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Peri-urbanisation and loss of arable land in Kumasi Metropolis in three decades: Evidence from remote sensing image analysis

Kabila Abass[a,*], Selase Kofi Adanu[b], Seth Agyemang[a]

[a] Department of Geography and Rural Development, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[b] Centre for Remote Sensing and Geographic Information Services (CERGIS), University of Ghana, Legon, Ghana

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ABSTRACT

This paper examined the effects of peri-urbanisation on arable land in Kumasi Metropolis. The study involved classification of Landsat Thematic Mapper (TM) 1986 imagery and images from Enhanced Thematic Mapper Plus (ETM+) 2004 and Landsat 8 Operational Land Image and Thermal Infrared Sensor (OLI/TIRS) image for 2016 to show land use and cover changes in the Metropolis. The results show that the Metropolis has undergone significant land use and land cover changes in thirty years with negative repercussions for food crop production. While urban land use increased by 54.6% between 1986 and 2016, arable land declined by 15.6% over the same period. The results show a strong positive correlation between the size of arable land and crop output over a fifteen-year period. The paper calls for legislative enforcement as well as standards on urban land use and development as enshrined in the 2016 Land Use and Spatial Planning Act to ensure that land use in the city is consistent with sustainable principles.

1. Introduction

About 50% of the world's population lives in urban centres and it is projected that future population growth will occur in cities (Cohen, 2003; McGranahan and Satterthwaite, 2003; Satterthwaite et al., 2010). It is projected that, the population of the world will reach 6.29 billion, which is 69% of the total world population by 2030 (United Nations, 2010). By the year 2050, it is expected that the world's urban population will increase by more than two thirds, with about 90% of the increase taking place in the urban centres of Africa and Asia (United Nations Population Division, 2015). The urban population of developing countries is especially projected to grow at an average annual rate of 2.4%, which is twice the 1.2% urban growth rate in the developed world (Golden, 2004). The current rates of population growth and urbanisation in Sub-Saharan Africa are and will be the highest in the world, providing impulsion for monitoring of land cover and land use change based on remote sensing (Toure et al., 2016). In view of the fact that a huge proportion of urban population resides in peri-urban areas, the question of how peri-urbanisation is to be managed has become one of the topical issues in spatial planning and sustainable urban development in the 21st century (Watson, 2009). Peri-urbanisation is a 'process by which rural areas located on the outskirts of established cities become more urban in character, in physical, economic, and social terms, often in piecemeal fashion' (Webster, 2002, 5). In countries of the developing world, peri-urbanisation is becoming increasingly an important issue because of continuous and rapid urbanisation (United Nations, 2001; Cohen, 2006).

Urbanisation is one of the key processes affecting human societies, especially over the last century. It has brought a lot of benefits economically to a lot of countries with tremendous improvements in the provision of social services to communities (Raddad et al., 2010). If not properly managed, however, urbanisation can create adverse consequences (GOG, 2012). A major challenge is farmland decline as rapid urban expansion eats up available peri-urban and rural lands compelling farmers living in urban fringes with huge population to migrate to new locations where they can find farming space. It is estimated for example that every year, 1.5 million farmers in China lost their farmlands since the last decade due to urban expansion (Lu et al., 2003). Due to urbanisation, communities are rapidly going through a transition from the natural rural vegetation to man-made urban engineered infrastructure (Golden, 2004) with negative implications for the environment. The process of urbanisation has been associated with different environmental and resource problems worldwide, including habitat loss, land cover change, species extinction and alteration of hydrological systems (Chen et al., 2014). Rapid urbanisation (Weeks, 2015), and urban sprawl (Bruegmann, 2005) are key factors for extensive land cover and land use change.

Peri-urbanisation, a process by which hitherto rural and non-urban

* Corresponding author.
E-mail addresses: kabass.cass@knust.edu.gh (K. Abass), sadanu@ug.edu.gh (S.K. Adanu), sagyemang.cass@knust.edu.gh (S. Agyemang).

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areas become urbanised, presents challenges to peri-urban dwellers. As Ode and Fry (2006) note, traditional farming activities come into conflict with alternative economic, residential and recreational interests within the peri-urban zone. Conversion of agricultural lands to urban use causes scarcity of productive land as non-farm activities increase land values leading to high competition for land, landscape fragmentation, neighbour conflicts and environmental pollution (Clark et al., 2007). As a result, urban expansion into urban fringes increases pressure on the agricultural land, which could impact negatively on socio-economic conditions of communities (e.g. Mandere et al., 2010). Between 1982 and 2003, the total area devoted to cropland, rangeland and pastureland in the United States dwindled by 76 million acres in the lower 48 states, while the total area of urban land increased by 36 million acres (Wu, 2008). Similarly, when urban sprawl invaded farmlands in China, farmers lost the most valuable resource on which they have lived for generations (Sui and Zeng, 2001; Xiao et al., 2006; Liu et al., 2010). Between 1996 and 2002, for example, arable land dwindled from about 130.03 million hectares to about 125.93 million hectares (Lu et al., 2005). The expansion of urban areas in China has resulted in over 40 million farmers losing their farmland at a rate of 2 million acres per year (Elhadary et al., 2013). Another clear example is that of Hanoi, Vietnam, where rural communities have lost their main sources of livelihood, in the form of production of fresh food such as fish, pork, and vegetables for urban residents as a result of rapid increase of residential and commercial developments (Tacoli, 2003).

Although urbanisation is a challenge to the survival of rural agricultural economies, it is also an opportunity for creating urban market for farm products and creation of alternative jobs for off-farm employment, emergence of new markets for higher value goods and income from recreational activities (Levi and Sperry, 2007). Depending on the challenges and opportunities, farmers in peri-urban areas tend to develop several strategies such as intensification, on and off-farm diversification and having multiple income portfolios to secure their livelihood in such a dynamic environment (Clark et al., 2007; Sharp et al., 2007; Wilson, 2007; Zasada et al., 2011, Afriyie et al., 2014). These dynamics imply that farmers would respond differently to the forces that cause change within the peri-urban spaces.

