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Research Article

Evaluation of Land Use/Land Cover dynamics in and around Gondar Town, North West Ethiopia using Remote Sensing and GIS Technologies

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Abstract

The present study examines the utilization of Geographical Information System and Remote Sensing in mapping land use land cover modification in and around Gondar, Ethiopia between 1999 and 2017 therefore on notice and analyzes the modification that has taken within the study area between these periods using satellite image classification methodology. So as to attain these objectives, Satellite images of Landsat ETM+ for years 1999 and 2004 and Land sat OLI 8 for 2017 are obtained and processed using ArcGIS. The maximum likelihood formula of supervised image classification has been accustomed to generate land use land cover maps. Land use land cover classification, change map, has been done by using Arc GIS code. The modification results showed during 2004, the areal extent of agricultural lands, settlements and bush/shrub lands have accrued to fifteen.74%, 24.03 and 25.66%, respectively, whereas forest lands and barren lands areal extent has remittent to twenty seven.83% and 5.33%, respectively. By the year 2017, the areal extent of bush/scrub lands accrued by 42.5%, followed by settlements (25.46%) and barren lands (8.496%). The region extent of forest lands and agricultural lands was decreased to 10.03% and 13.37% respectively by the year 2017. Further, the modification results showed a continuous decline of forest lands throughout the study period. The known causes for forest lands decrement were population pressure and associated demands.

Keywords: Land use/land cover, change detection, supervised image classification, remote sensing.

Introduction

Land could be a compound and active factor that consists of, geology, topography, hydrology, soil and small climate and society of plants and animals that are often get together below the management of climate and people actions. The inequality in the land should be known, distinguished and therefore the information conversed via the bulk comprehensive and value effectual means that if people are to know completely different sorts of land use. Land cover (LC) and land use (LU) are two key basics recitation the terrestrial surroundings in relative to both natural processes and human activities. Land cover refers to objects located on the planet exterior which are of furthermore natural or anthrop genetic origin. In distinction, land use refers to matters that symbolize human actions that consequence in the making of products and services for society. Land use amendment is that the conversion of land use because of human intervention for numerous functions, like for agriculture, settlement, transportation, infrastructure and producing, parks, recreation uses, mining and fishery (Turner and Meyer, 1994; Turner *et al*., 1995).

Land cover change refers to the modification of the prevailing land cover or complete conversion of the land cover to a replacement cover sort. Land use amendment is related to land cover amendment whereas land cover could amendment without the alteration of land use (Turner and Meyer, 1994). Anthropogenic actions have distorted the land use and land cover within the developed and developing countries within the centuries. The land cover and its pattern changes are major reason of environmental ruin, impact on biodiversity and climate transform from local to provincial scales (Denge and Srinivashan, 2016). However, these environmental changes happen at many spatial and temporal scales which will extremely vary amid regions. Land-use and land-cover amendment could be a very important issue in environmental amendment, that in twist may augment international global climate change (Turner *et al*., 1994; Lambin and Geist 2001); thence, the study of land use and land cover amendment is an element of a worldwide analysis program (Jia *et al*., 2004; Mundia and Aniya, 2006).

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Land use and land cover amendment, that are determined by each anthropogenic activities and natural incident (Meshesha *et al*., 2012), pressure on food safety, livelihood systems, and global sustainability (Reid *et al*., 2000). The prior advantage of land-use and land-cover study is that it's one among the majority correct techniques to grasp land-use and land-cover mechanism. Timely and precise data concerning land-use and land-cover modification is incredibly important for higher administration of the higher cognitive process. there's an in-progress insist for up-to-date land-use and land-cover data for any kind of a sustainable development program wherever land-use and land-cover function one of the main input criterion.

