Consequences of Temporal Land Cover Changes on Ecosystem Services in Babile Elephant Sanctuary, Eastern Ethiopia

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Abstract: Land cover (LC) change has been identified as one of the leading drivers of change in the ecosystem and its services. However, information on the impact of temporal land cover change on the ecosystem and ecosystem services in Ethiopia is largely unknown. Thus, this study examined the impacts of temporal LC changes on the ecosystem and ecosystem services (ESs) provision in Babile Elephant Sanctuary (BES) during the period of 1977 to 2017 using a landsat image analysis and questionnaire survey. In BES, woodland covered the largest area in the year 1977, 1997 and 2017, followed by bushland and agricultural land. However, there was a consistent decline in woodland and bushland from 56.5% and 31.1% coverage in the year 1977 to 45.3 and 27.2% in the year 2017, respectively. Agricultural land and settlements increased from the year 1977, when they covered about 3.5 and 0.1%, respectively to 2017, when they covered 17.3 and 3.4%, respectively. We found significant ($p<0.05$) differences in the social perception of the positive and negative impacts of land cover change on ecosystem services. The respondents recognized the negative impact of agricultural land expansion and settlement on the ecosystem such as the provision of wild food, livestock feed, medicinal plants, fresh water, fuel-wood, raw materials and climate regulation leading to an increase in food shortage and vulnerability to frequent drought and flood. Therefore, it is necessary to take urgent measures to prevent the losses in ecosystem and ecosystem services as a result of land cover change that occurs because of human activities.

Keywords: Agricultural land expansion; Biodiversity; Human well-being; Human settlement; Landstat image analysis; Questionnaire survey

1. Introduction

Protected areas play a major role in the conservation of biodiversity (Rands *et al.,* 2010; Palomo *et al.,* 2014). Traditionally, protected areas have been established to safeguard important landscapes and seascapes, major species, and their habitats (Haslett *et al.,* 2010; Watson *et al.,* 2014). In the last few decades, there has been a major increase in conservation areas to reduce biodiversity loss and enhance ecosystem integrity, function, and services (Lopoukhine *et al.,* 2012). Moreover, there is the Convention on Biological Diversity (CBD) of Aichi Biodiversity Target 11 to make 17% of the terrestrial surface and 10% of the marine realm ecosystem into the protected area by 2020 (CBD, 2010). Currently, the amount of area assigned as protected area globally is 17 million km^2 (12.7% of the land surface) and 6 million km^2 (1.6% of the marine surface) (CBD, 2010). However, extra land to set aside for conservation of biodiversity are challenged by the globally rising demand for food and other purposes, creating trade-offs between areas dedicated to biodiversity conservation versus agriculture (Smith *et al.,* 2010). Therefore, there is a need to find an optimal balance between conservation and development especially in developing countries, where addressing widespread food insecurity and poverty is a regional priority.

Over the past few centuries, significant changes in Africa's ecosystems and their biodiversity have been observed (Kareiva and Marvier, 2012). These changes have resulted in shifts in biodiversity and ecosystem conservation approach, moving from the wilderness-center towards human wellbeing and nature thinking, in which the relationship among nature and humans are well considered (Kareiva and Marvier, 2012). Thus, protected areas should provide habitats for many species, but they also provide essential goods and ecosystem services (ES) for human well-being (Palomo *et al.,* 2014; Watson *et al.,* 2014). In Africa, although ecosystems and ES have been documented to support the livelihoods of many poor people (Davies, 2002), there is scarcity of scientific knowledge to identify important areas for conservation action where biodiversity conservation will produce the greatest benefits for ES for many poor people who depend on natural resources (MA, 2005; Reyers *et al.,* 2009; Egoh *et al.,* 2011).

The majority of peoples in Africa depend on a continuous supply of ES from nature to society such as provisioning of wild plant and animals for protein, wood for cooking, water for drinking or poles for fencing

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(Guzha *et al.,* 2018). Even if Africa's ecosystems provide bundles of ES, the services they deliver are seriously threatened. For instance, Millennium Ecosystem Assessment (MA, 2005) showed that more than 60% of ES are seriously threaten or transformed, and affecting our commitments to enhance the production of food, fuel, and fiber; regulation of water supplies; and reduce our exposure to natural hazards like drought and floods (Kareiva *et al.,* 2007; Swinton *et al.,* 2007). Therefore, it is important to safeguard ecosystems and their services.