Ghana is urbanising rapidly. With well over 70% of the total population in rural areas at independence in 1957, the country now has about 51% of its total population living in urban centres, thus crossing the urban divide (GOG, 2012). The urban population growth rates of 4.7%, 3.3%, 4.6% and 4.3% were recorded for the periods 1960–1970, 1970–1980, 1984–2000 and 2000–2010 respectively. Compared to the national population growth rate of 2.4%, 2.6%, 2.7% and 2.5% for 1960–1970, 1970–1980, 1980–1984, 1984–2000 and 2000–2010 respectively (sum of urban and rural), it is clear that the urban growth rate is higher. By 2030, the country's urban share of the national population is projected to hit 65% (GOG, 2012).

As cities expand, housing deficits continue to increase amidst the generally low levels of income of the Ghanaian working population, land tenure insecurity and escalating high cost of building materials. The limited supply of public sector housing should have provided the opportunities for private sector housing to do business. This has not materialized fully due to the challenges of high bank interest rates on loans which is a disincentive for housing development. As a result, housing provision is principally through self-help initiatives (Obeng-Odoom, 2009). To meet accommodation needs for residential purposes, peri-urban lands are particularly attractive. This is because land value diminishes away from the city centre. The outward growth of such housing developments, often uncontrolled and unregulated, give rise to the sprawling city (Farooq and Ahmad, 2008). Uncontrolled and scattered sub-urban development increases problems of traffic, destroys open spaces and depletes local resources (Peiser, 2001).

In the last two decades, in the Kumasi Metropolis, rapid urbanisation has affected agriculture in a dramatic fashion (GSS, 2014). The increased demand for land for residential, industrial and commercial uses has occurred at the expense of agricultural land use. According to the Ghana Statistical Service estimate, about 95% of the cultivable lands have undergone conversion through housing construction and other forms of physical infrastructure (GSS, 2014).

The effects of urban expansion into rural areas have been documented by Afriyie et al. (2014) and Cobbinah and Amoako (2012). However, the effect of peri-urbanisation on arable land in the Ghanaian context is under researched. This paper therefore examines peri-urbanism and its effects on arable lands in Metropolitan Kumasi. This will contribute to the small but growing body of scientific discourse in this area.

2. The growth of kumasi and the peri-urban development

Kumasi has seen a tremendous growth in terms of population and infrastructural expansion. It grew at 5.2% annually between the 1984 and 2000 inter-censal years but grew at an unprecedented growth rate of 5.4% from 2000 to 2010. Compared to the 2.7% and 2.4% annual national growth rates for the periods 1984–2000 and 2000–2010 respectively, the Metropolis has grown about twice the national growth figures (Afrane and Amoako, 2011). This is attributed to Kumasi being the Asante State capital and currently Ashanti regional capital. Being a nodal city coupled with its rich and varied natural resource endowments make it not only a transit location but also an important commercial centre for a large number of migrants from across different parts of the country and beyond. Since 1960, migrants from other parts of the country to Kumasi and foreigners accounted for 63% and 13% respectively of the total population (Korboe, 2001 cited in Quagraine, 2011).

The rapid growth of the population of the city has necessitated a substantial demand for housing resulting in an annual housing growth rate of 8.6% between 1984 and 2000 (Afrane and Amoako, 2011). This development has a significant effect on the physical structure of the Kumasi Metropolis, with expanding peri-urban settlements. The development of peri-urban Kumasi does not strictly follow formal urban planning and development processes and is influenced largely by factors that are beyond the control of the city authorities (Afrane and Amoako, 2011; Afriyie et al., 2014). A complex mix factors are at play and include among other things individual housing preferences, desire for new lifestyles outside the inner city, improvement in transportation links, demographic trends, price of land, traditions and constraints at the metropolitan level (Afriyie et al., 2014).

The Kumasi Peri-urban Interface (KPUI) falls within an area that spans 9 and 20 km from the City centre (Owusu-Ansah and O'Connor, 2010). Its width has been estimated to range from 20 to 40 kilometers. This has however changed over time because of its fluidity and it is almost certain to continue doing so with future urban growth (Brook and Dávila, 2000). The width of the peri-urban zone around the City is also not uniform (Afrane and Amoako, 2011). This area has over the years experienced massive changes in terms of land use as well as social and economic activities. This has culminated in a rural-urban mix of residents, haphazard distribution of buildings which are either fully completed or at different levels of construction (Owusu-Ansah and O'Connor, 2010).

As Kumasi grows outward, it absorbs previous peri-urban lands and many other villages which hitherto were in rural locations. Their rural characteristics are gradually changing due to the influence of urban way of life which is changing the hitherto agriculturally dominated economy to a multiple use landscape (Busck et al., 2006). Simon et al. (2004) are of the opinion that these changes are as a result of in-migration, growth and changes in population composition that result in land use and economic diversifications. With the increased urbanisation, land within the urban centres become relatively scarce. Consequently, the price (value) of a parcel of land goes up beyond the reach of an average Ghanaian. Land values decrease however, with distance from the city centre. These dynamics and the increased proximity and

connectivity of KPUI to Kumasi make these places tenure hot spots. The uncontrolled influx of migrants into the adjoining rural areas gives the population its heterogeneous characteristics where different people with diverse interests compete for the available natural resources especially land. The composition of the population in the KPUI will include indigenes, farmers, migrant residents, recreational users, natural resource users, speculators, industrial users and developers. An estimated population of 400,000 is said to commute daily from these areas to work in the city (KMA, 2011).

Peri-urbanisation, among other things, results in rapid conversion of agricultural lands to housing and small-scale industries, a development that undermines the traditional dominant crop production within the KPUI (Aberra and King, 2005). While this is happening, livelihood opportunities are also being created precisely because of the proximity to large urban markets and availability of wage employment opportunities (Afriyie et al., 2014).