Land-use changes occurring from the high rate of urbanization (settlements), agriculture; pasturing and deforestation and road growth are a number of the causative factors to land cover changes within the present study area. These changes in land-use and land-cover are due to the population growth, land utilization rate and climate. Growth of this study area has resulted not only in the exhaustion of natural resources, however, worsening of the surroundings. Agriculturally productive and non-productive land and forest land are remodeled into residential. The land use and land cover pattern of this study area are the results of natural and socio-economic factors and their consumption by the human in time and area. The unrestrained growth of urban development has unfavorably affected the study area ecosystem that has managed to ultimately replicate on weather factor and finally go-ahead to local climate alteration.

Land use and land cover modification is additionally one among the first environmental issues in the Federal Democratic Republic of Ethiopia (Kebrom and Hedlund, 2000; Gete and Hurni, 2001; Gessesse and Kleman; 2007; Abate, 2011; Ebrahim and Mohamed, 2017). There was a quick development of cultivated land at the cost of forest lands usually within the highlands of the country (Gete and Hurni, 2001; Gebremicael *et al*., 2013; Ebrahim and Mohamed, 2017). Within the northern highlands of Ethiopia, there are few leftover forests, that are found in sacred and inaccessible places (Bongers *et al*., 2006), and cultivation is extended to the steepest areas wherever access is obviously restricted (Gete and Hurni, 2001). Further, many studies show in Ethiopia countenance severe land use and land cover issues, principally as a consequence of population growth and that they need for new agricultural lands, that have another to the clearing of forests and alternative natural land covers. Preceding studies conducted in numerous elements of the country at various scales (Argaw *et al*., 1999; Kebrom 1999; Tekle and Hedlund 2000; Ayalew *et al*., 2005; Garedew *et al*., 2009; Meshesha *et al*., 2012) have addressed the requirement for vital concentration to the matter since the associated land degradation and soil erosion issues are important to accumulated food insecurity, moreover as social and economic troubles. Furthermore, agricultural outputs, that decide rural revenue stage and wealth, are extremely affected by problems associated with land use/land cover. And there are many studies in and around the present study area additionally stating similar issues as mentioned below. The exchange of forest to agriculture amid (1985 and 2011) periods in Angereb watershed, Ethiopia was studied by Getachew and Melesse (2012). The rise of wet season flow (peak flow) and reduce of dry season flow (base flow) at El Diem station of blue Nile Basin during 1970–2010 were additionally attributed to the conversion of vegetation covers into agriculture and grasslands over massive areas of the basin (Gebremicael *et al*., 2013). Different studies in Chemoga watershed (Woldeamlak and Sterk, 2005) and Gedeb catchment (Koch *et al*., 2012; Tekleab *et al*., 2013), have also accounted significant effects of land use and land cover changes on stream flow. To do this study began to perceive and estimation the impact of land-use and land-cover of this study area. since it is very little or no others researcher's work established regarding the case by using GIS and Remote sensing technologies urban land use and land cover amendment detection analysis and alter the estimation of this study area nevertheless, additionally researchers are well-known concerning the study area and there's the high rate of urbanization within the study area. The development of land use and land cover amendment within the study area has scientific and developmental significance for the future. The researchers think about this project can present bottom line info on considerations of land use and land cover amendment and dynamics in relative to vegetation cover amendment within the study area. essentially, such info is significant for examination the past and present condition and forecasts the longer-term trends of the land use and land cover amendment and increasing such technique of protecting the soil degradation and increasing such techniques to others town.

Remote sensing and Geographical Information Systems (GIS) are authoritative tools to get precise and timely data on the spatial division of land use/land cover changes over vast areas (Guerschman *et al*, 2003; Rogana and Chen, 2014). Past and present studies conducted by teams and establishments around the world, typically, has supposed on the utilization of land use and land coverchanges. GIS presents a versatile environment for collection, storing, displaying and analyzing digital knowledge essential for land use amendment detection (Demers, 2005). Remote sensing satellite imagery is that the majority necessary knowledge resources of GIS. Satellite imagery is employed for detection of synoptic knowledge of earths outside (Ulbricht and Heckendorf, 1998).

