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ARTICLE

Changing land use/cover of Ghana's oil city (Sekondi-Takoradi Metropolis): implications for sustainable urban development

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ABSTRACT
Sekondi-Takoradi has been a preferred city in Ghana for many individuals after the discovery of oil in the area in 2007. This paper sought to analyze the land-use/cover change of Sekondi-Takoradi Metropolis between 1991 and 2016, and its implications on the sustainability of the city. A combination of GIS and remote sensing techniques were employed in the study. The findings of the study revealed a substantial land use/cover change over the period under investigation. Farmlands, open forests, and closed forests were converted into built-up areas. Furthermore, areas covered by water were also encroached by the built-up environment. These show evidence of unguided expansion of the physical growth of Sekondi-Takoradi Metropolis. To address the situation, the Sekondi-Takoradi Metropolitan Assembly in collaboration with public land and environmental agencies should undertake sustainable urban development initiatives such as urban growth boundary strategies and also encourage vertical physical land development to protect the city's nature reserves.

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Land use/cover; change; urban development; sustainability; Sekondi-Takoradi; Ghana

Introduction

Land plays a pivotal role in human existence and development on earth since human beings depend on land for virtually everything including basic needs such as water, clothing, and shelter. However, over reliance on land for various uses to satisfy human needs are now changing the land use and land cover (LULC) patterns in various parts of the world. According to the FAO (2000), land cover refers to the observed biophysical cover on the earth's surface, which literally means what can be seen on a given land. Land use on the other hand refers to 'arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it' (FAO 1998). Putting the two definitions together, Briassoulis (2000) classifies LULC change as the increase or decrease in the area extent of a given LULC type. Globally, statistics show that between 2000 and 2010, forest land cover increased by about 1 percent (153,510 km^2) in Australia and Asia, decreased by 2.49 percent (400,750 km^2) in America, and decreased by 4.82 percent (341,450 km^2) in Africa (FAO 2012). In Europe, agricultural lands declined by 1.5 percent (70.836 km^2) between 2000 and 2009 whilst Africa had some 3 percent (382,991 km^2) gains in the agricultural land in the same period (FAO 2012).

The West Africa Land-Use Land Cover Time Series data analysis from 1975 to 2013 found substantial LULC change in the region with countries like Togo, Burkina Faso, Benin, and Ghana being the hot spots for such changes (Tappan et al. 2016). For example, there was a loss of about 406,432 km^2 savannah vegetation and 100,176 km^2 loss of forest lands. The analysis further found human settlements increasing in coverage by about 140 percent from 15,172 km^2 to 36,412 km^2 with coastal areas (including the study area Sekondi-Takoradi) contributing very much to this increase (Tappan et al. 2016). Human activities on earth inevitably cause some LULC change but the rate of such changes in West Africa is of great concern as it has resulted in fast

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depletion of the natural vegetation especially in urban areas. This is critical because such changes are contrary to the objectives of sustainable development goals (SDGs) especially Goal 11 (sustainable cities) which calls for preservation of the natural vegetation in city's physical landscape to enhance the quality of life of urban dwellers (UN, 2015; Mensah et al. 2017).

After the discovery of oil in commercial quantities in 2007 in Ghana, Sekondi-Takoradi (Ghana's oil city) the closest major city to the oil fields has been the point of attraction for many individuals (both foreigners and Ghanaians). A report by the STMA (2011) showed that the city is now witnessing rapid increase in socioeconomic activities with several infrastructural projects taking place in the hospitality, health, commercial, industrial, and educational sectors of the city. For instance, the 2010–2013 spatial development plan of Sekondi-Takoradi Metropolis stressed on changing physical landscape due to pressures on land for various development projects. These changes have consequences on the sustainability of the city but previous studies have barely focused on the causes of LULC change in the city. They have failed to look at the linkages between LULC change and the sustainability of the city which is very important to global development agenda of cities which support initiatives that contribute to achieving sustainable communities by 2030 (UN 2015). It is therefore to bridge this knowledge gap that this paper was written. The paper aims at analyzing the LULC change of Sekondi-Takoradi Metropolis between 1991 and 2016, and its implications on the sustainability of the city. It is guided by the following research question: *What is the nature of LULC change of* Sekondi-Takoradi?

