Impacts of Phased–out Land Restoration Programs on Vegetation Cover in Eastern Tigray, Ethiopia

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Impacts of phased–out land restoration programs on vegetation cover in Eastern Tigray, Ethiopia

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Abstract:
Background: The aim of this study was to investigate the impacts of phased–out land restoration programs on vegetation cover in Eastern Tigray, north Ethiopia. Both the Thematic Mapper (TM) and Enhanced Thematic Mapper plus (ETM+) Landsat imageries at 30 meter by 30 meter spatial resolution was used to examine the land use and land cover conditions of the study area before (2007), during (2010), and after (2017) the phase–out of IWM projects.
Results: The results indicated that there is a clear variation between the treated and untreated watersheds in terms of vegetation cover status. It is confirmed that for treated and successfully recovered watersheds both the bush/shrub land (19.6 ha), and grassland (8.95 ha) have been increased. However, it was decreased by 9.8 and 11.3 ha in two watersheds after the project phased–out.
Conclusions: The soil and water conservation practices of each watershed have been significantly affected after the phased–out of the IWM projects. An increase to in the bush/shrub lands has been observed in all of the study sites (Adikesho, Deberewahabit and Gemad) by 19.6, 8.95 and 18.9 ha's during the intervention period.

Keywords: IWM, Remote Sensing and GIS, Eastern Tigray, Ethiopia

Background

Vegetation cover and changes are the outcome of both natural and anthropogenic processes (Muluneh, 2003; Emiru and Gebrekidan, 2013). It is dynamic in nature and provides a broad understanding of the interaction and relationship between anthropogenic activities with the environment (Briassoulis, 2006; Gessese, 2018). Land degradation in the form of soil erosion has been one of the most important challenges in the highlands of Ethiopia affecting agricultural productivity and food security. Predicted annual soil loss rates from the cultivated croplands vary over a wide range and can reach up to 130 tons/ha in the year of 2010 (Hagos et al., 1999) and over the last three decades cover about 23% of the land degradation in the country (Gebreselassie et al., 2016). The change in vegetation cover both directly and indirectly affects environmental conditions, economic status, and society at various spatial and temporal scales (Briassoulis, 2004).Land use/ land cover (LULC) has also been recognized by a variety of national and international bodies as a critical factor mediating between socioeconomic, political, and cultural behavior and global environment changes such as climate and biodiversity (Turner and Meyer, 1994). The LULC alterations are generally caused by population growth and increasing pressure on land resources and increasing socioeconomic necessities create a pressure on LULC, mismanagement of agricultural, urban, range and forest lands which lead to severe environmental problems such as landslides and flooding (Seto et al., 2002; Barros, 2004). According to Abate (1994), LULC changes and socioeconomic dynamics have a strong relationship; as population increases the need for cultivated land, grazing land, fuel wood; settlement areas also increases in order to meet the growing demand for food and energy, and livestock population.

To alleviate these challenges, different land restoration activities also called integrated watershed management (IWM) were widely implemented since 1980s on selected large watersheds located mainly in the highly degraded parts of the highlands of Ethiopia (Zeleke, 2006). Integrated watershed management is a holistic approach that regards a watershed as a holistic system where social, cultural, economic, and environmental components interact together, and includes the management of the socioeconomic, human, institutional, and biophysical which is linking between soil, water, and land uses (Wang and Innes, 2005). According to Bekele and Tilahun (2007); Brooks and Eckman (2000), integrated watershed management has been promoted in many countries as a suitable strategy for improving productivity and sustainable intensification of agriculture while at the same time managing the resources. The purpose was mostly for implementing natural resource conservation and development programs (Asrat et al., 2005). However, most of the integrated watershed management programs in Tigray were phased–out after 5 years implementation period. Phase–out refers to the withdrawal of project support for activities related to watershed management practices by the governmental and non–governmental organizations where such responsibilities are handed over to the local institutions (Zeleke, 2014). A number of watershed management projects were phased–out in Tigray as well as in the study area (Example: under sustainable land management project about 34 watershed projects were phased–out). Despite the importance of impact evaluation and monitoring of such integrated watershed management interventions studies on impact of IWM on vegetation cover change after the watershed projects phased–out is rather limited in Ethiopian highlands. Available studies on impact evaluation are also mainly for more successful watersheds. Hence, this study is aimed at evaluating the vegetation cover status of six phased–out watersheds project and determine the status of vegetation cover changes after phased–out the watershed projects considering both successful and unsuccessful watersheds.

2. Materials and Methods

2.1. Study area

The study was conducted in six watersheds (Negash, Debrwahabit, Gemad, Debretsion, Laelay wukro and Tsigerda) located in the Kilte Awlaelo district, eastern Tigray, northern Ethiopia (Figure 1). The district is located at a distance of 45 km to the north of the regional capital (Mekelle city). Geographically, the study district is located at 13°33′ 00″ and 13°58′00″ North and 39°18′ 00″ to 39°41′00″ East with elevations that ranges from 1760 to 2720 meters above sea level.

