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Spatio-Temporal Mapping of Land Use/Cover and Population Change in a Biosphere Reserve: The Case of Lake Bosomtwe Basin in Ashanti Region, Ghana.

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abstract

This paper examined land use and land cover (LULC) dynamics over 34 years in the Bosomtwe biosphere vis-à-vis population trends within a buffer of 5km using an integrated remote sensing and geographic information systems (GIS) approach to assess the changes in the land use and land cover. Supervised classification and post-classification change detection technique in GIS was applied to three multi-temporal Landsat images (1986, 2007, and 2020). The date selection was informed by the availability of Landsat imagery with limited cloud cover. The analysis showed that the built-up category recorded the highest percentage change (260.2%) with an annual rate of 7.7%. Forest cover recorded a loss of 66.3% of area coverage with an increase in farmland from 50.8% in 1986 to 68.5% in 2020. Besides, Lake Bosomtwe was contracted by 0.76 km2 over the period under review. There was a strong positive correlation between population density and both cropland ($r = 0.89$) and built-up areas ($r = 0.70$). It is recommended that intensification of monitoring activities by the district assembly would help to reduce the anthropogenic activities being conducted in the area.

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Introduction

Land use and land cover (LULC) are closely related terms often used interchangeably (Anderson et al., 1976), but are not the same. Land cover relates to the physical nature or form of the land surface (Mather, 1999) however, in the broadest sense, it encompasses vegetation, water, desert, ice, and other physical features, including those created by man (Turner et al., 1994; Rawat & Kumar, 2015). On the other hand, land use describes the way and the purposes for which human beings employ the land and its resources (Lambin et al., 2003). Thus, land use connotes a functional role of land for economic activities (Rawat & Kumar, 2015).

Al-doski et al. (2013) noted that LULC is a key environmental variable for understanding the causes and trends of human and natural processes, which have important implications for the global environment. Land-use changes result in land cover changes that affect biodiversity, ecosystems, water, radiation budgets, trace gas emissions and other processes that come together to affect climate and the biosphere (IGBP, 1990; Defries et al., 1999; Riebsame et al., 1994; Lambin et al., 2003). LULC can also affect soil fertility, land productivity, and sustainability of environmental services (Lupo et al., 2001; Alemayehu et al., 2019). Furthermore, land degradation, desertification, biodiversity loss, habitat destruction, and species transfer result from converting natural land covers (Meyer & Turner, 1995).

In understanding how LULC change affects and interacts with global earth systems, information is required on the changes that occur, where and when the changes appear, the rates at which they occur, and the social and physical forces that drive those changes (Lambin, 2003).

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Monitoring the changes in LULC is very crucial for planning, decision-making, sustainable development and launching programmes to save the environment.

There are various approaches to the monitoring of LULC and they include traditional techniques such as field surveys and remotely sensed images such as aerial photographs, and satellite images among others (Al-doski et al., 2013). Satellite remote sensing has become the most common source of data for environmental monitoring and detecting, quantifying, and mapping LULC changes at small, medium, and large scales, because of its availability, repetitive data acquisition and reasonable time interval (Forkuo & Frimpong, 2012; Hasan et al., 2021). Scientists have therefore, used remote sensing data since the 1970s when aerial photographs taken were used to produce topographical maps and to identify LULC changes (Wang et al., 2016; Mohajane et al., 2018). For instance, Kavzoglu et al. (2019) used object-based techniques to determine the LULC changes in Istanbul's metropolitan city over five years. They concluded that although Landsat imagery is of low resolutions they are equally adequate for change detection analysis. In describing the vegetation change of the Azro forest in the Middle Atlas of Morocco over 30 years (1987 and 2017), Mohajane et al. (2018), used Landsat imagery made up of Multispectral Scanner (MSS), Enhanced Thematic Mapper Plus (ETM+), Thematic Mapper (TM), and Landsat 8 Operational Land Imager (OLI). Complemented by a ground-based survey and the normalized difference vegetation index (NDVI), to identify and improve the discrimination between LULC categories identified in the area. Not only that but Ayele et al. (2018), in quantifying the spatiotemporal dynamics of LULC change between 1995 and 2014 in Northern Ethiopia, used multi-temporal cloud-free Landsat Thematic images.

There exists some literature such as (Appiah et al., 2015; Basommi, et al., 2015; Addae & Oppelt, 2019) on the application of remote sensing and GIS in LULC research in Ghana. For example, Gumma et al. (2011) in mapping irrigated areas in Ghana, fused 30m and 250m resolution remotely sensed data. In addition, the technology was also used in north-eastern Ghana to assess the driving forces of LULC (Kleemann et al., 2017), while Osei-Wusu et al. (2014) used the same to assess the LULC in the Lake Bosomtwe biosphere.

Like many other developing countries, Ghana has been experiencing significant land cover changes. For instance, Ghana's closed forest area declined by an average of 46,000 hectares per year between 1990 and 2010, while the open forest area increased by 74,000 hectares per year (FAO, 2016). The Lake Bosomtwe biosphere (study area) has not been left out of this menace. It is one of the three biosphere reserves designated in 2016 by the World Network of Biosphere Reserves (WNBR) (EPA, 2018). Like any other biosphere reserve which aims at improving the relationship between people and their environment, Lake Bosomtwe is also conformed to three zones according to the UNESCO technical report (2021); namely, core, buffer, and transition. The core is to provide information about ecosystem functions and processes, which are strictly protected and conservation of biodiversity; adjacent buffer zone allows management techniques to be developed, explored, and learned about. This helps in maintaining semi-natural ecosystems, including their biodiversity but with limited human interference, and transitional area to support and encourage local communities, enterprises, and communities in maintaining sustainable social-economic and land-use systems with least restrictions in terms of human activity (Price et al., 2010; UNESCO, 2021).

