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RESEARCH ARTICLE

ASSESSMENT OF SOIL EROSION AND LAND USE LAND COVER CHANGE USING RUSLE MODEL, GIS AND REMOTE SENSING: A CASE STUDY OF WOMBEYA WATERSHED, AWASH BASIN, ETHIOPIA

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ABSTRACT

Soil erosion is a natural phenomenon, where environmental determinants, such as climate, soil, topography, and vegetation affect the extent and magnitude of soil loss. Human impact on the natural system through deforestation, intensive land cultivation, uncontrolled grazing, and construction activities are often accelerating the rate of soil erosion. Spatial and temporal change of land use/land cover (LULC) is increasingly recognized as an important driver of environmental change such as soil degradation. Soil erosion models, for instance, RUSLE integrated into GIS has used to assess the spatial distribution of soil loss and identify areas of concern. This study was aimed at assessing the LULC change and soil erosion trends in the Wombeya watershed between 1986 and 2017. This study applies the RUSLE model to explore soil erosion in the watershed. In the last four decades, soil erosion has been increased from 146 t $ha^{-1}yr^{-1}$to 214 t $ha^{-1}yr^{-1}$. Crop field and homestead show an increase in the expenses of forest and grassland. However, for the complete understanding of soil erosion causes exploring other impacts such as climate change is essential.

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INTRODUCTION

Soil erosion is a natural phenomenon, where environmental determinants such as climate, soil, topography, and vegetation affect the extent and magnitude of soil loss (Mutua *et al.,* 2006; Butt *et al.,* 2010). Human-induced impacts on the natural system through deforestation, intensive land cultivation, uncontrolled grazing and construction activities are often accelerating the rate of soil erosion (Thomas *et al.,* 2018; Reusing *et.al.,* 2000). The impact and extent of soil erosion is more severe in the developing world (Bayramin *et al.,* 2003) where farmers are highly dependent on subsistence farming (Lulseged and Vlek, 2008). Soil erosion affects soil productivity and soil organic carbon (Quine and Zhang 2002; Cruse and Herndl 2009). Land use/land cover change (LULC) is increasingly recognized as an important driving factor of soil degradation (Ahmet, 2010; Tadesse *et al.,* 2017). Therefore, understanding the dynamics and trend of LULC changes provides evidence-based support to improve soil and land management practices (Lu *et al.,* 2004, Cotter *et al.,* 2014). Studies have been demonstrated the stronger impacts of LULC change on soil erosion than rainfall variability (García-Ruiz 2010; Pacheco *et al.,* 2014; Wijitkosum, 2012; Alkharabsheh *et al.,* 2013) and on the livelihood of the rural community (Gessese, 2018). In Ethiopia, LULC change and the associated result on soil erosion have been observed (Tadesse *et al.,* 2018). Soil erosion models such as USLE and RUSLE integrated in GIS has been used to assess the spatial distribution of soil loss and identify areas of concerns (Bizuwerk *et al.,* 2008, Ioannis *et al.,* 2009; Tadesse *et al.,* 2017; Kayet *et al.,* 2018) and explore soil erosion relation with different factors such as land cover change (Cebecauer and Hofierka, 2008, Wijitkosum 2012). Land use land cover shifting and creation of active and dead gullies are witnessing across the Wombeya river watershed. Therefore, exploring the spatial and temporal dynamism of land use land cover and soil erosion is crucial for sound land use planning and soil and water conservation. Therefore, this study aimed at assessing the LULC change and soil erosion trends of the study area between 1986 and 2017.

MATERIALS AND METHODS

Description of the study area: The Wombeya watershed is located in upper part of Awash basin located southeast of Ethiopia covering an area of 1804 Km^2. The watershed experiences bimodal rainfall, the minor rains occur in March and April and major rains from July to August (Edossa *et al.,* 2010). Wombeya watershed elevation ranges between 887 and 3379 meters above sea level (Figure 1). The southern and eastern escarpments of the watershed have higher elevation and covered with trees mainly Eucalyptus and agricultural practices are being incremented on the hillsides. According to the Ethiopia statistics agency (ESA) (2007) census the population lives around the watershed estimated to 364,537.

