Urban sprawl and sustainability: A comparative Analysis of Accra and Kumasi urban regions.

Gerald Albert Baeribameng Yiran
Department of Geography & Resource Development, University of Ghana, Legon.
gyiran@ug.edu.gh

Abstract

One of the important developmental topics of global concern is how to achieve sustainable urban development in developing countries where urban sprawl is very rapid. This is because urban sprawl have adverse consequences on the environment and human welfare. Indicator-based methods have become popular among the approaches developed to determine sustainability of urban environments and have been widely used to measure sustainable development of cities. This paper uses Shannon's entropy to examine intra-city and inter-city land-use change patterns and the intensity and level of urban sprawl and then discusses the sustainability of the urban areas under study. The results show high growth rates of the urban regions. All entropy values were also very large near the upper limits, and thus reveal that both urban regions are sprawling at high rates, but the Accra urban region is sprawling faster than that of Kumasi. The results also show a high rate of densification (compactness) of built-up areas at the same time. Although both regions exhibit unsustainable development, the problem is worse in the Accra urban region, highlighting a difference in the development patterns of the regions. With the current pattern and form of development, it is not possible to achieve the pillars of sustainable development: to protect the environment while realizing economic and social goals. Thus, the sustainability of the growth of the regions is far from reality. It is recommended that an all-inclusive sustainable development planning framework be developed for the regions, but the plans should be region specific since each region exhibits different patterns.

Keywords:
Shannon's Entropy; urban sprawl; sustainable development; Accra; Kumasi

Introduction

Many cities all over the globe continue to urbanize at a rapid rate, resulting in the excessive conversion of natural landscapes into residential uses. The resulting land-use changes have severe consequences on the environment and human life. Thus, mitigating the adverse effects of urbanization has been at the centre of global engagements, leading to the coining of the concept of sustainable urban development. Sustainable urban development (SUD) is a new type of development that emerged after the popularization of the concept of sustainability and is made up of words with different meanings (Yigitcanlar et al., 2015). SUD is coined by marrying the sustainability and urban development concepts. Sustainability, according to Goonetilleke et al. (2014), connotes conserving ecosystems and their services, and at the same time providing for the needs of humans. In contrast, urban development represents any activity that advances the quality of human life through the use of natural resources. The use of natural resources in this regard will eventually deplete and/or degrade them. This means that sustainability and urban development contradict each other. Therefore putting these two contradictory terms together to form SUD amounts to setting the stage for an intellectual debate (Yigitcanlar et al., 2015).

However, urban development/growth in the developing world, particularly Asia and sub-Saharan Africa (SSA), is proceeding at a fast rate (UN-DESA, 2014, 2018), with dire consequencies for human wellbeing. The consequences of rapid urban development are said to be many and complex (Hiremath et al., 2013). One of the major challenges to SUD is urban sprawl (Bovet et al., 2018; Hennig et al., 2016; OECD, 2018; Wei, 2018). Although there is no agreed definition of urban sprawl, it is generally described as haphazard, poorly planned/unplanned, uncontrolled, uncoordinated expansion of low-density buildings occurring at the peripheries of urban centres (Akubia & Bruns, 2019; Altieri et al., 2014; Bhatta, 2010; Sinha, 2018). Urban sprawl often generates environmental, social and economic costs stemming from inefficient utilization of natural resources (Bovet et al., 2018). Studies have shown that urban sprawl might lead to debilitating effects on human wellbeing in terms of lack of potable water, food shortage and hunger, flooding, settlement segregation and increased urban warming, and thereby contribute to global climate change (Akubia & Bruns, 2019; Duque et al., 2019; Mockrin et al., 2018; Rain et al., 2011; Sulemana & Yiran, 2018). Some of these challenges, particularly the need to ensure human wellbeing while sustaining the environment in urban areas, have generated a lot of research interest in sustainable urban planning.

Sustainable urban planning can be considered as the purposeful intervention by city planners in urban development using various tools including regulations, stakeholder engagement and collective choice (Hopkins, 2001 cited in Cobbinah & Darkwah, 2017). Unfortunately, sustainable urban planning in SSA countries like Ghana is a mirage, as planners are unable to manage the environmental, economic and social consequences that arise due to urban sprawl (Cobbinah et al., 2015). For SUD to be achieved, there is the need for a balance between conservation of the environment and the development of urban areas that promotes equity in the provision of goods and services in such areas (Hiremath et al., 2013).

