Impacts of Watershed Management on land use/ cover Changes and Landscape Greenness in Yezat Watershed, North West Ethiopia

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Abstract

This study was conducted to assess the long term impacts of watershed management on land use/cover changes and landscape greenness in yezat watershed. The results of the study shown that between 1990 and 2021, built up area, plantation, natural forest, shrubland and grasslands were increased by + 254ha, + 712.3ha, 196.3ha, + 1070.8 and + 425.3ha respectively due to watershed management interventions. Conversely, cultivated land was decreased with a rate of -2658.7ha, in the study area. However, the reverse is true between 1990 and 2000 due large scale land degradation. Besides,the result of the study also shown that low landscape greenness value (-0.11) was observed between 1990–2000 and high landscape greenness value (+ 0.2) was observed between 1990–2021. The observed change in landscape greenness in watershed was due to the change in shrubland (+ 1070.8ha), grassland (+ 425.3ha), plantation (+ 712.3ha) and forestland (+ 196.3ha) covers between 1990 and 2021 years. Such observed changes in land use land covers, landscape greenness and cultivated land in the study watershed a have important implications on environmental benefits.

Introduction

The modification of Earth's terrestrial surface by human activities is commonly known as Land use/land cover change around the globe. Land use and land cover change have two separate terminologies that are often used interchangeably (Rawat 2015). Land cover refers to the biophysical characteristics of the earth's surface, including the distribution of vegetation, water, soil, and other physical features of the land. While land use refers to how the land has been used by humans and their habitat, usually with an emphasis on the functional role of land for economic activities (Lambin 2006; McConnecl 2015). Changes in land use and land cover may result in land degradation that manifests itself in many ways depending on the magnitude of changes. This alteration of LULC type coupled with poor land management practice in the region resulted in the exposure of land to erosion hazards (Solomon 2016). Land use/land cover (LU/LC) changes are major environmental challenges in various parts of the world, which is endowed with plenty of natural resources that sustain life for millennia (Qian et al. 2007).

In sub-Saharan African countries, rapid conversion from forest and woodland to agricultural land was driven by both proximate and underlying forces. The change processes are triggered by the interaction of anthropogenic and biophysical drivers(Gessesse and Bewket 2014; Kindu et al. 2015; Wubie et al.2016; Betru et al.2019; Alemayehu et al.2019). Bare land expansion, increased surface runoff production, sediment yield, and soil erosion are major environmental changes partly attributed to LULC dynamics. Moreover, severe farmland expansion and rapid urbanization are accelerated land use/land cover changes (Jiangyue et al. 2019). Such expansion of agricultural land at the expense of forest land, grassland, and shrub land and prolonged use for agriculture without conserving natural resources were the most detrimental factor for land use land cover change (Desalew and H. Gangadhara 2017; Nurelegn and Amare 2014). Land use and land cover changes are also increasing at an alarming rate generally throughout Ethiopia's highlands and lowlands (Bekele 2018). There was also a rapid expansion of cultivated land at the expense of vegetative land cover types, such as wooded grassland, woodland, shrubs and bushes, natural forest, and afro-alpine in various parts of the country(Gete and Hurni 2001; Gessesse and Kleman 2007; Rientjes et al. 2011; Gebremicael et al. 2013;).

Human activities that promote the conversion of forest land to agricultural and urban may result in bare land expansion, increased surface runoff production, and altered ecosystem services (Desalew and H. Gangadhara 2017; Nurelegn and Amare 2014). These environmental degradation processes have adverse impacts on local agricultural productivity, water resource availability and biodiversity loss, soil erosion, soil quality, and food security of communities (Berhan and Woldeamlak 2014). Land use and land cover change through inappropriate agricultural practices and high human and livestock population pressure have led to severe land degradation in the Ethiopian highlands (Binyam 2015).

This spurred the Ethiopian government to launch an extensive soil and water conservation program which began in the early 1970s (Gebregziabher et al., 2016; Nigussie et al. 2012; Alemayehu 2006; Woldamlak 2003). Since the early 1980s, land conservation efforts have been further expanded through the involvement of the World Food Program and similar initiatives that provided food-for-work incentives for conservation activities (Almekinders 2002). However, most performance measures of SWC efforts in the country ended up in remarkable failure, especially in highland parts of Ethiopia. The failure of most watershed management projects was attributed to a top-down approach, which disregards local knowledge, socioeconomic condition, and availability of resources(Johnson et al.,2009; Render and Ehui,2000). Watershed management has different approaches ranging from local to global scale, top-down to bottom-up, and sectorial to integrated(Tiwari et al. 2008). Top-down approaches were focused on technical and physical works alone and hence would not alone lead to the desired environmental objectives. It is more or less a fixed or rigid technology solution, which in most cases failed to bring desired results (Peraz and Tschinkel 2003).

In Ethiopia, from the 1990s now onwards, watershed management has been given attention and is being implemented in different parts of the country as a way of redressing the degradation of the natural resource base and increasing land productivity (Lakew *et al*. 2005; Gete 2006). After a while, there were occurrences of different human activities which promote the conversion of degraded land to forest land or agroforestry may result in improvement of land use land cover (Lambin et al. 2003, Fikir et al. 2009; Abiyot et al. 2018). Improvement in land cover can be achieved through the implementation of different natural resource management approaches among which community-based watershed management is the principal one(Abiyot et al. 2018). The combined effects of the extensive Soil and water conservation measures implemented since 2003 and the associated changes in land use land cover resulted in better surface cover conditions and improved vegetation cover through increased shrub land, grassland, plantation, and natural forest cover (Ayele et al. 2016). Such integrated watershed management not only improves vegetation cover but also reduces sheet and rill soil loss rates by about 89% from all LULC classes (Haregeweyn et al. 2012). Besides, watershed management practices increased vegetation cover (greenness) in the conserved watershed and also reduce the velocity of surface runoff and raindrop impacts (Zewdu et al. 2019; Fikir et al. 2009).

Watershed management in Ethiopian highlands is therefore not only related to the improvement and conservation of the natural and ecological environment, but also the sustainable development of Ethiopia's agricultural sector and its economy at large (Tesfa and Sangharsh 2015). However, its' impact on land use land cover changes, and landscape greenness has not been well-evaluated and studied through the integration of geospatial technologies. Thus, the general objective of the study is to evaluate the long-term impacts of watershed management on land use/cover changes and landscape greenness over 30 years.

Materials And Methods

Study Area information

The study was conducted in Yezat watershed in the Northwestern highlands of Ethiopia. Geographically, Yezat watershed is located 11°6'30"N–11°17'30"N latitude and 37°31'30"E–37°42'30"E longitude and covers 15100 hectares. The watershed bounds Yilmana Densa and Gonji Kolla district, Amhara Region. It is also found 430 km from Addis Ababa and 70km south of Bahir Dar (Lake Tana). Yezat River, which is the main river that drains into the watershed, is one of the tributaries of the Abay River. Moreover, the watershed is drained to Abay River which emanated from Adama mountain escarpment. Mount Adama is the peak of central Gojam highlands and it reaches 3528 m a.s.l.

Yezat watershed is one of the watersheds in the upper bule nile basin, in which participatory watershed management was implemented in 2001. The watershed was one of the degraded watersheds in the upper Blue Nile basin. As result, it is one of the critical watersheds which was selected by the SLM1 program in the Amhara regional state. Because, the watershed was pigeonholed by a problem of soil erosion, low soil productivity, low fodder supply, and intensive cultivation (Tesfaye and Fanuel, 2019). To curb the land degradation problem, many of these soil conservation projects were implemented following the severe drought of 1974 in Ethiopia (Enyew et al. 2013).

However, SWC measures were introduced in 2001 up to now with the regular government extension program supported by a sustainable land management program (SLMP) in the study area (Firew et al., 2014; Nigussie et al. 2017). During this time different efforts are underway on the implementation of physical, agronomic, and biological soil and water conservation practices within yezat watershed to reduce soil erosion, enhance soil moisture, modify the existed land use land covers, improve vegetation cover and crop yield, and soil fertility depletion (Tesfaye and Fanuel 2019).

The altitude of the study area ranges from 1474m to 3170 above sea level (Figure: 3.1). Yezat is stratified into lower (1461-2002m (4409.37ha), middle (2002-2419m (7932.72ha)) and upper (2419-3186m (2862.1ha) part of the watershed based on elevation change (Hurni, 1998). The watershed is mostly covered by moderately steep (7–16%), accounting for about 35.8% (5147.8 ha), and slope (7.7–16%) with 35.8% (5147.8 ha) followed by a very steep slope (> 30%) and gentle slope (0–7%) covering about 19.9% (2859.1ha) of the watershed. The higher elevation ranges are located in the southwest and the northeastern part of the watershed. As result, the southwest and the northeastern part of the watershed is the home to steep (16–30%) and very steep slope (> 30%) slopes, which cover around 2854.8(19.9%) and 3514 ha (24.4%) respectively. Besides, the slope gradient of the watershed ranges from 4 to 66.5^o (Lemlem 2016). And also, many small rivers and streams supply water to Yezat River.

Local Climate And Agro-ecology

The watershed is characterized by uni-modal rainfall patterns with rainfall extending from June to mid-October months. The mean annual rainfall of the study area was 1469mm with high inter-annual variability. whereas the value of the average annual minimum and maximum temperature of the study area is 8.8^{o}c and 25.2^{o}c respectively. The local agroecology in the study area is characterized as wet dega to moist kola, which contains several ecosystems and resource types (Hurni, 1998).

The vegetation resource of the study area consists of evergreen and semi-evergreen bushes, small trees, and occasionally larger trees. The study watershed headwater is covered by different types of plant species, including Juniperus procera (known locally as *tid)*, Hagenia abyssinica (known locally as *kosso)*, Albizia gummifera (*Sassa*), Podocarpus falcatus *(Zigba*), Cordia africana (*wanza*), and Ficus vasta (*Warka*) ,ccaica Abyssinica(*Yeabesha Girar*), Olea africana *(weyra*), Croton macrostachyus (Bisana), and Rahmnu sprinoides (Gesho). The study area also contains the exotic plants Nech Bahir Zaf (*Eucalyptus globules)*, Deccurence (Acacia deccurence**)**, and Sesbania (*Sesbania sesban).*

The major soil types of the watershed include Nitosols (786.4ha (5.2%), Vertisols (5281.3ha(35%), Lithosols (3076.6ha(20.4%), LUvisols (597.2(4%),Cambisols (4979.3ha(33%) and Rock surface (378.6ha(2.5%)(FAO, 2006). According to FAO classification (2006), Vertisols are the predominant soil type in moderately gentle slopes and in very deep soils of the study area. This soil class can be characterized by heavy black clay, mostly waterlogged during the rainy season. About 91.1% of the area is predominantly used for crop production and the population's livelihood depends on mixed farming (Tibebu 2014). Because the household communities are engaged in a mixed farming system of crop and livestock production.