The study makes important contributions in different ways. It first shows the LULC pattern of Sekondi-Takoradi over a 25-year time interval to know which LULC type is increasing, declining, or remaining unchanged for the city authorities to take the necessary land policies to address the situation. Furthermore, the findings of the paper facilitate easy comparison of the LULC of the study area before and after the discovery of oil in the area to guide future development controls to enhance oil-led development of the city. In terms of sustainability, the paper highlights the consequences of the LULC pattern on the sustainable urban development of the area and proposes land-use planning initiatives to enhance the sustainability of the city.

Land use change and sustainable urban development

A variety of factors have been advanced by natural and social scientists to affect the LULC change of an area. These factors can affect individual or small parcels of land (micro level) or a larger area (macro level). According to Briassoulis (2000), the factors influencing LULC change at both micro and macro levels can be grouped into biophysical (natural induced factors) and social factors (human-induced factors). Earlier study by Turner et al. (1990) categorized the social factors underlying LULC change into human driving forces, human mitigating forces, and proximate sources of change. Whilst the human driving forces focus on fundamental societal forces about changes in population, technology, and sociocultural and economic organization, the human mitigating forces counteract the negative effects of human driving forces such as all forms of formal and informal regulations. The proximate sources of change on the other hand cover human actions that directly affect the LULC of an area. The major proximate factors identified by Meyer and Turner (1994) include *harvesting* (hunting, fishing, fuel wood cutting, mining, grazing, and farming); *replacement* (clearing, plowing, irrigation, construction, and paving); and *external inputs* (plant/animal introduction, fertilizers, machinery, and herbicides).

A study by Verburg et al. (2004) relying on ideas from various disciplines in the natural and social sciences classified the factors influencing land use change into five broad themes: biophysical, economic, social, spatial interaction, and social policies. To them, the biophysical conditions of a given land such as its soil, geology, climate, rainfall, and drainage to a greater extent determine the suitability of that land for a given land use. The economic factors concentrate on the relation between location factors and land use where land is used for a given activity that generates the highest potential profit, that is, land-use decisions are made to satisfy utility-maximization of individuals. Verburg et al. (2004) further opined that in terms of social factors, individuals' cultural values, norms, preferences (lifestyles), composition of neighborhoods and means of transport serve as important determinants of LULC change. The spatial interaction factors focus on centripetal forces which deal with factors that cause the concentration of urban functions (such as economies of scale, localized knowledge spillovers, and labor markets) and centrifugal forces which concentrate on factors that influence a spatial spread of urban functions (such as congestion, land rents, and factor immobility). In addition to the above determinants, recent studies have found rapid urbanization, population growth, migration, industrialization, deforestation, and economic reforms as among the key social and economic contributors to LULC change in urban areas (Murayama et al. 2015; Gu et al. 2016; Owoeye and Ibitoye 2016).

The changes in LULC in urban areas often result in various environmental and socioeconomic problems (such as loss of biodiversity, flooding, congestion, pollution, health problems, etc.) which affect the livelihood of urban dwellers and consequently destruct the sustainable development of urban lands. Therefore to enhance the sustainability of urban lands, different models have been highlighted in the literature and these include the neotraditional development, urban containment, compact city, and eco-city models (Williams et al. 2000; Nelson et al. 2004; Jabareen 2006; Suzuki et al. 2010; Naess 2014). Ideas from these models have revealed that having a sustainable urban development requires a combination of interrelated concepts or elements such as diversity, density, mixed land uses, compactness, greening, and sustainable transport (Wheeler 2002; Nasar 2003; Neuman 2005; Jabareen 2006). Density in this context is the ratio of people or dwelling units per a given land area and at a high threshold (high density) it generates much interactions needed to make urban functions or activities viable. Compactness covers urban contiguity and connectivity, and when applied to existing urban area helps to control urban sprawl. This when achieved minimizes the cost of transporting energy, materials, products, and people from one area to the other. Sustainable transport lays much emphasis on walking, cycling, and efficient public transport that encourage social interactions. Mixed land uses focus on allocation of various land uses (such as residential, commercial, recreational, industrial, and institutional) in close proximity to avoid or limit the need to use car for various activities in urban areas. Similar to mixed land uses is diversity which apart from emphasizing on different land uses in urban areas recommends a mixture of building and housing types, and architectural styles to cater for the needs of different urban dwellers. Lastly, greening as an element of sustainable urban development embraces nature as an integral part of urban areas and therefore strives to conserve many green spaces (parks, gardens, forests, farmlands, etc.) in urban areas to enhance the well-being of urban dwellers. Hence to achieve sustainable urban development, many of the above elements or indicators have to be achieved in a given urban area.

