Impact of land use and land cover on ecosystem service values in Sekela Woreda, Amhara Region, North-Western Ethiopia

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Received: 05 November 2024 / Accepted: 16 August 2025

Abstract. Land use and land cover are important factors affecting ecosystem services through alteration of the natural environment. The purpose of this study was to assess the impact of changes in land use and land cover (LULC) on ecosystem service values (ESV) in Sekela Woreda. As part of the study, the spatial and temporal dynamics of LULC over the last three decades were analysed. Using ArcGIS 10.6 software, ESVs were obtained for each LULC class. The results of the research show that during the study period, there were changes in land use and land cover in the study area, with agricultural land declining by 4,079.66 ha (–14.98 %) and water bodies by 125.15 ha (–45%), while the area of wasteland, scrubland, woodlands and water bodies increased by 2670.57 ha (7.9%), 363.78 ha (3.87%) and woodlands by 1169.62 (3.22%), respectively. The research has shown that changes in land use and land cover have resulted in a decrease in ESVs of 0.865686 over the last 30 years (1985–2015). Consequently, LULC has had a negative impact on ecosystem services and functions over the past 30 years. Therefore, in order to manage ecosystems in this area in a sustainable manner, it is necessary to protect natural resources and take appropriate intervention measures.

Keywords: land use land cover, ecosystem services, Land cover changes, Landsat, satellite imagery.

1. Background of Study

Land use land cover (LULC) changes are one of the main factors in global environmental change (Fu Q. et al., 2017). LULC changes directly affect the welfare of the community through changes in environmental conditions, such as land degradation (Sánchez-Cuervo et al., 2012) and ecosystem services value (ESV) (Fu B. & Forsius M., 2015). Contemporary at global level modification of LULC has been widely recognized as one of the predominant factor of deprivation in ecosystem services (Costanza et al., 2014; Kubiszewski et al., 2017). The fast growing population and its increased socioeconomic demand have put pressure on LULCC not only in unprotected lands (Xu et al., 2019). Land use land cover change is one of the main drivers of degradation in ecosystem goods and services (Admasu S. et al., 2023).

The changes of status LULC have been increasing at both macro and micro scale in the world that inducing negative impact on biophysical systems (Foley et al., 2005). It has a larger influence on natural ecosystems and intensify human exposure to climate related hazard and socioeconomic crises (Lin et al., 2018). In the past centuries, the Earth's biosphere has been altered from a predominantly natural to most of man-made environment .The main reason for this alteration of natural environment is the land use and land cover change in addition to this inappropriately use of natural resources has been resulted radical loss of biodiversity (Fang et al., 2022). There are different socio-economic and environmental factors that are responsible for land use land cover change at different level (Gong et al., 2015).The presence of land use and land cover (LULC) changes is result of artificial activities that have modified the land surface different social and economic courses, affects ecosystem functions as well as stability of biodiversity (Marino et al., 2021). The land use and land cover (LULC) changes driven by the growing demands of mankind have a considerable effect on ecosystem services and functions (Muche et al., 2023). The concept of Land use and land cover (LULC) mostly used interchangeably used but two terms have very different connotations. Concept of Land use narrates the purpose of the land, other hand land cover denotes to the ground's surface cover biotic and abiotic components (Fisher et al., 2009, cited after Belay et al., 2022).

The change that occurs in land uses mainly related to deforestation that eventually affects the livelihoods of rural communities who are mainly dependent on forest resources for different purposes. Impacts of land use change on ecosystem services of forests and its implication for sustainable development vary across spatial, temporal and different groups who depend on this resource (Fei et al., 2018; Leitão et al., 2019). Ecosystems provide a wide range of functions and services essential for human well-being at various levels (Leitão et al., 2019).Ecosystems not only give provision services but also, it, provide regulating and supporting services which is critical for human well-being, health, livelihoods, and survival (Santos-Martín et al., 2013; Kumar et al., 2013). Land use and cover (LUC) changes are one of the main factors in global environmental change. It directly affects the welfare of society through changes in environmental conditions, such as land degradation and ecosystem services value (ESV). These ecosystem services have a large impact on quality of life (Achmad et al., 2020).

Ecosystems provide a variety of services to humans, including supplying provisions, regulation, support, and cultural significance. The provision of these services is determined by the structure, processes, and functions of these ecosystems (Yu & Bi, 2011). Changes in land use and land cover (LULC) are caused by several factors, including climate change, socio-demographic dynamics, human pressures and urban sprawl. These factors alter the structure and functionality of ecosystems and their capacity to provide ecosystem goods and services to society (Marino et al., 2023).Ecosystems are the basis for fabrication of different functions and services that are essential for human existence and wellbeing (Muleta et al.,2020). Ecosystem service changes caused by land use and land cover change (LULCC) is an important indictor and early warning of ecological changes (Belay et al., 2022).Ecosystems gives multiple services for supporting life on earth with changeable degrees based on the productive capacity of the ecosystems themselves at different area (Shifaw et al., 2019).

Ecosystem services are the multiple benefits human beings obtain directly or indirectly from ecosystems. These services include provisioning, regulating, supporting and cultural values (2005; Xie et al., 2015; Xu et al., 2019; Aneseyee et al., 2019). Land use/land cover (LULC) change is mainly caused by anthropogenic activities and it is one of the major causes leading to declining of the ES, driven by deforestation, expansion of agriculture, settlements, built-up areas, and mining (Kindu et al., 2016; Tolessa et al., 2017).

Land Use/Land Cover (LULC) changes alter the ecosystem structure and function, resulting in variations of the Ecosystem Service Values (ESVs) (Rotich et al., 2022). Ecosystem services refer to the benefits that humans derive from natural ecosystems and their components, including provisioning services (e.g., food), regulating services (e.g., carbon storage and sequestration), supporting services (e.g., habitat), and cultural services (e.g., aesthetic) (Qiu et al., 2021). Human well-being and the functioning of the global economy depend on ecosystem services, but these services are under threat because of the intricate interplays between people and the environment, which result in ecosystem degradation and biodiversity loss (Yin et al., 2022).

