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Land use/cover changes and dynamics of ecosystem services in Southeast Ethiopia

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Abstract

Human well-being was obsessed with the natural resource scheme that provides various functions vital to support management at various levels. Land use/cover (LULC) dynamics in 30 years within three intervals (1988, 2008, and 2018) evaluate its influence ecosystem services and predict the spatial patterns land-use changes in 2048. Geographic information system (GIS), the global value of coefficients` database, LULC dynamics, and Markov module of IDRISI 17.0 format were used to determine ESV and land-use changes predicted for 30 years. The results showed that agroforestry is expanded by 41.2, whereas forestland declined by 47.2% over the analysis period. Approximately the US dollar of 1.59 million ESVs was lost owed to LULC changes from 1988 to 2018 in the sub-watershed. Among the ecosystems reduced were nutrient cycling, raw material provision, erosion control, and soil formation. Changes in the extent of the forest of the study projected until 2048, indicating the area of the forest could continuously be reduced. This study's results could provide quantitative information, representing a base for assessing sustainability in the forest ecosystem management and for taking actions to mitigate their degradation. The use of LULC, along with established global ESV data sets, helps track past environmental changes and acquire quick and reliable results that can be used for the decision-making process. It is believed that the integration of LULC analysis and ecosystem service valuation as a tool that could help design payment for environmental services and rural development policies.

Keywords: Land use/Land cover, Hangadi Watershed, *Geographic information system (GIS), Ecosystem Service (ES)*

1. Introduction

Land use is a fundamental factor in any human activity supporting people's livelihoods and development (Diyer et al., 2013). Land cover can be conceptualized as the increasing demand for this limited resource has put pressure on land and its surface features. In so doing, it has altered the surface cover of land, influencing diverse collection of environmental processes and properties. Likewise, altering and managing the natural environment, such as managed forests with their functional roles in their respective catchment areas having a significant driver of change impelling the Earth's ecosystem services and climate, is land use (Steffen et al., 2015).

Studies have been conducted in Ethiopia on land use, and land cover changes are incredibly in the northern highland. They attested the expansion of cultivated land at the expense of forest land. Cultivated lands were overstretched to sloppy areas due to a shortage of cultivable land exasperating land degradation (Munro et al., 2008; Temesgen et al., 2014; Temesgen and Fantahun, 2014). Moreover, these studies have focused on the dynamics of cover changes and causes with little attention to integrate the resultant gains/losses in ecosystem services. The gain or loss could be used to sway policymaking processes concerning land and land-related resources (Tsegaye et al., 2010; Meshesha et al., 2014; Kindu et al., 2016; Tolossa et al., 2016) though studies conducted on land use and land cover changes, and ESV in the southern part of Ethiopia are minimal. In the South-eastern region, the Guji zone, particularly the study area was known by pastoral means of existence. Two decades ago, the local community and investors started coffee cultivation as agroforestry at the expense of natural forests without considering its impact on forests' climate and ecological potential. Studies on ecosystem service changes associated with the prevailing land-use types following conversion have lacked behind, and no attention was given to the change implications of the land use before making land-use change decisions. Hence, the present study was aimed to assess ecosystem services in different land-use types provide scientific knowledge to support policy decision making for land-use change planning and enhance the services overall as an option for climate change mitigation. Majority of the areas of Odo Shakisso district had already been replaced with semi-forest coffee, open canopy through selective thinning of emergent tree species and saplings (Aerts et al.,2011), with no fertilizer used (De Beenhouwer et al., 2015) except 988.4 ha forest in Hangadi watershed in the district.

This study was intended to quantify the values of services and see if these values increase or decrease across land uses. Hence, land use/cover dynamics in Hangdi watershed, Guji zone was first assessed and global database developed for different land use/cover was used as input for ESV of different land use/cover types to estimate the number of services gained/ lost due to land cover changes over spatial and temporal scales in the study landscapes. Thus, this study was conducted to analyze land use/cover dynamics and quantify the amount of ESV lost/gained due to changes in land use/cover types and predict in 2048.

2. Study Area and Methods

2.1. Study Area

The study was conducted in Hangadi Watershed, Odo-Shakiso district in Guji zone, the Oromia National Regional State, Ethiopia (Figure 1). The geographic location of district is 38^{0}10ˈE, 5^{0}34 N` and bordered in the south by the Dawa River which separates it from Arero, in the west by Bule Hora, in the northeast by Uraga, in the north by Bore, by Adola and Wadera and in the east by Liben districts. According to CSA's (2013) projection, the district population is 247,189 (128,491 men and 118698 women). The district's estimated area cover is 4165.62 square kilometers and has a density of 59.3 people per square kilometers. Most of the district's agroecology is Kolla, and plant species existing in the district are woodland species, woodland trees, and alpine plants. The woodland covers 309, 886ha.

