 2009, and 2017 respectively (Table 2).

| 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 |

The spatio-temporal dynamics of land use/land cover change in the watershed for Forest land use/cover, cultivated land use/land cover, urban built-up area land use/land cover, bush/shrub land use/land cover, bare land use/land cover, grass land use/land cover and water land use/land cover between 1979 and 2017 are presented hereunder.

#### 1. Forest land use/land cover

Forest land use/land cover type was represented by areas covered with dense trees, which include both Eucalyptus and coniferous trees, and riverine trees. Forest land covered 10550.52 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% between 1979 and 1984 and 52.6% between 1984 and 2009. However, it increased by 1.6% between 2009 and 2017. Sadly, the forest land cover decreased by 59.3% between 1979 and 2017. The decrease of forest land in the watershed was attributable to its transformation to other land use/land cover types. It was largely transformed to cultivated land and grassland between 1979 and 2017 (Table 3, 4, and 5; Figure 3 and 4).

#### 2. Cultivated land use/land cover

Cultivated land use/land cover was represented by areas used for rain fed crop production and scattered rural settlements usually associated with cultivated lands. Cultivated land covered 25005.24 ha (30.8%)
in 1979, 28639.27 ha (35.3%) in 1984, 43833.98 ha (54%) in 2009 and 51329.96 ha (63.2) % in 2017. It increased by 14.5 % between 1979 and 1984, 53.1% between 1984 and 2009, 17.1% between 2009 and 2017, and 105.3% between 1979 and 2017. Sadly, the cultivated land use/land cover increased by 105.3% between 1979 and 2017. The increase of cultivated land in the watershed was attributable to the transformation of other land use/land cover types into cultivated land use/land cover type. Large proportion of grassland, shrub/bush land, and forest land was transformed into cultivated land between 1979 and 2017 (Table 3,4, and 5; Figure 3 and 4).

3. 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 % between 1979 and 1984, 21.7 % between 1984 and 2009, 85.7% between 2009 2017, and 351 % between 1979 and 2017. Sadly, the urban built-up area cover increased by 351% between 1979 and 2017. The increase of urban built-up area cover in the watershed was attributable to the transformation of other land use/land cover types into urban built-up area cover type. Large proportion of grassland, cultivated land, shrub/bush land, and forest land was transformed into urban built-up area between 1979 and 2017 (Table 3,4, and 5; Figure 3 and 4).

4. Bush/Shrub land use/cover

Bush/shrub land use/land cover type was represented by land covered by shrubs and bushes and sometimes with scattered small trees mixed with grasses. Bush/Shrub land covered 17746.11ha (21.8%) in 1979, 12767.1ha (15.7%) in 1984, 7907.733 ha (9.7%) in 2009 and 5635.09ha (6.9%) in 2017. It decreased by 28.1% between 1979 and 1984, 38.1% between 1984 and 2009, 28.7% between 2009 and 2017, and 68.2% between 1979 and 2017. The decrease of bush/shrub land in the watershed was attributable to its transformation to other land use/land cover types. Its large proportion was transformed into cultivated land and grassland between 1979 and 2017 (Table 3,4, and 5; Figure 3 and 4).

5. Bare land use/land cover

Bare land use/land cover type was represented by areas with no or very little vegetation cover and characterized with 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 % between 1979 and 1984, 17.2 % between 1984 and 2009, 19.1% between 2009 2017, and 41.9 % between 1979 and 2017. The increase of bare land cover in the watershed was attributable to the transformation of other land use/land cover types into bare land cover type. Large proportion of cultivated land, grassland, and
shrub/bush land was transformed into bare land between 1979 and 2017 (Table 3, 4, and 5; Figure 3 and 4).