Ecosystems provide a wide range of valuable goods and services that contribute to supporting nature and human well-being. These goods and services that are commonly known as ecosystem services (ES) are categorized into provisioning (e.g., marketable goods), supporting (e.g., nutrient cycling), regulating (e.g., water and soil regulation), and cultural services (e.g., recreational and aesthetic values). These services maintain the ecological processes and functions and provide resources to support the life of all organisms. Depending upon the type and conditions, ecosystems deliver unique sets of services with varying quality and quantity. For instance, a forest ecosystem provides a different set of services than grassland or aquatic ecosystem (Costanza et al., 1997). Numerous studies have examined LULC shifts, their causes, and the consequent degradation of natural resources at the national, regional, and watershed levels in various regions of Ethiopia. Nonetheless, there exists a notable disparity about the degree of study, intent, and result of these investigations. Furthermore, the majority of them fail to take into account how LULC affects ecosystem services. Thus, area-specific knowledge of LULC dynamics is crucial for understanding how land use cover changes and how they affect ecosystem services, which is necessary to put the right policies in place. Investigating the amount and pace of LULC change and its effects on ecosystem services in the Sekela *Woreda* is the main goal of this study.

2. Materials and Methods

2.1. Description of the Study Area

Ten woredas make up the West Gojjam Administrative Zone, including Sekela *Woreda*. It is situated between 37° 00′00′ and 37° 20′ 00′ E and between 10°50′ 00″ and 11° 00′ 00″N and E (Fig. 1). It shared borders with JibieTehnan *Woreda* in the southeast, Burie *Woreda* in the southwest, Guagusa Guagusa *Woreda* in the west, Mecha Woreda in the north, Yilimana Densa *Woreda* in the northeast, and Quarit *Woreda* in the east. There are 28 Kebeles in Sekela *Woreda* (27 rural and 1 urban). The *woreda* is predicted to have a total population of 145631, of which 73168 (50.2%) are female and 72403 (49.8%) are male (CSA, 2013). Sekela *Woreda* has a landscape that is rocky and hilly, with elevation ranging between 1920 and 3533 meters above sea level. Approximately 65% of the *woreda* is covered by rugged mountainous and hills, 25% is covered by deeply dissected gorges and valleys and only 10% of the land is flat (SWARDO, 2023).

According to SWARDO (2023), *Woreda*'s mean annual temperature is around 18°C and its mean annual rainfall is approximately 1700 mm. The region experiences monomodal rainfall, with the rainy season lasting from June to September. The research region is divided into two agro-climatic zones according to height and temperature differential. These are Woynadega, which makes up 30% of the area, and Dega, which makes up 70% of the entire region (SWARDO, 2023).

Sekela *Woreda* has an estimated 77,009.49 hectares in total, of which 40,991.04 ha (53.23%) are arable land, 19,097.1 ha (24.8%) are forestland, comprising both forests and shrubs, and 16,780.05 ha (21.79%) are unproductive areas. 141.3 (0.18%) were covered by water bodies. *Erythrina brucei* (Korch), *Croton macrostachyus* (Bisana), *Albizia gummifera* (Sesa), *Juniperus procera* (Yehabesha Tid), *Podocarpus falcatus* (Zigba), *Cordia africana* (Wanza), *Augaria salicifolia* (Koba), *Acanthus* sp. (Koshishila), and *Carissa spinarum* (Agam) are a few of the major indigenous trees and shrub species that are still present in the study area.

Important exotic tree species may also be found in the region, including Decurens (SWARDO, 2023), *Cupressus lustianica* (Yefernge Tid), *Eucalyptus globulus* (Nechbahirzaf), and *Eucalyptus camaldulensis* (Key bahirzaf). Crop cultivation and livestock rearing together form the woreda's mixed agricultural system, which is its primary source of income. Barley (*Hordeum vulgare*), wheat (*Triticum aestivum*), teff (*Eragrostis tef*), maize (*Zea mays*), sorghum (*Sorghum bicolor*), and other cereal crops are the main crops grown in the region. In the region, root crops including potatoes (*Solanum tuberosum*) and onions (*Allium cepa*) are flourishing. In addition, pulses like *Phaseolus vulgaris* and *Pisum sativum* are being cultivated.