3. Materials and methods

3.1. Profile of study area

The Kumasi Metropolis, one of the thirty (30) units in Ashanti Region, stretches from latitude 6°35N′–6°40′N to longitude 1°30W′–1°35′W (KMA, 2011; GSS, 2014). It covers an area of approximately 214.3 Km^2 and about 0.9% of the total land area of the Ashanti Region. However, it has 36.2% of the population of the region. To the north of the Metropolis is Kwabre East District and Afigya-Kwabre District; to the east is the Bosomtwe District and Ejisu-Juabeng Municipality; to the west is Atwima Nwabiagya District and to the south of the Metropolis lies the Atwima Kwanwoma District. The Metropolis has a wet sub-equatorial climate with double maxima rainfall regime occurring in June and September with a moderate temperature (GSS, 2014).

Per the Ghana 2010 Census report, Kumasi Metropolitan Area (KMA) has a population of 1,730,249 and considered as one of the most rapidly growing metropolises in the country (GSS, 2014). Its population is composed of 826,479 males (47.8%) and 903779 females (52.2%). The number of households stood at 440,286, and has an average household size of 3.8 persons compared to the regional figure of 4.2%. The Kumasi Metropolis is made up of nine sub-metros which include, Nhyiaeso, Kwadaso, Bantama, Manhyia, Tafo, Suame, Subin, and Oforikrom and Asokwa (KMA, 2011; GSS, 2014).

3.2. Data and procedures

Data used for the land use and cover (LULC) change analysis were ortho-rectified Landsat Thematic Mapper (TM) 1986, Enhanced Thematic Mapper Plus (ETM+) 2004 and Landsat 8 Operationalised Landsat Imager/Thermal Infrared Sensor (OLIS/TIRS) 2016 images were downloaded from the United States Geological Survey (USGS) Global Visualisation Viewer website (http://glovis.usgs.gov) using path 194 and row 055. Landsat TM 1986, Landsat ETM + 2004 and 2016 images were used because the image sensors have seven spectral bands at a medium resolution of 30 m which is adequate for the analysis. These multispectral bands sufficiently captured data on other vegetation, built up/bare areas, farmlands and water bodies which are target objects for analysis. For all the dataset, level 1 data which has been geometrically corrected to UTM by USGS were obtained. For the Radiometric correction, Top of Atmosphere (TOA) reflectance and Dark Object Subtraction (DOS) were applied to all the images. Also line correction was performed on the 2004 image to correct for the Scan Line Corrector (SLC) error before applying the radiometric corrections. The images were clear and nearly free of clouds and readily available and accessible without any extra cost. These image scenes were subsetted using the district boundary shape file in ArcGIS 10.2 software. The characteristics of the satellite images used are shown in Table 1.

Table 1
Satellite images characteristics.

Image Year	Landsat Sensor	Bands used	Date acquired	Spatial resolution
1986	Thematic Mapper (TM)	1, 2, 3, 4, 5, & 7	21st April	30m × 30 m
2004	Enhanced Thematic Mapper plus (ETM+)	1, 2, 3, 4, 5, & 7	6th February	30m × 30 m
2016	Operationalised Landsat Imager/Thermal Infrared Sensor (OLI/TIRS)	1, 2, 3, 4, 5, & 7	7th February	30m × 30 m

The subset images were loaded into ERDAS imagine 2013 software for image pre-processing using bands 4, 3, 2 and 5, 4, 3 in false-colour composite, for visualization for the TM/ETM+ and the OLIS/TIRS images respectively. These bands were chosen because of the spectral properties which show high reflectance of green vegetation as they are chlorophyll absorbing bands (Lu et al., 2015). Specifically, bands 2 and 3 were used because they produced distinct spectral signatures for vegetation which is needed for analysis. Band 4 is a near infra-red band which shows contrast between vegetation and soil and band 5 which is a mid-infrared band helped to differentiate between vegetation and built up/bare areas for easy image classification.

Maximum Likelihood supervised image classification algorithm was used to classify the three images because of a priori knowledge of the area. Maximum Likelihood method was used because of the advantage of providing an index of certainty linked to the choice of each pixel to the given class. As a method, maximum likelihood classifier is user friendly and lends itself to easy operability and manipulation.

Land use and land cover classes generated were urban/built-up, farmland including fallow, vegetation (which consist of a mixture of light forests groves, grasslands and other green spaces) and water bodies. The classes were obtained using on-screen digitizing method by drawing polygons around identified land cover classes, that fall into similar pixel spectral characteristics.

Accuracy assessment of how close the classification agreed with the actual land cover on the field was performed by selecting samples of identified locations on the image that were checked directly in the field. For the 1986 and the 2004 images, the samples were obtained from high resolution Google Earth images, where persistent land uses such as water bodies, as well as permanent land marks were used as part of the reference points. A total of 308 reference points were used. For the 2016 image, Etrex garmin GPS was used to collect point data in geographic coordinates from visited sites along with samples extracted from Google Earth and loaded onto the classified imagery for accuracy assessment. For each land use and cover class, 8 sample points were picked with GPS giving a total sample size of 32. Accuracy assessment of classified imagery was done by comparing identified point locations such as urban/built-up areas, farmlands, vegetation and water bodies on the classified imageries with the referenced coordinate samples for built-up areas, water, vegetation and farmlands. A confusion matrix was obtained from which the overall accuracy was calculated for each classification. The overall accuracy has been computed by dividing the total correct (i.e., the sum of the major diagonal) by the total number of pixels in the error matrix. The accuracies of arable, built-up and vegetation were also computed in a similar manner but in this case using total number of pixels in the corresponding row or the corresponding column. From the producer's and user's errors, the omission and commission errors were computed. By subtracting producer's error (in percentage) from 100% one obtains the error of omission. Similarly, the error of commission was computed by simply subtracting user's error (in percentage) from 100%. The methodological workflow is shown in Fig. 1.