Materials and methods

Study area

The study was undertaken at the Sekondi-Takoradi Metropolis which serves as the industrial and commercial hub of the Western Region of Ghana. As the capital city of the region, it is strategically located due to its proximity to the sea, airports, and accessibility to major cities by rail and road. It can be found in south-western part of Ghana (Figure 1) which is about 280 km west of Accra and 130 km east of the Ghana Cote d'Ivoire border (Stemn and Agyapong 2014). It is predominantly covered by the tropical rain forest and mangrove vegetation types which favor green vegetation (Ghana Statistical Service 2014). The 2010 National Population Census of Ghana puts the total population of the Sekondi-Takoradi Metropolis at 559,548 people with an annual population growth rate of 3.2 percent. Since 2007, when oil was discovered and subsequently exploited in commercial quantities in 2011, the city has been given the name the 'Oil City' of Ghana. It is now the focal point for infrastructural developments, migrants, and employment opportunities due to the discovery of the oil. The current population density is 8140 persons/km^2 (CHF International 2012).

Data processing and analysis

Various softwares were utilized to get and analyze data in the study. For example, ERDAS Imagine 2013 was used to preprocess the satellite imageries and undertake supervised classification of land-use and land cover classes. Arc Map version 10.1 was further used to make layout and design maps for final printing. Microsoft Word and Excel 2013 were utilized to generate tables, and bar charts for various analyses in

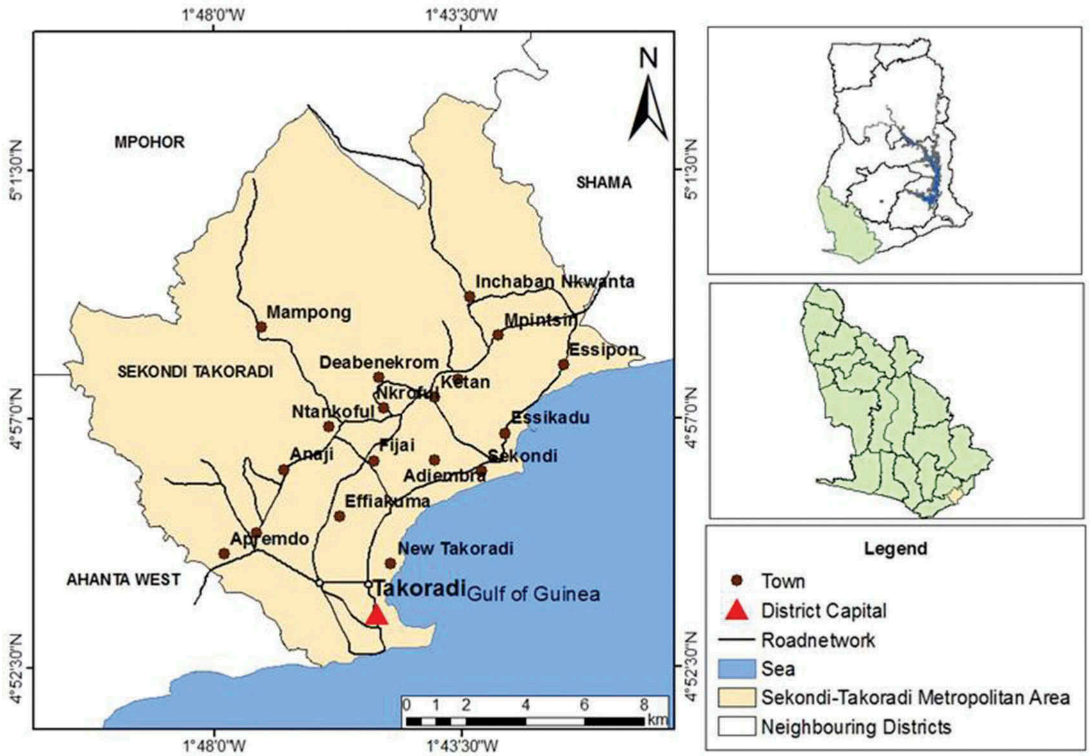

Figure 1. A map of Ghana showing Sekondi-Takoradi metropolitan area.
Source: GIS and Cartography Unit of University of Cape Coast (2017).

the study. The available satellite imageries were acquired from Landsat 04 MSS, 05 TM, 07 ETM+, and Landsat 08 OLI/TIR for the years 1991 and 2016. A remotely sensed data was acquired thereafter with radiometric corrections performed on them for the study area. This was done to remove atmospheric effects so as to improve the accuracy of the image classifications.

