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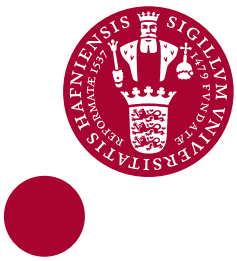

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Mapping the rural-urban transition zone: Peri-urban development in Accra, Ghana

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Introduction

Comparing satellite derived maps of urban growth in Africa can be difficult for reasons related to characteristics of the spatial development process, the applied definition of "urban", and the classification methodology. Peri-urban areas are especially, challenging, since there are often no crisp boundaries, but rather a rural-urban continuum with areas characterized by different 'degrees of urbanization'.

Different classification methods may easily come to different results concerning the categorization and boundary delineation of peri-urban areas, and direct comparison may, therefore, be misleading. This is discussed below with specific reference to the city of Accra, Ghana.

Characteristics of the spatial development

Accra is expanding in a largely uncontrolled manner. Individual builders typically erect houses gradually over several years when funds are available, as mortgage schemes are often not available. Individual housing development (often bungalow or villa type dwellings) typically takes place before infrastructure and service provision is implemented. Due to the slow building process, many fringe areas constitute rural-urban transition zones with houses in various stages of completion.

The visual landscape of these new urban areas is often dominated for several years by a high percentage of plots with natural vegetation or exposed surfaces between half-finished brick walls. Most of the recent development in peri-urban Accra is characterized by this appearance: wide areas of land dotted with large villas at various stages of completion (see fig.1a and 1b).

Figure 1a and 1b. Urbanising land: Buildings in various stages of completion

Definition of "urban"

Information about the magnitude and rate of urban growth is clearly important, but even though many countries have strict spatio-statistical methods to identify urban areas, there is no globally agreed definition.

According to the UN, *because of national differences in the characteristics that distinguish urban from rural areas, the distinction between the urban and the rural population is not yet amenable to a single definition that would be applicable to all countries*. (UN, 2018).

UN further states that *where there are no regional recommendations on the matter, countries must establish their own definitions in accordance with their own needs*.

Satellite-based methods are seen by UN mainly as an additional tool to assist census-based statistics on population numbers: *Images obtained by remote sensing may be of use in the demarcation or boundaries of urban areas when density of habitation is a criterion. For assembling information from more than one source, the importance of a well-developed system of geocoding should not be overlooked.*

It is hard to see how density of habitation could not be a criterion for defining urban locations. Moreover, the provision of fully geo-located census data is only in its infancy in many African cities including Accra.

Satellite data and air-photos will, therefore, be a vital source for delineating urban areas and monitoring urban growth.

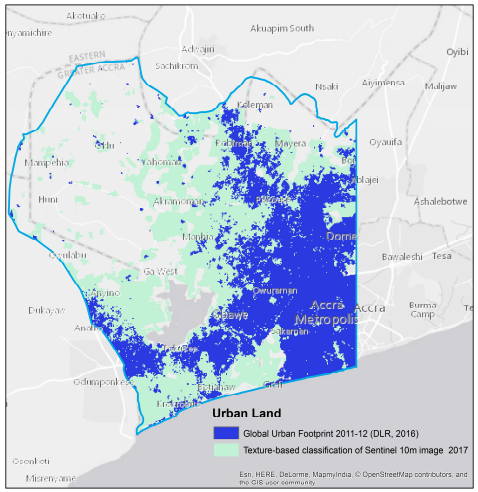

Figure 2. Recent urban and peri-urban development in Accra, Ghana

Classification methodology

Remote sensing-based attempts to delineate urban areas are plentiful and applied on many scales and types of imagery. Recently, the appearance of global datasets on urban areas and locations has put increased focus on how results from different studies may be compared to better understand the ongoing spatial development processes.

Differences in the underlying definition of urban may, however, hamper a direct comparison. A common, formal definition is not in sight for reasons discussed above and also because such a definition would most likely have to rely on information that is difficult to extract from a satellite image, at least on a large scale, such as the precise location of individual, completed buildings.