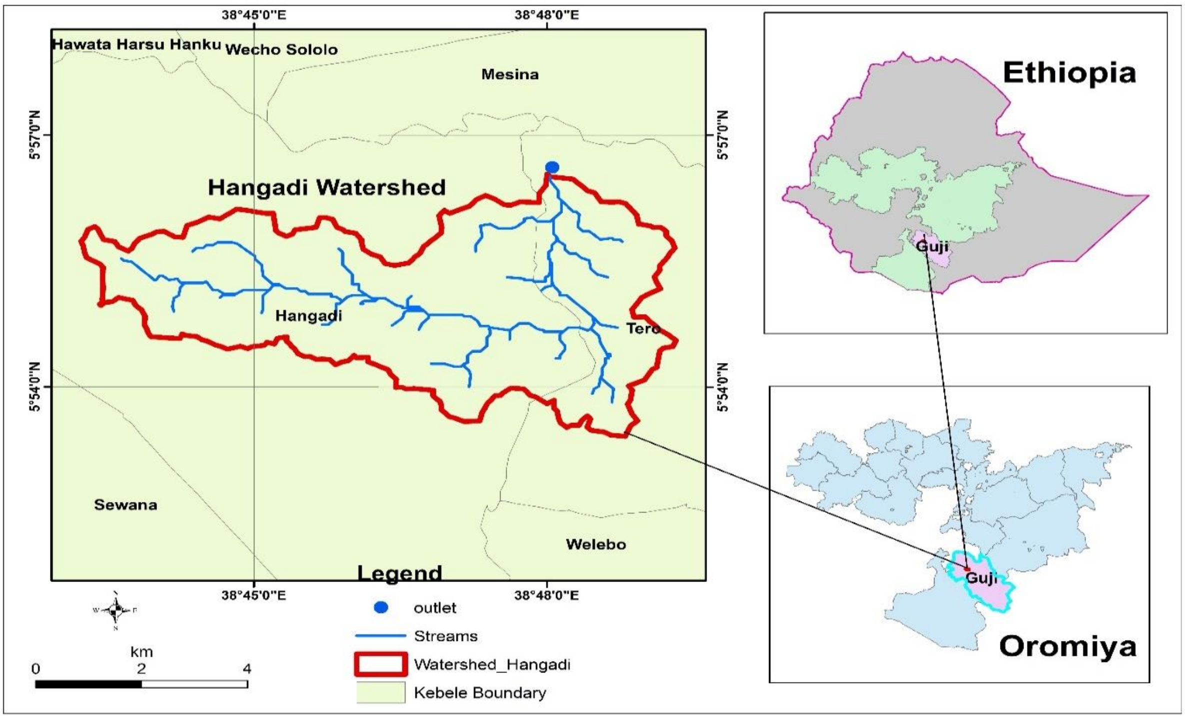

Figure 1 Map of Ethiopia showing the study watershed

2.2.Methods

In the first stage, satellite images from 1988, 2008, and 2018 were used to analyze deforestation trends. Thematic Mapper (TM), Enhanced Thematic Mapper (ETM), and Landsat 8 of the three acquisition years (1988, 2008, and 2018) with less than 10% cloud cover were acquired from path 168 and 059 raw for February and January, respectively. These months correspond to the dry season in the study area. It was so challenging to get cloud-free images in the other months in the study area. Source of land use/cover was freely downloaded Landsat imagery from http:// earthexplorer.usgs.gov. Three different imagery dates used to determine land use/cover were 28/02/1988 for Landsat5 TM, 11/02/2008 for Landsat7 ETM+, and 28/01/2018 Landsat8 of OLI, and all the images have a spatial resolution of 30m. The date and month of data acquisition all were during the dry season, allowing cloud-free images. The study's selected years were based on the significant political and economic changes in the country and the availability of data.

Pre-processing

The imagery was processed using ENVI 5.0, i.e., all the Pre-processing, image classification, and post-classification were done with the same software. ENVI provides pre-processing utilities for calibration, general-purpose tools, and data-specific tools. Imagery downloaded were geo-referenced and de-striped; thus, only the imagery used for the year 2008 was Landsat ETM+, the missed scan line, the gap-fill pre-processing was employed in ENVI5.0 to fill the missed line for the study area.

Image classification

During the field survey, two independent datasets were collected. The first dataset was training points to be used in supervised classification. The other dataset was ground-truthing points to be employed in evaluating the accuracy of classification during post-classifications.

The training dataset was 102 points, whereas the truthing ground locations were 126 points. To perform supervised classification, clustering pixels in the image into classes corresponding to user-defined training classes based on training dataset collected during the field survey. The training classes were defined by creating multiple irregular polygons and individual pixels as a region of interest. In ENVI software, the maximum likelihood classification algorithm assumes the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class was used. Each pixel is assigned to the class that has the highest probability. In this study, Hangadi watershed contains three major land use/cover classes: agroforestry, forests, and cultivated land.

Post-classification

In post-classification, the Confusion Matrix was employed to show the accuracy of a classification result by comparing the classification result with ground truth information, which was collected from the field and equal to 126 points. ENVI can calculate a confusion matrix (contingency matrix) using ground truth points. In each case, an overall accuracy, producer and user accuracy, kappa coefficient, confusion matrix, commission errors, and omission were reported for each land use/cover class of Hangadi watershed. The classification accuracy assessment reports for each land use/cover classes for the year 2018 are indicated (Table1).

Table 1.Confusion Matrix for 2018 land use/cover

	Ground Truth (Pixels)				Error of commission (%)	Producer Accuracy (%)
Classes	Forest	Agroforestry	Cultivated Land	Total		
Forest	34	1	0	35	2.86	97.14
Agroforestry	5	57	3	65	12.31	87.69
Cultivated Land	0	2	24	26	7.69	92.31
Total	39	60	27	126		
Error of omission (%)	12.82	5.00	11.11			
Producer Accuracy (%)	87.18	95.00	88.89			

Overall Accuracy = (115/126) =91.27%	
Kappa Coefficient = 0.86	

The overall producer's accuracy of land/cover maps over the study period was 87.9%. The overall user's accuracy of LU/LC maps over the study period was 91.27% and the overall Kappa statistics was 0.86. Both met the recommended value suggested by Janssen et al. (1994).

Change Detection Analysis

The Change Detection Statistics of three different years (1988, 2008, and 2018) classified imagery were computed by using ENVI5.0 software. To report a detailed tabulation of changes between three classified images, ENVI Classic has alternatives to report changes as pixel counts, percentages, and areas. In this case the area alternative was used and presented in table form.

Table 2. Description of land cover type in the study watershed

Land Cover	Description
Forest land	Areas dominantly occupied by natural forests
Cultivated land	Cropping fields owned by smallholder farmers
Agroforestry	Intensively managed semi-forest area in which forest-coffee, forest-coffee-enset and forest-enset deliberately used on the same land management units.