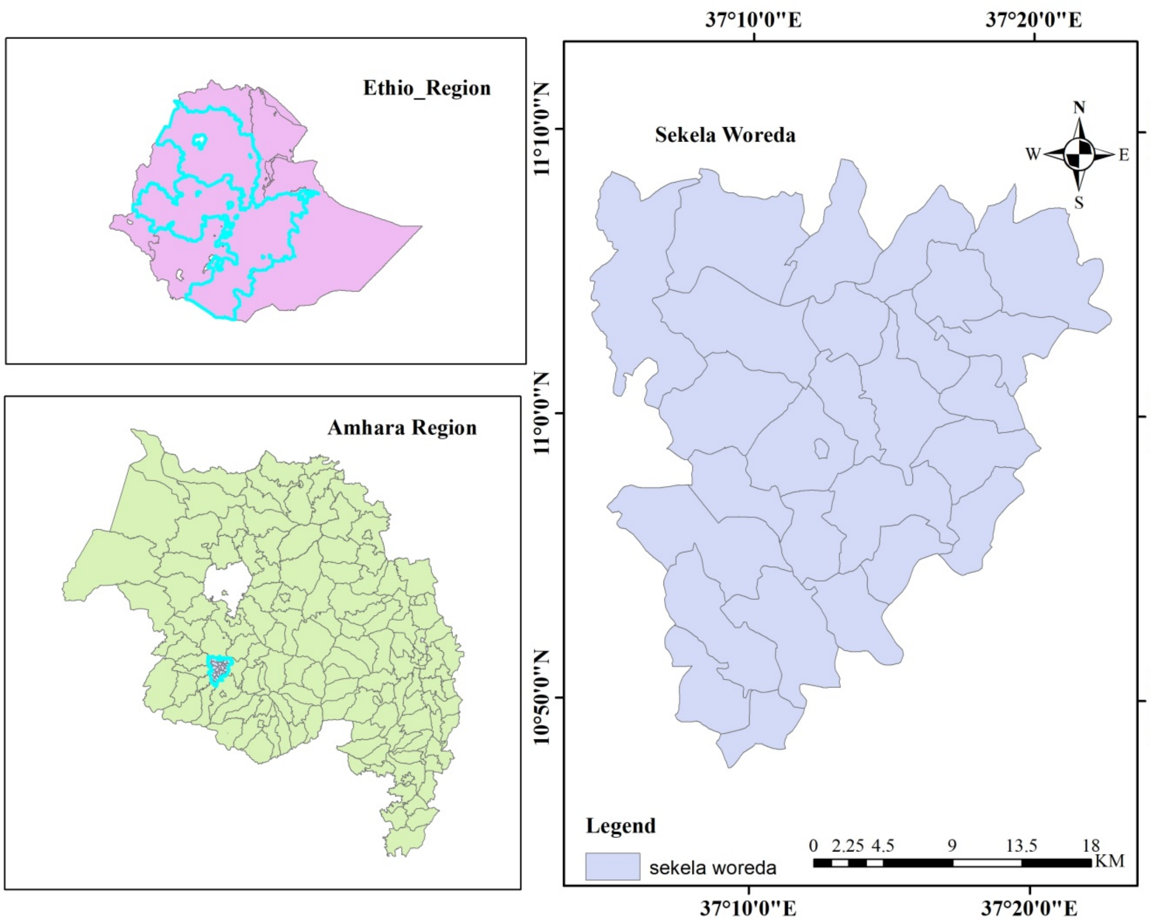


Figure 1. Study area map

2.2. Data Collection Methods

Time series Landsat satellite pictures (1959, 2000, and 2015) were acquired and downloaded from (USGS, https://www.usgs.gov/) in order to examine the patterns of land use and land cover in the study area. During the January–February dry season, all of the satellite photos are downloaded.

Using ArcGIS 10.6 software, the satellite image preprocessing and band combination were completed prior to the primary classification. The field data collecting methods used for the sample training regions for LULC classification and accuracy evaluation included hand-held GPS data collection, interviews, Google Earth, and previously gathered secondary data sources.

2.3. Data type and sources

The impact of the study area's changing land cover on ecosystem services was assessed through the analysis of satellite photographs. United States Geological Survey (USGS) website (https://earthexplorer.usgs.gov/) offers free access to land-sat satellite imagery. Data collected between 1985, 2000, and 2015 at regular intervals of 15 years (Table 1). Every satellite captured in January and February. Spatial resolution 30x30 m is achieved in these satellite photos.

Table 1. Land sat data used for land cover change analysis.

Year	Sensors	Path and Row	Bands	Pixel/ground resolution (m)	Observation Date
1985	Landsat 5 ETM*	P170 R052	Band 4 (NIR***) Band 3 (Red)	30x30	January 1, 1985
2000	Landsat 7ETM+**	P170 R052	Band 4 (NIR) Band 3 (Red)	30x30	January 4, 2000
2015	Landsat 8	P170 R052	Band 5 (NIR) Band 4 (Red)	30x30	February 21, 2015

Note: ETM* = enhanced thematic mapper, ETM+** = enhanced thematic mapper pulse, NIR***= Near Infrared.

2.4. Data Analysis Methods

2.4.1. Land Use Land Cover Classification and Change Detection Analysis

A sufficient number of sample training regions from each LULC category of each year were gathered after image preprocessing and band combination. Using the ArcGIS 10.6 software's supervised classification Maximum Likelihood classification algorithm, satellite pictures from each year were divided into five LULC categories (wood land, bush land, agricultural land, barren land, and water bodies) based on the sample training regions. For this kind of classification, the researcher must choose training areas to serve as the classification's foundation. Maximum Likelihood Classification computes the probability that a given pixel belongs to a certain class under the assumption that the statistics for each class in each band are normally distributed.

Using reference field data, the accuracy of the LULC classification was assessed in terms of producer, user overall accuracy, and Kappa coefficient. For each LULC category, Google Earth-Pro photos and around 40–50 ground truth points were gathered in the field for the purpose of image classification (Rawat & Kumar, 2015). In a similar vein, 30–40 ground truth data for every type of LULC were gathered for accuracy evaluation, taking into account their area coverage within the research region. An accuracy evaluation of the categorization picture verified that it met the necessary accuracy requirements with an overall accuracy of 85% for the years 1985 (86.61%), 2000 (86.1%), and 2015 (89.89%). Following the annual LULC categorization, a 30-year LULC change detection analysis was conducted using the following formula used by (Deka et al., 2019):

$$K= \frac{Ai-AF}{Ai} \text{ x } 100\%; \; C = \frac{K}{T} \quad \ldots\ldots (1)$$

where: K is the percentage of change in area of a land use and Ai and AF indicates the initial and final area of the land use taken into account. C is the land use dynamic degree of a given land use within the study period and T is the time period in years. LULC change detection matrixes were used to illustrate the direction and area of difference in LULC change in the give time (1985-2015).

2.4.2. Estimation of ecosystem service values

There different methods were established and used for assessment of ecosystem service valuation. From diverse approaches used for ecosystem service valuation methods one is market-based valuation approach that includes market price approach, cost-based approach and production function approach, revealed preference approach that include travel cost method and hedonic pricing, and stated preference approach including contingent valuation method and choice modeling (Deka et al., 2019). Ecosystem values for 11 biomes were developed by Kindu et al. (2016) and numerous other scholars. In this study, the benefit transfer approach was used to assess the ESVs in the area based on the global value coefficients or modified value coefficients for the target LULC types developed by other scholars, particularly in areas with limited data. The modification of ES value coefficients was carried out based on the benefit transfer (BT) approach, which is defined as the adaptation of existing values or data from one site to estimate the ESVs of other new similar sites in the absence of the site-specific valuation information (Aligas et al., 2023; Kindu et al., 2016). The relevant area in hectares is evaluated and shown in a raster in the ArcGIS 10.6 program. The LULC datasets for each year, which are utilized as proxies for the measurement of the ESVs, were created. Each LULC type is given a value coefficient throughout the ESV process. According to the following table (Table 2), which was used by (Aligas et al., 2023; Deka et al., 2019; Kindu et al., 2016), the total value of ecosystem services in the study area for each year was calculated by multiplying the area of a given LULC type with the corresponding modified ecosystem service value coefficients that are extracted from weight factors of the ecosystem services per hectare of each biome

$$\text{ESV}= \sum(A_{K\times V_{Ck}}) \tag{2}$$

where ESV = the total estimated ecosystem service value, Ak = the area (ha) and VCk = the value coefficient (US$ ha^{-1} $year^{-1}$) for LULC type ‘k’.

