

Dynamics of Land Use Land Cover Change and Urbanization in Jigjiga Town, Ethiopian Somali Regional State, Eastern Ethiopia

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Abstract This paper describes mainly by focusing on the land use land cover dynamics of Jigjiga town, the capital of Ethiopian Somali region. The implications of changes was also investigated using the working power of GIS environment. Satellite images were integrated with GIS working interface and it was very effective in analyzing the direction, rate and spatial pattern of the changes. The time interval considered was fifteen years of different times and three land use land cover maps were produced from each year (1985, 2000 and 2015) at the specified interval. These time intervals were taken based on the prevalence of the government changes coming to power with their respective policies and strategies. The analysis shows that four major land use land cover classes exist in the area. These include built-up area, grass land, shrub land and open areas. They show changes at times with variation in magnitude and pattern of changes. During the study periods, built-up areas are getting continuous increment while grass lands are continuously decreasing. This indicates as the pre-existing grass land areas are highly converted in to either built-up areas or any open area left over unutilized. This is done due to the increase in population in the area demanding plots of areas for their survival. On the other hand, shrub lands shows fluctuations due to similarity of spectral reflectance patterns with either grass lands or open areas where as open areas got continual increase since there exists left over plots in between different blocks and units of built-ups. The major general factors of the land use land cover changes include population growth and density, encouraging urban expansion policies, being economic corridor of the area attracting many people from different corners of the country and land ownership condition. Therefore, level of urbanization is directly interrelated with the existence of appropriate urbanization policy. Generally, different land classes undergo changes overtime due to the existence of factors like policies, population number, land ownerships and satellite image analysis using ERDAS and ARcGIS software is a very effective method in such a study.

Keywords Jigjiga town, LULC, GIS, Population growth, Land ownership

1. Introduction

Land use land cover change is by now the most prominent form of global environmental change phenomenon occurring at spatial and temporal scales [1]. Cities land use change is resulted from urbanization and development related activities in which most large cities are faced with urban sprawl problems, natural vegetation loss and open spaces prevalence [2]. Rapid and unplanned urbanization is a cause for environmental problems, bumpy living conditions and haphazard growth of cities [3] leading for detrimental impacts of human life. It is also obvious that highly productive peripheral agricultural areas are lost [4]. Therefore, it highly worth value to plan and control

urbanization process systematically and in an integrated manner to maximize the benefits of the people [5-7].

It is unquestionable that, rapid growth of cities was held in Europe and North America following the industrial revolution [8] in which pollution becomes a series issue and urban expansion is diverting ecosystem integrity through biochemical cycles disruption [9]. After WW II and global trade liberalization, the influence of cities become global though land use change in which since then was local and regional [10, 11]. The substantial growth of cities in Africa, Asia and Latin America during the last 20th century with no giving due emphasis to systems of urban regulations for environmental protection also contributes for a considerable environmental degradation [3]. The [12] also strengths this idea by saying, in the near future due to large population growth of such areas (global south) severe urban ecosystem and biodiversity challenges will appear due to their weak systems of formal government and planning.

