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Effects of urban growth on historical land use/land cover changes in the Sunyani Municipality, Ghana

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Abstract
Geospatial techniques are very effective in establishing the extent of, and trends in human-induced land use/land cover (LULC) changes in urban areas globally. However, despite the rapid urbanization of Sunyani owing to the exponential rise in the city's population, there are limited empirical studies on the effects of the rapid urbanization of the city on historical LULC changes and how that informs uban policy making. Employing historical population data, supervised classification techniques and remotely sensed Landsat data for the years 1986, 2000, 2005, 2011, 2015, and 2018, this study analyzes the extent to which the growth of the municipality has impacted the urban landscape. The municipality's population has been growing with an intercensal population growth rate of 2.3%. LULC trends in our study were similar to development in most mid-sized cities across the world. The study recorded a significant growth in area covered by built-up and farmlands resulting in a corresponding decrease in closed and open forest. The study therefore concludes that, the rapid urbanization of the city results in the conversion of green spaces into other land uses with consequences for growth management, service provision, mobility, diversity and livability, conservation of species and ecosystems and the restoration of damaged environmental components. Consequently, the study recommends the strict enforcement of land use regulations to protect land uses that are under the threat of urban expansion to ensure sustainable development in the city.

Keywords
Population growth; Urbanization; Land Use and Land Cover Changes; GIS and Remote sensing; Mid-sized cities

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1. Introduction

The 21st-century world is experiencing exponential increases in human population. According to the united nations (UN), the world's population increased from 2.5 billion in 1950 to 7.3 billion in 2015 and is projected to reach 9.8 billion by 2050 (UN DESA, 2010). Almost all the expected increases in human population are happening in developing countries in Asia and sub-Saharan Africa. This rapid population growth occurs simultaneously with rapid urbanization (Mosammam, et al., 2017). Recent estimates by the UN reveal that about 55 percent of the world's population currently live in urban areas (UN DESA, 2018). According to the report, America and Europe, are the most urbanized regions with urban population estimates of 82 and 81 percent respectively while Asia and Africa are the least urbanized with 50 and 43 percent urban population respectively. Despite the relatively low urban populations of Africa and Asia, they are expected to host about 90 percent of the projected 2.5

billion increase in urban population by 2050 (UNDESA, 2018). This will certainly significantly transform the urban landscape in these regions and impact negatively on the urban environment (Mosammam, et al., 2017).

The population and urbanization trends in Ghana are not different from what persists in developing countries across the world. According to Yankson et al. (2004), the urban population of Ghana grew from 9 percent in 1931 to 31 percent in 1984 and 44 percent in 2004. The country reached an estimated 51 percent urban population in 2010 with a majority of the urban population concentrated in a few major cities (GSS, 2014). Urbanization in Ghana is currently happening in medium-sized cities such as Sunyani, the administrative capital of the Bono region of Ghana. It lies in the transitional agro-ecological belt of the country between Latitudes 7°55'51.53" N and Longitudes 1°40'49.01", covering a total land area of 829.3 km². The population of the Municipality more than doubled from 60,344 in 1970 to 123,224 in 2010, with an inter-censual growth rate of 2.3 percent. The rapid growth of the city has resulted in significant changes in land use and land cover (LULC) and sprawl, and the situation is compounded by haphazard and inappropriate planning systems. With the recent increase in global advocacy for sustainable urban development, urban planners, developers, policymakers, and research organizations in Ghana have intensified efforts to develop innovative and novel approaches to plan and develop livable cities (Attua and Fisher, 2011). According to Dewan and Yamaguchi (2009), this will require accurate and timely monitoring and analysis of growth patterns in urban areas.

Geospatial technologies and tools are very effective and efficient in monitoring the extent and trends of growth in urban areas in recent years and have therefore received intensified research interest globally (Bhatta, 2010; Belal and Moghanm, 2011; Bhat et al., 2017; Abass et al., 2018). However, despite the rapid urbanization trends in Sunyani there is no known empirical study that has attempted to unpack the LULC dynamics of the city as a way of informing broader urban planning decision-making. Even if there is any such study, it did not adopt any of these modern technologies in assessing the effect of the rapid growth of the city on overall growth management, service provision and diversity among others. The few studies that have adopted such technologies in urban research in Ghanaian context have largely focused on established cities such as Accra (Yankson and Bertrand, 2012; Yeboah et al., 2017), Kumasi (Cobbinah and Amoako, 2012; Abass et al., 2018) and Takoradi (Aduah and Baffoe, 2013) while neglecting emerging mid-sized cities such as Sunyani.

However, mid-sized cities, including Sunyani are net recipients of migrants, projected as centers of enormous opportunity, and are becoming ideal locations to re-engineer the creative potentials of cities (Anaafo and Inkoom, 2016). This study, therefore, seeks to assess the extent to which the rapid urbanisation of the Sunyani municipality has impacted on the natural environment. Although this study is one case in the Ghanaian and developing country context, it represents one tendency in the bivariate relations between rapid urbanization and LULC change and will contribute significantly to the growing discourse on appropriate ways of dealing with the challenges of urbanization in emerging cities. It is also expected to generate much-needed data to help urban policymakers in Sunyani and elsewhere shape the contours of growth and development of emerging cities to promote efficient planning and build the resilience of medium-sized cities to the urbanization challenge.