According to Yigitcanlar and Teriman (2015), sustainable urban planning is undermined by the lack of complete and accurate information on cities. Comprehensive and precise spatial data is critical for spatial planning. The need for accurate data in Ghana is vital as many cities across the country are rapidly sprawling, characterised by scattered or leapfrog development, increasing vast expanses of single-use or low-density development and a paucity of functional open spaces, among others (Amoako & Cobbinah, 2014; Cobbinah & Aboagye, 2017; Jaeger et al., 2010). Several approaches including the use of indicators have been developed to provide information or assess sustainable development of cities. According to Guy and Kibert (1998), "indicators are parameters or values that provide information about a phenomenon" (cited in Hiremath et al., 2013: 556). Indicator-based approaches are popular and are being increasingly used to assess the sustainability of urban growth around the world as the information necessary to building a sustainable development system that incorporates development and environmental protection (Hiremath et al., 2013). Thus, this paper extends this knowledge by carrying out a comparative analysis of urban development of two urban regions. This will be achieved by accurately quantifying the urban footprint and detecting the trend of urban sprawl. However, urban areas are unique in terms of characteristics, activities and resources, and therefore, a comparative analysis will highlight the factors contributing to the different patterns of growth. Knowledge of this information will be used to assess the sustainability of the development of the cities. The study therefore undertakes a comprehensive examination of land-use change using time series data to quantify urban growth/sprawl by means of spatial metrics (Shannon's index) in the two largest cities in Ghana.

The paper uses Remote Sensing techniques to collect spatial data and bring them into the GIS environment to quantify and analyse the trend of urban expansion. The integration of Remote Sensing (RS) and Geographic Information Systems (GIS) technologies has gained popularity, and the tools have generally been used for research into urban growth and land-use changes (Bhatta et al., 2010a; Chong, 2017; Nkeki, 2016). GIS procedures were used to determine spatial measures (metrics) and statistics using temporal data extracted from satellite imagery (Moghadam & Helbich, 2013; Nkeki, 2016; Taubenböck et al., 2009). The use of spatial metrics (indices) to quantify urban growth/sprawl from multi-date satellite data has increased in recent times (Bhatta, 2010; Bhatta et al., 2010a; Jaeger et al., 2010; Mosammam et al., 2017; Ramachandra et al., 2012; Shaw & Das, 2018). The methods involved are described in detail in the next section.

Description of methodology

Choice of study areas

The two largest urban regions in Ghana, Accra urban region and Kumasi urban region are chosen for this study, as they are currently the most rapidly expanding regions, a trend primarily driven by population growth from rural-urban migration (Awumbila et al., 2014; Yiran et al., 2015). The influence of these cities has grown beyond their core towns into adjoining districts and regions. Thus catchment areas of the cities considered in this study are described as Accra Urban Region (AUR) and Kumasi Urban Region (KUR). AUR is located on the coast of Ghana (Figure 1). The region is mostly plain with gently undulating topography and has the Akuapim range to the north and the sea to the south limiting growth in some directions. This region (AUR) covers almost the entire area of Greater Accra Metropolitan Area (GAMA) and parts of Central and Eastern Regions where many people live and commute daily to Accra to work or transact business. KUR, on the other hand, is located close to the middle of Ghana (see Figure 1) and has no natural feature constraining development, although the topography is more undulating than AUR.

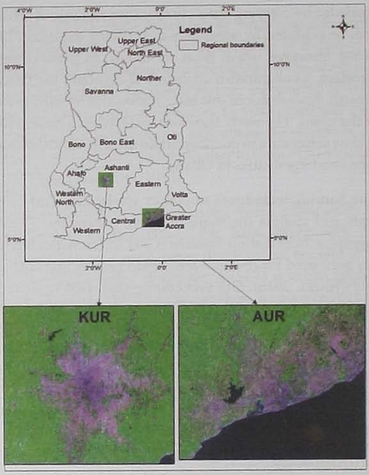

Figure 1 Map of Ghana showing the Study areas

This enables the growth of KUR to spread radially in all directions and cover areas beyond the former Kumasi Metropolitan Area where people live and commute daily to work and do business in Kumasi. These two urban regions, AUR and KUR, were chosen for this study because they are the most extensive and very fast-growing urban regions. The reason for their fast growth is because most of the jobs in Ghana, especially those termed 'white-colour', are located in these regions. They also house the largest market centres in the country, offering a lot of job opportunities in the informal sector, especially to those engaged in trading and other services (Yiran et al., 2015). These cities also host the best social amenities such as the best hospitals, most of the good schools across all levels of the educational ladder, the best entertainment centres, the best infrastructure and utility services, among others. These and many others constitute the pull factors attracting many people, especially from the hinterlands. Also, Songsore (2003) chronicled urban growth for the pre-structural adjustment period, which indicates natural increase as an essential factor in the growth of urban areas. However, the rate of growth of these cities outpaces the rate of infrastructure provision, creating huge housing deficits annually. Governments, in a bid to bridge the housing gap, liberalized the housing sector, leading to private and individual participation in housing provision (Fuseini et al., 2017). To meet the housing demand, more land has to be converted from other uses in and around these cities into residential land. But the land governance systems, especially land tenure in the two cities, are different (Ubink & Quan, 2008). The comparative analysis will highlight the role land governance plays in the growth of each region.

Satellite image acquisition and pre-processing

Three Landsat images for AUR and KUR were downloaded for classification from earth-explorer and the United States Geological Survey (USGS) website. Information about the bands is shown in Table 1. The initial intent was to start from around 1990, as those years marked the beginning of the implementation of the structural adjustment Program (Fuseini et al., 2017) but due to cloud cover, especially in KUR area, the images that met the less than 10% cloud cover criteria were between 2001 and 2020. So the images were downloaded within these time limits. The bands in Table 1 were chosen because they give an excellent contrast between built up and non-built up areas.