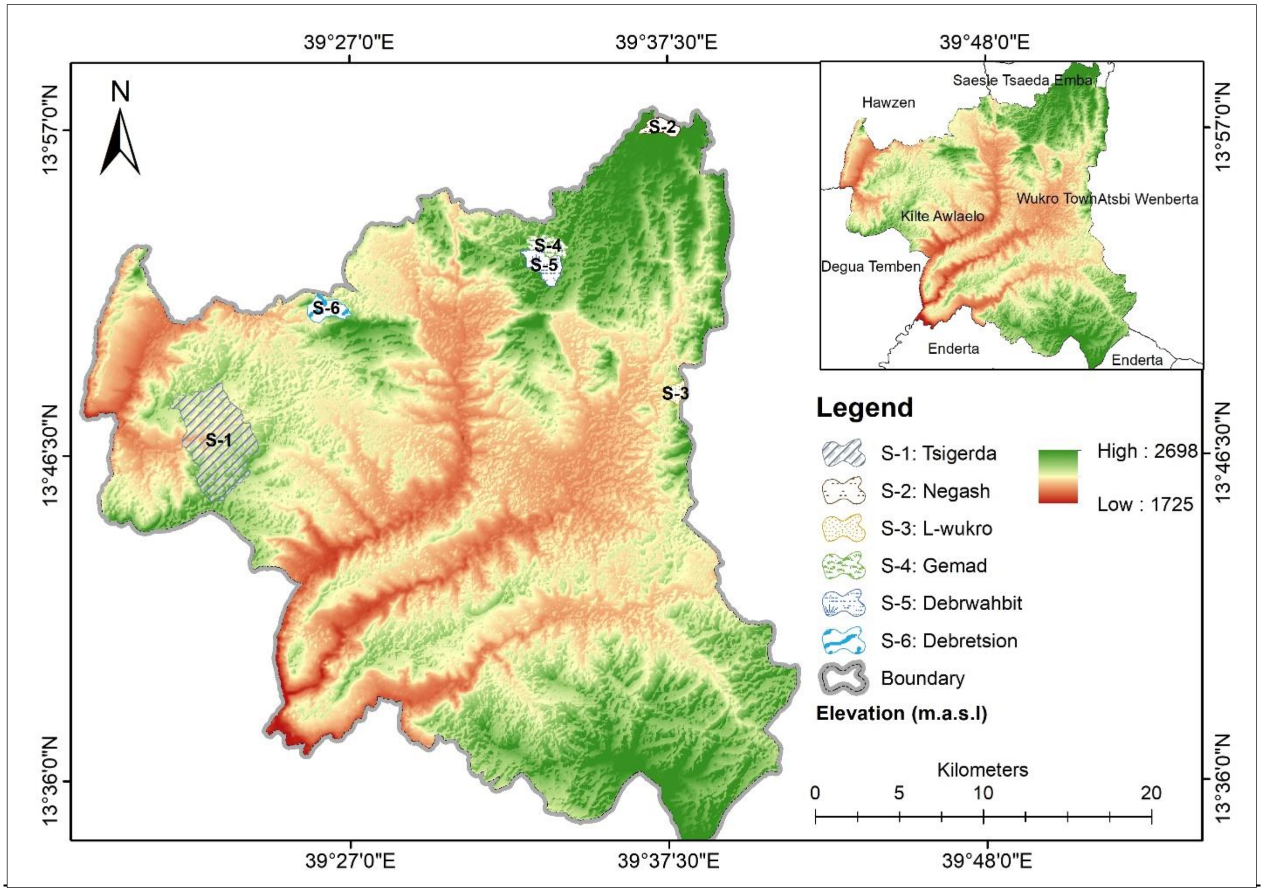

Figure 1: Location of the study area with the indication of studied watersheds

The total area of the district is about 101,758 ha, from which 21% is cultivated cropland, 7.8% grass land, 43.4% exclosures and the remaining 27.7% occupied by unproductive outcrop hills and residential areas (MoARD, 2007). The district has two main Agro–climatic zones: i) Douga/cool, humid highland zone (13.1%) which is located at altitudes of above 2500 meters above sea level; ii) Weina Douga (86.9%), which is located at an altitude that ranges between 1500 and 2500 meters above sea level (Rabia et al., 2013). The dry season occurs between October and January; while the rainy season occurs between June and September (Tigray Meteorological Agency, 2017).The maximum temperature was observed in May and June; while the minimum temperature was observed in the months between September and December

(Tigray Meteorological Agency, 2017). The study area is dominated by igneous and metamorphic rocks (Precambrian, Paleozoic) (Rabia et al., 2013). According to FAO (1998), the soil types of the district are Lithosols (43.8%), Vertic Cambisols (43.7%), Eutric Cambisols (6.7%), Chromic Luv isols (3.95%) and Chromic Cambisols (1.89%). The livelihood of the community mainly based on agriculture. Agriculture in the area is characterized as mixed farming in which involve both crops and livestock produced and managed on the same farm. The major crops grown are barley *(Hordeum vulgare),* wheat *(Triticum sativum),* teff *(Eragrostis teff) and* millet *(Eleusine coracana*). While the major livestock herds are sheep, camel, mule, donkeys, cattle, chicken and goats honeybee colonies are also included in the production system.

2.2. Methods of Data collection

2.2.1. Site selection

In this study, all the watersheds were purposefully selected from similar Agro–ecological zone (Weina–Degua), representing about 87% of the district, having an age of seven years after integrated watershed management project phased–out. The fact that all the watersheds were selected from the same agro–ecology is important to avoid any possible agro-ecological effects on vegetation cover. The selection of these six watersheds was done in consultation with the district watershed experts having detail knowledge about the watersheds. These study area comprises three successful and three unsuccessful watersheds based on the criteria set by the Tigray Bureau of Agriculture and Rural Development. The criteria's are: i) Ecological status such as vegetation cover (%), groundwater recharge (mm), flood reduction, surface run–off reduction and animal diversity in the watershed; ii) socio–economic (availability of irrigation water, women participation, and fodder production and availability); iii) Status and maintenances of implemented physical and biological soil and water conservation measures.

Table 1: Criteria's used to evaluate the performance of integrated watershed management practices in Tigray, Ethiopia (BoARD, 2017).

Status of the watershed	Performances evaluation in (%)									
	Ecological					Socioeconomic			SWC	
Successful	Vgt	Gwat	Rf	Rsrf	IAD	IiWat	IWP	IfP	Bio	Phy
S–1	80	35	53	63	38	60	90	80	85	75
S–2	75	35	60	65	41	63	85	75	85	73
S–3	75	30	50	59	33	55	78	70	80	69
Unsuccessful										
S–4	40	15	19	21	13	19	15	21	31	39
S–5	45	17	9	11	12	17	27	18	29	36
S–6	45	14	16	17	21	21	19	19	33	47

Note: **Vgt**: vegetation cover, **Gwat**: Ground water recharge, **Rf**: Reducing flooding, **Rsrf**; Reducing surface runoff, **IAD**; Increase animal diversity, **IiWat**; Increased irrigation water availability, **IWP**; Increased women participation, **IfP**: increased fodder production, **Bio:** biological, **Phy:** physical; **S–1**=Negash, **S–2=**Debrewahabit, **S–3**=Gemad, **S–4**=Debretsion, **S–5**=Laelay wukro, **S–6=** Tsigerda

In this study, all the data were collected from both primary and secondary data sources. The primary data were obtained from focus group discussions (experts, users, administrators), transect survey and the satellite image analysis from United States geological survey (USGS).

Whereas secondary data were collected from published and unpublished documents like climatic data and project reports from relevant offices.

2.3. Vegetation cover

For the vegetation cover change analysis, the Enhanced Thematic Mapper ETM+ Landsat images were acquired from the USGS (https://earthexplorer.usgs.gov/) for three different years (2007 – before IWM implementation, 2010–IWM project phase–out year, and 2017– the current situation i.e. seven years after implementation of IWM). The image pre–processing techniques such as radiometric, geometric and atmospheric corrections have been applied to produce a good quality of findings. According to Hassan *et al*. (2016), image pre–processing was vital to establish a direct association between the acquired data and physical occurrences of the study area. These all satellite images were geometrically corrected to a common coordinate system using the Universal Transverse Mercator (UTM) map projections in Zone 37, WGS 84 datum in ArcGIS 10.3.Image classification was used in converting image data into thematic data (Serra et al., 2003). For this study, supervised classification was used in the analysis of vegetation cover changes. Therefore, representative points that represent the different land cover classes were marked using GPS during the field visit. A total of 490 ground control points (GCPs) from successful performing watersheds and 640 GCPs from unsuccessful performing watersheds were collected. These points were used to sample representative signatures for the various land cover types described in Table 2 and determine the level of accuracy of the LULC classifications made following maximum likelihood classification methods. According to Congalton and Green (2008), a minimum of about 30 random ground points per class was used for accuracy assessment in each watershed.

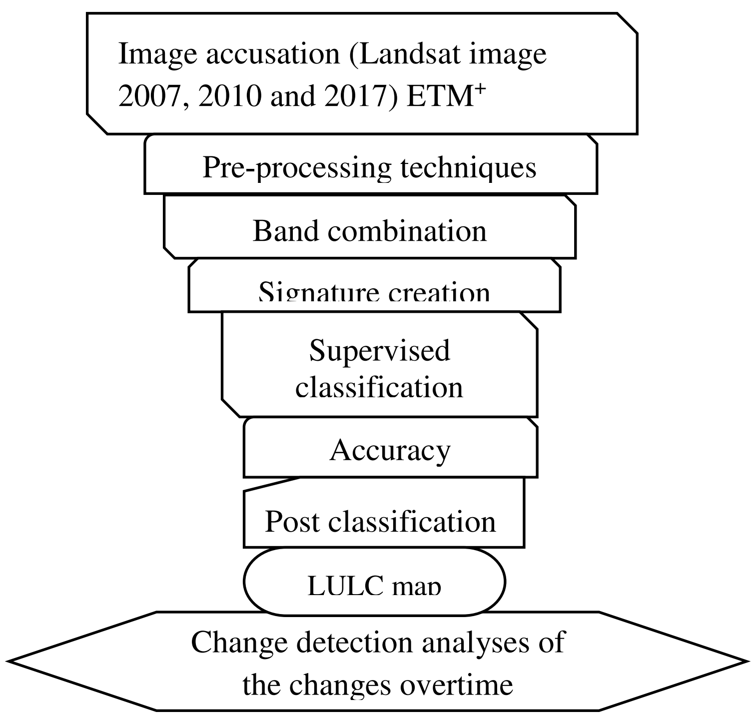

Figure 2: Flow chart of image analysis and Land use/land cover classification (Gidey et al., 2017)

Table 2: Description of land use and land cover types

Land use land cover type	Description
Settlements	Land covered by rural village's houses, which included towns and small villages (Fissaha *et al.*, 2017).
Shrub /Bush Land	Land covered by small trees, bushes, shrubs and it is less dense than the woodland (Fissaha *et al*., 2017).
Grazing Land	Areas with more than 50% covered with grasses (mixed with some shrubs) and less than 50% herbaceous and have bare lands usually used for grazing by livestock.
Cultivated Land	Areas of land prepared for rain-fed and irrigated crops, which includes areas currently under crop, fallow and land under seedbed preparation (Tahir *et al*., 2017).
Bare land	Land, which is mainly covered by bare soil and rock outcrops, rock covered lands and composed of exposed rock (Fissaha *et al*., 2017 and Belay et *al*., 2015).

