Urban Growth and Land Use Land Cover Change of Bahir Dar City

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Abstract

This study analyzed the land use-land covers (LULC) changes of Bahir Dar city and their causes for the last 30 years from 1986 to 2016. The satellite images used for the study are TM multi-spectral for 1986, ETM+ multi-spectral for 1998 and 2006, and Libra for the recent 2016 from which four LULC maps were generated by using pixel-based supervised image classification and changes of three periods were analyzed in a GIS. Furthermore, to identify the causes for the city expansion, questioners and key informant interviews were conducted. The analysis result showed that agricultural area, wetland, and open land depicted a decrease of 52.95%, 36.28%, 97.32% respectively while the built-up area, vegetation cover and water body showed an increase of 818.83%, 54.99%, and 2.4 %, respectively during the entire study period 1986—2016. Besides, the annual rate of built-up area expansion was 12.4%, 6.8% and 13.8% between 1986-1998, 1998-2006, 2006-2016 and became 27.3% from 1986- 2016. The identified causes for Bahir Dar city expansion were population increases, economic development, government, and urban policy. Thus, Bahir Dar city expansion has an influence on the land use-land cover change of the surrounding area, which in turn has ecological, socio-economic, and environmental impacts. Therefore, precise and current information about the city urban expansion and its influence on land use land cover changes will provide better information for urban planners and other concerned stakeholders to design strategies, put forward the right policies and monitoring mechanisms for urban growth and to appreciate effective urban management.

Keywords: Urban Growth, Land use land cover change; Satellite Image; Ethiopia

1. Introduction

Nowadays, the world is urbanizing rapidly [1]. In today's interconnected world, even though there is difference in the level o f urbanization, more than half of the population is currently living in urban areas and a projected 70 per cent will be living in urban areas by 2050. So that urban settlements are growing and will persist to grow whether this is planned or simply spread [2]. Thus, urbanization of fast manner has accelerated social and economic development greatly and global cities are engines of economic growth and hub of modernization for the worldwide economy and the surrounding area of their respective nations [3]. However, this urbanization process brings major modification in the land use- land cover pattern of the concerned area. It causes various negative effects in terms of physical environment such as loss of agricultural land, surface and groundwater depletion, flooding, landslides and change of other geomorphic features [4]. The rapid expansion and growth of urban areas changed the natural landscape and make massive environmental, ecosystem, and social impacts, that limit the capacity of cities to provide basic services and facilities, degrading of life, and the environment.

Today, human beings experience a remarkable shift to urban living. Therefore, that urban area becomes hot spots that constrain environmental change at many ways [5]. Especially in developing countries due to rapid population growth,

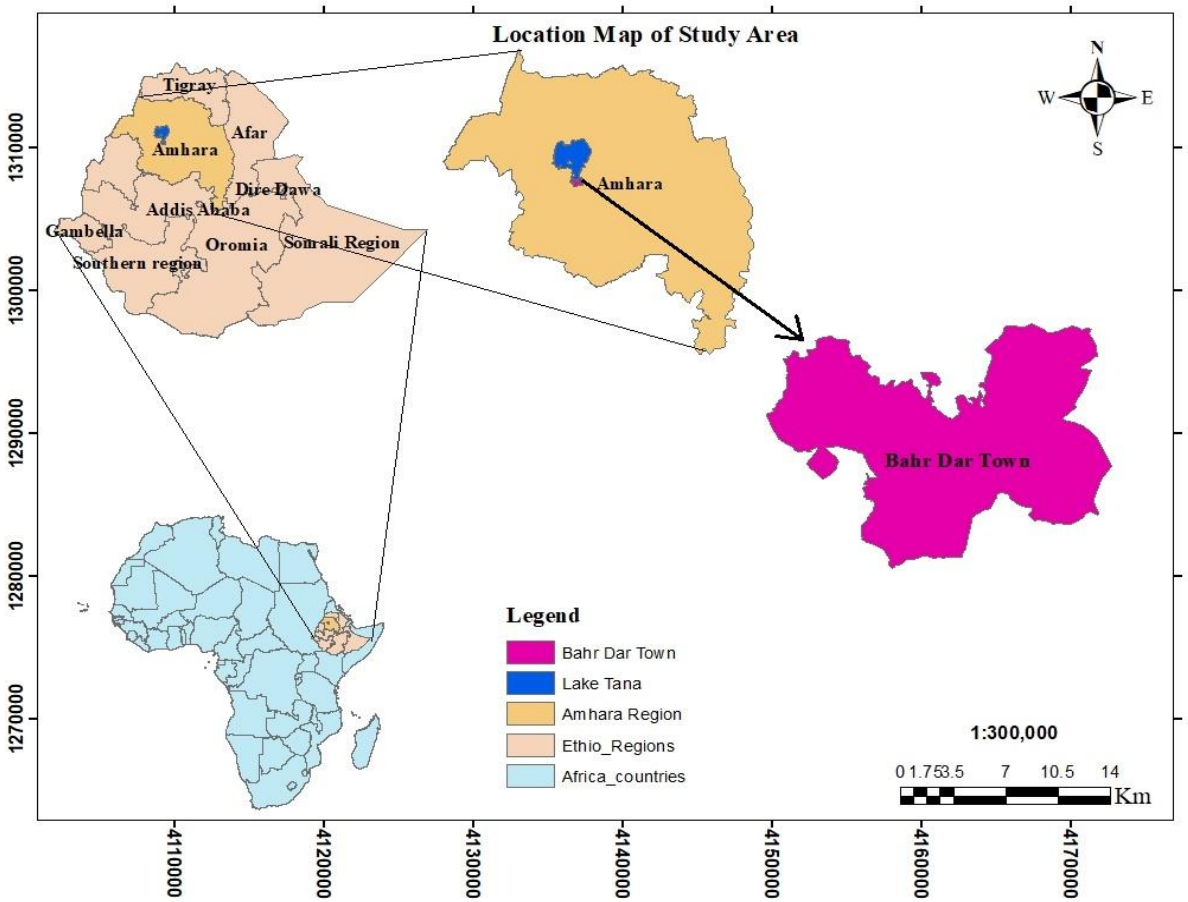
economic development, and infrastructural development, urban expansion is the big challenge of recent century [6]. Hence, urbanization created various environmental harms that range from local to the global scales [7]. As a result, urban expansion and associated land use land cover change alter the world landscape and create a series of ecological and environmental impacts [8].