Table 2. LULC class, their biome and valuation coefficients used for ecosystem services.

LULC categories	Equivalent Biome	ESV coefficients in US$/ha^{-1}/year^{-1}
Cultivated lands	Cropland	225.56
Bush lands	Shrub lands	969
Bare lands	Urban	0
Water body	Water body	8103.30
Wood lands	Tropical forest	986.69

Sources: Assefa et al. (2021), Kindu et al. (2016).

Ecosystem services are often divided into four categories: provision, regulation, support, and cultural services. As a result, in addition to the equations above, the ecosystem values supplied by the various functions in the research region and year were also determined using Equation 3, which is shown in Table 3 and is utilized by Aligas et al. (2023), Msofe et al. (2020), and Abdurahman et al. (2023).

$$\text{ESVf}= \sum(\text{Ak x VCfk}) \quad\ldots\ldots\ldots\ldots \tag{3}$$

where ESVf is the estimated ecosystem service value of function f, A_k is the area (ha) and VC_{fk} is the value coefficient of the function f (US$ ha^{-1} $year^{-1}$) for LULC category ‘k’.

Table 3. LULC categories and their corresponding ecosystem sub-service function values.

Ecosystem service	Biome and ESV coefficients in USD/ha^{-1}/year^{-1}				
	Water body	Forest	Grass	Bush lands	Bare land
Provision service					
Water supply	280.73	8.00	117.45		

Food production	171.10	32.00		187.56	
Raw materials	198.54	51.24			
Genetic resource	45.64	41.00			
Medicinal resources	33.10				
Regulating services					
Water regulation	981.84	6.00	3.00		
Waste treatment	1153.95	136.00	87.00		
Erosion control	63.14	145.00	29.00		
Climate regulation	208.36	223.00			
Biological control			23.00	24.00	
Gas regulation	67.35	13.68	7.00		
Disturbance regulation		5.00			
Supporting services					
Nutrient cycling	103.72	184.40	25.00		
Pollination		7.27	10.00	12.00	
Soil formation	48.50	10.00			
Habitat	716.51	17.30			
Cultural services					
Recreation	76.89	4.8			
Culture	54.65	2.00	0.80		
Total	4204.02	986.69	293.25	225.56	0.00

Source: Value coefficients adopted from Kindu et al. (2016).

Calculating the discrepancies between the estimated values for each LULC category using the provided formula (Equation 4) allowed for the determination of the change in ecosystem services in the research region throughout the specified period. Percentage of ESV

Change = $\left(\frac{ESVt2 - ESVt1}{ESVt1}\right) \times 100$………………………………………………………………... (4)

where ESVt2 (US$ ha^{-1} $year^{-1}$) = the estimated ecosystem service value in the most recent year, and ESVt1 (US$ ha^{-1} $year^{-1}$) = the estimated ecosystem service value in the previous year. Positive values suggest an increase in the ESVs, whereas negative values imply a decrease in the ESVs.

2.3.3. Ecosystem servce sensitivity analysis

There are situations where the LULC types and matching coefficient values match exactly. Sensitivity analysis is therefore necessary to verify the change in the proportion of ecosystem services across the research period. Every LULC type's coefficient was changed. As a result, the sensitivity coefficient was determined using Equation 5, which is displayed below.

$$CS = \frac{(ESVj - ESVi1)/\mathrm{ESVi}}{VCjk - VCik/VCik} \quad (5)$$

where, ESV is estimated ecosystem service value, VC is the value coefficient, i and k the initial and adjusted values respectively, and k is the LULC class. The sensitivity coefficient is always below 1, which indicates the most critical accuracy of ecosystem service value index.

3. Result and Discussion

This section presents the trends of land use land cover change, the impact of land use land cover change on ecosystem services in the study area.

3.1. Land Cover Changes for the Period 1985-2015

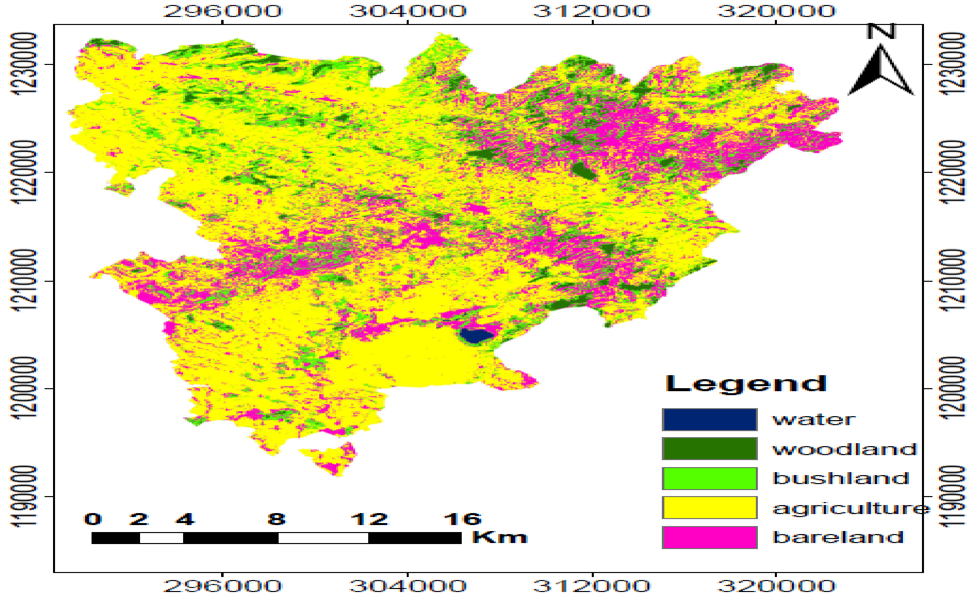
Five main land cover categories were found by applying the supervised image classification algorithm to land satellite photos from the years 1985, 2000, and 2015.These consist of agricultural terrain, barren ground, woodland, bush land, and bodies of water.