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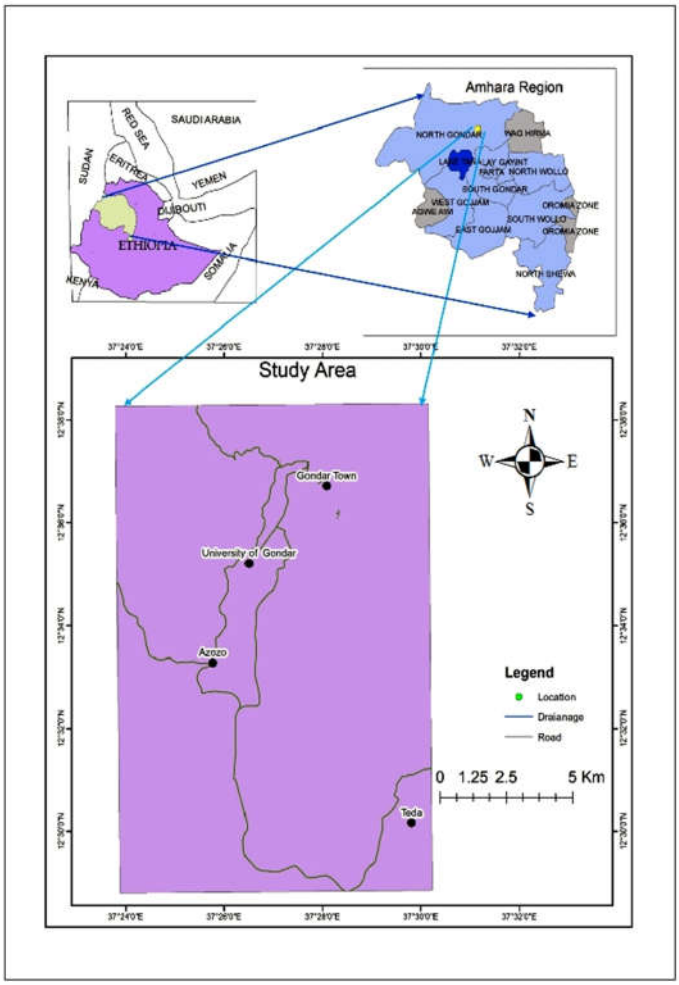
Fig. 1. Location and accessibility map of the study area.



As such, this is important to map the land cover and observe temporal amendments with a vision to providing change approximation and models for the larger part of the land and its wealth so as to create straightforward informed decision making on improvement measure. This has thus resulted in augmented land cover amendment and an alteration and modification within the status of land use and land cover over time lacking any careful and complete attempt (with the help of Remote Sensing information and GIS to assess this position because it amendments over time by a read to sensing the land cover change and additionally produce effort to forecast similar and also the likely changes that may occur during this status so planners will have a basic instrument for planning. it's therefore, essential for a study like this to be carried out within the present study area.

Materials and methods

Study area: The study area situated in between 37°29'41"–37°30'12"E longitudes and 12°28'46"–12°38'22"N latitudes covering total area of about 208.34 Sq.km^2 (Fig. 1).

The study area accessed through one main asphalt road that connects Addis Ababa with Sudan and the other rout extends from Gondar town to Mekelle in northern direction and to other districts. There are also some area is accessible through gravel roads to reach the proposed district through vehicles especially the north and east of the study areas. Since the area is highly raged and mountainous, some of the area is even is not accessible through vehicles, even on foots especially the north and east of the study areas.

Data collection: Major types of spatial data used in diverse years to study the land use land cover dynamics of the study area were ETM+ (1999 & 2004), and Landsat 8OLI (2018). The images were got from the United States Geological Survey (USGS) Earth Resources Observation Systems (EROS) data center in the Landsat Archive (http://earthexplorer.usgs.gov/). The years were selected by taking into reflection of quality and accessibility of images. The images were obtained in the same season to shun the consequence of seasonal differences. The images were geometrically and radio metrically corrected, if needed. Pre-processing of the images like sub-setting and layer stacking assignment were performed ahead of the beginning of the real supervised classification.

