Spatiotemporal analysis of urban growth in three African capital cities: A grid-cell-based analysis

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(1) **Motivation**: The purpose of this study is to examine the spatiotemporal pattern and dynamics of the urban growth in three African capitals of different sizes (2000 - 2014) using remote sensing and LandScan population data, and a grid-cell-based method. Since a comparative analysis of urban land-cover changes in different African capital cities using a grid-cell-based method has not yet been conducted, this study might be useful in the context of urban studies and landscape and urban planning of African cities.

(2) **Methodology**: Maximum likelihood supervised classification method was employed for classifying the Landsat imageries. Six land-cover categories were classified, namely urban, bareland, cropland, grassland, forest and water. A grid-cell-based method (1 km × 1 km grid cell) was used to reveal the spatial distribution of the land-cover changes and population change in density between 2000 and 2014. The grid-cell-based analysis has three steps:

- Create 50 km × 50 km fishnet to make empty grid cells. Overlap land-cover maps with the 1 km grid cells.
- Use zonal statistics in ArcGIS® software package to summarize the number of pixels of each category contained in each grid cell.
- Combine the tables for the two time points based on the grid cell code ID. With the combined tables, the change in the proportion or density of each land-cover category between the two time points is determined.

Subsequently, the correlation between the changes in the density of all the land-cover categories, and between the changes in the density of the urban land-cover category and changes in population density are determined.

(3) **Data**: Landsat ETM+/OLI/TIRS imageries in two time points (2000 and 2014) were adopted to prepare the land-cover maps (Fig. 1) and detect the spatiotemporal land-cover changes in Bamako, Cairo and Nairobi. LandScan population datasets, developed by Oak Ridge National Laboratory (ORNL), are used to determine the grid-based population density in three cities.

(4) **Results**: The results show these three capital cities have undergone a rapid urban growth in the past 14 years (Fig. 2a). In all three cities, a substantial loss of bareland was detected due to urban expansion. Bamako, classified as a small-sized African capital, had the highest urban growth rate (7.95% per year), and this was at the expense of its bareland and green areas (grassland and forest). On the other hand, Cairo, classified as a big-sized African capital, had the lowest urban growth rate (3.45% per year), while Nairobi, classified as a medium-sized African capital, had the increase of the urban growth rate (6.97% per year). The urban expansion of both Cairo and Nairobi occurred mostly in their barelands. However, unlike Cairo, Nairobi’s green areas (especially cropland) also decreased. The results also show that the spatial pattern of the changes in population density varied across the three cities (Fig. 2b). A weak correlation between the change in urban density and the change in population density was observed in all three cities. This level of correlation might have been affected by the vertical urban development in the three cities, which tends to increase population density, but has not been captured in image analyses. Although the correlations were low, there was evidence for a significant positive relationship between population growth and urban expansion in all three cities.

Figure 1: Land-cover maps of three cities in (a) 2000; (b) 2014

Figure 2: Density change maps of (a) urban; (b) population in three cities from 2000 to 2014