In stage two, the ESV of the three LULC types identified for the period; the methods used by Costanza et al., 1997 and Li et al., 2007. The most representative biome was used as a proxy for each LULC category, including (1) Cropland for cultivated land, (2) Forests for forest land (3) Tropical forest for agroforestry (Table 3). The total value of ecosystem service in the study landscape for 1988, 2008, and 2018 was obtained following the methodology (Li et al., 2007) and (Hu et al., 2008):

$$\mathbf{ESV}=\Sigma\ (A_K\ X\ VC_k) \quad \mathbf{(1)}$$

Where ESV is the estimated ecosystem service value, Ak is the area (ha) and VCk the value coefficient (US \$ $ha^{-1}yr^{-1}$) for LULC k (Table 3). In addition to estimating LU/LC change effects on the total value of ecosystem services, the impacts of such changes on 17 individual ecosystem services in the study landscape (TEER, 2010). The values of services provided by the individual ecosystem were calculated using the following equation (Hu et al., 2008).

$$\mathbf{ESV_f}= \Sigma\ (\mathbf{A_K\ X\ VC_{fk}}) \quad (2)$$

Where ESV_f is the estimated ecosystem service value of function f, A_k is the area (ha) and VC_{fk} the value coefficient of function f (US \$$ha^{-1}yr^{-1}$) for LU/LC category k. The value coefficients can be obtained from Costanza et al. (1997).

The biomes used as surrogates for the land use categories are approximate matches because of differences in climate and geographic distribution. Given the inexact match, sensitivity analyses were conducted to determine the estimated values' dependence on the applied value coefficients. The value coefficients for cultivated land, forest land and agroforestry were adjusted by 50% and the corresponding coefficient of sensitivity (CS) was calculated using Eq. (3) (Li et al., 2007; Hu et al., 2008). The robustness and reasonability of the estimation of ESV were determined using (Li et al., 2007; Hu et al., 2008).

$$\mathrm{CS} = \frac{(\mathrm{ESVj}-\mathrm{ESVi})/\mathrm{ESVi}}{(\mathrm{VCjk}-\mathrm{VCik})/\mathrm{VCik}} \quad (3)$$

Where CS is Coefficient of Sensitivity, ESV_i and ESV_j are initial and adjusted total estimated ecosystem service values respectively, and VC_{ik} and VC_{jk} = initial and adjusted value coefficients (US \$ $ha^{-1}yr^{-1}$) for LU/LC type 'k'.

Table 3. Biome equivalents for the LULC categories identified in this study and summary of their ecosystem service valuation coefficients (VC).

Land use and Land cover Categories	Equivalent Biomes	Ecosystem Service Coefficients (US $\$ha^{-1}yr^{-1}$)
Cultivated Land	Cropland	92
Forest Land	Forests	2007
Agroforestry	Tropical forest	302

Markov analysis and prediction of land use/cover for 30 years

Images were converted from Envi to Markov module of Idrisi 17.0 format, and land use/cover changes were estimated from 1988 to 2018 for 30 years. Cellatom provides for cellular automata in IDRISI typically used in dynamic modelling where the future state of a pixel depends upon its current state. Iterations number was specified, and with each iteration, the filter was applied to the image then the resulting image was reclassified according to the "reclass file." The output image was used as input for the next iteration. In this case, assuming the condition/scenario remains the current situation, the next 30 years of land use/cover were predicted by using the 2018 land use/cover image as the initial scenario. Adding 30 years to it could be the year 2048.

3. Results

3.1. Land use/ cover change for 1988, 2008 and 2018

Most of the forest areas existed in the 1988 and 2008 maps were reduced in the 2018 map (Table 4 & Figure 2). On the contrary, the following map showed the predominance of agroforestry. In general, a continuous change was taking place for most LULC types over the study period (1988-2018).

In 1988, the dominant land use/land cover classes were forest and agroforestry, which covered an area of 1866 ha (53%) and 1136 (32%). The least coverage was cultivated land accounted for 517 ha (15%). Of all land use/land cover classes, 85% of the study area was covered by green vegetation such as forest and agroforestry. In comparison, the remaining 15% was covered by cultivated land in 1988 (Table 4). Unlike 1988, in 2008, the dominant land use/land cover classes were forest and cultivated land covering an area of 1464. 46 ha (41.61%) and 1235. 99 ha (35.12%), respectively. The agroforestry had the least area coverage of about 818.98 ha (23.27%). From all the three land-use classes, 64.88% was covered by green vegetation such as forest and agroforestry, while the remaining 35.12% was covered by cultivated land in 2008 (Table 4 & Figure 3). In 2018, the dominant LULC class was found to be agroforestry covering an area of 1575.4 ha (44.8%) followed by forest land 988.4 ha (28.1%) and the cultivated land accounted for 955.1 ha (27.1%). Over the whole period, forest land was decreasing whereas the agroforestry was increasing except during 2008.

Table 4. Area of LULC types during 1988, 2008 and 2018

LULC type	1988		2008		2018	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Agroforestry	1136	32	818.98	23.27	1575.4	44.8
Cultivated land	517	15	1235.99	35.12	955.1	27.1
Forest land	1866	53	1464.46	41.61	988.4	28.1
Total	3519	100	3519.43	100	3519	100