Land cover (LC), change in the surface cover on the land, has been highlighted as one of the leading direct drivers of terrestrial ecosystem change (MA, 2005; Reyers *et al.,* 2009; Guzha *et al.,* 2018). Land cover change is the changes in the natural habitats into human mediated ecosystems such as crop cultivation, settlement, and grazing that changes the biogeochemical cycles, hydrology, and climate of an ecosystem (Reyers *et al.,* 2009). For instance, studies showed that conversion of the natural ecosystem into agricultural land can have direct consequences on agricultural productivity through loss of pollination and disease regulation services which may be considered as an ecosystem disservice (Rientjes *et al.,* 2011; Abram *et al.,* 2014; Sérgio *et al.,* 2017). It also drives biodiversity loss through habitat loss and fragmentation (Reyers *et al.,* 2009). Therefore, there is a critical need to protect areas that are important to support the provisioning of ES (Chan et al., 2006) in Africa where the conversion of the natural ecosystem to agricultural land is expanding at an alarming rate (Barbier, 2004; Gibbs *et al.,* 2010). Although a few studies have examined and mapped ES as a function of LC change, such studies are inadequate in East Africa. For instance, out of 153 ES case studies reviewed at global scale by Seppelt *et al.* (2011), over 50% of the studies were located in only six countries outside Africa (US, China, Sweden, UK, Mexico and Canada) and no such studies have been conducted in East Africa. Further, very few of the studies analyzed multiple ES (Seppelt *et al.,* 2011). Moreover, case studies of land cover change in Africa have also been conducted to examine the effects on single ES (Chan *et al.,* 2006; Reyers *et al.,* 2009; Winowiecki *et al.,* 2015; Sérgio *et al.,* 2017; Guzha *et al.,* 2018). Thus, assessment of the impact of temporal LC change on multiple ES is necessary in order to implement appropriate land use management. The aim of this study was to examine the impact of temporal land cover (LC) change on Elephant Sanctuary (ES) in Babile Elephant Sanctuary (BES), Eastern Ethiopia.

2. Material and Methods

1.2. Study Site

Babile Elephant Sanctuary (BES) was established in 1970 to protect the only viable elephant population in the Horn of Africa. The sanctuary is situated in the trans-boundary area between Oromia and Somali National Regional States, and covers an area of 6892 km². It is located 560 km east of Addis Ababa (capital city of Ethiopia) and 45 km east of the City of Harar (capital of Harari National Regional State). Its geographical position is within latitudes of 08°22'30"- 09°00'30"N and longitudes of 42°01'10"- 43°05'50"E (Figure 1) and has an elevational range of 850m to 1785m above sea level. Topographically, it is predominantly characterized by flat to gentle slopes which comprise 84% of the total BES area while the remaining 16% consists of complex valleys and deep gorges. Four main drainage river valleys (Fafem, Daketa, Erer and Gobele) rise from Garamuleta-Gursum highlands, and these extend southwards through the sanctuary to join Wabi Shebelle River Basin. A wide range of wildlife species inhabit BES including the African elephant (*Loxodonta africana*), Lion (*Pantehera leo*), Leopard (*P. pardus*) and Hamadryas baboon (*Papio hamadryads*). BES is also shelter for a range of antelope species and birds.

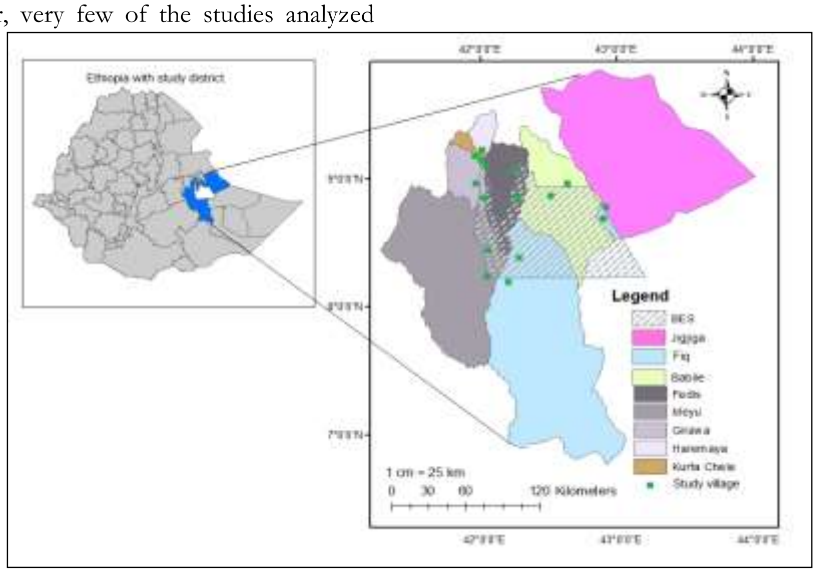


Figure 1. Location of Babile Elephant Sanctuary and surrounding districts, Eastern Ethiopia.

2.2. Image Acquisition, Processing, and Classification

Landsat images were used to analyze land-cover change between the years 1977, 1997 and 2017. Dry season and cloud-free landsat images (two images per assessment year path-165 raw-054 and path-166 raw-054) with the spatial resolution of 30m were accessed from the United States Geological Survey (USGS) Earth Explorer (http://earthexplorer.usgs.gov). The acquisition of data was carried out during the months of December, January, and February. Satellite images of the year 1977, 1997 and 2017 were imported in ArcGIS 10.2 for processing and analysis. World Geographical System (WGS) 1984 geographic coordinate system were used and projected to Universal Transverse Mercator (UTM 37N) Zone for further analysis. All images were geo-referenced and checked for sensor imperfections to assure consistency across three study years. To minimize scene-to-scene variability caused by the effects of solar zenith angles, earth-sun distance, atmospheric influence, and sensor differences (Thomas *et al.,* 1987; Cogliati *et al.,* 2015) images were pre-processed using geometric and radiometric corrections. After all the images were corrected in the same way, all scenes from the same year were mosaicked together to cover the study area.

