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**Characterising spatial and temporal patterns of urban evolution in Sub-Saharan Africa: The case of Accra, Ghana**

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**Abstract**

Rapid urbanisation and globalisation are creating relentless spatial transformation across the globe. There is a growing interest in understanding and conceptualising the emergent and often contested spatial morphologies and typologies in cities as they mediate the competing demands of global and local forces. This paper examines spatial and temporal development patterns in a Sub-Saharan Africa context using Accra, the capital and rapidly growing city of Ghana, as case study and explores the emerging urban form. By classifying Landsat satellite images (1986-2017) and using landscape/spatial metrics to characterise Accra's spatial development along four concentric rings, we find growing complexity and fragmented spatial growth patterns in Accra. Despite the spatial fragmentation, a Contiguity Index of 0.64, 0.49 and 0.56 for 1986, 2000, and 2017 respectively show that Accra's urban form is not amorphous nor polycentric but monocentric. The study demonstrates that using landscape metrics to characterise spatial development patterns under buffer zones leads to better understanding of the temporal and changing form of the city under various conditions. We reflect on the implications of these findings for urban policy and planning in Accra and other similar Sub-Saharan African cities

**Keywords:** globalisation; spatio-temporal dynamics; housing; urbanisation; spatial planning; urban form

## 1. Introduction

Urbanisation – an increase in the proportion of people living in towns and cities (Firebaugh, 1984) – is fundamentally shifting the development trajectory of the African continent. With average annual urbanisation rate of 3.6%, Africa is currently the world's fastest urbanising region (UNDESA/PD, 2013). Some of the continent's cities are growing at an average of 5% per annum, faster than any other region globally (UN Habitat, 2014), with a sharp increase in demand for housing, infrastructure and other basic services. Unfortunately, demand often outstrips the capacity of city authorities - leading to unfolding patterns of development that are spontaneous, unplanned and lack the necessary services (Cobbinah et al., 2015; Cohen, 2006). To match supply with the burgeoning housing demand, many Sub-Saharan African governments have shifted from direct housing provision – a policy transition linked to economic liberalisation (i.e. globalisation) – to creating an enabling environment for private sector investment in urban housing and infrastructure provision (Ghana Statistical Service, 2014; van Noorloos and Kloosterboer, 2018).

Labelled as 'African urban fantasies' (Watson, 2014), and fueled by the desire to create world class and modern cities, new private investments in housing and urban development are ongoing in urban Africa. Foreign and domestic companies are investing heavily in African urban property (e.g., Bhan, 2014; Côté-Roy & Moser, 2018; Grant, 2015; van Noorloos and Kloosterboer, 2018; Watson, 2014). Current African property investment patterns often take a form inspired by Dubai, Shanghai and Singapore[1] examples: entirely new cities are comprehensively planned and built as autonomous

[1] Ghana government engages Singaporean master-planner to 'redevelop Accra' https://citinewsroom.com/2018/10/07/govt-engages-singaporean-master-planner-to-redevelop-accra/

enclaves on the outskirts of existing cities. In other cases, existing urban centres are being redeveloped and transformed into entirely new cities. The emergence of gated communities, as now seen in many African cities, is associated with spatial impacts such as fragmented and unsustainable urban forms (see Jenks et al., 2008).

Characterising and understanding the changing urban form is crucial given that urbanisation and the emergence of 'new cities' – driven by globalisation – will continue to trigger relentless spatial transformations in urban Africa for the foreseeable future. Spatial development patterns in urban areas are one of the most important elements used to determine urban form (e.g., Herold et al., 2003; Kim et al., 2016; Seto & Fragkias, 2005). Understanding the processes and mechanisms of the evolution of spatial development patterns can, therefore, contribute to new approaches in the planning and management of Sub-Saharan African cities to generate a more sustainable urban form. Yet, research into the spatial development patterns of Sub-Saharan African cities is at infancy (Acheampong et al., 2017; Agyemang, Silva, & Poku-Boansi, 2019; Toure et al., 2018).

We examine spatial development patterns in Accra, the capital city of Ghana in this paper, and to explain the emerging urban form between 1986 and 2017. This timeframe is significant because it parallels Ghana's integration into the global economy following implementation of structural adjustment programs (see Grant 2009; Yeboah, 2000). Our aim is to understand how spatial development patterns evolved in Accra (from the inner city to the peripheries) and what the evolution reveals about the urban form. Accra has benefitted greatly from globalisation relative to the rest of Ghana. The city has remained the major recipient of inward foreign direct investment to Ghana since the 1980s. Accra is also an important city in the West Africa sub-region. It is experiencing dramatic spatial transformation driven by both local and global forces. While several studies (e.g., Yeboah, 2000; Doan & Oduro, 2012) have examined urban expansion in Accra, Ghana, and underlying drivers, these studies have either focused on the peri-urban areas or relied on cumulative urban growth rates – which do not account for the unique dynamics of spatial development across time and scales - from inner city to the peripheries (see Seto & Fragkias, 2005).

We ask two central questions: how can we measure and describe the emerging spatial and temporal patterns of urban development in Accra, and what urban form does the prevailing spatial patterns reveal? The urban growth patterns at any time and scale reflect the prevailing, yet dynamic, social, economic and political conditions (see Seto & Fragkias, 2005). Our research is based on analyses of Landsat satellite images for Accra and spatial/landscape metrics, which allowed us to measure spatial changes across scales and time.

The remaining sections of the paper are structured as follows: Section 2 presents an overview of urban evolution and underlying drivers across a variety of contexts; Section 3 describes the research setting and methods used; Section 4 presents the analysis and discussion. The paper concludes with some reflections on urban development patterns in Accra, and implications for planning in Section 5.

## 2.0 Urban evolution patterns

The evolution of Sub-Saharan African cities has generated much controversy among scholars. While (e.g., Doan & Oduro, 2012; Oduro et al., 2014) concluded that urban development patterns in Sub-Saharan African cities like Accra and Kumasi follow discernible patterns with a clear monocentric spatial structure (see also Angel et al., 2005), Agyemang et al. (2019) concluded that Sub-Saharan African cities do not have a clear spatial structure that can be explained by existing urban models. While they (Agyemang et al., 2019) observed a monocentric spatial structure in Kumasi City-Region before the year 2000, the subsequent spatial structure became amorphous.

Classical urban models such as the concentric zone model (Burgess, 1925/1967) depict cities as having a monocentric structure with a central core around which development proceed (Blumenfeld, 1954). Monocentric spatial form places the highest density development in the urban core, where major economic activities, peak land values and high order functions are enclosed by suburban areas of low-density residential development and emerging retail concentrations (Beauregard & Haila, 2000, p. 28). Indeed, scholars have concluded that many cities, first, assume a monocentric urban form and then later evolve into polycentric form (e.g., Beauregard & Haila, 2000; Muller, 1997). A transition of cities from monocentric to polycentric forms has been observed in some cities of North America, Europe, Asia and Latin America (e.g., Chen et al., 2016a; Dökmeci & Berköz, 1994; Gilbert, 1993; Muller, 1997; Vasanen, 2012). Polycentric urban form is characterised by the development of new centralities, urban centers and sub-centers at the suburbs and edges of cities (Jenks et al., 2008). In this paper, monocentric and polycentric terms are used to refer to the spatial distribution of the main urban center and sub-centers in an urban region (after Angel et al., 2005, pp. 64-67) rather than a morphological and functional perspective, their meaning of which have generated much controversy and debate (see Davoudi, 2003; Burger & Meijers, 2012; Green, 2007; Vasanen, 2012). The next sub-section gives a general overview of the drivers of urban transformation.

## 2.1 Drivers of urban transformation: An overview

Globalisation is often the starting point for debates about contemporary urban restructuring and transformation (Grant, 2009; Marcus & Kempen, 2000; Sassen, 2001). Globalisation is a term generally used to describe a drive towards greater economic, political, and cultural integration across nations (Sklair, 2002). The spread of information, capital, communication technologies, neoliberalism, trade liberation, foreign direct investment and structural adjustment programs, are processes of globalisation (Leichenko & O' Brien, 2008; Scholte, 2005). Contemporary structural changes within cities are largely adaptations to changes that are externally induced (Grant, 2009; Knox, 1997; Marcus & Kempen, 2000). More specifically, changes in metropolitan function, the structure of metropolitan labour markets, and the physical form of cities can partly be explained with reference to globalisation processes (Friedmann, 1986).

Globalisation restructures cities and transforms contemporary social, and institutional processes (Sýkora & Bouzarovski, 2012). Changes in urban form linked to globalisation have received significant research attention (e.g., Chen et al., 2016a; Jenks et al., 2008; Wu & Sui, 2016). While descriptive accounts of these changes have increased, there is little certainty with respect to the emergent form of cities as they respond to processes of globalisation and urbanisation. Debates are ongoing about whether cities assume polycentric form (Beauregard & Haila, 1997; Beauregard & Haila, 2000; Chen et al., 2016a; Knox, 1997; Muller, 1997), fragmented form (Labbé & Boudreau, 2011; Kozak, 2008) or desakota form (McGee, 1991; Wu, 2008; Wu & Sui, 2016) in response to globalisation forces.

Essential to understanding globalisation and emerging urban form is the recognition that societies and cities are neither closed nor linear; rather they are open, dynamic and fluid (see Allmendinger, 2009, pp. 185-191). Cities as open systems interact with external environments, which influence relationships and interactions among the agents, including government, developers, investors, citizens and other actors. This consequently leads to emergence of new spatialities. This idea of an open and non-linear world brings complexity to the fore, where relationships and processes lead to uncertain emergence (Hillier, 2012). According to De Roo (2010), complexity is the "unparalleled representative of a vision that portrays our reality as continuously evolving" (p. 19). Complexity is thus linked to dynamic processes of development and qualification of a reality in which situations, including spatial situations, are discontinuously changing and dependent on their context (De Roo, 2010). Therefore, Section 2.2 examines in detail, the underlying forces driving urban transformation in Africa with a focus on Sub-Saharan Africa.