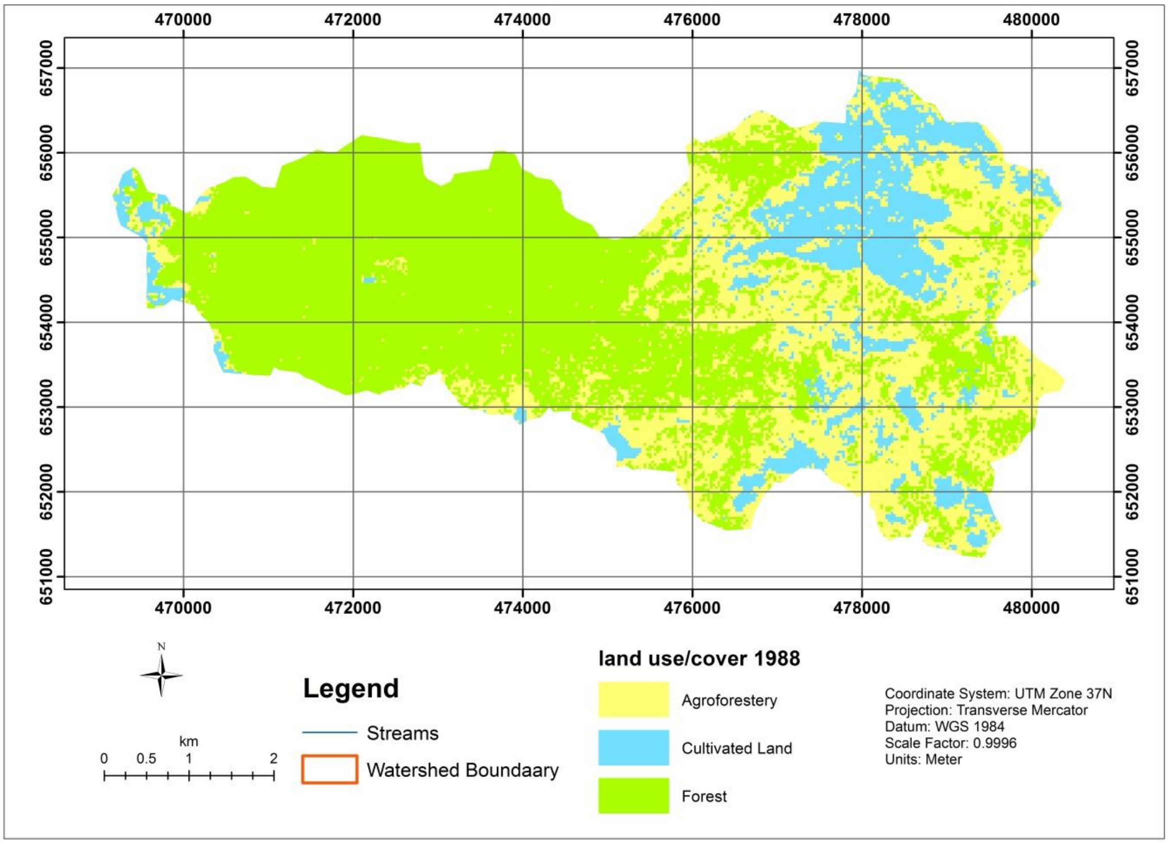

Figure 2. Land use/land cover map of Hangadi Watershed (1988)

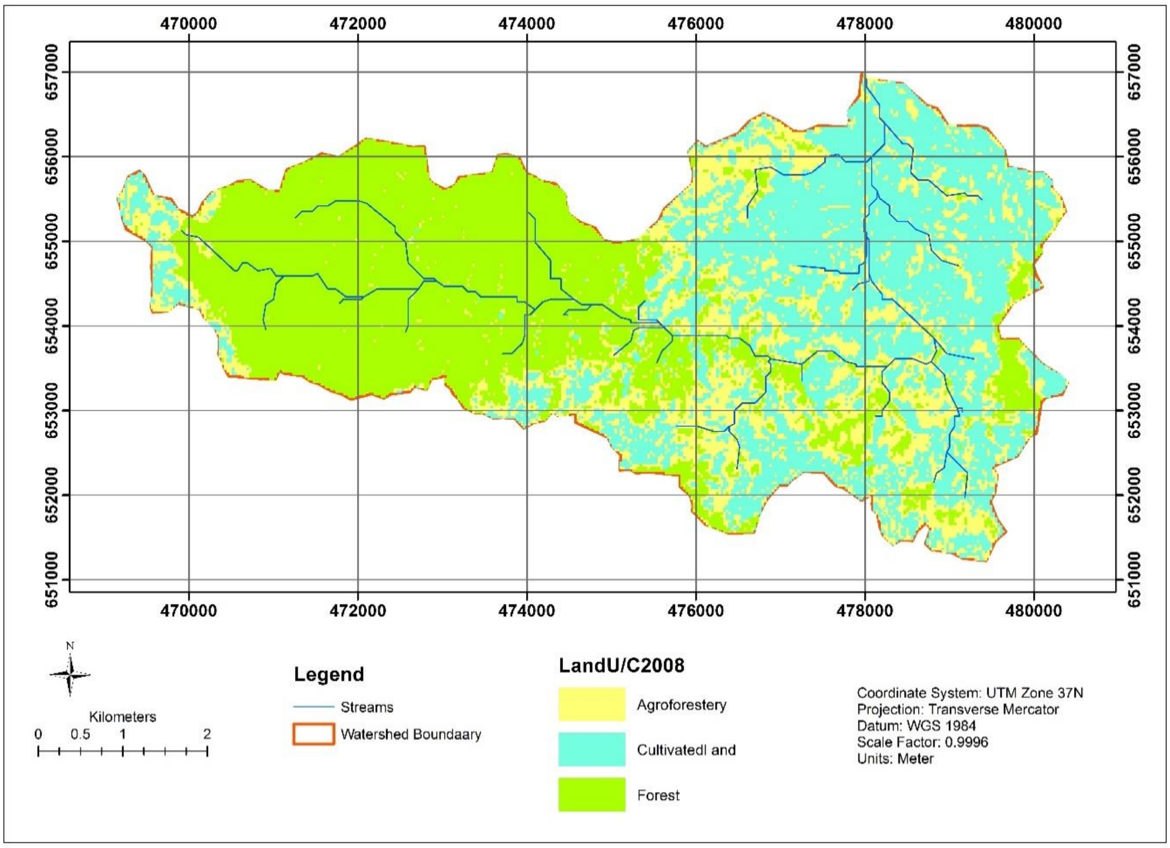

Figure 3. Land use/land cover map of Hangadi watershed (2008)