Data Sources And Methods Of Data Analysis

To collect relevant data from primary sources and secondary sources, household surveys, in-depth interviews, focus group discussions, field observation, ground control points, and satellite imageries and mapping were held in the study area. For this study, four-time series Landsat images, namely Landsat 5 TM of 1990, Landsat 5 ETM of 2000, Landsat 5 ETM + from 2010, Landsat 8 OLI_TIRS of 2021 were obtained from https://earthexplorer.usgs.gov/ from January to February at path-169/row-052 as the main sources of input data for the land use/ cover analysis.

The selection of the years of investigation was based on key events in history with significant influence on land cover changes. The year 1990 and 2000 gave pieces of evidence of land cover changes due to governmental change and the beginning of agricultural leads to industrialization program before watershed management intervention and rural land certification program. Besides, the year 2010 showed the land cover during watershed management intervention and after the rural land certification program. Lastly, the year 2021 showed land cover characterization of the current situation. The present and past information on land cover land use classes for the study area were generated from Google Earth, KII with elderly people, and a GPS receiver.

Luc Classification

Before image classification, all Landsat images used for this study were checked for geometric correction. Since all Landsat images were geometrically rectified by USGS to the projection of UTM, Zone 37N, 1984 spheroid, and WGS 84 Datum, there was no need for any geometric correction as they were all correct compared with 2021. Detailed digital image preprocessing was also undertaken for atmospheric correction, radiometric correction, subset, and mosaic using ERDAS Imagine 15.

In this study, about 480 GCPs (training site sample) were collected from each LUC class representative for the 1990, 2000, 2010, and 2021 study periods. A supervised classification method of maximum likelihood classifier algorithm was used to produce thematic LUC classes of the reference years as indicated in Table. 2. Maximum likelihood classifier was selected as it is confirmed by various LULC change studies for its ability in generating accurate LULC classification (Getahun& Van Lanen 2015; Jacob et al. 2015).

The normalized difference vegetation index (NDVI) is the most widely used index for the estimation of the change in landscape greenness (Chen et al. 2006; Ruilang et al. 2008). In this study, normalized difference vegetation index (NDVI) was computed from preprocessed Landsat images of 1990, 2000, 2010, and 2021. NDVI is an empirical formula designed to separate green vegetation from other surfaces based on the vegetation reflectance properties of the area source (Huang et al. 2021). NDVI value of the result was between − 1 and 1. NDVI values greater than zero indicate the presence of vegetation whereas negative values indicate no vegetation and correspond to the presence of water bodies (Kiage et al. 2007).

$$\mathrm{NDVI} = \frac{NIR - Red}{\mathrm{NIR} + \mathrm{Red}} \text{ ……………………………………………………….1}$$

Where NDVI = normalized difference vegetation index, NIR = reflection from near-infrared wavelength region, Red = reflection from red wavelength region.

According to Hasselmann & Barker (2008), Normalized vegetation index (NDVI) can be classified into five classes: very week NDVI value (< 0.1), week NDVI value (0.1 to 0.2), moderate NDVI value (0.2 to 0.3), high NDVI value (0.3 to 0.45) and very high NDVI value (> 0.45) (Hasselmann & Barker 2008).

Accuracy assessment

The accuracy of the classified image can be checked by comparing classified pixel points with pixel points collected as a reference from fieldwork, Google Earth, and top sheet maps (Congalton& Green 2008). For this study, a total of 100 reference data collected from fieldwork earth was used for accuracy assessment for Landsat image 2021. Whereas, Google earth and top sheet maps with a scale of 1:50000 were used for the Landsat images of 2010, 2000, and 1990 for accuracy assessment Error matrix is a commonly used method to check the accuracy of classified images with inferential and descriptive statistics. The matrix is composed of columns and rows that indicate the ground truth data pixel numbers and the classified image class pixel numbers respectively (Congalton 1991). ERDAS Imagine 2015 was used to generate overall accuracy, kappa coefficient, producer's and user's accuracy of classified image.

Land Use/ Cover Change Detection

Land cover change detections were done from land cover categories derived for different periods (Singh 1989). In this method, a land cover map and area of each cover type were produced for four reference years (Bewket& Abebe 2013; Getahun& Van Lanen 2015; Jacob et al. 2015), comparisons (Gete and Hurni 2001; Shcuz et al. 2010; Mosammam 2016) between the subsequent land use/ cover changes were made for four periods of analysis such as between 1990 and 2000, 2000–2010, 2010 and 2021, and 1990 and 2021.

The spatiotemporal in land use/covers classes of the four-period series of maps were analyzed based using tables and graphs. In addition, a conversion matrix showing the direction of change in each LUC class over space and time was also done for four periods of analysis using ERDAS imagine 2015 environment (Dress et al. 2010; Teferi et al. 2010; Regienties 2011). As a result, the changes over the past 31 years were analyzed with a rate of change for each land cover class calculated in terms of the percent of change (Ebrahim and Mohamed 2017) and rate of change (Abate 2011b; Barana et al. 2016) using Eqs. 1 and 2, respectively.

Percentage change = $\left(\frac{X-Y}{Y}\right) * 100$…………………………… (Eq. 2)

Rate of change (ha/year) = $\left(\frac{X-Y}{Z}\right)$……………………………... (Eq. 3)

Where = X is an area of LULCC (ha) in time 2(previous year land cover), Y is an area of LULCC (ha) in time 1(Current year land cover) and Z is the time interval between X and Y in years (number of years between X and y.

Results And Discussion

Land Use Land Cover Analysis

In this study six major land use/ covers, such as shrublands, natural forest, grassland, cultivated land, built-up area, and plantation were identified in the study area (figure.1). Throughout the study period, cultivated lands were followed by shrublands were the highest coverage compared to other land use/covers. Moreover, the analysis of land use land cover patterns in the studied watershed signifies that the growth of plantation and built-up areas at the expense of other land use land cover types over the last three decades(table.5, figure.4). During these periods, plantation and the built-up area was expended from 0.6%, 0.01 to 1.1%, 0 + .1% respectively. However, the remaining land use land covers showed signs of increased and decreased within these three decades due to watershed management interventions (table.6)

Landscape Greenness Using Normalized Difference In Vegetation Index (Ndvi)

Normalized vegetation index (NDVI) was computed to see the landscape greenness condition of the study area by using the Landsat images of 1990, 2000, 2010, and 2021. Figure .3 indicated that landscape greenness was reduced dramatically during the 1990–2000 periods. A significant portion of the watershed's natural vegetation has been significantly degraded, as seen by the decline in forest and shrub grasslands (Barana et al. 2016). The reduction of landscape greenness was due to inappropriate land resources management. During this period, the landscape is more vulnerable as a result of the rising dynamics of LU/LC (reduction in vegetation cover, soil degradation, and the depletion of biodiversity, which in turn leads to environmental deterioration) (Barana et al. 2016). In a degraded watershed, the conversion of shrub land and grassland into cropland and bare land covers was the cause of the decreasing change in landscape greenness (i.e. the amount of cropland and bare land grew by 41.9 ha and 26.7 ha, respectively) (Abiyot et al. 2018).

However, there was a significant increase during the post-treatment period b/n 2000–2010 and b/n 2010–2021 due to different types of watershed management interventions (i.e. afforestation, reforestation, and area closure). The highest NDVI value was increased from 0.43(2000) to 0.74(2021). While the low value decreased from − 0.11(2021) to -0.07(1990) (figure.6). Different studies also showed that landscape restoration through reforestation and tree planting activities have improved vegetation cover and changed other land uses biomass production, and biodiversity (Wanj et al. 2011; Shanwad et al. 2012; Pathak et al. 2013). The significant soil and water conservation efforts that were carried out in the study area have undoubtedly contributed to the improvement of the vegetation cover (Fikir et al. 2009).

In protected watersheds, shrub land and grassland cover raised by 20.6 ha and 22.5 ha, respectively. This observed shift in shrubland and grassland cover was responsible for the observed increase in the greenness of the landscapes (Abiyot et al. 2018). Over the past 20 years, there has been a discernible improvement in the vegetation cover. These improvements are due to the adoption of integrated SWC strategies, especially in the watershed where local communities defended and protected enclosure areas (Solomon et al. 2017).

The implementation of different management practices (e.g. area enclosure and plantation and plantation of grass and other plant species) has converted some bare land into grassland and plantation in the conserved watershed (Zewedu et al. 2019). Relatively, a high NDVI value was available in the central parts of the watershed. Such higher availability of NDVI value was used to understand the hydrological and other environmental issues of the watershed. The availability of high vegetation cover, which used to indicate the availability of high groundwater potential, high soil moisture, rainfall, biodiversity, carbon sequestration, and land productivity. Siraw et al. (2019) and Abiyot et al.(2018) also agreed that the availability of high vegetation cover, which used to provide many environmental benefits (i.e. some environmental benefits include protection of biodiversity, reduced soil erosion, increased carbon sequestration, reduced runoff, and flood hazard, enhance soil moisture and groundwater availabilities). The forest cover has been enhanced by the regeneration of the vegetation in numerous catchment locations (i.e the area under dense forest increased from 32.5 ha to 98 ha) (Fikir et al. 2009).

Based on table.5 and table.6, NDVI value was classified into five major classes, such as very weak (< 0.1), weak, (0.1–0.2) Moderate (0.2–0.3), High (0.3–0.45), and very high (> 0.45). The area with NDVI value < 0.1(very weak vegetation density) was increased from 12241.9 ha (1990) to 13618.4ha (2000) due to the expansion of agricultural land and high wood demand. Fenta et al.(2020) also agreed that natural vegetation is deforested due to the expansion of population, agricultural land, and low management practice. Conversely, such NDVI value classes decreased between 2000–2010 (-765.9 ha) and 1990 and 2021(-765.9 ha) due to the improvement of moderate, high, and very high NDVI classes (table.8).