6. Water body land use/ land cover

Water body land use/land cover type was represented by areas covered by lake water in the catchment permanently. Water body 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% between 1979 and 1984. However, it decreased by 7.8 between 1984 and 2009. It increased by 0.1% between 2009 and 2017. It decreased by 5.1% between 1979 and 2017. The decrease of water body land use/land cover in the watershed was attributable to its transformation to other land use/land cover types. Its large proportion was transformed into grassland and cultivated land between 1979 and 2017 (Table 3, 4, and 5; Figure 3 and 4).

7. Grassland use/cover

Grassland use/land cover type was represented by land predominately covered with grasses, forbs, grassy areas used for communal grazing. Grassland covered 26607.96 ha (32.8%) in 1979, 29374.75 ha (36.2%) in 1984, 23657.14 ha (29.1%) in 2009 and 17919.11 ha (22%) in 2017. It increased by 10.4% between 1979 and 1984. It decreased by 19.5% between 1984 and 2009, 24.3% between 2009 and 2017, and 32.7% between 1979 and 2017. The decrease of grassland use/cover type in the watershed was attributable to its transformation to other land use/land cover types. It was largely transformed into cultivated land between 1979 and 2017 (Table 3, 4, and 5; Figure 3 and 4).

The overall decline of bush and shrub land, forest, grassland, and water land use/land cover type with 68.2%, 59.3%, 32.7%, and 5.1% respectively between 1979 and 2017 is bad news for the watershed as the potential of the watershed to contribute in mitigating flooding disaster risk decline with the decline of these land use/land cover types. Moreover, the overall increase of urban built-up area, cultivated land, and bare land use/land cover type with 351%, 105%, and 41.9% respectively between the year 1979 and 2017 implies the increase in flooding disaster risk in the watershed as such land use/land cover types exacerbate the run-off conditions in the watershed.
### 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   | %    |
| 1  | Forest            | 10550.52                      | 13   | 8925.75 | 10.9 | 4232.253 | 5.2 | 4298.85 | 5.3 |
| 2  | cultivated land   | 25005.24                      | 30.8 | 28639.27 | 35.3 | 43833.98 | 54 | 51329.96 | 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 | 17746.11                     | 21.8 | 12767.1 | 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         | 26607.96                      | 32.8 | 29374.75 | 36.2 | 23657.14 | 29.1 | 17919.11 | 22  |
| 8  | Total             | 81236.79                      | 100  | 81236.79 | 100  | 81236.79 | 100 | 81236.79 | 100 |

### Table 4
Rate of Change of land use/land cover in Huluka Watershed

| No | Land use/cover class | Change of land use/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. Matrix for land use/cover change for 1979 to 2017
3.3. Drivers of Land Use/Land Cover Change in Ambo Huluka/Ambo Town’s Watershed

Qualitative methods of data collection (focus group discussions, key informant interview, and personal observation) were employed to collect data on local residents’ perceptions on proximate and underlying causes of land use/land cover change in their area. The qualitative analysis of drivers of land use/land cover changes is presented hereunder.

### 3.3.1. Proximate Drivers of Land Use/Land Cover Change

#### 1. Infrastructural Expansion:

Discussants of the focus group discussion were asked to opine on the causal linkage between infrastructure expansion and land use/land cover change in Huluka watershed. Similar perceptions were explored across the three streams of the watershed (upstream, midstream, and low stream). Accordingly, infrastructural expansion was perceived as one of the proximate causes of land use/land cover change in Huluka watershed. It was also possible to observe current expansion of infrastructures like construction of houses for Ambo University expansion (Figure 5). One of the key informants said “Infrastructural development is relevant for us as we need roads, telecommunication, and electrification. However, any infrastructural development in this watershed must not result in degradation of land resources in this watershed.” (Key informant one, Huluka Watershed). Moreover, discussants of the focus group discussion appreciated the expansion of infrastructure in Huluka watershed. However, they suggested that expansion of any infrastructure in Huluka Watershed should be preceded by appropriate environmental impact assessments to mitigate the negative impacts of infrastructural expansion. In other words, failure to institutionalize environmental impact assessment in projects of infrastructural expansions like roads...
and construction of houses for different purposes was claimed to result in irreversible deforestation and degradation of natural resources in Huluka Watershed.