Satellite images were classified into six land cover classes (Table 1) according to the USGS standard classification scheme (Mohan *et al.,* 2011) using maximum likelihood supervised classification. Training sites (n=48) were developed and signature file was created to be used in the supervised land cover change classification by using ArcGIS 10.2. The classified images were verified using ground control points (n=48) across the study area. ENVI 5.0 was used for accuracy assessments. ENVI was used to evaluate change detection between the years using a change detection matrix (see Figure 2 for a schematic flow chart of the methodology).

Table 1. The description of the land cover classes used in BES, Ethiopia.

LC classes	General description
Agricultural land	Areas of land ploughed or prepared for crop growing (i.e., both areas identifiably under crop agriculture and land under preparation).
Bushland	Areas with shrubs, bush and small trees in which multiple stems and branches are produced from the base of the main stem.
Woodland	Areas dominated by *Acacia* species with mean height of above 5 m and the canopy cover ranges from 10% to 40% for open woodland and above 40.
Bare land	Areas with essentially no vegetative cover
Riparian forest	A type of forest found along the major perennial rivers. The vegetation is usually evergreen (due to continuous water supply from the rivers).
Settlement	Land, which is mainly covered by rural villages

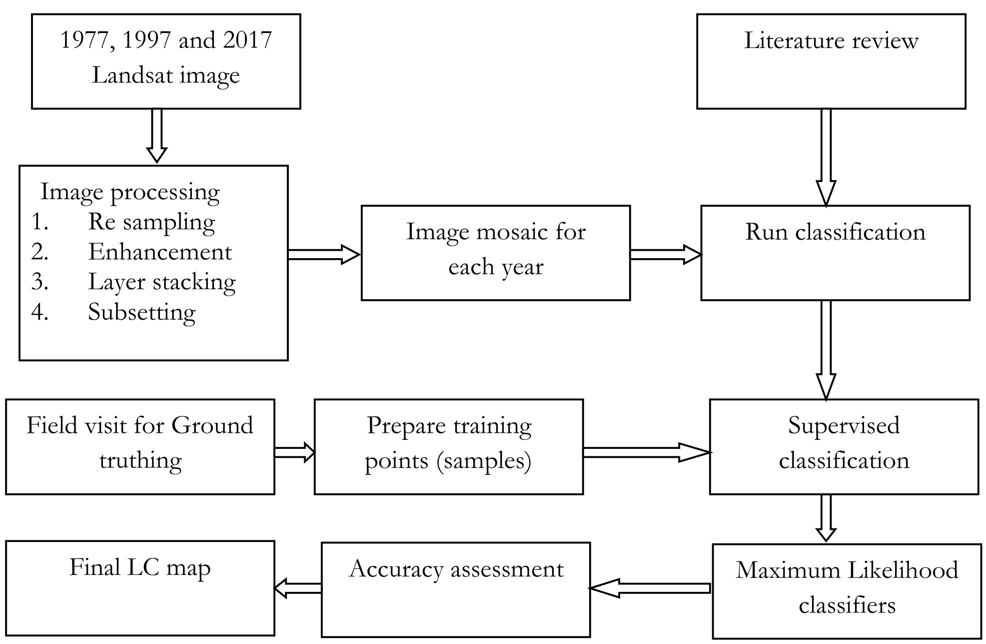


Figure 2. Flowchart showing the procedures employed to arrive at the final LC map.

2.3. Focus Group Discussion and Household Interview

Identification of the different ES and associated functions were done on the basis of an integrated ES assessment framework developed by De Groot *et al.* (2002). Ecosystem services in this paper are to refer "both tangible goods and intangible services provided by the park ecosystem" as used by the Millennium Ecosystem Assessment (MA, 2005). These services include regulating, provisioning and cultural services that directly influence human wellbeing and supporting services needed to sustain the provision of other services (MA, 2005). Since almost all population in and around BES depends on agriculture production, it is reasonable to assume that ES indicators related to the sustainability of agricultural (livestock and crop) production are in high demand. The majority of the human population does not have access to treated water for domestic use. Finally, climate regulation is an important global ES. Therefore, considering the above background, baseline ES indicators were developed as guiding indicators for the focus group discussion.

We conducted the Focus Group Discussions (FGDs) from December 2016 to May 2017 in a total of eight districts with people from 16 villages, who live inside (n=8 villages) and adjacent (n=8 villages) to the BES. FGDs were done with at least 10 people (Nyumba *et al.* (2018) in each village and were mainly elders and ecosystem users that were able to recollect events in the land cover and ecosystem service changes in BES. Thus, the FGD participants were selected purposively who had been living in the respective location for at least 40 years and willing to fully engage in a group discussion. The average age of the participants involved in FGDs was 55. The FGD was meant to validate checklists of ES drawn from the above background and investigate additional services provided by the study area (Table 2). The FGD allowed exchange of information and interactive discussion of community members (interviewees), guiding each other in conceptualizing questions while giving researchers with important insights into views and perceptions. The discussions were guided using a checklist of questions related to land cover change and its drivers as well as their effect on ecosystem and ecosystem service change in the area. Participants of the FGD were inquired to reach an agreement concerning all questions. This supported researchers to obtain better estimates for each community (e.g. regarding ES, land cover etc.). A questionnaire was developed on the basis of the results of the FGDs for the household survey.