Areas with NDVI values of high vegetation density (0.3–0.45) and very high vegetation density (> 0.45) increased by 296.8ha and 135.1ha between 1990 and 2021 respectively due to watershed management interventions. Zewedu et al. (2019) also agreed that increased NDVI value in the conserved watershed is attributed to the plantation of grasses and trees through community-based watershed development programs to stabilize physical conservation structures(soil bunds, stone bunds) and rehabilitate gullies and other degraded lands through area enclosure. This result also coincides with the previous research conducted in Ethiopia (Nega et al.2019; Zewedu et al.2019; Mekonen and Brhane 2011; Damene 2012; Gebrehiwot and Veen 2014) and elsewhere for example(Raynolds et al. 2006 in the arctic; Shanwad et al. 2012; Singh et al. 2013 in India). They also agreed that a significant improvement in NDVI value was observed at conserved sites. In the protected watershed, shrubland and grassland cover grew by 20.6 ha and 22.5 ha, respectively, while they shrank by 50 ha and 49.3 ha in the control watershed. The conversion of shrubland and grassland into cropland and bare land covers was the cause of the decreasing change in landscape greenness in the control watershed (Zewedu et al. 2019).

Land Use/ Cover Change Between 1990 &2000

Based on analysis of satellite images of 1990,2000,2010 and 2021 six major land use land cover types were identified, namely built-up area, cultivated land, grassland, Natural forest, plantation, and shrubland. As indicated in table.1 and figure.1, the land occupied by shrubland, grassland, and natural forest in 1990 was 4671.3ha, 427.9 ha, and 54.2ha and in 2000 it decreased to 1659.9 ha., 224 ha. and 19.3 ha respectively(table.6). Moreover, the land use land cover categories like natural forest land, shrub land, and grassland showed decrease amounted to -34.9ha,-3011.4ha and − 203.9ha also the average rate of change for these LU/LC classes was − 3.5ha/year, -301.1ha/year and − 301.1ha/year respectively due to the continuous expansion of cultivated land, built-up area and plantation(figure.7 & table.9,10). Barana et al. (2016) also agreed that tree plantations and cultivated lands both increased at a similar pace of 30.07 and 27.46 ha each year, respectively.

Figure 7. Showed that natural forest, shrubland, and grassland cover change were the main feature that can easily be detected in the study area. The reasons behind this could be many, according to the idea of key informants and household respondents, the major factors that have caused and being causing deforestation and degradation in the study area are sorted out as clearing of forests for farmland expansion, expansion of timber production, exploitation of forest resource for firewood, charcoal production, and construction purpose. All these factors become highly pronounced with the existence of large farmland expansion in the study area, following the increase in population and their dependence on forest resources.

The main reasons behind LULC change were a mix of the 1975 land reform, the 1980s forest development and villagization program, the civil war, repeated changes in political structure, and population pressure (Ebrahimand Mohamed 2017). Temesgen et al (2018) also analyzed that forest coverage decreased from 3.5% in 1985 to 2.6% in 2000 and 1.9 in 2015 forest coverage decreased from 3.5% in 1985 to 2.6% in 2000 with an annual diminishing rate of 37.6 and 24.4 ha/yr between 1985–2000 and 2000–2015 periods, respectively. Similarly, shrub land and grasslands also decreased at a rate of 328.7 and 97 ha/yr, and 45.2 and 62.2 ha/yr, respectively, between the 1985–2000 and 2000–2015 periods. On the other hand, Getachew et al. (2011) and Ebrahimand Mohamed (2017) found that natural forest, shrub land, and grassland were reduced due to the conversion of areas once covered with vegetation to cultivation without adequate use of soil and water conservation.

Similarly, lands occupied by built-up area, plantation, and cultivated land in1990 was 1.3ha, 88.3ha, and 9828.7ha and in 2000 it was increased to 4 ha., 12996.6ha, and 167.9 ha respectively. Besides, the land use land cover categories that show an increase are a built-up area, plantation, and cultivated land amounted to + 2.7 ha, + 135.7ha, and + 3167.9ha respectively and also the average rate of change for these LU/LC classes was + 0.3ha/year,+13.6ha/year and + 316.8 ha/year respectively.

In these periods, 3.5ha, 0.1ha, and 0.2ha of the built-up area were converted from cultivated land, natural forest, and shrubland respectively. Conversely, a significant area of built-up area was reverted to cultivated land (1.1ha) and plantation (0.2ha) (table.11). During this time, some areas of cultivated lands were reverted from the built-up area (1.1ha), grassland (337.7ha), natural forest (15.8ha), plantation

(44.6%) and shrublands (3035.1ha). While, 3.5ha, 56.9ha, 0.5ha, 34.2ha, and 175.3ha of cultivated land were in reverse converted to the built-up area, grassland, natural forest, plantation, and shrublands

respectively. Similarly, gains and losses in natural forest, grassland, shrubland, and plantation also take place in the study area (table.11). In Ethiopia, population pressure, resettlement initiatives, climate change, and other man- and nature-induced driving forces are mostly to blame for the rapid changes of LULC witnessed in recent decades. The most important causes of the natural landscape and resource degradation, which have negative effects on the environment and way of life, are anthropogenic activities (Motuma et al. 2021).

During the time's focus group discussion, more than 85% of the communities' members also described that the major cause for the reduction of forest, shrubland, and grasslands was the expansion of agricultural land, expansions of settlements, and expansion of infrastructures. Temesgen et al. (2018) also found that there were continuous expansions of cultivated land and built-up area and the withdrawal of forest, shrubland, and grassland during the 1985–2015 periods. Moreover, Jiangyue et al.(2019) ascertained that acute farmland expansion and rapid urbanization in Central Asia have accelerated land use/land cover changes. During this period, forest, shrubland, and grassland cover declined. The results of this study are in line with those of a few earlier investigations that found more forest, shrubland, and grassland cover in watersheds that had been reduced (Alemayehu et al.,2009; Haregeweyn et al. 2012). This reduction can be brought about by the local community due to an increase in the demand for farmland expansion and population growth. Tatek and Daniel(2019) also agreed that the main factors influencing land use/land cover changes included the extension of cultivated land, the removal of trees for fuel wood and construction, population growth, land tenure policies, and climate variability.

During the time of focus group discussion and key informant interview, it was also found that the major cause of grassland, shrub land, and forest reduction were the expansion of cropland, expansion of infrastructures (school, health, and road, expansion of settlement and its conversion into the plantation. Similarly, Solomon (2016) also found that the prevalence of various types of agricultural activities, firewood and charcoal production, cutting of trees to fulfill the demands of construction materials, settlement expansion and income generation are directly or indirectly accelerating the occurrence of land use and land cover change. Due to this the natural vegetation cover of the study area especially, forestland, shrublands, and grassland shrinking from time to time. Similarly, there was a roughly 40%, 21%, and 12% decline in grasslands, forest lands, and shrub-bushlands, respectively. Alemayehu et al. (2009) and Haregeweyn et al. (2012), on the other hand, noted that a decreased, natural forest, grassland, and shrubland cover in watersheds that were not well-served. This discrepancy could be caused by high cropland. Natural resources were degraded as a result of this unmanaged land cover alteration (Tatek and Daniel 2019). Both natural and human variables directly affect LULC alterations, with anthropogenic pressure brought on by globalization serving as the primary motivator (Motuma et al. 2021).

Land Use Land Cover Change Detection Between 2000 & 2010

Some changes indicated a decrease or rise in specific land use or land cover when the 2010 LULC classification was compared to the 2000 LULC classification (figure.9). Plantation, built-up area, natural forest, shrubland, and grassland are the land use land cover categories that showed increases, with respective areas of + 361.2ha, + 50.5ha, + 74.8ha + 1070.8ha + 2050.3ha, and + 585ha. The average rate of change for these land use land cover classes was + 36.1ha/year, + 5.1ha/year, 7.5ha/year, 205ha/year, and 58.5ha/year (table.9, 10).

Cultivated land showed a decreasing pattern of 312.2ha between 2000 and 2010 with an average rate change of -312.2ha/year, among other land use land cover categories. Such transformation of farmland, bare land, and other types of LULC into grassland, shrubland, and forestland, has a variety of beneficial effects that improve ecosystem functions and services (Gascoigne et al. 2011; Nyssen et al. 2015). Abiyot et al. (2018) also ascertain that following the intervention, grassland and shrubs had grown over significant damaged and bare regions. Before the intervention (in 2005), there were 171 ha of bush/shrub and 34 ha of grassland, respectively. They were later extended to 617 ha and 152 ha during the intervention respectively. Cultivated land has gradually decreased from 26.7 percent in 1986 to 18.4 percent in 2019, due to a rise in forest and homestead land in response to watershed management intervention (Tilahun and Awdenegest 2020).

During this time, 0.1, 66.5, 0.2, 1.7, and 6.3 ha of grasslands were converted into built-up areas, cultivated land, natural forest, plantations, and shrublands respectively (table, 11). Whereas, about 0.1,221.9,30.9,78.5 and 37.8 ha of shrublands were reverted to the built-up area, cultivated land, grassland, natural forest, and plantation respectively. Moreover, around 0.1, 341.9, 1.7, 63.5, and 37.8 ha of plantations were reverted from built-up areas, cultivated land, grassland, natural forest, and shrublands. Likewise, losses and gains also take place in shrublands, natural forests, built-up areas, cultivated land, and so on (table.11).

In 2000, natural forest remains can be found on steep hillsides and around churches, although they are few. During this time, the watershed's degraded shrub grassland, which occupied a sizable section of the area was often changed into other cover types, like shrubland, grassland, and forest land. Field surveys revealed that the vegetation cover, which was sparse and small in 2000, has now grown larger and transformed into shrubland, grassland, Plantation, and natural forest in 2010.

Land Use Land Cover Change Detection Between 2010 & 2021

The land occupied by shrubland, grassland, natural forest, plantation, and the built-up area was 3710.2 ha, 809 ha, 94.1 ha, 529.1 ha, and 54.5 ha accordingly in 2010, as shown in table.6 and figure.5, and it rose to 5742.1 ha, 853.2 ha, 250.5 ha, 800.6 ha, and 255.3 ha in 2021. In contrast, agricultural land declined from 9874.8 ha in 2010 to 7170 ha in 2021. The amount of natural forest land, shrub land, grassland, plantation, and built-up area also increased, reaching 156.4 ha, 2031.9 ha, 44 ha, 271.5 ha, and 200.8 ha, respectively. Additionally, for these LU/LC classifications, the average rate of change was 14.2 ha per year, 184.7 ha per year, 4 ha per year, and 18.3 ha per year, respectively. Nevertheless, the amount of cultivated land declined by -2704.8ha at a rate of -245.9ha/year (table.9) due to human interventions.