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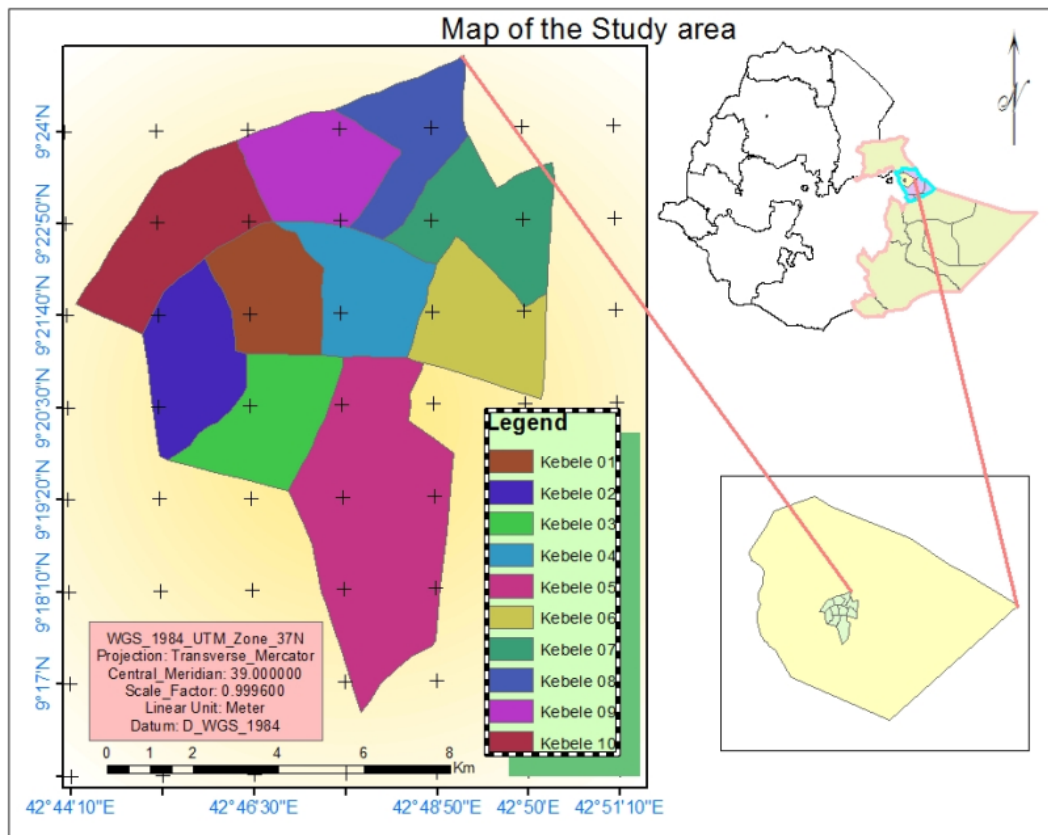


Figure 1. Location map of the study area

Even though the relation between cities haphazard growth and environmental degradation stay long for urban dwellers, it is recently that cities governance is becoming a global agenda [13]. Awareness of environmental degradation and the planet as a system with limits to growth emerged in both civil society and among decision makers [14]. Recognizing cities as engines of economic growth and centers of production and consumption also implied acknowledging that cities drew on resources from all over the globe [10].

The interconnected global environmental agenda of cities is thus woven into the history of the wider global environmental agenda [15].

Urbanization level in Africa (37.1%) is low as compared to developed countries like Europe (72.7%) and North America (79.1%). But urbanization in developing world (may reach to 3% or even 4% a year) is now progressing faster than developed one [16]. Ethiopia, which is a country in Africa is the least urbanized having only 16% of its population living in urban centers [17]. However, its rate of urbanization is 4.4% due to high population growth rate (2.73%), high rural-urban migration and increasing number of urban centers [18] with an average urban population growth of 3.98%. Hence, by 2050 about 42.1% of the total population is expected to be inhabited in urban centers [12].

When it comes to Jijiga town, it is one of Ethiopia's intermediate towns which is growing alarmingly. The town is increasing at a rate of 9.9% per annum [19]. Therefore, the need for monitoring urban development is imperative to help

curb the problems of Urban Sprawl and LULC dynamics [13]. Identification of the patterns of sprawl and analyses of spatial and temporal changes would help immensely in the planning of infrastructure facilities [6]. The present rate of population growth and the projected figures also signify the prime responsibility of the planning department to plan for a future housing development which is attractive, affordable and sustainable - socially, economically, culturally and environmentally.

It is, therefore, the intention of this study to narrow, if not to fill, this gap and provide an in depth understanding of the patterns of LU dynamics, levels of urbanization and implications for planning appropriate land management in the study area.

2. Study Area

Jijiga town (which is the capital city of the Ethiopian Somali region) is found within fafan zone and is located at 675 km from Addis Ababa and at closer distance to Hargeysa, the port of Somalia land. It is astronomically located at 9°30' N latitude and 42°50' E longitude. Relatively speaking it is bounded by towns of Hadew, chinaksen, Togochale and Lefe-isa in the West, North West, East and north east respectively. Because of its internal and local advantages, the town has high growth potential. Today it has become an important urban center in the region being

playing pivotal role in the political, economic and social arena of the region [20]. Climate through its basic elements (Temperature, Rainfall, wind and humidity etc) has a significant influence in urban planning. Temperature has an influence on urban land use planning since it influences housing typology, housing units, extent of green area etc for enhancing human comfort and creating good urban environment [21]. Hence, the average annual temperature of the town is 20°C indicating the existence of sub-tropical temperature condition whereas the mean monthly temperature varies from 17.34°C to 21.43°C in December and April, respectively. The hottest month is May while December is the coldest month with an average annual temperature of 20.02°C [22] representing sub-tropical agro-climatic ecological zone. Accordingly, this subtropical temperature condition in general has moderate impact on urban land use planning; housing typology and spacing [21].