Table 2. Demographic characteristics of communities participating in Focus Group Discussions.

District	Number of participants	Female participants [%]	Avg. Age	Avg. education [years]	Avg. education of females [years]
Midhega Tola	11	54.5	56	5	3
Fedis	10	40.0	47	3	2
Babille Oromiya	13	53.8	62	8	5
Gursum	10	60.0	51	4	5
Babille Somali	10	50.0	63	5	4
Giraw	11	36.4	48	6	7
Meyu	12	33.3	55	3	2
Haromaya	12	41.7	59	8	7
Total	89	46.1	55		

Questionnaire interviews were conducted with samples of respondents from 16 villages in 8 districts to gather information on the history of land cover and associated ecosystems and ES change (Table 3). A total of 100 key informants who were mainly ecosystem users were interviewed (inside BES, and outside BES located at least 0.1-5 km apart from BES). The average age of the respondents was 47. Perceptions and awareness of respondents on current land cover types of BES in relation to ES as well as the trend of different land cover types and ES over the last four decades and reasons why land cover types and ES have changed were captured. Moreover, the questionnaire addressed issues regarding land cover trend and livelihood changes in the communities as well as individuals' perceptions on the trends of ES provision change over time as a result of the land cover change. The interviewees ranked the areas as "low important", "medium" or "highly important" to provide ES to people's livelihoods following the methods of Marianne and Patrick (2013) and Bengtsson *et al.* (2019) in the year 1977 and 2017. We also examined how respondents explained the effect of LC change (either positive or negative) on the ES. Finally, the respondents were requested to identify ES that were impacted by each LC change type. Furthermore, the respondents scored that the intensity of each LC change impact varied from 1 (low intensity) to 24 (maximum intensity). Unselected ES were rated as neutral.

Table 3. Demographics characteristics of communities participating in questionnaire interviews.

District	Number of participants	Female participants [%]	Avg. Age	Avg. education [years]	Avg. education of females [years]
Midhega Tola	12	66.7	54	6	6
Fedis	12	41.7	38	4	3
Babille Oromiya	12	50.0	57	7	4
Gursum	12	58.3	48	6	5
Babille-Somali	13	46.2	51	4	6
Giraw	13	38.5	56	3	6
Meyu	13	30.8	32	5	3
Haromaya	13	46.2	43	6	5
Total	100	47	47		

2.4. Data Analysis

Descriptive Statistics was used to present land use land cover change within and between years (1977, 1997 and 2017). Differences between the perceived impacts of the LC change on ecosystem services were explored using a non-parametric Kruskal–Wallis statistical test. All analyses and graphical presentations were performed using R statistical program (version 3.2.2, R Core Team, 2015).

3. Results

3.1. Land Cover (LC) Classes and Changes in BES

The study had an overall classification accuracy of 93.6%. In Babile Elephant Sanctuary, woodland covered the largest area in the years 1977, 1997 and 2017, followed by bushland and agricultural land (Table 4). However, there was a consistent decrease in woodland and bushland from 56.5 and 31.1% coverage in the year 1977 to 45.3 and 27.2% in the year 2017, respectively. The share of riparian forest cover during the study period (1977-2017) also showed a downward trend from 8.6 to 6.3 and 6.3 to 3.1% in the years 1977 to 1997 and 1997 to 2017, respectively (Table 4). Agricultural land, bare land and settlements increased from the year 1977, when they covered about 3.5, 0.3 and 0.1%, respectively to 2017, when they covered 17.3, 3.7 and 3.4%, respectively (Table 4; Figures 3).

Table 4. Area and proportion of land cover in Babile Elephant Sanctuary in 1977, 1997 and 2017.

Land cover type	1977		1997		2017	
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Riparian forest	74918.97	8.8	54793.17	6.3	27145.17	3.1
Agricultural land	30428.64	3.5	91725.93	10.5	151408.62	17.3
Bare land	2462.94	0.3	11688.39	1.3	32246.91	3.7
Bushland	271496.88	31.1	245813.04	28.1	237617.73	27.2
Settlement	1202.59	0.1	9632.07	1.1	29446.56	3.4
Woodland	493548.57	56.5	460405.44	52.7	396193.88	45.3
Total	874058.6	100	874058.6	100	874058.6	100

Table 5. Area and rate of land cover change in Babile Elephant sanctuary between 1977 to 1997 and 1997 to 2017.