Although the Lake is of national and global importance because of its rich biodiversity, localized pollution, and the degradation of the forest cover in its catchment area are undermining its integrity (UNESCO, 2016). Evidence of changes in the LULC in the Lake area has been confirmed by recent studies (Adjei et al., 2014; Appiah et al., 2015; UNESCO, 2016). These studies show that while forests and other vegetative cover are dwindling, built-up is increasing. Both Adjei et al. (2014) and Appiah et al. (2015) have observed that there are pieces of evidence in support of marginal conversions of the Lake to other uses. Besides, population growth with its increasing demand for agricultural land, residential and tourism facilities significantly contribute to the area's LULC changes. These studies were undertaken at least five years and beyond and ought to be updated.

The objective of this study is to analyze changes in LULC within a 5km buffer area around Lake Bosomtwe over the past 34 years (1986, 2007, and 2020) using satellite imagery, specifically Landsat imagery. The study also evaluates the correlation between the changes in LULC, and population density. We hypothesize that there have been no significant alterations in LULC, and that population density is not a contributing factor to any observed changes.

Materials and Methods

Study Area

Theories have been advanced on the origin of Lake Bosomtwe. While some authors attribute the lake to be a caldera formation when the top of a volcano blew off (Boateng, 1960) others have contended that it is an impact crater, the result of a meteorite impact over a million years ago (Otu, 2010). According to Turner et al. (1996), the crater currently forms a closed basin with the basement impact breccia sealing off the lake from groundwater inputs.

The area is one of Ghana's three UNESCO biosphere reserves, an essential tool for forging healthy human-ecosystem interactions for sustainable development. The study area lies between latitude 6° 25′ 30″ and 6° 35′ 30″ north of the Equator and longitudes 1° 29′ 30″ and 1° 19′ 0″ west of the Greenwich (Figure 1). The land adjoining the Lake rises steeply from 152 to 427 m. The study area falls within three districts, namely, Bosomtwe, Bosome Freho and Bekwai Municipality. Climatologically, the area lies within the wet semi-equatorial belt in Ghana. Temperatures are high, with a mean monthly temperature of about 26ºC and total annual rainfall between 125 and 150 cm. In terms of vegetation, the area is associated with moist semi-deciduous forests. Within the 5km buffer, 39 communities exist, with Kuntanase being the largest community. Subsistence agriculture is the primary means of livelihood.