2.3.1. Accuracy assessment

Confusion or error matrix was common practice to verify the accuracy of the land use, land cover map of the study. The accuracy map was verified according to Viera and Garrett (2005). Based on these authors, a Kappa coefficient value greater than 0.8 denotes a strong agreement; a value between 0.4 and 0.8 denotes a moderate agreement and a value below 0.4 represent poor agreement. Kappa coefficient was calculated using the following equation (1-4) proposed by Congalton and Green (2008).

$$\text{Overall accuracy} = \frac{n\sum_{i=1}^{k} nii}{\mathrm{n}} \;\ldots\ldots\;(\text{eq.1})$$

$$\text{Producer's accuracy} = \frac{\mathrm{nii}}{\mathrm{Gi}}\ldots\ldots\ldots\;(\text{eq.2})$$

$$\text{User's accuracy i} \;= \frac{\mathrm{nii}}{\mathrm{Ci}}\ldots\ldots\ldots\ldots\;(\text{eq.3})$$

$$\text{Kappa coefficient} \;= \frac{n\sum_{i=1}^{k} nii - n\sum_{i=1}^{k}(GiCi)}{n^2 - \sum_{i=1}^{k}(GiCi)} \ldots\ldots..\;(\text{eq.4})$$

Where, i = the class number, n = total number of classified pixels that are being compared to ground truth, nii= number of pixels belonging to the ground truth, Ci = total number of classified pixels belonging to class i, Gi = total number of ground truth pixels belonging to class i.

2.4. Data processing and analysis

2.4.1. Vegetation cover

Changes in vegetation cover due to the implementation of integrated watershed management interventions were analyzed by comprising the raster maps of 2007, 2010 and 2017 using confusion matrix. Change statistics were computed by comparing image values of one data set to the corresponding value of the second data set in each period by the following equation suggested by Kindu et al. (2013) and Peng et al. (2008).

$$\text{LULC change} = (\text{Area in final year} - \text{Area in initial year}) \ldots\ \ldots\ldots\ldots \quad \text{(eq.5)}$$

$$\text{LULC change in Percentage} = \left(\frac{\text{Area in final year} - \text{Area in initial year}}{\text{Area in initial year}}\right) * 100 \ldots \quad \text{(eq.6)}$$

3. Results and Discussion

3.1. Implemented land restoration activities and status

From field survey observation different soil and water conservation practices was implemented in the study area. However, in unsuccessful watersheds (Debretsion, Lealy wukro and Tsigerda) physical and biological soil and water conservation for gully treatment was not used variety of technology. According to Habtamu (2011), management of watersheds can be made by using a variety of technologies such as vegetation conservation like grass contours, alternative tillage techniques and physical structures like terraces, stone bunds and gabion check dam for gully treatment. But the principle is to achieve sustainable development in the watershed that can still be managed by the community of the watershed after the project phased-out. The current status of land restoration activities in both watersheds were damaged after watershed project phased-out. Whereas, in unsuccessful watersheds most of the structures were 100 present destroyed, Example, gabion check dam, loss stone check dam, terraces and percolation pond (Table 3). The major factor for failure of soil and water Conservation in this watershed was less of biological conservation like grass and lack of maintenances, after the watershed project phased–out. Mekonen and Tesfahunegn (2011) in Medego watershed northern Ethiopia found that lack of maintenance is one the factor for failure of soil and water conservation strictures.

Table 3: soil and water conservation practices and status

Name–w	U–slope	No of structures	Damaged SWC in %	Ml–slope	No structures	Damaged SWC in %	L–slope	No of structures	Damaged SWC in %
S–1	hillside terrace	35	20	half moon	37	24	gabion check dam	25	28
	Terraces	65	20	stone bund	68	22	loss stone check dam	18	22
	stone bund	15	26	stone bund	14	33	percolation pond	4	75
S–2	shallow trench	98	11	hillside terrace	103	20	deep trench	31	6
	hillside terrace	41	21	deep trench	79	16	gabion check dam	40	42
	stone bund	60	41	shallow trench	39	23	Pond	9	22
				half moon	35	20	lose stone check dam	25	60
S–3	shallow trench	55	34	half moon	37	29	gabion check dams	9	33
	deep trench	27	29	hillside terrace	23	21	Lose stone check dams	32	59
	shallow trench	9	33	shallow trench	49	38	percolation pond	4	75
	stone bund	50	34	deep trench bund	22	27	hand dug well	18	44
S–4	hillside terrace	65	49	Half moon	180	30	Gabion check dam	25	100
	Shallow trench	70	32	Stone bund	68	22	Loss stone check dam	37	94
	Stone bund	81	43				Percolation pond	2	100
S–5	hillside terrace	95	62	Deep trench	75	17.3	Half moon	250	33.2
	Stone bund	103	59.2	Shallow trench	56	42.8	Gabion check dam	9	100
S–6	hillside terrace	125	28	Half moon	200	18.5	Gabion check dam	7	100
	Stone bund	121	24.7	Hillside terrace	25	36	Lose stone check dam	2	100
	Shallow trench	35	14.2	Deep trench	65	26.1	Farm pond	3	100

*Note: **U–slope** = upper slope, **Ml–slope**= middle slope**, L–slope** =lower slope; **S–1**=Adikesho, **S–2=**Debrewahabit, **S–3**=Gemad, **S–4**=Debretsion, **S–5**=Laelay wukro, **S–6**= Tsigerd*

3.2. Vegetation cover status for the study years (2007 – 2017)

This study has identified five major land use land cover types, which include bush/shrub land, cultivated land, bare land, grass land and built–up area (Figure 3).The results showed that the most dominant land use type in Adikesho, Deberewahabit, Debretsion and Tsigerda watersheds were cultivated cropland in the year of 2007 (before the implementation integrated watershed management), while, in Gemad and Laelay wukro watersheds the dominant land use were bush/shrub land (Table 4 and Figure 3). However, during intervention period (2010) bush/shrub lands were the most dominant land use land cover types in all watersheds except S–4 and S–6 watersheds. Whereas after the implementation of integrated watershed management project phased–out cultivated land was covered large area in same watersheds. This indicated that the status of vegetation cover were changing from time to time and from places to places (Figure 3).