1.1 Conceptualising Urbanisation and Land Use Land Cover Change

Urbanisation has been with us since humanity moved away from nomadism to sedentary lifestyles based on human settlement formation and the domestication of wild animals and farming for consumption. The UN Habitat (2013) indicates that just about a century ago, two out of 10 people globally were living in cities. Fast forward to 2021, the World Bank (2021) estimates that by 2050, the urban population would more than double, and 7 out of 10 people in the world will be living in cities. Global urbanisation dynamics also have regional differences. The UN Habitat (2013) further indicates that while the majority of urban dwellers in the 1950s where located in urban areas in developed countries, the trend has since changed with 7 out of 10 urban dwellers presently found in developing countries.

UNDESA (2012) also indicates that nearly all the expected growth in world population will happen in urban areas in the developing regions of the world which will see their urban population rise from 2.7 billion in 2011 to 5.1 billion in 2050. Quite important for this study, however, is the number of people living in mid-sized growth and transition cities, thereby contributing to the relevance of the study and choice of study area. The UNDESA (2018) observes that urban growth is happening at a faster pace in cities with fewer than 1 million inhabitants, many of which are in Asia and Africa. The report further indicates that while one in eight people live in 33 megacities worldwide, nearly half of the world's urban population reside in medium size settlements with fewer than 500,000 inhabitants. These are the type of cities conceptualised as mid-sized growth and transition cities in this study. These urbanisation dynamics have implications for the urban environment, energy and resource consumption and most fundamentally, land use and land cover changes. These also have implications for urban sustainability, particularly of mid-sized cities which have the potential to sustainably navigate some of the urban plagues that have bedevilled established cities globally. Some of the effects of urbanisation on the sustainable development of cities in general and LULC changes in particular, will be further examined.

To start with, one of the most widely discussed effects of urbanisation is urban sprawl. While there is no consensus on what urban sprawl means, Galster et al., (2001) define sprawl as a condition of land use for a given point in time or a process of land use change over a certain period. The effects of this widely discussed urbanisation dynamic is dispersed land development (Ewing et al., 2002; Alberti, 2005) which is said to have further consequences for land consumption, the loss of agricultural land resources as well as poor access to jobs, schools, hospitals and other essential social services (Schneider and Woodcock, 2008). Another emerging area of concern is climate change. Urbanisation and climate change are discussed as having reciprocal effects on each other. The concentration of population, industries and critical infrastructure accompanied with the consumption of energy and natural resources are seen as drivers of climate change. Conversely, the concentration of people, industrial and cultural activities in cities, make them centres of innovation, where strategies for reducing the emission of greenhouse gases and improving mitigation and adaptation can be harnessed (UN Habitat, 2011).

Essential to this study is, however, LULC changes in a mid-sized growth and transition city and how geospatial analysis can increase our understanding of city dynamics and catalyse the emergence of innovative policy tools to guide sustainable urbanisation. It is important to begin this discussion by defining what constitutes urban land and therefore urban land cover. For purposes of this study, urban land is simply the land cover types present in a particular urban space as measured against the percentage of impervious surface (Arnold and Gibbons, 1996; Schneider and Woodcock, 2008). Land-cover on the other hand is the physical characteristics of the earth's surface, in relation to the spatial mix of vegetation, water, soil and other physical features of the land, including land cover resulting from human activities, such as settlements (Ramachandra & Kumar, 2004). Urbanisation, has various effects on LULC and our understanding of those effects are important to the creation of sustainable cities. Some of the effects of urbanisation on LULC is loss of vegetation which results in increase in impermeable non-transpiring, non-evaporating, concretized land surfaces (Hussein et al., 2014; Kumar et al., 2012; Buyadi et al., 2013; Ibrahim, 2017). Again LULC changes in urban areas affects humidity in the air (Abdullah, 2012) and can result in the phenomena general referred to as urban heat island effect (Ibrahim, 2017). These emerging understanding of the effects of LULC changes require that studies such as the present are undertaken to generate much needed scientific data to guide sustainable urban planning, particularly in rapidly urbanising mid-sized cities.

2. Materials and Methods

2.1 Study Area

The study was conducted in Sunyani, the regional capital of the Bono Region of Ghana. It is situated at the central part of the region at latitudes 70.20°N and 70.05°N and longitudes 20.50°W and 20.30°W. The municipality has an aggregate land area of 829.3 square kilometers and a total population of 123, 224 with about 84.6 percent of its population currently living in urban areas (GSS, 2014). The city is growing rapidly to engulf surrounding peripheral communities. The municipality falls within the wet Semi-Equatorial Climatic Zone of Ghana with monthly temperature and relative humidity ranging between 23ºC and 33ºC and 70 percent and 80 percent respectively (GSS, 2014). It also experiences a bimodal precipitation pattern with annual average precipitation of 88.99 mm. Sunyani falls within the moist–semi-deciduous forest zone and covers portions of two major forest reserves (Yaya and Amoma forest reserves) (GSS, 2014). However, as a result of recurrent bushfires, logging, unsustainable agricultural practices, infrastructural and residential development, and other anthropogenic activities in the rapidly growing city, these reserves have been severely degraded. This has altered the general climatic condition of the municipality resulting in the dry up of most of the rivers and streams which supply water for domestic and industrial purposes (GSS, 2014). Figure 1 shows the location of Sunyani within the National and Regional context of Ghana and Bono region, respectively.