In the conserved watershed, cultivated land and bare land covers decreased by 30.4 ha and 23.3 ha, respectively (Abiyot et al. 2018). The forest cover has been improved by the restoration of vegetation in numerous catchment locations. Farmers also acknowledged during focus group talks that the vegetation cover has grown and that the current change is a result of the intervention. In 2010, riparian trees that were not present in 1990 began to grow along the valley floors that the rivers followed (Fikir et al. 2009).

During these time events, 4.1, 2235.1, 228.7, 986.1, and 154.5 ha of shrublands were reverted from built-up area, cultivated land, grassland, natural forest, and plantation respectively. Conversely, 18.93, 754.32, 143.86, 154.4, and 187.11ha of shrublands were reverted to the built-up area, cultivated land, grassland, natural forest, and plantation respectively. In this period, gain and losses also take place in built-up area, natural forest, plantation, Grassland, and cultivated land (Table.10). Between 1990 and 2000, bare land had a significant change in LULC (decreased by 23 km2), while, shrub land and forest cover experienced increases of 18 km2 and 10 km2, respectively (Fenta et al. 2016). During these time intervals, forest and settlement land coverage have expanded from 20.9 to 39.2 and 9.2 to 22.6 percent, respectively due to watershed management intervention (Tilahun and Awdenegest 2020).

In the study watershed, some degraded grounds have been turned into grassland and shrubland through the application of various management strategies, such as area enclosure and plantation of grass and other plant species. The results of this study are in line with those of several earlier investigations that found more grassland cover in watersheds that were conserved (e.g., Damene 2012; Mekuriaw 2017).

During the time of key informant interview and focus group discussion, the researchers found that planting of trees like Sesbania sesban, Acacia saligna, and Acacia decurrens was principally responsible for the rising change in shrub land cover within the study area.

Land Use Land Cover Change Detection Between 1990 & 2021

When the 2021 LULC classification was compared with the 1990 LULC classification, some changes showed a decrease or increase in particular land use land cover (figure.6). The land use land cover categories, which showed increases are plantation, built-up area, Natural forest, shrubland and grassland accounting for + 712.3ha, + 254ha and + 196.3ha,+1070.8ha and + 196.3ha respectively and also the average rate of change for these land use land cover classes were + 23ha/year, + 8.2ha/year,6.3ha/year, 34.5ha/year and 13.7ha/year respectively(Table.9,10). Among other land use land cover categories cultivated land was shown to decrease pattern of -2658.7ha between 1990 and 2021 with an average of rate change − 85.8ha/year (Table, 9, 10).

During the field observation, focus group discussion, and key informant interview, the researcher found that forest land cover, shrubland, grassland, and plantation were increased due to area closure, controlling illegal cutting of trees, reforestation, and afforestation which was started through community mobilization in 2003. Some studies conducted in the previously degraded parts of northern Ethiopia also agreed on the improvement of vegetation cover due to plantation and enclosure of the previously degraded hillsides in the period since the 1980s. For example, a study conducted by Woldeamlak (2002) in Chemoga watershed, East Gojjam revealed that the increased of forest cover at a rate of 11 ha per annum from 1957–1998, even though it is a eucalyptus plantation. A similar study by Amare (2007) and Amare et al. (2011) in the Eastern Escarpment of Wello, Ethiopia, and Munro et al. (2008) in Tigray highlands disclosed that vegetation cover improved since the 1980s owing to land rehabilitation efforts of the community supported by the government and multilateral donor agencies. Besides, Participatory forest management through plantation and community nursery expansion is the base for forest cover improvement in the watershed (Fasika et al. 2018).

On the other hand, Different studies also showed that landscape restoration through reforestation and tree planting activities has improved vegetation cover and changed other land uses biomass production, and biodiversity (Wanj et al. 2011; Shanwad et al. 2012; Pathak et al. 2013). Moreover, the implementation of different watershed management practices (e.g. area enclosure and plantation and plantation of grass and other plant species) has converted some bare land into grassland and plantation in the conserved watershed (Zewedu, 2019). Over the past two decades, a discernible improvement in vegetation cover has been seen. These benefits are due to the application of integrated SWC strategies, especially in regions where enclosure areas were defended and preserved by the local population (Solomon et al. 2017).

Table.10 indicated that 0.3ha of the study area was covered by a built-up area in 1990 and remained the same in 2021. The remaining 1.1ha of the built-up area was changed to other land use types. Specifically, 0.7ha of the built-up area was changed to cultivated land, 0.1ha to grassland, 0.1ha plantation, and 0.2ha was to shrub land. During this period, the conversation of other LU/LC types to build up amounted to only (254.2ha) compared with 1.1ha built-up areas were lost to other land use/land cover types and so on. During this time event, the amount of gain is more than the amount of loss. During the time of discussion, the Key informants also agreed that there was the expansion of urban and rural settlements due to population growth. As result, the gain of the built-up area from other land use is more than it's lost to other land uses. Besides, losses and gains also take place in shrublands, natural forests, plantations, grasslands, and cultivated land (table.11).

Siraw et al. (2019) and Abiyot et al.(2018) also agreed that in the control watershed, the amount of cropland and bare land increased by 41.9 ha and 26.7 ha, respectively. In contrast, in the conserved watershed, these land covers decreased by 30.4 ha and 23.3 ha, respectively. Such observed changes in the amount of vegetation, crops, and bare land in the protected watershed have significant effects on improving soil fertility, and biodiversity, controlling soil erosion and food production, recharging groundwater, sequestering carbon, and rural livelihood systems. Fenta et al. (2016) also found that the strategies used to manage the watershed, including the construction of stone bunds to restore the watershed's degraded parts and the development of treated plots combined with or without enrichment plans are the main cause of the existed land use land cover changes.

The best way to restore the vegetation-degraded landscape of the study area is to undertake various SWC operations, such as area enclosure, stone terraces, soil bunds, contour ditches, moisture retention reservoirs, and check dams. According to a supplementary survey conducted in the research area, 98% of the respondents saw an improvement in the vegetation cover in their area during the previous 18 years. This resulted from the right SWC implementation, notably the use of area enclosure to safeguard against livestock and human intervention and improve restoration (Fikir et al.2009).

The conversion was taken place from one land use land cover category to another between 1990–2000, 2000–2010, and 2010–2021 periods are presented in table.11. Belay (2002) explained that the conversion of one land use land cover category to the other was the common phenomena in land use land cover studies. The diagonals of matrixes from the table are the persistence. While the off diagonals are the conversions from one category to others. The detail of each conversion is presented from the table category (table.11).

Conclusion

The results indicated that watershed management in Yezat watershed has brought significant improvement in landscape greenness and land use land cover change modification. Between 1990 and 2000. Natural forests, shrublands, and grasslands were decreased by the rate of -34.9ha yr, -203.9ha yr, and 3011.4 ha yr respectively. During this period low landscape greenness value (-0.11) was observed in the study area due to the continuous expansion of cultivated land and built-up area with a rate of + 3167.9ha yr and + 2.7 ha yr respectively. Conversely, between 1990 and 2021, plantation, natural forest, shrubland, and grasslands were increased by + 712.3ha, 196.3ha, + 1070.8, and + 425.3ha respectively due to watershed management interventions. While, cultivated land decreased with a rate of -2658.7hayr, in the study area.

During this period, a high landscape greenness value (+ 0.2) was observed. The area with an NDVI value of < 0.1(very weak vegetation density) was increased from 12241.9 ha (1990) to 13618.4ha (2000) due to the expansion of agricultural land and high wood demand in the study watershed. Besides, an area with an NDVI value of high vegetation density (0.3–0.45) and very high vegetation density (> 0.45) was increased by 296.8ha and 135.1ha between 1990 and 2021 respectively due to watershed management interventions.

Such observed changes in landscape greenness in the study watershed were due to the change in shrubland (+ 1070.8ha), grassland (+ 425.3ha), plantation (+ 712.3ha), and forestland (+ 196.3ha) covers between 1990 and 2021 years. Besides Such observed changes in landscape greenness and cultivated land in the study watershed have important implications for the improvement of soil moisture, soil fertility, biodiversity, groundwater recharge, carbon sequestration, soil erosion land productivity, and ecosystem services. Thus, the study has concluded that watershed management has the potential to modify the existed land use land cover changes, and vegetation condition of degraded watersheds.

