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Analysis of Spatio-temporal urban expansion of Bure town since 1989, Northwest Ethiopia

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ABSTRACT- Bure town has characterized by having different landscape arrangement. After three decades, there areal coverage of the town expand in the all direction than ever before and the physical appearance of the town is gradually changed. Thus, analyze the expansion of the town is the key consideration of the study. To complete this study, 1989 and 2019 SPOT images were used .The changes happened in the town was analyzed using ERDAS IMAGINE 2015 and arc map 10.5. Thus, four classes are identified. In 1989 the built-up area covered an area of 7.25 km2 but it again increased in to 14.81 km2 in 2019. In contrast, the forest, grasslands and farmland covered an area of 2.66 km2, 3.35 km^2 and 7.28 km^2 in 1989 respectively but they decreased in to 1.14 km^2, 2.44 km^2 and 2.15 km^2 in 2019 respectively. As a result, in the period comparisons, the built-up areas are increased by 7.56km^2 with rate of 0.25km^2 per year. In contrast, the grasslands, forest and farmlands are decreased by 0.91 km^2, 1.52 km^2 and 5.13 km^2 respectively with rate change of 0.03 km^2, 0.05 km^2 and 0.17 km^2 per year respectively. Therefore, the rapid expansion of the town causes many problems, such as infrastructure planning, uncontrolled urban sprawl at the expense of agricultural lands. Hence, planners and resource managers need a reliable mechanism to assess the consequences of Bure town horizontal expansion quickly and effectively.

Keywords: detection, expansion, spatial, temporal

I. INTRODUCTION

Urban Land use and land cover dynamics arethe main issues of world environmental dynamic (Prakasam, 2010) and the word land use and land cover dynamics are mostlyplausible (Steduto et al., 2012). Land use change is the alteration of land use (Jokar et al., 2013; Elfert & Bormann, 2010) due to humanintervention for various processes (Bewket, 2002; Meyer and Turner,1992). Such as for settlement, transportation, infrastructure and manufacturing, park recreation uses, mining and fishery (Ellis,2011). In contrast, urban land cover change refers to the shift of urban land cover from one category of land to another within a category due to human intervention for different processes (Bewket, 2002;Baral et al.,2009;Melese, 2004). Thus, understandthe urban level land use land cover change is essential for tackling future prospect of urban land use and land cover change driven impacts on sustainable socio-economic development (Schreier et al., 2003; Bureau, 2005).

Urbanization is the process whereby large numbers of people settle in an area of non-agricultural activities (Anthony, 2011). In addition, urbanization is defined as an increasing share of population living in urban areas and those declining share of living in rural areas (Meyer andTurner, 1992). Currently, more than half of the world's population resides in urban areas (Bhatta,2010). The number of urban population has increased dramatically from 200 million in 1900 to about 2.9 billion in 2000 andit is estimated to reach 5 billion by 2030 (Braimoh and Onishi, 2007).Thus, this continuous increases of urban population will leave burden to the urban areas for the occurrence of irreversiblerapid land use and land cover change at the expense of the surrounding agricultural areas (Bhatta,2010).

As an agent, urban growth contributing factors vary within and between different parts of the world (McCarthy & Knox, 2012). Hence, urban expansion in developed countries is a result of economic growth while in developing countries has mainly resulted from demographic growth (Cohen, 2006;Clark, 1998). Many countries in the world including Sub-Saharan Africa have recently experienced rapid urban expansion ratebecause of massive rural-urban migration and internal growth (Alaci, 2010).

As the urban population grows housing needs alarmingly continue and forcing more agricultural land, forestland andgrasslandsare enforced to convert into human settlements (Bekele, 2010). This land use category conversion from one class type to the other can bring the expansion of one class type at the expense of the other (Inki & Arbaminch, 2018;Berhe, 2006). In this phenomenon, in the history of urban expansion built up area anxiouslyincreases from time to time (Mebiratu, 2015) by suppressing the agricultural land and imposed socio-economic impacts in the surrounding agricultural population than the other social groups (Nigussie, 2011).To be honest,Urban expansion creates various opportunities for people living in the urban area, but it is also accompanied by several negative consequences (Mebiratu, 2015;Fenta, 2017) with a significant reduction on agricultural lands (Raddad, 2010; Kedir, 2010). As the result,the conversion of farmlands into urban built-up areas reduces the amount of lands available for food and crop production that can support both urban and rural areas (Tassie, 2018).Thus, its physical expansion bring ecological and socio-economic impacts in the surrounding population (Kedir, 2010).Moreover, the highest rate of built-up areas expansion in the urban areas against forests, grasslands and croplands imposes external imagedifferencewhen comparisons have made before and after the changes of urban areas (Hurniet al., 2005; Wondimu, 2011; Mebiratu, 2015).

