URBAN LAND USE/LAND COVER CHANGES IN THE TEMA METROPOLITAN AREA, GHANA (1990 – 2010)

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ABSTRACT

Land use and land cover changes are local and place specific, occurring incrementally in ways that often escape our attention. This study sought to detect changes in land cover in the Tema Metropolis of Ghana from 1990 to 2010. Multispectral Landsat Thematic Mapper data sets of 1990, 2000 and 2007 were acquired, pre-processed and enhanced. Unsupervised classification of the images was performed and six land cover classes (water, wetlands, closed vegetation, open vegetation, cropped lands, and built-up) were derived. The post-classification change detection technique was performed to derive the changes in land cover and their corresponding change matrices. Between 1990 and 2010, built-up areas expanded steadily to become the most prevalent land cover type in the metropolis, reducing vegetation cover dramatically. High population growth with its attendant rise in the demand for housing, and increasing commercial activities, were found to have influenced land cover changes over the period.

Key Words: Land use, land cover changes, Change detection, Population, Tema, Ghana

INTRODUCTION

The Earth's surface, throughout its history and existence, has undergone changes and modifications at varying space and time scales – some over short time spans and others over many years; some reversible and others irreversible. The pace, magnitude and spatial reach of direct and indirect alterations of the Earth's land surface by humans in recent decades, according to Lambin et al. (2001), are unprecedented. Lambin et al. also posit that land use and land cover change are the most important effectors and outcomes respectively, of human induced earth surface alteration. Furthermore, when aggregated globally, both changes are so insidious that they considerably affect key aspects of earth system functioning.

The land use and land cover pattern of a region is largely considered to be an outcome of natural and socio-economic factors and their utilization by man in time and space (Fuller & Gaston, 2009). Changes in both phenomena directly impact biotic diversity worldwide (Sala et al., 2000); contribute to local and regional climate change as well as to global climate warming (Chase et al., 1999; Houghton et al., 1999); are the primary source of soil degradation and, by altering ecosystem services, affect the ability of biological systems to support human needs. Such changes also determine, in part, the vulnerability of places and people to climatic, economic or socio-political perturbations (Kasperson et al., 1995).

According to the Intergovernmental Panel on Climate Change (IPCC, 2000), despite improvements in land cover characterization made achievable by earth observing satellites, global and regional land covers and, in particular, land uses are poorly enumerated. Urban landscapes are proportionally the fastest emerging land cover type resulting from the fact that 50 percent of the world's population, for the first time in human history, now live in towns and cities (UN Habitat, 2009). Urban expansion has increased the exploitation of natural resources and has changed land use and land cover patterns. Yuan et al. (2005), for instance, have linked regional economic vitality with urban growth or expansion, particularly the movement of residential and commercial land use to rural areas at the periphery of metropolitan centres.

Recently, UN Habitat (2009) reported that nearly half of the world's population and three quarters of all westerners live in cities. World population, according to DESA (2009, 2010), is expected to increase by 2.3 billion, passing from the 2009 estimate of 6.8 billion to 9.1 billion by 2050. In that time, the report (DESA, 2010) projects the population living in urban areas to gain some 2.9 billion, passing the 2009 figure of 3.4 billion to 6.3 billion by 2050. Urban areas of the world are expected to absorb all population growth projected over the next four decades, drawing in concurrently, some of the rural population (DESA, 2010).

Furthermore, it is indicated that, the expected population growth in urban areas will be concentrated in the cities and towns of less developed countries, with 66 percent of the 2050 population projection for less developed countries being urban, and 86 percent of the same projection for more developed countries being urban. Overall, the world population is expected to be 69 percent urban in 2050. As an inevitable process which results from economic development and rapid population growth (Rimal, 2011), urbanisation, especially for developing countries, places much pressure on existing urban structures such as housing and transportation. Problems emanate from the spatial distribution of the increasing urban population on the land that serves consequently as a fundamental determinant of land use/land cover changes (Small, 2004). The increasing need for land and land resources forces urban dwellers to acquire and develop land at the fringes of urban centres.

Substantial amounts of data about the Earth's surface are required for effective monitoring and analysis of land use/land cover changes. Previously, throughout the world, such information on land use/land cover change were generated primarily through conventional ground survey methods which were not only time consuming, costly, tedious and demanding lots of manpower, but also somewhat impractical for monitoring dynamic changes over shorter periods (Chaudhary et al., 2008). Recent advances in Geographic Information System (GIS) and Remote Sensing (RS) tools and techniques enable researchers to model urban growth effectively, with remote sensing providing an excellent source of data from which updated land use/land cover information and changes can be extracted, analysed, and simulated efficiently. Satellite remote sensing, for instance, as depicted in the works of Alberti et al. (2004), Goetz et al. (2004), and Yang (2002), has the potential of providing accurate and timely geospatial information that describe changes in land use/land cover of metropolitan areas.

In Ghana, Songsore (2003) suggests that the population, consistent with observed trends in most parts of Africa, is becoming largely urbanised. Indeed, data published by the Ghana Statistical Service (GSS, 2002) indicated that the urban population increased from 23 percent in 1960 to 44 percent in 2000. Furthermore, the urban settlements – settlements with population of 5000 or more – increased from 98 to 364, accounting for 8.3 million people. This rapid urbanisation is largely driven by demographic factors such as rural urban migration and improved natural growth rate in cities (GSS, 2002; Songsore, 2003). Like the nine other largest urban areas in Ghana – Accra, Kumasi, Sekondi-Takoradi, Tamale, Ashaiman, Obuasi, Koforidua, Cape Coast, and Wa – the statistics provided by the GSS indicate a consistent rise in population figures of the Tema metropolis in the 1970, 1984 and 2000 Population and Housing Censuses.