Secondary data on areas cultivated with staple crops in the Metropolis were also analysed from 2001 to 2015. It was however not

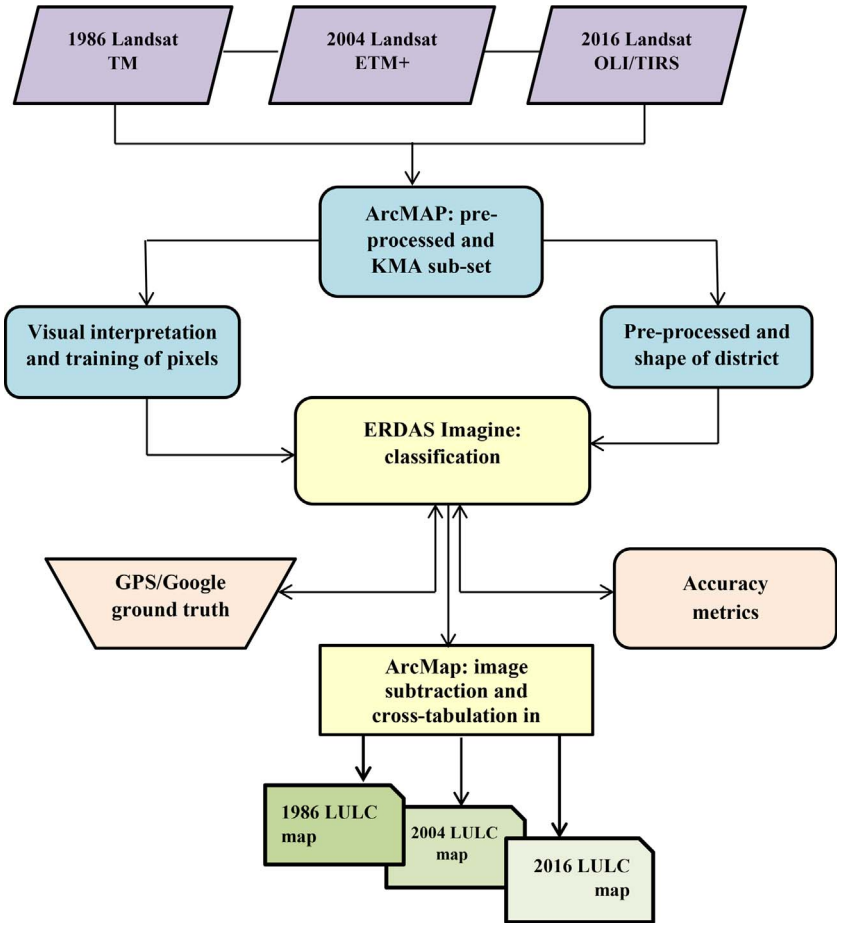

Fig. 1. Methodological work flow in ERDAS Imagine and ArcGIS.

possible to do analysis for output levels of same crops before 2001 due to poor record-keeping culture. The 2016 statistics are also unavailable for use in this paper because they are yet to be validated by the relevant agencies. Cropped area and crop output relationship analysis was calculated using a Pearson product-moment correlation.

4. Results

4.1. Accuracy assessment

The maximum likelihood classification yielded overall accuracy of 81.17%, 72.00% and 70.00% for the 1986, 2004, and 2016 LULC maps respectively; indicating high agreement with the ground reference data. The producer's and user's accuracies are shown in the various error matrix tables (See Tables 2a, 2b and 2c). For example, in Table 2a, the producer's accuracy for water, arable land, built-up/bare area and vegetation are 100%, 74.23%, 96.25% and 73.28% while the user's accuracy for water, arable land, built-up/bare land and vegetation are 83.33%, 66.67%, 86.52% and 73.85% respectively. The error of omission for water, arable land, built-up area and vegetation are respectively 0.0%, 25.77%, 3.75% and 26.72%. The computed error of commission for water, arable land, vegetation and built-up/bare area in percentage terms are respectively 16.67%, 33.33%, 13.48% and 26.15%. The interpretation of these statistics is simple. This means that although 100% (producer's accuracy) of water bodies have been correctly identified as water bodies, only 83.33% (user's accuracy) of areas identified as water bodies are actually water bodies. This implies that there is a commission error of 16.67%. For arable land use, although 74.23% have been correctly identified as arable, only 66.67% of the areas called arable are actually arable. In the case of built-up/bare area, 96.25% have been correctly identified but only 86.52% are truly built-up/bare area. In the case of vegetation still using the 1986 image, 73.28% of areas covered by it have been correctly identified but only 73.85% of the areas shown actually is correct. The producer and user accuracy results together with their respective errors for the 2004 and 2016 images are captured in Tables 2b and 2c.

Table 2a
Error Matrix for 1986 image.

Classified Data	Water	Arable	Built-up/Bare land	Vegetation	Total	User's accuracy	Commission error
Water	5	0	0	1	6	0.8333	0.1667
Arable	0	72	3	33	108	0.6667	0.3333
Built-up/Bare land	0	11	77	1	89	0.8652	0.1348
Vegetation	0	9	0	96	105	0.7385	0.2615
Total	5	92	80	131	308		
Producer's accuracy	1	0.7423	0.9625	0.7328			
Omission error	0	0.2577	0.0375	0.2672			

Overall Classification Accuracy = 81.17%.

Table 2b
Error Matrix for 2004 image.

Classified Data	Water	Arable	Built-up/Bare land	Vegetation	Total	User's accuracy	Commission error
Water	7	0	0	5	12	0.5833	0.4167
Arable	0	48	7	16	71	0.6761	0.3239
Built-up/Bare land	0	6	106	30	142	0.7465	0.2535
Vegetation	0	16	4	63	83	0.7590	0.2410
Total	7	70	117	114	308		
Producer's accuracy	1	0.6857	0.9060	0.5526			
Omission error	0	0.3143	0.094	0.4474			

Overall Classification Accuracy = 72.00%.