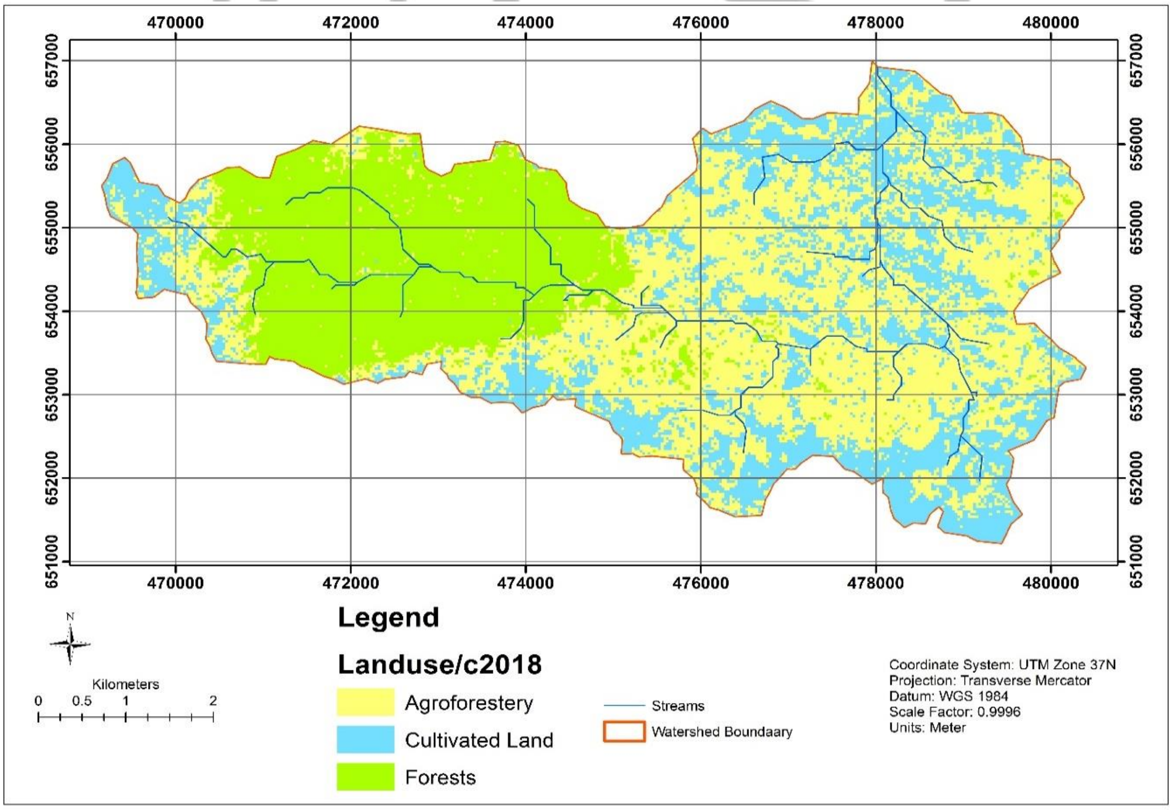

Figure 4. Land use/land cover map of Hangadi watershed (2018)

3.2. Land use/cover change from 1988 to 2008

The land use/land cover change matrix indicated the direction and extent changes from 1988 to 2008 (Table 5). From 1988 to 2008, the net gain of cultivated land was 720.18, followed by agroforestry 318.42 hectares. The diagonal values in the table show the unchanged area coverage of that particular LULC class during the study period (Table 5).

Table 5. LULC Matrices of Hangadi Watershed (1988 and 2008)

Area (ha)		Initial Image				
		Forest	Agroforestry	Cultivated land	Row total	Class total
Final image	Forests	**1328.22**	129.51	7.56	1465.29	1465.29
	Agroforestry	299.97	**425.07**	94.41	819.45	819.45
	Cultivated land	238.86	583.29	**414.54**	1236.69	1236.69
	Class Total	1867.05	1137.87	516.51		
	Class Changes	538.83	712.8	101.97		
	Image Difference	-401.76	-318.42	720.18		

3.3. Land use/land cover change from 2008 to 2018

From 2008 to 2018, agroforestry increased by 757.53 ha, but cultivated land decreased by -280.98 ha (1236.69 ha in 2008 to 955.71 ha in 2018). Forest land decreased considerably 1465.29 in 2008 to 988.74in 2018 (-476.55) (Table 6).

Table 6. Matrices of Hangadi watershed (2008 and 2018)

Area (ha)		Initial Image 2008				
		Forest	Agroforestry	Cultivated land	Row total	Class total
Final image 2018	Forests	956.97	20.07	11.7	988.74	988.74
	Agroforestry	418.32	509.49	649.17	1576.98	1576.98
	Cultivated land	90	289.89	575.82	955.71	955.71
	Class Total	1465.29	819.45	1236.69		
	Class Changes	508.32	309.96	660.87		
	Image Difference	-476.55	757.53	-280.98		

3.4. Rate of land use/land cover change

Results showed that cultivated land area increased while forest and agroforestry declined considerably in the whole period (1988-2018) (Tables 5 and 7). First period (1988-2008), cultivated land increased by 720.18 ha, which approximately equivalent to 20.727 ha/yr, while the decrements of forest land and agroforestry were -401.76 and -318.42 ha (-20.088 and -15.921 ha/yr) (Table 5). In the second period (2008-2018), the rate of increase in agroforestry was 757.53 ha (50.949 ha/yr). The rates of change for the cultivated and forest land were -280.98 and -476.55 ha (57.582 and 95.697 ha/yr). Though forest land declined in both periods, agroforestry considerably increased in the second period.