Table 1 Landsat imagery used for classification

Accra urban region				Kumasi urban region			
Date	Landsat[1]	Bands	Bounding coordinates	Date	Landsat	Band	Bounding coordinates
26/12/2002	LE07	7, 4, 2	Upper left	02/04/2001	LE07	7, 4, 2	Upper left
17/01/2011	LE07	7, 4, 2	5° 52' 47"N, 0° 34' 06"W	06/02/2010	LE07	7, 4, 2	6° 55' 47"N, 1° 50' 19"W
02/01/2020	LC08	7, 5, 3	Lower right 5° 20' 58"N, 0° 04' 09"E	09/01/2020	LC08	7, 5, 3	Lower right 6° 30' 15"N, 1° 24' 09"W

The LE07 images had gaps, and these were corrected using the gap-fill extension in ENVI 5.3 before calibration. Exoatmospheric calibration was performed on all images because they came from different sensors and dates and thus needed to be on a common scale to enable comparison. The images were then subset using the bounding coordinates of the upper left and lower right coordinates for the respective regions shown in Table 1 during the band combination procedures. Due to cloud cover, it was not possible to get the same dates, as can be seen in Table 1, but these slight differences in dates did not affect the work.

Image classification

Supervised classification algorithm in ENVI 5.3 was used to classify the images into five classes (Table 1). Due to difficulty in defining urban areas, especially in relation to satellite-derived data (Møller-Jensen et al., 2020), this study limited the urban areas to impervious surfaces (buildings and some roads) referred to as built-up areas. The maximum likelihood classifier was used to perform the classification. The maximum likelihood classifier was chosen because it is parametric and also a popular method for classifying Landsat images (see for example, Osmanet al., 2016; Ramachandra et al., 2012; Yiran et al., 2012).

1 LE07 is Landsat 7 Enhanced Thematic Mapper (ETM+) and LC08 is Landsat 8

The training samples or regions of interest (ROIs), explained in Table 2, were selected using Google Earth in conjunction with unsupervised classification.

Table 2 Definition of land use classes

Class	Description
Built-up area	Buildings, road network, and other impervious surfaces in the urban area
Vegetation	Forest, grassland, farms with crops, shrubs, bushes, etc.
Soil	Bare land, gravel roads, burnt areas, farms with dead or withered crops, excavated areas, exposed soils, bare playgrounds/school parks etc.
Water bodies	Lakes, rivers, lagoons, ponds, dams, sea
Clouds[1]	Cloud cover
shadows	Shadows of clouds

This was done by taking coordinates of unique and large areas on the unsupervised classification in ENVI and searching for these locations in Google Earth. The time slide bar on Google earth was slid to the year corresponding to the year the image was taken or a little after it was taken (whichever is available) to see what feature that was. Though pixel-based classification usually produces a "salt" and "pepper" effect, smoothing was not applied because some land uses, especially in the peri-urban areas, are even smaller than the size of a pixel[2] and would be lost if smoothing and aggregation were applied. As with many land cover classification studies, post-classification accuracy assessment was done, and this was found to be within what many studies have reported (e.g., Nkeki, 2016; Yiran et al., 2012). After classification, three of the land cover classes (Vegetation, soil and water bodies) were combined into one class called non-built-up. This resulted in only two classes; built-up and non-built-up areas. The resultant classified images for each region were uploaded in ArcMap and converted to shapefiles amd the areas of the classes calculated.

However, the sea and lake Bosumtwi, which are at the lower boundaries (Figure 1) of the subsets, were deleted before the areas of the classes were calculated. There were a few clouds and cloud shadows on the 2001 and 2010 images of KUR, but those over/near built-up were selected and added to the built-up class while the rest were added to the non-built-up class. This was done in ArcMap after the classified images were converted into shapefiles.

1 Clouds and shadows were found on the KUR images
2 Pixel is picture element of size 30m x 30m

Shannon's entropy

Shannon's entropy (H_n) is an index which measures the amount of in-fill/concentration (compactness) or dispersion (sprawl) of a geographical feature among many zones (Bhatta et al., 2010a; Yeh & Li, 2001a). This measure was chosen because it is a most widely used measure for studying urban sprawl (e.g. Chong, 2017; Nkeki, 2016; Rahimiet al., 2019; Vani & Prasad, 2020; Yeh & Li, 2001b). H_n was calculated to quantify urban sprawl developments in the two urban regions. Shannon's entropy is calculated using equation 1 taken from Chong (2017):

$$H_n = -\sum P_i \log_{10}(P_i) \quad \text{.......} 1$$

Where P_i is the proportion of built-up area in the i^{th} zone and n is the total number of zones in each region.