The mean annual rainfall of Jijiga is just about 598 mm. The mean monthly amount of rainfall varies between 10.2 mm to 102.2 mm in February and April, respectively [22].

3. Methodology

Since land use land cover analysis is a complex phenomenon, it becomes difficult to effectively analyze it using a single research design. Hence, a mixed design that includes (qualitative and quantitative approaches) was applied for this research due to its importance for triangulation of sources and interpretation.

Data was collected from sources (both primary and secondary sources) using instruments of hand held GPS (for collecting training and ground verification data used for image classification and accuracy assessment respectively), in depth interview with key informants (about the types, impact, magnitude, distribution and ways of mitigation), and reviewing of related documents such as articles journals, books and census reports.

Method of data analysis

Pre-processing of satellite images prior to image classification and change detection is essential. Due to spatial, spectral, temporal and radiometric resolution constraints, the complexity of physical environment cannot be accurately recorded by normal remote sensing sensors [23]. Hence, before performing the classification of remote sensing data, it is important to pre-process the data to correct the error during scanning, transmission and recording of the data [24]. Radiometric correction was performed for correcting the data for sensor irregularities and compensating the effects of atmosphere through histogram equalization, haze and noise reduction. Image enhancement was performed in order to improve the quality of the image.

Suitable band selection of different false color composite images was done to enhance the raw satellite image for identification of different land cover classes in the study area.

Image Classification and Accuracy Assessment

In this study unsupervised and supervised image classification operations were performed to produce land use and land cover maps of the study area from land sat images. Firstly, Preliminary land use and land cover classes were determined based on the information acquired from unsupervised classification and field observation. Then Landsat images of each study year were independently classified with supervised classification technique. Maximum Likelihood Algorithm was applied to classify the land use and land cover types in ERDAS Imagine 10 software. Finally, the accuracy of the classification results was tested using data for accuracy assessment. Therefore, the error matrices and other statistics, which includes producers and user's accuracy and kappa statistic, were employed to determine the accuracy of classes obtained from the image classification Process.

In this study, Post classification method was used to detect analysis of land use and land cover changes. It is used when users separately classify two temporal satellite images and then differentiate those two date classified images. In this study, the Post classification comparison was employed using separately classified Landsat images and then a comparison was made for the LULC maps.

4. Results

Accuracy Assessment

It is inevitable that errors occur from any digitally generated land cover maps of remote sensing imagery. These errors may result from the source (error during data acquisition) or image processing (errors of classification techniques). Therefore, an assessment of the classification accuracy is needed to guaranty the reliability of the result [23]. Accuracy assessment helps to evaluate a classified image file. The accuracy assessment cell array is an organized way of comparing your classification with ground truth data, previously tested maps, aerial photos, or other data [24]. There is some similarity between accuracy assessment and training classifiers in that both use the same data sets. However, there is a possibility for overestimation of classification accuracy simply because of using the same data sets both for training and testing purposes. To avoid this problem, it is good to use randomly selected pixels, which can be checked with reference to ground verified data [25].

The values of Kappa statistics are categorized into 3 groups based on agreement of classification: a value of greater than 0.8, between 0.4 - 0.8 and below 0.4 represents strong, moderate and poor agreements of classification respectively [26]. The accuracy assessment result for this classification made in ERDAS imagines software provides an overall classification accuracy of 84% and 0.7728 kappa statistics indicating as the classification reveals moderately agreed and acceptable result of classification.