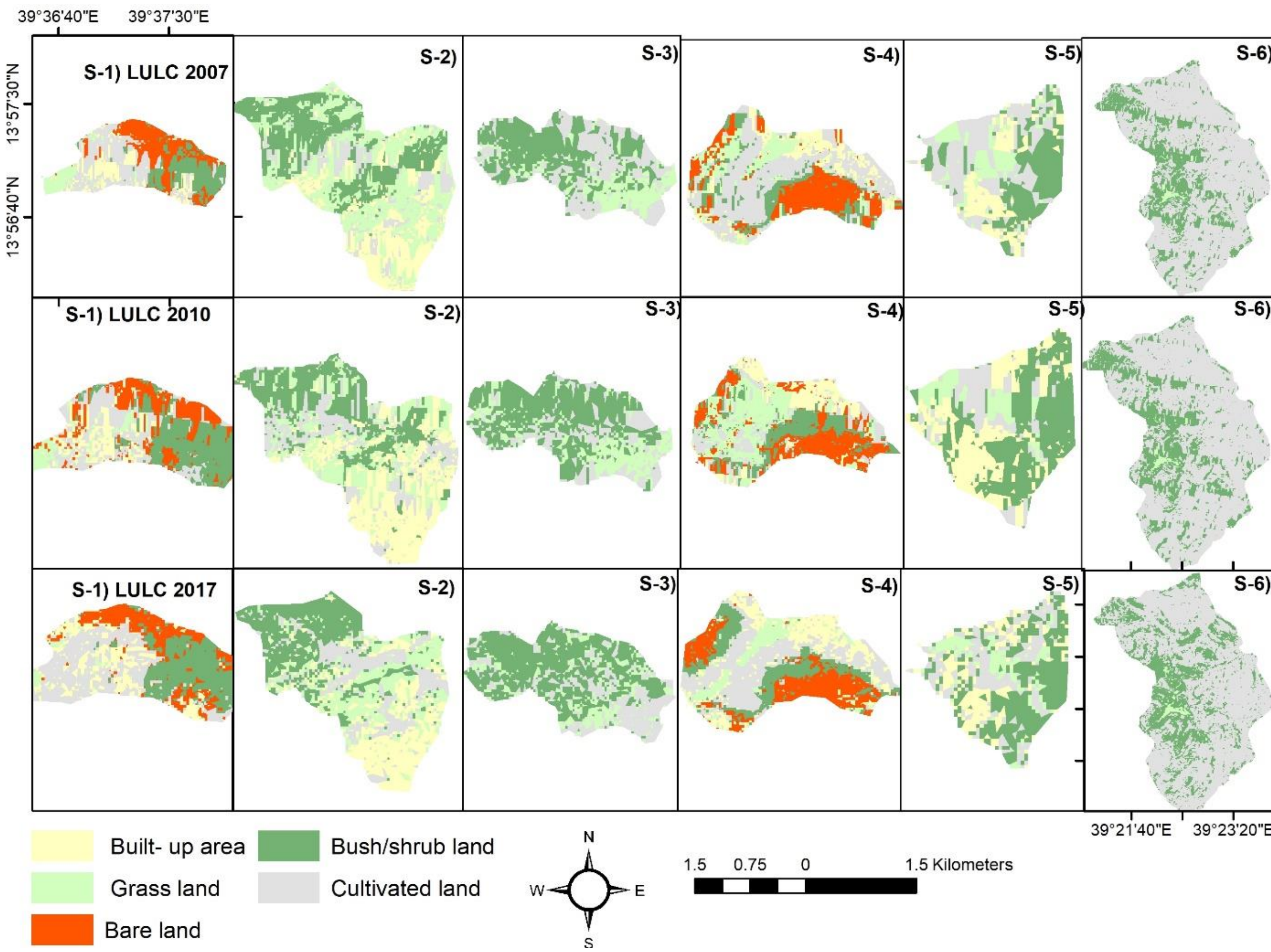

Figure 3: Land use land cover types of the study area during the periods of 2007, 2010 and 2017

Table 4: Land use land cover changes from 2007 to 2017 in all watersheds.

	Land cover types and their magnitude for the year 2007											
	S–1		S–2		S–3		S–4		S–5		S–6	
Land use	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
Bush/shrub	38.0	22.5	80.22	26.43	96.7	43.6	36.1	13.9	35.6	33.6	498.6	25.1
Cultivated	52.6	31.2	108.78	35.84	79.0	35.6	98.1	37.9	26.3	24.8	1467.0	73.9
Built–up area	21.0	12.4	63.85	21.03	–	–	32.7	12.6	32.4	30.6	–	–
Bare land	44.7	26.5	–	–	–	–	59.4	22.9	–	–	–	–
Grass land	12.4	7.4	50.70	16.70	46.3	20.8	32.7	12.6	11.6	11.0	19.9	1.0
	2010											
	S–1		S–2		S–3		S–4		S–5		S–6	
Land use	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
Bush/shrub	57.6	32.6	89.17	29.30	115.6	52.1	54.3	21.0	46.9	30.6	508.1	25.6
Cultivated land	42.2	23.9	80.70	26.52	55.2	24.9	45.4	17.5	17.1	22.6	1433.4	72.2
Built–up area	25.0	14.1	73.97	24.31	–	–	36.7	14.2	–	–	–	–
Bare land	36.6	20.7	–	–	–	–	58.6	22.6	34.9	27.8	–	–
Grass land	15.2	8.6	60.48	19.87	51.2	23.1	64.1	24.7	11.2	10.0	44.1	2.2
	2017											
	S–1		S–2		S–3		S–4		S–5		S–6	
Land use	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
Bush/shrub	47.8	27.7	89.46	29.43	104.3	45.4	50.4	19.5	39.7	37.4	558.6	28.1
Cultivated land	52.7	30.5	72.90	23.98	57.9	25.2	80.5	31.1	20.8	19.6	1405.9	70.8
Built–up area	28.4	16.4	76.41	25.13	–	–	46.6	18.0	35.2	33.2	–	–
Bare land	32.9	19.1	–	–	–	–	53.6	20.7	–	–	–	–
Grass land	10.9	6.3	65.25	21.46	67.6	29.4	27.9	10.8	10.3	9.7	21.1	1.1

Note: ***S–1****=Adikesho,* ***S–2=****Debrewahabit,* ***S–3****=Gemad,* ***S–4****=Debretsion,* ***S–5****=Laelay wukro,* ***S–6****= Tsigerda*

3.3. Vegetation cover change analysis during 2007–2017

There was a significant LULC change in the watersheds. The area of cultivated cropland decreased during the intervention period in both watersheds (Adikesho, Deberewahabit, Gemad, Debretsion, Lealay wukro and Tsigerda) which are about 19.7%, 25.81%, 30.2%, 53.73%, 35.0% and 2.3% respectively. Whereas, bush/shrub land increases by 51.6%, 11.16%, 19.6%, 50.40%, 31.6% and 1.9% during this years (2007–2010) respectively (Table 5). This due to watershed management implemented in the watershed. This finding is in line with the findings of Ali (2009) in Lenche Dima watershed of the Blue Nile basin that described after implementation of integrated watershed management bush land increases from 17% to 22% in the years of 1986 and 2000 respectively. Similarly, Alemayehu et al. (2009) in eastern Tigray that described after implementation of integrated watershed management cultivated land decreased from 55% to 52% in the years of 1994 and 2005 respectively. Similarly, Hussien (2009) in Lenche Dima found that cultivated land was declined from 52% in 1986 to 48% in 2000; due to implementation of integrated watershed management practices. Although, built–up area increased in both watersheds during watershed implementation after watershed project phased–out. This could be due to increasing of population pressure and land distribution for female and meal youngest householders for construction of houses. This also corresponds with the findings of Kashaigili and Majaliwa (2013) population growth has one of the most important causes for land use land cover change to fulfill the demand of the population. However, bare land decreased during watershed implementation and after phased–out watershed project in all watersheds (Table 5). Kebrom and Hedlund (2000) Kalu area north central Ethiopia reported that built–up area was increased between the year of 1958 and 1986 due to population pressures. While, bare land were continuously decreased by 1.4% and 8.5% respectively. While, Miheretu and Yimer (2018) in the Gelana sub watershed reported that bare land increased from 0.41% in 1964 to 0.43% in 1986 and to 1.43% in 2014; due to lack of integrated watershed management practices.