Image classification was done to convert the remotely sensed data into thematic data and thematic characteristics such as land cover and land use were considered. The image classification system was based on the United States Geological Survey (USGS) classification system. This was due to the fact that it has features of several existing classification systems and also amenable to data derived from remotely sensed imageries and photographs from satellites (Avery and Berlin 1992). The supervised classification was adopted for the 1991 and 2016 imageries. An area of interest (AOI) file was created using the boundary of the study area and the boundary was developed from a raster image that was opened in Arc Map 10.1. This image was digitized into shape file extension making it a vector layer. It was later opened in ERDAS Imagine 2013 and superimposed on the 1991 and 2016 imageries one after the other. The superimposition of the boundary of the study area as an AOI file was done to subset or clip out the needed area for image classification. Signatures from various features needed for consideration were created into AOI files and afterward the files were classified into six categories based on the USGS classification system (Table 1). The classified imageries for 1991 and 2016 were produced as thematic images. Specific color codes were assigned to the various classified thematic images in their various attribute tables for better cartographic view.

Aside image classification, change detection of LULC for the time interval under study was done to enable the study to draw informed conclusions. The change detection covered the discovery of changes in

Table 1. Description of LULC units used in the study.

Land-use/cover (LULC)	General description
Water	It includes all areas within the landmass that are persistently covered by water. Its categories include stream, lakes, reservoirs, bays, and estuaries.
Barren land	Land areas of dry and exposed soil surface as a result of both human activities and natural causes.
Farm land	It broadly covers land used primarily for production of food and fiber. It includes cropland and pasture, orchards, groves, vineyards, nurseries, and ornamental horticultural areas, confined feeding operations, and other agricultural land.
Built-up	Comprised of areas of intensive use with structures. This category covers community service areas, residential areas, commercial and industrial areas. It also includes lands cleared in readiness for development.
Open forest	Forest lands with a tree-crown aerial density (crown closure percentage) of 5 percent. It includes 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.
Closed forest	Forest lands that have a tree-crown aerial density (crown closure percentage) of 10 percent or more, regime. It includes deciduous, evergreen, and mixed forests.

Data analysis, 2018.

the form of location and extent, and identification of features in space (Asubonteng 2007). Postclassification change detection technique was used and this involved an overlay of independently classified images to identify changes in LULC in terms of aerial extent, spots of change, and the path of change. The LULC maps were loaded into matrix union thematic tool with the help of Raster GIS analysis tool in ERDAS Imagine 2013 to indicate the changes between the time interval under investigation in a form of change map and change matrix which was then used for analysis. The change maps for the various images were later opened in Arc Map 10.1 for management, map layout and map design for the final map display of the work in JPEG image file extension. Likewise, the change matrix for the images of various years were opened in Microsoft Excel 2013 for the generation of the change matrix tables for the respective years images. The above GIS and remote sensed data were supplemented with relevant secondary materials on the topic under study.

Results

The LULC change analysis conducted on the 1991 satellite imagery revealed that in 1991 substantial portions of lands in the study area were covered by open forest (6716 ha) followed by closed forest (4594 ha). Farmlands covered 301 ha with built-up lands taken about 580 ha of the total land area. This suggests that by 1991 the forest cover of the area was very high signifying much greenery of Sekondi-Takoradi Metropolis (Table 2). Closed forest, open forest and farmlands together covered about 70 percent of the total land area of Sekondi-Takoradi Metropolis.

However, during the 1991 and 2016 time interval closed forest was found to have greatly reduced in size losing over 4000 ha of land (4558 ha). Similar was the situation of open forest which slightly reduced from its previous land coverage of 6716 ha in 1991 to 6614 ha in 2016 (Figure 2). Another important observation made in 2016 was the loss of farmland to other land uses. A total of 300 ha of farmlands were lost. In fact, apart from built-up lands which recorded more gains than loss between the 1991 and 2016 time interval, there was generally a decreasing trend of LULC change in the city with various LULC classes losing substantial portions of their land sizes. The excessive increase in built-up lands at the expense of the natural environment is not ideal in terms of sustainable urban planning as this causes huge destructions to the natural ecosystem and its accompanying services essential for human survival. These observations suggest that during the 1991 and 2016 time interval much pressure was put on the existing lands to satisfy the needs of the residents in Sekondi-Takoradi.