The minimum and maximum values of H_n are zero (0) and $\log_{10}$ (n), respectively. Values close to zero (0) indicate highly clustered (very compact) built-up areas while values closer to $\log_{10}$ (n) show dispersed (sprawl) areas (Chong, 2017; Deka et al., 2011; Yeh & Li, 2001b). Half of the value of $\log_{10}$ (n) is usually taken as the threshold, and when H_n is larger than the threshold value, the region is considered to be sprawling. Determining the threshold is robust and is easily computed for any study area mathematically (Bhatta et al., 2010b).

In calculating H_n for this study, the multiple ring buffer tool in ArcGIS Analysis ToolBox was used to generate a series of concentric buffer zones at 1 Km intervals around points used to represent the city centres. The 1 Km buffer was chosen because of potential information loss due to aggregation effects when larger size buffers are used (Yeh & Li, 2001b). For AUR, Accra was used as the centre where AUR originated and started to expand, while Kumasi was used as the centre of growth for KUR. These points were obtained from the town/village shapefile data of Ghana. All buffers were dissolved to eliminate overlaps in the zones. The Tabulate Intersection tool in Statistics in the Analysis Toolbox in ArcGIS was used to compute the intersection of the land-use classes and the buffer zones. The tool generates a table that presents the areas of the two classes (the built-up and the non-built-up areas) in each zone. The area values of the intersecting layers were used to do the entropy calculation. All the tables (i.e. the tables generated with the tabulate intersection tool) were exported to Excel to enable easy calculation of the entropy. In Excel, the ratio (R_i) of the area of the built-up area to the total area in the i^{th} zone was calculated using equation 2 from which the proportion (P_i) needed for equation 1 was obtained by equation 3 (see Chong, 2017).

$$R_i = (\text{Area of built-up})_i \,/\, (\text{area of built-up} + \text{Area of non-built-up})_i \quad \text{.......} 2$$

$$P_i = R_i / \text{sum } R_i \quad \text{.......} 3$$

The values obtained from equation 3 were then substituted into equation 1 to compute the Shannon's entropy for each year in each region. Finally, the change in entropy (dE) from one time to another was calculated using equation 4. With the change in entropy, a decrease in entropy (i.e. a negative value) over time means the region's development is compacting or densifying while an increase in entropy (a positive value) means the region's development is spreading or dispersing (Chong, 2017).

$$dE = H_{n(t2)} - H_{n(t1)} \quad \text{......} 4$$

Where t1 and t2 are the first and second reference years respectively.

Results

This section presents the results of the study by first describing urban growth in the regions as seen from the classified images and then comparing them using the Shannon's entropy indices.

Urban growth in AUR and KUR

The AUR has grown over the years in terms of filling the open spaces within it and expanding into surrounding areas. As can be seen in Figure 2, over the past two decades, the region has grown tremendously.

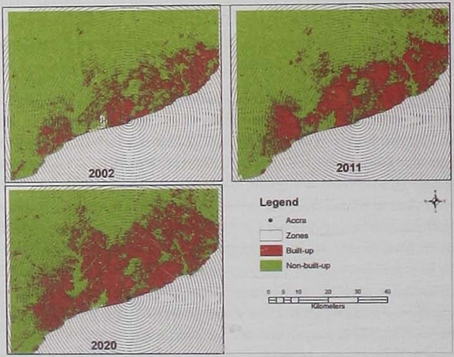

Figure 2 Urban growth of AUR from satellite imagery (2002 to 2020)

In 2002, there were a lot of greens (non-built-up areas) within AUR, but some of these were filled up by 2011 with the reds (buit-up areas) while at the same time the red spots expanded into the hinterlands, and those which existed increased in size and new ones appearing. In effect, the built-up area has increased in size by in-filling and expansion. The in-filling and expansion of the built-up area continued into 2020. The extent of built-up areas in each year was extracted from the classified images to quantitatively assess the rate of growth of the urban region (Figure 3). From Figure 3, the average growth rate of built-up areas between 2002 and 2011 is 28.2 square Km/annum while that between 2011 and 2020 is 31.3 square Km/annum. This translates to 5.6% per annum and 4.2% per annum respectively, even though the last decade had a nominal increase in the growth rate of about 3 square Km/year. This means that AUR is growing averagely at 4.9% per annum. The growth in AUR is constrained in the south by the sea and in the north by the Akuapem range, leading to the growth in the south-west to north-east orientation as in Figure 2.

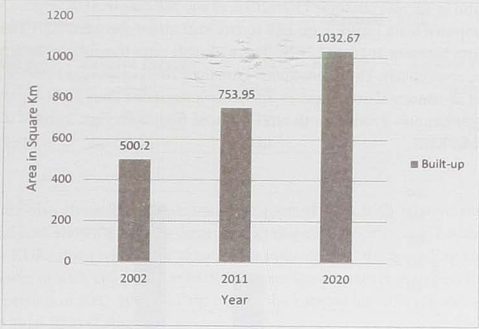

Figure 3 Changes in built-up extent in AUR

KUR, on the other hand, has a radial or concentric growth (Figure 4). The radial growth is due to the fact that, though the land has hills/mountains, they are not elongated and therefore do not constrain development very much in any direction. As shown in Figure 4, the built-up class (red) increased immensely from 2001 to 2010.