Declarations

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Figures

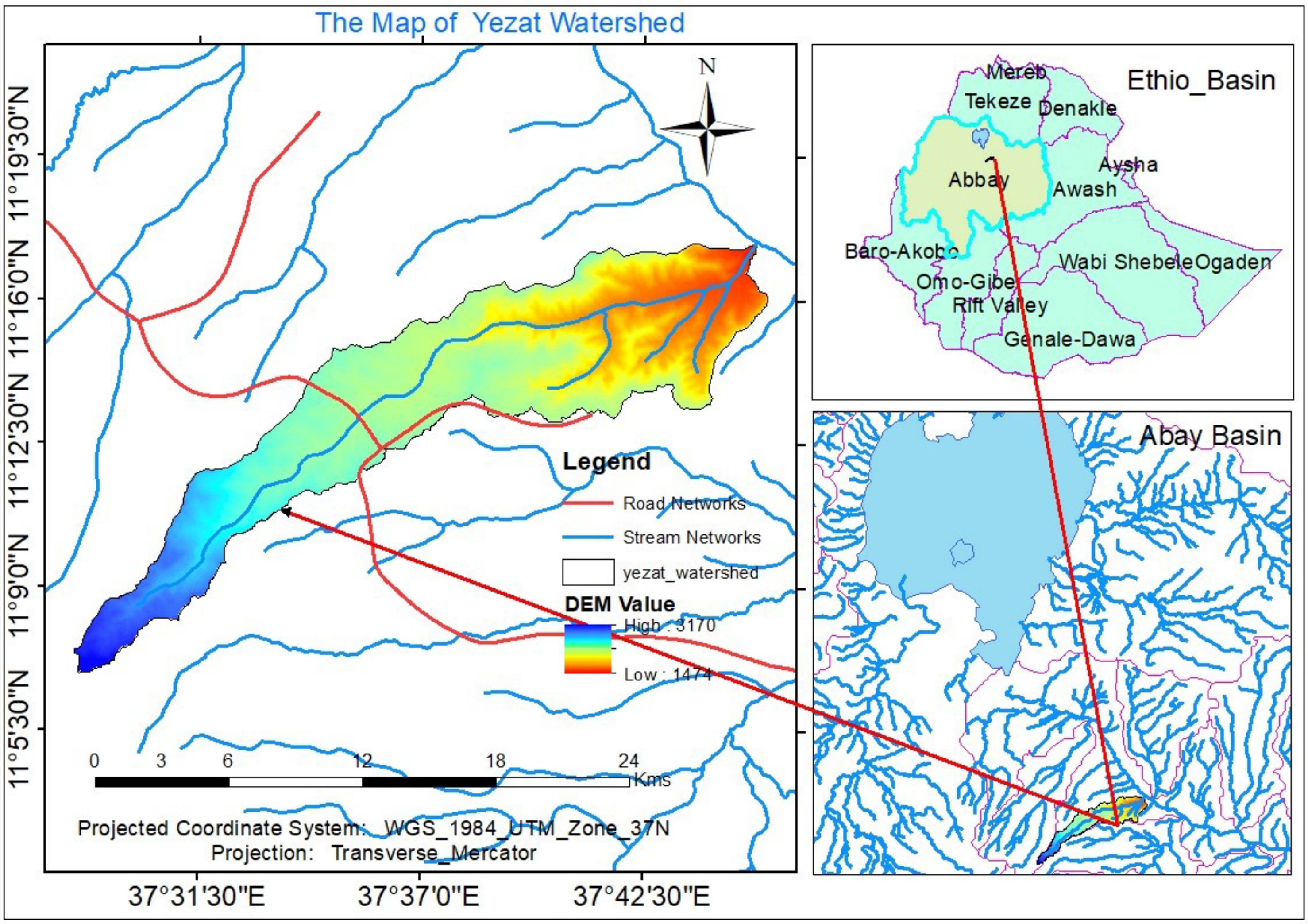

Figure 1

Locational map of Yezat Watershed, Northwest highlands of Ethiopia

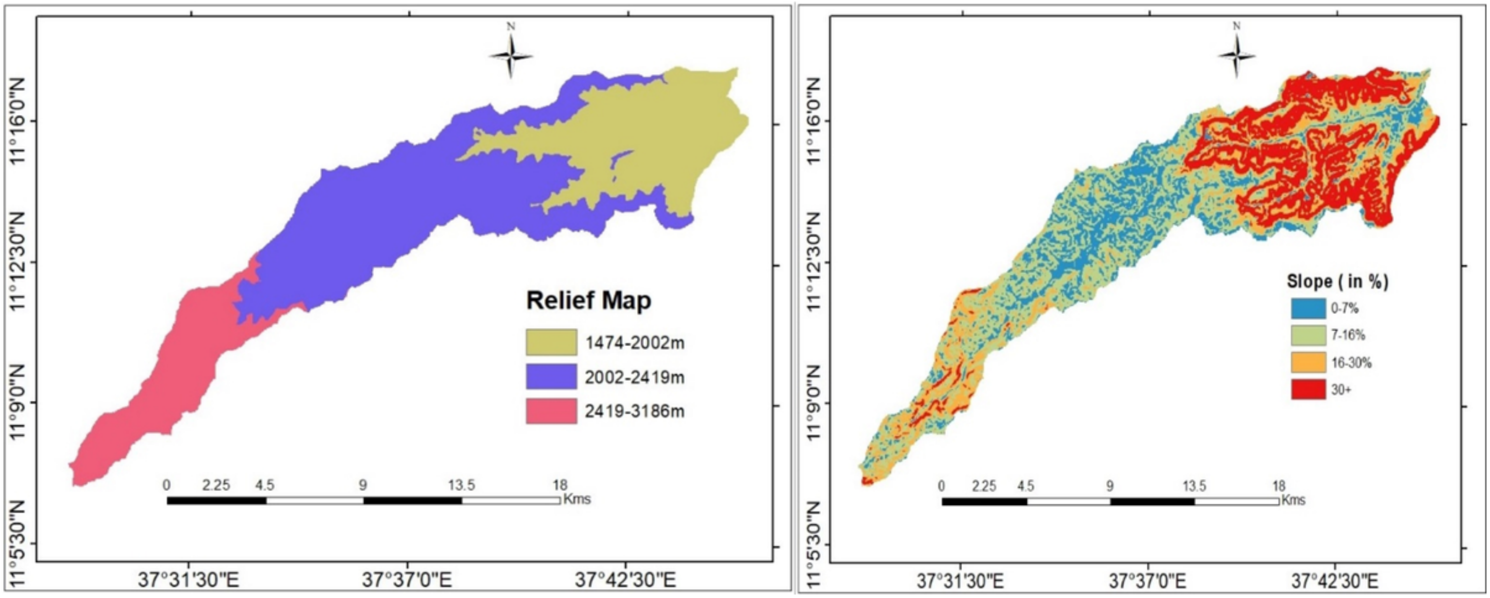

Figure 2

Relief and slope map of yezat watershed

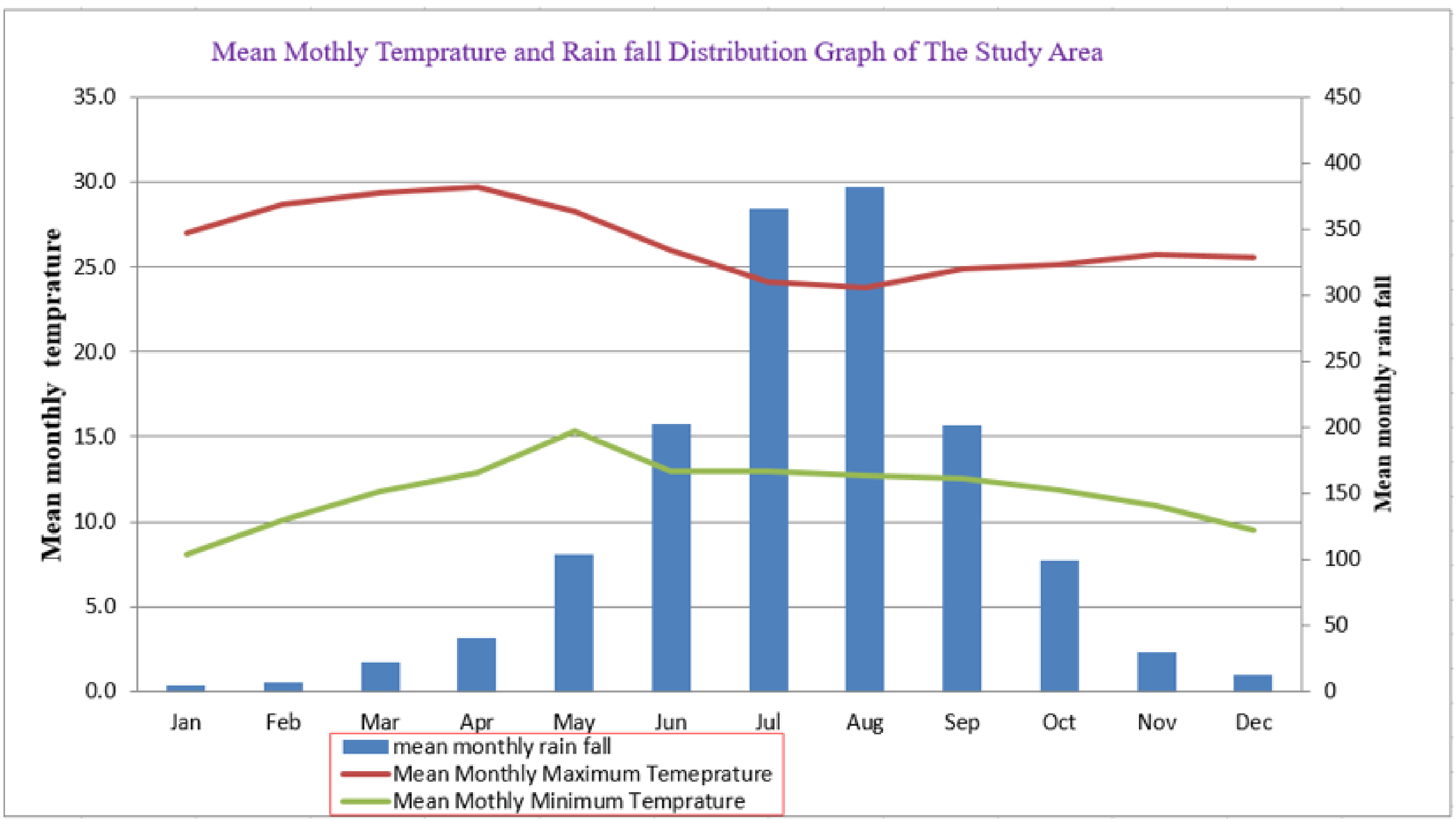

Figure 3

mean monthly rainfall, minimum and maximum temperature1990-2021

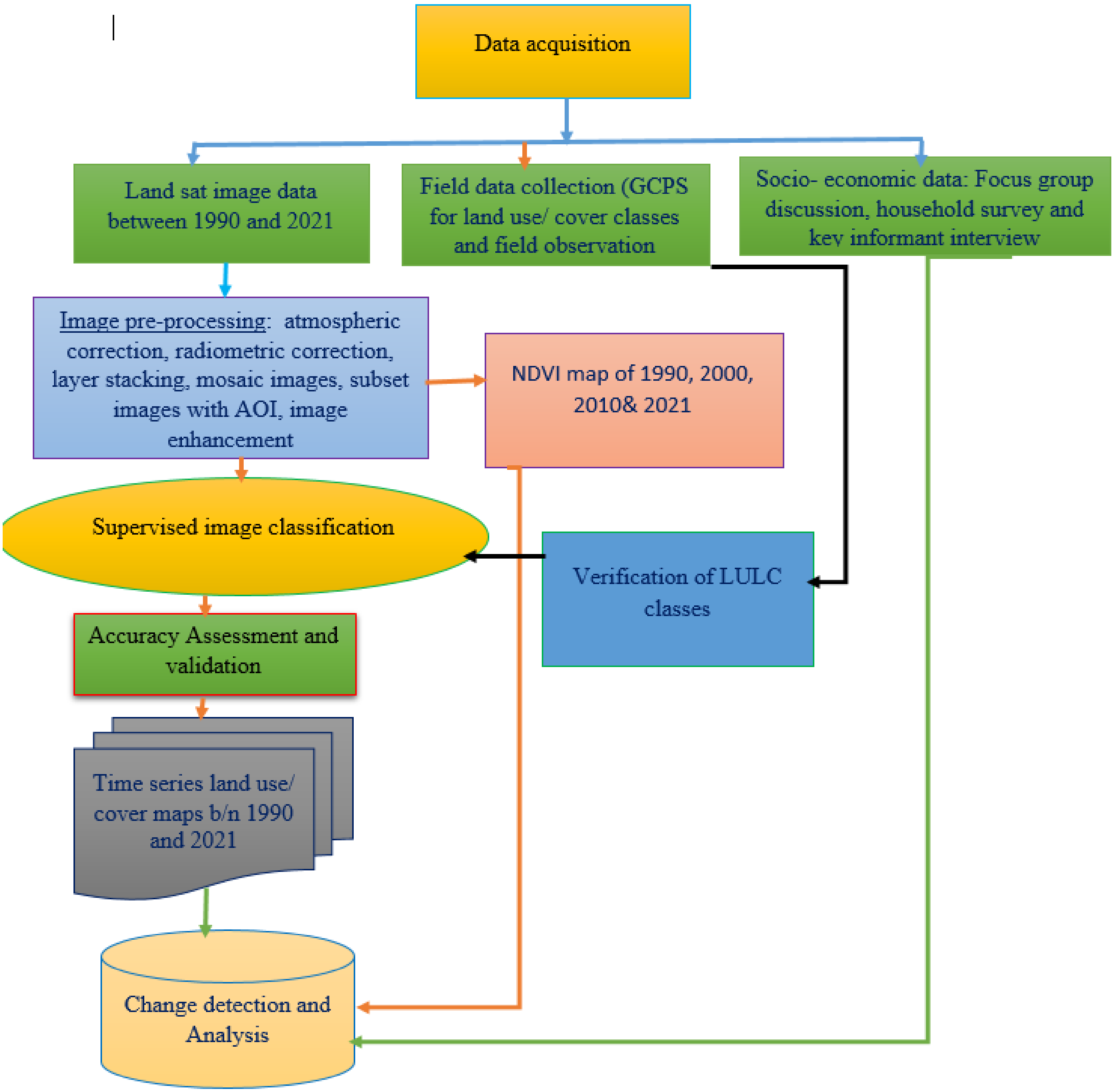

Figure 4

Methodological flow charts for land use land cover change analysis

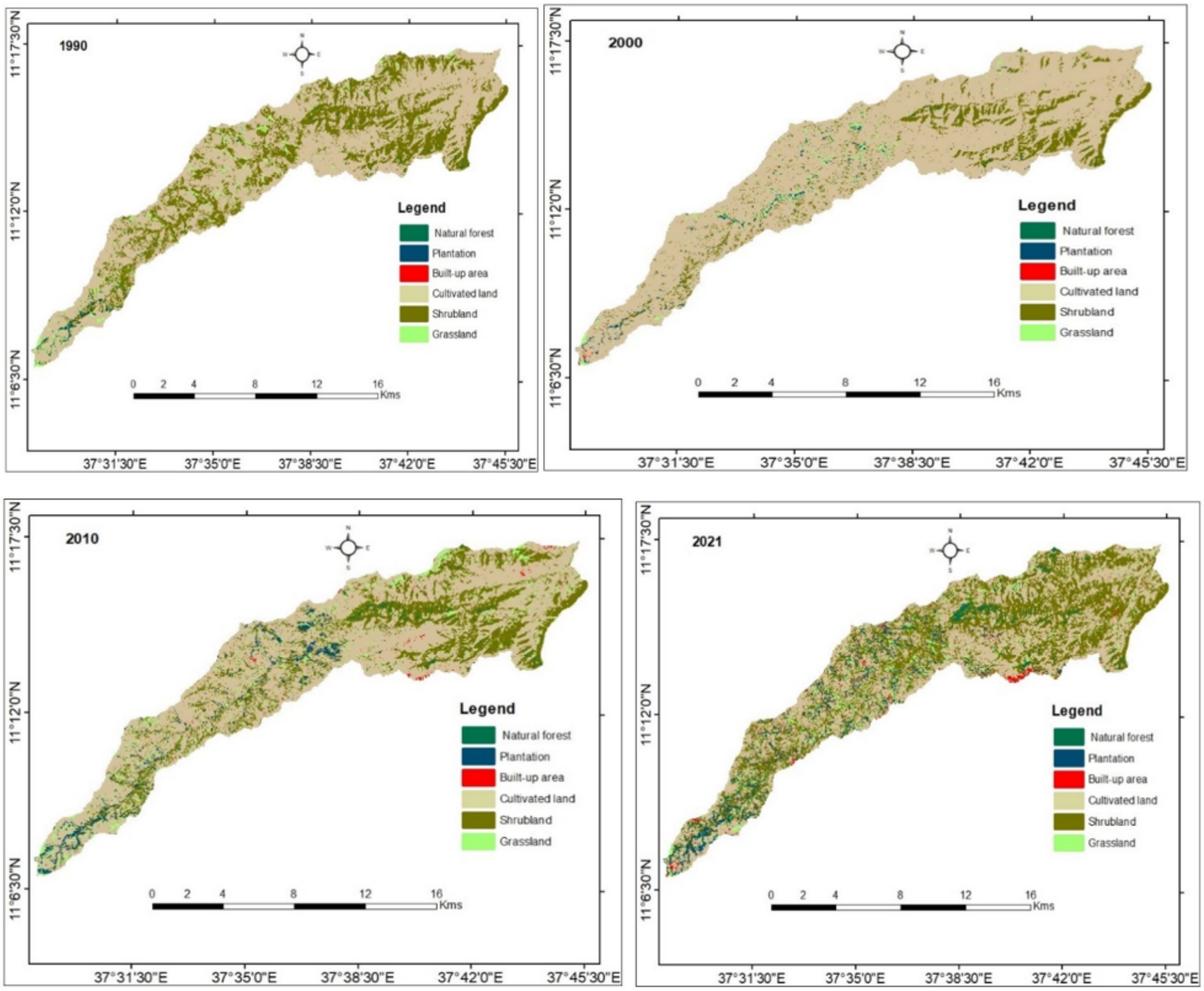