Supervised image classification: Digital image classifications in remote sensing have a grouping of pixels of an image to set of categories, such pixels within the similar category area unit having like properties. The overall type of image classification is predicated on the finding of the spectral response patterns of land cover categories. Remote sensing studies aiming at image categorization has intensively attracted the commitment of the remote-sensing society as classification outcome is the basis for several environmental and socioeconomic applications. Scientists and practitioners have created immense diligence in developing sophisticated classification approaches and techniques for rising classification accurateness. However, classifying remotely detected data into a thematic map remains a challenge, as a result of several factors, like the problem of the landscape during a study area, selected remotely sensed data, and image-processing and classification approaches could involve the accomplishment of a classification. Several aspects, like the spatial resolution of the remotely sensed data, numerous sources of data, a classification system and accessibility of classification software system should be taken into consideration once choosing a classification technique to be used. Numerous classification strategies have their own virtues. The question of that classification approach is suitable for a particular study isn't straightforward to answer. There are many alternative approaches to classifying remotely sensed data. Though supervised and unsupervised classifications area unit the foremost common classification approaches.

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Table 1. Description of land use and land cover classes.

S.No.	Land use types	Description
1.	Agricultural lands	This category includes most flat areas and also some steep slopes where various crops were grown, either on a rain fed basis or using irrigation. And also includes areas currently under crop, fallow and land under preparation.
2.	Water body/drainages	Area covered by water
3.	Barren lands	Land surface without vegetation cover or with rocky land
4.	Settlements	Urban and rural housing area
5.	Bush/shrub lands	Land covered by small trees, bushes/shrubs
6.	Forest lands	Area dominated by high forests including plantations

Table 2. Summary of the classified land use/land cover from 1999.

S.No.	Land use types	Area km^2	Area %
1.	Agricultural lands	18.67	8.95
2.	Water body/drainages	2.93	1.41
3.	Barren lands	11.66	5.6
4.	Settlements	46.43	22.29
5.	Bush/shrub lands	29.46	14.14
6.	Forest lands	99.19	47.61
7.	Total	208.34	100

The unattended modification detection technique is employed less often in practice because of the problem in identifying and labeling change trajectories. Regarding urban land use/cover classification, supervised classification technique with most chance formula is one in all the foremost common extensively used firm classifier by researchers. Supervised classification is often used to cluster pixels during datasets into classes matching to user-outlined training categories or the procedure of using samples of familiar uniqueness (i.e., pixels antecedently assigned to informational classes) to categorize pixels of unidentified identity. This classification kind needs that investigator to opt for training areas to be used because of the basis for classification. In brief, throughout supervised classification, the user should describe training sites (sample pixels) in a picture that are representative of actual classes and so straight the image processing software package to use these options as references within the rest of classification.

Development of classification scheme: Based on the prior information of the study area and supplementary information from different resources about the study area six different types of land uses and land cover classes have been identified for the study area. According to researcher the identified six classes are Agricultural land, Water body/drainages, Barren lands, Settlements, Bush/shrub lands and Forest lands. The descriptions of these land use and land cover classes are given in Table 1.

Results and discussion

Land use and land cover dynamics: The areal extent of six land use- Land cover types and their spatial distribution, for 1999, 2004 and 2017, are presented in Table 2, 3 and 4 and Figs. 2-4 respectively. In 1999, 47.61% of the land was covered with forest lands followed by settlements (22.29%), bush/shrub lands (14.14%), agricultural lands (8.95%), barren land (5.6%) and water body / drainages (1.41%) of the study area. In year 2004, 27.83% of the land was covered with forest lands followed by bush/shrub lands (25.66%), settlements (24.03%), agricultural lands (15.74%), barren land (5.33%) and water body/drainages (1.41%) of the study area. During 2017 42.5 % of the land was covered with bush/shrub lands followed by settlements (25.46%), agricultural lands (13.37%), forest lands (10.03%), barren land (8.49%) and water body / drainages (1.41%). In general by the year 2004, the areal extent of agricultural lands, settlements and bush/shrub lands have increased to 15.74%, 24.03 and 25.66%, respectively, while forest lands and barren lands areal extent have decreased to 27.83% and 5.33%, respectively. By the year 2017, the areal extent of bush/shrub lands increased by 42.5%, followed by settlements (25.46%) and barren lands (8.496%). The areal extent of forest lands and agricultural lands was decreased to 10.03% and 13.37% respectively by the year 2017.