Land use land cover distributions

From the below classified map of jigjiga town in 1985, it is possible to observe that the highest portion of land use land cover was occupied by Grassland (37.8%), followed by shrub land (35.9%) and Open Area (23.9%). On the contrary, the least percentage of land use land cover share was occupied by Built-up Area (2.4%). This difference in percentage share of land classes at this period was attributed to the existence of insecurity revealing low population number, inappropriate urban development policy, people's low attitude of settling in urban areas being life at the time was highly associated with pastoral activities and even above all the low level development of country. Such conditions in turn leads for the domination of grass lands and shrubs by allowing for the existence of naturally prevailing vegetation type land covers. In relation to this [27] also found in his study that in areas where low population number and questionable security issues prevail, there is low level of urbanization and more of vegetation type cover domination. Particularly, [20] on his analysis to the city says, the area where the town of Jigjiga is located was once a forest area covered with indigenous trees, mainly acacia. Inside the forest a number of wild animals such as: lion, leopard, hyena, elephant, gazelle, bushbuck, ostrich and others are reported to have sheltered. The area was also rich in pasture with

abundant water resource. This idea supports being the area in 1985 was dominantly covered with grasses and shrubs.

From the below classified map of jigjiga town in 2000, it is possible to observe that the highest portion of land use land cover was occupied by Shrub land (40.4%), followed by Open Area (31.1%) and Grass land (16.4%). The same is also true that, the least percentage of land use land cover share was occupied by Built-up Area (12.1%) though it shows an increase in its share. This increasing share of built-up areas at this study period is an indicator as the prevailing problems are becoming minimal with in the specified time interval (15 years, from 2000 to 1985). Hence, this indicates as the number of population is increasing, the urban development related policies are getting emphasis and the attitude of people is becoming more corresponded with the opportunities of living in urban areas. [24] in his study also proofs that, the existence of increasing number of population and prevalence of appropriate urban policy have a direct influence on urban development. As to (28) it is also true that, the process of urbanization is a universal phenomenon taking place all over the world, where humans dwell in higher concentration. All countries are prone to this bewildering phenomenon mainly responsible due to the increase in population growth, policy appropriateness, economic development and infrastructure initiatives.