2. Agricultural Expansion:

Discussants were asked to opine on the causal linkage between agricultural expansion and land use/land cover change. Similar perceptions were explored across the three streams of the watershed (upstream, midstream, and low stream). Discussants agreed that agricultural expansion is one of the causal factors for land use/land cover change in the watershed. The same concern was also raised by the key informants as all of them claimed that agricultural expansion is one of the causes for land use/land cover change in the watershed. It was also possible to observe current expansion of agriculture to forest areas in the watershed (Figure 6).

3. Increased Demand for Fuel Wood and Wood for Construction:

Discussants were asked to opine on the causal linkage between increased demands for fuel wood and wood and land use/land cover change in Huluka watershed. Similar perceptions were explored across the three streams of the watershed (upstream, midstream, and low stream). The discussants of the focus group discussion agreed that the increase in demand for fuel wood and wood for construction is one of the causal factors for land use/land cover change in Huluka watershed. The same concern was also raised by the key informants as all of them claimed that increase in demand for fuel wood and wood for construction in their area has resulted in change in land use/land cover. It was also possible to observe current increased demand for fuel wood and wood for construction in Ambo town and Huluka watershed (Figure 7).

4. Local Environmental Factors:

Discussants were asked to opine on the causal linkage between local environmental factors like soil quality and topography and Land Use/Land Cover Change. Similar perceptions were received across the three streams of the watershed (upstream, midstream, and low stream). Participants of the focus group discussion agreed that the soil type of the watershed contributes much for land use/land cover change in the watershed due to its vulnerability to change. Moreover, hilly areas in the watershed were perceived to contribute much for land use/land cover change in Huluka Watershed. The same concern was also raised by the key informants interviewed as all of them claimed that local environmental factors (soil type and topography) are among the causes for land use/land cover in Huluka watershed. It was also possible to observe the physical impact of local environmental factors on land use/land cover in Huluka watershed (Figure 8).
5. Local Biophysical Drivers:

Participants of the focus group discussion were asked to opine on the causal linkage between local biophysical drivers like flooding and land use/land cover change. Similar perceptions were explored across the three streams of the watershed (upstream, midstream, and low stream). Discussants agreed that flooding disaster risk is a major biophysical driver for land use/land cover change in Huluka Watershed. For instance, many of the agricultural land areas in the watershed were reported to be affected by flooding risk resulting in soil erosion, decrease in soil fertility, and decrease in agricultural production. In addition, fire risk on forests and grasses was reported as one of the local biophysical factors contributing for land use/land cover change in Huluka Watershed. Furthermore, prevalence of drought during dry season of the year was reported to affect growing plants in the watershed. The same concern was also raised by the key informants interviewed as all of them attested that local biophysical drivers are among the causes of land use/land cover change in Huluka watershed. It was also possible to observe local biophysical drivers contributing for land use/land cover changes in Huluka watershed (Figure 9).

6. Local Social Events:

Discussants were asked to opine on the causal linkage between local social events and Land Use/Land Cover Change in Huluka Watershed. Similar perceptions were not explored across the three streams of the watershed (upstream, midstream, and low stream). For instance, no local social events were claimed by the discussants to be associated with land use/land cover change in both upstream and midstream of the watershed. However, sudden displacement and abrupt policy shifts in their locality were reported as local social events contributing for land use/land cover change in low stream of Huluka Watershed. In relation to the aforementioned local social events in the low stream of the watershed, the sudden displacements of farming households associated with the expansion of Ambo University and abrupt policy shifts like land lease policy were reported to contribute for land use/land cover change in their area. The same concern was also raised by the key informants interviewed as all of them from the low stream of the watershed noted that local social events have contributed for land use/land cover change in their area.