Thus, even if urban areas cover a very small part of the world's land surface, their fast increment drastically changed the natural landscape and created enormous environmental, ecosystem, and social impacts (9, 10, 12, and 13). From a LULC transformation aspect, the change which takes place by urban expansion has a substantial consequence on the environment, ecosystem, and society (5).These impacts are most significant in developing countries where there is a limited capability to manage the environmental and social consequences of speedy urban expansion (49).

Bahir Dar, which is the capital city of Amhara National Regional State (ANRS) of Ethiopia, has experienced greater challenges due to speedy urbanization. The city is one of the fastest growing cities located in the northwestern part of the country. It is supposed to be in a dynamic state of expansion following the nomination of the city as the capital of Awraja, an administrative unit or hierarchy next to a region used during the previous regimes, in1948. Following the fall of the former government of Ethiopia in 1991, Bahir Dar was selected as the seat of the regional government of the Amhara National Regional State [14]. With this, Bahir Dar experienced major growth and expansion. The expansion has posed severe threats to the land use- land cover of the city and its adjacent natural environment. Therefore, the study was initiated to explore Bahir Dar city expansion and associated land use land cover (LULC) change, assesses the pattern of BahirDar city built up area expansion from 1986-2016 and identifies causes for Bahir Dar city expansion.

2. Description of the Study Area

Bahir Dar city is the capital of the Amhara National Regional State of Ethiopia. It is located at 11" 38'N, 37"10'E on the Southern side of Lake Tana. The altitude of the city is about 1801m above mean sea level and covers an area of 16,000 hectares [34, 14]. In relative terms, Bahir Dar is found at a distance of 567 km from the capital city of Ethiopia, Addis Ababa along the Addis Ababa - Debre Markos road. Literally, Bahir Dar means a city situated on or very close to the shore of Lake Tana and Blue Nile [35, 36]. Today, it is one of the fast growing largest cities in the country. With its growth, different service sectors such as education, health, transport, and communication have grown and the city has expanded rapidly throughout the 20th century [37]. Due to this it is becoming a top commercial center of the Amhara National Regional State and used as a center for the city metropolitan administration. Thus, a number of factors that include commercial, administrative importance, service as well as historical factors have accounted for the growth and development of Bahir Dar. Moreover, according to 2014 UNSCO report, Bahir Dar city registered as one of the beautiful cities in Africa.



Map1: Location Map of Bahir Dar City

Historically, beginning of the city was 'associated' with the establishment of Kidane Miheret Church at the current site of St. George's Church around the 14th century. Latter for the first time the Bahir Dar city municipality was established in 1936[38] (FUPI, 2006). Thus, there has been a settlement at or around Bahir Dar for many centuries, but the economic growth of the city began in earnest in the 1950s, when its status was raised to a regional capital. The city has been the regional capital and economic center for northwestern Ethiopia since 1958, when German experts prepared a comprehensive master plan for its development. The city was the capital of Western Gojjam Administrative Region in 1987 and since 1991 has been the capital city of the ANRS. With this investment in hotels and factories is growing and expansion of the city has given further opportunities for construction and related businesses [39].