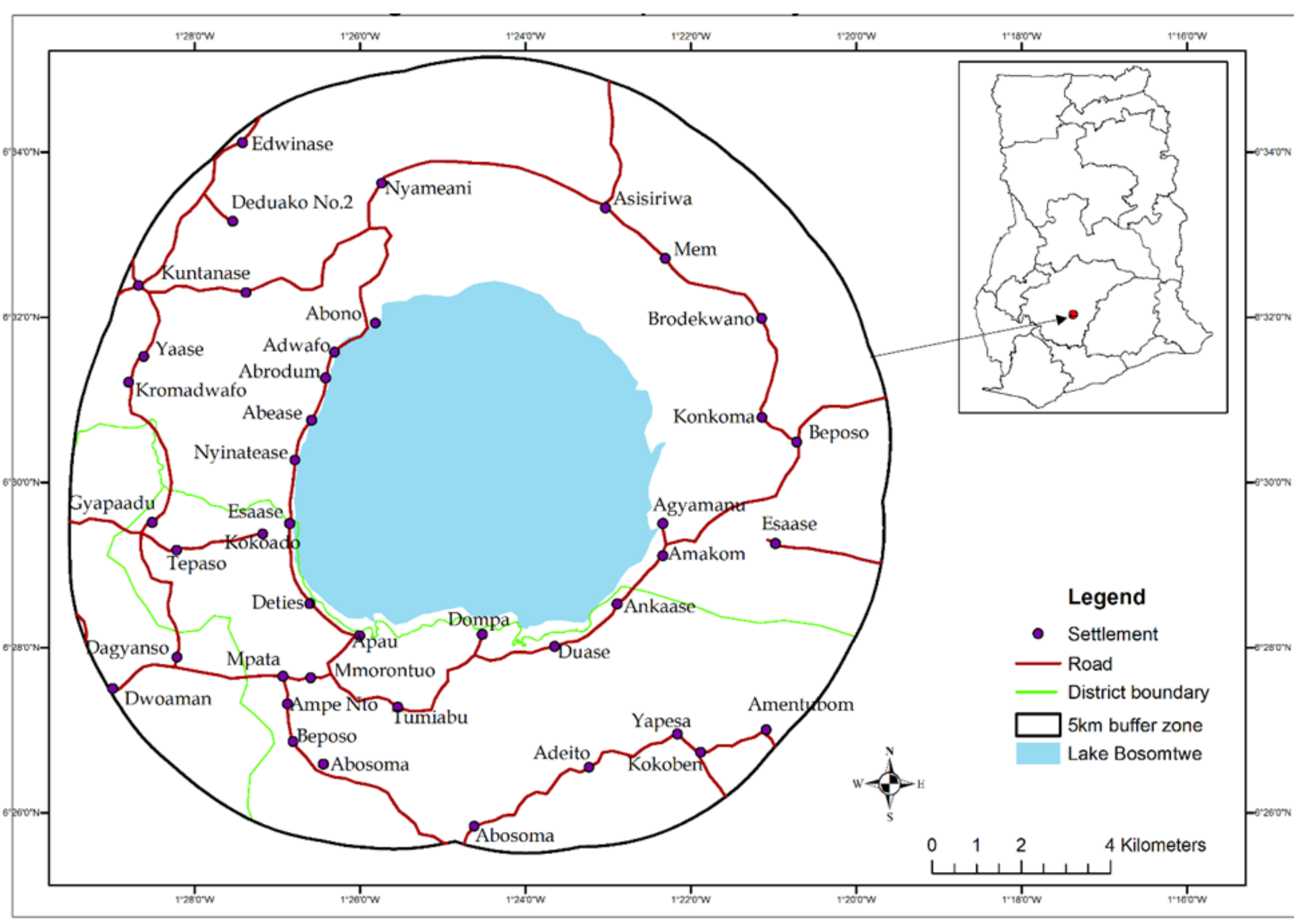

Figure 1: Location of Study Area in Ashanti Region, Ghana
Source: Field Study, 2021

The typical food crops grown are cassava, maize, and plantain while cocoa is grown as a cash crop. Additionally, fishing is an essential economic activity. The Lake and its environs have gained popularity as tourist sites (Tripadvisor, 2022). In terms of population, the area has witnessed a gradual growth from 13,204 in 1970 to 33,762 in 2021 (Ghana Statistical Service, 2022). Thus, over 51 years, the area has only witnessed variations in density over five different periods.

Data Acquisition

The following Landsat images covering path 194, rows 55 and 56 with 30 m spatial resolution were used; Thematic Mapper (TM) scene from 1986; Enhanced Thematic Mapper Plus (ETM+) scene from 2007; and Landsat 8 Operational Land Imager (OLI) scene from 2020 (Table 1). The images were downloaded from the United States Geological Survey (USGS), Glovis website (https://glovis.usgs.gov/) and were already rectified in terms of terrain precision, systematic terrain, and geometric systems.

The selection of the satellite images and years was influenced by their availability and the quality of the image, especially for those with limited or less than 30% cloud cover and captured during the dry season (from October to April) in Ghana. However, for the study area, the cloud cover for the 1986 image was 1.31%, in 2007 was 0.33% and in 2022, no cloud cover.

Image processing

The image processing was accomplished in various stages: scene identification and download, sub-setting, classification, accuracy assessment, and change detection (Chart 1). Ground truthing and accuracy assessment were done for the most current satellite image (Landsat 8 OLI, 2020) and inferences were made to the other two images (1986 and 2007). LULC change was accomplished using post-classification comparison (El-Hattab, 2016). The ground truthing involved going out into the field with printed classified images, a digital camera, and a handheld Global Positioning System (GPS) device - specifically the Garmin GPSMAP 64csx. With the help of this GPS device, we were able to identify the exact physical locations of different LULC types. This data was then compared with the information obtained from the remotely sensed data to check its accuracy. Where discrepancies occurred, we made corrections to the remotely sensed data based on the ground truth data.

Table 1: Satellite data characteristics

Satellite Scene	Path/Row	Date of Acquisition	Land Cloud Cover (%)	Scene Cloud Cover (%)	Collection Category
Landsat 4-5 TM C2 L1	194/55	11 January 1986	1.00	1.00	T1
Landsat 7 ETM+ C2 L1	194/55	13 January 2007	0.00	0.00	T1
Landsat 8-9 OLI/TIRS C2 L1	194/56	09 January 2020	21.42	27.99	T1

