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Inter-regional pattern of urbanization in southern Ghana in the first decade of the new millennium

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ABSTRACT

We analyze amounts and spatial patterns of land cover and land use change (LCLUC) and particularly change to Built for four contiguous regions of southern Ghana between 2000 and 2010. Our objective is to understand the degree of urban expansion relative to urban densification during this time frame, to understand the relationship between population growth and LCLUC at the census district level, and to explain the patterns of New Built LCLUC throughout this study area. During the study period 1.5% of the study area transitioned to Built, an increase of 56% Built area since 2000, while population increased by 33%. Most (84% of total study area) of this change to Built involved conversion from Agriculture al land use and occurred predominantly in suburban and periurban areas zones of the Accra and Kumasi metropolitan areas. While total population and amount of Built LCLU variables co-vary strongly at the census district level at the beginning and end of the study period, change in population and Built are less strongly correlated. In fact, we observe that new Built development increased at a greater rate than population growth within peri-urban areas of Accra and Kumasi, frequently occurring as spaced residential land use composed of large houses with minimal urban infrastructure.

1. Introduction

Rural to urban migration is a ubiquitous trend within countries of the Global South (Aide and Grau, 2004). On top of this, countries within Sub-Saharan Africa have birth rates that greatly exceed the replacement level (ICF International, 2015). The result of these two demographic trends for Sub-Saharan Africa has been the rapid expansion and densification of cities over the past decade or two (United Nations Population Division, 2012). Within Ghana, the Sub-Saharan African country of focus in this study, the total population increased from almost 19 million in 2000 to nearly 25 million in 2010—an annual rate of growth of 2.7%—based on data from the censuses in the respective years (Ghana Statistical Service, 2012b). During the same period, the Accra Metropolitan Area (AMA) and Kumasi Metropolitan Area (KMA) census districts (analogous to counties in the U.S.), containing Ghana's two largest urban populations, grew 24.5% and 73.6%, respectively. Concomitant with such rapid urban population growth has been extensive land cover and land use change (LCLUC), particularly from urbanization–the increase in the percentage of the population living in urban places (Weeks, 2015), and urban sprawl–the expansion of urban areas into the adjoining countryside (Bruegmann, 2005). Urban expansion has occurred as Built LCLU on formerly agricultural lands in peri-urban and urban hinterlands of Accra and Kumasi, reducing convenient food sources for the growing population (Cobbinah, Gaisie & Owusu-Amponsah, 2015; Møller-Jensen, Kofie, & Yankson, 2005).

Here we build on previous studies of LCLUC in Ghana, with greater emphasis on urbanization and on the 2000 to 2010 time period. Yorke and Margai (2007) mapped LCLUC in the Densu river basin, located east of Accra using Landsat imagery and post-classification comparison and found that the primary changes in the basin were urban growth, expansion of agricultural land, and decreasing forest cover. Pabi (2007) mapped LCLUC for eight sites in the district of Kitampo in northern Ghana using Landsat imagery and a post-classification comparison approach, finding that a decrease in dense woodlands and an increase in non-intensive cultivation were the primary changes. Also for northern Ghana,

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Braimoh (2004) used a similar approach to correlate land use change and migration, and determined that decreasing woodlands and increasing agricultural land were useful correlates of higher migration rates. For a similar study area, Braimoh and Vlek (2005) found that the effect of accessibility to roads on agricultural land cover was greater than the effect of population growth. For western Ghana, Kusimi (2008) used image differencing of Landsat data to analyze LCLUC in the Wassa West district and determined that substantial changes in LCLU had occurred due to expansion of mining, farming, urbanization, lumbering and fuel wood extraction. Studies by Møller-Jensen and Yankson (1994) and Møller-Jensen et al. (2005) are among the few that have examined LCLUC in the more urbanized southern Ghana by analyzing patterns of peri-urban development in the outskirts of Accra.

While the specific focus is on Ghana, our research builds on and contributes to an ever-wider literature on urbanization and urban sprawl throughout the developing world (see especially Seto, 2003, Seto, 2005 and Seto, Sánchez-Rodríguez, & Fragkias, 2010). Every country in the world not already highly urbanized is moving in that direction, with Sub-Saharan Africa lagging behind other regions but in the process of catching up. These trends seem obvious to people on the ground in each locale, but the vast number of growing cities throughout the world renders it impossible to track broader patterns of LCLUC without the assistance of remotely sensed imagery (Sutton, 2003; Montgomery, 2008; Schneider & Woodcock, 2008; Sutton, Taylor & Elvidge, 2010).