4.2. Land use/cover conversions in the kumasi metropolis

The study analysed satellite images to assess the extent of urban encroachment on non-urban land use in Metropolitan Kumasi. Land use and cover classes analyzed were built up/bare land, farmland including fallow and newly planted fields, other vegetation types and water bodies. The results reveal that the dominant land cover type in the KMA is urban, which has increased in area over the years (see Fig. 2a–c and Table 3). Comparing the satellite images, an inverse relationship between urban expansion on the one hand and the arable land on the other has been established. In 1986, urban land-use covered approximately 6,258 ha of the total land area of KMA but increased to 22,610 ha in 2016, an increase of 54.6% in thirty-years. The area covered by farmlands however fell from 92978 ha (31%) in 1986–4625 hectares (15%) in 2016. Between 1986 and 2004 however, arable land increased marginally by 80 ha (0.1% decline).

The result of the satellite image analysis is further corroborated by data from the Ministry of Food and Agriculture (MoFA) on cropped areas of major staples in the KMA (See Table 4). Evidently, total cropped areas for all staples have seen steady decline from 2001 to 2015. With a total land area of 10331 ha devoted to the cultivation of urban and peri-urban staple crops such as maize, cassava, yam, cocoyam, plantain and rice in 2001, arable land area declined to 1694 ha (16.94 Sq. km) in 2015; a loss of 8637 ha constituting about 83.6 percentage decline over the period. Output of all major crops but rice has declined over the same 15-year period (see Table 5) with cropped areas showing strong positive correlations with output for all the six major staples cultivated in the metropolis (see Table 6).

5. Discussion

5.1. Accuracy assessment

The error matrix as applied in this work is useful for a series of descriptive and analytical statistical techniques. The overall accuracy is perhaps the simplest descriptive statistics. This in addition to the accuracies of the individual land use categories – water, arable land, built-up and vegetation give some idea about accuracy of classified images (e.g. Congalton, 1991).

Traditionally, the total number of correct pixels in a category is divided by the total number of pixels of that category as derived from the reference data (i.e. column total). This accuracy measure indicates the probability of a reference pixel being correctly classified and is really a measure of omission error. This accuracy measure is called producer's accuracy simply because the producer of the classification is interested in how well a certain area can be classified (Congalton, 1991). On the other hand, if the total number of correct pixels in a category is divided by the total number of pixels that were classified in that category, then this result is a measure of commission error. This measure, called user's accuracy or reliability, is indicative of the probability that a pixel classified on the map or image actually represents that category on the ground (Story and Congalton, 1986).

Different errors are encountered in an image classification. Typically, interest focuses on thematic accuracy, which is the correspondence between the class label assigned by the classification and that observed in reality. The confusion matrix appears to provide an excellent summary of the two types of thematic error that can occur, namely, omission and commission (Foody, 2002). Errors of omission refer to the samples of a certain class of the reference data that were not classified as such. Errors of commission refer to the samples of a certain class of classified data that were wrongly classified (Janssen and van der Wel, 1994). However, other sources of error may contribute to the pattern of misclassification depicted in the confusion matrix (Foody, 2002). Nonthematic errors, for instance, may result in misrepresentation, typically under-estimation of the actual accuracy (Congalton and Green, 1993). Unfortunately, nonthematic errors can be large and particular concern focuses on errors due to misregistration of the image classification with the ground data (Foody, 2002).

5.2. Peri-urbanisation and depletion of arable land

The Kumasi Metropolis has undergone rapid urbanisation having received a large number of migrants from within and outside the Ashanti Region. This is due to a combination of factors which are economic, socio-cultural, historical and political in nature. In addition to migration, natural increase also explains the burgeoning population. Considering the fact that the metropolis is spreading more horizontally than vertically (Quagraine, 2011), urban and peri-urban land has come under intense pressure from competing demands (Afriyie et al., 2014; Abass et al., 2013). According to Malpezzi et al. (1990), about 50% of

Table 2c
Error Matrix for 2016 image.

Classified Data	Water	Arable	Built-up/Bare land	Vegetation	Total	User's accuracy	Commission error
Water	6	0	0	2	8	0.75	0.25
Arable	0	36	18	10	64	0.5625	0.4375
Built-up/Bare land	0	3	118	32	153	0.7712	0.2288
Vegetation	2	17	8	88	115	0.6783	0.3217
Total	8	56	144	132	340		
Producer's accuracy	0.75	0.6429	0.8194	0.5900			
Omission error	0.25	0.3571	0.1806	0.4100			

Overall Classification Accuracy = 70.00%.