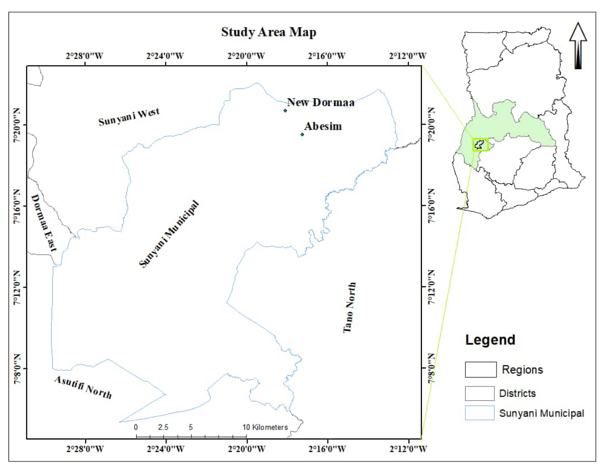

Figure 1. Map of the Study Area in the Context of Ghana and Bono Region

2.2 Data acquisition and sources

Population data for the study were obtained from the 2010 population and housing census district analytical report and the 4-year medium-term development plan for the municipality (GSS, 2012; SMA, 2014). However, due to data unavailability in the years 2005, 2011, 2015, and

2018 as censuses were not conducted within these periods, population figures for these years were calculated based on the annual population growth rate for the municipality between 2000 and 2010 estimated at 2.3% per annum (GSS, 2012; SMA, 2014). Spatial data for the study were downloaded from the U.S Geological Survey (USGS) Earth Explorer database due to the unrestricted access and extended temporal coverage of the dataset. A total of six (6) datasets were acquired for this study comprising of Landsat 5, 7, and 8 images for the years 1986, 2000, 2005, 2011, 2015, and 2018. The selection of the various years for the images used in this study was based on data availability and cloud cover percentage. Also, field observation and ground truth data collection exercises were conducted to collect a total of 250 points, 50 each for the various LULC classes which served as the basis for image analysis, classification, and accuracy assessment. A summary description of the Landsat datasets used in the study is presented in Table 1.

2.3 Data analysis

The spatial data for the study was processed using ENVI 5.3 and ArcGIS 10.2. Image processing techniques such as geometric, atmospheric, and radiometric corrections, image enhancement, and classification were used in this study. All the images were geo-referenced and projected to World Geodetic System (WGS84) and Universal Transverse Mercator (UTM) zone 30 north. Images with atmospheric distortions and scan lines were corrected using QUick atmospheric correction and the gap-fill methods in ENVI. Supervised classification techniques were used in image classification. The maximum likelihood algorithm was used to classify the images based on the training data obtained from the field observation and ground-truthing. The images were classified into six (6) classes namely closed forest, open forest, built up, farmland, and bare land. Table 2 describes the different LULC classes used in the study. The post-classification change analysis method was used to determine the changes in land cover types over time. An inter-pixel analysis of LULC classes was conducted to determine the changes in LULC classes. The annual and percentage annual rates of change for the different land cover classes were also estimated using MS Excel. A confusion matrix was computed from the referenced (50 points per class) and classification data from which the user accuracy, producer accuracy, overall accuracy, and Kappa coefficient were computed to determine the extent of accuracy in the classification.

3. Results

3.1 Analysis of population trends in the Sunyani Municipality

The study revealed variation in population trends in the Sunyani municipality. Though population data was unavailable for the base year of the study (1986), an estimated population of 98,183 was recorded in the municipality in 1984. This increased significantly to 179,165 in 2000 and 200,739 in 2005. The year 2011 however experienced a reduction (126, 058) in the population of the municipality due to the division of the municipality into two namely the Sunyani municipality and Sunyani wast district before the 2010 population and housing census. The rising trend in the population of the municipality however continued after 2011 with the years 2015 and 2018 recording estimated population values of 138,062 and 147,809 respectively (Table 3).

3.2 Accuracy assessment of classified images

The assessment of the accuracy levels of the classified images revealed very high overall accuracy and Kappa coefficient values for the study periods. Among the six different periods of the study, the highest overall accuracy (88.8%) was recorded in 2018 whereas the lowest (73%) was recorded in 2000. The 1986, 2005, 2011, and 2015 image classifications recorded overall accuracy values of 80 percent, 75 percent, 86 percent, and 80 percent, respectively. Similar to the trend of overall accuracy assessment, the highest Kappa coefficient value (0.86) was recorded in 2018 while the lowest (0.66) was recorded in 2000. Kappa coefficient values of 0.75, 0.70, 0.83 and 0.75 were recorded for the 1986, 2005, 2011 and 2015 images, respectively. Table 3 is a summary of the accuracy assessment records of the classified images.