Specifically, Bure town is one of the rapid expanded and urbanized town where land use and land cover change areperformed clearly by pushing the farmlands,forestareas and grass lands for residential house construction (Dessie & Kleman, 2007; Dereje, 2007; Mengistu, 2008; Dessie & Christiansson, 2008) in all direction especially since the last decade and this sprawl bring dramatic image differences appearance in the town. Furthermore, the town is marked by various elevation arrangements which give an opportunity to analyze what land use and land cover change have happened in relation to the trend of time. Having derived by these views and the rapid sprawl of the town, this study analyze the trends, patterns and, extents of urban land use and land cover change in North West Ethiopia with particular reference to Bure town.

II. RESEARCH METHODOLOGY

2.1. Location and descriptions of the study area

Bure town lies between 10°40'51.5"to10°43'33.1"N and 37°2'44.9"to 37°5'0.6"E. In administrative term, itis found in Bure district, Amhara Regional state (Figure.1). The study area has special coverage of 20.54km^{2}and the town is located around 410km northwest of Addis Ababa and forms the parts of the North Western highlands of Ethiopia.

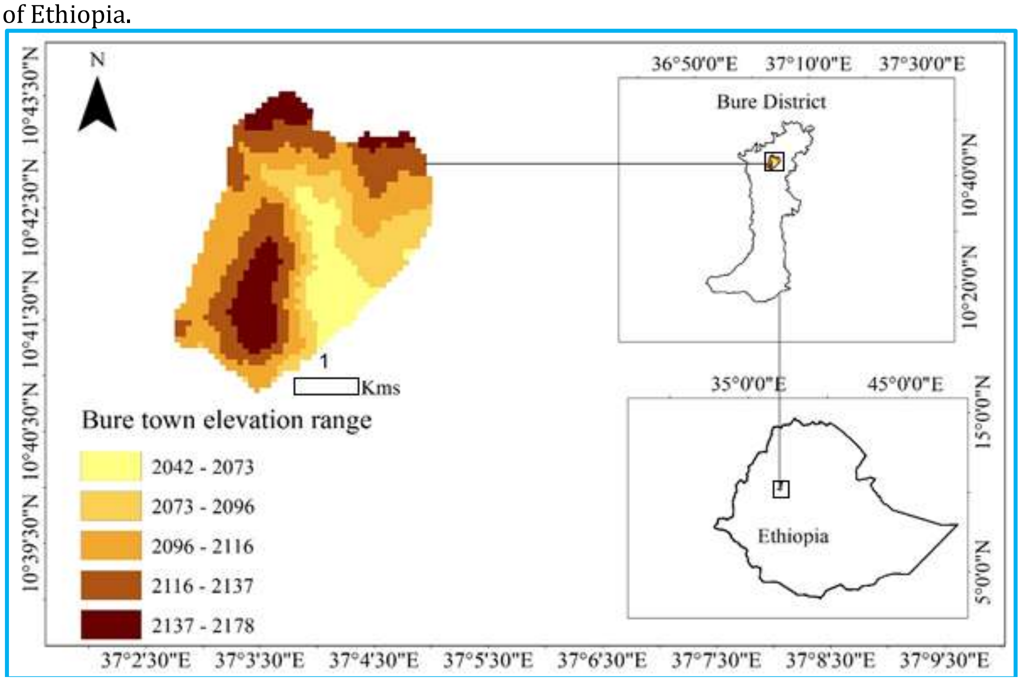

Figure 1.Location map of Bure town

2.2. Topography of the study area

The study area is consisting of different topographic conditions with steep slopes at the south centeral parts of the town while level to very gentle slope at the eastern and western parts of the town (Figure 2). The elevation ranges 2042 to 2178 meter above sea level. According to FAO, 2004 classification the topography of the study area consists of 2.45km^2 from level slope, 7.23km^2 from very gently slope, 3.29km^2 from gentle sloping, 2.17km^2 from sloping, 2.11km^2 from strongly slope, 2.14km^2 from moderate steep and 1.15km^2 from very steep. Most parts of the study area are found within very gently slope while small parts of the study area are just found in very steep slope (Figure 2).