Table 4. Land covers classification.

Land cover classes	Land cover description
Woodland	Vegetation or trees covered around 5m in height and denser than bush/shrubs land and the area coverage is more than one hectare
Bush land	Land covered by small trees, bushes and scattered trees (less dense than woodlands)
Agricultural land	Areas allocated to all types of agricultural production
Bare land	Land surface which is mainly covered by bare soil and grazing lands land and both urban towns and rural villages
Water body	Include lakes, rivers and streams

The land cover groups of agriculture and barren lands had the greatest coverage in 1985, with 45,071.01 ha (58.53 %) and 14,109.48 ha (18.32 %), respectively, as seen below in Figure 3A and Table 4. The least amount of land was shared by water bodies, 7,701.39 ha (10%), 9,860.31 ha (12.8%), and bush lands, which made up 267.3 ha (0.35%) of the total land use land cover respectively. The result is in line with that of (Hagos et al., 2023), the largest Land use land cover change classes were occupied by cultivated land in the case of *S*uluh River Basin, Northern Highland Part of Ethiopia.

A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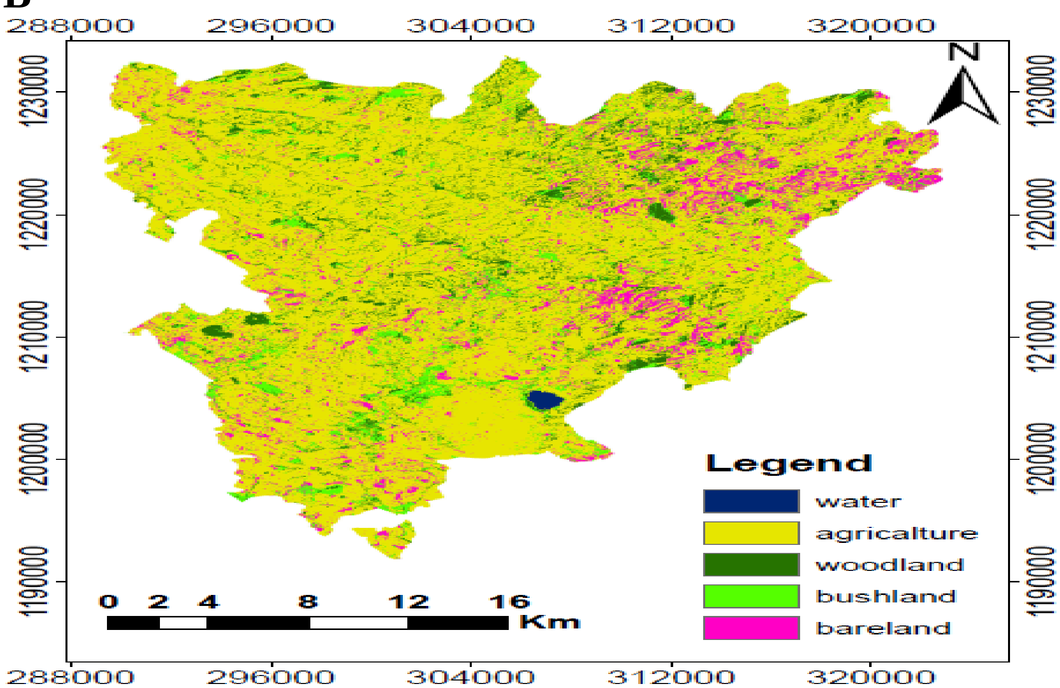
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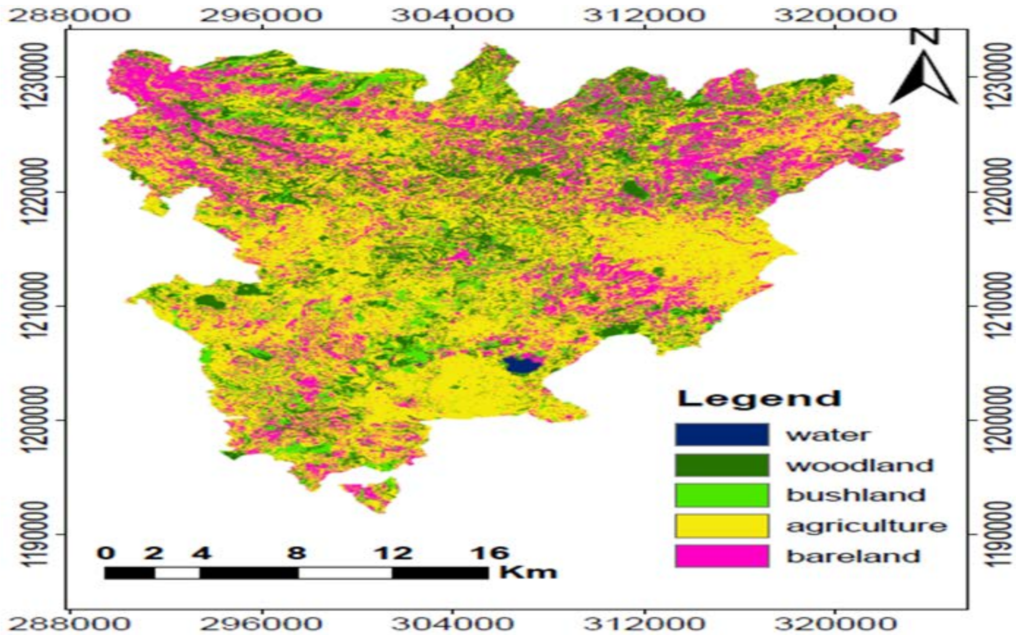

Figure 2. Land cover changes of Sekela Woreda: A - in 1985, B - in in 2000 (Source: Landsat 7^{ETM+} (2000)), C - in 2015 (Source: Landsat 8 (2015))

Table 5. Sekela *Woreda* land covers type in 1985.