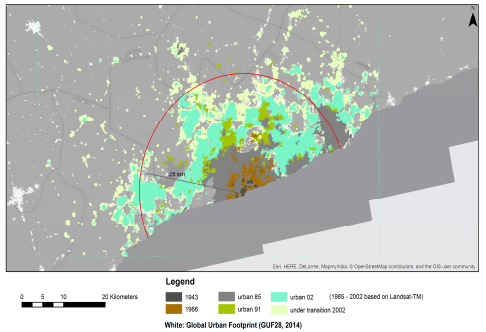

Figure 3. Urban expansion. Sources: AUE (2016), Møller-Jensen et.al (2005), Esch (2013)

Classification method, therefore, rely on identifying proxy variables related to spectral, textural or contextual image information, rather than computation of distances between well-known objects. As an example, the degree of urbanization in the peri-urban areas of Accra is identified by Møller-Jensen (2013) to be somewhat related to specific sub-segment texture measures.

It is, however, not likely that a clear link can be identified between spatial properties, such as image texture, and a formal, transparent definition of urban in the traditional sense. Similar issues arise with other methods for delineating urban areas based on remote sensing; The definition of urban is specific to, and 'hidden' within, the applied method (and case), and it is therefore very difficult to link the definition with specific 'real-life' spatio-statistical properties of the identified urban areas.

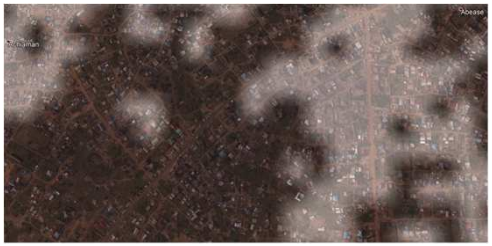

Figure 4. Examples of peri-urban development (Google based on 2015 images). White areas are classified as urban by both Global Urban Footprint and Sentinel texture classification. All other areas are classified as urban/urbanising by Sentinel classification only.

Examples

To illustrate the fact that care should be taken when comparing different remote-sensing derived maps of urban expansion, fig. 2 shows the global data set Global Urban Footprint (DLR, 2016) together with a new classification based on a Sentinel-2 10m image covering the western parts of Accra.

This classification is based purely on texture-measures computed from co-occurrence matrices. Basis for computations is the second principal component of the image bands (10m resolution) with a kernel size of 87x87 pixels for texture. A maximum likelihood classification has been performed with training areas for 4 classes: Urban, Urbanizing, Non-urban and Water. Urban and Urbanizing have subsequently been combined.

Visual comparison with high resolution images (Google Earth) in fig.4 indicates that GUF is 'conservative' in terms of when to assign a pixel as urban. The sentinel-based classification is more 'liberal' and includes substantially more areas that, by visual comparison with the high-resolution images, seems to be urbanizing. It should be noted that the GUF map is based on images from 2011-12 while the Sentinel image is from 2017. Comparison was made with high-resolution Google images from 2015.

Fig.3 shows the GUF classification for Accra superimposed on an earlier texture-based classification of urban growth from 1985-2002 (Møller-Jensen, 2005) with 1944 and 1966 extent added (AUE, 2016). Fig.5 indicates the total extent of areas designated as urban within the western parts of the city for both GUF, sentinel classification and 1985-2002 classification (same area as fig.3).

It can be seen that the urban class of the GUF data is comparable to the areas designated as urban in 2002. Urban growth estimations based on direct comparison of these two datasets could therefore lead to the conclusion that the spatial expansion has slowed down, while comparison with the more inclusive sentinel-based classification indicates that Accra is still expanding fast.

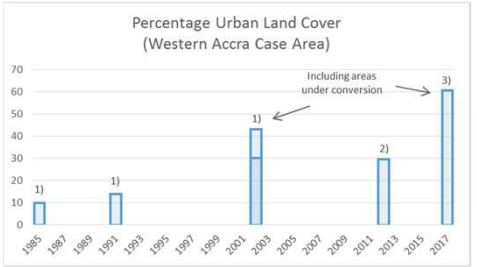

Figure 5. Urban/urbanising land cover in % of case area size.
1) Landsat-TM (Møller-Jensen, 2005), 2) Global Urban Footprint (Esch et al 2013), 3) Texture-based analysis of Sentinel 10m

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