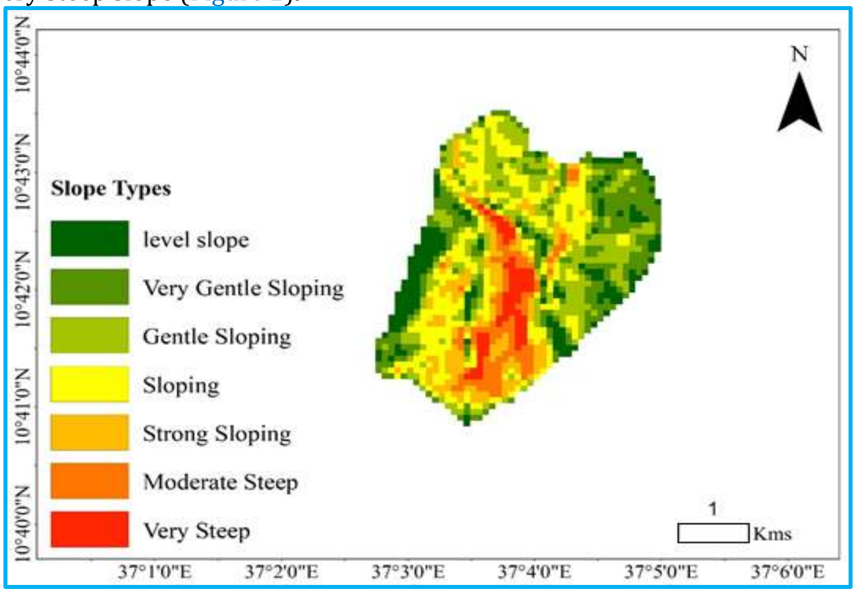

Figure 2. Slope map of Bure town

According to the National Meteorological Agency as measured at Bure town (10°42'55.9"Nand 37°4'33.1"E with elevation 2137m), the climate condition of the town is generally characterized by Weyina-Dega. The highest rain fall is recorded in the summer season i.e. from June to August and the lowest rain fall is recorded in winter season (from December to February). The average temperature of the town is 20˚c and its total annual rainfall is 1470mm.

III. DATASOURCES AND METHODS OF COLLECTION

3.1. Satellitedata

The data used to create the spatial data base used for this study were obtained from the Canadian Mapping Authority which were taken in 1989 (SPOT)and 2019 (SPOT) during February months. These years and months were selected in order to have a clear difference with in each land use and land cover categories of the area for supervised classification. Advanced Spaceborn Thermal Emission and Reflection Digital elevation model 30 *30 meter resolution was downloaded from United State Geological SurveyAdministration and was used for basin delineation and slope generation.

3.2. Fielddata measurements and observations

The field data collection were done randomly to verify the classified image and to collect the necessary land use and land cover data for accuracy assessment. The ground control points were collected using Garmin Global Position System model 72 devices.

IV. METHODS OF DATA ANALYSIS AND INTERPRETATION

4.1. Satellite data and image classification

Pre-processing: Thepre-processing activities such as layer stacking, haze correction and topographic correction were carried out on the SPOT images using ERDAS IMAGINE 2015. In addition, the land sat images were extracted by mask with the study area DEM by arc map 10.5.

Image classification: Supervised image classification systems were carried out using ERDAS IMAGINE 2015 after preprocessing activities. Finally; farmland, forest, grassland and built-up area were produced corresponding to the tworeference years and the result sent to Arc GIS 10.5 software to display, quantify and interpret (Table 1).