Land cover type	1977 to 1997			1997 to 2017		
	Area (ha)	Rate (ha yr^{-1})	Change (%)	Area (ha)	Rate (ha yr^{-1})	Change (%)
Riparian forest	-20125.8	-1006.3	-2.3	-27648	-1382.4	-3.2
Agricultural land	61297.3	3064.9	7.0	59682.7	2984.1	6.8
Bare land	9225.5	461.3	1.0	20558.5	1027.9	2.4
Bushland	-25683.8	-1284.2	-2.9	-8195.3	-409.8	-0.9
Settlement	8429.5	421.5	1.0	19814.5	990.7	2.3
Woodland	-33143.1	-1657.2	-3.8	-64211.6	-3210.6	-7.3

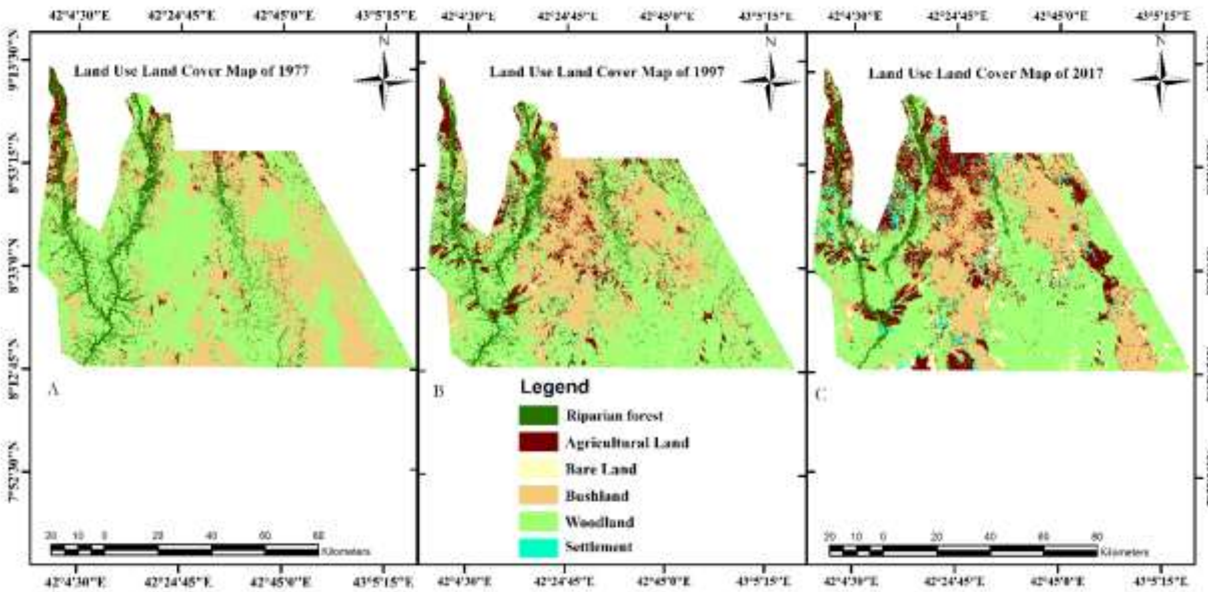


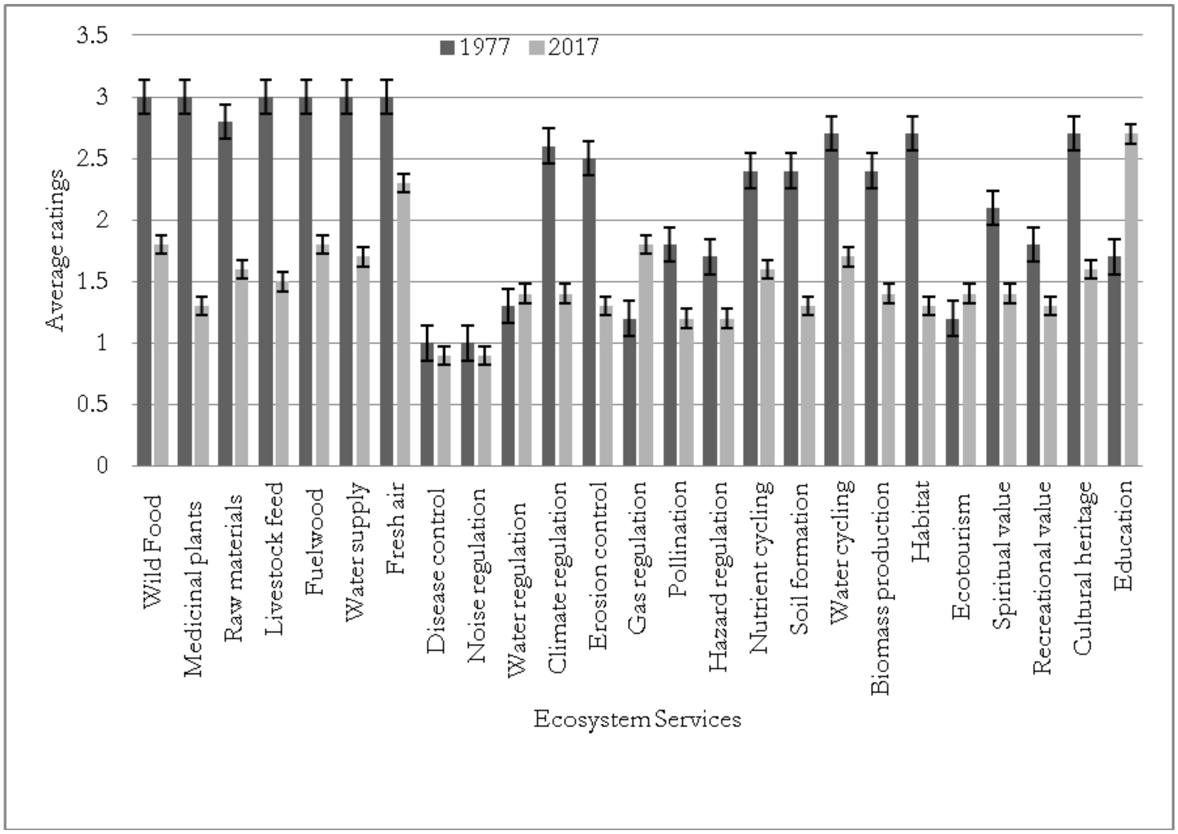
Figure 3. A comparative map showing the actual land use land cover change in Babile Elephant Sanctuary in 1977 (a), 1997 (b) and 2017 (c).