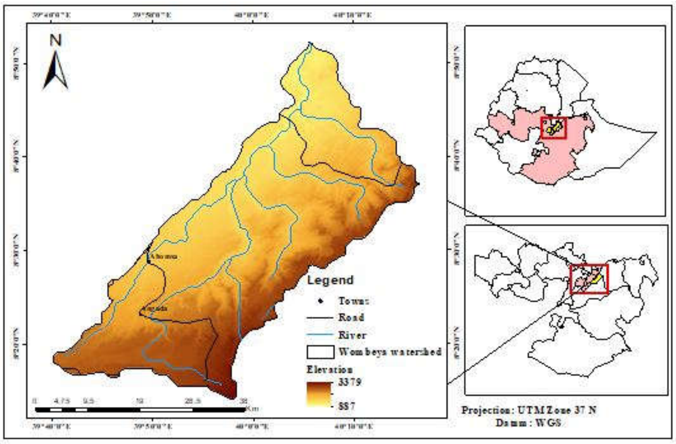


Figure 1. Location map of Wombeya watershed, southeastern Ethiopia

Methodology

Data acquisition and analysis: RUSLE adapted by (Renard *et al.* 1997) is a predecessor of the Universal Soil Loss Equation (USLE) first developed by (Wischmeier and Smith, 1978). RUSLE is an empirical model used to estimate soil loss and identify soil erosion-prone areas based on the climate, topography, soil properties, and land use conditions (Renard *et al.,* 1997). This empirical model equation stated as:

$$A = R * K * L * S * C * P \quad (1)$$

Where: A =computed average annual soil loss in t $ha^{-1}year^{-1}$
R = rainfall-runoff erosivity factor MJ mm t $ha^{-1}yr^{-1}$
K = soil erodibility factor
L = slope length factor
S = slope steepness factor;
C = cover management factor and
P = conservation practice factor.

A. Erosivity (R) factor: Soil loss is closely related to rainfall partly through the detaching power of raindrops striking the soil surface and partly through the contribution of rain to runoff (Morgan, 1995). According to Hurni, (1985) the R factor value has been calculated using equation 2.

$$R= -8.12 + 0.562P \quad (2)$$

P is the mean annual rainfall (mm) for the respective years of (1986, 2000 and 2017) has been obtained from the metrological stations around the study area. P values for 1986, 2000 and 2017 have been computed from the mean precipitation value of the year between 1982 and 2017. Once the mean annual rainfall for each year has been computed the R factor value was calculated using equation 2 and interpolated to the whole watershed using inversed distance weighting method. The metrological data has been collected from four metrological stations across the watershed such are Guna abajama, Metehara, Teferi Birhan, and Welenchiti.

B. Erodability (K) Factor: Renard *et al.* (1997) describe erodability as the vulnerability and susceptibility of soil type to detachment by erosion. It is determined by the cohesive force between the soil particles and may vary depending on the presence or absence of plant cover, the soil's water content and the development of its structure (Wischmeier and Smith, 1978). The higher erodibility value implies the vulnerability of the soil to erosion due to rainfall, splash or surface flow (Hudson, 1981). K for each soil types in the watershed has been determined following Stewart *et al.* (1975), which determines the K value based on soil texture i.e. sand, clay and silty, the percentage of each soil along with organic matter. The soil data for the study area has been extracted from the FAO harmonized world soil database (HWSD), (2012).

C. Topographic (LS) Factors: The influence of land surface slope (vertical distance/horizontal distance) has a positive impact on the amount of runoff and eroded sediment (Wischmeier and Smith, 1978). Steeper slope accelerates the speed of runoff; consequentially, the amount of sediment would be higher. Slope length is defined as the horizontal distance from the origin of overland flow to the point where deposition begins or where runoff flows into a defined channel (Renard *et al.,* 1997). The slope length and slope steepness can be used in a single index, which expresses the ratio of soil loss as defined by (Wischmeier and Smith, 1978). The LS factor has been calculated using from 30-m resolution DEM data. The L (slope length) and S (slope steepness) factors were calculated using topographic information using formula proposed by McCool *et al.* (1987) and used in Sharma and Bhadori (2010).

$$L= (\lambda/22.13)^{m} \quad (3)$$

Where: L is slope length factor, λ is field slope length (in m), m is a dimensionless exponent that depends on slope steepness, being 0.5 for slopes exceeding 5%, 0.4 for 4% slopes, and 0.3 for slopes <3%. Digital elevation model (DEM) was used to derive the slope percent. The field slope length (l) determined from 200 m grid size, and the S factor for slope longer than 4 m derived as follows:

$$S = 10.8\sin\theta + 0.03 \text{ for slope} < 9\% \quad (4)$$

$$S = 16.8\sin\theta - 0.50 \text{ for slope} \geq 9\% \quad (5)$$

D. Land use land cover and Cover (C) Factor: Human activities such as plugging, burning or heavy grazing disturbs the protective layer, and expose the underlying soil (Adugna *et al.,* 2018, Assefa *et al.,* 2015, Bewket and Teferi, 2009). Therefore, vegetation cover is the main factor in soil erosion assessment and so in RUSLE. Land use land cover and C factor can derive from satellite image through supervised classification (e.g. Teka et al 2017, Abate and Angassa, 2016; Sharma and Bhadoria, 2010,) and from normalized difference vegetation index (NDVI) (e.g. Ahmet *et al.,* 2010; Tadesse *et al.,* 2017, Thomas *et al.,* 2018). Land use land cover change and C factor value of the study area has been analyzed for the year 1986, 2000 and 2017 through supervised classification. Further, unsupervised classification compiled with ground truthing and interview of the local elder community has been used as a guide for the selection of training sites for supervised classification. This provides preliminary information about the potential spectral clusters to be assigned to thematic classes and for accuracy assessment (Jensen 2003, Leica Geosystem 2003). The accuracy assessment determined using error matrix and Kappa statistic is essential to measure the correct classification of pixels (Congalt and Green 1999, Lillesand and Kiefer 2004). LULC classification of 2017 has been evaluated using 280 ground-truth GPS points. However, the 1986 and 2000 classification accuracy was evaluated from local elder

Table 1. Characteristic of satellite images

Path	Row	Date of acquisition	Sensor	Satellite
168	54	21 Jan 1986	Thematic Mapper (TM)	Landsat 5
167	54	30 Jan 1986	Thematic Mapper (TM)	Landsat 5
168	54	13 Feb 2000	Enhanced Thematic Mapper Plus (ETM+)	Landsat 7
167	54	06 Feb 2000	Enhanced Thematic Mapper Plus (ETM+)	Landsat 7
168	54	10 Jan 2017	Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS)	Landsat 8
167	54	03 Jan 2017	Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS)	Landsat 8

Table 2. C factor value for different land use

LULC	C factor value	References
Forest	0.01	Hurni (1985)
Cultivated land (cereal)	0.15	Hurni (1985)
Homestead	0.99	Eweg and van Lammeren (1996)
Grassland	0.01	Eweg and van Lammeren (1996)
Shrubland	0.01	Hurni (1985)

Table 3. P factor value of Wombeya watershed

Land Use Type	Slope (%)	P factor
Agricultural Land	0-5	0.11
	5-10	0.12
	10-20	0.14
	20-30	0.22
	30-50	0.31
	50-100	0.43
Other Land	All	1.00

discussions to recall about LULC history covering, this approach has been using by (Abate and Angassa 2016, Musa *et al.,* 2018). Furthermore, the possible drivers and consequences of the changes have been also explored using group discussions with local elders and key informants such as agricultural development. The study area was not entirely contained within a single Landsat scene therfore two Landsat images of path 1684 row 54 and path 167 row 54 were mosaicked to get complete coverage of the study area (Table 4). Therefore, six images two for each year was mosaicked and the study area extracted using shapefile. Satellite imagery with minimum (<5%) cloud cover obtained in January and February was used as a source of data for the detection of LULC changes. Thematic Mapper (TM) of Landsat 5 scenes obtained for the 1986, the Enhanced Thematic Mapper Plus (ETM+) of Landsat 7 scenes obtained in 2000 and the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) of Landsat 8 scene images obtained from USGS website were used (Table 1). The present land-use/cover study used 1986 as the base of the changes in 40 years with comparing 2017 and 2000 image were used to examine the change dynamics. All scenes used in this study were obtained from the website of the U.S. Geological Survey (USGS), Earth Resources Observation and Science (EROS) Center. The LULC change of Wombeya watershed has been explored for the last 40 years; 1986 year has been taken as the baseline to understand the change with respect to 2000 and 2017. The C factor is defined as the ratio of soil loss from land with specific vegetation to the corresponding soil loss from continuous fallow (Wischmeier and Smith, 1978). In this study, the C factor values were derived from different kinds of literature (Table 2). P is the support practice factor which is the ratio of soil loss with a support practice such as contouring, strip cropping, or terracing to reduce soil loss (Renard *et al.,* 1997). The conservation practices factor values depend on the type of conservation measures implemented and require mapping of conserved areas for it to be quantized.

As in the case of Wombeya watershed where data are lacked on permanent management factors or when there were no management practices, P factor values determined by integrating slope and agriculture (Wischmeier and Smith, 1978; Bewket and Teferi 2009). This classifies land use into agricultural and other land use/land cover class and intercepts with a land slope (Table 3). The extracted agricultural land map from the other LULC overlaid with a slope map to produce a P factor map. P factor of land covers other than agricultural land has been assigned to 1 (Tadesse *et al.,* 2018).