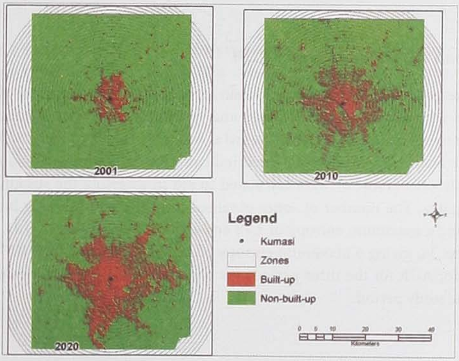

Figure 4: Urban growth of KUR from 2001 to 2020

Similar to AUR, the built-up areas consumed the non-built-up within KUR as well as its periphery. The expansion and in-fill also continued into 2020, as was the case in AUR (Figure 5). The growth rates of KUR computed from Figure 5 are 23.6 square km/annum between 2001 and 2010 and 14.2 square Km/annum between 2010 and 2020. These growth rates translate to 20% per annum and 4.3% per annum, respectively. The phenomenal growth of 20% per annum between 2001 and 2010 can be described as abnormal and requires further investigation. Thus KUR is growing averagely at about 12.2% per annum. From growth rates deduced from both Figs. 3 and 5, it is clear AUR is growing faster than KUR.

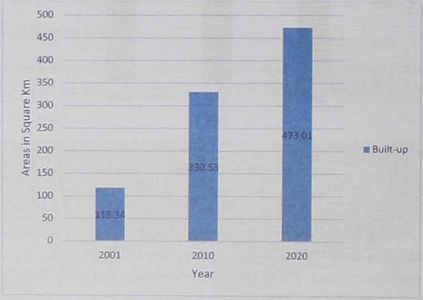

Figure 5: Area of land use classes in KUR (square Km)

Comparing urban sprawl in AUR and KUR

After exploring the growth pattern in the two urban regions, it is necessary to investigate the degree of sprawl in each region to ascertain the level and nature of sprawl and determine whether or not they are developing sustainably. Urban sprawl is being assessed because it is known to pose a challenge to SUD. Shannon's entropy is a good indicator for determining urban sprawl or urban growth. Thus, entropies (Table 3) were calculated to aid in assessing the sustainability of urban growth in the regions. The number of zones obtained from the multiple ring buffer analysis for AUR was 50, giving a maximum entropy of 1.70 and a threshold entropy of 0.85. The number of zones for KUR was 34, giving a maximum entropy of 1.53 and a threshold of 0.77. From Table 3, all the entropies for AUR for the three periods are bigger than 0.85, which means AUR has been sprawling over the study period.

Table 3: Shannon's entropy calculations

Accra (AUR)			Kumasi (KUR)		
Year	Entropy	Relative Entropy	Year	Entropy	Relative Entropy
2002	1.529	0.90	2001	1.051	0.686
2011	1.570	0.92	2010	1.292	0.844
2020	1.601	0.94	2020	1.277	0.834

The entropies are also closer to the maximum entropy of 1.70, with relative entropies ranging between 0.90 and 0.94, showing a strong dispersed development or sprawling. A similar observation can be made for KUR, albeit with lower values. This indicates that the sprawling and its degrees or intensities are lower in KUR compared to AUR. Whereas the changes in entropies for AUR are both positive for the periods of 2002-2011 and 2011-2020, the entropy for KUR is positive for 2001-2010 but negative for 2010-2020 (Table 4).

Table 4: Change in entropy over time

Accra		Kumasi	
Period	Change in entropy	Period	Change in entropy
2002-2011	0.041	2001-2010	0.241
2011-2020	0.032	2010-2020	-0.015

As stated earlier, a positive change shows a sprawling development, while a negative value shows compacting development. Thus, while AUR is constantly sprawling, KUR saw densification or compact development between 2010 and 2020. The sprawling and densification observed between the two regions are visually illustrated in Fig. 6.

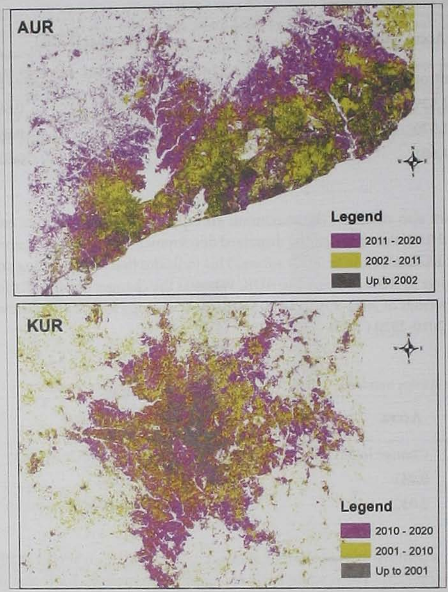

Fig. 6: Spatial pattern of sprawl in AUR and KUR

It can be seen in Fig. 6 that the pink colour which represents the development in KUR between 2010 and 2020 is more of filling in the spaces while in AUR, it is both filling and expansion. Thus, whereas AUR is sprawling and densifying at the same time, KUR sprawled very fast between 2001 and 2010 and then compacted between 2010 and 2020.