Table 5 : Land use land cover change for the study period (2007 to 2017)

	Land use land cover change for the 1st period (2007–2010) during IWM project											
	S–1		S–2		S–3		S–4		S–5		S–6	
Land use	ha	%	ha	%	ha	%	ha	%	ha	%	Ha	%
Bush/shrub	19.6	51.6	8.95	11.16	18.9	19.6	18.21	50.40	11.3	31.6	9.5	1.9
			–		–	–	–	–		–	–	–
Cultivated	–10.4	–19.7	28.08	–25.81	23.9	30.2	52.72	53.73	–9.2	35.0	33.7	2.3
Built–up area	4.0	19.0	10.12	15.85	–	–	4.02	12.30	2.5	7.8	–	–
Bare land	–8.0	–18.0	–	–	–	–	–0.86	–1.45	–	–	–	–
Grass land	2.8	22.3	9.78	19.29	5.0	10.7	31.34	95.81	–0.4	–3.9	24.2	121.4
	2nd period (2010–2017) after project phase-out											
	S–1		S–2		S–3		S–4		S–5		S–6	
	ha	%	ha	%	ha	%	ha	%	ha	%	Ha	%
Bush/shrub land	–9.8	–17.1	0.29	0.33	–11.3	–9.7	–3.92	–7.21	–7.2	–15.4	50.5	9.9
Cultivated land	10.5	24.8	–7.80	–9.67	2.7	4.9	35.10	77.31	3.7	21.7	–27.4	–1.9
Built–up area	3.4	13.7	2.44	3.30	–	–	9.93	27.06	0.3	0.7	–	–
Bare land	–3.7	–10.2	–	–	–	–	–4.99	–8.52	–	–	–	–
Grass land	–4.3	–28.4	4.77	7.89	16.4	32.0	–36.11	–56.38	–0.9	–7.7	–23.1	–52.3

Note: **S–1**=Adikesho, **S–2=**Debrewahabit, **S–3**=Gemad, **S–4**=Debretsion, **S–5**=Laelay wukro, **S–6=** Tsigerda

Seven years after the integrated watershed management project phased–out (2010–2017) study period bush/shrub land decreased in Adikesho, Gemad, Debretsion and Lealy wukro which is about 17.1%, 9.7 %, 7.21% and 15.4% respectively (Table 5). However, the coverage of bush land increased by 0.33% and 9.9% in Deberewahabit and Tsigerda watersheds respectively (Table 5) during the same period. These findings are in line with the findings of Zeleke and Hurni (2001) in the Dembecha area of Gojjam who reported that rapid reduction in the bush/shrub and forest land due to increase in agriculture and settlement areas. While, cultivated land increased after watershed project phased–out (2010–2017) in Adikesho, Gemad, Debretsion and Lealy wukro watersheds but decreased in Deberewahabit watershed (Table 5). This is due to a successful integrated watershed management and the area was protected from free grazing by the community after phase-out watershed projects. Gebresamuel et al. (2010) in Northern Ethiopia reported that cultivated land was decreased by 5% and 9% from 1964 to 1994 for Maileba watershed and Gum Sellasa watersheds respectively; this is due to the implementation of exclosures on degraded croplands to rehabilitate degraded croplands. Grass land decreased in S–1, S–4, S–5 and S–6 after phased–out watershed project. Kebrom and Hedlund (2000) Kalu area north central Ethiopia reported increased settlement at the expense of shrub lands between 1958 and 1986; cultivated land at the expense of grass land between 1957 and 1994.

3.4. Comparison of Vegetation cover change during and after project phased–out

The vegetation cover change (land use cover change) of in all watersheds was significantly different between the years of 2007 and 2010 (before and during the implementation of integrated watershed management). The change analysis results showed that the increase of, bush land, grassland and built–up areas between the years of 2007 and 2010 in both successful and unsuccessful performing watershed projects (Figure 4).Whereas, cultivated land and bare land were decreased in the study years. This was due to implementation of integrated watershed management practices.

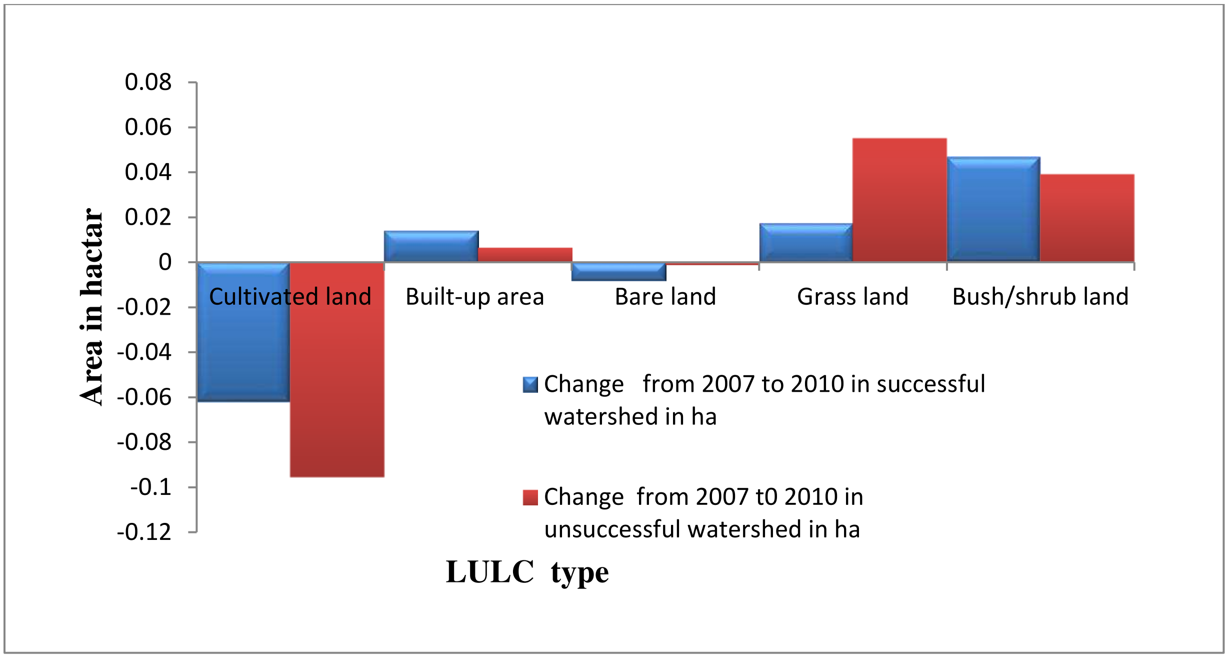

Figure 4: Comparison of LULC change between successful and unsuccessful performing watershed between the years of 2007 before integrated watershed project implemented and 2010 after integrated watershed management implemented.

However, after the watershed management project phased–out the land use and land cover changes are significant in both successful and unsuccessful performing watersheds (Figure5). While, cultivated land and built–up areas were increased in both successful and unsuccessful performing watersheds projects between the years of 2010 and 2017 (after watershed project phased–out). This was due to the increased in population pressure, land distribution for youngest female and meal households house construction and lack of best land management practices after the watershed project phased–out. This finding is in line with Kebrom and Hedlund (2000) in Kalu area north central Ethiopia reported that built–up area increases at the expense of shrub lands between 1958 and 1986 and cultivated land increase at the expense of grass land between the year of 1957and 1994. Bare lands decreased in the study years. Whereas, grass land was increased in good performing watersheds, but decreased in a poorly performing watershed. And also bush land increase in poor (unsuccessful) performing watershed, but decreases in successful performing watersheds.