Source: Glovis website

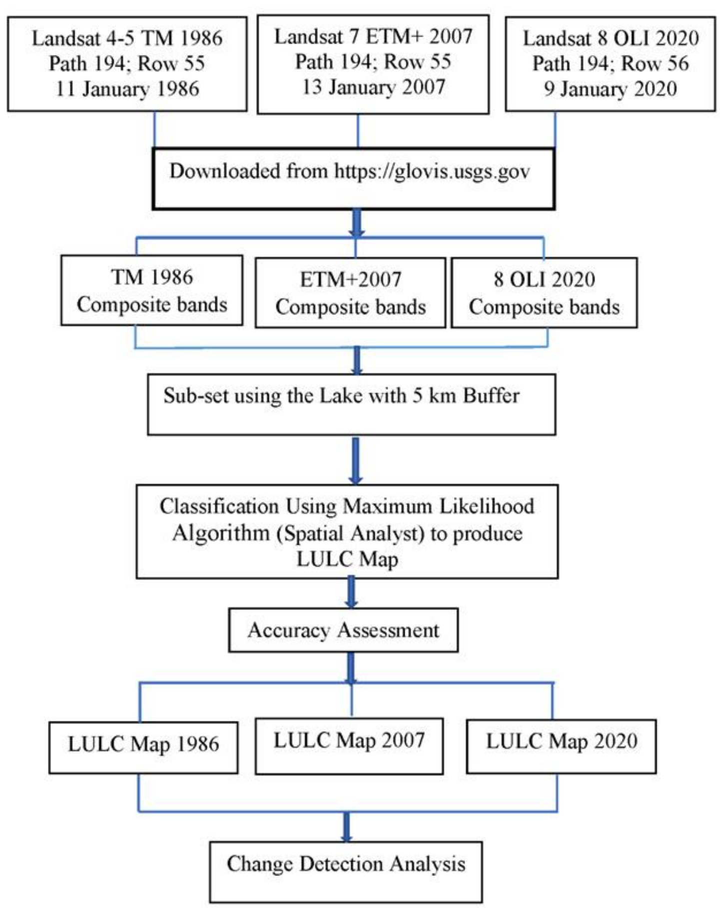

Chart 1: Flow chart of the methodology adopted for handling images

Source: Authors' construct (2023)

ArcMap 10.8 software was used to process and analyse the images. From on-screen digitizing, the boundary of the lake was delineated from the 1986 image. The lake boundary was then used for the creation of a 5km buffer zone around it. The 5km buffer was selected due to satellite data availability without mosaicking two or more images. Besides, it coincides with the biosphere reserve. The area was later used to subset the study area from the Landsat scenes of 1986, 2007 and 2020, and a false colour composite imagery was created (Figure 2).

The next stage was a classification of the images. Classification involves sorting pixels into a finite number of categories or classes based on their pixel values. This can be accomplished using two approaches, namely unsupervised and supervised. The former involves the grouping and labelling features in an image according to their spectral homogeneity and spectral distance which is automated. When knowledge about the LULC is scarce, such a method is applied (Capolupo et al., 2020). In the latter approach, one has control, where pixels representing patterns are identified with the help of other sources of data. With the identified patterns in the imagery, the computer is trained, which coaches the necessary algorithm to assign each pixel of the image to a specific category. However, this approach is not free of errors, and the analyst must refine the outcomes (Mohammady et al., 2015; Capolupo et al., 2020).

Table 2: Description of land use and land cover class

Land use /cover classes	Description
Mixed arable cropping	Mixed arable crop fields and grass/herb with scattered trees fallow lands
Mixed arable & tree cropping	Mixed arable and tree (cocoa) crops in widely open forest areas with shrubs ground cover.
Forestland	Forested areas with closed or nearly closed canopies
Built-up	Land covered by buildings and other man-made structures such as roads
Waterbody	Areas covered by water bodies