Discussion

As noted by Yigitcanlar et al. (2015), sustainability assessment tools such as indicators link past and present-day activities to future development goals. Thus urban growth rate, as well as Shannon's entropy index, were used to assess SUD. The results show that the growth rates in the two regions are high, which conforms to the findings of Toure et al. (2020). AUR is growing faster than KUR, and this is not surprising because Accra, as the national capital, receives more migrants than Kumasi due to more diversified employment and livelihood activities in Accra (GSS, 2014). Also, whereas KUR sprawled in the first decade and compacted in the second decade, AUR's growth continued

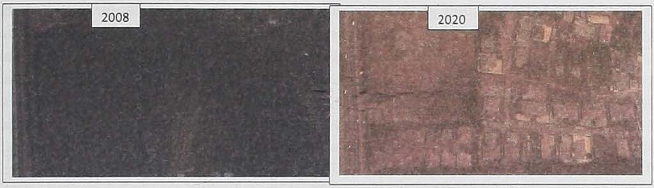

Fig. 7: Built-up development near Abokobi in the Ga East District of the Greater Accra Region

In 2008, the Abokobi area in Fig. 7 was occupied by trees and shrubs with a few isolated buildings. The 2020 image, however, shows almost an entirely built environment within a decade. Although the western portion of the 2020 image is not built-up, it has been cleared in readiness for development. The inference here is that more open space lands used for agricultural purposes, forests, grasslands and bushes are being cleared for other uses such as residential, commercial and industrial uses. This compact and sprawl development could be attributed to the involment of numerous private estate agencies in housing provision and land tenure insecurity arising mostly from sales to multiple users (Barry & Danso, 2014; Danso & Manu, 2013) which make people develop properties immediately after initiating the process of acquiring the land. The estate agencies acquire large tracts of land, develop them into single occupancy units and sell or rent them out to people. Another factor that propelled the sprawl is that the urban regions were surrounded by independent satellite towns which also grew rapidly. In AUR these satellite towns include Abokobi, Pukuasi, Amasaman, Kasoa, Dodowa, Ashaiman, Adenta, and Dawenya, just to mention a few. In KUR also, some of these satellite towns include Ejisu, Abuakwa, Ofinso, Kwabre, Asokore-Mampong, Nkawie, and Atwima. This has resulted in the regions having many centres of growth, which is similar to the polycentric cities in Europe (Westerink et al., 2013). According to Westerink et al. (2013), polycentrism is proposed as a sustainable urban form because it is aimed at combining the demand for urban living with preservation of peri-urban land. But the case of the two regions presented here cannot be described as sustainable though they exhibit polycentrism. This is because the satellite towns, especially in AUR, have chiefs and family heads who dispose off land, and therefore they grew rapidly outward, meeting the growth from the city. The case of KUR is slightly different because of the centralized land sale system as the Asantehene has to endorse all lands leased/sold (Ubink & Quan, 2008). So instead of containing development, they spread out rapidly in areas without approved land-use plans.

The sprawl from both cities and their satellite towns is believed to be fueled by inadequate housing provision by the formal sector in developing countries (Jiboye, 2011; Owusu-Ansah et al., 2019) which led to the liberalization of the housing sector (Fuseini et al., 2017; Vidyarthi, 2018). The results tend to support this post-liberalization concept, as the sprawling is higher after the 2000s, with the proliferation of many estate developers. The private/informal housing providers maximize the use of the land for building and in some cases pave the remaining part of the plot in the compound (Fig. 7). This leads to developments that undermine green growth of cities and therefore unsustainable development, as it is argued that the development of green compact cities (i.e. urban containment and densification) can lead to SUD (e.g., Alawadi, 2017; Nilsson et al., 2014). This is because the core strategies of the compact development plan are sustainable transportation, mixed land use, vertical development, densification, green space and diversity, thereby making it able to contribute to environmental, social and economic goals of sustainability (Bibri et al., 2020). But scholars like Westerink et al. (2013) and Næss (2014) have shown that there still exist some envrionmental issues such as air pollution and urban heat that could militate against compact development and have proposed a balanced compact urban development. The pro-balanced compact development scholars argue that compact development, if not checked, could lead to many socio-economic consequences, such as increased urban inequality, income segregation (Andersen, 2019; Guo et al. 2019; Malik et al., 2020) and public health concerns like cardiovascular diseases, obesity, etc. (Kabisch et al., 2016; Restivo et al., 2019). Balanced, compact development is very critical as the kind of sprawl and densification (see Fig. 7) taking place in both AUR and KUR is the low density type which consumes large spans of land within a short time. This is largely because the majority of the housing units in these areas are not high rising buildings and also house single families, and thus are not able to reduce the housing deficit.