## 2.2 Drivers of urban transformation in Africa

The evolution of many African cities is markedly different from cities in many parts of the developed world. Indeed, urbanisation in Europe, North America and parts of Asia is linked to economic growth and restructuring, which explains the evolution of these cities from monocentric to polycentric and desakota forms as observed by (e.g., Dökmeci & Berköz, 1994; Knox, 1997; Wu & Sui, 2016). In addition, the evolution of these cities is often marked by deliberate economic and planning policy objectives to reposition these cities to become competitive in attracting global capital (Newman & Thornley, 2005). Africa's urbanisation, on the other hand, is variously described as *urbanisation* *without development* (Boadi et al., 2005; Cheru, 2005; Davis & Henderson, 2003) because the urban population typically surpasses what the available resources can support. Symptoms of this phenomenon include major social and economic challenges like informal employment, proliferation of slums, social polarisation, rapid and spontaneous urban expansion, which all stem from systemic governance failures and unequal distribution of urban or national wealth (Cheru, 2005; Cobbinah et al., 2015; UN Habitat, 2010)

Consequently, scholars (e.g., Balbo, 1993; Larbi, 1996) argue that many African cities are characterised by fragmented urban form. According to Jenk et al. (2008, p.5), urban fragmentation can occur through the individual or combined effects of globalisation, neoliberal policies and laissez-faire planning and development. The concept of urban fragmentation has varied meanings and interpretations. It is sometimes used to describe the dividing and differentiation of spaces in the city (e.g., Grant & Nijman, 2004; Kempen & Murie, 2009). It is defined as "a state of disjointing and separation which is often coupled with socio-economic and/or ethnic divisions" (Kozak, 2008, p. 256). Urban fragmentation is typically manifested in clearly geographically delineated spatial disparities between the affluent and the poor within the city (Jenks et al., 2008). Urban fragmentation in developing countries is usually described as a state of planned and spontaneous settlements drawing together in a "sort of continuously discontinuous pattern" (Balbo, 1993, p. 23). Urban fragmentation thus occurs when various degrees of spatialities (e.g., spatial expansion, informal settlements, slums and gated communities) emerge and coexist within the city. Urban fragmentation, as used in this paper, transcends the inequalities of spaces and places in the city to include a phenomenon of urban growth as result of the emergence of new urban nuclei rather than the expansion of existing built-up areas (e.g., Herold et al., 2003; Seto & Fragkias, 2005). That is, fragmentation occurs when new urban patches emerge and grow faster than existing urban areas. This process may also be analogous to urban sprawl – a phenomenon of low-density spatial development characterised by scattering of new developments on isolated lands (see Yeh & Li, 2001).

The drivers of spatial development patterns within the African context have received the attention of some scholars. The presence of major roads, population increase, accessibility of the city centre and distance to existing built-up area (e.g., Braimoha & Onishi, 2007; Linard et al., 2013; Oduro et al., 2014; Seto et al. 2011; Vermeiren et al., 2012) have been reported as significant drivers of urban spatial development patterns. Vermeiren et al. (2012) mapped the growth of Kampala, Uganda using Landsat images for the period 1989 and 2010, and by developing a spatially-explicit logistic regression model, they found that growth was concentrated along the major roads and areas near the city center. These findings were confirmed by Linard et al. (2013), who developed Boosted Regression Tree models to predict the spatial pattern of rural-urban conversions in 20 large cities across Africa using urban change data between 1990 and 2000.

Other variables such as land tenure arrangement, land use policies, international capital flows, and the informal economy affect spatial development patterns although these are often difficult to quantify (Seto et al. 2011). Studies (e.g., Briggs & Mwamfupe, 2000; Grant, 2009; Yeboah, 2000:2003) have reported on the influence of globalisation on urban spatial growth in Africa. Yeboah (2000, 2003) examined Accra's physical expansion for 1975, 1986, 1992 and 1997 after the implementation of SAP. Findings demonstrated that Accra's spatial form was 'unicentric' and characterised by 'quality residential sprawl', i.e., the dispersion of mostly residential development into the peripheries. Undoubtedly, the impact of globalisation is mostly evident in new urban nuclei that emerge in the peri-urban area through policy initiatives such as special economic zones. Bagamoyo Port, located 35 miles north of the congested port of Dar es Salaam, Tanzania's capital, is one of such special economic zones which has brought about spatial transformations that were not envisaged during the project implementation. Land values have appreciated, while the city has expanded in the direction of this project ahead of provision of public utilities (Kanai & Schindler, 2018). Doan & Oduro (2012) observed similar development patterns in Greater Accra Metropolitan Area, Ghana where growth around Tema, a port city was much faster than in other parts of the peri-urban zone. Unfortunately, these studies do not examine the patterns of spatial development at the inner city. Hence, comprehensive understanding of the evolving spatial patterns (i.e. from the inner city to the peripheral areas) is limited.

In Ghana, like much of Sub-Saharan Africa, land is mainly owned by communities and families, with designated traditional authorities responsible for its management in their capacity as trustees (Gough & Yankson, 2000; Yeboah & Shaw, 2013). Therefore, state planning – with limited capacity – often has limited influence on physical development, with individuals dictating the pace of development (Andersen et al., 2015; Korah et al., 2017; Yeboah & Shaw, 2013). It is also common to find developers defying statutory land use plans rather than adhering to them (e.g., Ahmed & Dinye, 2011; Boamah et al., 2012), resulting in unguided "physical expansion of existing built-up areas into Greenfield land or surrounding rural settlements" (Acheampong, 2019, p. 175).

The foregoing discussion highlight African cities as complex entities emerging from a combination of political, economic, social and cultural processes. As rightly put by Grant (2009, p. 154), "globalising (African) cities are neither global or traditional cities, neither formal or informal cities, neither fully urban nor rural in orientation; rather they are in the process of combining". This implies that, even the most sophisticated models developed to predict the drivers and spatial growth of African cities will be limited because the "basic problem is the *de facto* sociospatial fluidity and relentless dynamism of the urban phenomenon under modern capitalism: its endemic tendency to explode inherited morphologies of urbanism at all spatial scales" (Brenner & Schmid, 2014, p. 743). This suggests "…new socio-spatial categories would need to be elaborated for grasping the emergent, always contested morphologies and topologies of interconnection, ....and place-making in and through which Accra, or any other places we have come to know as 'cities', are produced and transformed" (Brenner, 2011, p.694) while urban scholarship will have to transcend the frontiers of existing urban form theories in order to better depict the spatial evolution of sub-Saharan African cities (Agyemang et al., 2019). In this paper, we lean more towards inductive rather than deductive approaches – in the process, we do not rely on theories of urban form to explain the evolution of Accra but but rather from empirical data and observation.

## 3. Study Area and Methods

### 3.1 Study Area

The study area is Greater Accra Region (GAR) which is bordered on the north by the Eastern Region, on the east by the Volta Region, on the south by the Gulf of Guinea, and on the west by the Central Region (Figure 1). It is has a total land area of approximately 3,245 $km^2$, making it the smallest region of Ghana in terms of total area. The GAR is the most urbanised region in Ghana with 87.4% of its total population living in urban centres (Ghana Statistical Service [GSS], 2012). With a population of 4 million as at 2010, GAR's population density was 1,200/$km^2$, making it the most densely populated region in Ghana (GSS, 2012). The centre of population of GAR is Greater Accra Metropolitan Area (GAMA) which comprises Accra Metropolitan Area, Tema Municipal Area, Ga South, Central, West and East, La Dade-Kotopon, Ledzorkoku-Krowor, Adenta, Ashaiman, Kpone Katamanso and LaNkwantanang-Madina. These areas exist as separate administrative units but have grown into a major urban agglomeration, not only in a physical sense but also economically and functionally (Songsore, 2008). This greater metropolitan region, which had a combined population of 1.3 million in 1984, now stands at over 3.4 million people (World Bank, 2017). In recent times, physical developments have surpassed GAMA and into the adjoining districts of GAR, Eastern, Central and Volta Regions, creating a City-Region in the process (see Agyemang et al., 2017).