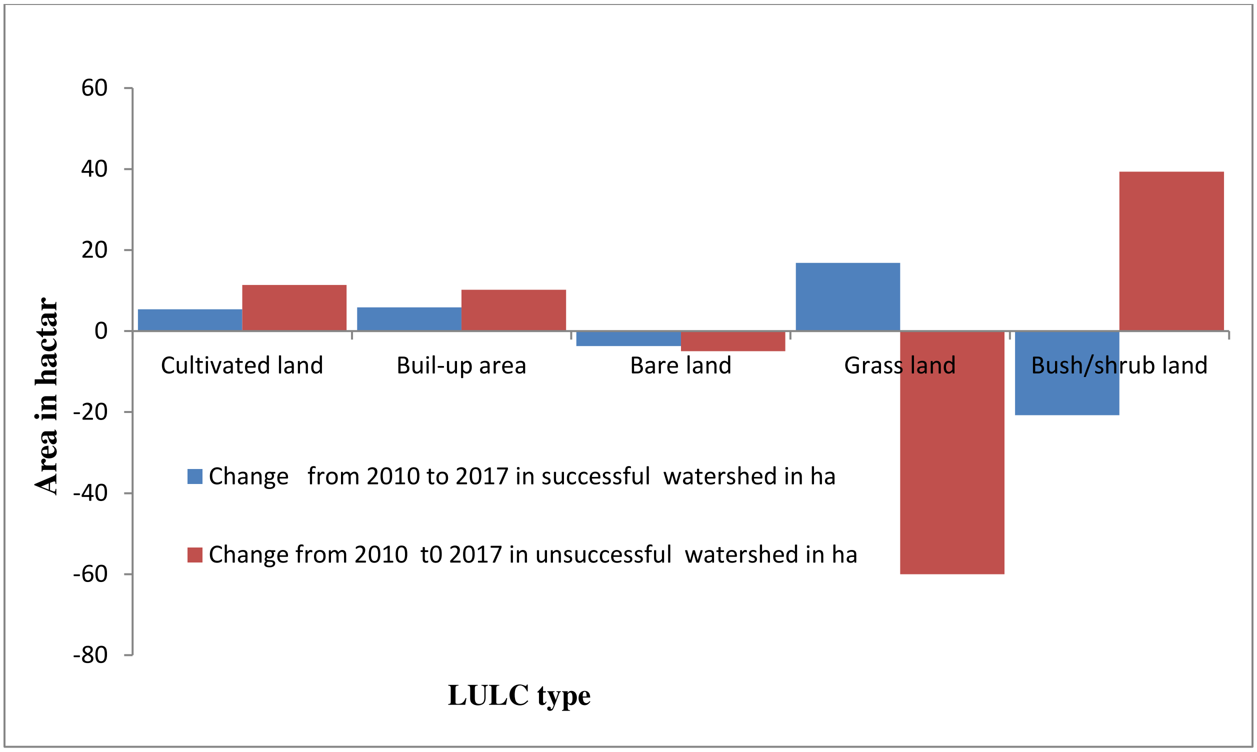

Figure 5: Comparison of LULC change between successful and unsuccessful performing watershed between the years of 2010(before integrated watershed project implemented and 2017 (after integrated watershed management implemented).

3.5. Accuracy assessment

The results of the image classification of 2017 were validated by creating a confusion matrix from which different accuracy measures are derived. The confusion matrix was established in Adikesho, Deberewahabit, Gemad, Debretsion, Lealy Wukro and Tsigerda watersheds using 150, 150, 90,150,120 and 90 ground control points which were not used in the classification of the 2017 Landsat image. The overall accuracy of the classified satellite image to obtain the land use coverage of the 2017 in Adikesho, Deberewahabit, Gemad, Debretsion, Lealy Wukro and Tsigerda watersheds were about 87.61 %, 87.7%, 84.4%, 85.3%, 84.9% and 86.8% respectively, and the Kappa coefficient was about 0.81, 0.83, 0.77, 0.82, 0.80 and 0.85 respectively. The kappa coefficient values are measures of agreement between the reference or observed data and land use/cover values in the classified image. According to Viera and Garrett (2005) Kappa coefficient characteristics; Kappa value greater than 0.80 denotes a strong agreement, between the observed and the classified values, 0.4 and 0.8 moderate agreements and values below 0.4 represents a poor agreement. According to these ranges, the classification accuracy in S–1, S–2, S–4 and S–6 watersheds had a strong agreement with the reference data; while in Gemad and Laelay wukro watersheds were ranges under moderate agreement.

4. Conclusions

The soil and water conservation practices of each watershed have been significantly affected after the phased–out of the IWM projects. An increase to some extent in the bush/shrub lands has also been observed in all of the study sites (Adikesho, Deberewahabit and Gemad) by 19.6, 8.95

and 18.9 ha’s during the intervention period. However, after the phased–out of the projects, a decrease in shrub land was observed in Adikesho and Gemad by 9.8 and 11.3 ha. Furthermore, a remarkable increase by 18.21, 11.3 and 9.5 ha have been observed for the bush/shrub land during the intervention period and decrease after phased–out by 3.92 and 7.2 ha in S–4 and S–5 watersheds. Whereas, built–up area increased during and after phased–out of the watershed projects in all watershed. This is due to increasing trend of population growth and land distribution for youngest households for house construction in the area, but cultivated land increased after the integrated watershed management phased–out, while, and decreased during watershed management implementation. It can be concluded that vegetation cover change after the watershed project phased–out reduced but during the project was improved in most of the watersheds.

Ethics approval and consent to participate

The authors declare no conflict of interest.

Consent for publication

All authors have read the manuscript and agreed to publish.

Availability of data and materials

All important data are attached

Competing interests

The authors declare that they have no competing of interests.

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Authors' contributions

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Authors' information (optional)