3.3.2. Underlying Drivers of Land Use/Land Cover Change

1. Demographic Factors:

Participants of the focus group discussion were asked to opine on the causal linkage between demographic factors and land use/land cover change. Similar perceptions were explored across the three streams of the watershed (upstream, midstream, and low stream). Discussants agreed that natural increase and migration into the area are demographic factors contributing for land use/land cover
change in Huluka Watershed. For instance, increase in human population in the watershed was claimed by the discussants as one of the drivers for degradation of land resources in Huluka Watershed. The same concern was also raised by the key informants interviewed as all of them confirmed that demographic factors are among the major causes of land use/land cover change in their watershed. It was also possible to observe the undesirable situation of Dendi Crater Lake at the upstream of the watershed attributable to increase in human population in the watershed (Figure 10).

2. Economic Factors:

Participants of the focus group discussion were asked to opine on the causal linkage between economic factors and land use/land cover change. Similar perceptions were explored across the three streams of the watershed (upstream, midstream, and low stream). The discussants agreed that market growth and commercialization, urban expansion, and price increase are the economic factors contributing for land use/land cover change in Huluka watershed. For instance, market growth and commercialization was claimed by the discussants to encourage production of high value agricultural products like vegetables. Urban expansion was also claimed to encourage conversion of land use from agriculture to non-agricultural land use. Price increase was also claimed as one of the economic factors causing land use/land cover change in the watershed (Figure 11).

3. Technological Factors:

Participants of the focus group discussion were asked to opine on the causal linkage between technological factors and land use/land cover change in Huluka watershed. Similar perceptions were explored across the three streams of the watershed (upstream, midstream, and low stream). Discussants agreed that technological factors like agro technical change (intensification) and agricultural production factors contribute for land use/land cover change in Huluka watershed. For instance, contour farming, using improved crop varieties, and crop rotation were claimed by the discussants as agro-technical change factors contributing for land use/land cover change in upstream of Huluka Watershed (Figure 12). The same concern was also raised by the key informants interviewed as all of them confirmed that technological factors are among the factors causing land use/land cover change in Huluka watershed. It was also possible to observe the influence of technological factors on land use/land cover change at upstream of the watershed.

4. Policy and Institutional Factors:

Participants of the focus group discussion were asked to opine on the causal linkage between policy and institutional factors and land use/land cover change. Similar perceptions were explored across the three streams of the watershed (upstream, midstream, and low stream). The discussants agreed that policy and institutional factors like formal policy and property right contribute for land use/land cover change.
in Huluka Watershed. For instance, expansion of agriculture to forest areas and resulting deforestation and flooding risk in the watershed was claimed by the discussants to be highly associated with weak forest conservation policy and weak forest management institutional framework in the watershed. The same concern was also raised by the key informants interviewed as all of them contended that policy and institutional factors contributes for land use/land cover change in their watershed.

5. Cultural Factors:

Participants of the focus group discussion were asked to opine on the causal linkage between cultural factors and land use/land cover change. Similar perceptions were explored across the three streams of the watershed (upstream, midstream, and low stream). The discussants agreed that cultural factor like public attitudes and beliefs and individual and household behavior in the watershed contribute for land use/ land cover change in Huluka Watershed. For instance, change in public attitudes and beliefs towards natural forest conservation in the watershed were claimed by the discussants to be resulted in land use/land cover change in the watershed. In other words, expansion of agricultural land to forest areas is currently much encouraged and practiced by local people in the watershed. The same concern was also raised by the key informants who also confirmed that cultural factors are among the major factors for causing land use/land cover change in Huluka watershed.