Trends of land-use/land-cover changes: Change analysis was conducted using post-classification image comparison technique, which was used in order to minimize possible effects of atmospheric variations and sensor differences with spatial resolution.

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Table 3. Summary of the classified land use/land cover from 2004.

S.No.	Land use types	Area km^2	Area %
1.	Agricultural lands	32.70	15.74
2.	Water body/drainages	2.93	1.41
3.	Barren lands	11.1	5.33
4.	Settlements	50.1	24.03
5.	Bush/shrub lands	53.51	25.66
6.	Forest lands	58	27.83
7.	Total	208.34	100

Table 4. Summary of the classified land use/land cover from 2017.

S.No.	Land use types	Area km^2	Area %
1.	Agricultural lands	27.85	13.37
2.	Water body/drainages	2.93	1.41
3.	Barren lands	17.7	8.49
4.	Settlements	53.03	25.46
5.	Bush/shrub lands	88.55	42.5
6.	Forest lands	20.89	10.03
7.	Total	208.34	100

Fig. 2. Land use/Land cover map of year 1999.

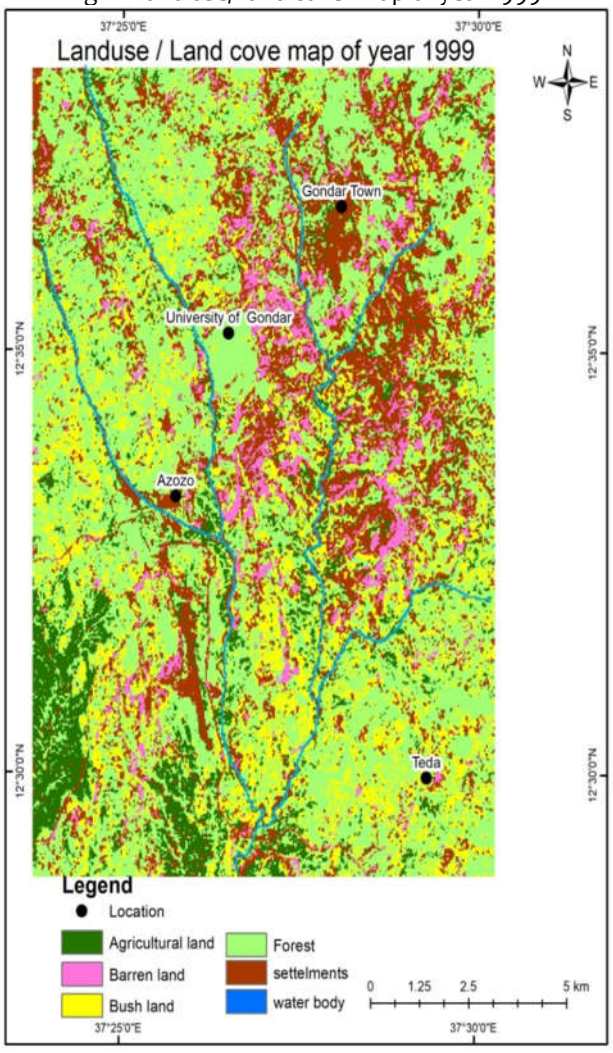

Fig. 3. Land use/Land cover map of year 2004.