3.2. Potential Ecosystem Services Provided by BES

Focus group discussion identified 24 (7 provisioning, 7 regulating, 5 supporting and 5 cultural) ES provided by BES (Table 6 and Figure 4). Table 6 shows the description of the potential supply of four ES (provision, supporting, regulation and cultural ES). Provision of food, water and raw materials, water-flow regulation, erosion control, climate regulation and soil formation and nutrient cycling were the most important ES provided by BES. The area was also serving as an important site of eco-tourism as well as research and education due to a combination of topography and ecosystem networks (Table 6).

Table 6. Ecosystem services (ES) provided by Babile Elephant Sanctuary, eastern Ethiopia.

ES category	Sub-ES type	Services provided by the sanctuary's ecosystem
Provisioning services	Wild Food	Wild foods and fruits
	Water provision	Provision of water for multiple purpose
	Raw materials	Use of wood and sand for different purpose
	Livestock feed	Animal fodder
	Fuelwood	Fuel wood and charcoal wood
	Medicinal plants	Medicinal plants for human and livestock disease
	Cultivation	Production of crop, grazing land and bee hive
Regulating services	Climate regulation	Regulate microclimate
	Water regulation	Regulates different water sources
	Desertification regulation	Reduce expansion or invasion of desert
	Air purification	Regulation of air quality
	Waste Regulation	Waste treatment, recycling and reduction
	Noise regulation	Reduce disturbance and sound noise
	Erosion regulation	Holding soils, prevent wind, sheet and gully erosion
	Disease regulation	Pest and disease control
Supporting services	Nursery	Growth place for plant species and habitat for wildlife
	Refugium	Place for living organisms
	Soil formation	Soil development and formation
	Nutrient cycling	Nutrient cycling and retention
Cultural services	Recreation	Opportunities for recreational activities
	Ecotourism	Opportunities for tourism activities
	Spiritual	Traditional beliefs, religious significance
	Research and education	Provide services for formal and informal education



Note: *Higher numbers display a higher provision. 1 = Low important; 2 = Medium importance; 3 = Very important to provide ecosystem services (N=120).*

Figure 4. Average ratings of the trends of ecosystem services delivery change from Babile Elephant Sanctuary between 1977 and 2017.

3.3. Perceived Impacts of Land Cover (LC) Change on Ecosystem Services

We found significant differences among the perceived impacts of LC change on nineteen ecosystem services. Respondents perceived that services such as the provision of wild food, medicinal plants, raw materials, livestock fodder, fuelwood, climate regulation, water cycling, biomass production and provision of habitat for living things were negatively impacted as a result of the expansion of agricultural land and settlements (Table 7). Conversely, natural ecosystem i.e., riparian forest, bushland and woodland were perceived as providers of wild foods, medicinal plants, raw materials, livestock fodder, fuel wood, noise regulation, climate regulation, hazard regulation, biomass production, habitat for wild animals, water cycling, ecotourism and education services (Table 7).

Table 7. Kruskal–Wallis test and Dunn groups to compare the impact of land cover change on ecosystem services.