Source: Adopted from CERSGIS, 1995

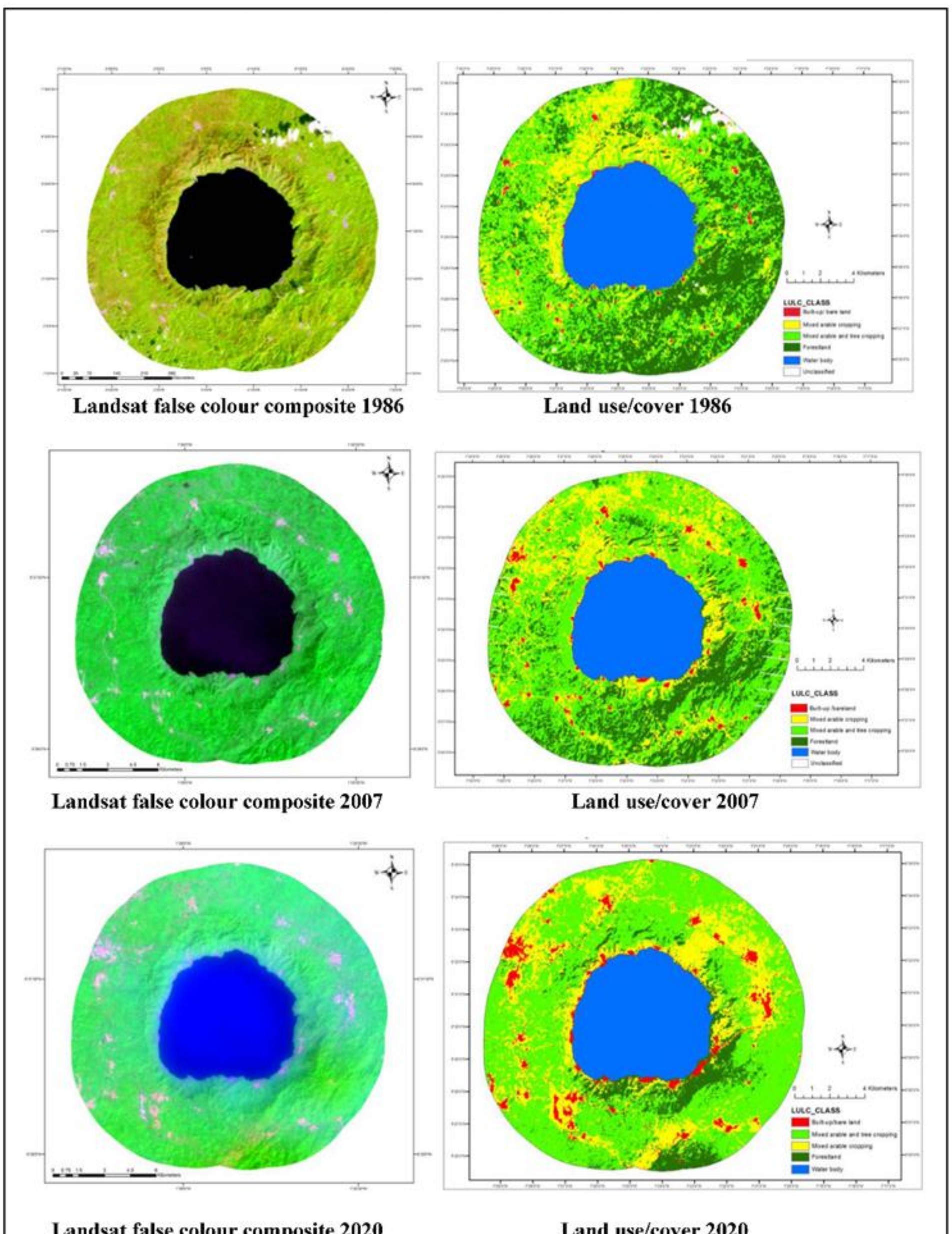

Figure 2: False colour composite and classified imagery

Accuracy Assessment

One is interested in the accuracy of the results of the classification. A scientific way of assessment cannot be achieved without a quantitative method of evaluation. The general methodology as indicated (Verde et al., 2018; Hasan et al., 2021) is the use of a confusion matrix (or error matrix). A table that shows the correspondence between the classified results and a reference image. In this case, ground truth data with a GPS receiver recorder and topographic maps were used. One of the accuracy indicators frequently used is the Kappa coefficient of agreement. It is used to summarize the results of an accuracy assessment used to evaluate LULC classifications obtained by the remotely sensed data (Cohen, 1960; Bloch & Kraemer, 1989). The standard estimator of the kappa coefficient along with the standard error of this estimator requires a sampling model that is approximated by simple random sampling thus.

Kappa = 1, perfect agreement exists.

Kappa = 0, the agreement is the same as would be expected by chance.

The interpretation of Kappa is that when the value is less than 0.20, then it is a poor agreement. A value between 0.20 to 0.40 indicates a fair agreement. For moderate agreement, it will be between 0.40 to 0.60, whilst from 0.60 to 0.80 will be a good agreement. For a very good agreement, the value will be 0.80 to 1.00 (Bloch & Kraemer,1989).

Using the most recent satellite image (Landsat 8 (OLI) 2020), a total of 150 reference points were created by the simple random sampling technique. GPS points taken from the field, points from the topographic maps with a scale of 1:50,000 and Google Earth images of the study area were used as referenced materials. An overall accuracy of 87.33% with a Kappa coefficient of 0.83 was achieved (Table 3). The values indicate very good agreement because it is within the 0.80 to 1.00 range. Furthermore, both the producer and user accuracies for the various LULC categories were also generally high.

Change detection

To identify and quantify the spatial distribution of changes taking place in the biosphere and its environs and to have an insight into the processes at work, change detection was carried out. There are various forms of change detection techniques. However, there is still no universally accepted method of detecting change or assessing the accuracy of change detection map products. For this study, the post-classification comparison technique, which compares independently classified images from different time periods was employed to detect changes in land use and land cover.

Table 3: **Classification Error Matrix for 2020 Landsat image using a simple random sampling technique**

LULU	BUL	FOR	WAT	MATC	MAC	Total	User accuracy	Kappa
BUL	9	0	0	0	1	10	90.00%	
FOR	0	16	0	4	0	20	80.00%	
WAT	0	0	28	0	0	28	100.00%	
MATC	0	10	0	52	0	62	83.87%	
MAC	0	0	0	4	26	30	86.67%	
Total	9	26	28	60	27	150		
Producer accuracy	100.00%	61.54%	100.00%	86.67%	96.30%		87.33%	0.83

MAC: mixed arable cropping; MATC: mixed arable and tree cropping; FOR: forestland; BUL: built-up/bare land; WAT: water