3. Methodology

The types of spatial data used to study Bahir Dar urban expansion and land use- land cover dynamics of the study area were TM multi-spectral for year 1986, ETM+ multi-spectral years for 1998 and 2006, Libra for 2016(Table 1 below). The images were obtained from Global Land Cove Facility (GLCF) accessed electronically through the Earth Science Data Interface (ESDI) [40].

Table 1: Spatial datasets used for this Study

Year	Sensor	Spatial Resolution (m)	Acquisition date	Path and Rows
1986	TM multi-spectral	30	L5170052_1986_0103	P170r52
1998	ETM+ multi-spectral	30	L5170052_1998-1206	P170r52
2006	ETM+ multi-spectral	30	L71170052_2006-1102	P170r52
2016	Libra	30	LC08_L1TP_170052_2016	P170r52

The satellite images of the years were selected by taking into consideration events such as the National Urban Development Policy Framework approval time, government change and availability of Land sat images. After acquiring satellite images from different portals, image enhancement and composition were applied to improve image quality and better determination of land cover classes.

Besides, to understand the major causes of Bahir Dar city expansion questioner and key informant interviews with elderly communities were used. All respondents used to fill the questioner are people who have an age of 60 or more years to get reliable information from their age experience. Moreover, the key informants for interview were selected using snowball sampling technique considering their age (elderly community member who have an age of 60 and above) continually living in the area for 20 and more years, willingness to participate in the interview and considered by local people as knowledgeable about the study area. Besides, ANRS Officials and experts of Agricultural Institute, ANRS Forest and Wild animal Protection Institute, ANRS Mining Agency, ANRS Water, irrigation and Energy Resource Development Bureau, ANRS Urban planning Institute, ANRS Culture and Tourism Bureau, Sanitation and Beautification Bureau, Investment Bureau, Infrastructure Expansion Bureau were selected using purposive sampling techniques by considering them having adequate knowledge about the issues. In addition, secondary data sources, such as technical reports and published works were used.

Then classification is the process of sorting pixels into a finite number of individual classes, or categories of data, based on their data file values. Nevertheless, there is no universally accepted classification as it is influenced by specific user's objective and sometimes by geographic location; therefore the need to contextualize the land use land cover classification to the local situation is needed [50]. Based on this, land uses are classified in to six classes.

1. Water bodies (river, open water, lakes, ponds, and reservoirs)
2. Vegetation covers (forestland, bush forest, nursery, and every kind of garden plots).
3. Built up area (residential, commercial and services, industrial, transportation, roads, construction sites, mixed urban, and other urban)
4. Agricultural area (crop fields, fallow lands & land under preparation)
5. Open land (Open spaces with little or no vegetation, beaches, dunes sands bare rocks, sparsely vegetated areas)
6. Wetland (area partly covered by water and marshlands).

Then a pixel based supervised image classification was performed using the Maximum Likelihood Classifier. In this stage, a number of both classification and reclassification procedures were used in order to improve the classification and neglect misclassified cells. Then, the classified result was checked and verified for their accuracy. The main purpose of the accuracy assessment is to assure classification quality and user confidence on the product [41]. Therefore, accuracy of the classified image of the recent 2016 was assessed by comparing the value of the classified image with field points collected using GPS and additional points for water bodies taken from the Google earth, which carried out by creating error matrix. The matrix compares information obtained by reference sites using GPS to that provided by classified image for the sample areas. Accordingly, overall accuracy, producer's and user's accuracies, and Kappa statistic were calculated from the error matrix for the recent year 2016. Finally, the LULC changes between four periods (i.e., 1986–1998, 1998–2006, 2006–2016 and 1986–2016) were quantified. Images of different reference years were first independently classified, and, afterwards change detection processes were performed. The percentages of land use/land cover change detection were made using the following formula [42, 43].

$$\text{Percentage LULC Change} = \frac{(\text{PercArea final year}\_\_\text{Area intial year})}{\text{Area initial year}} * 100$$

Hence, positive values suggest an increase whereas negative values imply a decrease in extent of LULC. Image classification, accuracy assessments, and change analysis were undertaken in Erdas Imagine10 software. Moreover, annual rate of urban area expansion (RUE) for the periods: 1986–1998, 1998–2006, 2006—2016, and 1985–2016 was calculated using the following relationship [14, 18].

