Spatiotemporal Analysis of Urban Growth in Three African Capital Cities: A Grid-cell-based Analysis

D01

Poster presented on CSIS Days 2015

Hao HOU*, Ronald C. ESTOQUE and Yuji MURAYAMA

Department of Spatial Information Science, Graduate School of Life and Environmental Sciences, University of Tsukuba

*Contact Email Address: houhao880828@gmail.com

Introduction

- Urban areas cover less than 1% of the Earth's surface, but 54% of the world's population resided in urban areas in 2014.
- Africa is predicted to have the highest increase rate in urban land-cover in this century. However, few urban studies in African cities have been done.
- The purpose of this study is to examine the spatiotemporal pattern and dynamics of the urban growth of three rapidly urbanizing African capital cities with remote sensing and LandScan population data.

Methodology

- The maximum likelihood supervised classification method was employed for classifying the Landsat images. Six land-cover categories were classified, namely, urban, bareland, cropland, grassland, forest and water.
- After mapping, a land-cover transition matrix for each city was produced.
- Use grid-cell-based analysis to detect detailed information has: 1. Create fishnet and overlap land-cover maps; 2. Use zonal statistics to summarize changes into tables; 3. Combine the tables and check the correlation.
- Use equations on the right side to quantify and check correlation among changes in density of each land-cover category (CLD) as well as the change in population density (CPD).

$$LA(ha) = NT \times GA/10000 \quad (1)$$

$$CLD(\%) = \frac{LA_j - LA_i}{GA} \times 100 \quad (2)$$

$$CPD(people/km^2) = PD_j - PD_i \quad (3)$$

LA: the area of land-cover type t in a grid cell.
NT: the number of pixels of land-cover type t in a grid cell.
GA: the area of each grid cell.
PD: the population density in a grid cell.

Results

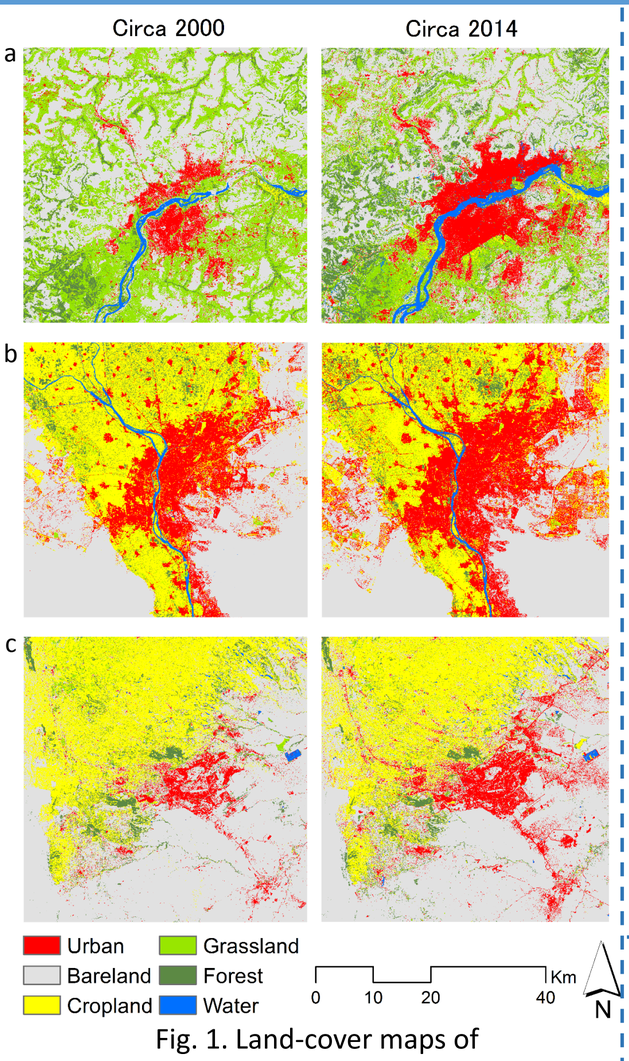

Fig. 1. Land-cover maps of (a) Bamako; (b) Cairo; and (c) Nairobi.

Table 1. Land-cover transition matrix (× 1000 ha).