The Tema metropolis, however, is poorly enumerated with regards to spatio-temporal land use/land cover information which is essential for the planning, implementation and monitoring of development schemes to meet the increasing demands for basic human needs and welfare while at the same time preserving biodiversity. Also, modelled future scenarios of land cover patterns necessary to adequately plan for such growth in population and increasing pressure on the region’s land resources are lacking. This study, therefore, seeks to provide spatio-temporal information on land cover changes in the Tema metropolis that are necessary for zoning and planning. Specifically, the study seeks to generate a land cover classification scheme and maps for the Tema metropolis; establish land cover changes of the metropolis from the period 1990 to 2010 and the rate of transition of the changes and; identify some factors that have contributed to the changes in land cover.

STUDY AREA

The Tema Metropolitan Area is a coastal metropolis located in the Greater Accra Region of Ghana. Its capital – Tema, is located 25km east of the country's capital, Accra. Located between latitudes 5° 35" N – 5° 50" N and longitudes 0° 10" W – 0° 05" E, the region covers an area of approximately 365.78 square kilometres (Figure 1). The metropolitan area is bounded to the West by the Adenta and Leedzokuku Krowor municipalities, to the North by the Ga East and Akuapim South municipalities, to the East by the Dangbe West district, and to the South by the Gulf of Guinea. Situated at the centre of the area is the newly created Ashaiman municipality.

The Tema Metropolis lies within the coastal savannah vegetation zone with low annual rainfall averaging 800mm distributed over less than 80 days. The rainfall pattern of the area is bimodal with the major season falling between the months of April and mid-July, and a minor rainy season around the month of October. The mean monthly temperature ranges from 24.7° C in August (the coolest) to 28° C in March (the hottest) with an annual average of 26.8° C. The nearness of the region to the equator makes daylight hours practically uniform during the year. Relative humidity is generally high, varying from 65 percent in the mid-afternoons to 95 percent at night. Predominant wind direction is from WSW to NNE with speeds ranging between 8km/h to 16km/h. The vegetation cover of the metropolis is primarily shrub and grassland with isolated trees that are only denser towards the northern fringes of the metropolis – the foothills of the Akuapem-Togo mountain range.