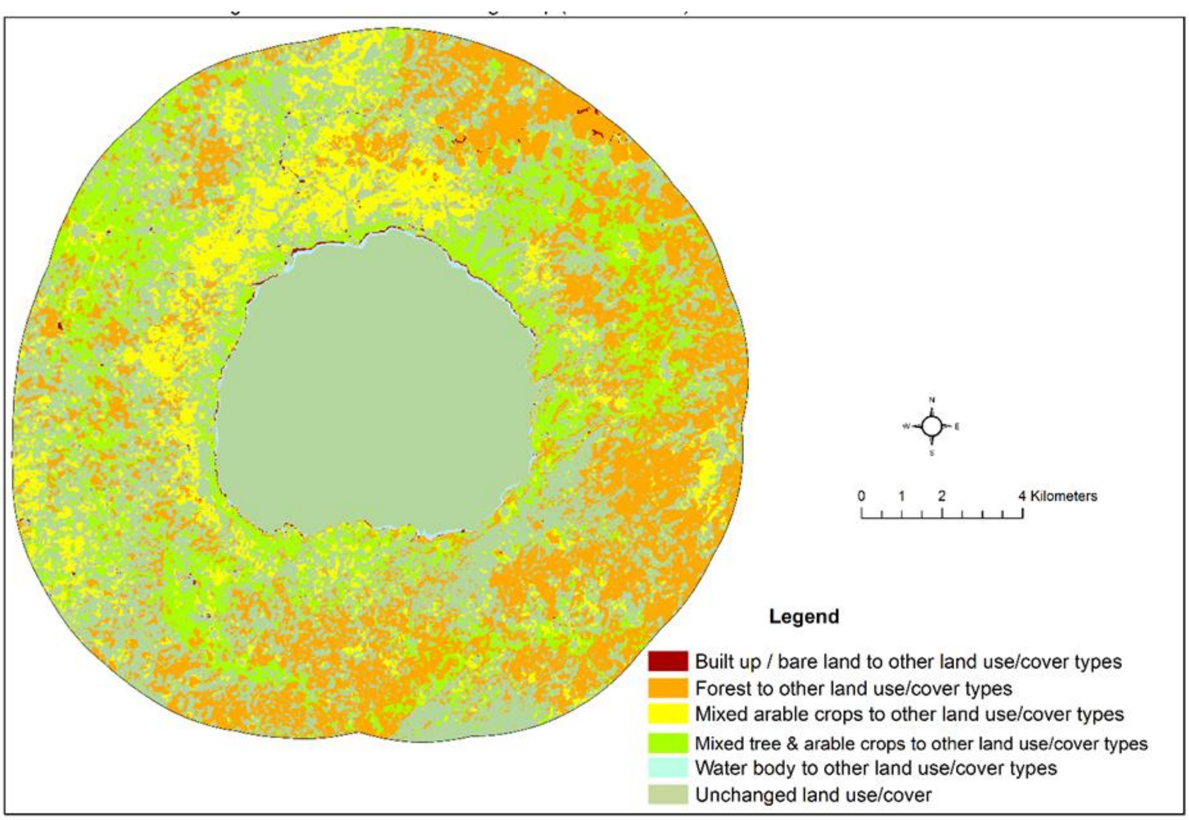

Figure 3: Land use and land cover change map (1986-2020)

As noted by (Dobson et al., 1995; Jensen & Im, 2007; Chen et al., 2012) in change detection analysis, it is desirable to use remotely sensed data acquired on anniversary dates. Unfortunately, this was not the case. For instance, although the images were acquired in the same month, they were not anniversary dates. However, considering the season that the images were acquired, the influence of seasonal sun-angle and phenological differences were not compromised. This was achieved by using topographic correction methods. The angle of the sun was normalized by dividing image values by the sine of its elevation angle.

The LULC change detection was carried out using ArcGIS 10.8. The three independently classified and coded raster land use and cover data sets (1986, 2007 and 2020) were vectorized using the ArcGIS 10.8 conversion tools. The union tool of ArcGIS 10.8 which creates a new coverage by overlaying two polygon coverages was then applied to the 1986 and 2007, 2007 and 2020 and finally 1986 and 2020 polygons respectively. The attribute data of the resultant coverages were then queried to detect areas of change and no change. This made it possible to interpret changes more efficiently taking advantage of -from, and -to, information (Figure 3). The total number of equivalently classed pixels were also computed by subtracting the class total statistics of 1986 from 2007, 2007 from 2020 and finally, 1986 from 2020 (Table 4). It is worth stating that a positive value indicates an increase in LULC category size, and a negative value indicates a decrease in category size.

Population in the Study Area

Population data from the Ghana Statistical Service were used to analyse the population trend among the 39 communities identified within the study area over the years. The data covered 1970, 1984, 2000, 2010 and 2020. Apart from the absolute population figures, the land area computed via the Geographic Information Systems was also used to compute the density. However, there were gaps in the population data among a few communities that did not necessarily influence the analysis.

Results and Discussion

The study first investigates LULC dynamics. Figure 2, shows the spatial distribution of LULC of the study area for 1986, 2007 and 2020 while Tables 4 and 5 show the area statistics of the LULC units and the extent of changes that have occurred. The area statistics were calculated, considering the pixel count and the total size of the study area. In 1986, area categorized as mixed arable and tree (mostly cocoa) crops in open forest areas was the dominant (87.31 km^2, representing 33.95%) LULC type. The next was closed or nearly closed forestlands (73.17 km^2, representing 28.45) while, Lake Bosomtwe, the only water body classified, occupied 48.98 km^2 (19.04%) and mixed arable cropping, including grass/herb fallow plots, occupied 45.14km^2 (17.55%). Built-up had the least (2.59 km^2, thus, 1.01) area coverage.

Between 1986 and 2007, three of the land use and land cover categories, namely, built-up, mixed arable cropping, and mixed arable and tree cropping, increased area coverage (Tables 4 and 5). However, the built-up category had the highest percentage change of 67.57%. Mixed arable and tree cropping increased in size by 18.65 km^2, representing a percentage change of 21.36% while mixed arable cropping also had a percentage increase of 14.05%, representing an area of 6.34 km^2. On the contrary, the forest category recorded a substantial reduction in size. About 23.41 km^2 (-31.99%) of forestland was lost. Thus, almost a third of the forest cover in the area was deforested. The size of the Bosomtwe Lake was also contracted by about 0.76 km^2, representing a percentage change of about -1.55%.