Table 7. Rate of Changes in LULC classes (1988-2018)

LULC class	1988-2008		2008-2018		1988-2018	
	Area change (ha)	Rate of change (ha/yr)	Area change (ha)	Rate of change (ha/yr)	Area change (ha)	Rate of Change (ha/yr)
Forest land	1328.22	66.411	956.97	95.697	973.26	32.442
Agroforestry	425.07	21.2535	509.49	50.949	694.98	23.166
Cultivated land	414.54	20.727	575.82	57.582	287.46	9.582

3.5. Accuracy Assessment of 1988, 2008 and 2018 maps

The overall classification accuracy assessment results for the three reference years: the lowest overall classification accuracy was 90.9091% for 1988 and the highest was 92.39% for 2018. The accuracy level is well over the minimum requirement of 85% as set by Anderson et al. (1976) for practical land use/land cover change analysis. The highest kappa statistic was 0.8827 for 2018 and the lowest was 0.8629 for 1988, all of which showed strong agreement with the ground information.

3.6. Landscape Ecosystem Services

The study area's net ecosystem service value was reduced by 38.4% over the three decades of the study period, from US$ 4.14 million in 1988 to US$ 2.55 million in 2018 (Table 8). The leading cause of this reduction was deforestation. In general, the contributions of the other land uses to ecosystem services are minimal. To maximize the ESV of the watershed, making trade-offs between each service, such as production and production, is crucial. The estimated annual values of ecosystem functions and their changes are presented in Table 9.

Table 8. Total ecosystem service values estimated for each LULC category and changes from 1988 to 2018 in the study following Costanza et al. (1997) and Li et al. (2007) valuation coefficients.

ESV (US$ million				ESV(US$Million)		
LULC Class	1988	2008	2018	1988-2008	2008-2018	1988-2018
Forestland	3.75	2.94	1.98	-0.81	-0.96	-1.77
Agroforestry	0.34	0.25	0.48	-0.09	0.23	0.14
Cultivated land	0.05	0.25	0.09	0.2	-0.16	0.04
Sum	4.14	3.44	2.55	-0.7	-0.89	-1.59(38.4%)

Table 9. Estimated annual value of ecosystem functions ($ESV_{f\ in}$ US$ million per year).

Ecosystem Service	ESV_{f1988}	$ESV_{f\ 2018}$	Change	CC_f (%)
Climate regulation	0.516086	0.359048	-0.1570376	-0.30429
Disturbance regulation	0.00933	0.004942	-0.004388	-0.47031
Water regulation	0.011196	0.00593	-0.0052656	-0.47031
Water supply	0.014928	0.007907	-0.0070208	-0.47031
Erosion control	0.45717	0.242158	-0.215012	-0.47031
Soil formation	0.03002	0.025638	-0.004382	-0.14597
Nutrient cycle	1.720452	0.911305	-0.8091472	-0.47031
Waste treatment	0.261174	0.223051	-0.0381234	-0.14597
Pollination	0.007238	0.013371	0.0061334	0.847389
Biological control	0.016952	0.029224	0.012272	0.723926
Food production	0.14443	0.161974	0.0175442	0.121472
Raw material	0.61619	0.350731	-0.265459	-0.43081
Genetic resource	0.076506	0.040524	-0.0359816	-0.47031
Recreation	0.249888	0.167415	-0.0824728	-0.33004
Cultural	0.006004	0.005128	-0.0008764	-0.14597
Sum	4.137564	2.548347	-1.5892168	-0.38409

The effect of using alternative coefficient to evaluate total ESV in the study area over the study period are shown in Table 10. The coefficient of sensitivity ranged from 0.8 to 0.98. For the sensitivity analysis results to be reliable, the sensitivity of ESV to changes in the value coefficients must be relatively low (CS<1). The coefficient of sensitivity (CS) resulting from a 50% adjustment in the value of the service value coefficient, indicated that the total ESVs estimated in this study were relatively inelastic concerning the change in the value coefficients (Table 10). CS was highest for forestland (0.98) because of the vast area and high-value coefficients for these land-use types. Overall, the sensitivity analysis indicated that all the CS results were less than 1; the total value of ecosystem services is not sensitive to VC change. Hence, the value of VC was suitable, and the results are credible despite uncertainty in the value coefficient.

Table 10. The sensitivity of the Ecosystem Service Value

Land utilization type	ESV US$ million		Coefficient of Sensitivity	
	1988	2018	1988	2018
Forestland±50%	3.75	2	0.90	0.98
Agroforestry±50%	0.34	0.5	0.90	0.88
Cultivated land±50%	0.05	0.09	0.80	0.88

The transition probability and area matrix created according to land use maps in 1988 and 2018 by running the CA-Markov model in INDRISI software based on suitability atlas already created (Tables 11 and 12, respectively). The predictive results map for the next 30 years is obtained with a 5*5 contiguity filter, whose running cycle is 30 years. Figure 5 is the predicted map of 2048. Table 11 displays a summary of the probability matrix for important land use and land cover conversions of all classes in the Hangadi watershed that will take place next 30 years (2018-2048). For instance, the probability of change for the forest to forest is 52.13%, while the probability of change forest to agroforestry is 35.01% and so on for other land use classes. The real 1988 map was used as the base map for estimating future LULC scenarios for 2048 using the CA-Markov model. In this regard, Markov and cellular automata used to predict for 2048 as future changes of LULC. The predicted LULC for 2048 indicates that the net percentage estimate would be 539.97, 1730.42 and 1249.54 ha for forest, agroforestry and cultivated land, respectively in Hangadi watershed (Table 12). Figure 5 displays the projected 2048 of LULC classes of the study area.