Land cover type	Area in hectare	Percentage
Agricultural lands	45,071.01	58.53
Bare lands	14,109.48	18.32
Bush lands	9,860.31	12.80
Wood lands	7,701.39	10.00
Water bodies	267.30	0.35
Total	77,009.49	100.00

Source: Land sat 5^{ETM} (1985).

Likewise, as seen in (Fig. 2B and Table 6), the satellite data from 2000 revealed that, comprising 52,532.8 ha (68.21%) of the study area, agricultural which had the greatest coverage. While water bodies made up 145.15ha (0.19%) that list area coverage bare lands 10,691.42 ha (13.89%), forests 6,394.7 ha (8.3%), and shrub lands shared 7,246.42 ha (9.41%).

Table 6. Sekela *Woreda* land covers type in 2000.

Land cover type	Area in hectare	Percentage
Agricultural lands	52,532.80	68.21
Bare lands	10,691.42	13.89

Bush lands	7,246.42	9.41
wood lands	6,393.70	8.30
water body	145.15	0.19
Total	7,009.49	100.00

Source: Landsat 7^{ETM+} (2000).

The satellite data from 2015, which was displayed in Figures 2C and Table 7, also showed that agricultural land had the maximum coverage, accounting for 40,991.04 ha (53.23%) of the study area. On the other hand, 16,780.05 ha (21.79%), 10,224.09 ha (13.28%), 8,873.01 ha (11.52%), and 141.3 ha (0.18%) were inhabited by bare land, shrub land, woodland, and water bodies, respectively.

Table 7. Sekela *Woreda* land covers type in 2015.

Land cover type	**Area in hectare**	**Percentage**
Agricultural lands	40,991.04	53.23
Bare lands	16,780.05	21.79
Bush lands	10,224.09	13.28
Wood lands	8,873.01	11.52
Water body	141.30	0.18
Total	77,009.49	100.00

Source: Landstat 8 (2015).

According to satellite data collected between 1985 and 2000, the coverage of agricultural fields expanded from 45,071.01 ha in 1985 to 52,532.8 ha in 2000, a 9.68% growth, with an annual mean change rate of 497.45 ha (0.65%) each year. On the other hand, at an annual mean change rate of 227.87 hectares per year, the covering of bare lands decreased by 3,418.06 ha (4.43%). Similar reductions were made to bush lands, forests, and water bodies, totaling 2,613.89 ha (3.39%), 1,307.69 ha (1.7%), and 122.15 ha (0.16%), with corresponding annual mean changing rates of 174.26 ha, 87.18 ha, and 8.14 ha. This finding showed that, overall, over these times, 13,495.3 ha (9.86%) of land covers changed from being woods, bushes, and barren areas to agricultural fields. These findings suggest that there were increases in agricultural production throughout this time.

Satellite data shows that the amount of agricultural land covered dropped by 11,541.76 ha (14.98%) between 2000 and 2015, with an annual mean changing rate of 769.45ha (1%), throughout that time. Water bodies also decreased by 3.85 hectares. With an annual mean change rate of 405.91 ha, 198.51 ha, and 165.29 ha per year, respectively, the covering of bare lands, shrub lands, and forests rose by 6,088.63 ha (7.9%), 2,977.67 ha (3.87%), and 2,479.31 ha (3.22%) as shown in Table 8 and 9 and Figure 6.

Table 8. Land coverage (in ha) for the period 1985, 2000 and 2015.

Years	Agricultural lands	Bare lands	Bush lands	Woodlands	Water bodies
1985	45,071.01	14,109.48	9,860.31	7701.39	267.30
2000	52,532.80	10,691.42	7,246.42	6393.70	145.15
2015	40,991.04	16,780.05	10,224.09	8873.01	141.30

Sources: own computed from satellite data, 2024.

Table 9. Land Cover Changes for the period 1985-2015.

	1985-2000		2000-2015		1985-2015
Land cover type	**Area in ha**	**Percentage**	**Area in ha**	**Percentage**	**Area in ha**
Agricultural lands	7,461.79	9.68	-11,541.76	-14.98	-4,079.966
Bare lands	-3,418.06	-4.43	6,088.63	7.90	2,670.57
Bush lands	-2,613.89	-3.39	2,977.67	3.87	363.78
wood lands	-1,307.69	-1.70	2,479.31	3.22	1,169.62
water bodies	-122.15	-0.16	-3.85	-0.01	126.00

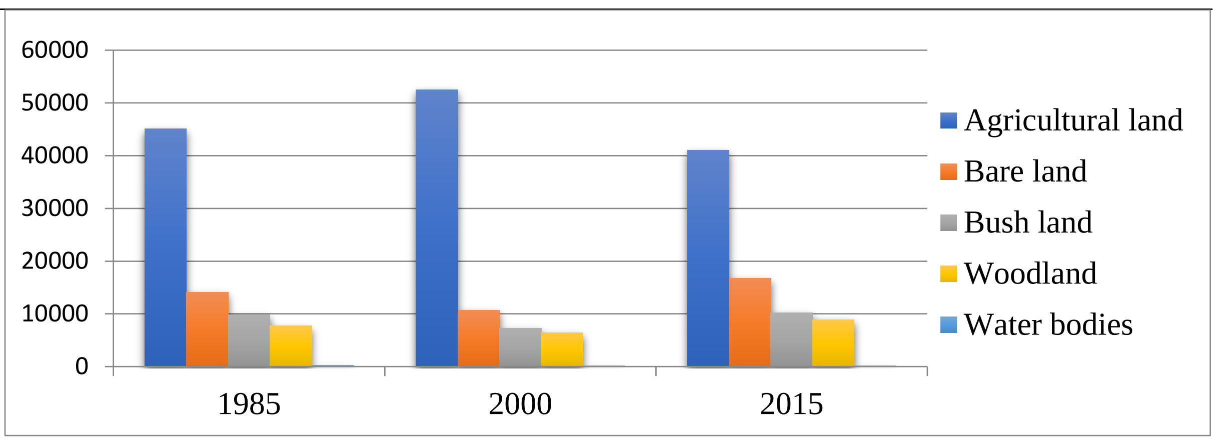

Figure 3. Land cover changes of Sekela *Woreda* in 1985, 2000, 2015

3.3. Ecosystem Service Valuation and Change in Ecosystem Service Values

The study area's ESVs varied over time due to the dynamics of LULC in the area, as determined by the total ESVs, which were derived from the LULC pattern of the study area (Aligas et al., 2023; Assefa et al., 2021). The Table (10) showed the changes in LULC and the corresponding ESVs in the last 30 years of Sekela Woreda.