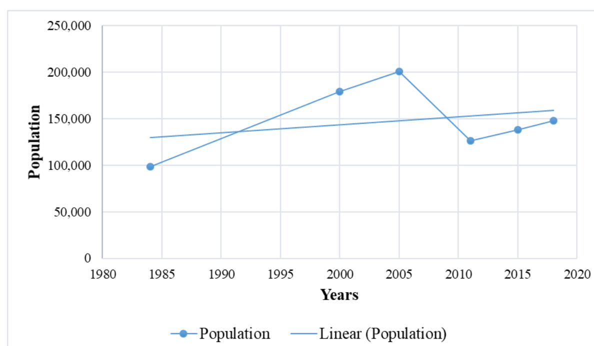

Figure 2. Analysis of Population Trends in the Sunyani Municipality

Table 1. Landsat Images Used in the LULC Analysis

Landsat	Satellite Sensor	WRS Path/Row	Acquisition Date	Spatial Resolution	Spectral Resolution	Source
Landsat 5	ETM	195/055	1/18/1986	30m	7	Earth Explorer
Landsat 7	ETM	195/055	2/2/2000	30m	8	
Landsat 7	ETM	195/055	2/15/2005	30m	8	
Landsat 7	ETM	195/055	1/15/2011	30m	8	
Landsat 7	ETM	195/055	12/12/2015	30m	8	
Landsat 8	OLI	195/055	28/12/2018	30m	11	

OLI Operational Land Imagery, ETM Enhanced Thematic Mapper, and TM Thematic Mapper

Table 2. Description of LULC Classification Schemes

LULC Classes	Descriptions of LULC Classes
Closed Forest (CF)	These are areas covered with a dense vegetative cover typical of tropical rainforest. These areas are covered with trees whose branches and leaves form a closed canopy allowing little or no light penetration.
Open Forest (OF)	These are areas covered with shrubs, herbaceous perennials, grasses, fallowing farmlands, and patches of forests.
Built-Up	These are areas with residential (urban, peri-urban to rural settlements), commercial, and industrial structures. They are dominated by settlements, tarred roads, and concretized surfaces.
Farmlands (FL)	These are areas under cultivation. They are usually covered by cash crops, perennial crops, cereals, etc.
Bare Land (BL)	These are areas not covered by vegetation. They include burnt areas, untarred roads, etc.

Source: Modified from Appiah (2017)

3.3 Analysis of LULC variations for the 1986 and 2000 images

The results of the study revealed variation in LULC classes for the different study periods. Analysis of the 1986 image revealed a high degree of degradation in the study area evident by the dominance of the open forest cover compared to the other LULC classes. The observed LULC dynamics are indicative of the nationwide wildfire incidence in 1983 which resulted in a large-scale forest disturbance in the municipality. The study area in the year under consideration was therefore dominated by the open forests with limited built up, bare land, farmland, and closed forest cover. The open forest covered an area of 29503.8 ha representing 58.2 percent of the total land area of the municipality. This was followed by the closed forest and farmland which covered 9203.9 ha and 7053.2 ha representing 18.2 percent and 13.9 percent of the total landmass, respectively. Only small patches of bare land were observed with a total area of 2724.2 ha representing 5.4 percent of the land area of the municipality. The built-up, however, occupied the smallest land area with an estimated land cover of 2185.1 ha representing only 4.3 percent of the total land area of the municipality.

In 2000, there were differences in the dynamics of the LULC classes from 1986 which was dominated by the open forest class. The open forest class lost its dominance having lost a considerable portion of its area to the other land cover classes as a result of the increase in human activities in the municipality. In 2000, farmland became the dominant class in the municipality with an estimated area of 19136.6 ha representing 37.8 percent while the open forest-covered 17846.7 ha representing 35.2 percent. This was followed by the closed forest and built up which covered 6805.7 ha and 4865.1 ha of the area representing 13.4 and 9.6 percent respectively. Also, the bare land lost part of its area coverage in 2000 becoming the smallest land cover class in the municipality with an estimated area coverage of 2015.0 ha representing 4 percent of the total landmass (Figure 3).

Table 3. Summary of Accuracy Assessment Records of Classified Images

Year	Overall Accuracy (%)	Overall Kappa coefficient (k)
1986	80	0.75
2000	73	0.66
2005	75	0.7
2011	86	0.83
2015	80	0.75
2018	88.8	0.86

3.4 Analysis of the LULC variations for the 2005 and 2011 images

In 2005, the open forest experienced a marginal increase in its area coverage and regained its dominance as the highest LULC class in the municipality. It covered 16550.5 ha representing 32.2 percent of the total land area of the municipality. The farmland, however, lost a substantial portion in the year under review and became the second-highest class with an estimated coverage of 14107.8 ha representing 27.8 percent. The bare land ranked next in coverage and was followed by the built-up with estimated land areas of 7200.4 ha and 7069.8 ha which represented 14.2 and 14 percentage points, respectively. Also, the closed forest experienced a further reduction in its area coverage and occupied only 5740.8 ha representing 11.3

percent being the least for the year under review. This trend indicates a further increase in human activities in the municipality from the previous years.