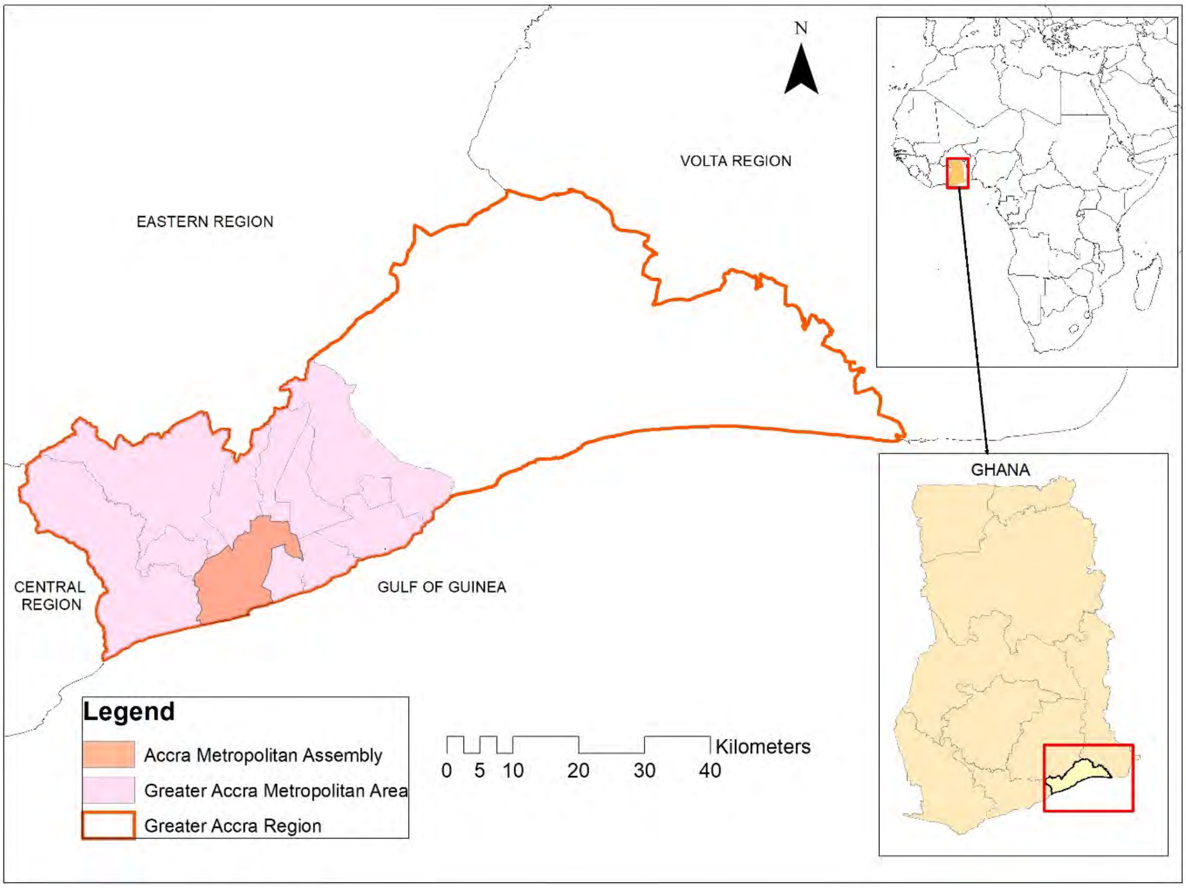



**Figure 1:** Location Map for Accra Metropolis, GAMA and Greater Accra Region

Although Accra is not among the largest cities of the world, or even of Africa, its growth rate and the extent of ongoing transformation, linked to globalisation, is remarkable (Grant, 2009). Annual growth rate is estimated at 4% between the 2000 and 2010 (GSS, 2012). During the period 1990-2000, the spatial footprint of the city increased more than 300%, stretching for about 36 miles from east to west, and 18 miles from south to north (Yeboah, 2000, p. 68). Grant and Yankson (2003, p. 65) describe Accra's spatial extent as "stretching for about 25 kilometres from east to west, and about 12 kilometres from north to south". Tema harbour, which is now the country's largest seaport, and Accra airport (Kotoka International Airport), the country's only international airport, have become the most important gateways through which the Ghanaian economy is integrated into the global economy (Oduro, 2010, p. 120). Today, there are about 44 foreign embassies in the city of Accra (Accra Metropolitan Assembly, 2014). Accra is the major recipient of all inward foreign direct investment to Ghana since the 1980s. An analysis of Ghana's Investment Promotion Centre quarterly reports (1994-2017) indicate that over 83% of all inward FDI projects are located in Accra. The city's rapid growth rate, economic reliance on globalisation, rapidly changing spatial dynamics and under-representation in urban research make it a novel and significant study area.

### 3.2 Methods

#### 3.2.1 Spatial data acquisition, processing and classification

In this study, we used raster spatial data comprising Landsat Thematic Mapper (TM) 1986, Enhanced Thematic Mapper Plus (ETM+) 2000, and Landsat 8 Operationalised Landsat Imager/Thermal Infrared Sensor (OLIS/TIRS) 2017. Selection of the above years was influenced by the desire to use images with minimum cloud cover, and 1986 was the year Ghana's economy became more integrated into the global economy. These raster data were downloaded using path 193 and row 56 from the United States Geological Survey (USGS)[2]. The satellite images had a 30m spatial resolution and geometrically corrected to WGS 1984 UTM Zone 30N coordinate system. Although the 30m resolution images are not the optimum in terms of showing spatial details, these images have been successfully used in other studies to analyse urban land use/cover changes (Acheampong et al., 2017; Korah et al., 2018; Seto et al., 2002).

These images contain multispectral bands which capture data on vegetation, water bodies, built-up, and bare areas which were sufficient for analysing urban land use/cover changes. To improve the quality of the output, all the images were downloaded with minimum scene cloud cover. The 1986 image had a scene cloud cover of 16%, however, the clouds did not affect the area of interest (Greater Accra Region). The clip geoprocessing processing tool in ArcGIS 10.4 was used to clip the multispectral bands to the study area extent.

The *clipped* bands were combined in ArcGIS 10.4 to form composite images for 1986, 2000 and 2017. To produce natural colour of the composite images, the following combination of bands were used: TM (5, 3, 1), ETM+ (7, 5, 3), and OLIS/TIRS (7,5, 3). Training sample were taken based on three broad land cover/use classification namely; 'Built-up', 'Non-built-up' and Water. In this study, the built-up cover class comprised the physical aspect of the urban fabric including roads, all buildings used for residential, commercial and industrial purposes. The non-built-up category included farmlands, grasslands, bare-land, forests and other vegetation.

Training samples for each of the three classes were created by visual interpretation of (a) true colour composites of the Landsat imagery, and (b) very high-resolution imagery. With help of the *interactive supervised classification* tool in ArcGIS 10.4, training samples were tested for accuracy and representativeness of each classified image. More training samples were added or removed as and when necessary until maximum classification accuracy was achieved.

Using the supervised *maximum likelihood classification* algorithm in ArcGIS 10.4, the Landsat satellite images were classified into three discrete land cover classes identified as 'Built-up', 'Non-built-up' and Water. In this study, the emphasis is analysis of urban growth patterns, therefore, the three discrete land cover classes were reduced to two classes namely: 'Built' and 'Non-Built'. The 'Non-Built' included water bodies.

**3.2.2 Measuring spatial patterns of urban growth**

Essential to quantifying, describing and understanding urban spatial development is the use of spatial metrics (e.g., Acheampong et al., 2017; Liu et al., 2010; Hu et al., 2007), and landscape metrics (e.g., Deng et al., 2009; Herold et al., 2003; Seto & Fragkias, 2005) adopted from landscape ecology (O'Neill et al., 1988). These quantitative indices can be used to objectively quantify the pace, amount, intensity, complexity and pattern of urban growth by computing them directly from thematic maps.

This study adopted the Annual Urban Expansion Rate (AUER), a historical metric that computes the mean annual rate of expansion of built-up land of a spatial unit between two periods – the base year and the ending year (Acheampong et al., 2017). The result of the index is a representational figure of the rate at which the built-up land of a spatial unit is increasing. It can be represented as:

$$AUER_i = [\left(\frac{ULA_i^{t2}}{ULA_i^{t1}}\right)^{\frac{1}{t2-t1}} - 1] \times 100 \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

[2] https://earthexplorer.usgs.gov/

Where AUERi is Annual Urban Expansion Rate; $ULA_i^{t2}$ and $ULA_i^{t1}$ are the area of built-up land at time $t^1$ and $t^2$ respectively.

There are many landscape metrics present in FRAGSTATS Version 4, a spatial pattern analysis program developed by McGarigal, Cushman and Ene, for quantifying the structure (i.e., composition and configuration) of landscapes (see McGarigal et al., 2012). Table 1 is a summary of the available metrics used in this paper. The area-weighted mean patch fractal dimension (AWMPFD) metric describes the degree to which the shape of an urban area is irregular or complex. The fractal dimension describes the complexity and the fragmentation of an urban area by a perimeter–area proportion (Herold et al., 2003). It has a value within the range of the range of 1 and 2. AWMPFD value greater than one indicates the shape of an urban area is complex, irregular and fragmented (see McGarigal, 2015) while values closer to 1 indicates the urban form has a simple shape such as a square or circle, and compact (Herold et al., 2003; Seto & Fragkias, 2005). AWMPFD is hypothesised to increase during the early periods of urban spatial development when new urban nuclei and expansion of existing urban space create irregularly shaped landscape patterns; this metric is, however, expected to decline as urban form becomes more regular (Seto & Fragkias, 2005). Equation 2 is a representation of AWMPFD.

$$\mathrm{AWMPFD} = \sum_{t=1}^{m} \sum_{j=1}^{n} [(\frac{2\mathrm{In}(0.25_{p_{ij}})}{\mathrm{In}_{a_{ij}}})(\frac{a_{ij}}{A})] \text{ ........................... } (2)$$

Where m is Number of patch types (classes), n is number of patches of a class, p(ij)—perimeter of patch ij, a(ij)—area of patch ij, and A—total landscape area.

**Table 1**: Spatial metrics used in this paper

| Metric | Category | Description | Units | Range |
|---|---|---|---|---|
| Class Area (CA) | Area | Total Urban Area | Kilometers | CA>0, no limit |
| Urban Edge Density (ED) | Edge metric | Edge density of urban area | Meters per hectare | ED≥0, no limit |
| Area weighted mean patch fractal dimension (AWMPFD) | Shape complexity | Area weighted mean value of the fractal dimension values of all urban patches, the fractal dimension of a patch equals two times the logarithm of patch perimeter (m) divided by the logarithm of patch area ($m^2$); the perimeter is adjusted to correct for the raster bias in perimeter | None | 1≤AWMPFD≤2 |
| Number of urban patches (NUMP) | Size and variability | Number of urban patches | None | CA>0, no limit |
| Mean urban patch size (MPS) | Size and variability | Mean urban patch size | None | CA>0, no limit |

| | | | | |
|---|---|---|---|---|
| Contiguity Index (CONTIG) | Urban spatial structure | Measures the extent to which an urban spatial structure is monocentric or polycentric by expressing the largest urban patch as a fraction of the entire built area and multiplied by 100 | Percent | 0< CONTIG≤100 |

**Source:** Base on Angel et al. (2005), Herold et al. (2003), McGarigal et al. (2015), and Seto & Fragkias (2005)

Urban edge density (ED) measures the total edge of urban areas relative to the total landscape and should increase with new urban nuclei but may decline as urban areas agglomerate and boundaries dissolve (Herold et al., 2003; Seto & Fragkias, 2005). Relative size is described by the mean urban patch size (MPS). The MPS is a function of the number of urban patches (NUMP) and the size of each urban area, and can either increase or decrease through time. Higher NUMP and lower MPS values indicate more fragmented patterns of a landscape (Kim et al., 2016). Decreasing values of MPS implies that new urban centers are growing faster than existing urban areas (Seto & Fragkias, 2005). In other words, urban development occurs because of new and multiple nuclei emerging rather than existing areas merging and enveloping each other. The NUMP is a measure of disconnected urban parts in the landscape and is anticipated to increase during periods of rapid urban nuclei development but may decrease if urban areas expand and merge into continuous urban configuration (Seto & Fragkias, 2005). Refer to McGarigal (2015) for further and detailed explanation of the metrics.