In this study C, R and P factors maps of 1986, 2000 and 2017 have been developed, but a single map of K and LS factors map was developed. In order to minimize geo-location errors and to improve the horizontal accuracy, the input factors of RUSLE were co-registered to a common geographic reference. All the layers was projected to WGS84 datum zone 37 N with a grid cell size of 30 meters. Once all the factors had been developed the quantitative output was computed on a pixel-by-pixel base (using raster calculator function) in ArcGIS.

Land cover change analysis: The classified images was overlaid for change comparison (Lu *et al.,* 2004; Abate and Abate and Angassa, 2016). The amount of changed area (CA), change extent (CE) and the annual rate of change (CR) variables were used to determine the magnitudes of change in terms of LULC. The variables were calculated as follows (Abate and Angassa 2016, Mussa *et al.,* 2017):

$$CA = TA\ (t_2)\ -TA\ (t_1) \qquad (6)$$

$$CE = (CA/TA\ (t_1)\ *\ 100 \qquad (7)$$

$$CR = CE/\ (t_2-t_1) \qquad (8)$$

Where TA is a total area, t_1 and t_2 are the beginning and ending time of the land cover studies.

RESULTS

LULC dynamics in Wombeya watershed: The classification has been achieved 91% of accuracy in 2017, and 82% and 87% for 1986 and 2000, respectively. Similarly, the Kappa coefficient of 2017 is higher with 0.89 followed by 0.81 for 1986 and 0.86 for 2000. In the last four decades, continuous decreases of forest and grassland have been witnessed. Forest has been decreased by 38% (142 km^2) with a 6.8% annual rate of decline. The annual decline of grassland is 2.6% and a total of 54 km^2 has been converted to cultivated land mainly (Figure 2 and Table 4). Farmland has been increased significantly with an annual rate of 5.9% and a total of 125 km^2 (14%) increases mainly on the expenses of forest mainly (Table 4). Homestead has been also increased steadily from 1986 to 2017. The result obtained from the key informant interview and group discussion have demonstrated the major change with respect to land cover is the conversion of forest and grassland areas to agricultural land and settlement due to urbanization population growth.

CA= Changed area, CE=Change extent, the CR= annual rate of change

Potential Soil loss

Cover and management (C) Factor: Due to the fact that farmland and homestead are vulnerable to direct rainfall the watershed are being exposed to soil loss in the last four decades. Further, the decline in forest and grassland coverage maximized the rate of soil loss (Table 4 and Figure 2).

Rainfall Erosivity (R) factor: The mean annual rainfall has been decreased from 1986 to 2017 consequentially the R factor. Yet the highland areas have experienced high erosivity factors (Guna abajama) and low in the lowland areas (Metehara) (Table 5). The mean annual rainfall has been decreasing throughout the study period, consequentially the R factor value. The interpolated R factor value of Guna abajama has been decreased from 764.1 mm ha^{-1} $h^{-1}y^{-1}$ in 1986 to 526.3 mm ha^{-1} $h^{-1}y^{-1}$ in 2017 (Table 5).

Soil Erodibility (K) factor: 47.2% of the watershed is dominated by Lithosols (Table 6). According to Stewart *et al.,* (1975) this soil has moderate erodibility characteristics. The soil with high erodibility characteristics Eutric Cambisols covers 2.4%.