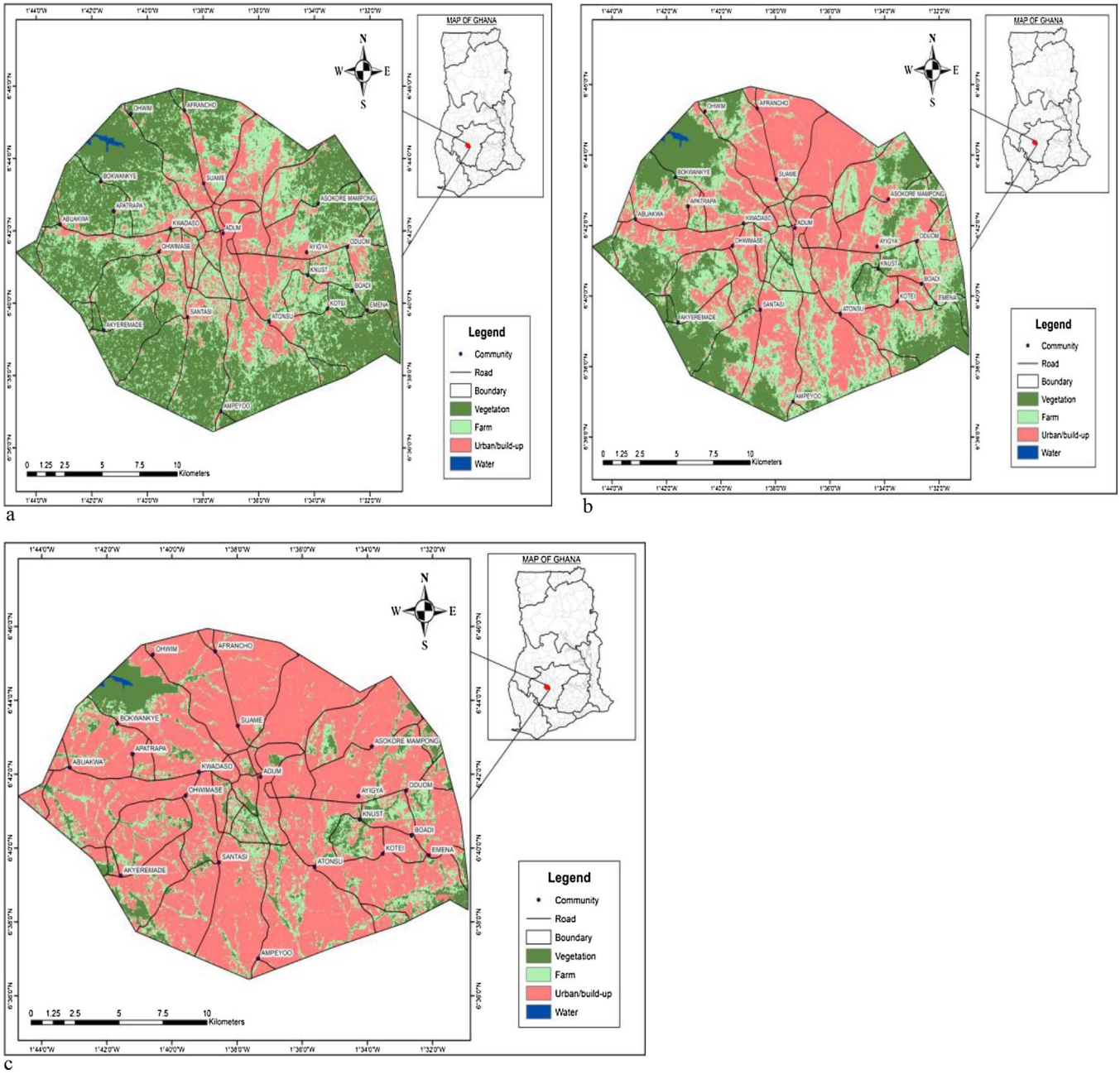

Fig. 2. a) Classified Land Cover of KMA 1986. b) Classified Land Cover of KMA 2004. c) Classified Land Cover of KMA 2016.

Table 3
Land use Land Cover (change) statistics for KMA.
Source: Computed from the classified satellite images

Land-use/Land-cover Type	Area (hectares)			Percentage change		
	1986	2004	2016	1986–2004	2004–2016	1986–2016
Urban/Built-up	**6257.82** (20.9%)	**13433.31** (44.9%)	**22609.53** (75.5%)	114.7	121.7	261.3
Farmland	**9297.66** (31.0%)	**9377.19** (31.1%)	**4625.19** (15.4%)	0.9	−50.7	−50.4
Vegetation	**14327.66** (47.8%)	**7092.63** (23.7%)	**2679.39** (9.0%)	−50.5	−62.2	−81.3
Water	**65.71** (0.2%)	**45.72** (0.2%)	**34.74** (0.1%)	−30.4	−24.0	−47.1
Total	**29948.85**	**29948.85**	**29948.85**	–	–	–

all buildings in Kumasi are single storey compound houses and most multiy-storey buildings do not go beyond three levels. The growth and expansion into the peri-urban area remain largely unplanned, uncontrolled and haphazard. This trend does not promote the compact city development necessary for natural landscape conservation. This observation supports the findings of Møller-Jensen et al. (2007) where urbanisation of the fringe areas of Accra is taking place at a pace that has increased from 10 km^2 per year for the period 1985–1991 to 25 km^2

Table 4
Cropped area (in hectares) of staple crops in KMA (2001–2015).
Source: Statistics, Research & Information Directorate (SRID), Min. of Food & Agriculture (2016)

YEAR	Maize Area (in ha)	Cassava Area (in ha)	Yam Area (in ha)	Cocoyam Area (in ha)	Plantain Area (in ha)	Rice Area (in ha)	Total Area (in ha)
2001	3626	4865	439	254	1126	21	10331.0
2002	3630	4870	439	253	1127	20	10339.0
2003	3630	4870	440	250	1130	20	10340.0
2004	3449	4773	449	238	1116	24	10049.0
2005	2300	3117	219	217	1740	25	7618.0
2006	2466	3283	240	221	1795	25	8030.0
2007	1242	3003	22	21	1205	12	5505.0
2008	1002	2500	20	18	1008	10	4558.0
2009	820	1766	21	15	1038	15	3675.0
2010	382	468	10	10	950	15	1835.0
2011	344	445	10	10	983	16	1808.0
2012	340	400	8	8	905	60	1721.0
2013	330	380	7	7	900	62	1686.0
2014	336	382	7.2	7.2	911	63	1706.4
2015	335	372	7	7	910	63	1694.0

Table 5
Output (in Metric Tonnes) of Major Crops in KMA (2001–2015).
Source: Statistics, Research & Information Directorate (SRID), Min. of Food & Agriculture (2016).

	Crops					
Year	Maize	Rice	Cassava	Yam	Cocoyam	Plantain
2001	5036	3	51142	3406	2390	9027
2002	5125	3	51163	3406	2391	9027
2003	5130	10	51160	3410	2390	9030
2004	4874	28	47726	3478	2271	8922
2005	3001	28	27883	1647	1713	15465
2006	3046	30	28089	1800	1680	16065
2007	1534	14	2569	187	118	10785
2008	1202	10	22140	175	104	9428
2009	1066	17	19426	263	86	9708
2010	573	36	5620	100	40	8930
2011	378	39	5339	102	10	9833
2012	425	156	5200	83	32	9050
2013	396	186	5320	70	28	9450
2014	437	195	5730	79	36	10021
2015	402	195	5580	70	35	9100
Total	32625	950	351893	18276	13354	153841

Table 6
Summary descriptive statistics & correlation results.