Ecosystem service	Riparian forest	Agricultural land	Bare land	Bush land	Settlement	Woodland	Kruskal-Wallis test
Wild foods	**+(a)**	**-(a)**	-(a)	+(a)	**-(a)**	**+(a)**	25.2*
Medicinal plants	**+(a)**	**-(a)**	-(a)	+(a)	**-(a)**	**+(a)**	17.4*
Raw materials	**+(a)**	**-(a)**	-(a)	**+(a)**	**-(a)**	**+(a)**	23.8*
Livestock fodder	**+(a)**	**-(a)**	**-(a)**	+(a)	-(a)	**+(a)**	74.3*
Fuel wood	+(a)	**-(a)**	-(a)	+(a)	-(a)	**+(a)**	44.2*
Water supply	+(a)	**-(a)**	**-(a)**	**+(a)**	-(a)	+(a)	52.1*
Fresh air	+(a)	-(a)	**-(a)**	+(a)	-(a)	+(a)	19.4
Disease control	-(b)	+(b)	+(b)	-(b)	-(a)	-(b)	28.7
Noise regulation	**+(a)**	+(b)	+(b)	+(a)	**-(a)**	+(a)	34.1*
Waste Regulation	+(a)	+(b)	-(a)	**+(a)**	-(a)	+(a)	25.3*
Climate regulation	+(a)	**-(a)**	**-(a)**	+(a)	-(a)	**+(a)**	20.7*
Erosion control	**+(a)**	-(a)	-(a)	+(a)	-(a)	-(a)	9.25*
Gas regulation	+(a)	+(b)	-(a)	-(b)	-(a)	+(a)	16.2
Pollination	+(a)	-(a)	-(a)	+(a)	+(b)	+(a)	29.7
Hazard regulation	+(a)	-(a)	**-(a)**	**+(a)**	+(b)	**+(a)**	35.4*
Nutrient cycling	-(b)	-(a)	**-(a)**	+(a)	-(a)	-(a)	18.4*
Soil formation	-(b)	-(a)	**-(a)**	-(b)	-(a)	+(a)	26.3*
Water cycling	**+(a)**	**-(a)**	-(a)	**+(a)**	+(b)	**+(a)**	33.8*
Biomass	**+(a)**	**-(a)**	-(a)	+(a)	-(a)	**+(a)**	19.2*
Habitat	**+(a)**	**-(a)**	-(a)	**+(a)**	-(a)	+(a)	14.7*
Ecotourism	**+(a)**	+(b)	-(a)	+(a)	+(b)	**+(a)**	22.1*
Spiritual values	+(a)	-(a)	-(a)	+(a)	+(b)	+(a)	30.6
Recreational value	+(a)	-(a)	-(a)	-(a)	-(a)	-(a)	26.2*
Cultural heritage	+(a)	-(a)	-(a)	-(a)	+(b)	+(a)	22.7
Education	+(a)	**+(b)**	+(b)	**+(a)**	+(b)	**+(a)**	31.5*

Note: * = *Statistically significant at 5% probability level. Letters in parentheses represent statistically different groups as identified by the Dunn test. Bold ones represent the most remarkable results.*

4. Discussion

In general, out of the six land cover (LC) types identified in Babile Elephant Sanctuary (BES), three of them, namely, agricultural land, settlements and bare land, increased in size and proportion over 40-year period while riparian forests, woodland and bushland declined in cover, suggesting that natural ecosystem was converted into agricultural land, settlements and bare land. Our study demonstrated that land cover change in semi-arid ecosystem of eastern Ethiopia was perceived and identified as one of the factors that caused change in ecosystems and their services, particularly in and around protected areas. A total of 55 plant species composed of 24 families were recorded in Babile Elephant Sanctuary (BES) (Abdala and Fenetahun, 2017).

We found that agricultural land has been increasing at the highest rate for the last four decades compared to other land cover (LC) types during the study period (1977–2017). In contrast, natural habitats (riparian forest, bushland and woodland) were lost substantially during the study period with an annual average loss rate of 4475 ha. Consistent with the results of this study, Yirmed *et al.* (2008) revealed that since in 1970, the natural area of BES has shrunk by an estimated value of 82% as a result of anthropogenic factors. Current Ethiopian policy that is increasingly discouraging pastoralism in favor of permanent settlement and population growth is the major factor for the observed land cover change in Babile Elephant Sanctuary (BES) (Gebeye, 2016). Similar to the results of other studies (Mc Granahan and Satterthwaite, 2003; Bailey *et al.,* 2015), we found that land cover change was correlated with change in the overall provision of ES. When the natural ecosystems are lost, ES such as the provision of wild foods, livestock fodder, raw materials and medicinal plants, and recreational value are also lost (Figure 5), all of which are fundamental to human well-being.

This study indicated that provisioning services including harvesting and collection of food, raw materials, medicinal plants, and fuel-wood, fodder provision for livestock and water supply were the most important ecosystem provided by the area. Communities around the study area have a long tradition of using plants for curative purposes against human and livestock diseases because of lack of access to hospitals, and medical and veterinary facilities. Moreover, the sale of medicinal plants has become a significant source of income within the communities around Babile Elephant Sanctuary (BES). Many plants have been also collected for housing and fencing materials. In-line with other study conducted in other part of Africa (Shackleton *et al.,* 2007), wild foods and fruit collection for household consumption or for sales are common in the study area especially for herders and school children. The fuel-wood collected from BES was accounted for the major energy source. Similarly, Shackleton *et al.* (2007) also reported that raw material from forest potentially contributed approximately 28% to the gross income of rural livelihoods in South Africa.

Fuel-wood accounts for about 35% of energy consumption in African countries and represent a valuable commercial commodity in peri-urban areas (EFTEC, 2005). A study conducted in Madagascar showed that estimated value of fuel-wood for communities per household/ year was $39 (Shyamsundar and Kramer, 1996). The fuelwood gathered from the natural forest amounts to about 15% of the average household annual income, valued at $279. Sale of medicinal plants is a common source of income, with yearly earnings of $2.9 million (FAO, 2002). Similarly, collection and sale of medicinal plants is very common and has become an important source of income in BES. Like other African countries (Bowen-Jones *et al.,* 2003), fodder provision for livestock was the other most important provision services provided by the study area. The ecosystem of BES plays interlinked roles in the service of water provision: water-flow regulation and water-quality.