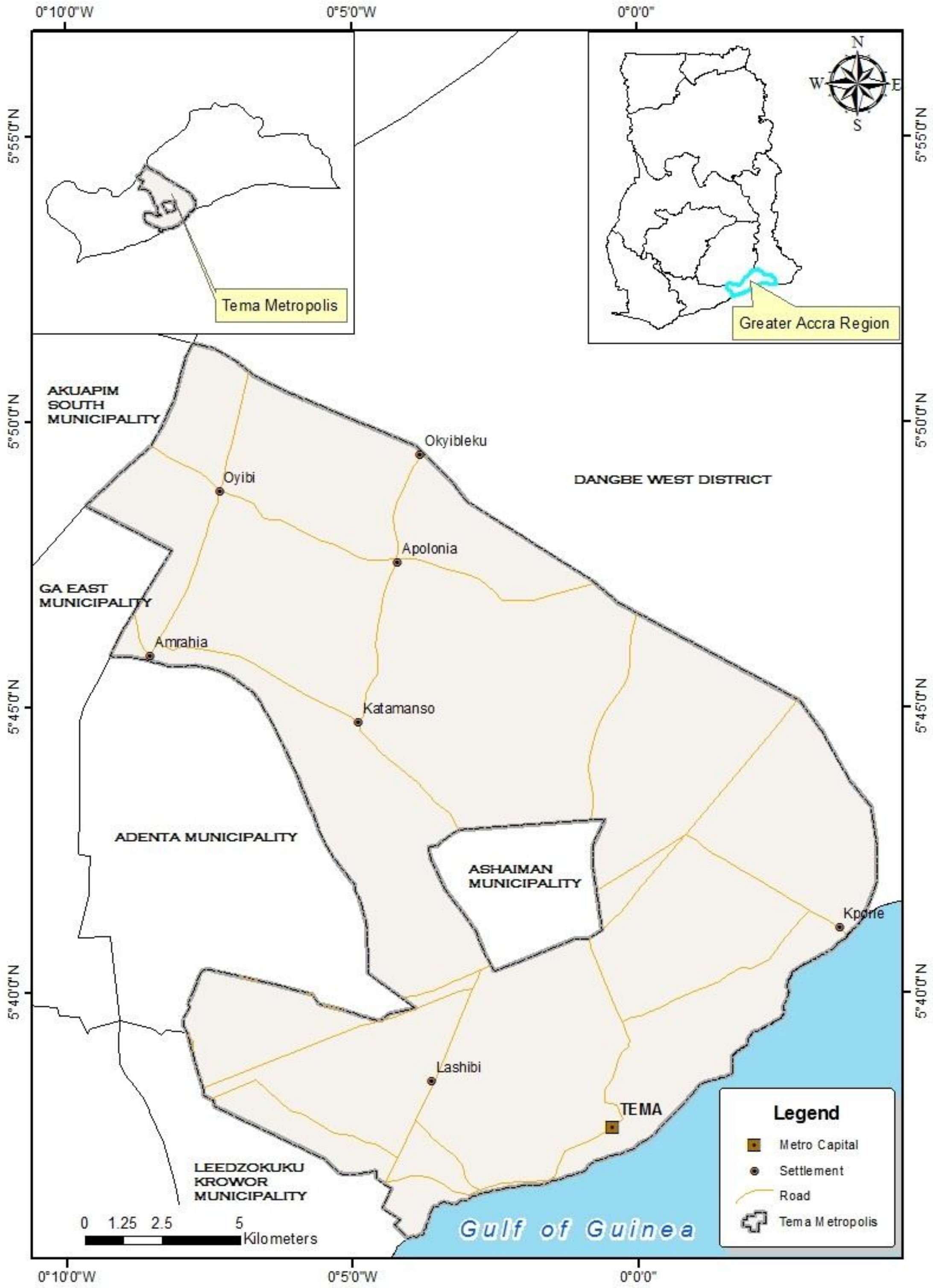

Figure 1: Map of study area

MATERIALS AND METHODS

Primary and secondary data sets were employed in the study. Primary data was derived from Landsat satellite imagery. Landsat TM and ETM+ satellite image data sets of 1990, 2000, and 2007 were used. All images were captured at approximately the same period during the dry seasons of the respective years. During that period, all land surface features exhibit consistent reflectance properties irrespective of the year of acquisition (Eastman, 2006). Spectral bands 1, 2, 3, 4, 5, 6, and 7 of each image set were stacked in ArcGIS and used in an image-to-image geometric projection, using the 1990 image as master.

Table 1: Satellite images

Satellite	Image number	No. of bands	Pixel spacing metres (m)	Capture date
Landsat TM	p193r056	7	30 x 30	25 Dec 1990
Landsat TM	p193r056	7	30 x 30	04 Feb 2000
Landsat ETM+	p193r056	7	30 x 30	06 Jan 2007

Source: ftp://ftp.glcf.umd.edu/glcf/Landsat/WRS2/p193/r056/.

Image pre-processing

The satellite images for the study were radiometrically corrected to remove the haze and noises of the haze in the image. They were also geometrically corrected and projected to the Universal Transverse Mercator (UTM) zone 30 North. The spatial extent of the three sets of Landsat images was far greater than the study area and so the images had to be subset to a smaller area using a bounding rectangle around the Tema metropolitan area. The subset images were then geometrically registered to each other before all other image processing and analyses were performed.

Image enhancement

Linear contrast stretching was applied to improve the appearance of the images. Linear contrast stretch was applied to the 2000 and 2007 Landsat TM and ETM+ images respectively since they were more difficult to visually interpret. With minimum histogram values of 82 and maximum values of 151, these 70 levels – between minimum and maximum – occupied less than a third of the full 256 levels available. The application of the contrast stretching uniformly expanded this small range to cover the full range of values from 0 to 255. This stretch enhances the contrast in the image with light toned areas appearing lighter and dark areas appearing darker, thus making the visual interpretation much easier.

Image classification

Unsupervised classification was carried out on the images in the ERDAS Imagine 9.3 suite. In ERDAS, unsupervised classification is performed using an algorithm called the Iterative Self-Organising Data Analysis Technique (ISODATA). Using the ISODATA, unsupervised classification with 100 classes and a 95 percent confidence threshold was performed on all three images. With maximum number of iterations set at 15, the final result was images with 100 groups of pixels – each represented by a unique grey-scale colour. One after another, each class was highlighted to determine which land cover class it belonged to by inferring from the Google Earth multi-spectral images. Clusters that belonged to the same land cover class were then assigned a unique colour. In all, six land cover classes were distinguished. These are water, wetlands, closed vegetation, open vegetation, cropped lands and built-up. Table 2 presents a description of each land cover class.

Table 2: Description of land cover classes (Level I)

Land cover	General description
Water	All areas characterised by still, open waters such as ponds or lakes. Also included in this class are channels of moving water including canals, streams and lagoons.
Wetlands	Areas where the water table is at, near or above the land surface for prolonged periods of the year. Fresh water marshes with their associated vegetation are classified under this category.
Closed vegetation	Areas dominated by closely knit trees and dense vegetative cover. It also encompasses all vegetated areas that expose no bare soil.
Open vegetation	This class describes all areas that depict sparsely located trees, shrubs and patches of bare soil. Areas of extensive grass cover and isolated thickets are classified under this category.
Cropped lands	Lands under annual tillage and lands that have been cleared in preparation for crop cultivation, and lands left untilled such as fallow lands are identified as cropped lands.
Built-up	Community service areas (parks, playing grounds, lorry parks), residential areas, commercial and industrial areas are classified as built-up areas. Lands that have been cleared in readiness for building construction are also classified as built-up.

Population and biophysical data

Population data from the Ghana Statistical Service were collected and examined. The objective was to draw on some relationship between the increase in population of the metropolis, and the changes that have occurred in land cover with particular interest in built-up. The figures were derived from the national population and housing censuses conducted in 1970, 1984 and 2000. Secondary data were also collected from the Tema Development Corporation (TDC) and the Tema Metropolitan Assembly (TMA) on land ownership and administration in the metropolis. In-depth interview guides were used to gather information from some chiefs and traditional leaders regarding human activities on land, land tenure, ownership and administration. The chiefs and traditional leaders were purposively selected, because they are the custodians of the land and are directly in charge of the issue or sale of land for any developmental endeavour outside the Tema Acquisition Area. Their responses were considered against the results derived from the processed satellite images in an attempt to understand emergent trends in changes with respect to land use and land cover in the metropolis.

Rainfall data, which is also considered as a predisposing environmental factor that causes land cover changes by Geist and Lambin (2002), were collected from the Ghana Meteorological Service Agency and examined. Average annual rainfall figures for the period for the metropolis were computed from the data.