$$RUE = \frac{UAi + n - UAi}{n * UAi} * 100$$

Where,

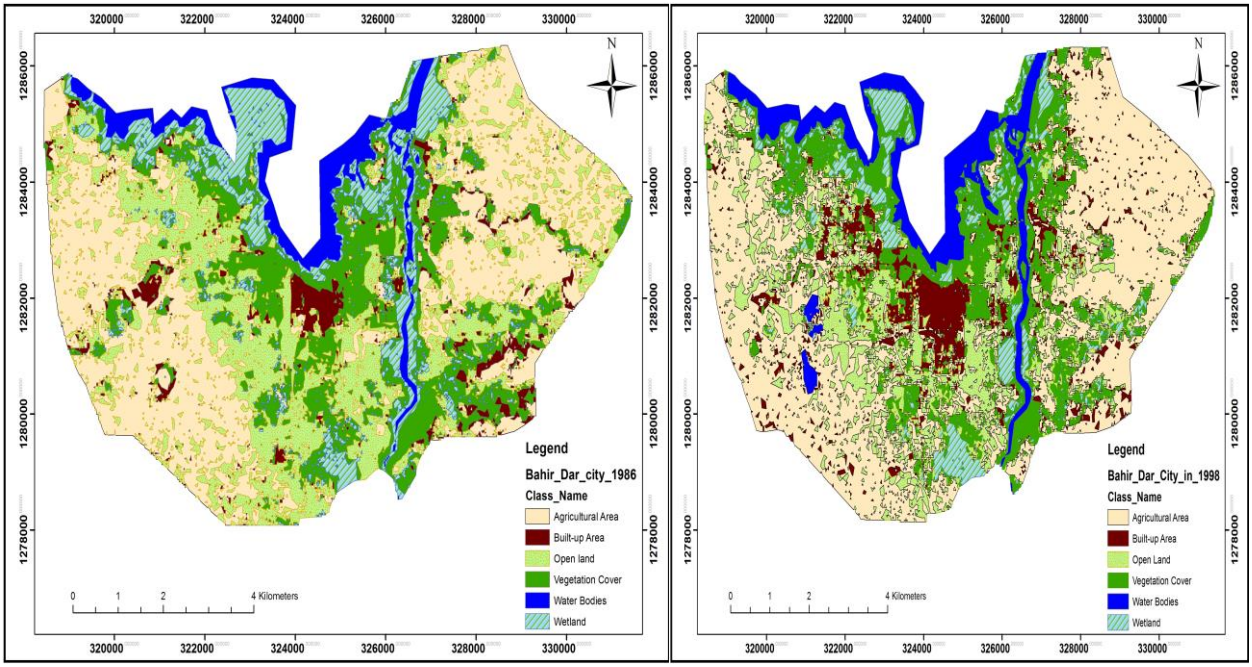
UAi+n is the urban area in hectare (ha) at time i+n
UAi is the urban area in hectare (ha) at time i
n is the interval of the calculating period (in years)

Lastly, the socio-economic data about BahirDar city expansion and land use land cover changes collected through questionners,interview and focus group discussion was analyzed using multiple response analysis and narration. Finally, secondary data investigated in different sources was used accordingly.

4. Results and Discussion

4.1.Land use/land cover classification of Bahir Dar City

The six LULC classes (built-up areas, water bodies, agricultural area, wetlands, open land and vegetation cover) were identified for the years 1986, 1998, 2006 and 2016 (Fig. 1), and the area for each LULC classes has been presented (Table.1).



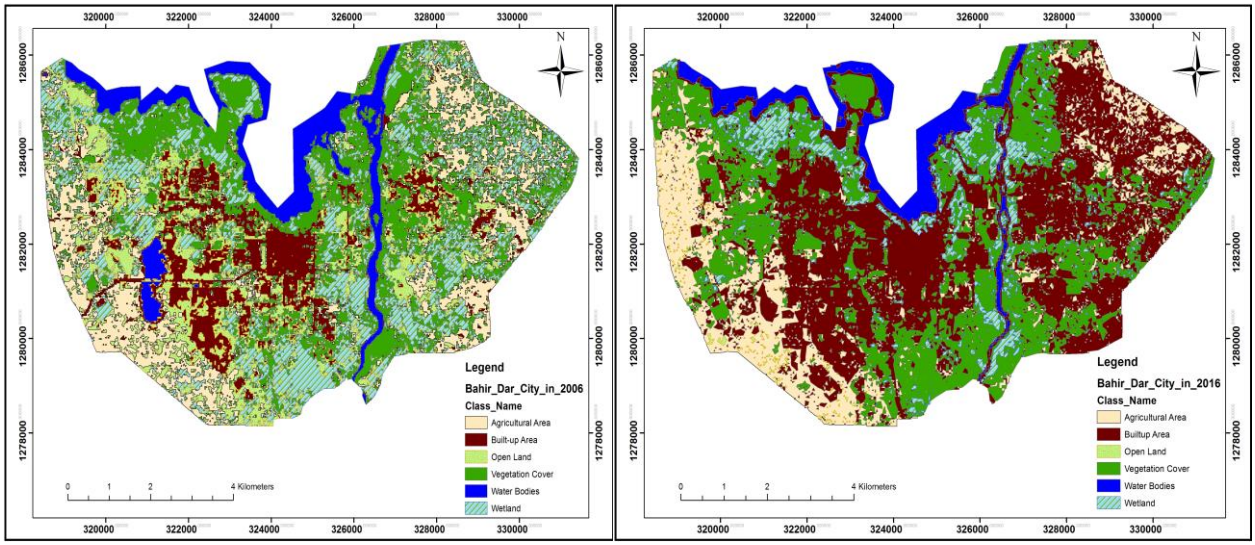
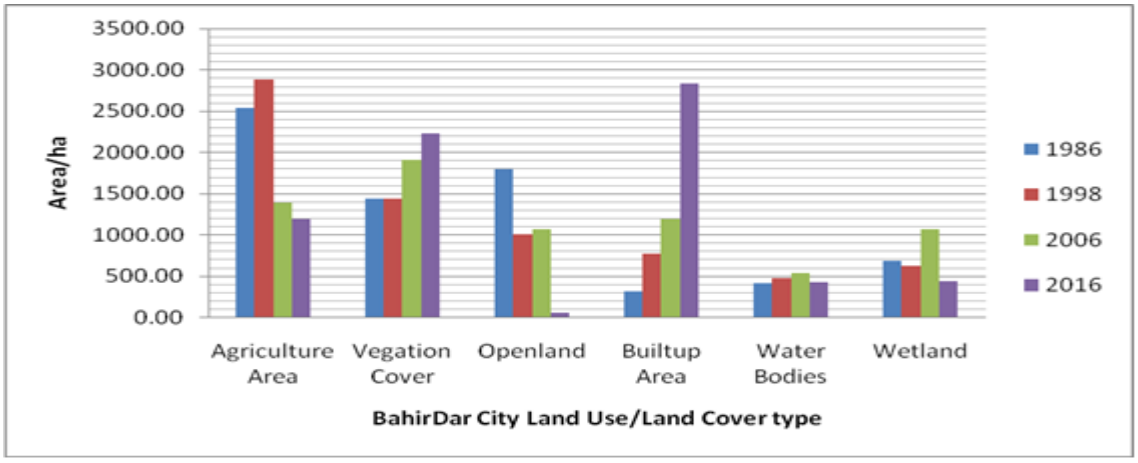