Figure 5

Land use land cover of 1990, 2000, 2010 and 2021 of Yezat watershed

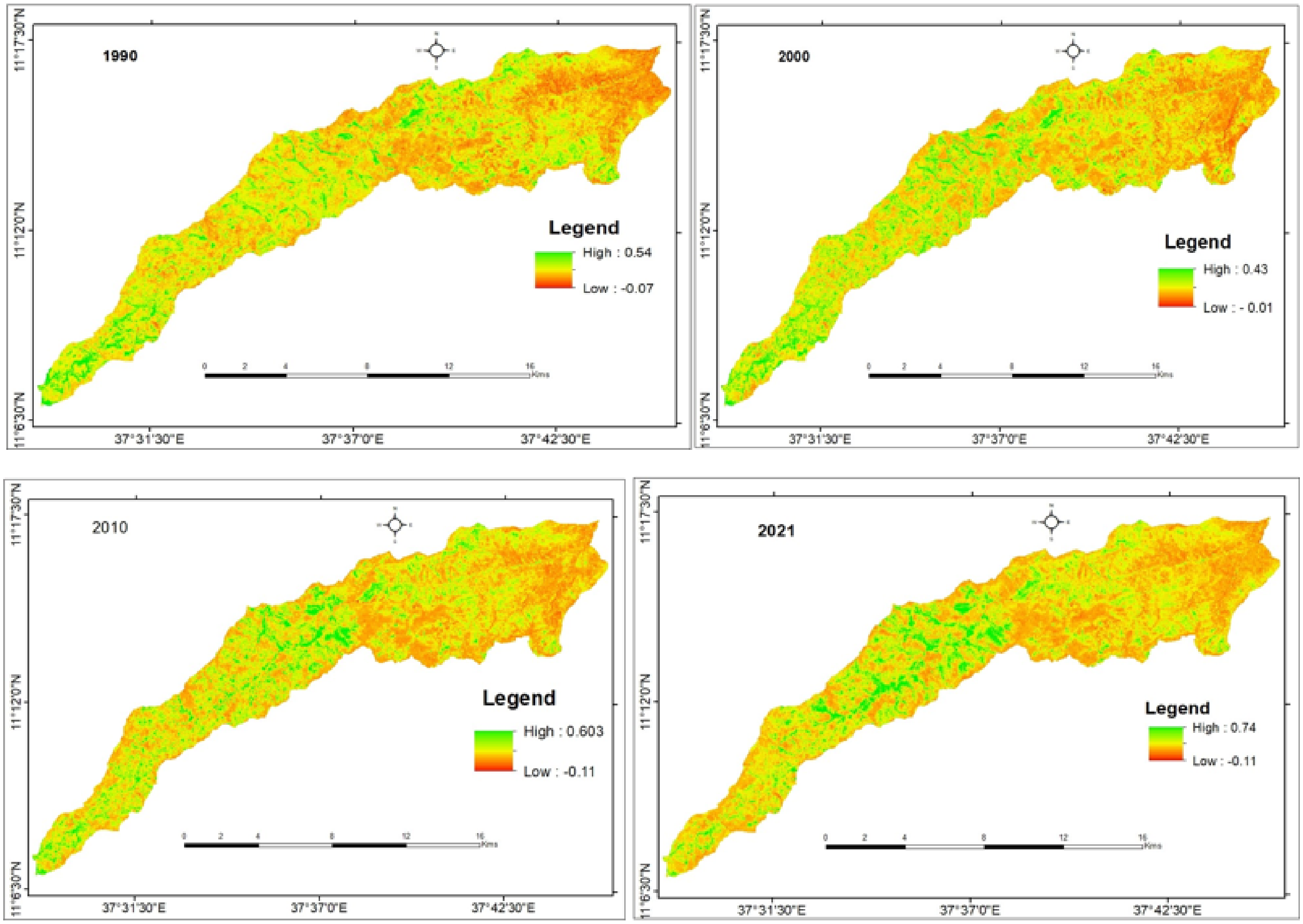

Figure 6

Spatial variation of NDVI values in yezat watershed between 1990 and 2021

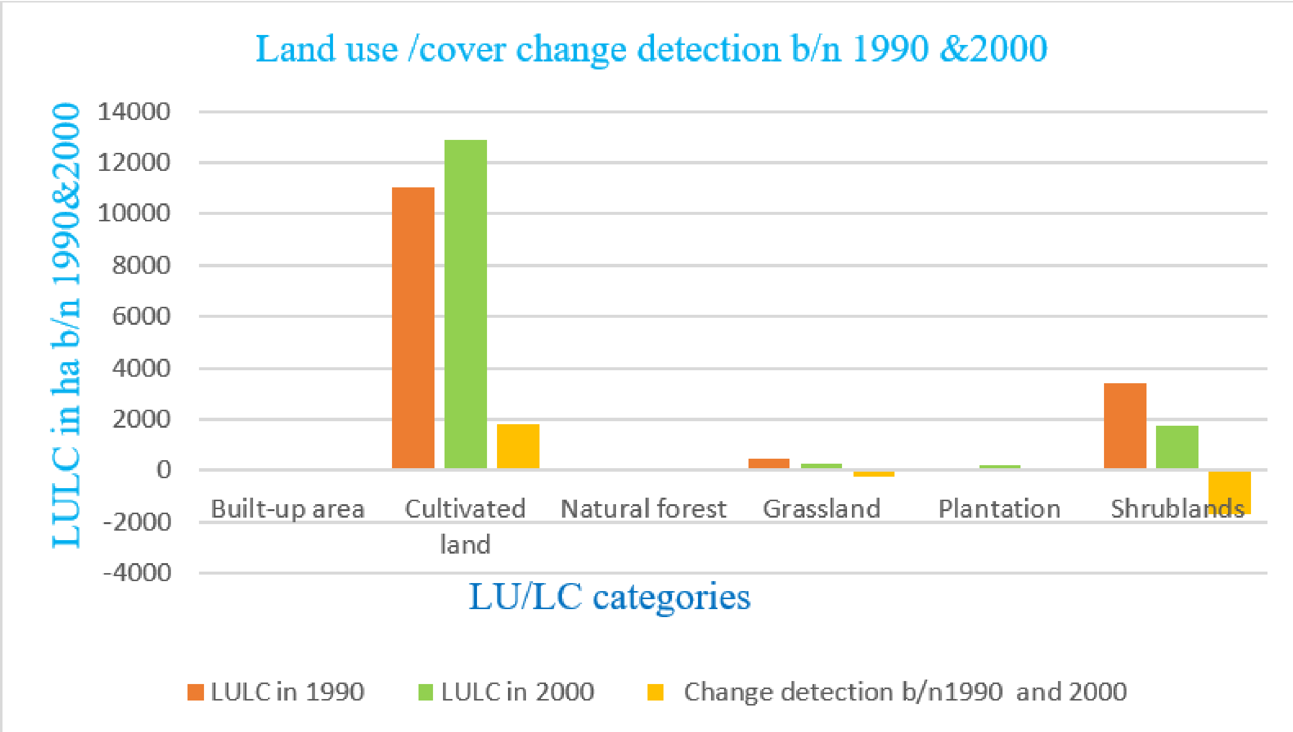

Figure 7

land use land cover change detection between 1990 and 2000 in the study area

Figure 8

A represents firewood collection for domestic consumption represents cutting of trees for construction purposes, C is charcoal production to get income and D represents the burning of shrubland for farmland expansion.