Table 1. Descriptions of land cover classes identified in Bure town (1989-2019)

No.	Land cover types	Description
1	Forest	Area covered with trees
2	Built-up area	Area covered with residential area
3	Grassland	Area covered with grass
4	Farmland	Areas used with crop cultivation

Field data analysis

Ground control points collected for the purpose of undertaking accuracy assessment to validate and compare the classified images with the true geographical phenomena. After the ground control points collected by GPS from the field and recorded in Microsoft office Excel 2010 spread sheet so as to put the latitudes and longitudes coordinate points as they represented the types of geographic phenomena.

Accuracy assessment: After the supervised classification taken place on the land SPOT images, accuracy assessment also under taken to compare the classified images with geographical data that they are assumed to be true. The accuracy assessment of the LULC map have been under taken by comparing the field data collected by GPS with the classified images in ERDAS IMAGNE 2015 software . Four lands used land cover classes were identified using visual image interpretation and field survey. Thus, from the supervised digital image classification, in this study, accuracy assessment was done for the 2019 satellite images. The overall accuracy was calculated by summing the number of pixels classified correctly and divided the number of pixels. Thus the overall accuracy of 2019 was 94.61.

Land use and land cover detection: The amount of different land use and land cover types of the study area quantified from the produced maps, which depicted in percentiles. A combination of information collected from field, local people knowledge through informal interviews and cross checked with satellite images used in the analysis of land use and land cover change detection. The land cover maps for the three period were analyzed based on land use and land cover types area comparison. The changes over 30 years were analyzed and rate of change for each land use land cover type was calculated. In the meantime, the rate of land use and land cover changes for the three periods from1989-2019 were compute using the following formula (Lambin et al., 2003).

$$\mathbf{R} = \frac{Q2 - Q1}{T} \quad \ldots\ldots 1$$

Where R= Rate of change, Q1=initial year land use/ land cover in km^2, Q_2 = recent year land use/ land cover in km^2, T= timeinterval between initial and recent years.

V. RESULTS

5.1. Spatial and temporal distribution of land use land cover change and accuracy assessment

5.1.1. Landuse and land covers classification for 1989

The study area has been defined to have four land use and land cover units, which namely, farmland, forest, built up area and grassland. The land use and land cover classification for 1989 satellite image in Figure 3 showed that majority of the study area was under farmland and built-up area accounting for 7.28 km^2 and

7.25km^2 respectively(Table 2). The central parts of the study area were covered by built-up areas while mostly forest areas werefound the north eastern part of the town (Figure 3).

Table 1.Land use land cover classes and their corresponding areas for 1989.

Land cver type	Area (km^2)	Land cover (%)
Foresto	2.66	12.95
Grassland	3.35	16.31
Farmland	7.28	35.44
Built up Area	7.25	35.30
Total	20.54	100