3.4. Effects of Land Use/ Land Cover Change on Residents’ Livelihoods in Huluka Watershed

Participants of the focus group discussions were asked to opine on the effects of land use/land cover change on their livelihoods in Huluka Watershed. Similar perceptions were explored across the three streams of the watershed (upstream, midstream, and low stream). Accordingly, the discussants claimed the following negative effects: increased flooding risk; increased soil erosion; increased sedimentation into the lake (Dendi lake) and rivers (Huluka, Awaro, Debits, Boji, Bolo, Aleltu, Karkaro, and Korke); decrease in soil fertility resulting from flooding risk; and change in climatic parameters (decrease in annual rainfall and increase in heat during dry season). The same concern was also raised by all the key informants interviewed who contended that the land use/land cover change in Huluka watershed has negatively affected their livelihood underpinned by degradation of natural resources.

The participants of the focus group discussion were further asked to opine on the reciprocal cause-effect relationship between flooding risk and land use/land cover change in Huluka Watershed. The discussants affirmed that flooding risk in their watershed is highly linked to land use/land cover change as deforestation aggravate flooding caused by other factors. In other words, land areas without forest cover were claimed by the discussants to be much vulnerable to flooding. On the other hand, flooding risk in Huluka watershed was claimed to contribute for land use/land cover change in the watershed. Hence, reciprocal cause-effect relationship was claimed by the discussants to exist between flooding and land
use/land cover change in Huluka Watershed. The same concern was also raised by the key informants interviewed in the watershed.

Participants of the focus group discussion were also further asked to suggest effective adaptation measures for land use/land cover change in Huluka Watershed. Similar suggestions were explored across the three streams of the watershed (upstream, midstream, and low stream).

Accordingly, the following adaptation measures were suggested by the discussants: Compost preparation and use; practicing 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 appropriate institutional framework for forest and other natural resources’ management.

Participants of the focus group discussion were also further asked to opine on the strengths of the current community-based soil and water conservation measures practiced in their watershed. Similar perceptions on the strengths were explored across the three streams of the watershed (upstream, midstream, and low stream). Accordingly, the discussants identified the following strengths: increased soil fertility; healing of degraded land areas; conserved soil and water resources; reduced negative impacts of flooding risk on farmers’ livelihoods; increased yield from crop production; and improved social capital among local farmers and between farmers and agricultural development professionals.

Participants of the focus group discussion were also further asked to opine on the weaknesses of the current community-based soil and water conservation measures practiced in their Watershed. Similar perceptions on the weaknesses were explored across the three streams of the watershed (upstream, midstream, and low stream). Accordingly, the discussants identified the following weaknesses: poorly supervised and managed soil and water conservation measures; appropriate tree species were not planted on the established soil and water conservation structures; rehabilitation of degraded lands was not considered in the soil and water conservation measures practiced; Some soil and water conservation measures practiced had negative downstream impacts due to poor management; established soil and water conservation structures were not protected from interference of livestock; and non-structural soil and water conservation measures (land use planning, and awareness creation and education were not well integrated into the current community-based soil and water conservation practices).

4. Discussion

The decrease in the forest land use/land cover type by 59.3% between 1979 and 2017, the increase in cultivated land use/land cover type by 105.3% between 1979 and 2017, the increase in urban built-up area by 351% between 1979 and 2017, the decrease in shrub/bush land use/land cover type by 68.2% between 1979 and 2017, the increase in bare land use/land cover type by 41.9% between 1979 and 2017, the decrease in water body land use/land cover type by 5.1% between 1979 and 2017, and the decrease
in grassland land use/land cover type by 32.7% between 1979 and 2017 confirmed that there was dynamic land use/land cover change in Ambo town's watershed over 38 years (1979–2017) with implications for grave environmental and management issues.

Infrastructural expansion, agricultural expansion, increased demand for fuel wood and wood for construction, local environmental factors (examples: soil quality, topography, and land use/land cover), local biophysical drivers (examples: flooding and land use/land cover change), and local social events were confirmed to be perceived proximate causes of land use/land cover change in the watershed. On the other hand, demographic factors (examples: natural increase and migration of human population into the watershed), economic factors (examples: market growth and commercialization, urban expansion, and price increase), technological factors (examples: agro technical change, and agricultural production factors), policy and institutional factors (examples: formal policy and property right), and cultural factors (examples: public attitudes and beliefs and individual and household behavior) were confirmed to be perceived underlying causes of land use/land cover change in the watershed.

