Spatial Analysis and Modeling of Urban Land Use Changes in Lusaka, Zambia:

A Case Study of a Rapidly Urbanizing Sub-Saharan African City

January 2018

Matamyo SIMWANDA

Spatial Analysis and Modeling of Urban Land Use Changes in Lusaka, Zambia:

A Case Study of a Rapidly Urbanizing Sub-Saharan African City

A Dissertation Submitted to
the Graduate School of Life and Environmental Sciences,
the University of Tsukuba
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy in Science
(Doctoral Program in Geoenvironmental Sciences)

Matamyo SIMWANDA

Abstract

To curb the unplanned urban development and promote urban sustainability in sub-Saharan African (SSA) cities, there is need to understand the spatial patterns of the urbanization process overtime. In this research, Zambia's capital city Lusaka, one of the cities experiencing rapid urbanization in SSA, is taken as a case study to examine and understand the urbanization process overtime (1990 – 2030) from an African context. The main objectives of this study are to examine and project the spatiotemporal patterns of urban land use (ULU) changes in Lusaka city and to expound their implications for future urban sustainability. To achieve these objectives, firstly the study developed an approach that integrates remote sensing and GIS techniques to classify ULU and assess the spatiotemporal change patterns of six ULU types including four residential ULUs (unplanned high density residential (UHDR) or informal settlements; unplanned low density residential (ULDR); planned medium-high density residential (PMHDR); and planned low density residential (PLDR) areas); plus commercial and industrial (CMI) areas; and public institutions and service (PIS) areas. Secondly the study investigated the drivers of the observed ULU changes using a multi-criteria evaluation (MCE) technique known as Analytic Network Process (ANP) along with consultations with experts and field (household) surveys. Finally, the study employed the neural networks-Markov model to simulate scenarios of future ULU changes in Lusaka and explore different alternatives for achieving urban sustainability by 2030. Three scenarios were evaluated: (1) Spontaneous scenario; (2) environmental conservation and protection scenario; and (3) strategic urban planning scenario, for the years 2020 and 2030.

The results show that the city experienced rapid urban growth, with about a 233% increase in the total ULU area between 1990 and 2010. Lusaka has emerged as a highly unplanned city displaying a chaotic spatial pattern with approximately 40% of the city representing unplanned residential land use dominated by informal settlements (30%). Informal settlements (i.e., UHDR) have been the fastest

growing ULU as a direct consequence of an escalating population dominated by the poor migrants from rural areas for economic opportunities and prospects for access to social services. However, with economic declines and reduced economic opportunities in other major cities in the country, there has been an increase in urban-urban migration further increasing pressure on the land in Lusaka. On the other hand, lack of proper urban planning and a development system that has failed to respond to high demands for land has led to the emergence of informal land markets and corrupt forms of land acquisitions. This has led to the emergence of unplanned low density residential areas as a consequence of urban-urban migration and informal land markets. The growth of these unplanned residential land use has outpaced the planned medium-high and low density residential land use. The growth of commercial and industrial land use has also been high, and consistent with high-density residential land use and the escalating city population.

The results also reveal that urgent policy and planning interventions are required. From the future ULU change scenarios evaluated in this study, the results suggest that a spontaneous (i.e., a business as usual) scenario is perilous as it signals an escalating problem of unplanned settlements. The environmental conservation and protection scenario was determined to be inadequate as most of the green spaces and forests have been depleted. The strategic urban planning scenario has potential for achieving sustainable urban development as it predicts sufficient control of unplanned settlements expansion and protection green spaces and forests. Thus, the results of the scenario-based ULU change analysis can be used to implement urban planning and policy measures required to curb the historically unplanned growth and encourage strategic sustainable urban development.

In terms of scientific contributions, this study has made contributions both from the methodological and empirical standpoint. From the methodology standpoint, the study presented a new approach for classifying ULU in the context of complex urban landscapes of SSA cities like Lusaka. Secondly, a new framework was developed to investigate drivers of ULU changes using a

MCE technique known as Analytic Network Process (ANP). The study also developed a neural network-Markov model which is easily manageable, transparent and replicable that can be used as an early warning tool for understanding the impacts of future urban land changes.

From the empirical standpoint, this research has demonstrated that focusing on ULU changes especially the consideration of unplanned versus planned development, is crucial to future sustainable urban development in SSA cities like Lusaka. The information provided is essential for strategic urban planning that can curb the observed unplanned urban development and can also help the planning authorities to decide on what type of infrastructure to develop and public social services to provide especially in unplanned areas. Thus, this study provides guidance and stimulates visionary debate and urban development planning that can create a clear road map to sustainability. The information provided can also be beneficial to African cities and other similar cities in the developing countries worldwide.

Keywords: Lusaka, Urban Land Use Change; Drivers and Indicators; Multi-criteria Evaluation; Urban Land Change Modeling; GIS; Remote sensing

Contents

List of Tables

List of Figures

List of Photos

Acronyms/Abbreviations

AHP	Analytic Hierarchy Process
ANN	Artificial Neural Network
ANP	Analytic Network Process
asl	Above Sea Level
CMI	Commercial and Industrial
FoM	Figure of Merit
GIS	Geographical Information System
JICA	Japan International Cooperation Agency
LUC	Land Use/Cover
LUCC	Land Use/Cover Change
LCC	Lusaka City Council
MCE	Multi-Criteria Evaluation
PIS	Public Institutions and Service
PMHDR	Planned Medium-High Density Residential
PLDR	Planned Low Density Residential
RDA	Road Development Agency
SSA	Sub-Saharan Africa
UHDR	Unplanned High Density Residential
ULDR	Unplanned Low Density Residential
ULU	Urban Land Use
UN	United Nations
UNDP	United Nations Development Programme