Crop	N	Mean	Sd	Range	Pearson's Correlation (r)
Maize	15	2175.00	1984.20	4752	0.998017
Cassava	15	23814.20	18699.06	45963	0.990526
Yam	15	1218.40	1482.99	3408	0.999768
Cocoyam	15	890.30	1075.92	2363	0.993550
Plantain	15	10256.07	2297.21	7143	0.924569
Rice	15	63.33	75.97	192	0.968215

per year for the period 1991–2002, devouring large tracts of agricultural, vegetation and other open spaces. Urbanisation may come with challenges and opportunities (Levi and Sperry 2007).

In the Kumasi Metropolis, peri-urbanism has affected land use patterns with much of its natural physical environment being converted to urban land use (Afriyie et al., 2014; Abass et al., 2013). Urban land is generally considered by city authorities to be more rewarding compared to agricultural land and that economic turnaround is more likely to take place on urban land. This thinking has been identified to accelerate the process of land conversion from arable to urban land (Zhang and Yang, 2000; Zhang, 2000; Skinner et al., 2001). The present reality is that landscaped areas, prime agricultural lands, most vegetative cover/other green spaces, natural habitats and other ecologically-sensitive areas within the Kumasi Metropolis are being converted to construction areas such as housing for the growing population, roads to improve the vehicular circulatory system, industries for mass production (Abass et al., 2013; Adjei Mensah, 2014a,b; Asare, 2013; Corubolo and Mattingly, 1999; Intsiful, 2016; Quagraine, 2011) and also for the construction of public structures such as educational institutions, centralized ministries and sports stadium (Quagraine, 2011). As Gregory (2005) points out, farmland availability declines with increasing proximity to the city where most farmland is being allocated for housing resulting in rising land loss and landlessness in these areas. With greater competition for land comes escalating land values which makes it out of reach to the poor farmers within the *peri*-urban interface.

The Metropolis has 37,456 (8.5%) households that engage in agriculture out of a total household size of 440,286 (GSS, 2014). Both satellite image analysis and statistics from MoFA however, have shown a huge decline in the size of arable land in Kumasi Metropolis due to expansion in the urban area over a period of nearly thirty years. The marginal increase of 79.5 ha (0.1% increase) in the arable land between 1986 and 2004 however, could be accounted for by an increase in backyard gardens. Indeed, arable land for maize, rice, cassava, yam, cocoyam and plantain has shown a consistent decline between 2001 and 2015 in all the districts surrounding KMA (see Ministry of Food and Agriculture (MoFA), 2016). In the Bosomtwe District, for example, cropped area for maize, rice, cassava, yam, cocoyam and plantain in 2001 were 4270, 359, 6077, 630, 1864 and 2,021 ha respectively. These fell to 1643, 156, 2170, 336, 440 and 1900 respectively in 2015. A similar observation was made in the Ejisu-Juaben Municipality. This is supported by similar findings in Accra and Kumasi (Stow et al., 2016), Tamale (Naab et al., 2013), Secondi-Takoradi (Aduah and Baffoe, 2013) Ghana, where a substantial amount of farmland has been lost to other land uses as a result of rapid urbanisation of the area and urban sprawl. In Secondi-Takoradi for example (Aduah and Baffoe, 2013) found a doubling of the urban area at the expense of other land use forms. With urban expansion occurring on hitherto agricultural lands in peri-urban and urban hinterlands of Accra and Kumasi, convenient and productive agricultural food sources are being reduced for the burgeoning population (Cobbinah et al., 2015; Møller-Jensen et al., 2005; Stow et al., 2016). Given that urbanisation occurred at the expense of agricultural and other non-urban land uses it has implications for food crop and pastoral farming in the peri-urban interface. Our current finding is however inconsistent with Stow et al. (2016) who found expanding agriculture with expanding urban space.

The reduction in arable land inevitably puts pressure on the limited available arable land. The increased land pressure according to Adu

(1992), has led to more intensive cultivation and shorter periods of fallow within Kumasi urban and peri-urban areas with the topsoil at many places deficient in nutrients and organic matter. This has negative effects on crop output. This finding is consistent with the observation made by Chen (2007) that rapid urbanisation can lead to irreversible changes in the physical and biotic character of the natural surface that may lead to complete loss of soil productivity. This development may pose a serious threat particularly to those peri-urban dwellers whose livelihoods are tied to the land. This according to Chen (2007) presents a huge challenge to future food security.

Besides, data from the Ministry of Food and Agriculture points to a consistent decline in the output of major staples within Kumasi Metropolis (see Table 4) and the surrounding districts (MoFA, 2016), a trend partly attributed to loss in arable land as a result of urban expansion (Afriyie et al., 2014). It is clear that total output of major staples except for rice and plantain in the Kumasi Metropolis have all shown consistent decline between 2001 and 2015. It is significant to note that this declining output trend in the metropolis does not mirror the larger regional picture. Indeed, output statistics from MoFA for Ashanti Region generally have shown increasing trend (see MoFA, 2016). Similar declining trends have been observed in other parts of the world. In Concepción (Chile), 1,734 ha of wetland and 1,417 ha of forest and agricultural lands were converted to residential areas over the period 1975–2000 (Matuschke, 2009). In Delhi, Firdaus and Ahmad (2011) note that total cropped area declined by 50% from 1306 to 608 km^2 while non-agricultural use increased by 123.76% between 1961 and 2004. The case of rice and plantain as having deviated from the general trend may be due to the following: Rice is grown mainly in marshy or wetland areas which are naturally unattractive to urban dwellers and so may not have been threatened by urban encroachment. Plantain is ubiquitous and can grow practically anywhere due to the basic reason that as a crop, it thrives under a wide range of environmental conditions. While other factors as climatic, soil condition, land tenure arrangements, government policies among others may have partly influenced crop yield, it was difficult to disentangle the effects of these factors due to data unavailability. As a result, their effects on food crop output in the Metropolis have not been examined in this paper.