Increased flooding risk, increased soil erosion, increased sedimentation into the lake and rivers, decrease in soil fertility resulting from flooding risk, and change in climatic parameters (decrease in annual rainfall and increase in heat during dry season) were identified as the perceived major negative effects of land use/land cover change in the watershed.

The increase in urban built-up area land use/land cover by 351% over 38 years (1979–2017) has serious implication for urban development in the watershed in the years to come. Land use is closely related to the urban development process of rapid urbanization that takes place in most developing countries. The ways in which 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 may 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 has led 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). These urban challenges were also confirmed to affect the urban development process in Ambo town and its watershed. As the aforementioned challenges are underpinned by unplanned urban expansion, only sustainable land use planning and management and sustainable urban development are feasible solutions. Protecting land from urban expansion is claimed 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).
The increase in cultivated land use/land cover type by 105.3% over 38 years (1979–2017) in Ambo town’s watershed has serious implication for environmental and livelihood issues. For instance, the increase in cultivated land was at the expense of forest cover and bush/shrub land use/land cover and this affects the livelihoods of human population and other members of the ecosystem in the watershed. Scholars of sustainable development recommend integrated watershed management to address diverse water related issues in the watershed. To this end, sustainable land management (SLM) has vital contribution. The main objective of SLM is thus claimed 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 decrease in the forest land use/land cover type by 59.3%, the decrease in shrub/bush land use/land cover type by 68.2%, and the decrease in grassland land use/land cover type by 32.7% over 38 years (1979–2017) were confirmed in Ambo town’s watershed. This has serious implication for environmental issues like natural disasters in the watershed. For instance, deforestation and logging are regularly blamed for exacerbating the disastrous effects of floods generated by extreme rainfall. 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 because the trees 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, need forests to improve the human well-being of the urban population by creating green spaces. Besides this, forests provide multiple ecosystem services for people living in rural areas (Dessie & Tadesse, 2013). 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 & Tadesse, 2013).

The decrease in water body land use/land cover type by 5.1% over 38 years (1979–2017) was confirmed in Ambo town’s watershed. This has serious environmental implication in the watershed as ecosystem services from the water body (Dendi lake) is detrimentally affected by human induced and natural factors. Some of the ecosystem services water bodies like wetlands provide include: Habitat for aquatic birds, other animals and plants, fish and shell fish 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, sustainable wetland conservation and restoration policies and strategies should be integrated in sustainable local development and poverty alleviation policies and strategies as environmentally sound economic development is the basis for sustainable development that creates livelihood options and employment opportunities for current as well as future generations (Ogato, 2013b).
5. Conclusions

The purpose of the study was to analyze change in land use/land cover in Huluka watershed where Ambo town is situated and explore local perceptions on its causes and negative effects. Four period of satellite images were used to analyze the dynamics of change in land use/land cover in the watershed. To this end, Landsat TM and ETM + imagery for the periods 1979, 1984, 2009, and 2017 were used. 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 and ETM + imagery for the period, 1979–2017.

Forest area, cultivated land area, urban built-up area, bush/shrub land area, bare land area, grassland area, and water area were identified as the seven types of land use/land cover in the watershed. The overall decline of bush and shrub land, forest, grassland, and water land use/land cover type with 68.2%, 59.3%, 32.7%, and 5.1% respectively between 1979 and 2017 is bad news for the watershed as the potential of the watershed to contribute in mitigating flooding disaster risk decline with the decline of these land use/land cover types. Moreover, the overall increase of urban built-up area, cultivated land, and bare land use/land cover type with 351%, 105%, and 41.9% respectively between the year 1979 and 2017 implies the increase in flooding disaster risk in the watershed as such land use/land cover types exacerbate the run-off conditions in the watershed.