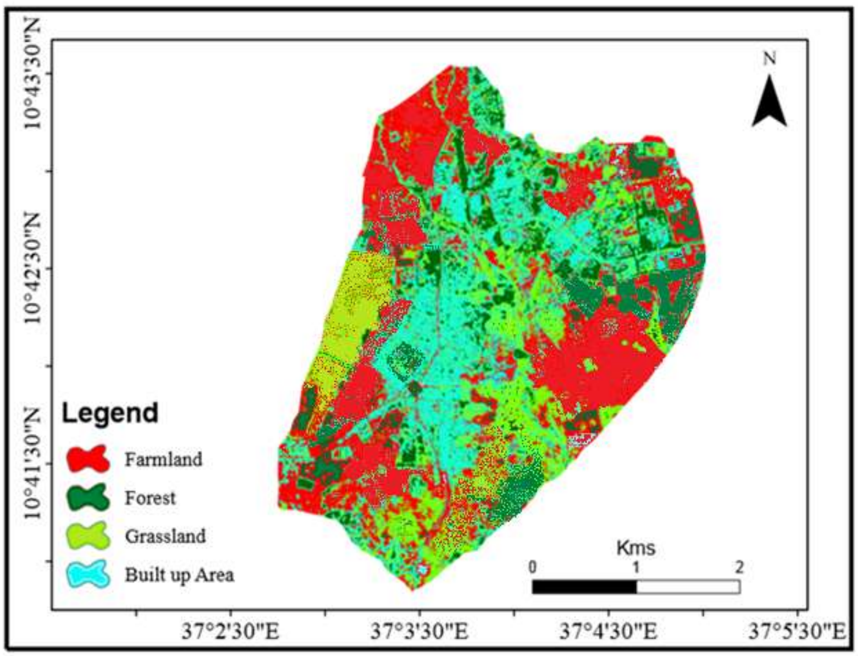

Figure2.Land use land cover classification map of study area for 1989

5.1.2. Land use land cover classification for 2019

The land use land cover classification for 2019 from SPOT image (Figure 4) showed that most parts of the study area are covered by built up area and also found in the central parts the study area while forest is covered small proportional area as compared with the other land class types in the study area which accounts 14.81 km^{2}and 1.14k m^{2}respectively. Mostly farmlands are located north western and north eastern parts of the study area and accounting for 2.15 km^2 while the grassland found south western and south eastern edge parts of the town and accounts for 2.44km^2 (Table 4).

Table 4.Land use land cover classes and their corresponding areas for 2019.

Land cover type	Area (km^2)	Land cover (%)
Forest	1.14	5.55
Farmland	2.15	10.48
Grassland	2.44	11.87
Built up area	14.81	72.10
Total	20.54	100

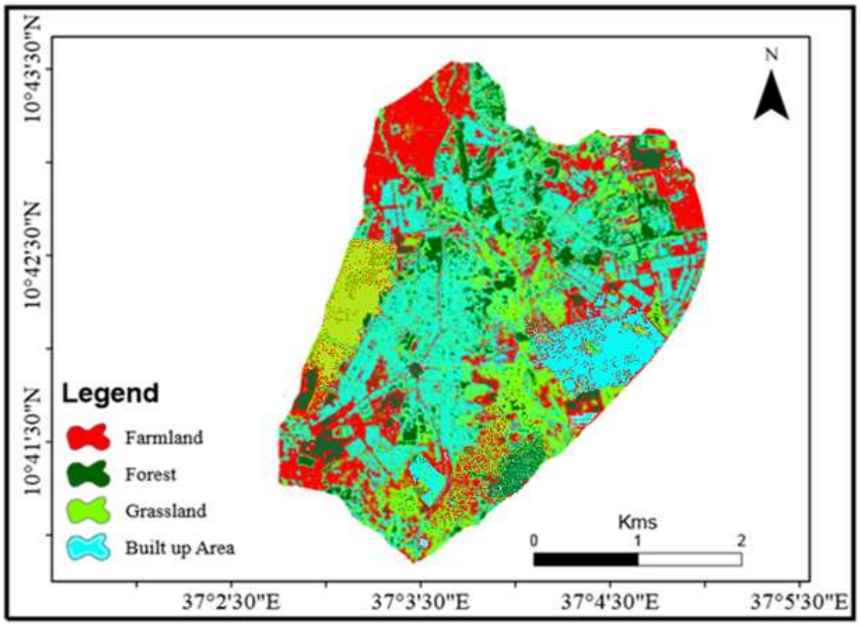

Figure4. Land use land cover classification map of study area for 2019

5.1.3. Accuracy result

The result of the of overall accuracy assessment of 2019 year classified Land sat imageries were analyzed Table 5. As its name implies, the accuracy assessment depicted the degree of correctness of assigning a pixel to the predefined land use and land cover classes. Therefore, the base line requirement of the overall accuracy assessment is greater than or equal to 80 (Congalton, 1991). Thus, in doing this study, 2019 year over all accuracy result became above the requirement level Table 5.

Table 5.Classification accuracy statistics of LULCC classes in 2019

Class name	Accuracy (%)	
	2019 G.C	
	Producers	Users
farmland	100	98.01
Forest	98	92.91
Grassland	98	87.5
Built up area	100	100
Overall classification	94.61	

5.1.4. Land use and land cover change detection

The Change detection analysis was conducted using post classification image comparison technique. Accordingly, change of land use/ land cover between 1989 and2019 were computed using post classification result.