Data analysis

Change detection studies based on remote sensing and GIS, according to Bektas and Goksel (2005), have generally focused on obtaining the information of how much, where and what type of land cover change occurred between different time intervals. It involves determining and/or describing changes in land cover properties based on co-registered multi-temporal remote sensing data. Post-classification change detection was employed to highlight changes in land cover. It is a quantitative method of change detection that is sensitive to spectral variations, provides a "from-to" change information, and results in a change map and change matrix. Change maps and matrices were developed for the period 1990 – 2000, 2000 – 2007, and 1990 – 2007.

RESULTS

Data available from the Ghana Statistical Service depict a growing trend in the population of Tema since 1970. Table 3 shows the census figures for 1970, 1984 and 2000.

Table 3: Census figures for Tema Metropolitan Area

Date	03/1970	03/1984	03/2000
Tema	60, 767	100, 052	141, 479

Source: Ghana Statistical Service, 2002.

The figures from Table 3 shows that the population of the Tema metropolis barely doubled from 1970 to 1984, and this remained somewhat the same in the period 1984 to 2000.

State of land cover in 1990

In 1990, open vegetation occupied about 43 percent of the study area (Table 4 and Fig. 3). It was mainly across the middle sectors of the metropolis and permeated down through the eastern and south eastern corridors. Built-up areas were spread and concentrated mostly in the bottom half of the metropolis to the coast and occupied approximately 30 percent of land cover. Closed vegetation was located primarily in the northern fringes of the metropolis with small patches in the southern parts. This land cover took up about 12 percent of the study area. Almost 8 percent of the study area was covered by wetlands which were dotted all over the metropolis, occurring in all other land cover types. Approximately 7 percent of the area was detected as cropped lands and they occurred in similar places as built-up. Water was found to be the smallest land cover type and it took up barely 0.6 percent of total land cover.

State of land cover in 2000

Built-up areas increased distinctly in coverage to become the most prevalent land cover in the metropolis, increasing from a little over 30 percent in 1990 to almost 35 percent of total land cover (Table 4 and Fig. 3). Open vegetation reduced in coverage area from about 43 percent in 1990 to about 31 percent. The land cover remained consistent, however, in the middle belt of the study area giving way in relatively smaller areas to built-up and closed vegetation. Closed vegetation increased noticeably from about 12 percent in 1990 to 26 percent of total land cover. The land cover extended southwards into previously open vegetated and wetland areas in the middle sector of the study area. In-depth interviews with the chiefs in the area revealed that in 1994/95, officials of the Greater Accra Regional Agroforestry Unit initiated an agroforestry project in the metropolis which involved the participation of the chiefs in the area.

The project assisted the chiefs in the cultivation of a variety of trees and fruit trees on selected sites. Fruit tree species such as mangoes and non-fruit ones like teak were planted. This project contributed to the significant increase in closed vegetation between 1990 and 2000. Furthermore, rainfall data available from the Meteorological Service Agency for the Tema metropolis depicted a significant increase in amount of annual rainfall beginning in 1995 as shown in fig 2.

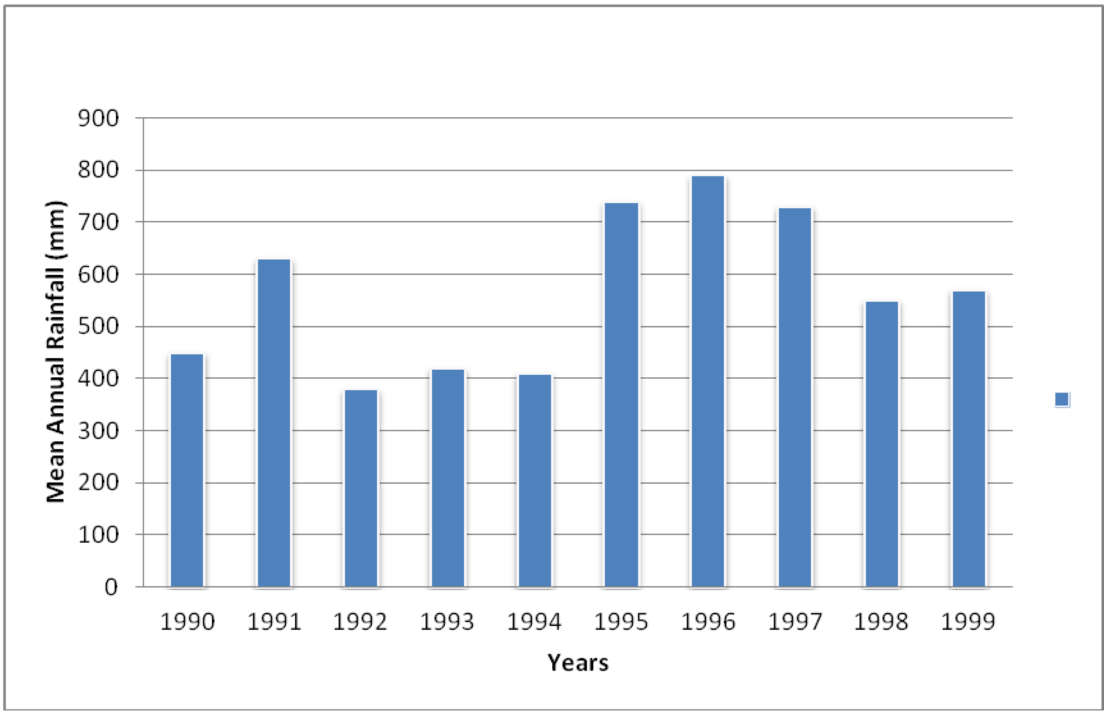

Figure 2: Annual rainfall data for the Tema metropolis 1990 – 1999.
Source: Meteorological Service Agency, 2011.