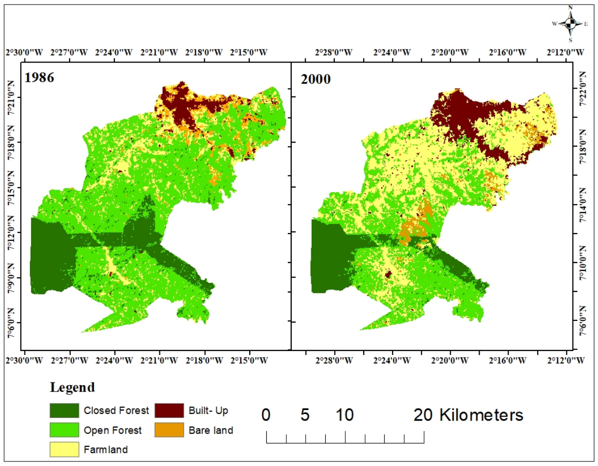

Figure 3. LULC Variations for 1986 and 2002 Images

In 2011, though the open forest experienced a marginal decrease in its area coverage, it remained the dominant LULC class in the study area. The class covered an area of 16334.1 ha representing 32.2 percent of the total land area of the municipality. The farmland also experienced a further reduction in its area and covered 11265.8 ha representing 22.2 percent. The deficit in coverage of these classes resulted in an increase in the built-up and bare land classes. The built-up recorded an estimated area coverage of 7762.5 ha representing 15.3 percent while the bare land occupied 9558.9 ha representing 18.9 percent of the land area of the municipality. The closed forest, however, saw no change in its area coverage from the previous year occupying a total area of 5748.2 ha which represents 11.3 percent (Figure 4).

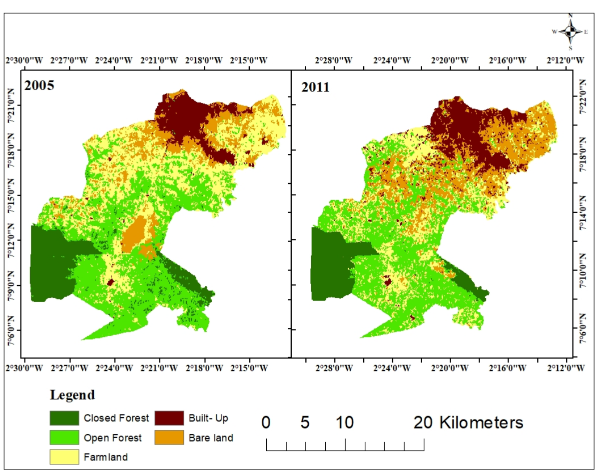

Figure 4. LULC Variations for 2005 and 2011 Images

3.5 Analysis of the LULC variations for the 2015 and 2018 images

An entirely different dimension in LULC coverage was observed in the study area in 2015. The increase in farming activities in the municipality saw farmlands transition into other LULC classes in the municipality. In the year under review, farmland regained its dominance with an estimated area coverage of 15894.8 ha representing 31.4 percent of the total landmass of the municipality. The open forest, though second in rank in terms of area coverage experienced a substantial reduction in its area coverage from the previous year. The class covered 14136.0 ha representing 27.9 percent of the total land area of the municipality. The built-up class also continued its increasing trend from the previous years and occupied an estimated area of 9293.9 ha representing 18.3 percent of the total land area of the municipality. Also, the area of bare land was further reduced to 5635.7 ha being 11.1 percent of the total land area of the municipality. The closed forest covered 5709.0 ha representing 11.3 of the total land area. This was consistent maintenance of its cover under two consecutive years of review which may be due to the strict protection of the forest reserves in the municipality.

The 2018 image showed highly significant alterations in LULC patterns in the municipality. Though the open forest was the dominant LULC class in the municipality in 2018, its area coverage was lower compared to 2015. The open forest covered 13844.6 ha which represents 27.3 percent of the total land area of the municipality. This was followed by the farmland and built-up classes with estimated land areas of 12479.8 ha and 10790.0 ha representing 24.6 and 21.3 percentage points, respectively. It is interesting to note that by 2018, the built-up area was becoming one of the dominant LULC classes in the municipality. The bare land also saw a further increase in its area coverage in 2015 while the closed forest experienced a reduction in its area coverage. The bare land covered an area of 8796.8 ha while the closed forest class covered an area of 4759.0 ha representing 17.4 and 9.4 percent respectively (Figure 5).

A critical analysis of the general extent of changes in LULC classes in the municipality reveals an exponential increase in human activities from 1986 to 2018 which resulted in changes in the LULC patterns of the municipality. The steady increase in the built-up, reduction in open and closed forest, and irregular change patterns of farmlands is an indication of the rapidly urbanizing nature of the municipality. As revealed in Figures 4.1, 4.2, and 4.3, the built-up class experienced a rising trend in area coverage from the base year (1986) to the final year (2018) of the study. By 2018, the built-up which occupied only a small portion of the area in the base year (1986) had become one of the dominant LULC classes occupying 21.3 percent of the total land area of the municipality.