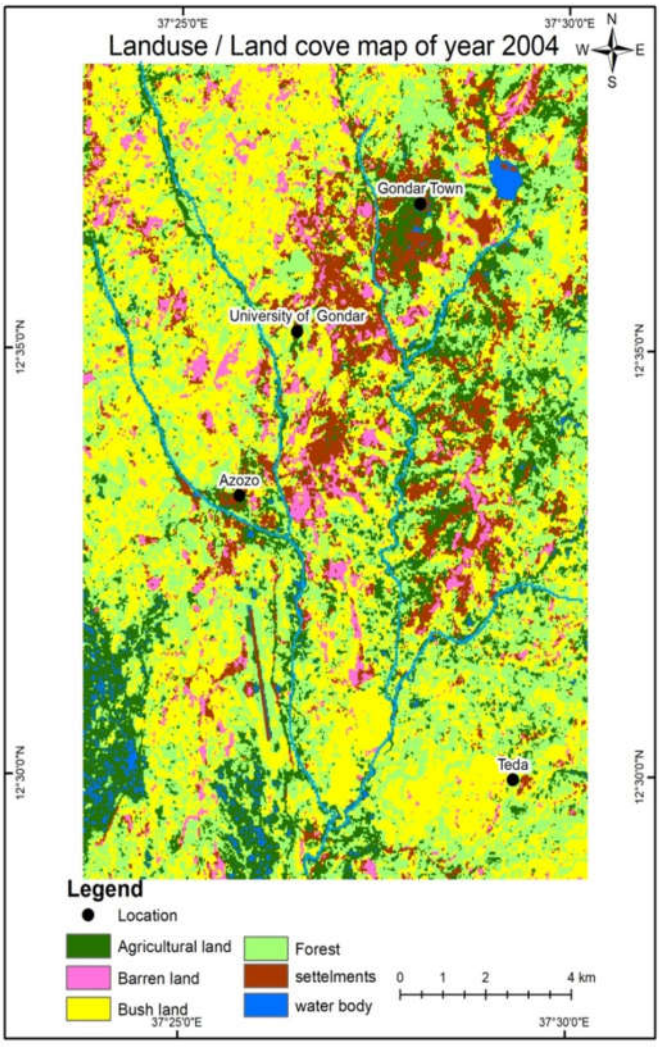

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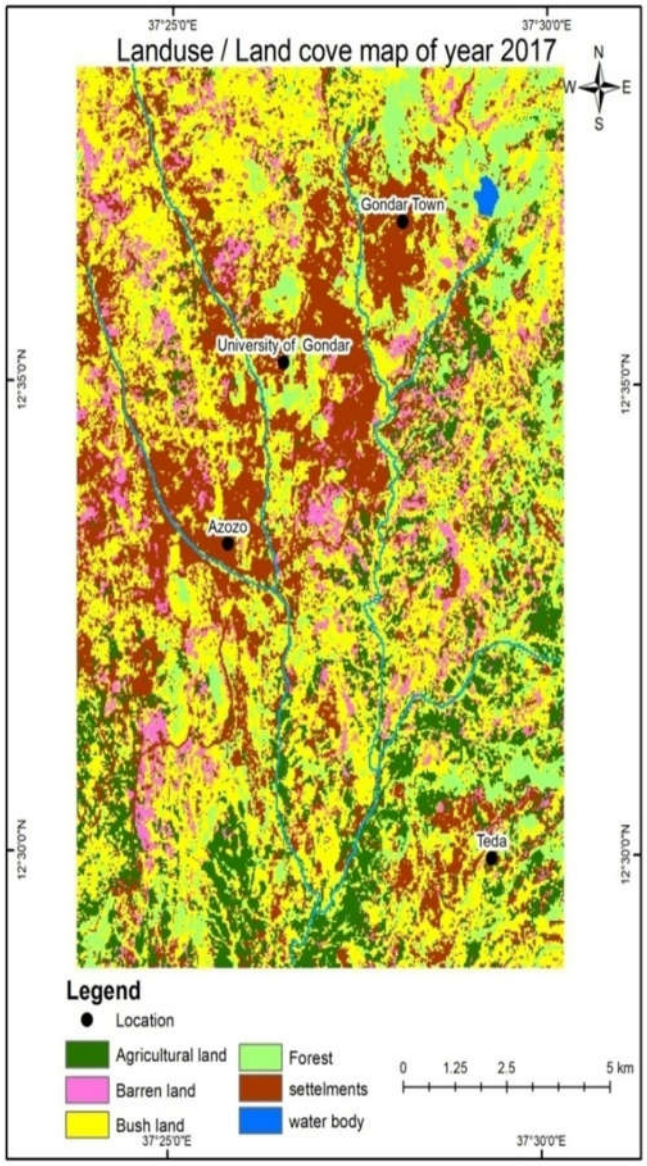
Fig. 4. Land use/Land cover map of year 2017.