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Figures

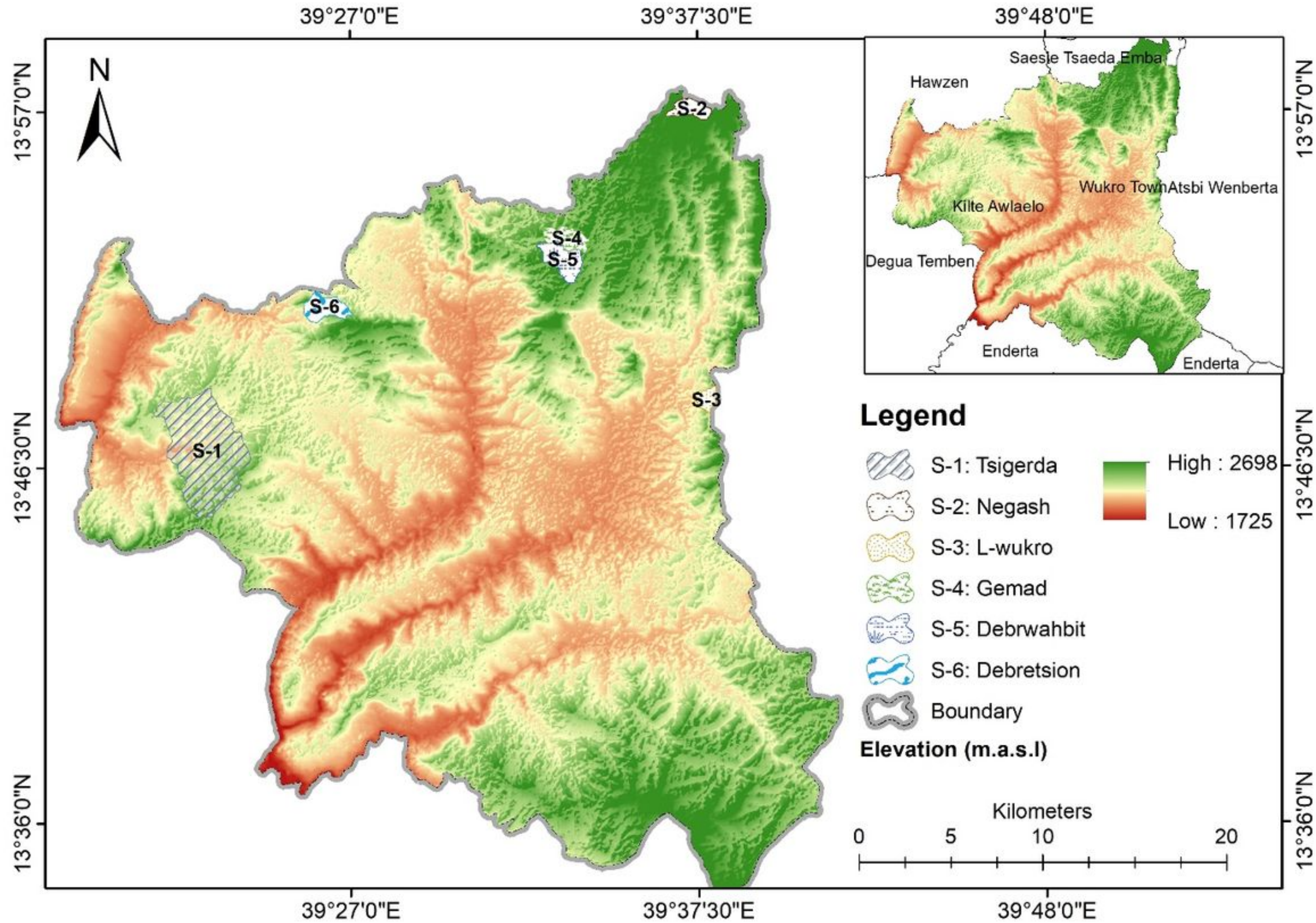

Figure 1

Location of the study area with the indication of studied watersheds

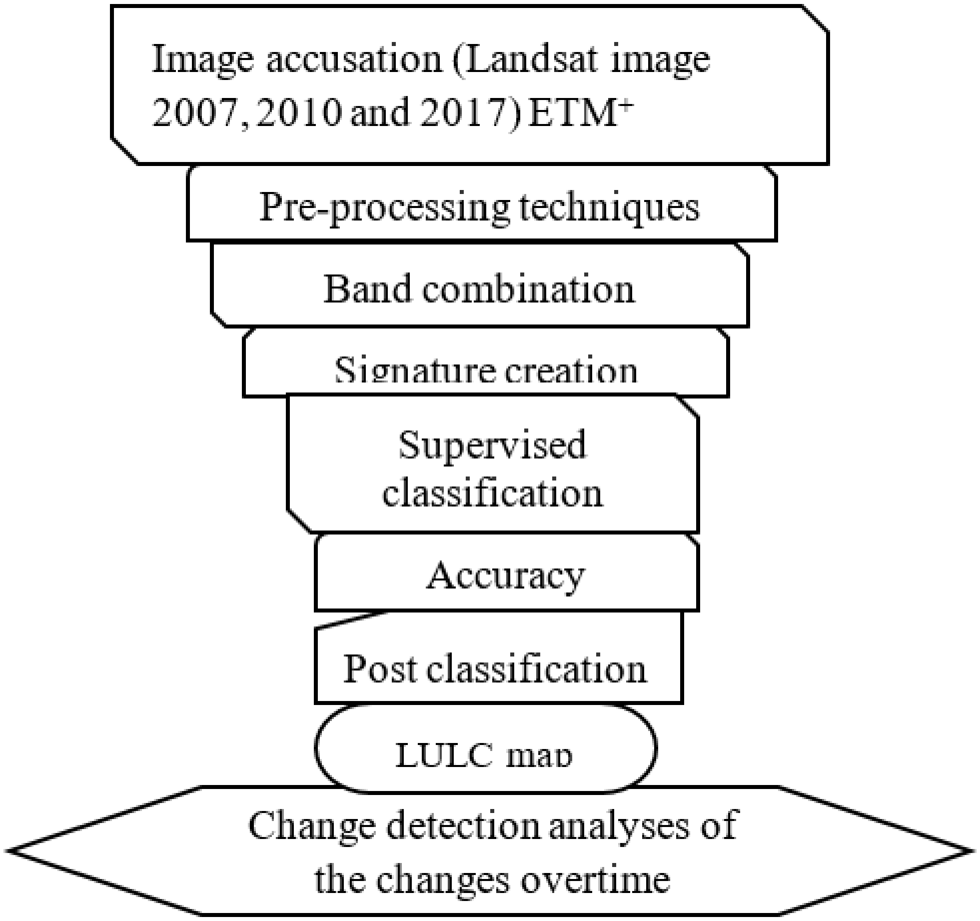

Figure 2

Flow chart of image analysis and Land use/land cover classification (Gidey et al., 2017)

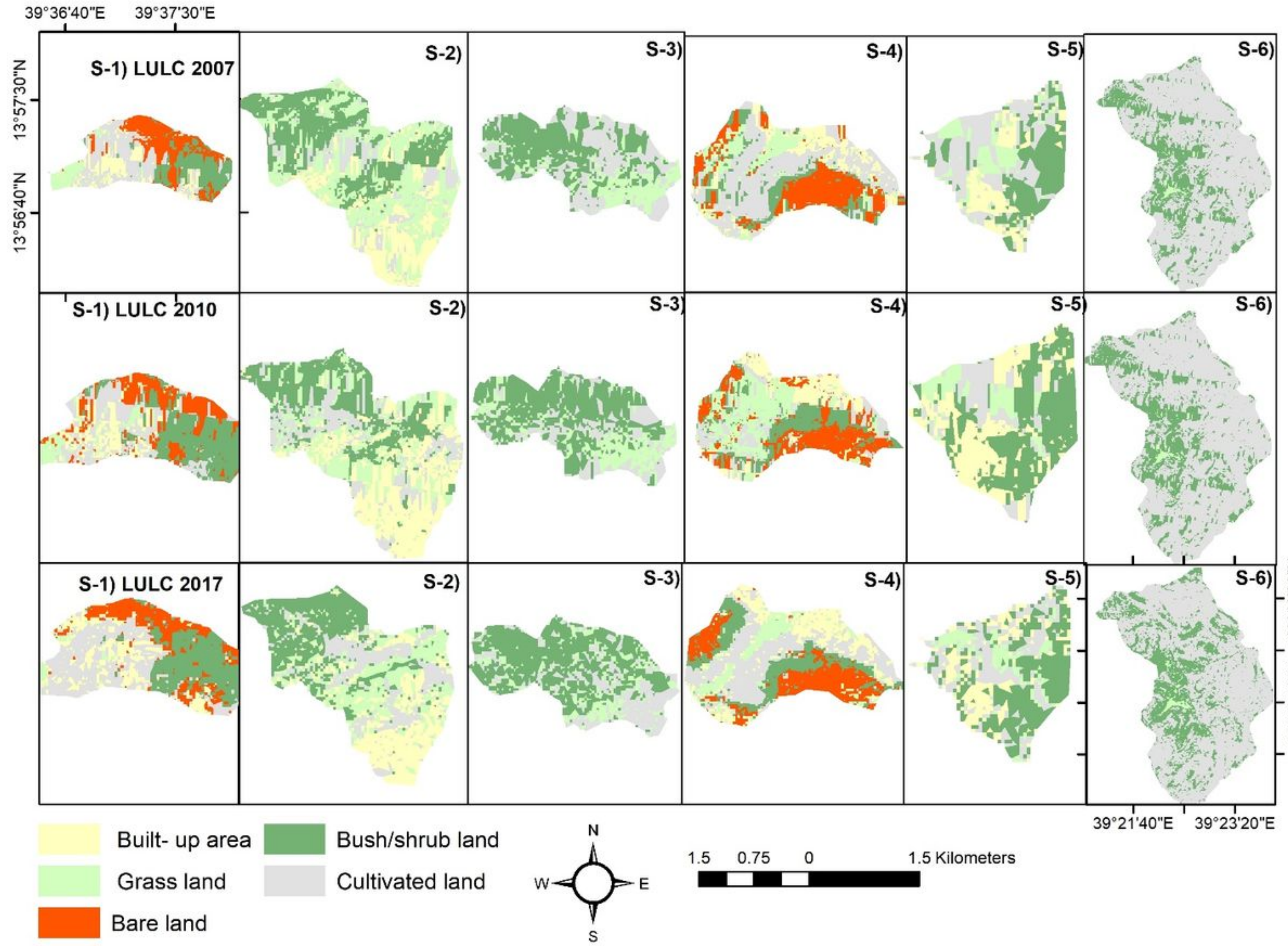

Figure 3

Land use land cover types of the study area during the periods of 2007, 2010 and 2017