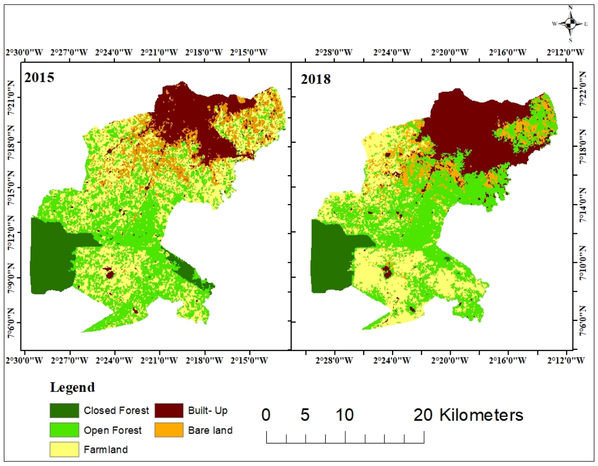

Figure 5. LULC Variations for 2015 and 2018 Images

The farmland, however, saw a fluctuating trend in its area coverage. The open forest class, which represented the most dominant LULC class in the municipality in the base year also experienced an inconsistent reducing trend until the final year of the study. It, however, remained the highest LULC class in the final year of the study. Also, the closed forest which was the second dominant LULC class in the study area in the base year experienced a generally reducing trend over the study period. Though its area coverage was maintained in 2011 and 2015, the class further reduced in 2018 becoming the lowest compared to the other LULC classes in the study area by the final year of the study (Table 4).

3.6 Analysis of the trends in LULC between 1986 and 2000

The analysis of the 1986 and 2000 images revealed that, between those 14 years, the open forest class reduced by 11657.1 ha representing 23 percentage loss from its base area coverage. The period also experienced a reduction in the closed forest and bare land by an estimated 2398.1 and 709.2 ha representing 4.7 and 1.4 percentage points, respectively. The other LULC classes, however, increased within this period with the farmland and built-up classes gaining 12083.4 ha and 2680.0 ha which represent 23.8 and 0.4 percentage points gain, respectively over its base cover. The trend indicates a gradual rise in human disturbances in the municipality as a result of the rise in population.

3.7 Analysis of the trends in LULC between 2005 and 2011

Trends similar to the previous years were observed in the changes in LULC classes between 2005 and 2011. However, within this period only the open forest and farmland experienced a reduction in their area while the other classes either increased or maintained their area. The open forest reduced by 216.4 ha while the farmland reduced by 2841.9 ha representing 0.4 and 5.4 percentage points reduction, respectively. These decreases resulted in transitional increases in the built-up and bare land with 1.4 and 4.4 percentage point increases in their area covered, respectively. The closed forest, on the other hand, maintained its area coverage having recorded no change within the period.

3.8 Analysis of the trends in LULC between 2015 and 2018

Between 2015 and 2018, there was a reduction in the closed forest, open forest, and farmland while the other classes experienced increases in area coverage. The closed forest lost an estimated 950.0 ha representing 1.9 percent while the open forest and farmland lost 0.6 and 6.7 percentage points, respectively. The loss of farmlands within this period was the highest over the entire study period. The losses of the open forests and farmlands resulted in corresponding increases in the built-up and bare land by 3 and 6.2 percentage points, respectively.

It is also interesting to note that as the city develops, both farmland and built-up classes continued to increase while the closed and open forest classes decreased until a stage in the development of the city where the closed forest is almost exhausted or put under strict protection. Further development in the built-up became possible at this stage only through the conversion of farmlands due to their ease of conversion compared to other LULC classes. This pushes agriculture activities to the periphery.

3.9 Analysis of the trends in LULC between 1986 and 2018

A final assessment of the changes in the trend of LULC classes over the entire study period from the base year (1986) to the final year of reference (2018) revealed an entirely different dimension in area coverage. Over the entire study period, there was a tremendous decrease in the open and closed forest cover by 4444.8 ha and 15659.2 ha which represents 8.8 and 30.9 percent losses, respectively from their base coverages. Interestingly, the built-up class increased by an estimated 8604.9 ha which represents a 17 percent increment over its base area. The farmland and bare land also gained 5426.6 ha and 6072.6 ha representing a 10.7 and 12 percent increase over their base area respectively (Table 5).

Table 4. Composite Table of LULC Changes for the Study Periods

	LULC 1986	LULC 2000	LULC 2005	LULC 2011	LULC 2015	LULC 2018						
Class Name	Area (Ha)	Cover (%)	Area (Ha)	Cover (%)	Area (Ha)	Cover (%)	Area (Ha)	Cover (%)	Area (Ha)	Cover (%)	Area (Ha)	Cover (%)
CF	9203.9	18.2	6805.7	13.4	5740.8	11.3	5748.2	11.3	5709	11.3	4759	9.4
OF	29503.8	58.2	17846.7	35.2	16550.5	32.7	16334.1	32.2	14136	27.9	13844.6	27.3
FL	7053.2	13.9	19136.6	37.8	14107.8	27.8	11265.8	22.2	15894.8	31.4	12479.8	24.6
BU	2185.1	4.3	4865.1	9.6	7069.8	14	7762.5	15.3	9293.9	18.3	10790	21.3
BL	2724.2	5.4	2015	4	7200.4	14.2	9558.9	18.9	5635.7	11.1	8796.8	17.4

Closed Forest (CF), Open Forest (OF), Farmland (FL), Built-Up (BU), Bare land (BL)

Table 5. Composite Table for the Analysis of the Trends in LULC for the Study Period