From 2007 to 2020, similar dynamics were observed. An expansion of land area continued for the two agricultural LULC categories as well as the built-up class. The area under mixed arable cropping increased from 51.48 km^2 (19.82%) to 59.61 km^2 (22.87%), while mixed arable and tree cropland increased from 105.96 km^2 (40.79%) to 119.11 km^2 (45.70%). The built-up class also increased significantly from 4.34 km^2 to 9.33 km^2 representing a percentage change of over 115%. The other two LULC categories experienced a reduction over the 13 years. Forestland was reduced from 49.76 km^2 (19.16%) to 24.66 km^2 (9.46%) and finally waterbody from 48.22 (18.56%) to 47.90 km^2 (18.38%).

It can be observed from Table 5 that during the years under review (34 years), that is, from 1986 to 2020, the built-up category has seen the most significant expansion. It recorded the highest percentage change of about 260.23% at an annual rate of 7.65%. This result confirms an earlier observation (Boamah & Koeberl, 2007) who noted increasing human activities in the form of several accommodation facilities such as hotels springing up around the Lake.

Table 4. LULC areas for the different study periods

LULC classes	1986 km^2	1986 %	2007 km^2	2007 %	2020 km^2	2020 %
Mixed arable cropping	45.14	17.55	51.48	19.82	59..61	22.87
Mixed arable & tree cropping	87.31	33.95	105.96	40.79	119.11	45.70
Forestland	73.17	28.45	49.76	19.16	24.66	9.46
Built-up/bare land	2.59	1.01	4.34	1.67	9.33	3.58
Water body	48.98	19.04	48.22	18.56	47.90	18.38

Table 5. Actual and percentage change in LULC between the study periods

LULC classes	1986 - 2007 km^2	1986 - 2007 % Change	2007 – 2020 km^2	2007 – 2020 % Change	1986 - 2020 km^2	1986 - 2020 % Change
Mixed arable cropping	6.34	14.05	8.13	15.79	14.47	32.06
Mixed arable & tree cropping	18.65	21.36	13.15	12.41	31.80	36.42
Forestland	-23.41	-31.99	-25.10	-50.44	-48.51	-66.30
Built-up/bare land	1.75	67.57	4.99	114.98	6.74	260.23
Waterbody	-0.76	-1.55	-0.32	-0.66	-1.08	-2.20

The forest cover class is the most severely threatened. It has lost 66.30% of its area coverage to different land use and land cover types at an annual deforestation rate of 1.95%. It is also evidently clear that farmlands have increased. In 1986, farmlands (mixed arable cropping and mixed arable and tree cropping) occupied 51.50% of the total study area (Table 4). In 2020, these two agricultural practices together occupied 68.58%. It is also worth noting that the only water body classified, the Bosomtwe Lake is receding at an annual rate of 0.06%, according to the findings in this study. Similar findings of the Lake have been reported earlier by Adjei et al. (2014) and Appiah et al. (2015).

Diverse LULC conversion occurred between 1986 and 2020, as shown in Table 6. The total area of land LULC retention was 132.08 km^2. The cover category that had the most significant retention was water (Lake Bosomtwe). As expected, the most converted LULC category was the forest. About 57.20 km^2 of forestland was converted to farmlands. Of this, 44.42 km^2, representing the highest conversion from one cover type to another, was converted to mixed arable and tree cropping. Another 12.78 km^2 was converted to mixed arable cropping. Interviews conducted during the accuracy assessment suggest that most forestlands were set ablaze during the 1983-84 nationwide bushfire disaster. These bushfires have been described in the literature (Ampadu-Agyei, 1988; Nsiah-Gyabaah, 1996) as the most devastating fire disaster ever witnessed in Ghana. The bushfires were assisted by extensive drought and strong harmattan winds that destroyed farmlands, cocoa, food crops, villages, timber, and forest vegetation. The raided forests were converted to agricultural lands, especially for cocoa cultivation.

The conversion of 28.78 km^2 of mixed arable and tree crop fields to mixed arable crop fields is another evidence of vegetation degradation in the area. The modification involves degrading widely open forest areas with a ground cover of shrubs to grass/herb with or without scattered trees. These results confirm an earlier finding by Adu-Boahen et al. (2014) that the catch in the lake has declined and the men whose main occupation was fishing have resorted to subsistence farming.

However, Table 6 shows that some vegetation regeneration occurred in some places after the 1983 nationwide bushfires. This is evident in the conversion of 3.20 km^2 of mixed arable cropping fields and 4.70 km^2 of mixed arable and tree cropping areas to forestlands. The transformation of 22.84 km^2 of mixed arable crop fields to mixed arable and tree cropping fields is another evidence of vegetation regeneration. This is because the vegetation is usually degraded to grass/herb with or without scattered trees in mixed arable cropping areas. On the other hand, mixed arable and tree cropping areas typically have more trees and dense shrub cover.

Population

The causes of change in LULC can be categorised into two types: physical and anthropogenic. The latter refers to human activities such as agriculture and domestic services. To investigate the correlation between changes in LULC and population density (as shown in Figure 4), the study examined the changes over a period of 51 years in 39 communities.