Wetlands now covered an area of about 6 percent, a fall from the 1990 figure of 8 percent. Field visits revealed that such areas that were liable to flooding were demarcated as part of areas to be developed and houses had indeed sprout up in their stead. Interviews with the chiefs confirmed that such areas were not reserved from housing developments. Cropped lands now took up just about 1 percent which is an indication of an extensive reduction from the 1990 average area of about 7 percent. A greater percentage of this reduction in cropped lands occurred in the areas south of the metropolitan area. Data from the TDC indicates that these areas lay in what is known as the Tema Acquisition Area (TAA) – an area of approximately 163.17 square kilometres that was given to the TDC to manage for a 125 year lease term. Parts of this area that lay undeveloped were leased out to farmers whiles others farmed on them without permit.

However, with the rise in demand for housing and serviced plots from the TDC, and with the corporation's quest to fulfil its mandate, these plots under tillage in the TAA were gradually taken from the farmers for development into residential quarters. Water coverage in the metropolis appreciated only marginally, still covering less than 1 percent of total land cover.

State of land cover in 2007

Built-up further increased in coverage area to about 41 percent. The land cover now permeated the middle sectors of the metropolis with small isolated patches occurring in the northern fringes. About 37 percent of the metropolis was now covered by open vegetation (Table 4 and Fig. 3). This is indicative of an apparent increase of about 5 percent from the area covered in 2000. Closed vegetation, this time around, decreased from 26 percent in 2000 to a total area of about 14 percent. The interviews with the chiefs made known that in 2005/06, tree species such as teak that had been planted during the agroforestry project of the mid 1990s had been harvested for sale as electricity transmission poles. The trees have since not been replanted and the lands have thus been outgrown with grass. Some of the trees are also cut by the local people for use as fuel wood even though the practice is forbidden by the chiefs. "We remind the people continually that cutting of trees for fuel wood is not allowed, but the practice continues even though we seize the fuel wood of those we occasionally apprehend," intimated the land sales person from the Kwaku Teye sub-division.

Furthermore, with an increasing population and an increasing demand for housing, the chiefs intimated that some parts of the areas that were under the agroforestry project have been sold to individuals to put up buildings. These occurrences would thus have accounted for the decrease in areas covered by closed vegetation. Again, parts of the untended agroforestry project lands have been leased to interested persons who now cultivate vegetables on those lands. Cropped lands, which covered less than 1 percent in 2000, thus increased to cover more than 1 percent. Water, although exhibiting an increase in coverage area relative to the area covered in 1990 and 2000, still covered less than 1 percent of total land cover.

Table 4: Area of the land cover of Tema Metropolis (1990, 2000, 2007)

Years	**1990**		**2000**		**2007**	
Land cover	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
Water	2.12	0.57	2.13	0.58	3.25	0.89
Wetland	27.96	7.65	21.83	5.97	22.13	6.05
Closed veg.	42.45	11.61	95.44	26.09	50.23	13.73
Open veg.	158.1	43.22	115.58	31.59	135.08	36.93
Cropped land	24.16	6.61	3.24	0.89	5.44	1.49
Built-up	110.98	30.34	127.56	34.88	149.65	40.91
Total	**365.78**	**100**	**365.78**	**100**	**365.78**	**100**

Source: Fieldwork, 2011.