	LULC 1986 - 2000	LULC 2005 - 2011	LULC 2015 - 2018	LULC 1986 - 2018								
Class Name	Area (Ha)	Cover (%)	Annual (%)	Area (Ha)	Cover (%)	Annual (%)	Area (Ha)	Cover (%)	Annual (%)	Area (Ha)	Cover (%)	Annual (%)
CF	-2398.1	-4.7	-0.3	7.4	0	0	-950	-1.9	-0.6	-4444.8	-8.8	-0.3
OF	-11657.1	-23	-1.6	-216.4	-0.4	-0.1	-291.4	-0.6	-0.2	-15659.2	-30.9	-1
FL	12083.4	23.8	1.7	-2841.9	-5.6	-0.9	-3415.1	-6.7	-2.2	5426.6	10.7	0.3
BU	2680	5.3	0.4	692.7	1.4	0.2	1496.1	3	1	8604.9	17	0.5
BL	-709.2	-1.4	-0.1	2358.5	4.7	0.8	3161.1	6.2	2.1	6072.6	12	0.4

Closed Forest (CF), Open Forest (OF), Farmland (FL), Built-Up (BU), Bare land (BL)

4. Discussion

4.1 Analysis of population trends in the Sunyani Municipality

The study revealed an increasing trend in the population of the municipality over the study period. Though some aspects of the data (2011, 2015, and 2018) revealed a decline in population from the previous years, this was largely due to the division of the municipality into Sunyani municipal and Sunyani west district and not a natural manifestation of population reduction in the municipality. The rising population after the separation as revealed in the 2015 and 2018 figures indicates a trend consistent with the population dynamics before the division of the municipality in 2010. Such rising trends in urban population have been largely reported in urban areas in developing countries due to their characteristic high fertility rates and rural-urban migration (Hegazy and Kaloop, 2015; Yousif et al., 2015; Stow et al., 2016; Bhat et al., 2017). The rapidly growing population of the municipality has implication for growth management and landuse planning generally, and housing, transportation, environmental protection, and energy and materials use.

Also, socioeconomic factors such as employment, proximity to resources, and basic amenities have been widely cited as pull factors to urban areas in Africa (Hegazy and Kaloop, 2015; Bhat et al., 2017). According to Yeboah et al. (2017), socio-economic and urban biased development policies in Ghana which centralized developmental activities in urban areas attracted many rural folks into cities which have largely raised the population of cities in Ghana. The situation in Sunyani is particularly worrying as it is estimated to host an estimated 83.1% urban population growing at 3.6% per anum compared to the 51% national urban population and 4.2% growth rate (GSS, 2014, Abass et al., 2018). A characteristic feature of such rise in urban population is the rise in demand for housing, schools, roads, and other infrastructural facilities to accommodate immigrants which contributes to the conversion of agricultural lands, green spaces, open spaces, and other ecologically sensitive habitats with negative impacts on the general environmental condition of the municipality (Hegazy and Kaloop, 2015, Yousif et al., 2015, Stow et al., 2016). The results are consistent with many studies which have established relations between population growth and urbanization (Hegazy and Kaloop, 2015; El Garouani et al., 2017; Abass et al., 2018). E.g., In a study in Egypt, Hegazy and Kaloop (2015) reported that rapid growth in urban population has a corresponding impact on urban expansion and natural resources base within the urban environment. In a similar study in Morocco, 2 reported that accelerated growth in the urban population in Fez generated a rapid growth and expansion of the city resulting in negative impacts on the natural environment. Many studies in Ghana have also reported that a greater percentage of the country's population is concentrated within cities (Asuah, 2014; Yeboah et al., 2017). According to Asuah (2014), the urban population of Ghana increased from 23% in 1960 to 29% in 1970 and 32% in 1984 to 44% in 2000 and 51% in 2010 with an annual growth rate of 4.2% compared to the national growth rate of 2.5%. Yeboah et al. (2017). also reported that the population of Accra doubled between 1984 and 2000 with the city hosting about 25% of the urban population of Ghana and increasing at a rate of 3.4% per anum. This growth in urban population according to the authors is the driving force of the rapid urbanization trend in the city with unintended negative impacts on the environmental condition of the city.

4.2 Analysis of the LULC patterns and trends for the Sunyani Municipality

The assessment of the accuracy levels of the classified images revealed very high overall accuracy and Kappa coefficient values for the study periods. The differences in the image classifications can be attributed to the differences in the quality of images used in the study resulting in some misclassifications of LULC classes. However, with all the Kappa coefficient values of the different study periods falling within the substantial (0.60–0.80) and almost perfect agreement (0.81–1.0) ranges (Mangi and Marsh, 2002), it can be concluded that there were limited deviations between the classified image and the reference data used for accuracy assessment. Analysis of the general extent of changes in LULC classes in the municipality reveals that the Sunyani municipality is urbanizing rapidly. This growth has resulted in significant modifications in the LULC pattern of the area. Interestingly, the built-up which covered only a small portion of the landmass in the base year was one of the dominant land cover classes at the end of the study period while the open forest which dominated in the base year lost a substantial part of its coverage by the final year of the study. This trend represents a highly spatial developmental pattern that puts green spaces which are the ecologically sensitive areas in the urban environment under intense pressure.