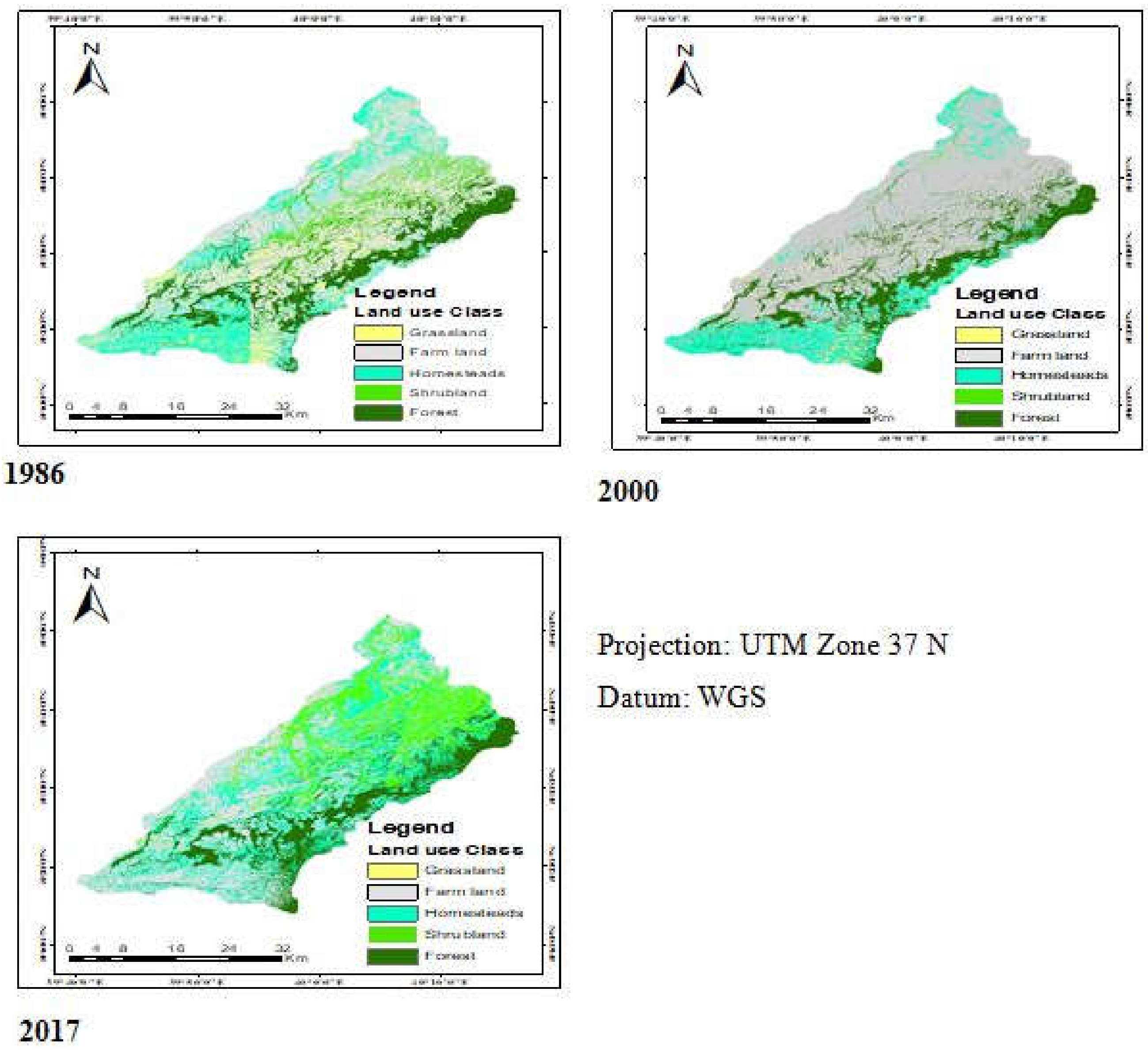


Figure 2. Land use land cover map of the Wombeya watershed

Table 4. Area coverage, the rate of LULC changes between 1986 and 2016 and C factor value of Wombeya watershed.

Land use	1986	2000	2017	1986-2000			2000-2017			1986-2017			C factor value
	Km^2	Km^2	Km^2	CA km^2	CE(%)	CR(%)	CA km^2	CE(%)	CR(%)	CA km^2	CE(%)	CR(%)	
Grassland	103	97	49	-6	-5.8	-0.4	-48	-49.4	-2.9	-54	-52.4	-2.6	0.01
Farmland	892	966	1017	74	8.3	0.6	51	5.3	0.3	125	14.0	5.9	0.15
Forest	365	271	223	-94	-25.8	-1.8	-48	-17.7	-1.0	-142	-38.9	-6.8	0.01
Homestead	246	267	304	21	8.5	0.6	37	13.9	0.8	58	23.6	2.8	0.99
Shrub land	198	203	211	5	2.5	0.2	8	3.9	0.2	13	6.6	0.6	0.02
Total area	1804	1804	1804	-	-	-	-	-	-	-	-	-	-

CA= Changed area, CE=Change extent, the CR= annual rate of change

Table 5. Mean annual rainfall and R factor value of Wombeya watershed

Stations	1981-1986		1986-2000		2000-2017	
	Mean	R value	Mean	R value	Mean	R value
Guna abajama	1374.8	764.1	1300.48	772.8	950.9	526.3
Metehara	445.8	242.4	514.2	280.9	486.5	265.3
Teferi birhan	1000.4	554.1	989.4	547.9	824.4	455.2
Welenchiti	893.4	493.9	895.7	495.3	868.9	480.2