Fig.1: Classified land use/cover maps of BahirDar city 1986, 1998, 2006 and 2006

Table 2: The classified land use land cover class of Bahir Dar city from 1986-2016

	1986		1998		2006		2016	
Land use class	Area/ha	%	Area/ha	%	Area/ha	%	Area/ha	%
Agricultural Area	2534.00	35.3	2885.94	40.2	1380.33	19.3	1192.23	16.7
Vegetation Cover	1437.00	20	1438.83	20.1	1906.24	26.7	2227.14	31.1
Built up area	308.00	4.3	767.61	10.7	1188.02	16.6	2830	39.5
Water bodies	412.00	5.7	464.76	6.5	536.15	7.5	421.92	5.9
Open land	1792.00	25.1	1001.25	14	1066.52	15	48.06	0.7
Wetland	686.00	9.6	612.99	8.5	1061.01	14.9	437.13	6.1

In 1986 the dominant land use of Bahir Dar city was agricultural area which is 35.3% followed by open land (25.1%), vegetation cover (20%), wetland (9.6%), water bodies (5.7%) and built up areas (4.3%) of the land available in the city. In 1998, also agricultural area was the dominant land use that is 40.2% followed by vegetation cover (20.1%), opens land (14%), built up area (10.7%), wetland (8.5%), and water bodies (6.5%).



In 2006, the agricultural area, which was dominant in 1986 and 1998 was reduced to 19.3%, the vegetation cover increased to (26.7%), the built-up area also increased to 16.6%, water bodies became (7.5%), open land (15%) and wetland (14.9%). In 2016, the main land use becomes built up area that was 39.5%, followed by vegetation cover

(31.1%), agricultural area highly decreased to (16.7%), water bodies showed a slight increase and become (5.9%), wetland reduced to (6.1%) and open land highly declined to (0.7%). These changes are graphically represented below.

Therefore, comparison of the land use land cover classification of the study area during the study period 1986-2016 indicated the dynamic increase of the built-up area from 308ha (4.3%) to 2830ha (39.5%) at the expense of agricultural land which decreased from 2534ha (35.3%) to 1192.23ha (16.7%), open land which decreased from 1792ha (25.1%) to 48.06ha (0.7%), wetland which decrease from 686ha (9.6%) to 437.13ha (6.1%). However, water bodies are almost the same but a bit change from 412ha (5.7%) to 421.92ha (5.9%) while the pattern of vegetation cover increased from 1437ha (20%) to 2227.14ha (31.1%). Hence, during the entire study period, built up area and vegetation cover augmented while agricultural area, open land, and wetlands become dwindled but the water body showed a negligible rise as shown in the figure below. The finding of the study agree with various studies which indicate increase of built up area at the expense of agricultural lands (14,18, 20, 21, 22,23,24, 26), open space(20, 24, 26,27),wetlands(22, 18) and the increase of vegetation cover(18, 27) and water bodies(26) due to urban expansion.