Table 11. Transitional Probability matrices of land use changes

	Forest	Agroforestry	Cultivated land
Forest	**0.5213**	0.3501	0.1287
Agroforestry	0.0131	**0.6108**	0.3762
Cultivated land	0.0012	0.4422	**0.5565**

Table 12. Area Coverage of each land use/cover and percentage projection for 30 years

No	Land use	Area (ha)	Area (%)
1	Forest	539.97	15.34
2	Agroforestry	1730.42	49.16
3	Cultivated land	1249.54	35.50

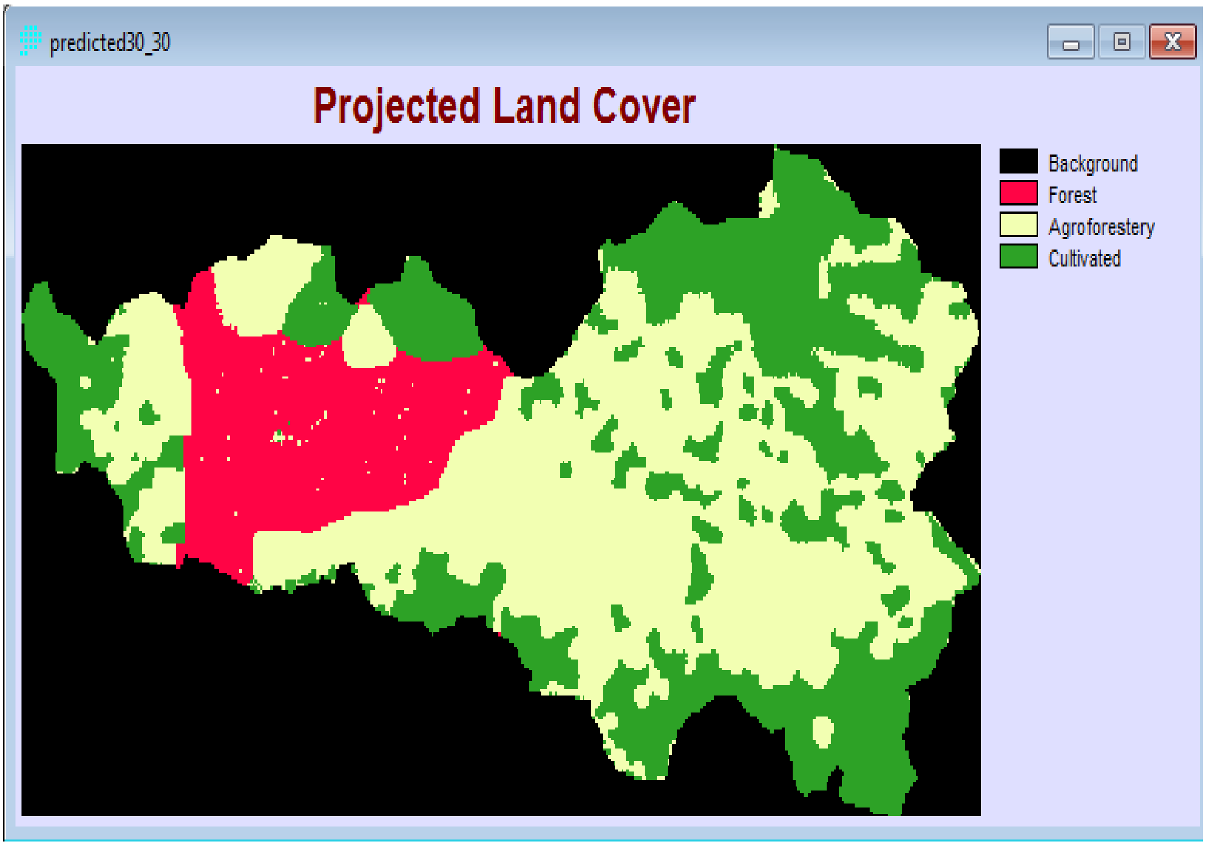

Figure 5. Projected land cover for 2048

4. Discussion

4.1. Analysis of land-use dynamics

Land use/cover analysis showed that forest cover decreased during the study period (1988-2018) as many studies in Ethiopia have revealed it (Reid et al. 2000; Tsegaye et al. 2010; Gebrehiwot et al., 2014; Meshesha et al., 2014; Tolessa et al., 2017; Markos et al.; 2018) and other tropical areas (Lira et al., 2012; Nahuelhual et al., 2014; Song and Deng, 2019). The change of one land use to other was dynamic and non-linear over the 30 years in the study area. The differences in land cover between the years may be attributed to government and policy changes in managing land and land-related resources. Moreover, interviews and group discussions outlined the map of 2008 showed the dominance of agroforestry over the two land uses since coffee was introduced to the area during this decade and planted at the forest's expense. The 1975 land reform by the Derg, military regime (1974-1991), was considered a radical measure that abolished tenant-landlord relationships in Ethiopia. The policy motto was designed to alter fundamentally the then agrarian relations and make those working the land the owners. Since 1974 and subsequent years till 1991, the provisions of the proclamation (No. 31/ 1975) include public ownership of all rural lands; distribution of private land to the tiller; prohibitions on transfer-of-use rights by sale, exchange, succession, mortgage or lease, except upon death and only then to a wife, husband or children of the deceased; and in the case of communal lands, possession rights over the land for those working the land at the time of the reform. The power of administering land was vested in the Ministry of Land Reform and Administration (MLRA) through Peasant Associations at the grassroots level with the abolition of the private and shared property of the land, thereby giving usufruct rights to all. The law provided 10 ha of land as the maximum a family can possess (Yigremew, 2002).

However, the state was unable to monitor and enforce laws, and as a result, forest land, shrub/bushland, and grassland were massively converted to settlement and agricultural land. In general, the country's institutional setup lacked the technical and financial capacity to deal with deforestation. Furthermore, technical issues overshadowed social issues related to participatory forest management. Besides, the political will to enforce laws and policies to curb deforestation can also be taken as a draw-back to deal with deforestation in Ethiopia for this study period (1973–1994).