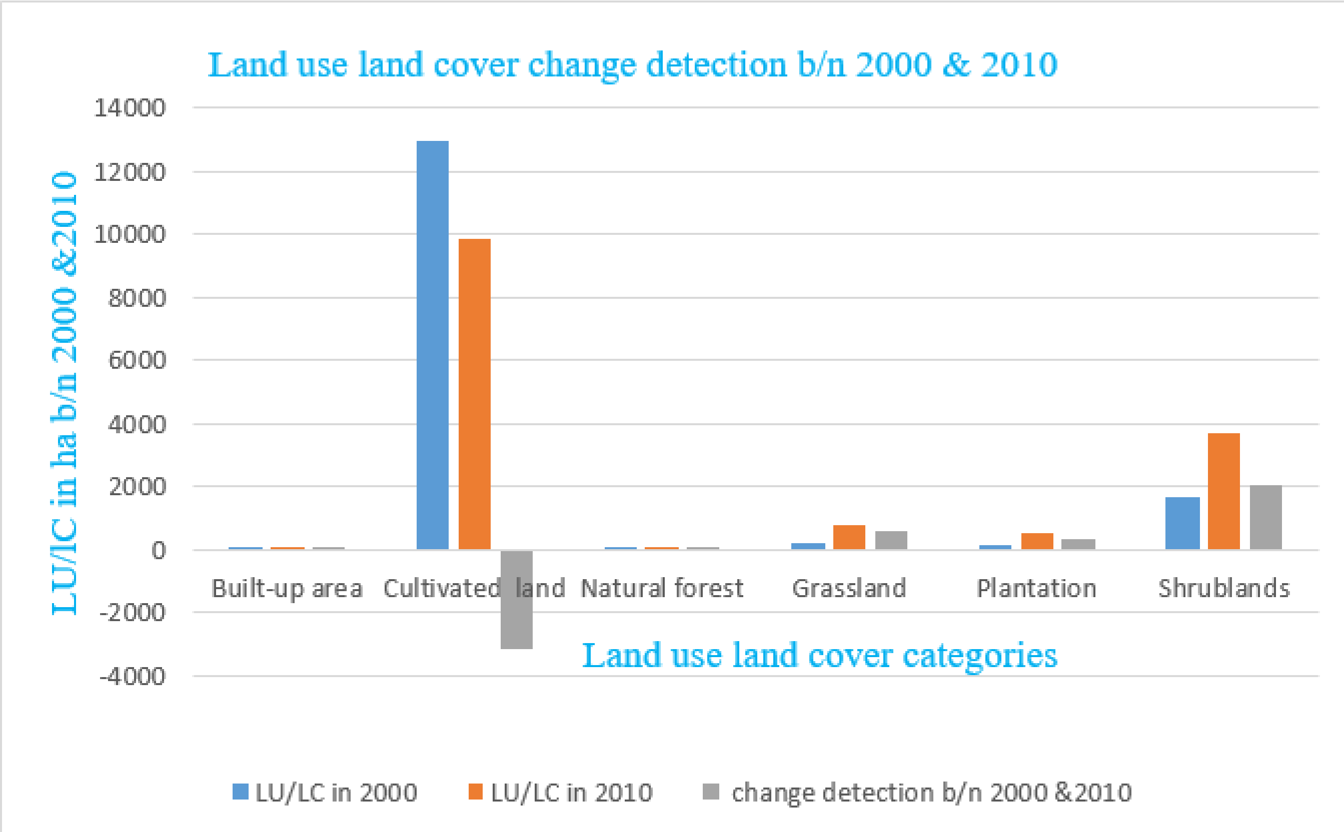

Figure 9

Land use land cover change detection between 2000 and 2010

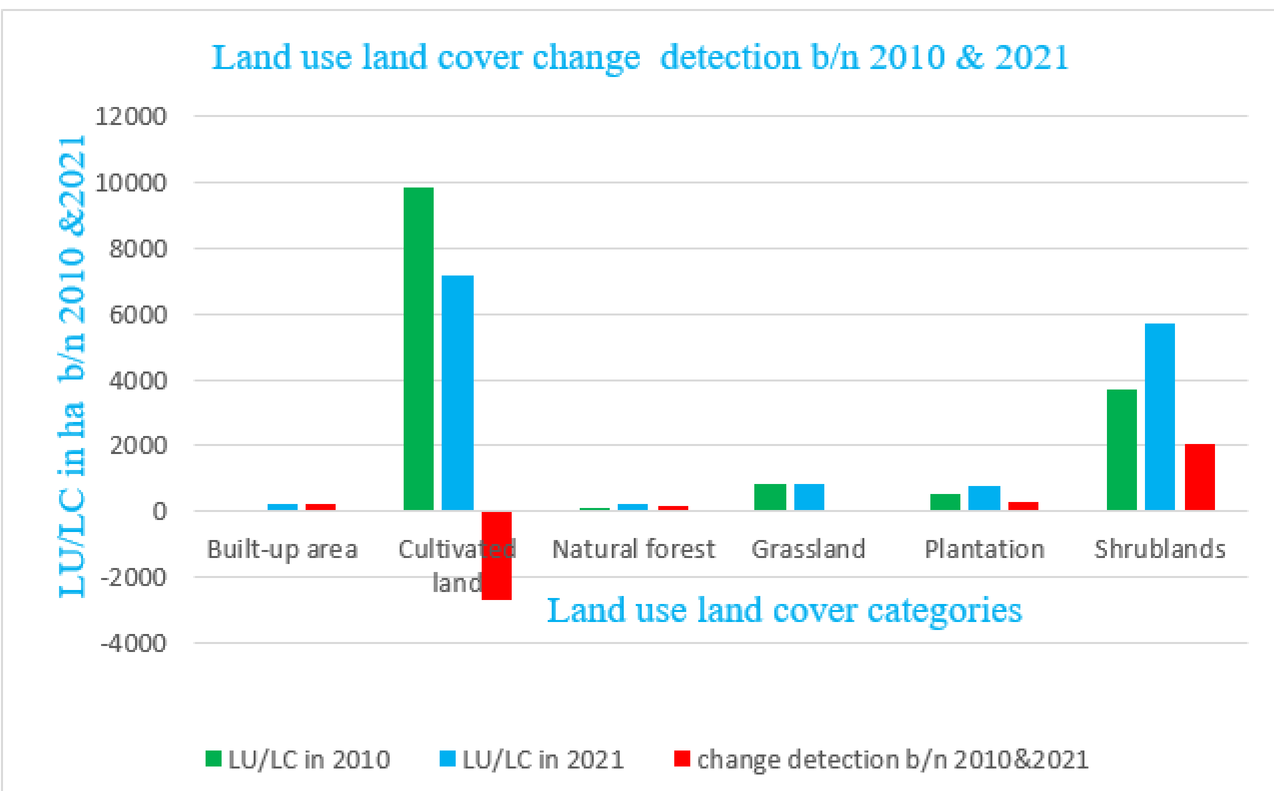

Figure 10

Land use land cover change detection between 2010 and 2021

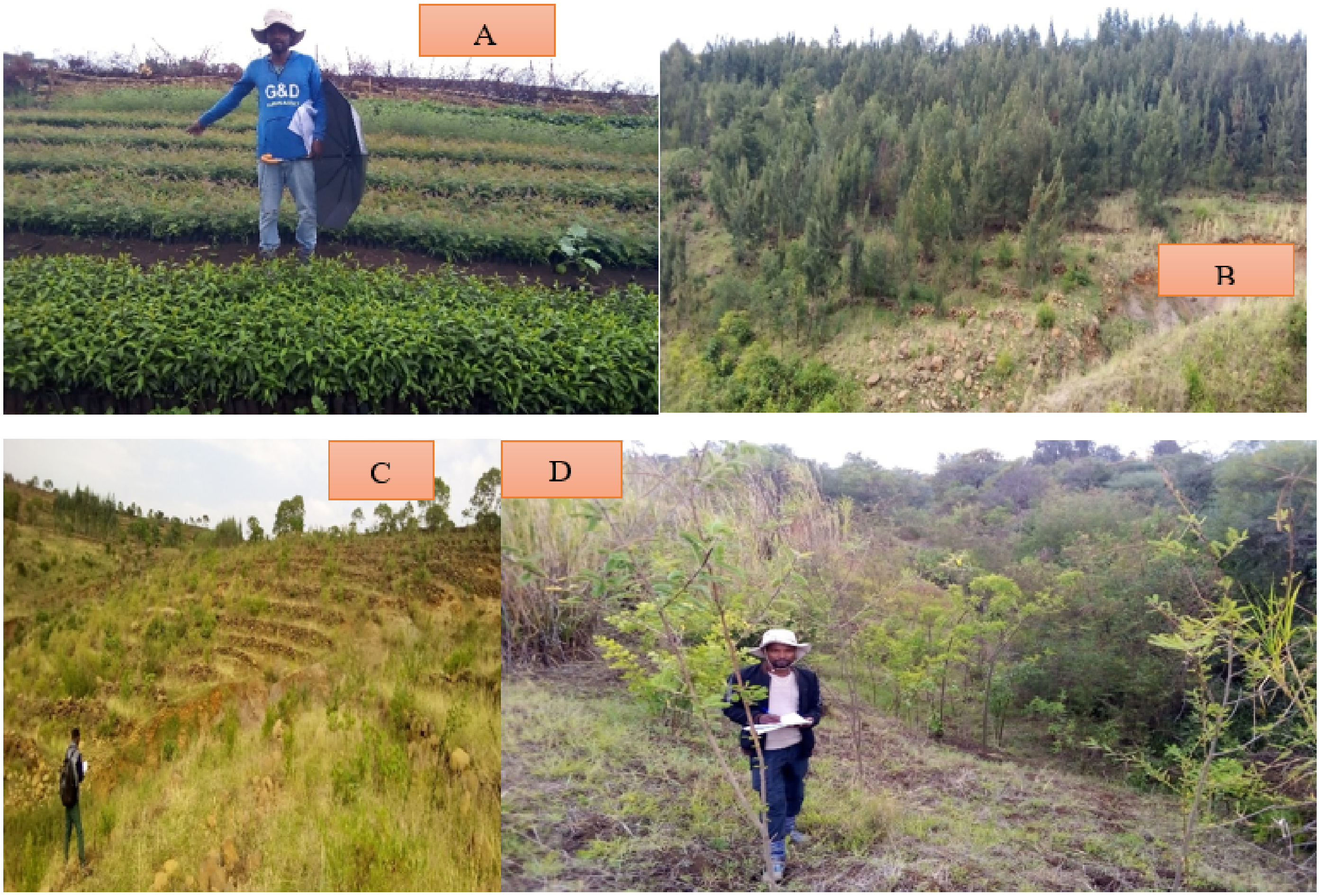

Figure 11

A is the nursery site of the study area, B is a plantation on degraded lands combined with a stone bund, C, represents area enclosure combined with bio-physical soil and water conservation and D is rehabilitated gullies in the study area during the intervention.