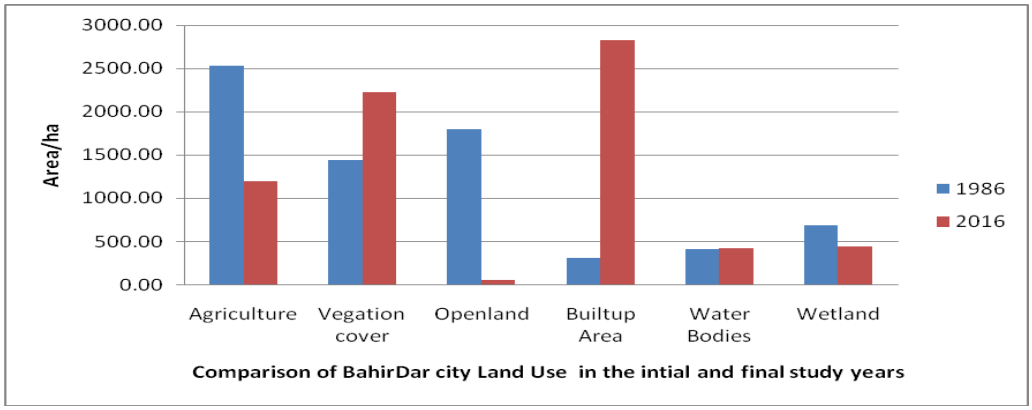


Table 3: Net change of Bahir Dar city land use land cover change from 1986—2016

Land use class	1986-1998		1998-2006		2006-2016		1986-2016(Total change)	
	Ha	%	Ha	%	Ha	%	Ha	%
Agricultural Area	351.94	13.89	-1,505.61	-52.17	-188.1	-13.63	-1341.77	-52.95
Vegetation Cover	1.83	0.13	467.41	32.49	320.9	16.83	790.14	54.99
Built up area	459.61	149.22	420.41	54.77	1641.98	138.21	2522	818.83
Water bodies	52.76	12.8	71.39	15.36	-114.23	-21.31	9.92	2.41
Open land	-790.75	-44.13	65.27	6.52	-1018.46	-95.49	-1743.94	-97.32
Wetland	-73.01	-10.64	448.02	73.09	-623.88	-58.80	-248.87	-36.28

Net-area changes of the six LULC classes are shown for the periods1986-1998, 1998-2006, 2006—2016 and 1986-2016(Table 3).The analysis for the period 1986-1998 showed an increase of agricultural area by 13.89% while after that it showed continuous decrease of 52.17%, 13.63% from 1998-2006 and 2006-2016 respectively. On the contrary, the built up area increase continuously by 149.22% from 1986-1998, 54.77% from 1998-2006, 138.21% from 2006—2016.Similarly, the vegetation cover showed an increase of 0.13% from 1986—1998, 32.49% from 1998-2006 and 16.83ha from 2006-2016. On the other hand, water bodies showed increase of 12.8% from 1986—1998, 15.36% and decreases of 21.31% from 2006-2016. Open land showed decrease of 44.13% from 1986—1998 and after that showed an increase of 6.52% from 1998-2006 and again a decrease of 95.49% from 2006—2016 respectively. Furthermore, wetlands decrease by 10.64%, then an increase of 73.09% from 1998--2006 and again decrease of 58.8% from 2006—2016. The land use land cover change of the city during the entire study period from 1986—2016 showed the decrease of agriculture area, wetland and open land by 52.95%, 36.28% and 97.32% respectively while the built up area and vegetation cover increased by 818.83% and 54.99% respectively but water bodies showed a bit increase of 2.41% within 30year study period. The decrease in wetlands may be associated to a retreat of the wetlands due to siltation, sedimentation, indiscriminate dumping of solid waste from urban infrastructure, lakeside landfill and subsequent use of this land for built up purposes. The researcher's observation is a witness for this. Nevertheless, the slight increase of water bodies may be

related to summer season rainfall amount, the construction of dam and reservoir in the periphery of the study area like 'koga' and others. However, the reason for vegetation cover increase maybe due to the governmental green economic development strategy 'implementation since 2007 and awareness creation program about the advantage of tree plantation and urban gardening for climate change mitigation and adaptation , large plantation of eucalyptus tree and chat for commercial benefit by surrounding farmers.