5.1.4.1. Land use land covers change detection between 1989and 2019

In the period between 1989 and 2019, there were increments of built-up areas but decreased in the rest of land use and land cover classes (Table 6). In 1989 the built-up area covered an area of 7.25 km^2 but it again increased in to 14.81 km^2 in2019. In the year between 1989 and 2019, the built-up areas were remaining unchanged to the other classes. But, it lost nothing to the other class types and again it gained 7.56km^2 from grasslands, forest and farmlands. Thus, in 30 years the built-up area showed total increased class change of 7.56km^2.

In contrast, the forest covered an area of 2.66 km^2in 1989 but it decreased in to 1.14 km^2 in 2019. In the year between 1989 and 2019, the forest areas were lost 1.52km^2 to the built-up areas and again it gained nothing from rest class types. In the year between 1989 and 2019, 1.14 km^2 was remained constant from being changed. Thus, in 30 years the forest area showed total decreased class change of 1.52km^2 .Similarly, the grasslands covered 3.35 km^2 in 1989 and decreased again to 2.44 km^2 in 2019 within 30 years. In the year between 1989 and 2019,2.44 km^2 was remained constant from being changed. But, it lost 0.91km^2 to other classes. Thus, the grasslands showed total decreased class change of 0.91 km^2 in 30 years (Table 6). Moreover,the farmland covered an area of 7.28 km^2in 1989 but it decreased in to 2.15 km^2 in 2019. In the year between 1989 and 2019, the farmland areas were lost 5.13km^2 to the built-up areas and again it gained nothing from rest class types. In the year between 1989 and 2019, 2.15 km^2 was remained constant from being changed. Thus, in 30 years the farmland area showed total decreased class change of 5.13km^2. Generally, during in the period comparisons between 1989 and 2019, the Built-up areas are increased by 7.56km^2 with rate of 0.25km^2 per year. In contrast, within 30 years, grasslands are increased by 0.91km^2 with rate change of 0.03km^2 per year. In addition, the forest decreased by 1.52km^2 within the entire time intervals with rate change of 0.05km^2per year. Similarly, the farmland lost 5.13km^2 within with rate changes 0.17km^2per years in 30 years (Table 6).

N.B. the land use land cover change (LULCC) matrixes grid cells have painted by using various color types (Table 6). The main reasons were the various grid cells painted by different colors so as to discriminate the area between remain unchanged and converted land class types in the comparison period. As a result, whites are represented the amount of area which were converted land class, theblue colors are represented remain unchanged class types and the red color is represented the total area covered by the study area.

Table 2.LULCC matrix between 1989 and 2019

	2019					
	Class Name	Forest	Farmland	Grassland	Built-up area	Total
		km^2	km^2	km^2	km^2	km^2
1989	Forest	1.14	-	-	+1.52	2.66
	Farmland	-	2.15	-	+5.13	7.28
	Grassland	-	-	2.44	+0.91	3.35
	Built-up area	-1.52	-5.13	-0.91	7.25	7.25
	Total	1.14	2.15	2.44	14.81	20.54
	Class Change	-1.52	-5.13	-0.91	+7.56	

VI. Discussions

6.1. Urban expansion at the expense of forest areas, farmlands and grass lands

The rapid development of urbanization causes many problems, such as infrastructure planning, uncontrolled urban sprawl at the expense of forest area, grassland and farmlandsin the different parts of the world (Maktav et al. 2005). Considering this idea, the expansion of the built up area in Bure town has become a cause for the reduction of areal coverage for the rest of the identified land use types since 1989. This is the general impression of the change analysis result conducted in the study area. Furthermore, the following discussions are done comparing the findings of this study with other similar studies are conducted by scholars elsewhere in the world.