The metrics described above were measured using FRAGSTATS software, which contains the *Patch Analyts* and *Patch Grid* algorithms (McGarigal et al., 2012). This software was integrated in ArcGIS 10.4 for analysis of the remote sensing data. The analysis was done at two levels: the whole of Greater Accra Region (GAR) and Greater Accra Metropolitan Area (GAMA). GAMA was further divided into four concentric rings (Figure 2). The analysis of urban development based on a series of concentric rings from the central business district (Agyemang et al., 2019; Schneider & Woodcock, 2008; Seto & Fragkias,2005; Xu et al., 2019) assumes that urban development is monocentric in form, or that growth spread outward from the central core (Blumenfeld, 1954). Such analysis is also grounded on traditional urban models that depict cities as series of concentric zones with distinct functions (Burgess, 1925/1967). However, there is no standard method for determining the radius of the city core and ensuing rings. Therefore, the choice of concentric rings and widths is largely based on the experience of the author/s (e.g., Agyemang et al., 2019; Seto & Fragkias,2005). The creation of buffer rings from the central business district (CBD) of Accra Metropolitan Assembly, which is the origin and centre of development in GAR was influenced by several factors.

The first consideration was the requirement of a standard buffer size by which urban development for 1986, 2000 and 2017 could be compared. Secondly, the widths of the buffers were influenced by the desire to capture variations in urban development within Accra from inner city to the periphery through time. The literature (e.g., Agyemang et al., 2019; Blumenfeld, 1954; Xu et al., 2019) suggest the city core has the highest density development, major economic activities, and few buildable lands, and enclosed by suburban and peripheral areas of medium to low densities. The first two buffers (Figure 2) were meant to capture variations in the inner and outer core while the last two aimed at understanding land use changes and driving forces in the urban-rural fringe comprising of the suburban and periphery. Thirdly, the spatial extent of Accra as reported by previous studies (Grant and Yankson, 2003; Yeboah, 2000) was considered to ensure no significant part of the built

area is omitted and that a maximum radius of 40km from the city core is ideal (see Schneider, & Woodcock, 2008, p. 664).
A 5km radius used as the CBD of Accra was arrived at using the built area density (defined here as area of built land divided by total land area) in 1986. Accra was divided into 1km rings extending outwards from the original city core. The densities were then examined in similar manner and a final core was established where urban land densities fell below 70 percent. High Resolution Google images were then used to confirm that the established core is the true extent both in physical and functional terms by ensuring that certain areas such as Government of Ghana ministries and offices were captured. Beyond the established core (i.e. inner core), a range of 5, 10, and 20 km buffers were used to divide the remaining landscape comprising outer core (5-10km), suburban (10-20km) and periphery (20-40km). Each buffer is unique and treated as an independent zone. For example, after creating the first buffer of 0-5km, the next buffer was 5-10km, then 10-20km and finally 20-40km. Therefore, during the analysis, a 5km buffer is not treated as part of a 10km buffer and the two are not treated under 20km buffer and so forth.

The computed metrics as shown in Table 1 were compared across the various years (1986, 2000 and 2017) for GAR, GAMA and the various buffer zones. The aim was to understand spatial development patterns and dynamics in Accra through time.

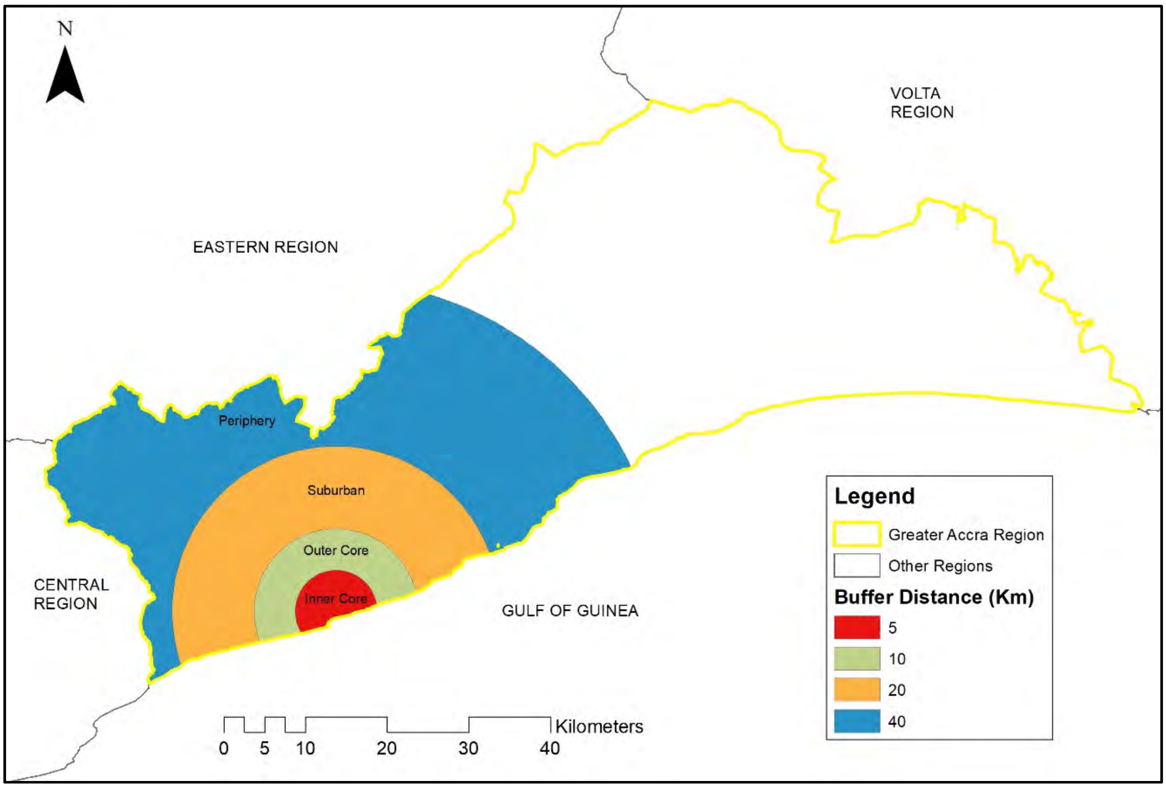
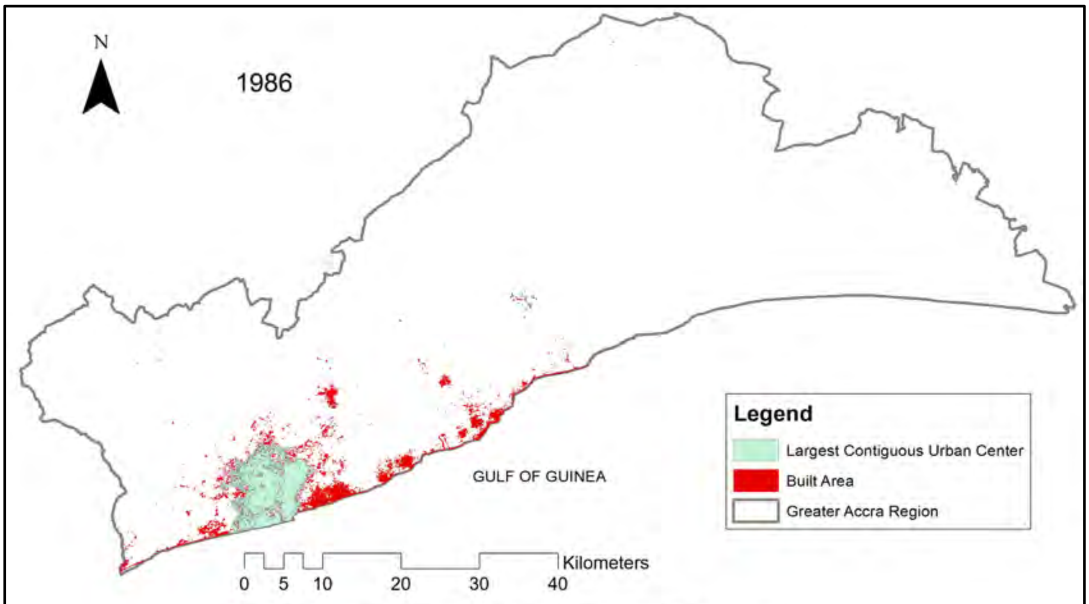



**Figure 2:** Buffer zones in Accra
**Source:** Authors

**3.2.3 Contiguity Index as a measure of urban spatial structure**
In landscape analysis, Contiguity Index (CONTIG) is used to measure the level of aggregation or clumpiness in a landscape (O'Neill et al., 1988). Landscapes characterised by large contiguous patches have high CONTIG while landscapes dominated by smaller and fragmented patches have low CONTIG. CONTIG has been applied in urban studies (Angel et al., 2005; Herold et al., 2003) to understand urban form or spatial structure. For instance, in trying to understand whether a city is more monocentric or polycentric using classified satellite images, the CONTIG can give an indication of the dominance of a large compact urban blob or the presence of other urban centers and sub-

centers. The CONTIG is calculated by using the area of consolidated polygons[3] that comprise the built area. The CONTIG is then derived from the ratio of the largest (maximum) polygon ($P_m$) to the sum of all polygons ($P_s$) at, for example, time T1, T2 and T3. For a comprehensive explanation of this process, see (Angel et al., 2005, pp. 64-67). Furthermore, by classifying the built area into various urban cluster sizes of connected pixels[4] (e.g., 0-10, 10-100, 100-1000, 1000-10000 hectares, etc.), and calculating the percent distribution of urban area under each cluster, it is possible to determine whether the city has a clear spatial structure or not (Angel et al. 2005). A higher percentage of urban clusters that are smaller than 10 hectares (0.1 km$^2$) may, for instance, suggest an amorphous spatial structure. Figure 3 is an example of the largest contiguous urban area in 1986 and corresponding percent distribution of urban area under each cluster.




| Urban Cluster Size (Hectares) | Area (Hectares) | Percent |
|---|---|---|
| 0-10 | 1241.59 | 12 |
| 10-100 | 615.02 | 6 |
| 100-1000 | 1831.12 | 18 |
| 1000-10000 | 6680.22 | 64 |

**Figure 3**: Largest contiguous urban area and distribution of areas under each cluster
**Source:** Authors

**4. Results and Discussion**

**4.1 Urban expansion and underlying drivers in Accra**

Results from the remote sensing analysis show that Accra has been expanding. The average annual rate of urban land-use change in Greater Accra Region (GAR) for 1986 and 2017 was 5.8 %, with the largest growth of 7.40% occurring between 1986 and 2000 (Figure 3). Total urban land increased nearly six-fold during the study period, from 111 km$^2$ in 1986 to 640 km$^2$ in 2017. Similarly, urban land area (ULA) for Greater Accra Metropolitan Area (GAMA) grew at an average annual rate of 5.1% between 1986 and 2017, with the fastest growth of 7.22% occurring between 1986 and 2000 (Figures 4 & 5).