Sprawl development also results in settlement segregation, and in some cases, high class and low-class settlements develop side by side, as is the case of Roman Ridge and Maamobi in AUR (Fig. 8). The road (Achimota road) in the middle of Fig. 8 separates the low-class settlement (Maamobi) from a high-class settlement (Roman Ridge). These settlement patterns have resulted in the development of slums which are dotted all over in the two regions and have become part of the urban footprint in many developing countries.

Fig. 8 Residential development in AUR

As can be seen, the streets in Maamobi are narrow or non-existent and do not make provisions for pedestrians and cycling, yet the majority of the residents do not own cars and rely on walking as a means of transport. It is also crowded with buildings and other structures and has no green space. The high-class area, on the other hand, is well planned and has some green spaces and a well laid-out street network which support walking and cycling. This is clear evidence that land-use planning can support green growth. Roman Ridge was a settlement for the colonial masters and inherited its beautiful plan from then. It has been maintained as a dwelling place for the high income class even after independence. Maamobi on the other hand evolved as a migrant settlement which attracts migrants from all over the country and beyond and has grown to assume the characteristics of a slum. Both regons have these types of slums at many locations within them. However, the slowing of sprawl in KUR is a positive sign, as it can make city authorities, if properly resourced, move in quickly to resolve land use planning issues in the peri-urban areas.

The growth of many cities in developing countries, in particular, is taking place outside planning zones and thus makes it difficult to implement control measures (Amoako & Cobbinah, 2014; Cobbinah & Aboagye, 2017). This means that the sprawl and densification of the regions do not follow a sustainable development planning framework. This has serious environmental and livelihood consequences (Cobbinah et al., 2017; Huang et al., 2018; Luo & Lau, 2019; Sulemana & Yiran, 2018). It calls for control of urban growth, especially the expansion of cities towards rural areas, through sustainable urban planning. Cobbinah & Darkwah (2017) noted that sustainable urban planning needs to be all-inclusive, that is, bring all stakeholders together to develop a land-use plan. This is particularly critical given the kind of land tenure system practised in Ghana where individuals, families and stools, own and dispense land at will (Kuusaana & Eledi, 2015; Mireku et al., 2016). So when the stakeholders are involved, they will know how to allot their lands for development according to the agreed plan by resolving some of the conflicts. Yigitcanlar & Teriman (2015) proposed an integrated urban planning and development process to aid in achieving SUD of cities, which is similar to the all-inclusive approach stated above. Such an integrated/inclusive process will produce a sustainable development plan which can resolve most of the environmental and socio-economic challenges (Chenet al., 2019; Dhiman et al., 2019; Gavrilidiset al., 2019; Jenks, 2019).

But the high rate of urban sprawl in Africa, which is projected to increase into 2100 (UN-DESA, 2018), poses a serious challenge to sustainable development planning. From the results, it can be seen that even though KUR shows compact development over the last decade, both regions show high, unsustainable rates of sprawl. As the areas develop without land-use plans, their densification or compact development will not follow proper procedures, resulting in several socio-economic and environmental challenges that do not foster sustainable development. The reasons for unsustainable development, through sprawl and densification, in these unplanned areas are known and almost the same across many developing countries. These include the lack of land-use plans, population growth, poor institutional arrangements and inefficient enforcement of regulations, lack of resources (both human and financial), improved transportation network, low land cost, changing lifestyle and rising incomes, among others (Bhatta, 2010; Denis, 2020; Koprowskaet al., 2020; Rahimi et al., 2019; Yigitcanlar & Teriman, 2015). It is observed that the sprawl and compact development taking place in these urban regions and many others in developing countries barely follow green compact development protocols, neither do they resolve the issues of land-use conflicts and other socio-economic effects expounded above. Thus, from all indications, the two regions are not on the path to SUD.

Conclusion

The study attempted to provide an understanding of the nature of sprawl in areas around the two big cities of Ghana, Accra and Kumasi, and how it can be a potential challenge to sustainable development. This was done using growth rates and spatial metrics such as Shannon's entropy to quantify urban growth (sprawl and compact development) in the cities. Landsat images were classified and used for the entropy calculations. The growth rates indicate very fast-growing regions. All entropy values were also substantial near the upper limits, and thus reveal that both regions (AUR and KUR) are sprawling. The rates of sprawl were higher for AUR than KUR, and over the last decade, KUR saw compact development while AUR continued to sprawl at a higher rate. This means that the nature of urban development in the two regions is different. However, the sprawl is taking place outside zones that have proper planning schemes, signifying that the negative effects of urban sprawl identified in the literature are present in the Areas. Thus, the conclusion is that the rates of sprawling in both regions are unsustainable and need to be checked. The compact development witnessed in the last decade for KUR should be monitored and sustained, but should incorporate the tenets of sustainable urban planning to achieve sustainable development. It is recommended that an all-inclusive sustainable development planning framework be developed for the regions. This will ensure a compact green growth as well as minimise the socio-economic challenges that accompany compact developments. The sustainable development plan should also be region-specific, as each region shows different development characteristics.