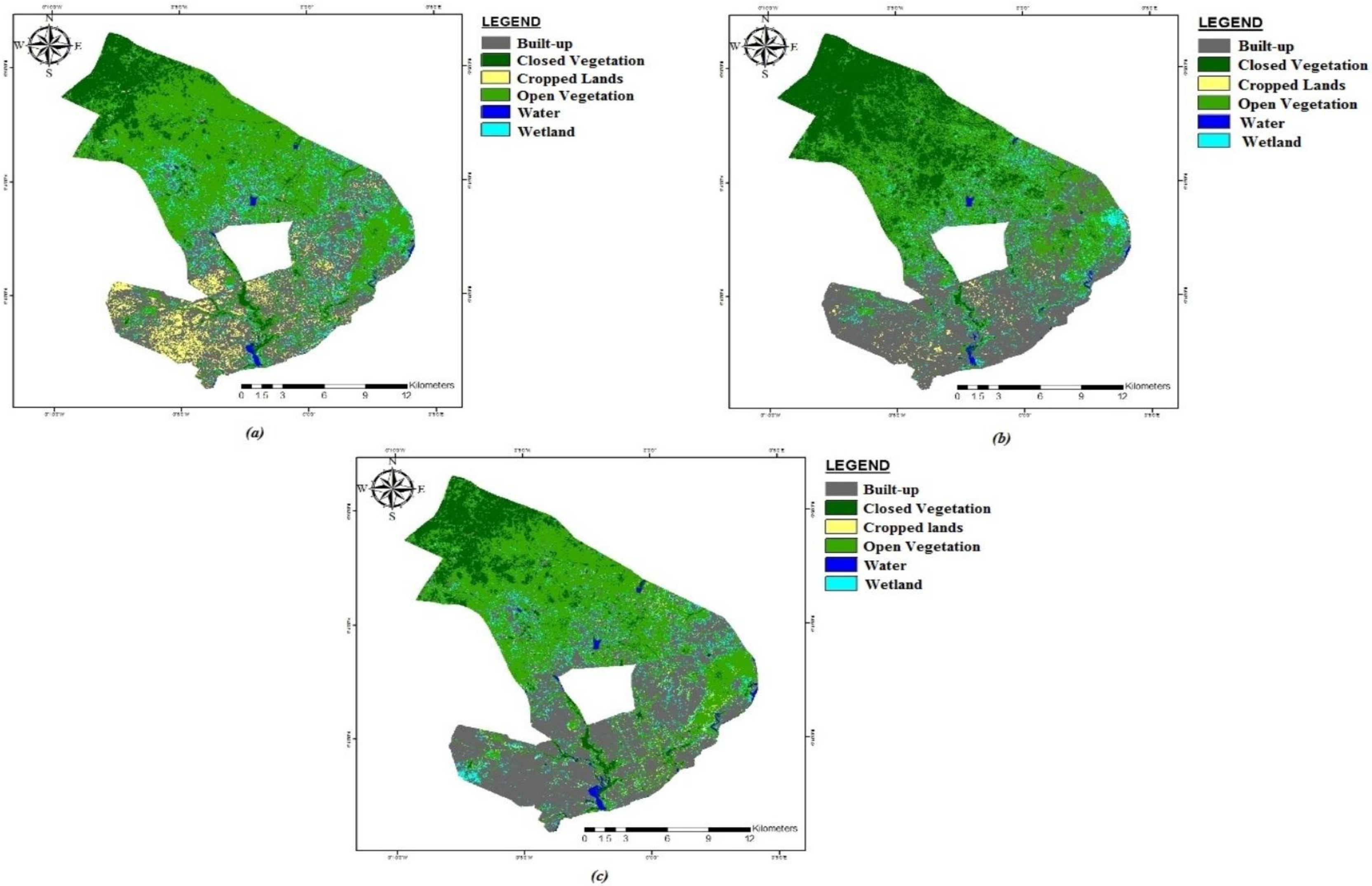

Figure 3: Land cover maps for *(a)* 1990, *(b)* 2000 and *(c)* 2007.
Source: Fieldwork, 2011.

The statistics (as shown in Table 4) indicate that between 1990 and 2000, water increased rather insignificantly at approximately 0.001 percent per annum. Wetlands reduced at 0.17 percent per annum, closed vegetation increased appreciably at approximately 1.45 percent per annum, and open vegetation decreased at approximately 1.16 percent per annum. Cropped lands also decreased at 0.57 percent per annum whiles built-up expanded at an estimated rate of 0.45 percent every year. Between 2000 and 2007, an annual increase of about 0.04 percent was exhibited by the area covered by water. Wetlands increased slightly at 0.01 percent per annum, closed vegetation reduced noticeably at 1.77 percent per annum, and open vegetation increased at an annual rate of 0.76 percent. Cropped lands witnessed an increase at 0.09 percent per annum, whereas built-up expanded significantly at 0.86 percent per annum.

Table 4: Rate of land cover increase/decrease (1990 – 2000, 2000 – 2007)

Years	**1990 – 2000**		**2000 – 2007**	
Land cover	Increase (% /annum)	Decrease (% /annum)	Increase (% /annum)	Decrease (% /annum)
Water	0.001	-	0.04	-
Wetland	-	0.17	0.011	-
Closed veg.	1.45	-	-	1.77
Open veg.	-	1.16	0.76	-
Cropped lands	-	0.57	0.09	-
Built-up	0.45	-	0.86	-

Source: Fieldwork, 2011.

Land cover conversion 1990 – 2000

Whereas about 14 percent of wetlands remained unchanged, about 54 percent of the land cover transitioned from wetlands in 1990 to open vegetation in 2000, while almost 29 percent of wetlands were also converted to built-up in the same period. Approximately 4 percent of wetlands also transitioned into closed vegetation. In that time, about 6 percent of open vegetation and approximately 1 percent of closed vegetation transitioned into wetlands. Furthermore, as 90 percent of closed vegetation remained unchanged, about 8 percent of this land cover transitioned into open vegetation and about 1 percent was converted to built-up areas.

An estimated 51 percent of open vegetation remained consistent, whereas about 35 percent of the land cover transitioned into closed vegetation and approximately 7 percent was converted into built-up areas. Also, about 94 percent of cropped lands were converted into built-up areas whiles an estimated 5 percent remained unchanged.

Land cover conversion 2000 – 2007

Wetlands of about 8 percent remained unchanged between 2000 and 2007. In the same period, 5 percent of wetlands were converted to cropped lands, 45 percent transitioned into open vegetation, and approximately 2 percent and 40 percent of wetlands transitioned into closed vegetation and built-up areas respectively. About 47 percent of closed vegetation remained unchanged. On the other hand, 51 percent transitioned into open vegetation, whiles approximately 1 percent transitioned into wetlands. Built-up areas also expanded to claim an estimated 1 percent of close vegetated areas.

Open vegetation remained unchanged in a total of approximately 65 percent. About 4 percent of the land cover, however, transitioned to closed vegetation with a further 11 percent transitioning into wetlands. In addition, 18 percent of open vegetation was converted to built-up and almost 1 percent was also converted to cropped lands. Almost all cropped lands were converted to built-up areas within this period.

Land cover conversion 1990 – 2007

In the entire period, 44 percent of wetlands remained unchanged. A total of 13 percent of wetlands transitioned into open vegetation within the period. Also, about 33 percent of the land cover was converted to built-up areas and an additional 10 percent converted to cropped lands. Closed vegetation remained unchanged for a total of 89 percent, whiles 11 percent of it transitioned into open vegetation throughout the period. Conversion of closed vegetation to built-up for the entire period took up a total area of approximately 2 percent.

A total of approximately 86 percent of open vegetation remained unchanged between 1990 and 2007. The area of open vegetation that transitioned into wetlands was about 4 percent, whereas the transition to closed vegetation took up about 8 percent. Additionally, 1 percent was converted to cropped lands and built-up took up less than 1 percent of open vegetation. Water remained unchanged throughout the period although its coverage area increased. Built up also underwent no conversion, but expanded to claim other land cover types.