As a result, the total estimated (ESVs) of Sekela Woreda were 29.485753 USD in 1985, 26.355872 million USD in 2000, and 29.052988 million USD in 2015, as shown in Table 9. According to Table 10, the Woreda total ecosystem value (TEVs) declined by 3.129837 million USD between 1985 and 2000, from 2000 to 2015 total ecosystem value rose by 2.696916 million USD between on other hand, from 1985 and 2015 it decreased by 0.432765 million USD. Average ecosystem value over the previous 30 years deteriorated by 0.865686 million USD. The results of (Aligas et al., 2023; Assefa et al., 2021; Gashaw et al., 2018) are consistent with this one (Admasu et al., 2023) who conducted study Dire and Legedadi watersheds on the Impact of land use land cover changes on ecosystem service values concluded that there is overall decreased of ESVs in watersheds during the study period as a result of the loss of important natural habitats, particularly natural forest, and grassland habitats. The Figure 4 below displayed the change in ESVs over time from various LULCs (biomes).

Table 10. Total estimated ecosystem service values for each land use and land cover.

LULC class	ESV (US$ million)			ESV (US$ million)		
	1985	**2000**	**2015**	**1985-2000**	**2000-2015**	**1985-2015**
Agriculture	10.166217	11.849298	9.245939	1.683081	-2.603359	-0.920278
Bare lands	0	0	0	0	0	0
Bush lands	9.554640	7.021781	9.907143	-2.532859	2.885362	0.352503
Woodlands	7.598884	6.308599	8.754910	-1.290241	2.446311	1.156026
Water bodies	2.166012	1.176194	1.144996	-0.989818	-0.031198	-1.021016
Total	29.485753	26.355872	29.052988	-3.129837	2.696916	-0.432765

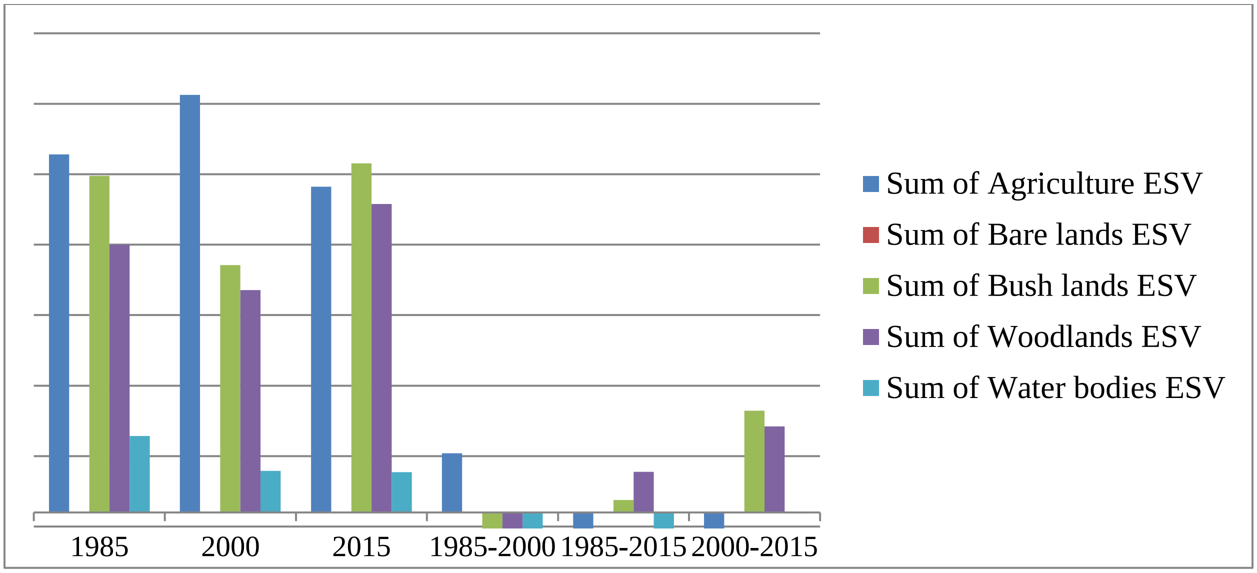

Figure 4. Sum of ecosystem services based on land cover.

According to ESV results, the amount of ecosystem services in the study area decreased between 1985 and 2000 and between 1985 and 2015 due to changes in land use and land cover. However, between 2000 and 2015, there was an increase in total ecosystem services of 55.23% due to the expansion of woodland land cover. The ESVs of cultivated land, wood land, bush land, and water body have changed by 15.78%, -16.97%, -26.50%, and -45.69%, respectively, between 1985 and 2000; between 2000 and 2015, there was a -21.97%, 38.77%, 41.08%, and -2.65% change in the ecosystem services ESVs for cultivated land, wood land, bush land, and water body, respectively. These changes are the result of changes in the LULC category, which influences the characteristics of ecosystem services ESVs. Table 11 shows the ESVs for the town during the preceding thirty years. The result is in line with the conclusions of earlier research (Assefa et al., 2021; Gashaw et al., 2018), which found that between 1984 and 2019, the LULC shift reduced the ecological values of Bahir Dar city by 8.92 million USD. Similar studies confirmed that changes in land use and cover have a major influence on ecosystem services (Mariye et al., 2022). The notion that ecosystem services in the study region are diminished as a result of land conversion to various land use land covers was also validated by another study carried out in Nepal (Shrestha & Acharya, 2021). Therefore, a major factor in the decline of ecosystem services in Sekela Woreda has been the frequency of land use and land cover changes.