The population of the area which stood at 13,204 in 1970 increased to 18,235 in 1984, an increase of 38.1% over 14 years. Over 16 years (1984 to 2000), the area experienced the highest increase in the population of 7,694 from 18,235 to 25,929 (42.2%) which might be attributable to both internal and external factors. From 2000 to 2021 the area experienced a slower percentage increase of 30% in 10 years and a further decrease of 0.2% from 2010 to 2021.

Table 6. LULC conversion matrix from 1986 to 2020 (km^2)

		Year 1986					
	LULC categories	**MAC**	**MATC**	**FOR**	**BUL**	**WAT**	**Total**
	MAC	15.92	28.78	12.78	0.40	0.28	58.16
	MATC	22.84	51.20	44.42	0.08	0.00	118.55
Year 2020	FOR	3.20	4.70	15.13	0.11	0.46	23.60
	BUL	2.44	3.23	0.84	1.95	0.37	8.83
	WAT	0.00	0.00	0.02	0.01	47.88	47.90
	Total	**44.41**	**87.92**	**73.18**	**2.55**	**48.99**	**257.05**

MAC: mixed arable cropping; MATC: mixed arable and tree cropping; FOR: forestland; BUL: built-up/bare land; WAT: water
Note: the matrix excludes all areas that were put into the unclassified category.

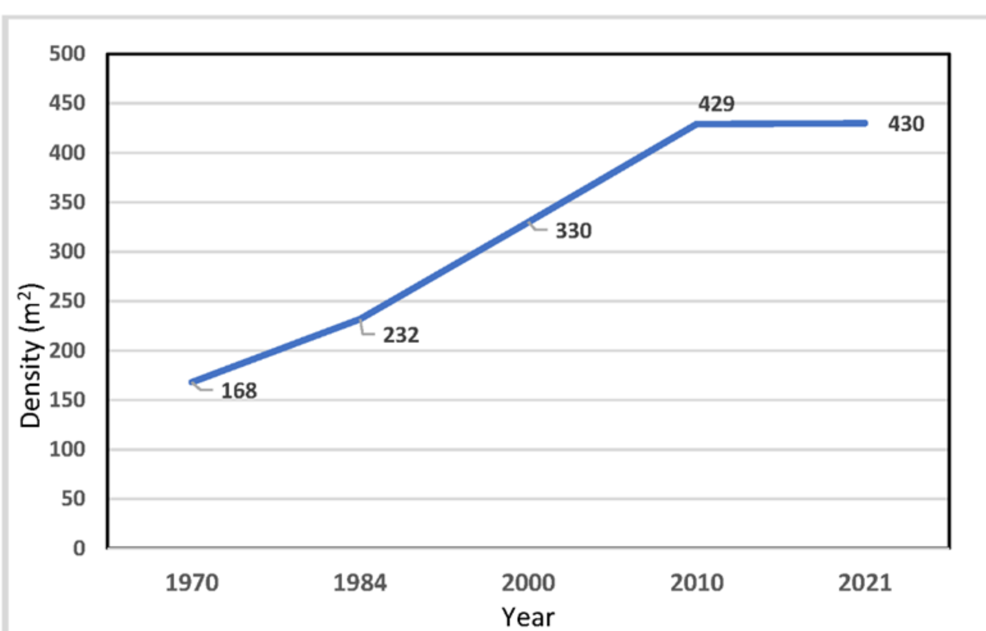

Figure 4: Population density
Source: Ghana Statistical Service (2022)

The population density which describes the number of persons living in a kilometre square area also increased steadily in the first 30 years but slowed down and increased thereafter (Figure 4). Except in 1970 when the population density, though, was high but less than 200 per km^2 (168 per km^2) and in the subsequent years, recorded high (more than 200 per km^2) density.

A correlation test was conducted using a correlation coefficient to compare two agricultural land use categories, which were merged into a single category called cropland. The data for LULC in 1986, 2007, and 2020 were analyzed along with population density data for 1984, 2010, and 2020. The analysis revealed a strong positive correlation between population density and both cropland and built-up areas. The correlation coefficient between population density and cropland is r = 0.89, while that between population density and built-up areas is r = 0.70. This suggests that an increase in population density is associated with a corresponding increase in cropland and built-up areas. There is also a significant negative correlation between population density and forestland/waterbody, with coefficients of -0.86 and -0.96, respectively.

The research indicates that the increase in population is one of the major factors responsible for the changes in LULC in the studied area. It can be inferred that the growing demand for agricultural products by the expanding population has led to the conversion of forestlands into croplands.

Conclusion

One of the main reasons for LULC changes is population growth. The study was conducted to examine LULC changes within 5 km of the Lake Bosomtwe biosphere reserve, analyzing changes that took place over 34 years. The study confirmed that changes did occur, and proved that utilizing remotely sensed data is effective in assessing LULC changes over time. By integrating this data with GIS technology, we were able to analyze the causes of change, such as population growth and density with a strong positive correlation between population density and, cropland and built-up areas. The technology made it possible to quantify and visualize the changes using maps. However, there were limitations due to the 30-meter spatial resolution of the Landsat images used, and the inability to select anniversary dates for the 34 years. Moreover, population trend analysis could have been enhanced if there were no gaps. The results could have been more robust if these challenges had been addressed. It is recommended that future research should use high-resolution imagery such as sentinel data with 10 meters spatial resolution to improve the accuracy of the analysis.

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Competing Interests

All authors of this article declare there is no competing interest.

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