Furthermore, looking at the LULC transitions among the various LULC classes between 1991 and 2016 time interval, it was found out that about 576 ha of built-up lands remained unchanged (Table 2). There was no change of lands between built-up lands and closed forest, and built-up and barren lands. On closed forest, as 20 ha remained unchanged, 2691 ha were converted into open forest and 1697 ha to built-up lands with barren lands also taking 134 ha of such lands by 2016 (Table 2).

An estimated 1959 ha of open forest remained steady, whereas it lost approximately 4442 ha to built-up lands. In addition to this, 111 and 193 ha

Table 2. LULC transitions in hectares between 1991 and 2016 at Sekondi-Takoradi.

					2016			1991	Interval
		Water	Barren land	Farm land	Built up	Open forest	Closed forest	Total	Loss
1991	**Water**	**0**	4	0	17	3	0	24	24
	Barren land	9	**221**	47	2,184	1,959	11	4,431	4,210
	Farm land	2	0	**1**	297	1	0	301	300
	Built up	1	0	3	**576**	1	0	580	4
	Open forest	6	193	111	4,442	**1,959**	5	6,716	4,757
	Closed forest	0	134	52	1,697	2,691	**20**	4,594	4,574
2016	**Total**	18	552	214	9,212	6,614	36	16,646	
Interval	**Gain**	18	331	213	8,636	4,655	16		13,869

Data analysis, 2018
*Figures **bolded in Table 2** above signifies various land use/cover which remain unchanged.
**The spatial resolution for the data is 30 × 30 m for each pixel from Landsat 7 ETM+.

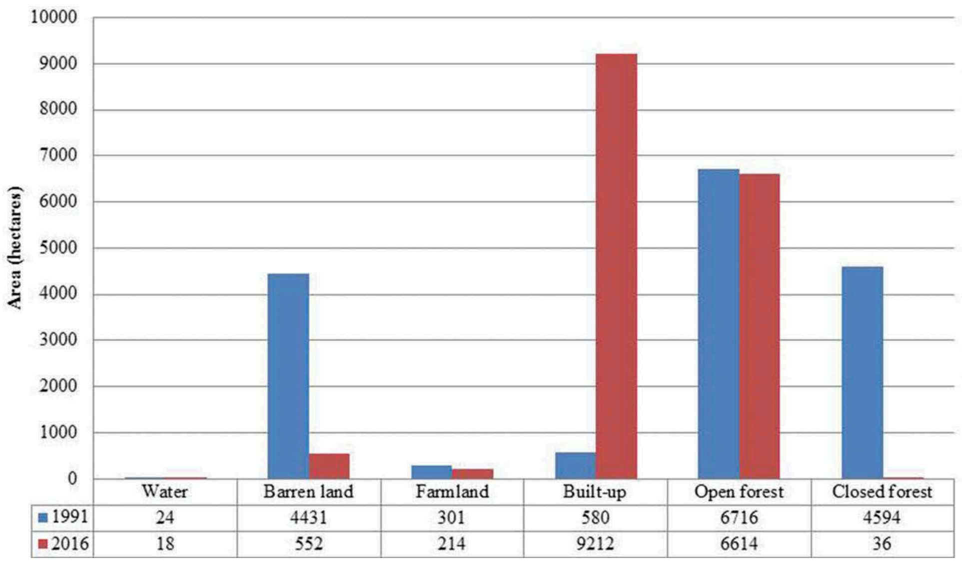

Figure 2. Area change of LULC in Sekondi-Takoradi between 1991 and 2016.
Source: Data Analysis, 2018.

of open forest were converted into farmland and barren land, respectively (Table 2). The LULC change analyses between farmland and other LULC classes found farmland losing a large tract of land to built-up lands. Specifically, 297 ha of farmlands were found to have been converted to built-up lands during the 1991–2016 time interval.