Table 11. Changes of ecosystem services in % across the years.

LULC- type	1985-2000	2000-2015	1985-2015

	% Change of ESV in million USD	% Change of ESV in million USD	% Change of ESV in million USD
Cultivated land	15.78%	-21.97%	-9.05%
Wood land	-16.97%	38.77%	15.21%
Bush land	-26.50%	41.08%	3.68%
Bare land	0.00%	0.00%	0.00%
Water body	-45.69%	-2.65%	-47.13%
Total	-39.62%	55.23%	-37.29%

3.4. Impacts of Land Use Land Cover on Individual Ecosystem

Table 12 presented below shows the effects of LULC modification in Sekela Woreda on specific ecosystem service functions based on data analysis. The table shows that the amount of land cover change in the research region has an impact on the ESVs for each function over time. The studied years saw a 1.082248 USD decline in the provision of services. In light of this, between 1985 and 2015, regulation services climbed by 0.318725 USD, supporting services increased by 0.084471 USD and cultural services fell by -0.42028 USD. As a result, according to the study's findings, ecosystem services are significantly impacted by changes in land use and cover in the studied region. These results are consistent with those of previous studies, including (Mariye et al., 2022; Sharma et al., 2019). It has been verified in each research region that changes in land use and cover have led to a drop in ecosystem service functions. On the other hand, research (Awoke & Debie, 2023) demonstrated that proper soil and water conservation techniques can enhance ecosystem service functions.

Table 12. Impacts of Land Use Land Cover on Individual Ecosystem.

Individual ES Function	**Individual Ecosystem Services Functions across period (1985-2015)**			
	1985	**2000**	**2015**	**Over all changes in ES function in USD**
Provision services	**4.092860**	**2.821731**	**3.0106012**	**-1.082248**
Water supply	1.294628	0.943425	1.311270	0.016642
Food production	1.137514	1.204442	0.799639	-0.337875

Raw materials	0.447688	0.357454	0.482706	0.035018
Genetic resources	0.327956	0.268370	0.370216	0.042260
Medicinal resources	0.884700	0.048040	0.046770	-0.837930
Regulating services	**7.628482**	**6.367183**	**7.947207**	**0.318725**
Water regulation	0.338235	0.202615	0.222763	-0.115472
Waste treatment	2.213686	1.667345	2.259269	0.045583
Erosion control	1.419527	1.146283	1.592002	0.172475
Climate regulation	1.773104	1.455882	2.008120	0.235016
Biological control	1.308491	1.427454	1.218936	-0.089555
Gas regulation	0.192379	0.147954	0.202467	0.010088
Disturbance regulation	0.385060	0.319650	0.443650	0.058590
Supporting services	**3.691180**	**3.048685**	**3.775651**	**0.084471**
Nutrient cycling	1.691180	1.375074	1.906438	0.215258
Pollination	0.695440	0.749321	0.658638	-0.036802
Soil formation	0.899770	0.709690	0.955830	0.056060
habitat	0.324757	0.214600	0.254745	-0.070012
Cultural services	**0.954170**	**0.683660**	**0.533890**	**-0.420280**
Recreation	0.575190	0.418500	0.197420	-0.377770
Culture	0.378980	0.265160	0.336470	-0.042510

3.5. Ecosystem service sensitivity analysis

The variation (change) in ecosystem services and its dependency on ecosystem service index was evaluated based on the elasticity the coefficients. Therefore, based on the elasticity of coefficients calculated based on adjustment of coefficients of each land use values by 50% from the initial values were presented in Table 13. Based on the results of CS, as indicated in table (13) that most of coefficient of sensitivity were greater than 1. These values indicate that the quantification and estimation of ecosystem services in the study area was moderately elastic. This is because if the CS value is greater than 1, the ESV is elastic, and if the CS is less than 1 and near to zero indicates the ESVs are lack elasticity (Assefa et al., 2021)

Table 13. Coefficient of sensitivity of LULC types in respective years.

	1985	**2000**	**2015**
LULC- class	CS	CS	CS

Cultivated lands	0.41	1.49	1.40
Bush lands	1.00	1.50	1.49
Wood lands	0.71	0.50	1.15
Water body	1.79	1.40	1.72

4. Conclusion

It is crucial to quantify and estimate the ESVs and changes they undergo over time as a result of LULC changes, as this information is crucial for assessing the effects of LULC. In addition, they provide data to aid decision-making on intervention strategies. Therefore, the purpose of this study was to assess the impact of land use and land cover changes on ESVs over the past 30 years, from 1985 to 2015. Based on the results of the study, it was concluded that there have been changes in land use and land cover in the study area that have a significant impact on ecosystem services. As a result, over the past 30 years, changes in local land use and land cover (LULC) have had a strong impact on ecosystem service values. The total ESV value in Sekela Woreda was estimated at 29.485753 million USD in 1985, 26.355872 million USD in 2000, and 29.052988 million USD in 2015, based on ESV estimates for this area in the corresponding years. According to these data, the total ESVs decreased by 3.129837 million USD between 1985 and 2015, and then increased by 2.696916 million USD between 2015 and 2015, with a decrease in the total value of ecosystem services of 0.432765 between 1985 and 2015. In addition, the ecosystem value of the study area has declined by an average of 37.33 % over the last 30 years (1985–2015). Furthermore, many ecosystem service functions are impacted by changes in land use and land cover over time in the study area. Provision services decline by 1.082248 million USD, regulating services and supporting services increased by 0.318725 and 0.084471 million USD, respectively, and cultural services declined by 0.42028 million USD compared to their initial ecosystem service values in 1985. Therefore, in order to reduce the negative impacts of land use and land cover changes, experts recommended developing and implementing appropriate land use and land cover plans based on the results of the study, which will contribute to improving ecosystem services. Furthermore, it is important to continuously assess ecosystem services in order to reduce the likelihood of disruptions to ecosystem functioning. The study recommends conducting additional research to assess ecosystem services using other economic approaches in order to improve the quality of the assessment.

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