(a) Bamako(1999-2014)	Urban	Bareland	Cropland	Grassland	Forest	Water	Total Time 1
Urban	12.29	2.60	0.15	1.30	0.19	0.12	16.66
Bareland	13.61	80.32	0.61	16.13	8.90	2.01	121.59
Cropland	0.15	0.29	0.67	0.60	0.65	0.40	2.76
Grassland	10.06	26.67	2.86	35.31	11.95	1.31	88.16
Forest	0.42	1.25	1.34	6.22	7.36	0.89	17.47
Water	0.00	0.00	0.00	0.00	0.00	3.36	3.36
Total Time 2	36.53	111.14	5.63	59.57	29.05	8.08	250.00
Net change (thousand ha)	19.87	-10.45	2.87	-28.59	11.58	4.72	
Annual change rate (%)	7.95	-0.57	6.92	-2.16	4.42	9.38	
(b) Cairo (1999-2015)							
Urban	40.98	0.69	0.00	0.34	0.21	0.02	42.25
Bareland	10.96	94.40	7.48	0.47	0.02	0.00	113.33
Cropland	11.18	0.51	53.23	4.88	5.88	0.15	75.82
Grassland	1.20	0.06	3.00	0.88	0.20	0.00	5.35
Forest	0.86	0.01	5.62	0.47	3.39	0.03	10.39
Water	0.39	0.01	0.07	0.01	0.06	2.33	2.87
Total Time 2	65.57	95.68	69.40	7.07	9.75	2.54	250.00
Net change (thousand ha)	23.32	-17.65	-6.43	1.72	-0.64	-0.33	
Annual change rate (%)	3.45	-0.97	-0.53	2.02	-0.38	-0.73	
(c) Nairobi (2000-2014)							
Urban	9.23	3.00	0.05	0.22	0.29	0.04	12.83
Bareland	13.70	120.80	2.80	1.52	2.84	0.10	141.75
Cropland	1.57	14.13	60.35	0.00	0.04	0.02	76.11
Grassland	0.04	0.75	1.58	0.63	0.11	0.00	3.12
Forest	0.78	3.24	1.55	0.00	9.88	0.01	15.46
Water	0.03	0.05	0.04	0.00	0.02	0.58	0.73
Total Time 2	25.36	141.98	66.37	2.37	13.17	0.75	250.00
Net change (thousand ha)	12.53	0.22	-9.73	-0.76	-2.28	0.02	
Annual change rate (%)	6.97	0.01	-0.91	-1.73	-1.06	0.23	

Table 2. Correlations (r) between the changes in the density of land-cover categories.

City		Urban	Bareland	Cropland	Grassland	Forest	Water
(a) **Bamako**	Urban	1					
	Bareland	-0.397**	1				
	Cropland	-0.064**	-0.080**	1			
	Grassland	-0.297**	-0.529**	-0.059**	1		
	Forest	-0.217**	-0.202**	-0.101**	-0.172**	1	
	Water	0.054**	-0.216**	0.053**	-0.060**	-0.161**	1
(b) **Cairo**	Urban	1					
	Bareland	-0.539**	1				
	Cropland	-0.135**	-0.670**	1			
	Grassland	-0.176**	-0.056**	-0.097**	1		
	Forest	-0.096**	-0.034	-0.225**	0.006	1	
	Water	-0.031	-0.054**	0.057**	-0.073**	-0.075**	1
(c) **Nairobi**	Urban	1					
	Bareland	-0.669**	1				
	Cropland	-0.036	-0.656**	1			
	Grassland	0.021	-0.130**	-0.112**	1		
	Forest	-0.067**	-0.202**	0.042*	0.005	1	
	Water	-0.006	-0.039	-0.035	0.021	0.02	1

** Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

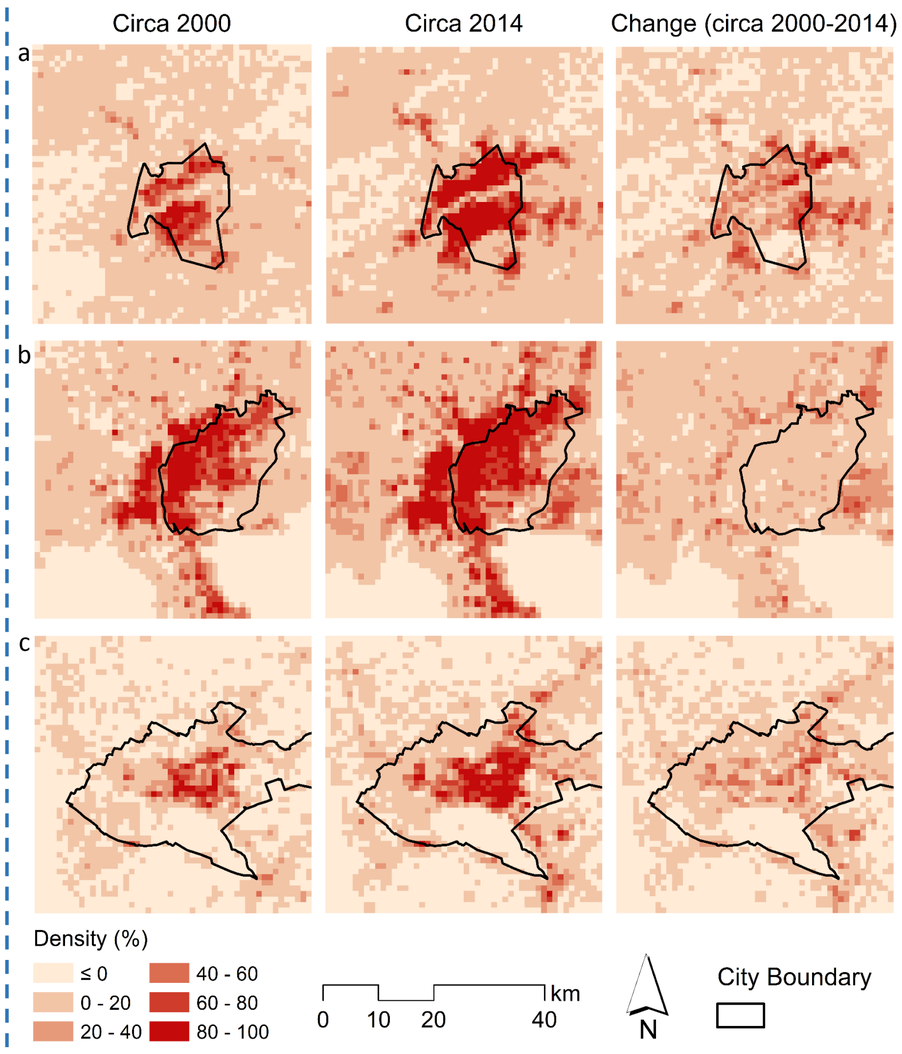

Fig. 2. Urban density maps of (a) Bamako; (b) Cairo; and (c) Nairobi ca. 2000 and 2014, and their respective density change maps in 1-km grid cells.

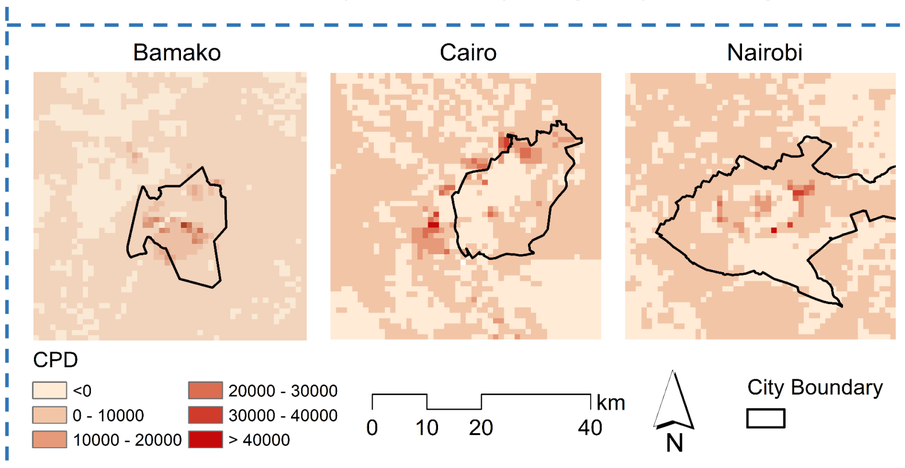

Fig. 3. Changes in the population density between 2001 and 2013.

- These three capital cities have undergone rapid urban growth in the past 14 years.
- In all three cities, the results show a substantial loss of bareland due to urban expansion.
- Although the urban density change and population density change had a weak correlation in all three cities, the correlation was statistically significant.

Discussion and Conclusion

- Bamako's urban expansion was at the expense of its bareland and green spaces, whereas the urban expansions of Cairo and Nairobi were at the cost of their bareland.
- In all three cities, there was a significant positive relationship between urban expansion.
- More attention should be paid to urban studies in Africa because of the projected rapid urban growth and the already observed unplanned urban expansion in the region.
- A grid-cell-based approach is a useful technique to link remote sensing and census data. If available, other variables, including but not limited to, ecosystem services, urban volume, transportation network and income distribution should be included in future analyses.

Acknowledgement

The construction of the land-cover database was financially supported by the Data Bank Project, University of Tsukuba, Japan. The spatial analysis of the database was supported by the Japan Society for the Promotion of Science through Grant-in-Aid for Scientific Research A (Representative: Tsutomu Suzuki) & B (Representative: Yuji Murayama).