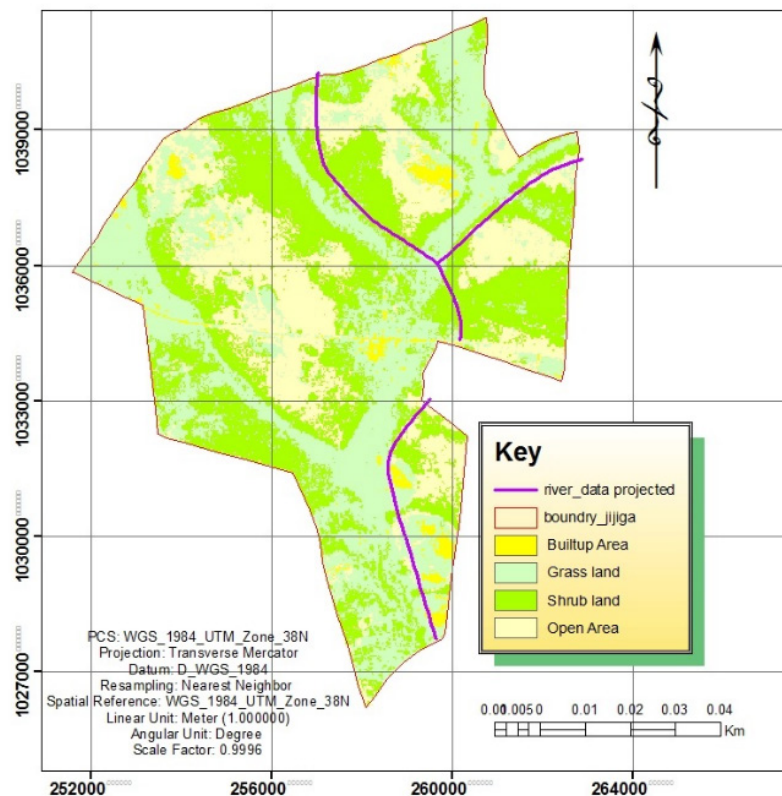


Figure 2. Land use land cover of jigjiga town in 1985

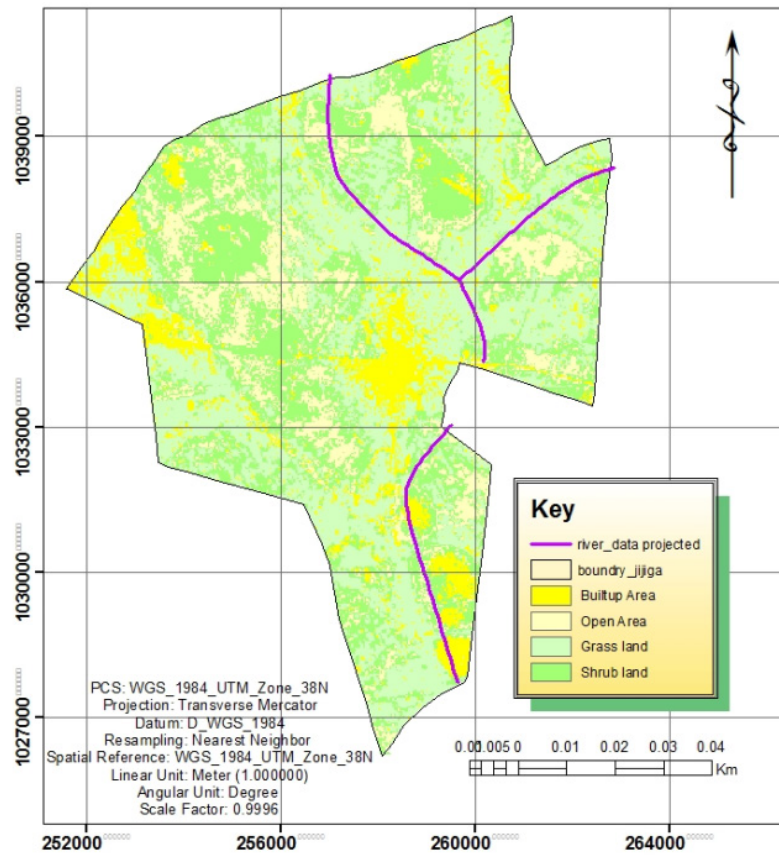


Figure 3. Land use land cover of jigjiga town in 2000

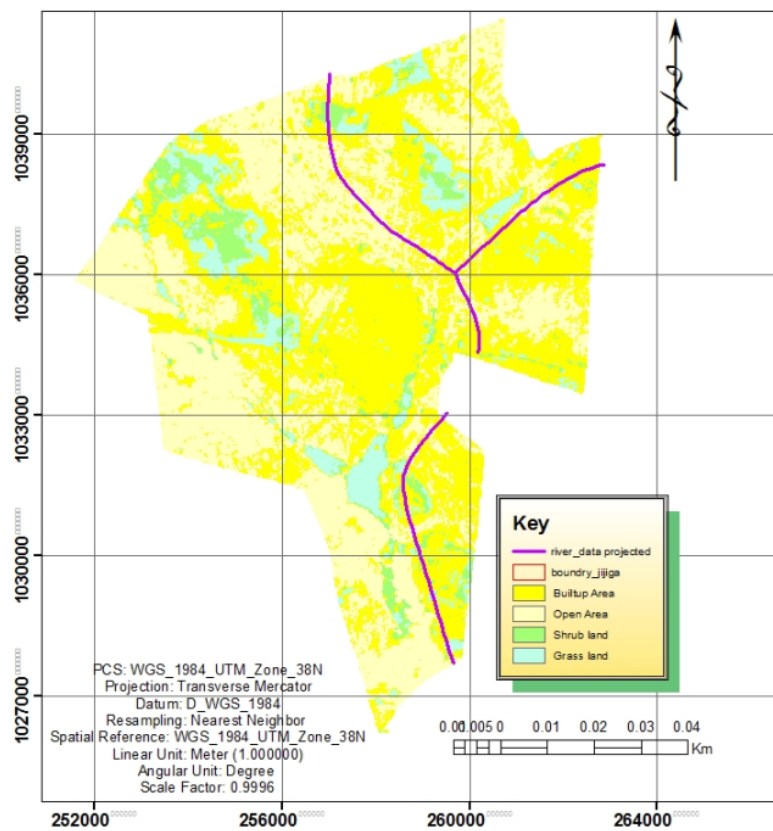


Figure 4. Land use land cover of jigjiga town in 2015

Table 1. Land Use Land Cover Distribution Analysis (1985, 2000, and 2015)

LULC classes	1985		2000		2015	
	Area (M ²)	Area (%)	Area (M ²)	Area (%)	Area (M ²)	Area (%)
Built-up Area	20556	2.4	103644	12.1	378477	44.2
Grass land	323946	37.8	140697	16.4	361332	8.5
Shrub land	307377	35.9	346167	40.4	44136	5.2
Open Area	204777	23.9	266148	31.1	72711	42.2
Totals	856656	100	856656	100	856656	100

The dominant percentage share of the land cover classes in 2015 was built-up area and Open Area having 44.2% of the total area each. The remaining 8.5%, 5.2% of the area was shared by Grass land and Shrub land respectively.