As a consequence of the loss of large areas of cropland many countries have transitioned from being predominantly self-sufficient in food production to net grain importers of food. In a period of 44 years (1950–1994), Japan lost more than half of its cropland which contributed to greater dependence on grain imports (70% in 1985, 25% in 1950). This pattern of increased dependence on imports has also occurred in South Korea and Taiwan (Brown, 1995). This is a wake-up call for Ghana.

The rapid conversions of arable lands to urban use forms as a result of urbanisation means rural farmers would have limited access to land, a natural capital, for their livelihood activities. The rural poor, particularly farmers who have been deprived of their land or whose tenure security is at risk and have little to sell, are the most vulnerable to such transformations (Corubolo and Mattingly, 1999; DPU, 2001). To this category of urban and peri-urban dwellers, adaptation to this new urban reality is a must. These changes, which may vary among the different segments of the peri-urban population, may manifest in the form of agricultural diversification and intensification, adoption of multiple income portfolios and outward migration to the rural fringe. But agricultural diversification and intensification could be jeopardized if the sprawling city is not controlled. There is empirical evidence to support adoption of agricultural intensification, diversification and multiple livelihood strategies of poor peri-urban farmers in Kumasi Metropolis, whose main sources of livelihood have been eroded by rapid urbanisation (Abass et al., 2013). Abass et al. (2013) also report of a response in the form of outmigration of peri-urban farmers to the rural fringe in order to access land to carry out their farming operations. This is supported by findings of Gyasi et al. (2017) on the effects of urbanisation on urban and peri-urban agriculture in Tamale where farmers seek to manage the agricultural threats and opportunities by various ingenious survival strategies, notably livelihoods diversification, use of new cultivars, and land use intensification. It is therefore critical for the city authorities to regulate or control urban development process so that prime agricultural lands are not completely eaten up.

The depletion of the natural landscape in Kumasi is taking place within the context of inadequate and weak policy regime. The legal framework that regulated planning practice and functions within the country for years were contained in various legislations, the concurrent operation of which was cumbersome and confusing because of different procedures and mechanisms for plan preparation, approval and implementation (Ghana Justice, 2016; Kyei, 2016; MESTI, 2015). Besides, there was a duplication of functions by the institutions established under the various enactments to undertake land use planning and management. Some of the planning standards adopted by the Town and Country Department under the Town and Country Planning Ordinance, 1945 (CAP 84), and the Town and Country Planning (Amendment) Act, 1960 (Act 33) have for long been outdated and out of tune with current international standards. These and the apparent lax in the enforcement of relevant legislation pertaining to land use in Ghana in general and Kumasi Metropolis in particular, provides the grounds for all forms of land use abuses by nonchalant citizens. In 1999, the Ghana Ministry of Lands and Forestry (1999) instigated a National Land Policy to regulate land development. However, even with regulations in place, extensive illegal development has occurred around the country, due probably to compromised law enforcement both by lack of resources and by local tribal chiefs with strong control over land development (Stow et al., 2016). The passage of Ghana's Land Use and Spatial Planning Bill by parliament into a law (Act 925) and given Presidential Assent in 2016 is a laudable move. This bill provides among other things a comprehensive legal framework for sustainable development of land and human settlements through a decentralised planning system. It is to enable planning authorities at the different levels of governance to control and direct physical development in an orderly and harmonious manner (Ghana Justice, 2016; Kyei, 2016; MESTI, 2015). The fact is that Ghana has all the best of laws and regulations but the problem is with enforcement and compliance. We can only hope that this Land Use Act will not end up like its precursors which faced enforcement challenges.

6. Conclusion and policy recommendations

This study addressed itself to peri-urbanism and loss of arable land in Kumasi Metropolis. The study shows a substantial expansion of urban land between 1986 and 2016. Satellite image analysis shows that Kumasi Metropolis is urbanising at a rapid rate leading to its horizontal expansion into the rural hinterland. This phenomenon has resulted in arable lands giving way to urban land use types which in general affects food production negatively.

In order to check the abuse and misuse to which urban and peri-urban lands are put, a vigorous public education is necessary using all available media outlets. This will inject some control and discipline into the manner in which agriculture and other prime lands are being converted to urban use forms. In this respect, there is an urgent need for collaboration among all relevant actors in the area of land administration, land use planning, zoning, land allocation and land utilization.

Peri-urban farmers can be encouraged and supported through Metropolitan Assembly to adopt agricultural intensification to ensure that food production becomes meaningful and sustainable. The city authorities should enforce zoning regulations to ensure that potential farmlands and green spaces are protected from urban development. The Metropolitan Assemblies and the traditional rulers together with other key stakeholders have a role to play. There is, however, the recognition of some challenges that come the way of these institutions in executing this mandate. Inadequate financial and human resources, weak institutional structure, chieftaincy and land disputes, low levels of commitment, undue political interference, ineffective teamwork among

others have been identified as some challenges (Mensah, 2005; Yeboah and Obeng-Odoom, 2010). These are however not too difficult to surmount.

To check the sprawling city from consuming prime arable lands, compact city model is the way to go. Vertical building style should be adopted but cannot be achieved if left to the individuals. This can be achieved with effective public-private partnership. It is argued that compact city structure will contribute in no mean way to sustainable development of the city in terms of land use efficiency among other benefits (Camagni et al., 2002; Thinh et al., 2002).

The initiative to protect forest reserves, open spaces, water bodies, wetlands, green belts, water catchment areas and other ecologically sensitive areas from urban encroachment and physical development as enshrined in the 2012 National Urban Policy is a laudable one. This must be backed by action. The passage of the Land Use and Spatial Planning Act (Act 925) in 2016 is a welcome news. There is the need to concentrate development in certain areas and promote the acquisition and preservation of agriculturally important public lands to ensure that the integrity of cultivable lands is not compromised. To succeed, the Metropolitan, Municipal and District Assemblies and other stakeholders must work in concert.

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