The government, (1991-extant) maintains the same status, where Article 40 of the 1994 (FDRE,1994) constitution (which concerns property rights) provides that the right to ownership of rural and urban land, as well as of all-natural resources, is exclusively vested in the state and the people of Ethiopia. "Land is a common property of the Nations, Nationalities, and Peoples of Ethiopia and shall not be subject to sale or other means of exchange" (Sub Article 3).

Article 40 makes land-related resources are the property of the state, which made the resources easily convertible to agricultural land: agroforestry and cultivated land in our case. The government also adopted the Agricultural Development Led Industrialization (ADLI) policy; a strategy viewed agriculture as the engine for the growth of the Ethiopian economy. Hence, mainly smallholder local farmers, settlers and investors convert forest land to agriculture: agroforestry and cultivated land driven by market-oriented production of high-value crops for national and international markets, for instance, coffee in our case (Dejene et al., 2013). The conversion of forest land into cropland concerning policy change results in the reduction of forests' ecosystem services. Many studies in tropics confirm the impacts of government policy on forest due to an extensive agricultural policy approach (Hu et al., 2008; Lira et al., 2012; Oestreicher et al., 2014; Qin et al., 2019).

Researchers concluded that there are problems with the current land tenure system. Studies in Oromia, Amhara and Tigray regions showed, the government had one imperative policy option: a movement from the existing insecure system towards a more stable and secure tenure system; it has detrimental effects on agricultural productivity and natural resources conservation. The current land policy neither guarantees farmers` rights over the land they use, maintains equitable access to land over time, provides incentives for investment in improvements or conservation or encourages farmers' entrepreneurial and experimental efforts to improve their lot. From a policy perspective, it does not foster agricultural intensification, improved environmental management, accretion capital formation, or rural development." (Tekie, 2000).

4.2. Landscape Ecosystem Services

Land use and cover change have been identified as critical drivers of alteration in ecosystems and their services. The overall ecosystem services of the study area were found to be reduced over the years due to the reduction of forest land, which is in agreement with the findings of (Li et al. 2007; Hu et al. 2008; Costanza et al. 2014; Kindu et al. 2016; Tolessa et al., 2017; Markos et al., 2018). The small decrease in ecosystem service values of cultivated land use 1988-2018 may be attributed to the abandonment of this land as agroforestry. When disaggregated based on ecosystem services such as raw material, recreation, and cultural services were also reduced in the study area, which confirms with other findings (Hu et al., 2008; Hao et al., 2012; Nahuelhual et al., 2014; Song and Deng, 2017; Leitẩo et al., 2019). The results of all analyses indicated that the ESVs calculated for the watershed was relatively inelastic with changes ESV coefficients suggesting the estimation of the ES value is reliable since all the CS values are less than one which was similar to the findings of Li et al. (2007), Hu et al. (2008), and Hao et al. (2012).

The land-use maps create tables 11 and 12 of the transition probability matrix and state transition area matrix for 1988 and 2018, and the result for 2048 is predicted. Table 12 is the statistical table based on the predictive results in 2048. In general, in 2048, the forest land area decreased significantly, and the remaining land area increased by a certain amount. Thus, to consider ecologically, the protection of forest land is necessary for planning.

5. Conclusion

Ecosystem service valuation based on LULC data at the local level and global datasets is vitally essential, demonstrating how much service value has gone astray through human cultivation in both spatial and temporal scales. Such estimation for both local and global levels significantly impacts decision-making processes by modifying the national inventory systems to reveal the actual values of the ES to be used as a foundation for sustainable development ultimately. The other benefit is related to crafting development planning, whereby benefits need to be in line with the services sought. The ecosystem service reduced due to deforestation might affect local communities' livelihoods, so the need to improve land for sustainable production is vibrant. Regards the significant LULC change observed in the last 30 years (1988-2018), agroforestry and cultivated land expanded by 38.7 and 74.3 %, respectively, whereas forest land decreased by 47.03 % over the analysis period.

Nutrient cycling, raw materials provision, climate regulation and erosion control were contributors to ESV loss, but food production (0.63) was the only positive value compared to others. Hence, the study area needs soil fertility management with conservation measures. The CS values selected land-use types (forest, agroforestry, and cultivated land) were less than one implied that the estimation is robust. CS for forest and agroforestry has the highest values. It was estimated that about the US$ multi-million loss of services in 30 years has revealed of ecological degradation. The agricultural development under the current pattern should take into related financial losses that occurred in ordinary settings, whether lost or transformed; crop production systems should have appropriate land use plans incorporating to protect the forest.

Many tropical countries' land-use policies encourage the reduction of woods to crop production, resulting in the loss of essential ESs (Lira et al., 2012). Moreover, the current investment policy put most natural forest/shrub areas converted to agro-processing industries affecting the natural setup of ecology and this also practiced in the sub-watershed. The need for appropriate intervention of rural land policies and active participation of smallholders for the long-term management of land assets (forest, shrub and grassland) is crucial to prevent the degradation of the ecological resources.

The analysis of the trends in the land-use change using Markov chains and CA shows the influence of these activities in the study area. The land uses of the watershed projected for 2048 show a similar trend as 1988-2018, where 877.6 ha of the forest will probably be lost. The agroforestry will increase to 1730.42 ha, and the cultivated land will increase by 294.44 ha. The government institutions involved with forest management policies must take action in the conservation, protection, and production of the forest system in the study area. Overall, this study's combined methods demonstrate the usefulness of remote sensing to monitor spatial and temporal changes of the watershed. The results of this study could provide quantitative information, representing a base for assessing sustainability in the management of these ecosystems.

6. References

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