However, many of the ecosystem services (ES) provided by the study area decreased and rated to be of medium importance in 2017. The reason might be that conversion of natural ecosystems or forest area to agriculture reduced the provision of important ES such as wild food and raw materials. Consistent with the results of this study, the decline in ecosystem provisioning services due to land cover change as a result of increased crop cultivation activities have been documented in West Africa (Leh *et al.,* 2013). Our results have demonstrated that LC change has large impacts on the provision of ES.

The results of this study have showed that regulating services that are of high value to the area were mainly linked to climate regulation, agricultural production, including water regulation, desertification regulation, disease and pest control, and erosion control. Similar to other semi-arid ecosystem, the area is highly susceptible to climate change and desertification. The weather patterns in this area (most notably the cutoff lows) result in frequent floods, which have an enormous impact on the region's economy (Billi *et al.,* 2015). In line with other previous studies (Lamarque *et al.,* 2011; Brancalion *et al.,* 2014; Smith and Sullivan, 2014), BES plays a vital regulating ecosystem role by regulating the local climate variation, retaining soils, and preventing soil erosion. However, most regulating and supporting ES were reported to have a higher delivery from the study ecosystem in past than in 2017. Better ES such as climate regulation, desertification regulation, nutrient cycling, soil formation, and erosion control were recognized to have delivered in the year 1977 than in 2017. Desertification (Hulme *et al.,* 2001), emergence of pests and disease (Tanser *et al.,* 2003) and soil erosion (Beniston, 2003) are being accelerated by local and regional land cover changes in Africa due to ecosystem change. Floods have often devastated semi-arid east African ecosystem, for instance, the 1998 El Niño floods killing more than 4000 people (Galvin *et al.,* 2001).

Rural people around the study area depend on subsistence farming and livestock production for their survival and cultivate crops such as groundnut, maize, and sorghum, and rear cattle, camel, sheep and goat using minimal inputs. Using such practices, farmers and pastoralist rely heavily on ES relating to soil fertility, water supply, rangeland productivity enhancement and regulation, erosion prevention, and pest control. Soil fertility through the accumulation of soils and organic matter is arguably one of the valuable supporting ES in BES. Studies showed that expansion of agricultural land in the expense of natural ecosystem can have impact on ES provision (Dale and Polasky, 2007), thus resulting in reduction of productivity which might be considered as an ecosystem disservice (Beniston, 2003; Zhang *et al.,* 2007). Other similar studies showed that ecosystem enhances nutrients availability to crop and fodder production by reducing the need for synthetic fertilizers and fallow phases (Campbell *et al.,* 2008). In Ethiopia, approximately 85% of the population's livelihood is derived from agricultural activities; the role of supporting services in protecting livelihoods is extremely important (Gebreselassie *et al.,* 2016).

Cultural ES provision includes eco-tourism and leisure, heritage sites, the use of natural ecosystem as rituals, spiritual worship, education and recreation is important ES supplied by BES. Eco-tourism is increasingly important source of income in East Africa. Thus, cultural ES are vital to attract more tourists. Of the cultural ES, education and ecotourism services provided by BES was increased and was also rated most important for securing people's livelihood in 2017 (Figure 5). The area is one of the eco-tourism and recreational destinations in eastern Ethiopia. Similarly, in 2000, tourism contributed an income of $10.7 billion in Africa (Gauci *et al.,* 2001; Neto, 2003; Fayissa *et al.,* 2008). The global contribution of Africa in tourism sector increased from 3.3% in 1990 to 3.9% in 2000 (Neto, 2003).

This study has demonstrated that for many years, BES has served scientists as an important study area to address many ecological and conservation research questions. This might be attributed to Africa's rich wildlife fauna and flora with large number of endemism (Maswera *et al.,* 2009) and culture. To safeguard tourism and recreation ES and enhance people's livelihood, biodiversity and cultural ES must be protected. On the other hand, spiritual values in BES were rated least important and their importance decreased sharply in 2017 in comparison with 1977. This could be caused by societal modernization and changing religious beliefs. Similarly, the recreational value of BES has been declined, which might be due to shortage of time as subsistence farming practices being time-consuming.

5. Conclusions

The results of our study have demonstrated that land cover change has been identified as one of the leading drivers negatively influencing natural ecosystem and their ecosystem services in Babile Elephant Sanctuary (BES). Consistently, increasing expansion of agricultural land and the drastic decline in ecosystem services have been observed in the BES ecosystem over time. Therefore, trans-sectoral policy development is needed to harmonize natural resource policies with other sectors, such as investment, agriculture, energy, and land administration. In addition, a plausible regulating ES based program would be crucial for socioeconomic development and ecological stability in the regions. These results are a first-step towards understanding the impact of land cover change on ecosystem and ES and identifying the underlying mechanisms in the study area. Further studies with experimental manipulation, are required to thoroughly test the effect of land cover change on ES.

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7. References

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