[3] After converting the processed raster images (showing only built area) to polygons

[4] Two pixels are connected if they intersect at either along one of their edges or at one of their corners

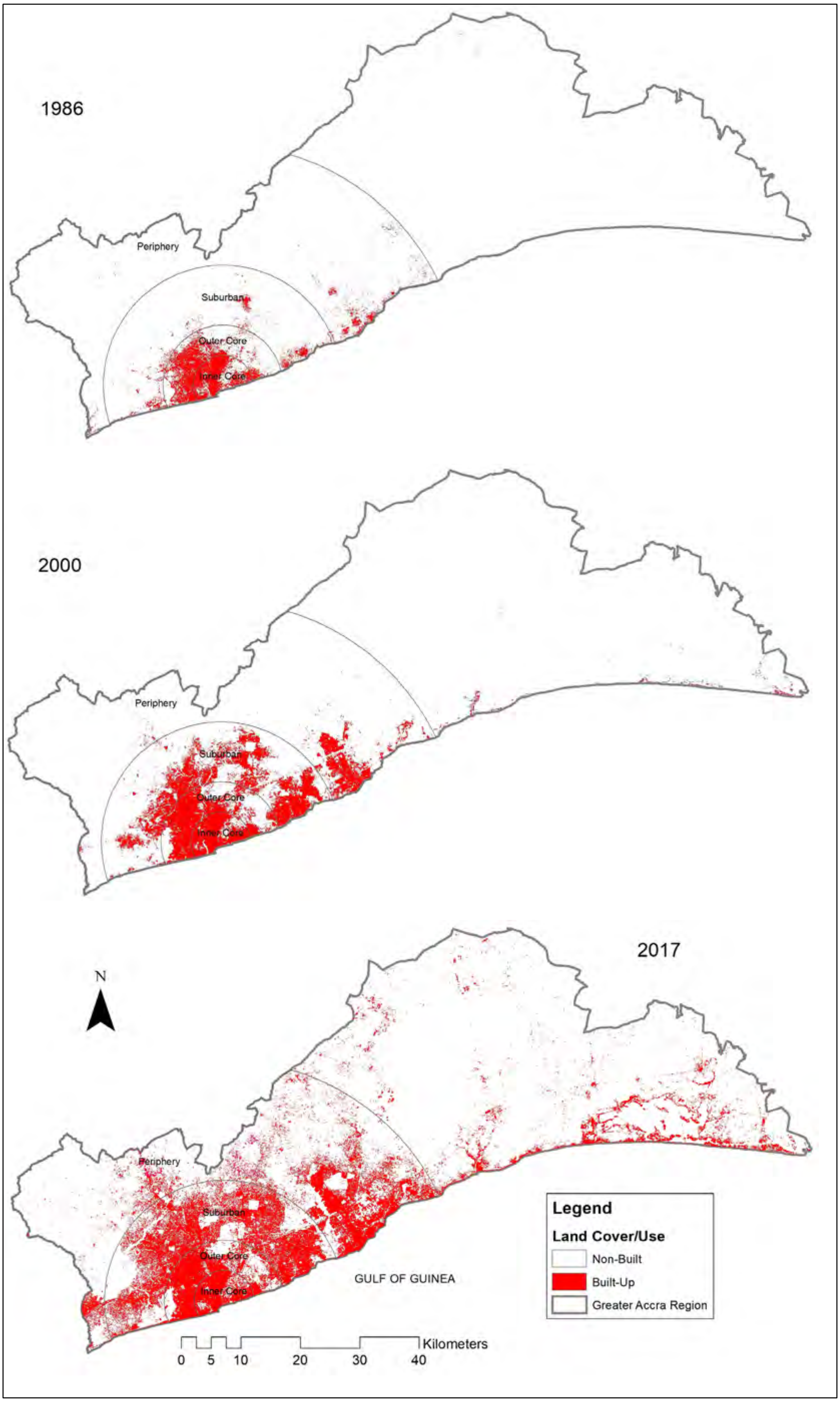



**Figure 4:** Land cover classification for1986, 2000, and 2017

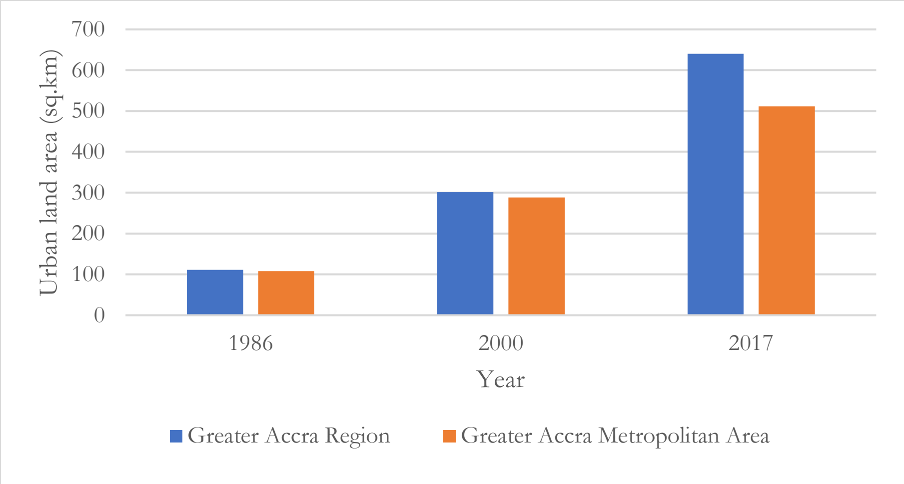


**Figure 5:** Urban land area for Greater Accra Region and Greater Accra Metropolitan Area

Several factors account for Accra's rapid growth. The main drivers are population growth and housing production. The population of GAR increased rapidly from about 3 million in year 2000 to about 4 million as at 2010 while the number of houses doubled from 287840 to 474621 within the same timeframe (GSS, 2012). Furthermore, previous studies (e.g., Agyemang et al., 2017; Doan & Oduro, 2012), concluded that housing and population increase drive spatial growth patterns in Accra. In particular, housing development intensified as a result of Ghana's economic liberation policies implemented under structural adjustment program (SAP) in the early to mid-1980s (Yeboah, 2000). Previously, housing production was done either by individuals or by the government for civil servants. The establishment of the State Housing Corporation and Tema Development Corporation were part of the government's policy of active and direct involvement in provision of public housing.

The neoliberal era of development in Accra began after the Government of Ghana implemented SAP as indicated earlier. At the heart of SAP was economic liberalisation, and state withdrawal from key sectors of the economy to give way to the private sector (privatisation) (GSS, 2014). Consequently, Government's policy on housing transitioned with emphasis on creating an enabling environment for private sector participation in housing delivery. The government promoted housing production by real estate companies and mortgage financing (Oduro, 2010). This policy enabled investment in real estate by both local and foreign companies in Accra. In recent years, there has emerged residential estates in and around Accra, including Western-styled gated communities that were alien to Ghana a few years ago (Figure 6). Furthermore, as discussed elsewhere (Yeboah, 2000, p.77), the SAP has made it possible for a variety of building materials to be imported into the country. Accordingly, there has been a surge in the construction of new homes to meet the growing demand by both Ghanaian and foreign nationals in Accra.

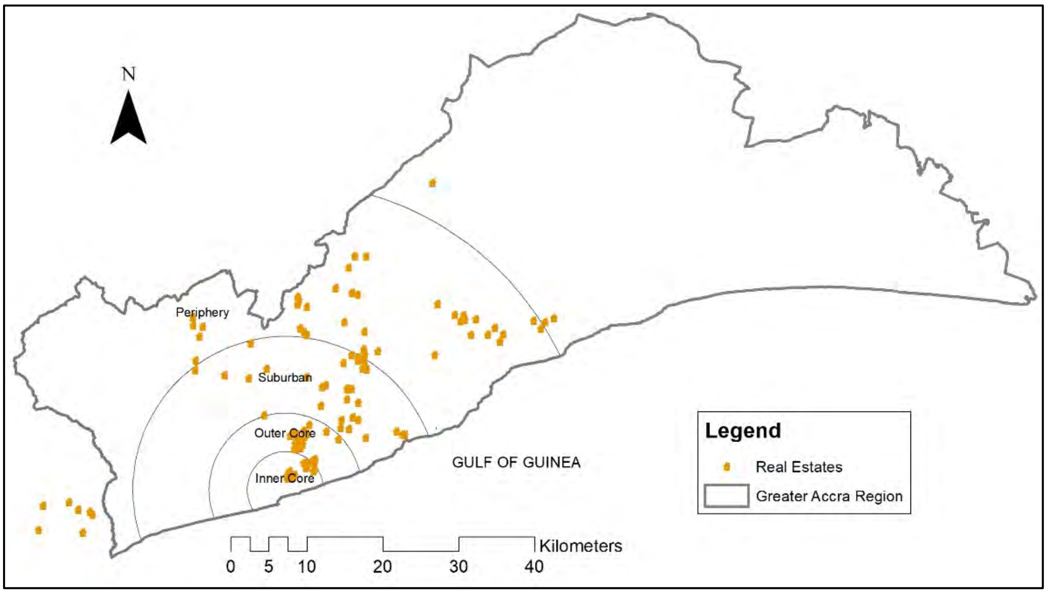



**Figure 6:** Location and distribution of residential estates in Accra
**Source:** Based on spatial data from Land use and Spatial Planning Authority, Accra, Ghana