Images of different reference years were first independently classified, and, afterwards, change detection processes were performed. The percentage of land use/land cover change detection was made using the following formula:

Percentage LULC Change= (Area final year -Area initial year)/ Area initial year x 100

From the results of classification during the 1999–2004 (table 5), the areal extent of barren lands -0.56 sq.km (-4.80274%), forest lands -41.19 sq.km (-41.5264) have decreased during these period. Conversely, the areal extent of agricultural lands, bush/shrub lands and settlements were increased by 14.03 sq.km (75.1473%), 24. 05 sq.km (81.63612) and 3.67 sq.km (7.904372%) respectively. Land-use/land-cover of the study area for the period 2004-2017 showed that areal extent of bush/shrub lands, barren lands and settlements have increased by 35.04 sq.km (65.48%), 6.6 sq.km (59.45946%) and 2.93 sq.km (5.848303%) respectively, while the areal extent of agricultural land and forest land have decreased by -4.85 sq.km (-14.8318%) and -37.11 sq.km (-63.9828%), respectively. The forest lands were decreased in all the study periods. The highest rate of decline of forest lands was during the 1999-2004 period. Agricultural lands showed increasing during 1999-204 period and decreasing during 2004-2017 period. Bush/shrub lands and settlement showed an increasing trend in the entire study period. On the other hand barren lands showed a decreasing trend in the entire study period. Here, positive values suggest an increase whereas negative values imply a decrease in extent of LULC. The accuracy assessment of the results was an important step in the analysis. First, the visual comparison was used to analyze the dataset, by overlapping it on high resolution Google Earth Image. The boundaries between some different land use/ land cover classes were observed and validated. Second, a qualitative validation was made in the field by comparing the dataset with the real land use/land cover in different points.

Conclusion

The proof obtained through analyses of multi-temporal satellite images using remote sensing application. The study has found that the area has beneath gone extensive land use and land cover alterations. in all of the study periods, the main positive areal extent modification have noticed in settlements and bush lands and negative areal extent amendment have notice in forest land and positive and negative changes were noticed from agricultural lands and barren lands. The shrinkage of forest lands was large and fast during the total study period. The causes for the land use and land cover changes of the study area include population pressure, cultivated lands expansions, increasing wood collection for fuel, and collection of farm implement and construction wood, charcoal. The increasing population associated the demands on natural resources through expansions of farmland, settlements, grazing lands, fuel wood and charcoal production. Thus, haphazard, rapid, unplanned urbanization threatens the sustainability of the development procedure by affecting the intense environmental components, like rainfall, temperature, and water level harmfully. So as to beat this problem, there's a necessity for systematic and complete coming up with for sustainable development of the cities with the healthy urban surroundings and protection of natural resources. This necessitates an integrated approach to urban about to ensure the conservation of water, moderation of climatic conditions etc.

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Conservative urban coming up with an increase in urban leafage might facilitate the nourishment of natural resources and people's livelihoods. A holistic approach to urban development is important with a major sensible role of the native body. There ought to also be effective integration of various line departments/agencies. The results of this study make sure that land use and land cover modification detection procedure image supervised classifications provide a good potential tool for characterizing and understanding land use and land cover changes occurring within the present study area.

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