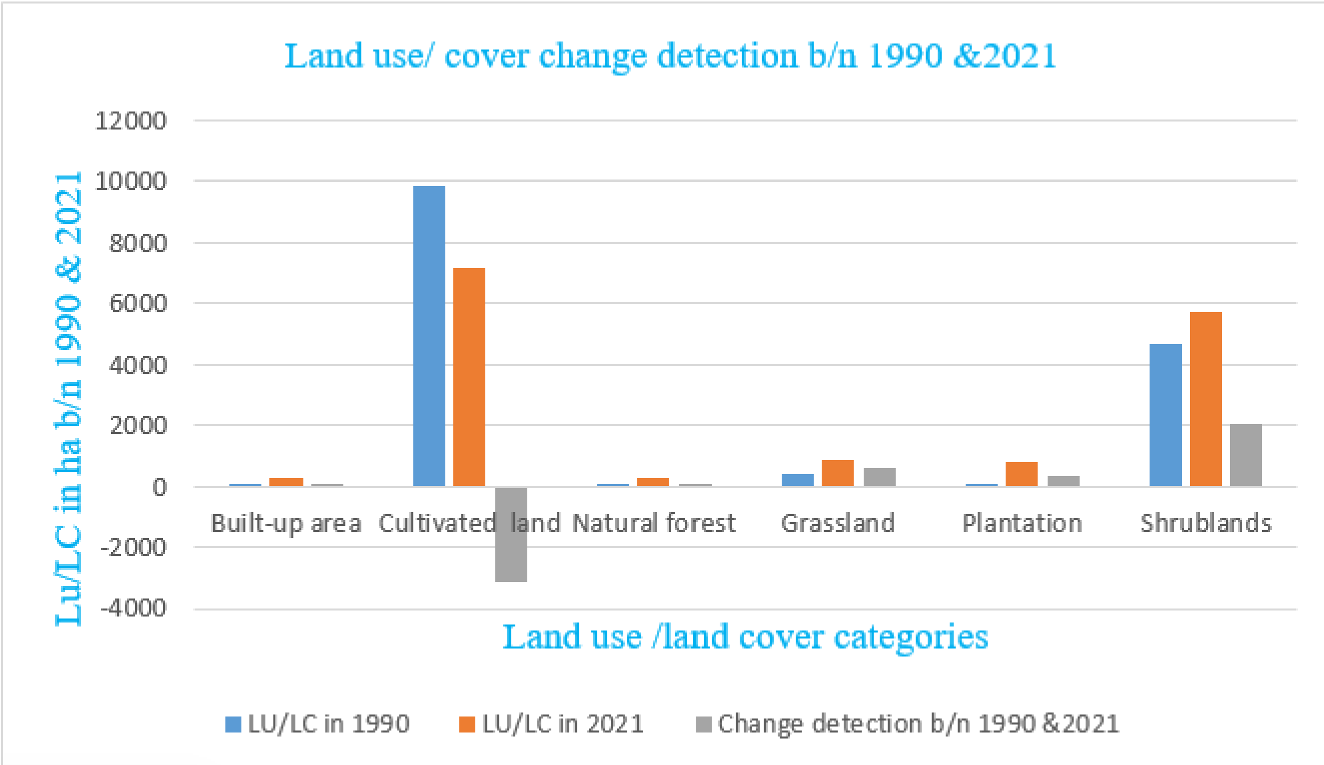

Figure 12

Land use land cover change detection between 1990 and 2021

Figure 13

A plantation on degraded lands and B soil bund on degraded cultivated land combined with area enclosure and homestead plantation in yezat watershed.

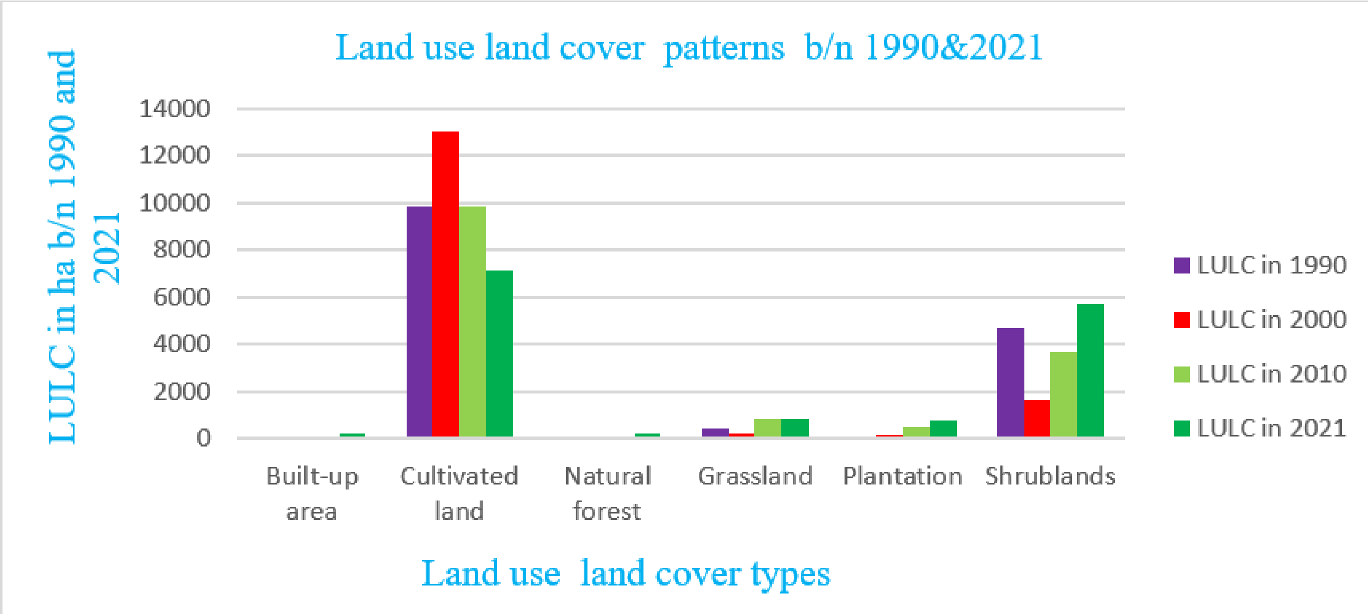

Figure 14

Patterns of land use land cover b/n 1990 and 2021.

Supplementary Files

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- Table1To9.docx