The dynamics in vegetation cover of the municipality between 1986 and 2000 could be traced to the 1983 national wildfire incident which resulted in the destruction of most forests and farmlands in the municipality. Though the 1986 image showed some percentage of closed forest cover, significant portions of the forest that could not recover from the disturbance were converted into open forests. Also, the destruction of most farms in the country during the fire incident resulted in a nationwide famine (Antwi et al., 2014). Agriculture, therefore, became a very lucrative venture due to the high demand for agricultural produce. With the majority of the population in the municipality engaged in agriculture within this period, the activities of these farmers may have resulted in the conversion of most of the open forest and bare lands into agricultural land to meet the food demands of the residents of the municipality and inhabitants of other parts of the region. This may have accounted for the increase in area covered by farmlands in the municipality within the period. This is supported by the literature in which Sunyani is discussed as an important hub for the production and distribution of cocoa and food crops such as maize and yam (Anane, 2013). However, the 1983 wildfire incident destroyed most of these farms which discouraged most of the farmers from engaging in cocoa farming (Antwi et al., 2014).

Nevertheless, increased farming activities after the incident may have contributed to the increase in farmlands and reduction in open forests and bare lands in the municipality. Also, the increase in the population of the municipality from 38,634 in 1984 to 61,992 in 2000 according to the GSS (GSS, 2002) may have increased the demand for housing and food and therefore the increase in built-up and farmlands in the municipality (Appiah et al., 2014). This might have put immense pressure on the limited infrastructural facilities of the municipality. Improving the infrastructure status of the municipality to meet the demands of the rising population may have resulted in the conversion of some forested parts of the municipality into recreational centers, markets, hospitals, roads, schools, and residential facilities. Around the same period, government policies on the expansion of the timber industry through the implementation of the Structural Adjustment Programme from 1983 to the early 1990s contributed to the conversion of some of the forested areas of the city to provide raw materials for the timber industry (Antwi et al., 2014).

The declaration of Sunyani as the cleanest city in Ghana by the Ghana Tourist Board in 2007 may have attracted some of the residents of the overcrowded cities in Ghana into the municipality. Due to the relatively cheap and easy access to land in the municipality compared to the established cities in Ghana, they can buy land at ease and convert into residential properties which may have increased the built-up class within this period. Also, the amendment of the 1994 forest and wildlife policy in Ghana, saw the introduction of the 2012 policy which apart from the reinforcement of the restrictions in the conversion of forest in protected areas also encouraged tree planting in degraded forest reserves all over the country (Antwi et al., 2014). Though greater portions of the degraded forest areas in the municipality were planted through this policy, the results of this study suggest that the rate of forest degradation is higher than reforestation which may have accounted for the consistent trend of forest losses in the municipality.

Interestingly, despite the introduction of the planting for food and jobs policy by the current government, aimed at increasing food production nationwide, the farmland saw a reduction in area coverage. The findings conform to previous studies by Appiah (2017) who observed a decline in dense forest cover of Bosomtwi while low forest, built-up, bare land, recent fallows, and grasslands increased. The trend of changes observed over the entire study period is supportive of the widely held notion that, during LULC transitioning from forest cover to other land uses, the LULC class which is predominantly featured is the built-up (Antwi et al., 2014; Stow et al., 2016; Yeboah et al., 2017). The observed trends in changes in LULC classes in the municipality may be due to a combination of factors such as the rising population of the city, non-compliance of chiefs to land use regulations, rural-urban migration, unfavorable government land-use policies, poor enforcement of land use regulations, increase in the provision of urban infrastructure and agriculture activities. These have been widely influenced by the quiet, clean, and relatively peaceful nature of the study area as well as its regional capital status which attracts a lot of people from the other parts of the country as well as rural people from the suburbs of the region to benefit from the business opportunities in the capital. Also, that the existence of higher institutions of learning such as the Sunyani Technical University, the Sunyani Nurses Training College, the Catholic University College of Ghana and the most recently the University of Energy and Natural Resources may have also contributed to the observed LULC changes in the city.

5. Conclusions

The study concludes that, the rapid population growth and accompanying urbanization and sprawl of the Sunyani Municipality has had significant impacts on the LULC dynamics of the city with built-up and farmlands experiencing a positive growth in area coverage at the early stages while green spaces were largely negatively impacted. There is evidence of the drying up of water bodies and a reduction in open and closed forest types with significant implications for diversity, livability, conservation of species and ecosystems and the restoration of damaged environmental components. However, at a stage in the growth of the city where green spaces are almost exhausted or put under strict protection, the built-up begins to make a transition into the other LULC classes.

This aids in meeting the residential and infrastructural needs of the rising population of the city while putting a threat on food and livelihood security as well as the environmental sustainability of the city. The study, therefore, recommends intensifying efforts by the Municipal Land Use and Spatial Planning Authority (LUSPA) and the assembly to enforce land use regulations to reduce human-induced landscape modifications as well as protect land uses, and species which are under the threat of rapid urbanization processes. Some of the measures that can be adopted by the LUSPA include the establishment Urban Growth Boundaries (UGBs), urban service limits and agricultural zoning. Additionally, periodic geospatial monitoring of the extent and trends of LULC changes in the municipality will be useful in making informed decisions to protect natural resources and ensure sustainable urban planning in the municipality.

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