References

Akubia, J. E., & Bruns, A. (2019). Unravelling the Frontiers of Urban Growth: Spatio-Temporal Dynamics of Land-Use Change and Urban Expansion in Greater Accra Metropolitan Area, Ghana. *Land, 8*(9), 131.

Alawadi, K. (2017). Rethinking Dubai's urbanism: Generating sustainable form-based urban design strategies for an integrated neighborhood. *Cities, 60*, 353-366.

Altieri, L., Cocchi, D., Pezzi, G., Scott, E. M., & Ventrucci, M. (2014). Urban sprawl scatterplots for Urban Morphological Zones data. *Ecological Indicators, 36*, 315-323.

Amoako, C., & Cobbinah, P. (2014). Urban Sprawl and the Loss of Peri-Urban Land in Kumasi, Ghana. *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*, 313-322.

Andersen, H. S. (2019). *Urban sores: On the interaction between segregation, urban decay and deprived neighbourhoods.* London: Routledge.

Awumbila, M., Owusu, G., & Teye, J. K. (2014). Can rural-urban migration into slums reduce poverty? Evidence from Ghana. *Migrating Out of Poverty Working Paper, 13*, 1-41.

Barry, M., & Danso, E. K. (2014). Tenure security, land registration and customary tenure in a peri-urban Accra community. *Land Use Policy, 39*, 358-365.

Bhatta, B. (2010). *Analysis of urban growth and sprawl from remote sensing data.* Berlin: Springer Science & Business Media.

Bhatta, B., Saraswati, S., & Bandyopadhyay, D. (2010a). Quantifying the degree-of-freedom, degree-of-sprawl, and degree-of-goodness of urban growth from remote sensing data. *Applied Geography, 30*(1), 96-111.

Bhatta, B., Saraswati, S., & Bandyopadhyay, D. (2010a). Urban sprawl measurement from remote sensing data. *Applied Geography, 30*(4), 731-740.

Bibri, S. E., Krogstie, J., & Kärrholm, M. (2020). Compact City planning and development: emerging practices and strategies for achieving the goals of sustainable development. *Developments in the Built Environment*, 100021.

Bovet, J., Reese, M., & Köck, W. (2018). Taming expansive land use dynamics–Sustainable land use regulation and urban sprawl in a comparative perspective. *Land Use Policy, 77*, 837-845.

Chen, C., Tabssum, N., & Nguyen, H. P. (2019). Study on Ancient Chu Town Urban Green Space Evolution and Ecological and Environmental Benefits. *Nature Environment & Pollution Technology, 18*(5).

Chong, C. H.-S. (2017). *Comparison of Spatial Data Types for Urban Sprawl Analysis Using Shannon'sEntropy.* A Thesis Presented to the Faculty of the Graduate School, University of Southern California in Partial Fulfilment of the Requirements for the Degree Master of Science (Geographic Information Science and Technology). University of Southern California, USA.

Cobbinah, P. B., & Aboagye, H. N. (2017). A Ghanaian twist to urban sprawl. *Land Use Policy, 61*, 231-241.

Cobbinah, P. B., & Darkwah, R. M. (2017). Toward a more desirable form of sustainable urban development in Africa. *African Geographical Review, 36*(3), 262-285.

Cobbinah, P. B., Erdiaw-Kwasie, M. O., & Amoateng, P. (2015). Rethinking sustainable development within the framework of poverty and urbanisation in developing countries. *Environmental Development, 13*, 18-32.

Cobbinah, P. B., Poku-Boansi, M., & Peprah, C. (2017). Urban environmental problems in Ghana. *Environmental Development.* doi:10.1016/j.envdev.2017.05.001

Danso, H., & Manu, D. (2013). High cost of materials and land acquisition problems in the construction industry in Ghana. *International Journal of Research in Engineering & Applied Sciences, 3*(3), 18-33.

Deka, J., Tripathi, O. P., & Khan, M. L. (2011). Urban growth trend analysis using Shannon Entropy approach-A case study in North-East India. *International Journal of Geomatics and Geosciences, 2*(4), 1062-1068.

Denis, E. (2020). More Urban Constructions for Whom? Drivers of Urban Built-Up Expansion Across the World from 1990 to 2015. In D. Pumain (Ed.), *Theories and Models of Urbanization.* (pp. 235-258). Cham: Springer.

Dhiman, R., Kalbar, P., & Inamdar, A. B. (2019). Spatial planning of coastal urban areas in India: current practice versus quantitative approach. *Ocean & Coastal Management, 182*, 104929.

Duque, J. C., Lozano-Gracia, N., Patino, J. E., Restrepo, P., & Velasquez, W. A. (2019). Spatiotemporal dynamics of urban growth in Latin American cities: An analysis using nighttime light imagery. *Landscape and Urban Planning, 191*, 103640.

Hennig, E. I., Soukup, T., Orlitova, E., Schwick, C., Kienast, F., & Jaeger, J. (2016). Urban Sprawl in Europe Joint EEA-FOEN Report. *EEA Report*(11), 1-5