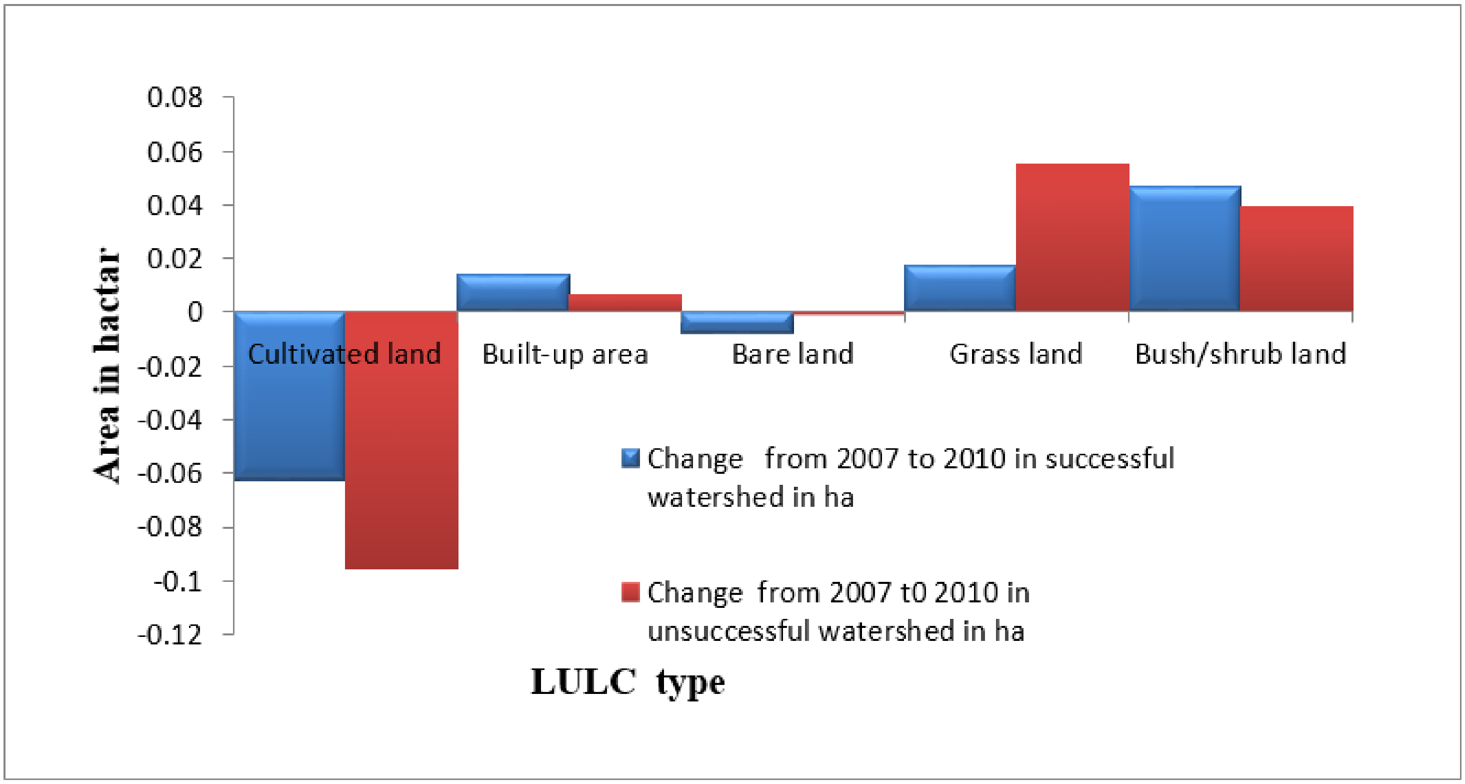

Figure 4

Comparison of LULC change between successful and unsuccessful performing watershed between the years of 2007 before integrated watershed project implemented and 2010 after integrated watershed management implemented.

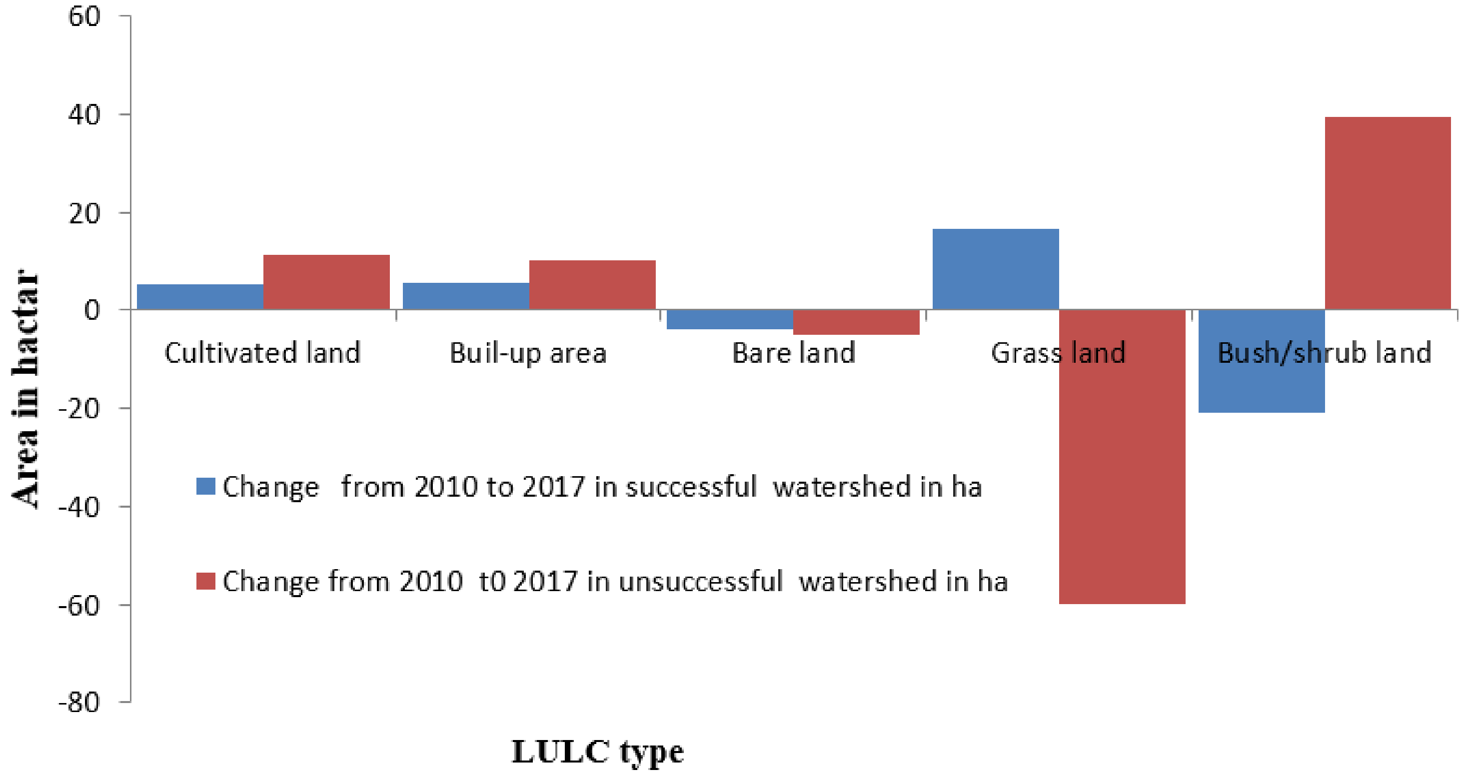

Figure 5

Comparison of LULC change between successful and unsuccessful performing watershed between the years of 2010(before integrated watershed project implemented and 2017 (after integrated watershed management implemented).