4.2. Urban growth pattern of Bahir Dar city from 1986- 2016

In this study, urban growth is the increase in physical extent of built up (urban) area. The high proportion of flat land escape and plain topography in Bahir Dar create a promising opportunity and potential to undertake various urban development activities. Hence, BahirDar city built up area expansion indicated by delineating the administrative boundaries for the year 1986, 1998, 2006 and 2016 (Fig 5**).**

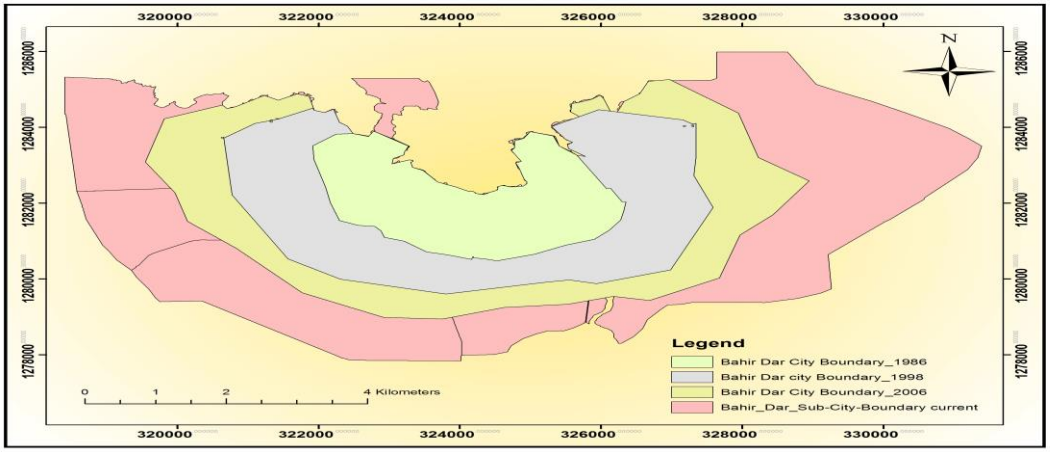


Figure 2. Bahir Dar city built up area

Table 4: The urban (built up) area expansion of Bahir Dar from 1986 to 2016

Year	Built-up area(ha)	Percentage change (% per year)			
		1986-1998	1998-2006	2006--2016	1986--2016
1986	308	12.4%	6.8%	13.8%	27.3%
1998	767.61				
2006	1188.02				
2016	2830				
Change (ha)		459.61ha (149.22%)	420.41ha (54.77%)	1641.98ha (138.21%)	2522ha (818.83%)

As indicated (in Table 3), the built up area of Bahir Dar was 308ha, 767.61ha, 1188.02ha and 2830ha in 1986, 1998, 2006 and 2016 respectively. Moreover, the annual rate of built up area expansion was 12.4%, 6.8% and 13.8% between 1986-1998, 1998-2006, 2006-2016 and become 27.3% from 1986- 2016. The finding of the study agrees with studies of (44-46) who reported decadal increase of the built up area. The built up area augmented continuously and great change observed from 2006-2016. This may be related with different factors. In 2004, the city was nominated as one of the metropolitan city in ANRS. Besides, the city serves as regional political center and administrative seat of ANRS and the surrounding districts. This has helped the city to play a balanced role in the political, socio cultural, economic, and environmental realms, promoting policy, regulatory and planning interventions. Due to these different infrastructures like government and Private offices, Banks, Insurance companies, modern shops, medical centers, colleges, and universities, commercial, residential buildings with related socio-economic activities are expanded and a cumulative effect contributes for further growth and physical developments of the city.

In 2005, Ethiopia approved the national urban development Policy to enhance the city service delivered systems and to make economically strong. In line with this, in 2008, Urban Local Government Development Project (ULGDP) that is funded by the World Bank was developed to support the implementation of the national urban development policy of Ethiopia. This project was administered through the Ministry of Works and Urban to address the constraints of limited resource and capacity that have hampered the implementation of the Policy framework in practice by offering a performance based matching grant to urban local governments, which meet specific performance. Since its launch in 2008, the cities have made improvements in planning, budgeting, financial management, procurement, revenue mobilization. This could be one of the factors for urban (built up area) increment.

4.3. Accuracy assessment of classified maps

For land cover mapping study by using remote sensing, assessing the reliability of the final classified map using classification accuracy is important. It helps to assure the classification quality and user confidence on the product [41]. In this study, the accuracy assessment of 2016 Bahir Dar city classified map was done by using 110 sampled ground truth points obtained from fieldwork and Google earth. However, due to difficulty of taking reference data for images of 1986, 1998 and 2006 accuracy assessment was not done but assumed its accuracy depends on the accuracy assessment result of 2016. The assessment of the accuracy classification was performed through the examination of the identity of some selected evaluation pixels representative of respective land covers. A common approach to reporting image classification accuracy is to calculate the proportion or ratio of the mapped area that has been correctly classified in comparison to reference data or ground data to the total area mapped. According to Herold, Couclelis, and Clarke (2005) the overall accuracy of all images greater than 85% is considered as a good result for remote sensing image based analysis. The accuracy assessment of study is lined with this and as indicated in the accuracy assessment Table 4 the overall classification accuracy is 86.36% and the overall kappa statistics is 0.8362.