From this table one can easily identify that, the percentage share of each land use classes is different at different times. Some of them (Built-up areas, and open areas) are increasing over time while others are either fluctuating (shrub lands) or decreasing continuously (grass lands) attributed to their respective situational factors. The continual increment of built-ups is associated with the availability of opportunities for large number of people, existence of appreciable concern for urban development issues by the government (especially after the fall down of the socialist government) which contributes an existence of open areas since the landownership condition is belonging to clans which runs out of the proposed plan. Hence, though the level of urbanization is fast due to such conditions, there exists unutilized leftover parcels in giant amount indicating as the expansion of built-ups are done at the expense of plan conformability. On the other hand the continuous decreasing of grass lands is due to the influence of rapid built-up expansions which gives its hand for the destruction of grass lands since residents provide more emphasis for residential construction than maintaining prevailing grass lands. This is evidenced from the study done by [29] as the sold parcels of urban areas and peripheries undergo changes since the new buyers primarily converted it in to their intended use (residence).

5. Change Analysis

Figure 5 portrays, the expansion of built up areas within 30 years. Therefore, large areas are occupied by built ups which were covered by other land classes in 1985. This land cover change analysis show that the rate at which land cover change occurred in all sub periods is different. The change for the sub periods (1985-2000 and 2000-2015) revealed that four important land cover changes were occurred. The results further revealed that, built-up and open area classes are increased continuously in all study periods. This means that, they are showing more increment in the second period (2015 - 2000) than the first (2000 - 1985). On the contrary, the grass land class is decreasing continuously in the study

periods with more decreasing magnitude in the first period than the second. The shrub land class is showing fluctuations across the study periods i.e increasing in the first period (2000 - 1985) while decreasing in the second (2015 - 2000).

Table 2 indicates, with in the specified time period of 30 years, built up areas have increased by 32.1% and open area is increasing by 11.1%. While grass land is decreased by 7.9%, shrub land is showing fluctuation with in the specified study periods at different values. From this analysis, the land covers are decreasing and/or increasing at insignificant rates except built up areas which shows a very high rate of increment indicating as the population number is increasing highly and the current urbanization policy is contributing for its expansion. This indicates as the level of urbanization in the town is higher.

Urbanization made the increase of residential and other built up areas. The rapid urbanization has magnified the effects of other peripheral issues such a like grazing lands. This is evidenced from the decrease of existing grass lands especially those of served for grazing purposes and the increase in the built up areas (Table 2). Hence the spread of urban areas in a horizontal direction has resulted in the loss of scattered trees, the depletion of open grazing lands, a shrink of agricultural crop fields and a general decline in the spatial extent and connectivity of non-built-up land use classes.

Driving forces of LULC change in the study area

The total population of the study area was 112,345 in 1994 showing an increase of above 70.8% over the population of 65,795 in 1994 whom 33,266 were men and 32,529 women [30]. The reason for such increase of population is rural-urban migration thinking better job opportunities, better income generation, better life and considering as modernization being living in towns especially for youngsters. Beyond this being economic corridor (strategic location of the town for trading and other economic activities) contributes its hand for the large number of population. This in turn leads for the expansion and construction of built-up areas either industrial or residential.

Thus population growth is certainly the greatest driving force in the observed land use/land cover dynamics particularly built-up areas. Another deriving factor for such high level of urbanization is the land ownership case. Since land ownership is clan based which is locally known as

“Gosa” they have the right to sell parcels of lands any time at different prices. This helps other people to buy simply plots of land and expand the urbanization level by constructing their residences which is substantiated by [29] as sale of land is the major cause of land use and land cover change. It is this issue that contributes more for the rapid level of urbanization in the study area. On the other side it has a negative impact for the existence of large open and unutilized areas in between and among each blocks of built-ups. Such

unplanned growth of urbanization will have an impact on the residents such as exposure to flooding, lack of access to infrastructure services and tribal based interest conflict. In line to this idea, [31] identified that the implications of rapid and unplanned urban growth include increasing unemployment, environmental degradation, lack of urban services, overburdening of existing infrastructure and lack of access to land and finance.