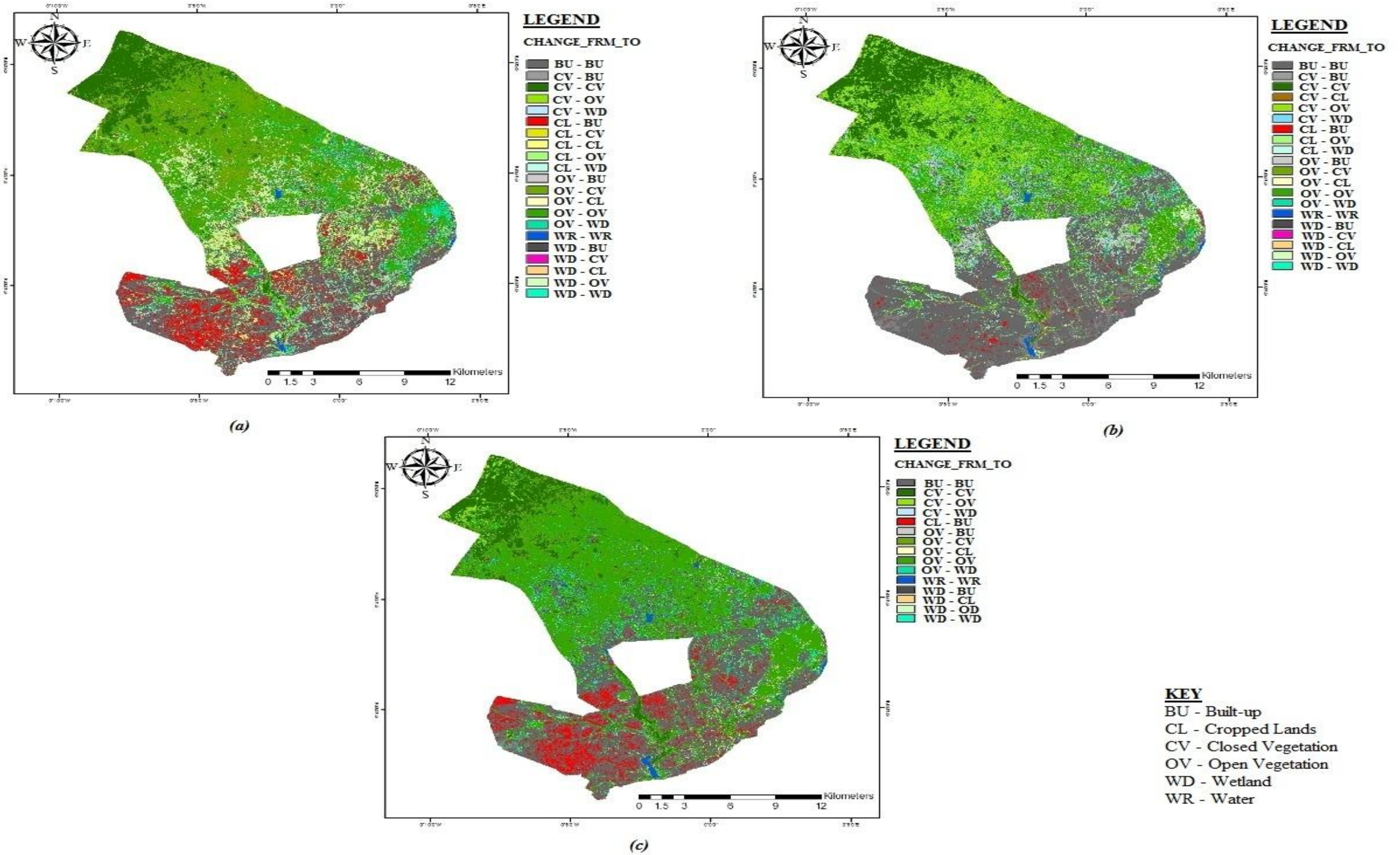

Figure 4: Land cover conversion maps for *(a)* 1990 – 2000, *(b)* 2000 – 2007, and *(c)* 1990 – 2007.

DISCUSSION

Factors influencing land cover changes

Causes of land cover changes have generally been compartmentalised into two broad groups. These are the proximate or direct causes and the underlying or indirect/root driving forces (de Sherbinin, 2002; Geist & Lambin, 2002; Lambin et al., 2003; Meyer & Turner, 1992; Zak et al., 2008). As posited by Geist and Lambin (2002), proximate causes of land cover changes include changes posed by infrastructure extension (transport networks, markets, industry, settlements etc), agricultural expansion (permanent or shifting cultivation), and other predisposing environmental factors such as land characteristics, soil quality, topography, rainfall etc.

Although changes as caused by predisposing environmental factors are not easily detectable by studying satellite imagery, infrastructure extension – herein categorised under built-up – and agricultural expansion can be visually interpreted and inferred from land cover classification and land cover change maps. Analysis of the generated land cover classification maps of the Tema metropolitan area and the consequent change maps for the years (1990, 2000 and 2007) indicate a consistent trend in the expansion of built-up areas. Stolbovoi (2002) describes land cover conversion as that which entails a change or transition from one land cover or land use type to another. The conversion matrices for the respective intervals, that is, between 1990 and 2000, and between 2000 and 2007, all show conversion from other land cover types to built-up. The change maps, however, indicate a decline in the area covered by cropped lands. Between 1990 and 2000, approximately 22.74 square kilometres of cropped lands were converted to built-up and this is, nonetheless, the single largest conversion from any land cover type to built-up. There was, nevertheless, an increase in cropped areas between 2000 and 2007 due mainly to the conversion of some parts of an originally agroforested area to vegetable farms. The change matrices also indicated a 1.48

square kilometre conversion of open vegetation to cropped lands and a 1.09 square kilometre conversion of wetlands to cropped lands.