**4.2 Patterns of urban growth: complexity, edge density, fragmentation and variability.**

Total urban area for all buffer zones except the 0-5km distance, increased between 1986 and 2017 (Figure 7). From 1986 to 2000, total urban area increased for all buffer zones. In the year 2000, urban area for the 0-5km distance was 40km$^2$; this figure remained unchanged for 2017 implying that all lands that could be developed in this area were fully utilised by 2000. Between 1986-2000, urban growth in the 10-20km buffer zone was more intense. In 1986, urban area in this zone was 17km$^2$, which increased by 7.7 times to 131km$^2$ in 2000 (Figure 7). Between 2000 and 2017, however, urban growth was fastest in the 20-40km buffer zone, which quadrupled from 48km$^2$ in 2000 to 148 km$^2$ in 2017. This trend could be attributed to increasing development pressure as a result of spillover from the inner and outer core zones. As these zones develop in time, little vacant land remains thus pushing land and housing prices higher. In this context, the sub-urban zone (10-20km buffer) becomes more attractive to developers, partly because of its proximity to existing urban development. As the sub-urban becomes fully developed over time, urban development overflows to the peripheries (20-40km buffer). This trend is observed in a study of Kampala in Uganda, which found that accessibility to the city centre and nearness to existing built-up area are strong determinants of urban growth (Vermeiren et al., 2012).

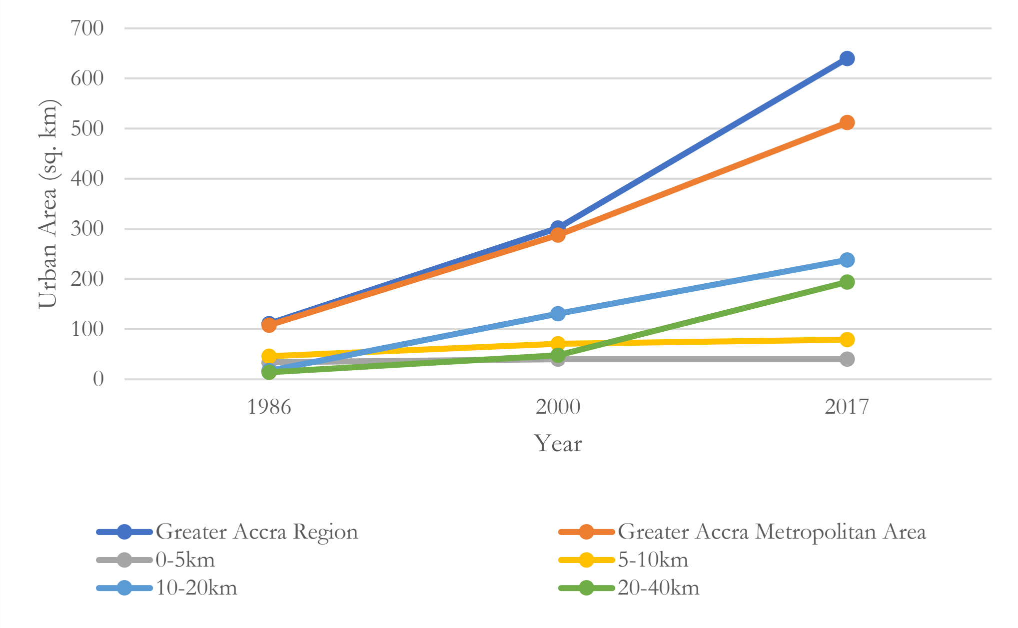



**Figure 7:** Spatial growth of Accra from 1986-2017

Values for the edge density spatial metric showed the development dynamics within GAR, GAMA and the four buffer zones during the study period. Edge density (ED) is expected to increase during the early periods of development as new urban nuclei emerge but should decline as urban areas merge together and form contiguous areas. Between 1986 and 2017, ED increased for GAR, GAMA, 10-20km and 20-40km buffer zones (Figure 8) suggesting a fragmented urban form as a result of the emergence of new urban nuclei rather existing urban areas fusing together. In all cases the rate of increase in ED was highest between 2000 and 2017 compared to 1986 and 2000. This finding supports previous studies that point to the continuous peri-urbanisation of Accra, where existing farmlands and hitherto undeveloped areas are being converted to residential and commercial uses (Oduro, 2010).

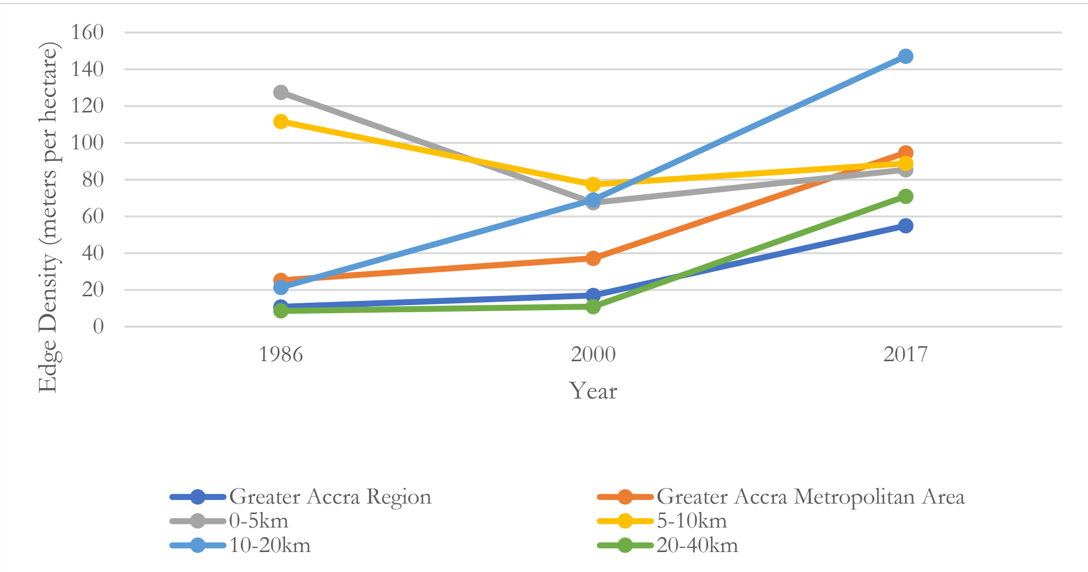



**Figure 8:** Edge density of Accra's spatial development from 1986-2017

ED values for the 0-5km and 5-10km buffer zones showed a different trend compared to the ones described earlier. For these zones, ED was highest in 1986 but declined in 2000, signifying the fusing of existing urban areas. However, instead of ED declining further for these zones in 2017, it rather increased slightly between 2000 and 2017 suggesting the emergence of new urban developments. This outcome is not surprising particularly for the 5-10km zone, given it had an urban area of 71km$^2$ as at year 2000 against total land area of 129km$^2$. The result however, is startling for the 0-5km zone which appeared to be fully developed by year 2000. The slight increase in ED for this zone could be attributed to the emergence of residential estates in this zone (see Figure 6). On the other hand, the ED values of these zones (inner and outer core) suggests the Central Business District (CBD) of Accra is developing in a discontinuous manner where, for instance, existing lateral compact structures are being redeveloped into high-rise buildings.

The area-weighted mean patch fractal dimension (AWMPFD) varied in time across the different zones. As anticipated, AWMPFD for GAR, GAMA, 0-5 and 5-10km buffer zones was high in 1986 and declined slightly in 2000 (Figure 9). In the early periods of urban spatial development, new urban nuclei create irregularly shaped and complex spatial configuration. This complexity, however, reduces as urban areas merge. The AWMPFD values for 10-20 and 20-40km buffers depict increasing complexity from 1986 to 2000 and then 2000 to 2017. Accra's current landscape is complex and fragmented as indicated by increased AWMPFD values across all levels (from GAR to 0-5km buffer) between 2000 and 2017. These finding support previous studies which found uncontrolled development and residential sprawl in Accra (Yeboah, 2000; Larbi,1996). The results further show that Accra does not follow an established urban development model, where urban spatial complexity increases initially, reach an apex, and then decreases over time as urban development merges (Herold et al., 2003; Seto & Fragkias, 2005).