Discussion

The overall LULC pattern (between 1991 and 2016 time interval) of Sekondi-Takoradi Metropolis shows a drastic decrease in the land coverage for closed forest, farmlands, and some reduction in open forest and water bodies but this is accompanied by rather a massive increase in the built-up lands from 580 ha in 1991 to 9212 ha in 2016. This shows a phenomenal expansion of the built-up lands of the city over the time interval under study (Figure 3) with such expansion taken place on farmlands, forests (especially closed forest), barren lands, and water bodies. This is synonymous to the situation in urban areas of developing countries such as the Eastern Ghats Region (India), Dhaka Metropolitan area (Bangladesh), and Al Gharbiya governorate (Egypt) where much agricultural lands and forests have been converted into built-up lands due to rapid urbanization (Belal and Moghanm 2011; Dewan et al. 2012; Ramachandran et al. 2018). For instance, in the Dhaka Metropolitan area, rapid urbanization resulted in built-up lands

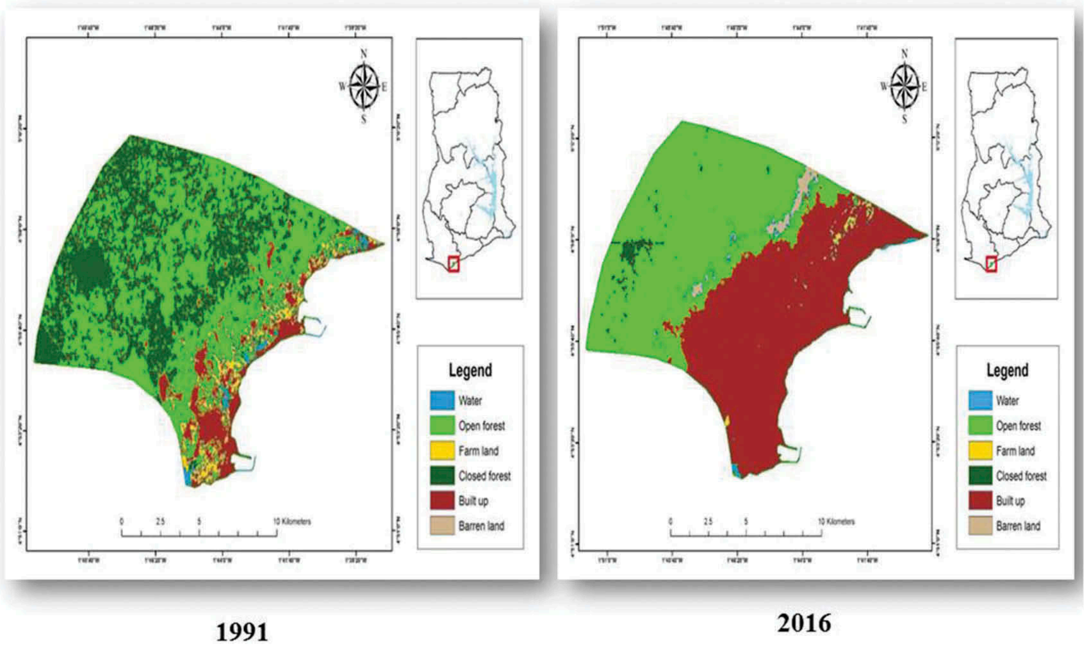

Figure 3. A land use/cover map of Sekondi-Takoradi between 1991 and 2016.
Source: Landsat Satellite imageries of 1991 and 2016.

increasing substantially from 5500 ha in 1975 to 20,549 ha in 2005 whilst at the same time interval cultivated land decreased drastically from 12,040 ha to 6236 ha. In the case of Egypt, due to urbanizaiton, Tanta and Quttour districts in the Al Gharbiya governorate had their agricultural lands decreasing by about 2377 and 1339 ha, respectively between 1972 and 2005. Although the results of the above literature is similar to the findings of the study area but the intensity of the expansion of the built-up lands at the expense of other land uses was found to be very high in the study area taken into consideration the magnitude of the expansion of built-up lands (over 15 folds) within the time interval (1991–2016) that the study was conducted. The foregoing suggests uncontrolled nature of physical developments taken place at Sekondi-Takoradi. This raises questions about the roles of government land and environmental agencies operating in the study area (such as the Physical Planning Department, Development Planning Unit/ Department, Environmental Protection Agency, and Forest Services Division).

These agencies as part of their mandates are supposed to protect the city's nature reserves and ensure orderliness of physical developments to prevent encroachment into these reserves (natural vegetation, water bodies, wetlands, etc.). However, what were observed from the LULC analyses were far from their mandates and hence suggesting some element of ineffectiveness in the performance of their roles as a probable factor for the seemingly uncontrolled nature of physical land development in the area.