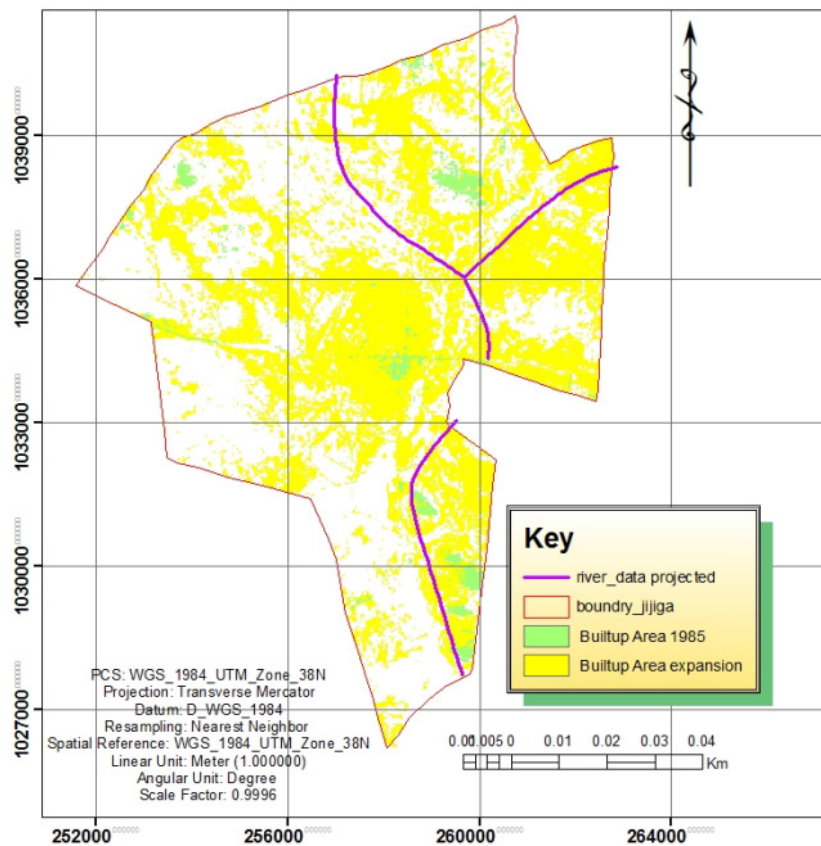


Figure 5. Built-up expansion image differencing between 2015 and 1985

Table 2. Conditions of changes for the land classes over the study years (1985, 2000, and 2015)

LULC classes	1985		2000		Change in % (2000 -1985)	2015		Change in % (2015 -2000)	Change condition
	Area (M ²)	Area (%)	Area (M ²)	Area (%)		Area (M ²)	Area (%)		
Built-up Area	20556	2.4	103644	12.1	9.7	378477	44.2	32.1	Increasing
Grass land	323946	37.8	140697	16.4	-21.4	361332	8.5	-7.9	Decreasing
Shrub land	307377	35.9	346167	40.4	4.5	44136	5.2	-35.3	Fluctuating
Open Area	204777	23.9	266148	31.1	7.2	72711	42.2	11.1	Increasing
Totals	856656	100	856656	100		856656	100		

6. Conclusions

As it is clearly seen from the classification results, the techniques and satellite imageries employed for the analysis were effective in extracting land cover classes for change detection. It is possible to behold that the developed Land use land cover schema was appropriate for the study area since there is no significantly unclassified area detected on the developed land use land cover map of the study. Beyond this the accuracy assessment result indicates as the result from the analysis is acceptable making the overall analysis a good indicator of the actual land cover classes in the area.

From the overall analysis in general and change detection in particular, more land parcels undergo changes than remaining holding their previous attributes. It is observed that, there is a change in every plots of the study area in respect to its changing dynamics indicating as the area is under a continual and dynamic change and transition. The change in one land use class is done at the expense of others. This implies as there exists land cover classes like built-up areas under continual increment while others like grass lands suffer continuous reduction. Hence, land cover classes never be stagnantly changed over time. But if there is no any checking mechanism such as timely land use analysis, there is a probability of dominating one over the other (built-ups over vegetated parcels) especially in urban settlements. This is attributed to the factors of urban expansion such as population increment, encouraging urban policies and the people perception towards settling in urban areas.

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