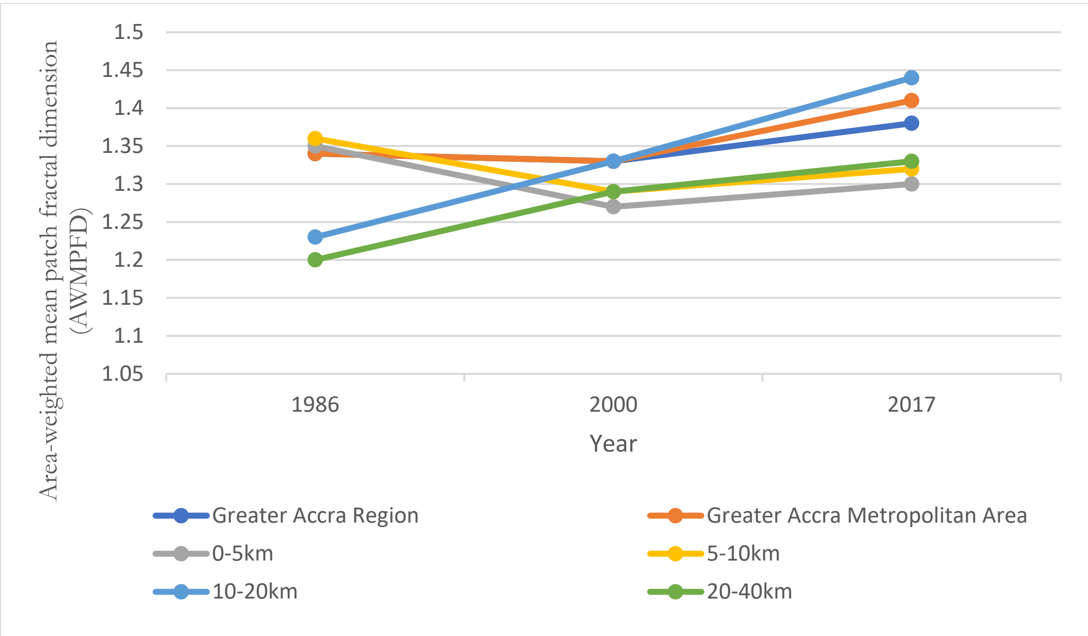



**Figure 9:** Area-weighted mean patch fractal dimension (AWMPFD)

The number of urban patches (NUMP), which measures the temporal patterns of new urban nuclei development, followed the anticipated trajectory for the 0-5 and 5-10 km zones (Figure 9). These zones recorded the lowest NUMP throughout the study period. Between 1986 and 2017, the NUMP declined (Figure 9) while MPS increased (Figure 10), suggesting that urban growth in these zones occurred primarily through annexation of vacant land by existing built-up areas rather than emergence of spontaneous and disconnected developments.

Between 1986 and 2000, NUMP for GAR, GAMA, and 20-40km zone declined (Figure 10). For example, GAMA had NUMP of 6937 and 5696 in 1986 and 2000 respectively. This suggests that urban development in these zones became more compact in 2000, evidence by the increasing MPS

(Figure 11). From 2000 to 2017, GAR, GAMA, 10-20 and 20-40km zones all witnessed an increase in NUMP (Figure 10). GAR had 6688 urban patches in 2000 and 30497 in 2017. Similarly, NUMP for GAMA was 5696 and 15765 in 2000 and 2017 respectively. The increase in NUMP is as a result of further urban development and sprawl into the peripheries of Accra. The MPS for GAR, GAMA and the 20-40km zone decreased in 2017 (Figure 11), reflecting the fragmented nature of urban development between 2000 and 2017. The increasing MPS values for the 0-5km, 5-10km, and 10-20km buffer zones in 2017 depict a more compact urban development (Figure 11).

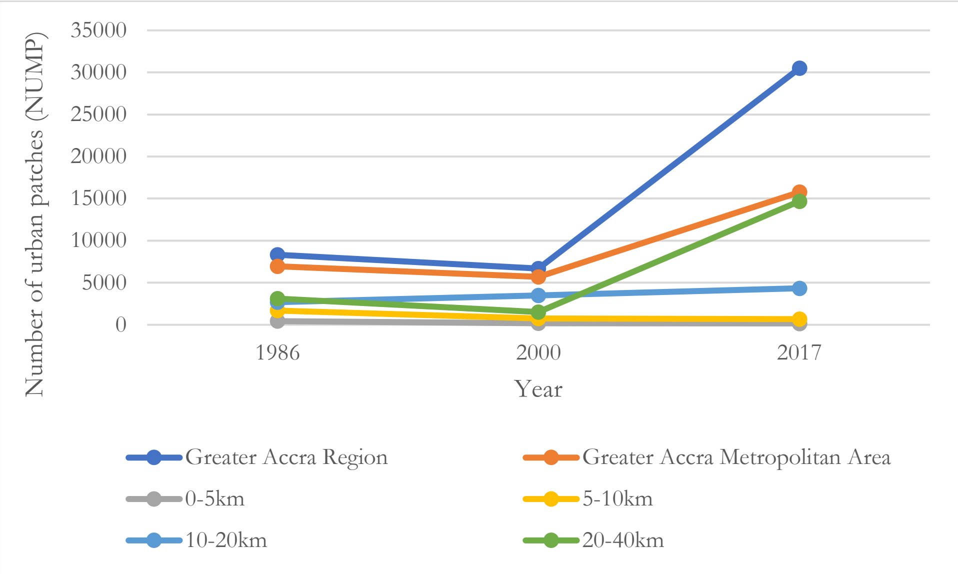



**Figure 10**: Number of urban patches (NUMP)

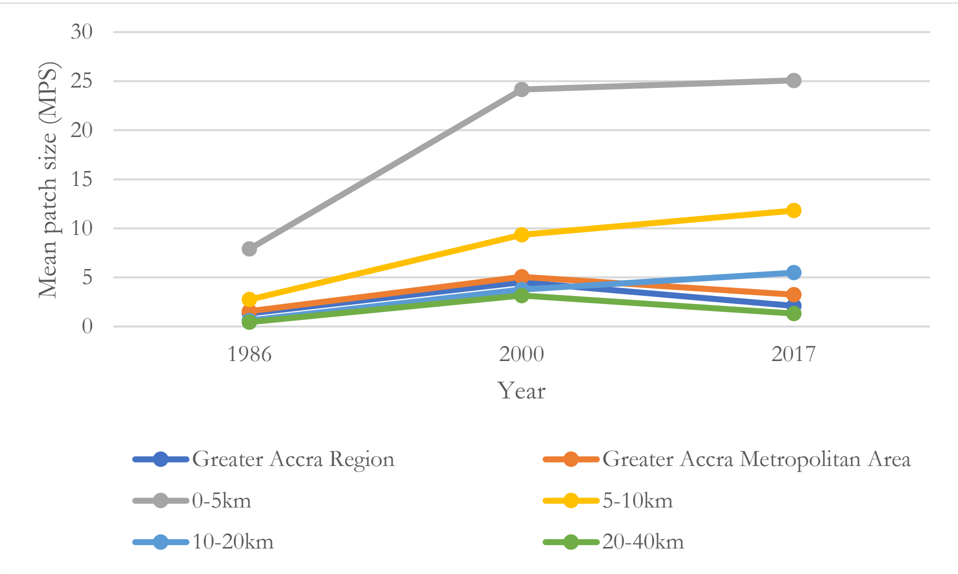



**Figure 11**: Mean patch size (MPS)

Results of the landscape metrics for Accra presented above indicate Accra's landscape is complex and evolving in a discontinuous manner. Urban growth can occur through either new nuclei development (measured by NUMP), or expansion of existing urban areas, measured by total urban area (Seto & Fragkias, 2005). Accra's spatial development trajectory is a combination of both the emergence of new urban nuclei and expansion of existing built-up areas. The underlying reasons for Accra's spatial dynamics are varied.

First, although, GAMA has become a contiguous metropolitan area (Figure 1), urban governance is the responsibility of the separate Metropolitan, Municipal and District Assemblies (MMDAs) that comprise GAMA. These MMDAs are responsible for planning and socio-economic development within their administrative jurisdictions. Each district assembly has decentralised state departments such as Town and Country Planning Department, Urban Roads Department and Development Planning Unit, etc. Consequently, the institutions and policies pertaining to GAMA can be disjointed and fragmented, leading to a lack of comprehensive land use planning to guide the development and transformation of GAMA (Grant & Yankson, 2003).

Secondly, after implementation of a structural adjustment program, the government prioritised development of infrastructure projects [e.g, port, airport and Export Processing Zones] in GAMA that facilitated more connections with the world economy (Grant & Yankson, 2003). The emphasis on infrastructure development has benefitted some areas more than others. For instance, while all the industrial estates and airport residential area were well planned, areas outside of this gateway projects have been unplanned (Grant & Yankson, 2003; Larbi, 1996). Spatial planning and effective development control is thus limited to state-controlled lands (representing less than 13%) of residential Accra and neglected the far more extensive customary lands which constitute over 80% of land in Accra (Larbi, 1996, p. 213). The complex land tenure arrangement and relatively low land prices at the urban periphery together with the lack of effective spatial planning and development control have resulted in a phenomenon of growing number of unauthorised structures not only in Accra but across major towns and cities in Ghana (e.g., Boamah et al., 2012).

In addition, Ghana's Investment Promotion Centre quarterly reports (1994-2017) indicated that about 84% of all inward FDI to Ghana are concentrated in GAR. This has led to increase in the presence of multinational and transnational companies in Accra. The workers of these companies mostly reside in estates and gated communities constructed by Ghanaian and foreign real estate development companies (Grant, 2009). Accra's fragmentation is fuelled by the development of exclusive villas and estates at the inner city and peri-urban areas, to meet the needs and preferences of upper and middle-income classes. In effect, globalisation is increasing pressure on land and housing, creating scarcity and high prices. Within the context of weak land market and development, land speculation in peri-urban areas tends to be widespread, leading to increasing urban development in GAMA without appropriate services and infrastructure (see Owusu, 2013). The next section examines Accra's spatial structure following the spatial development patterns.

**4.3 Understanding the spatial structure of Accra**

The largest contiguous built areas within Greater Accra Region (GAR) in 1986, 2000, and 2017 were 6680, 14753, and 34253 hectares while total built areas were 10368, 29932, and 61588 hectares respectively. The Contiguity Index (CONTIG) (expressed) in percentage terms of 64, 49, and 56 for 1986, 2000, and 2017 respectively show that Accra's spatial structure is more monocentric than polycentric despite the spatial fragmentation (Figure 12). The decline in CONTIG for 2000 and subsequent increase in 2017 further buttresses the earlier assertion that Accra's landscape is complex and evolving in a discontinuous manner. In effect, while NUMP – a measure of the emergence of new urban nuclei – increased for both GAR, GAMA, 10-20 and 20-40km buffer zones between 2000 and 2017 (see Figure 10), the increase did not translate into a polycentric urban form. While this finding is based on spatial configuration of urban centers and sub-centers, and may not hold true from a functional perspective, it corroborates that of previous studies (e.g., Angel et al. 2005; Oduro et al., 2014; Yeboah, 2003) which found evidence of monocentric tendencies by Ghanaian and Sub-Saharan African cities.