Another possible factor for the rapid expansion of the city's built-up area is the discovery of crude oil in the area in 2007 and its associated increase in population and building infrastructure. Studies have revealed that after the discovery of oil, Sekondi-Takoradi has become a point of attraction for many people (both Ghanaians and foreigners) and businesses resulting in excessive rise in the real estate sector (houses, hotels, and offices) and human population (Asafu-Adjaye 2010; Eduful and Hooper 2015; Mensah et al. 2018). Prior to the discovery of oil, in 2000, the population of the city was about 360,000 but in 2010 it rose to nearly 560,000 when commercial exploitation of the oil began. By the end 2016, the population of the area was estimated to be near 700,000 people giving the city an average population growth rate of 3.2 percent, higher than the national average of Ghana which is 2.5 percent (Fiave 2017; Mensah et al. 2018). These revelations clearly provide some linkages between the oil discovery and the expansion of the city into its reserved forests and farmlands to accommodate the growing population.

The above finding makes the changes in LULC of the city not the result of natural or biophysical means but rather due to replacement conditions (such as clearing of farmlands/forest to contain the increasing population, filling of water bodies for infrastructural development, construction activities, etc.) as indicated by Meyer and Turner (1994). These activities deplete biodiversity which is critical for sustainable urban development as opined by Elmqvist et al. (2015). To Elmqvist availability of many urban forests and green vegetation helps to provide many ecosystem services such as ameliorating the microclimate of an area and improving urban air quality to enhance the well-being of urban dwellers. The loss of farmlands as found in the changes in LULC of Sekondi-Takoradi means that farmers who rely on such lands for their livelihoods have to lose their jobs and search for other job alternatives for their survival. In Akure city (Nigeria), similar observation was made by Owoeye and Ibitoye (2016) which found the city losing much of its farmlands to the built environment (especially for residential housing development) relieving most farmers of their jobs. This development is contrary to the current national agricultural policy of Ghana (planting for food and jobs) which supports the conservation of more farmlands in order to encourage more Ghanaians, especially the youth, to go into agricultural activities (Ministry of Food and Agriculture, 2017). The loss of farmlands therefore serves as a disincentive to city dwellers who are interested in farming not to go into that venture but rather search for other jobs, especially 'white collar' jobs which are limited in the city and Ghana as a whole. This therefore serves as a contributing factor to the unemployment situation of the study area.

The reduction of water bodies, on the other hand, as against excessive rise in the built-up area also gives an indication that some individuals and developers are encroaching water areas for building purposes. That is filling up such areas with sand to make them conducive for construction of buildings and other infrastructure. This finding is consistent with studies by Mensah et al. (2018) and Aduah and Baffoe (2013) in the same city which found several buildings taking place on water ways. However, it is contrary to the situation in Nairobi (Kenya) where water areas despite the expansion of the city between 2000 and 2014 rather increased in size more than 30 percent (Murayama et al. 2015). This situation denies the city the opportunity to have and enjoy the benefits associated with conserved water areas such as wetlands and marshy areas.

Implications for sustainable urban development

The above findings have several implications for sustainable urban development of the area. First, the lateral expansion of the built-up area has huge consequences on the compactness of the city which is an important element in achieving sustainable urban development. Earlier study by Aduah and Baffoe (2013) using the Shannon's Entropy Index provided similar evidence by finding Sekondi-Takoradi to have low compactness due to the sprawling nature of its built environment. This prevents the city from enjoying the benefits associated with compact cities such as high social interaction due to close integration of communities, and easy access to social-economic facilities because of their close proximity to each other.

The horizontal spread nature of the built-up area further exposes the city authorities, national government, and multinational companies to incurring high cost in extending essential public facilities such as water, electricity, and telecommunication networks to newly developed areas at longer distances. This problem was evident in the area as new developed communities at far distances at the outskirts of the city were found suffering from frequent shortages of water supply due to difficulties in extending pipe-borne water supply to those areas by the city authorities (Coastal Resources Centre, 2013). The outward expansion nature of the city further makes the city more susceptible to having low building density which discourages more walking since it positions social-economic facilities at longer or greater distances which sustainable urban development discourages.