Infrastructural expansion, agricultural expansion, increased demand for fuel wood and wood for construction, local environmental factors (examples: soil quality, topography, and land use/land cover), local biophysical drivers (examples: flooding and land use/land cover change), and local social events were confirmed to be perceived proximate causes of land use/land cover change in the watershed. On the other hand, demographic factors (examples: natural increase and migration of human population into the watershed), economic factors (examples: market growth and commercialization, urban expansion, and price increase), technological factors (examples: agro technical change, and agricultural production factors), policy and institutional factors (examples: formal policy and property right), and cultural factors (examples: public attitudes and beliefs and individual and household behavior) were confirmed to be perceived underlying causes of land use/land cover change in the watershed.

Increased flooding risk, increased soil erosion, increased sedimentation into the lake and rivers, decrease in soil fertility resulting from flooding risk, and change in climatic parameters (decrease in annual rainfall and increase in heat during dry season) were identified as the perceived major negative effects of land use/land cover change in the watershed.

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

- Appropriate land use planning and management in the watershed should be practiced to reduce the negative effects of land use/land cover change in the watershed.
- Appropriate environmental impact assessment (EIA) should be conducted prior to 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.

**Declarations**

**Ethics approval and consent to participate**

'Not applicable'

**Consent for publication**

'Not applicable'

**Availability of data and material**

'Not applicable'

**Competing interests**

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Authors' contributions

Data were collected and analyzed by the first and corresponding author. Writing had been substantially contributed by the first and corresponding author. The second and third authors had been involved in critically advising, revising the manuscript and made possible suggestions for improving the quality of the manuscript. All authors read and approved the final manuscript.

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**Figures**

**Figure 1**

Geographical location of Huluka watershed
Figure 1

Geographical location of Huluka watershed
Figure 2

Elevation, slope, soil type, and rainfall distribution of Huluka watershed
Figure 2

Elevation, slope, soil type, and rainfall distribution of Huluka watershed
Figure 3

Land use/land cover Maps of Huluka Watershed for 1979 and 1984
Figure 3

Land use/land cover Maps of Huluka Watershed for 1979 and 1984
Figure 4

Land use/land cover Maps of Huluka Watershed for 2009 and 2017.
Figure 4

Land use/land cover Maps of Huluka Watershed for 2009 and 2017.

Figure 5

Land use/land cover Maps of Huluka Watershed for 2009 and 2017.
Figure 5

Land use/land cover Maps of Huluka Watershed for 2009 and 2017.

Figure 6

Agricultural Practices in Huluka Watershed (Source: Personal observation, 2015).
Figure 6

Agricultural Practices in Huluka Watershed (Source: Personal observation, 2015).

Figure 7

Practices related to increased demand for fuel wood and construction in Ambo town (Source: Personal observation, 2015).
Figure 8

Local soil type at downstream of Hulukawatershed (Left) and degraded hilly area at upstream of Huluka Watershed (right) (Source: Personal observation, 2015).

Figure 8

Local soil type at downstream of Hulukawatershed (Left) and degraded hilly area at upstream of Huluka Watershed (right) (Source: Personal observation, 2015).
Figure 9

Highly eroded area at Upstream (left) and flooded area at downstream of Huluka Watershed (right) (Source: Personal observation, 2015).

Figure 9

Highly eroded area at Upstream (left) and flooded area at downstream of Huluka Watershed (right) (Source: Personal observation, 2015).
Figure 10

Human settlement around Dendi Lake-Upstream of Huluka Watershed (Source: Personal Observation, 2015).
Figure 11

Ambo construction stone mining area at Sinkile Village, Ambo town-downstream of Huluka Watershed (Source: Personal observation, 2015).
Figure 12

Contour farming practice at Upstream of Huluka watershed (Source: Personal observation, 2015).