Based on the image classification and analysis performed for Bure town during in the period comparisons between 1989 and 2019, the built up areasare increased by 7.56km^2 with rate of 0.25km^2 per year. Similarly, this finding is directly agreed with the findings of Mundia & Aniya (2005), which is conducted inNairobi city expansion using images of 1976, 1988 and 2000 and the study revealed that the built-up area has expanded by about 1.95km^{2}per year. In addition, the study result of Bure town is directly agreed with the findings of Fenta et al. (2017), which is conducted in Mekelle City expansion from 1984 – 2014 using landsat images in ten year intervals, the result portrayed that the built-up area increased by 1km^2 per year andabout 88% of the built-up area was converted from agricultural lands. Likewise, the study also coincides with the findings of Lingereh (2016), which is conducted in Debre Markos town expansion from 1987 to 2016. The study result showed thatthe built-up area has expanded by 0.32km^2 per year by snatching lots of land from farmlands, forests and open areas.Moreover, the studyresult has also agreed with the findings of Fenta et al. (2017),which is conducted in Mekelle City expansion from the year 1984 – 2014 and theresults of this study have shown that there was an increased expansion of built up areas by 5% in the last 25 years from 1986 to 2010 at the expense of agricultural areas.

In contrast, based on the study result conducted in Bure town since 1989, the grasslands are decreased by 0.91km^2 with rate change of 0.03km^2 per year. In addition, similar finding also revealed by the Lingereh (2016) and the result portrayed that due to the urban expansion the grassland areas decreased by 0.13km^2 per year as comparison has mad in the period between 1987-2016.

Considering the image analysis result done in Bure town from the year 1989 to 2019, the forest decreased by 1.52km^2 with rate change of 0.05km^2 per year. Similarly, this result is strictlymatched with the findings of Mundia & Aniya (2005)and the study result showed that the urban expansion has been accompanied by loss of forests by urban sprawl. In addition, according to Lingereh (2016),due to the expansion of Debre Markos town, the forest area was decreased by 0.18km^2 per year in the last 29 years back.

Based on the image analysis result done in Bure town from the year 1989 to 2019, the farmland lost 5.13km^2 within with rate changes 0.17km^2 per years in 30 years. This result is directly agreed with the findings of Fenta et al. (2017)and the result portrayed that the farmland decreased by decreased by 0.39km^2 per yearin the time from 1989 – 2014. In addition, similar findings also revealed byLingereh (2016) and the study result portrayed that due to Debre Markos town expansion the farmlands are decreased by 0.01km^2 per year in 29 years.

VII. Conclusions

In Bure town land use and land cover changes have started to assess since 1989. Based on the land cover classification performed on the SPOT imageriesfarmlands, forest, grasslands and built-up areasland cover types are identified.In 1989 the built-up area covered an area of 7.25 km^2 but it again increased in to 14.81 km^2 in2019. In contrast, the forest,grasslands and farmland covered an area of 2.66 km^2,3.35 km^2 and 7.28 km^{2}in 1989 respectively but they decreased in to 1.14 km^{2}2.44 km^2 and 2.15 km^{2}in 2019 respectively. As a result, during in the period comparisons between1989 and 2019, the built-up areas are increased by 7.56km^2 with rate of 0.25km^2 per year. In contrast, within 30 years, grasslands are increased by 0.91km^2 with rate change of 0.03km^2 per year. In addition, the forest decreased by 1.52km^2 within the entire time intervals with rate change of 0.05km^2 per year. Similarly, the farmland lost 5.13km^2 within with rate changes 0.17km^2 per years in 30 years. Therefore, the rapid expansion of the town causes many problems, such as infrastructure planning, uncontrolled urban sprawl at the expense of agricultural areas and a concentration of resources at the expense of the surrounding countryside. Hence, planners and resource managers need a reliable mechanism to assess the consequences of Bure town horizontal expansion quickly and effectively.

VIII. Recommendation

The findings of the study gives clue for the concerned body including researchers and other stakeholders for further better investigation on the issues and bring possible intervention mechanisms for the dramatic land use land cover change in town. The study used 1989 and 2019 SPOT imageries only and thus,expansion of the town needs to be assessed using before 1989 SPOT imageries. In addition, the study only considers Spatio-temporal expansion of the town. Thus, it needs to be investigated the socio-economic impacts of Bure town expansion. Finally, based on the result of the study, built-up area greatly increaseshorizontally from time to time than the other class types. Hence, planners and resource managers need a reliable mechanism to assess the consequences of Bure town horizontal expansion quickly and effectively.Thus, strategies should be designed to promote the vertical than horizontal expansion of the town.

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Compliance with ethical standards

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