Underlying driving forces, again as put out by Geist and Lambin (2002), also take into account, for instance, demographic factors (natural increment and in/out migration etc), and policy and institutional factors (property rights, land tenure and ownership etc). Southworth and Tucker (2001) have suggested that population growth – natural increment or in/out migration – is a major driving force of land cover change in the cities of developing countries, particularly due to the relatively higher direct dependence on their surrounding natural environment to meet the numerous and diverse human survival and developmental needs (Ingram & Dawson, 2005).

With such rise in the number of people, such as depicted in the Tema metropolis, come an increasing need for land and land resources principally for the development of residential quarters and their concomitant social amenities. Correspondingly, a study of the land cover pattern for the three years under study revealed that built-up areas increased consistently, expanding from 110.98 square kilometres in 1990 to 149.65 square kilometres by 2007. Built-up areas in the metropolitan capital – Tema – which is to the south of the metropolis grew denser, whiles its fringes in the south-western, middle and eastern corridors experienced conversion from mainly cropped lands, open vegetation, and wetlands to built-up.

Besides population increment, a shift from farming or crop cultivation to real estate development or complete cessation of farming activities has influenced land cover changes in the metropolis. According to the chiefs and traditional leaders, in times past, plots of land were leased to farmers – most often without a fixed term. As the rise in demand for plots of land for housing surged, these lands were taken back and sold out. Some farmers are said to have purchased the plots of land leased to them and have now ventured into real estate development. Agroforestry projects that were carried out in some areas in the mid 1990s increased vegetative cover in the metropolis. A statement from one of the sub-chiefs is illustrative:

> Some people approached us in 1994/95 from the Regional Agroforestry Unit with this idea of planting fruit trees. We accepted because, we found it both profitable and good for our area. We got the understanding that we could, sometime in the future, sell the produce for profit. We then earmarked certain areas for the project and prepared the sites for planting while the Agroforestry Unit supplied us with seedlings.

This, however, lasted only until 2006 when the harvesting of some tree species without their replacement contributed to the fluctuation in coverage area of open and closed vegetation. Rainfall figures as depicted in the rainfall data for the metropolis, shows a relative increase in the amount of rain received beginning from the mid 1990s. This trend could have promoted tree and vegetative growth in open vegetated areas thus contributing to its transition to close vegetation.

The chiefs report that several real estate developers have also favoured their lands primarily due to the relatively flat topography of the area and the close proximity to the metropolitan capital – Tema. In their bid to meet the large undeveloped tracts of land required by these real estate firms, they have been pushed to sell lands previously untouched. Parts of these lands, field visits revealed, have already been fully developed into residential quarters whiles a greater part remains under various stages of development. The increasing population of the metropolis coupled with the increasing demand for land for residential development, and the shift from farming activities – and in some instances, complete cessation – to real estate development have thus been identified as factors that have influenced the changing land cover of the Tema metropolis.

CONCLUSIONS

This study provides empirical evidence of rapid urbanisation or growth of built-up areas in the Tema metropolitan area between 1990 and 2007. The expansion in built-up areas was predominantly in the areas immediately surrounding the metropolitan capital – Tema. They constitute the areas in the western, eastern and middle sectors of the metropolis. This expansion of built-up areas involved a rapid loss of, particularly, cropped lands and substantial areas of open vegetation. While open and closed vegetation fluctuated in coverage within the period, built-up areas increased steadily and water covered areas remained fairly constant.

The drivers of these changes are associated principally with the population growth of the Tema metropolis with the 1970 population and housing census as bench mark. The results obtained from the 1984 and 2000 population and housing censuses indicate consistent increase in the population of the area. With increasing population also comes an increasing need for land resources with particular regards to the location of residential complexes. Land tenure or ownership schemes, land policy and institutional arrangements also account for other drivers of land cover changes in the metropolis.

Squires (2002) has argued that the benefits of regional economic vitality, and by implication urban growth, notwithstanding, these benefits are increasingly balanced against ecosystem impacts including the degradation of air and water quality, loss of farmlands or cropped lands, and infrastructure costs. As it stands in the Tema metropolitan area, as at 2007, water, wetlands, closed and open vegetation together comprised 57.60 percent (approximately 210.69 km^2) of total land cover. This implies that a greater part of the metropolis still remained under land cover types that supported vital ecosystem services. The growing population of the area and its attendant increase in built-up areas, increase in pressure on existing infrastructure, and loss of ecosystem service-supporting land cover types, nevertheless, remains a threat to optimal ecosystem functioning and ultimately to global earth system functioning.

Recommendations

Following the findings and conclusions of this study, the following recommendations are made:

- The TMA and TDC should incorporate green spaces into zoning schemes in areas of the metropolis yet undeveloped. Real estate developers and private house builders should be encouraged by the TMA and TDC to plant trees along streets and in their houses. This not only serves aesthetic purposes, but also supports air purification, temperature regulation, and carbon sequestration.
- The Greater Accra Regional Agroforestry Unit, through the TMA and in conjunction with the chiefs, must develop sustainable strategies of ensuring the continuity of agroforestry projects. This will guarantee the permanence of such projects in the long term which will also enhance vital aspects of local ecosystem functioning.
- The TMA should set up a Geographic Information Systems and Remote Sensing centre in the physical planning department of the assembly. This centre would make use of GIS technologies and personnel to analyse remotely sensed satellite data of the metropolis on a frequent and timely basis. This will not only provide the planning department with adequate geospatial information, but also afford them the grounds to better appreciate the problems of urban expansion and to put in place relevant and timely interventions to address them.

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