(Source: NMA, Data compiled by the authors, 2017)

Table 6. Soil type and K factor value of Wombeya watershed

Soil type	Coverage		K factor value
	Km^2	%	
Chromic Cambisols	203	11.2	0.28
Chromic Luvisols	17	0.9	0.28
Chromic Vertisols	19	1.1	0.24
Eutric Cambisols	43	2.4	0.34
Eutric Nitosols	58	3.2	0.14
Lithosols	852	47.2	0.2
Orthic Luvisols	385	21.3	0.05
Pellic Vertisols	117	6.5	0.24
Vertic Cambisols	113	6.3	0.24
Total	1,807		

Table 7. P factor value and area coverage

Slope	1986		2000		2017		P factor value
	Km^2	%	Km^2	%	Km^2	%	
0-5	476	26.3	498	27.6	504	27.9	0.11
5-10	249	13.8	273	15.1	296	16.4	0.12
10-20	133	7.4	149	8.2	155	8.6	0.14
20-30	34	1.9	46	2.5	51	2.8	0.22
30-50	-	-	-		11	0.6	0.31
Other land use	915	50.6	841	46.5	790	43.7	1.00

Table 8. Soil loss severity extent of Wombeya watershed

Soil erosion severity (t/ha/yr)	Severity class	1986		2000		2017	
		Km^2	%	Km^2	%	Km^2	%
<12	Low	1265	70.0	1017	56.3	1001	55.4
12-25	Moderate	127	7.0	543	30.0	626	34.6
25-50	High	8	0.4	48	2.7	45	2.5
50-80	Very high	32	1.8	14	0.8	11	0.6
80-125	Severe	304	16.8	73	4.0	31	1.7
>125	Very severe	71	3.9	112	6.2	93	5.1

Topographic (LS) factors: The topographic factor ranges between 0 and 69.4 High impacts of topography has been observed along the gorges and mountains of the watershed (Figure 3).

Supporting conservation practice (P) factor: In the recent year's settlement and Agricultural practices are experienced in the steeper slope of the watershed. Farming at elevation 30 to 50 percent was not practiced in 1986 but in 2000 it has been cultivated and intensified in 2017. This intensifies soil erosion rate (Table 7).

Estimated soil loss in the Wombeya watershed: The result shows that soil loss in the Wombeya watershed has been increased throughout the period. In the 1980s estimated soil loss reaches 145.7 t ha^{-1} yr^{-1} and in 2000 and 2017 the estimated soil loss reaches 211.8 t ha^{-1}yr^{-1} and 214.2 t ha^{-1}yr^{-1}, respectively (Figure 4). The mean annual soil loss has been also increased from 19 t ha^{-1}yr^{-1} in 1986 to 25 t ha^{-1}yr^{-1} and 40 t ha^{-1}yr^{-1} in the 2000 and 2017 respectively. This exemplifies the increasing of soil erosion which was mainly associated with LULC cover change and poor soil and water conservation practices. The local community has also stressed the continuous grawth of agriculture and LULC changes are the main cause for the increase in soil loss. However, the extent of severing soil loss has been declined from 1986 to 2017 (Figure 4), this is due to the recent soil and water conservation practices implemented throughout the country.