Table 5: Accuracy assessment for 2016 classified map of Bahir Dar city

Land Use land Cover Map	Class Name	Reference totals	Classified Totals	Number Correct	Producers Accuracy	Users accuracy
2016 Classified Map of Bahir Dar	Unclassified	1	0	0	-	-
	Water Bodies	16	15	15	93.75%	100.00%
	Built up Area	18	14	14	77.78%	100.00%
	Wetlands	17	16	15	88.24%	93.75%
	Open Land	19	17	15	78.95%	88.24%
	Vegetation Cover	20	26	18	90.00%	69.23%
	Agricultural Area	19	22	18	94.74%	81.82%
	Total	110	110	95		
	Overall Classification Accuracy = 86.36%					
	Overall Kappa Statistics = 0.8362					

4.3. The causes for Bahir Dar city expansion and its Land use/land cover change

Urban expansion in recent times becomes a global phenomena but the rate of urbanization is rapid in developing countries. This urban expansion and associated LULC changes are derived by different factors. when respondents asked their view about the expansion of Bahir Dar city relative to the 1986, the majority 127(68.3%) replied as there are very fast change and 59(31.7%) as having fast change of expansion. Likewise when the respondents asked about the existence of observable social, environmental and economic changes the majority 150(80.6%) said yes while the remaining 36(19.4%) said no. Thus, the information described above indicated BahirDar city has recognized expansion relative to the initial 1986 study period. Furthermore, the respondents who said there are observable social, environmental and economic changes mentioned different causes for the existence of observable changes in BahirDar city relative to the initial 1986 study period as shown (in Table 5).

Table 5: Multiple response analysis for the cause of Bahir Dar city expansion

Question	Response	Responses		% of Cases
		N	Percent	
What are the causes for Bahir Dar city expansion?	Economic development	135	56.0%	90.0%
	Population increase	69	28.6%	46.0%
	Others(like government and urban policy)	37	15.4%	24.7%
Total		241	100.0%	160.7%
Dichotomy group tabulated at value 1.				

Source: Own survey data, 2017

Concerning the causes of Bahir Dar city expansion the multiple response analysis of 135(90%) of the responses indicated economic development whereas 69(46%) of respondents point out population augment and 37(24.7%) of responses indicated as others like government and urban policies are causes for BahirDar city expansion and existence of observable change. These factors result the expansion of service giving centers and settlements like residential houses, commercial centers, industrial centers, shops, road, light, water, institutions, offices, and other business centers. In line with this study, several studies indicated urban expansion had been largely driven by demographic change (32, 26, 45, 22, and 14), economic growth (32, 26, 22, and 14) and policy (32, 26, and 45).

Furthermore, the interviewed officials explained various factors as causes for Bahir Dar city expansion. Amongst those factors infrastructure expansion like roads, light and water services, residential houses, tourist facilities, hotels, restaurants, education and health centers, population increase and government policy change. Correspondingly, the key informants confirmed Bahir Dar city expansion in 1986 and now are different. Currently, Bahir Dar city expanded in north, south, east and west directions due to infrastructure expansion, population increase, economic development and change of life style of the community. With these hotels, roads, light, water, health center, telecommunication, education center, big buildings, and related service giving centers are expanded. The key informant interview with elderly community also confirmed recent expansion of Bahir Dar city and expressed the increase of Bahir Dar city infrastructure radically after the coming of Ethiopian People's Revolutionary Democratic Front (EPRDF) government in Ethiopia. As a result, the ruling system is changed from socialism to Federalism, free market system is promoted and the traders constructed different buildings for commercial purposes, asphalt roads are expanded, education, housing, and other service giving centers are also expanded. Moreover, the informants mentioned the present Alma building, Dib Anbessa hotel, Ethio-star and Zagole were previously part of Lake Tana and now become part of urban area. Besides, observation of Bahir Dar city in different corners during ground control point collection confirmed this.

5. Conclusion

The change detection analysis about the LULC dynamics of Bahir Dar city and the causes for it assessed using satellite images of year 1986, 1998, 2006, 2016; key informant interviews and other socio-economic data showed that Bahir Dar city has a significant change in its land use land cover during the last study periods. The built up area and vegetation cover continuously increased. However, agricultural area, water bodies, open land, and wetland showed both decreasing and increasing trends during the study periods with decline of wetland, agricultural areas, open land, and a slight increase of water body in the final study period. The boost in urban (built up) area in the city has been at the expense of agricultural area, open lands, and wetlands. The analysis result also indicated population increase, economic development, and other related factors like urban and government policy as causes for the land use pattern changed of the city. Hence, understanding of urban growth pattern and its impact on the surrounding environmental resources is exceptionally crucial for sustainable growth of urban infrastructure, urban land management, urban waste management and its expansion plan. Thus, appropriate urban planning policy should be designed to reduce the adverse effect of urban expansion and enhance the sustainability of surrounding environmental resources.

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