The diminishing nature of both closed and open forests signifies some loss of green spaces (such as parks and gardens) and for that matter poor protection of such spaces in the physical landscape of the city which is at variance with what is recommended by the eco-city model. Although the green vegetation of the city (both open and close forest) as at 2016 covered almost 50 percent of the total land area which is quite commendable as it is above the global average of 33 percent as observed by Dobbs et al. (2014). However losing 32 percent of such spaces within a 25-year period makes it critical. These green spaces often referred to as 'the lungs of cities' provide tripartite benefits (social, economic, and environmental benefits) to enhance the sustainability of cities (Jennings et al. 2012; Mensah 2014). These benefits include providing spaces for leisure and recreation, offering health benefits, and enhancing social integration and cohesion (social benefit). Economically, they provide job opportunities; and environmentally, beautify urban design, conserve biodiversity, improve air quality and ameliorate local climate. However, their diminishing nature in the current LULC of the Sekondi-Takoradi will make it difficult for their benefits to be well felt by the residents.

Furthermore, excessive increase in the built-up area indicates increment of more impervious surfaces (hard or concrete surfaces) in the city. High amount of such surfaces are not recommended in sustainable cities due to their poor absorption of running water and reflection of solar radiation back to the atmosphere hence contributing to environmental problems such as flooding and Urban Heat Island. This development put the city at risk of experiencing such environmental problems to hamper the socioeconomic development of the area.

Conclusion and the way forward

The findings of this paper give a clear indication of unguided expansion of the physical growth of Sekondi-Takoradi Metropolis which is shown in undue encroachment of forest reserves (both close and open forests), rapid diminishing of the city's farmlands, conversion of water bodies into built-up lands, and uncontrolled built environment. This is partly due to poor management of the LULC by the city authorities, and the discovery of oil which serves as a stimulus to draw more people and businesses to settle in the area, therefore putting pressure on the available LULC for various building activities. To correct the situation, the following measures have been suggested by the paper.

In checking the uncontrolled expansion of the built environment, urban containment policies such as urban growth boundaries strategy could be implemented in the area. In doing this, the Physical Planning Department of the city should liaise with the Land Use and Spatial Planning Authority to establish a well-defined urban growth boundary taking into consideration the current LULC pattern of the city. Expansion of physical developments beyond this boundary should strictly be prohibited. This when complied with will help to concentrate physical development in areas within the boundary to create the necessary building density and conserve much natural environment to enhance the sustainability of the city. Although in Hangzhou (China) the effectiveness of urban growth boundary has been found to be low (Zheng 2014) but generally in both developed and developing countries empirical studies have shown that this strategy helps to reduce indiscriminate urban expansion and conserve large amount of natural vegetation for future usage (Planning Institute of Australia 2006; Woo and Guldmann 2014; Horn 2015; Greenbelt Alliance 2016).

In addition to this, proposals for developing conserved nature reserves by individuals or organizations especially at the northern part of the city should be subjected to thorough checks, and cost and benefits analysis by the statutory planning committee and other technical experts before decisions are made. This will help avoid unnecessary conversion of forests and farmlands into built-up areas which the city is experiencing now. This in the long run will help the city to conform to objective five of the 2013 National Urban Policy of Ghana which focuses on improving environmental quality of urban dwellers.

The STMA in collaboration with government land and environmental agencies (especially the newly created Landuse and Spatial Planning Authority) should effectively undertake their roles to prevent undue encroachment of the city's forest reserves (both close and open forests) and water bodies. With the passage of Ghana's new Landuse and Spatial Planning Act of 2016 (Act 925) which have restructured the Physical Planning Department of STMA (now Town and Country Planning Department and Department of Parks of Gardens consolidated into one body) to have more powers than their previous mere advisory role, these agencies now have strong legislative and administrative support to effectively manage the city's land by undertaking stringent measures and routine surveillance of the city's physical land developments. This will help detect activities intruding into the city's nature reserves early for the necessary measures to be undertaken to correct the situation. Furthermore, the city authorities should encourage vertical physical land development as against lateral (horizontal) land expansion currently taking place in the city. This can be achieved by sensitizing the residents and private estate developers on vertical land developments and their contributions to sustainable urban development . This initiative will help to concentrate physical development on small piece of land and conserve much natural environment (forests, farmland, and water bodies) for the future generation. However, the vertical land development should be pursued with much care to suit the cultural and socioeconomic needs of the residents of Sekondi-Takoradi.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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