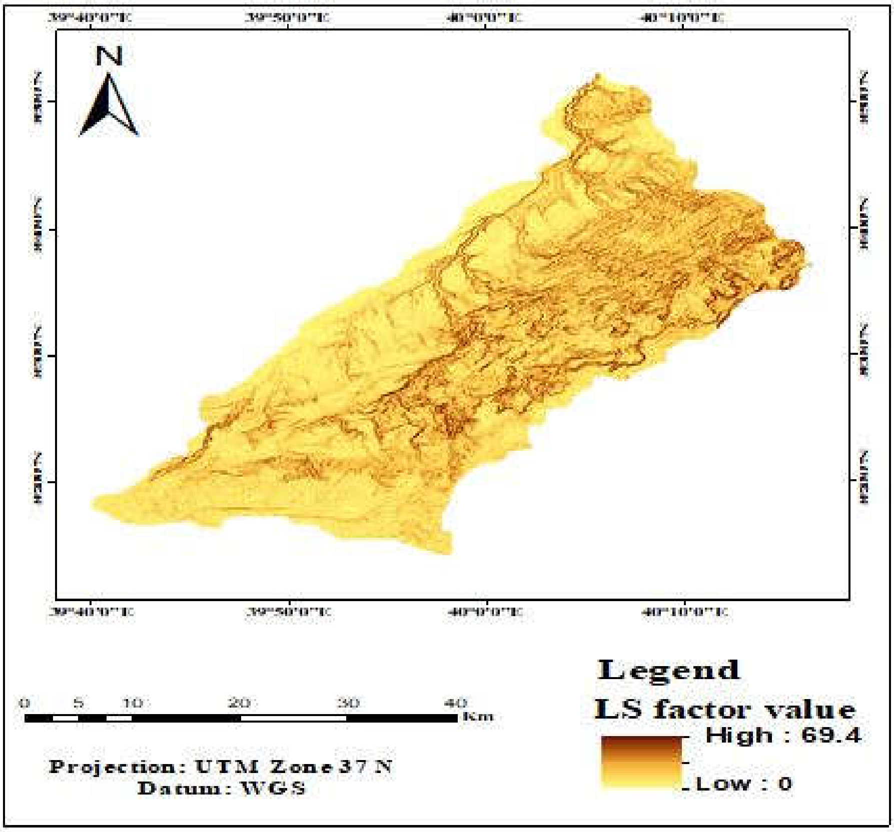
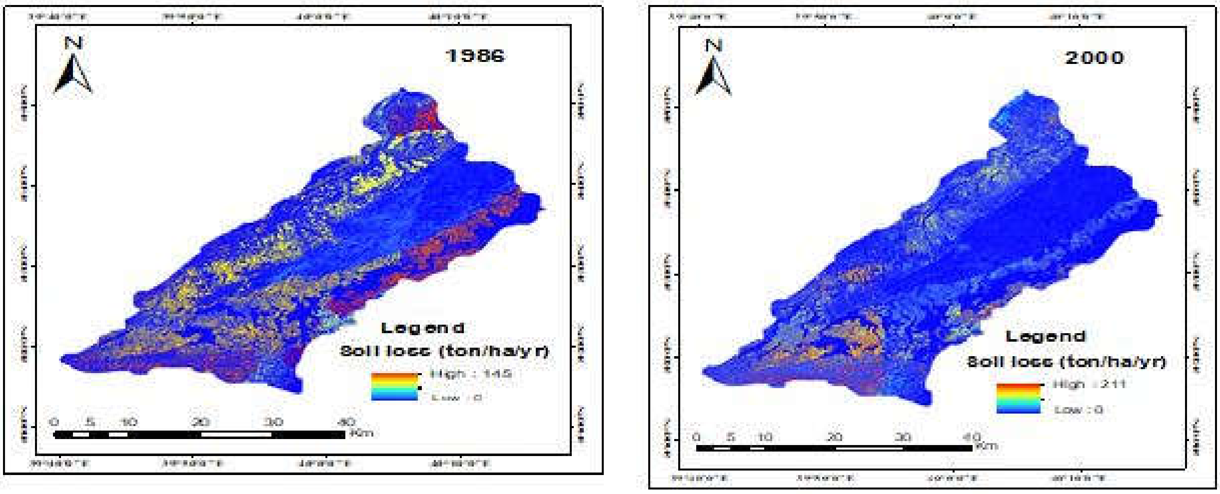
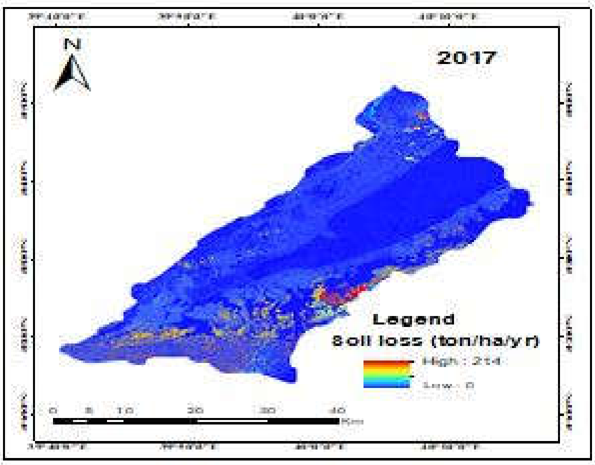


Figure 3. LS factor map of Wombeya watershed





Projection: UTM Zone 37 N

Datum: WGS

Figure 4: Estimated soil loss of Wombeya watershed, Central Ethiopia

Figure 4.

Soil erosion severity across Wombeya watershed: Following Bewket and Teferi (2009) soil loss severity classification in the Wombeya watershed most parts are lies in the low severity (tolerable soil loss class) i.e. 70% in 1986, 56.3% in 2000 and 55.4% in 2017. Yet, the extent of low soil loss shows a decline throughout the period and an increase of moderate soil loss areas. (Table 8).