In this paper we analyze the spatial pattern of LCLUC within four contiguous regions (equivalent to states or provinces) of southern Ghana in relation to population change from 2000 to 2010. The emphasis is on New Built LCLU, as determined from post-classification comparison of LCLU maps derived from classification of Landsat 7 Enhanced Thematic Mapper Plus (ETM+) for circa 2000 and circa 2010. We use "circa" as a date qualifier because of some uncertainty and variability in the LCLU map representations that stem from imagery limitations due to prevalent cloud cover. For brevity, we refer to the years 2000 and 2010 in the remainder of the paper. We use "Built" to represent a class of LCLU that can include various stages of urban development from land clearing with the intent to build settlements, to completely dense urban core, or forms ranging from a village of huts to industrial land uses. This Built class is similar to the Urban and Built Up Level 1 class of the US Geological Survey Land Use and Land Cover classification system (Anderson, Hardy, Roach, & Witmer, 1976); this is the level of urban LCLU classification and mapping that is appropriate for Landsat ETM + data, especially in areas of predominant cloud cover. The result of LCLUC involving transition from non-Built to Built from 2000 to 2010 is referred to as New Built.

Within the geographic and temporal context defined above, our objectives in this paper are three-fold: (1) to understand the degree of urban expansion relative to urban densification during this time frame; (2) to understand the relationship between population growth and LCLUC at the census district level; and (3) to explain the patterns of New Built LCLUC.

2. Study area

The study area consists of the Ashanti, Central, Eastern and Greater Accra regions (four of the ten regions within Ghana), which contain the two most populous metropolitan areas (Accra–including Ashiaman and Tema–and Kumasi) as well as an additional three of the country's seven most populous cities in 2010 (Cape Coast, Obuasi, and Koforidua). Overall, the study area includes 55% of the total population of Ghana as of 2010, as depicted in Fig. 1. Because of its political and economic stability compared to neighbors in the region, Ghana is the focus of extensive research and economic development interest, and one of the few West African countries having good population census and health survey data dating back to at least the 1990s. In 1950 the population of Ghana was 5 million, but the 2010 census counted 25 million Ghanaians and the United Nations (UN) projects the population to be 50 million by 2050 (United Nations Population Division 2015). In 1950 only 15% of the population lived in urban places, but by 2010 52% of the population was urban and by 2050 three-fourths of its people are projected to be urban. In 2010, Ghana Statistical Service (2012a) reported that 2,076,546 people lived in the AMA district (based on consistent boundaries between the two censuses; with an additional 330,756 people in Ashiaman and Tema, which are both part of the Greater Accra Metropolitan Area), 2,035,064 in the KMA district, 169,894 in Cape Coast, 143,644 in Obuasi, and 120,971 in Koforidua (Ghana Statistical Service, 2013).

The biophysical setting for the study area is mostly influenced by the equatorial wet-dry climate that varies along an aridity gradient from the Gulf of Guinea (which creates the southern boundary of Ghana) to drier lands in the north and particularly the northeast. Variability in natural vegetation conforms to the aridity gradient. Equatorial forests once covered most of the southern and western portions of the study area, but with deforestation, agricultural development and abandonment, forests have been replaced by secondary forest and shrub thicket. Much of the Eastern region and eastern portions of the Greater Accra region are covered by savanna vegetation, which has a high burn frequency from fires set to produce charcoal for cooking. Few non-vegetated lands occur in the study area and are mostly limited to tidal flats near the coast and some rock outcrops in more mountainous areas. Topography is generally flat to hilly, with the exception of low mountains west of Lake Volta and near Obuasi.

Agricultural land use is dispersed throughout the non-urban portions of the study area, with small subsistence agricultural plots intermixed with natural vegetation in a complex manner. The predominant crop types are cassava, yam, maize, banana, and plantain. Larger agricultural plots associated with commercial agriculture vary from palm oil plantations in the Central and Ashanti regions to larger mixed crop commercial farms in the savanna lands of the Afram Plain of the Eastern region.

3. Data and methods

Our general methodological approach was to generate 2000 and 2010 LCLU and LCLUC maps through classification of a dense time series of Landsat multispectral image data, extract population data from decadal census at the district level for the same years, and then to analyze distributions, changes and co-variability of Built LCLU and population variables. We derived and analyzed relative and absolute change, and normalized LCLU and population variables. Descriptive and inferential statistics and district-level map comparisons supported these analyses.

Data on LCLUC and particularly urbanization were derived from Landsat 7 ETM + data. Four adjacent Landsat image scenes, each covering approximately 165 km × 165 km, are required to cover the study area. A very small part of the western portion of the Ashanti region (5% of region and 2% of four-region study area) is not covered by these four Landsat scenes and was excluded from the study due to the high cost of data production relative to the limited added coverage. This area is mostly rural and experienced almost no urbanization within the study period (as interpreted from GoogleEarth imagery). Cloud-free images of the study area are rare and most scenes near the coast typically contain 20%–80% cloud cover, with the mean cloud cover per-scene around 50%. In addition, with the scan line corrector failure in May 2003 (resulting in SLC-off conditions), substantial data gaps are present near the edges of