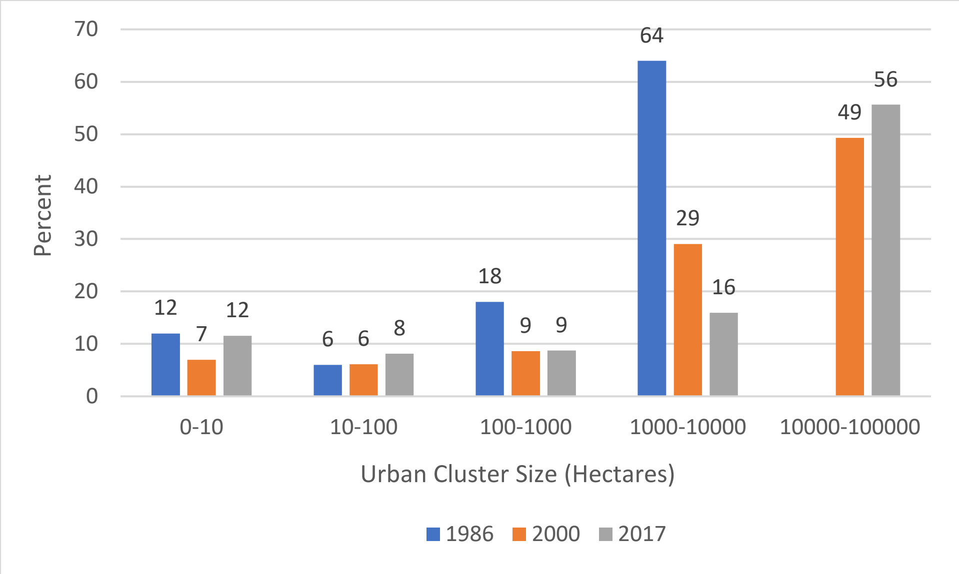



**Figure 12:** Urban area under the various cluster sizes in Greater Accra Region

**5. Conclusion**

Against the backdrop of rapid urbanisation and the "relentless dynamism of the urban phenomenon under modern capitalism" (Brenner & Schmid, 2014, p. 743), this paper examined the evolution of spatial development patterns in Sub-Saharan African context and the urban form that emerges in the process. We examined urban growth patterns in Accra, Ghana under four concentric rings between 1986 and 2017. Our findings show that Accra's urban form is dynamic and changing. Accra has developed in a discontinuous manner since opening up to the forces of globalisation in the mid-1980s. The spatial dynamic of the city is consequently shaped and enabled by global forces from above and local forces from below. We found that population increase and facets of globalisation, including foreign direct investment and structural adjustment programs, strongly conditioned urban transformations in Accra. Accra's spatial growth is particularly related to housing development, which is stimulated by state housing policies under the structural adjustment program. This spatial reality is inherently connected to economic restructuring in Ghana, which began in 1986 and exposed the country to globalisation processes. We found that spatial development in Accra is fragmented and complex – a spatial characteristic observed in many African cities. Accra's spatial fragmentation is partly an outcome of peri-urban land speculation and the development of new urban nuclei in the form of gated residential and estate communities in and around the city. We also found that Accra's spatial fragmentation does not lead to an amorphous or polycentric spatial structure but depicts a monocentric city.

The computed spatial metrics such as area-weighted mean patch fractal dimension (AWMPFD), edge density (ED) and number of urban patches (NUMP), all support our conclusion that Accra's spatial form is complex, irregular and fragmented. Accra's development does not follow a discernible pattern, as evidenced by the AWMPFD for Greater Accra Region, Greater Accra Metropolitan Area, 0-5 and 5-10km buffer zones. The AWMPFD for these zones declined from 1986-2000 and then increase again between 2000 and 2017. Therefore, Accra's spatial development does not converge towards a pattern of contiguous urban fabric and is instead discontinuously evolving and far from complete. By breaking the study area into buffer zones, our analysis shows that urban spatial configuration varied across time and scale. The landscape metrics employed in this paper proved useful for describing, understanding and comparing spatial configuration of urban growth across scales within the city. This is an improvement over using only growth rates for the entire study area, which does not indicate the unique dynamics of spatial development at certain locations (see Yeboah, 2000). For instance, our analysis revealed that while the 0-5km buffer zone has become more contiguous, evidenced by the declining NUMP between 1986 and 2017, the ED and AWMPFD for 2000 and 2017 show that spatial development in this zone is far from complete. Recently, this area has become slightly fragmented and complex in relation to spatial development. There are three plausible reasons for this: 1) the emergence of informal and make-shift structures around the edges, 2) the emergence of residential estates in this zone, and 3) the redevelopment of existing built-up areas. Yeboah (2003) observed that office buildings have started to emerge since 1997 at the heart of Accra in the form of buildings exceeding ten stories. While findings in this paper appear to confirm this trend, further research is required to assess the effect of globalisation on the central business district of Accra, particularly in relation to redevelopment projects.

Other cities in Sub-Saharan Africa with similar conditions to Accra may respond similarly in spatial terms to the forces of globalisation. As such, we submit that spatial planning and governance in many African cities should strive for better ways to meet the challenges of urban transformations driven by globalisation. We acknowledge that cities in sub-Saharan Africa have different historical, physical and socio-economic conditions that impact their spatial growth pattern. Nonetheless we argue that spatial planning can no longer rely on plans that do not account for the flow of global capital and its distributive effect on the urban fabric. Finally, we pose two important questions for urban policy and planning practice that arise this paper. The first is specific to Accra: how can the urban-poor adequately access housing in Accra, given that economic restructuring has led to housing provision being driven by the private sector and fundamentally targeted at the rich? The second, more general, question is whether planners in Sub-Saharan Africa are generally aware of the capacity for urban transformation that globalisation poses and whether they have or can acquire the training, resources or capacity to implement strategies to counter them? Addressing these questions will further the contributions of this paper and other and will further improve scholarly contributions to the under-served debate about spatial development patterns and emerging spatial form within the African context.

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**Appendix**

**Table 2**: Foreign Direct Investment Projects by Regions (1994-2017)

| **Region** | **FDI Projects*** | **Percent of Total** |
|---|---|---|
| Ashanti | 309 | 5.4 |
| Brong Ahafo | 40 | 0.7 |
| Central | 113 | 2.0 |
| Eastern | 117 | 2.1 |
| Greater Accra | 4762 | 83.9 |
| Northern | 52 | 0.9 |
| Upper East | 8 | 0.1 |

| | | |
|---|---|---|
| Upper West | 4 | 0.1 |
| Volta | 65 | 1.1 |
| Western | 209 | 3.7 |
| **Total** | **5679** | **100** |

* 2010 and 2016 values are missing (1994-2017)
**Source:** Compiled from Ghana Investment Promotion Centre quarterly reports

**Table 3**: Characteristics of spatial data

| Data | Year | Date Acquired | Spatial Resolution | Scene cloud cover (%) | Bands used |
|---|---|---|---|---|---|
| TM | 1986 | 22/12/1986 | 30m × 30m | 16 | 1,2,3,4,5, 7 |
| ETM+ | 2000 | 04/02/2000 | 30m × 30m | 10 | 1,2,3,4,5,7 |
| OLIS/TIRS | 2017 | 25/01/2017 | 30m × 30m | 8.25 | 1,2,3,4,5,7 |

**Source:** Authors

**Table 4:** Characteristics of data used and sources

| **Data type** | **Format** | **Source** |
|---|---|---|
| Landsat Satellite Images | TIFF | United States Geological Survey (https://earthexplorer.usgs.gov/) |
| Foreign Direct Investment in Ghana | Excel | Ghana Investment Promotion Centre, United Nations Conference on Trade and Development, World Bank (Development Indicators) |
| Gross Domestic Product Per Capita (GDPPC) | Excel | World Bank (Development Indicators) |
| Population and Housing Data | PDF and Excel | Various censuses of Ghana Statistical Service and World Bank |
| Real Estate Data | Shapefile | Land use and Spatial Planning Authority, Accra, Ghana |

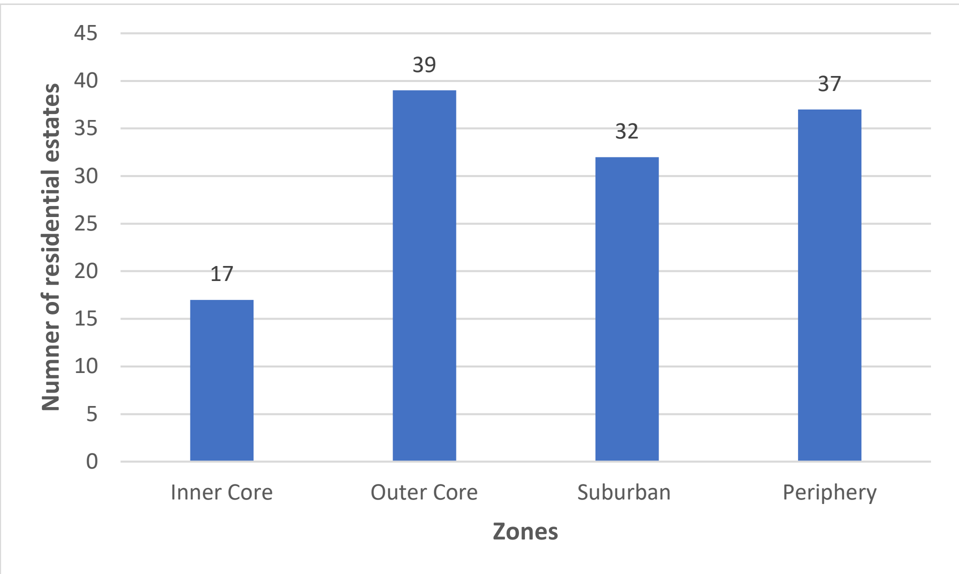


**Figure 13**: Distribution of Residential Estates across the buffer zones
**Source**: Based on spatial data from Land use and Spatial Planning Authority, Accra, Ghana