DISCUSSION

The conversion of woodland/forest and grassland areas to homestead and cropland has been observed in the Wombeya watershed, similar findings have been observed in the Abaya Chamo basin (WoldeYohannes *et al.,* 2018) and Yezat watershed Abay basin (Tadesse *et al.,* 2017). According to Mussa *et al.* (2017), WoldeYohannes *et al.* (2018) and Teka *et al.,* (2018) the main driving forces for LULC change are population grawth, regime changes in the late 1980s and conversion of forest land to cash crop fields and clearing of trees for charcoal. Invasive species have also a significant impact on LULC change (WoldeYohannes *et al.,* 2018). Tsegaye *et al.* (2010) stated the intense livestock brawsing results on the decline of woody plant species, indicating the severity of land cover degradation. The main effect for soil erosion is LULC changes, and soil loss is intense in steeper slope and open lands (Thomas *et al.,* 2018, Tadesse *et al.,* 2017, Sisay *et al.,* 2014). The volume of soil loss is high in the steeper and open areas of the Wombeya watershed. RUSLE is the most commonly applied soil loss estimation model (Erol *et al.,* 2015; Hasan *et al.,* 2012; Wang *et al.,* 2013; Ganasri and Ramesh, 2016, Ahmet, 2014, Tadesse *et al.,* 2017). It has been adapted to Ethiopian condition by Hurni (1985). Moreover, RUSLE model strength lies in giving predicted soil loss using limited information, especially in developing countries where data are scarce (Gebreyesus and Kirubel, 2009). Increment of the crop field and homestead intensifies the trend of soil erosion in the Wombeya watershed. Emre *et al.* (2018) study on the Maritsa, Mediterranean Basin demonstrated the adverse impact of land cover change on soil erosion and agricultural production. According to water and land research center (WLRC) (2016) between 1973 and 2015 removal of vegetation in the bale eco-region, Ethiopia intensifies soil loss. High soil loss is mainly from poor vegetation cover areas and steeper slope (Sisay *et al.,* 2014). However, due to the recent soil and water conservation practices, soil erosion severity has been decreased in the Wombeya watershed. Similar results have been also noted by Tezera *et al.,* (2016) in Anti tide watershed, Ethiopia and by Emre *et al.,* (2018) in Maritsa Basin, Mediterranean Basin. The contribution of farmers in mitigating soil loss from agricultural land is vital but lacks technical support and fund are hindering their positive impacts (Adugna *et al.,* 2015). Further, securing land tenure has a positive impact on the conservation of soil erosion by creating a sense of ownership (Abate, 2011; Tsue *et al.* 2014; Rabia 2012). The estimated annual soil loss in Ethiopia due to erosion is 1.5 billion ton of which 50% occurs in cropland (Assefa and Bork, 2015). Agricultural productivity of Ethiopia is adversely affected by soil erosion (Gelagay and Minale, 2016; Tamene *et al.,* 2006), consequentially farmer's food security (Deresa and Legesse, 2015). Soil erosion causes a decline in crop yields by reducing rooting depth, soil water holding capacity and depletion of soil organic matter and nutrients which eventually causes soil acidity (WLRC, 2016).

Conclusion

Forest in the Wombeya watershed has been declined in the study time period i.e. 365 in 1986 to 223 in 2017 similarly grassland declines from 103 km^2 in 1986 to 49 km^2 2017. On the other hand, homestead increased from 256 km^2 in 1986 to 304 km^2 in 2017 and farmland incremented from 892 km^2 in 1986 to 1017 km^2 in 2017. Soil loss in the Wombeya watershed has been increased from 146 t $ha^{-1}yr^{-1}$ in 1986 to 214 t $ha^{-1}yr^{-1}$ in 2017. LULC change is accelerating soil erosion in the study area. In the recent year, soil loss increment is low i.e. only 3 t $ha^{-1}yr^{-1}$ between 2011 and 2017 this could be the attribute of better soil and water conservation practices. Yet, forest clearing for crop field and conversion of grassland to homestead along with population growth played a vital role in intensifying soil erosion. The findings of such research will contribute to developing future watershed resources management strategies in response to sustainable land management. Soil erosion is the most serious causes of land degradation that influence tremendous pressure on productivity and environmental resilience. Beside LULC other anthropogenic activities such as climate change might cause direct and indirect effects on soil erosion at various scales. Therefore, assessing the impact of climate change on soil erosion is often necessary to get the full figure of soil erosion causes.

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