A Study on Urbanization and Future Sustainable Development in Shanghai Using Geospatial Predictive Models

January 2018

Hao GONG

A Study on Urbanization and Future Sustainable Development in Shanghai Using Geospatial Predictive Models

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)

Hao GONG

Abstract

Urbanization is not merely a biophysical change, but a rapid and historic transformation of human society, which makes the impact on geography, sociology, economy, public health, ecosystems and urban planning. In order to constrain and mitigate the risks in the unsustainable urban development, the mechanism and driving forces of the urbanization should be clarified. The process of identifying, measuring and quantifying the driving forces of the urbanization for each city has significant meanings in the urban studies. Furthermore, in order to provide a basis for urban development management, the geospatial predictive modeling presents a robust method to simulate the urbanization process built on the existing knowledge.

Shanghai has achieved remarkable economic growth in the past three decades. This study aims to utilize the observed land use/cover maps and the elucidated geographical driving factors of Shanghai to develop new geospatial predictive modeling method. With the developed model scenario analysis, this study intends to propose policy recommendations to support the sustainable future urban development of Shanghai. To achieve this purpose, the urban expansion of Shanghai from the late 1980s to present was analyzed and modeled by utilizing remote sensing, GIS, and machine learning. Based on the developed geospatial predictive model, the future landscape changes of Shanghai was predicted for

2020, 2030 and 2040. Specifically, this study assumed three future urban growth scenarios of Shanghai to explore and measure the sustainable development in each case.

Firstly, this research monitored the spatiotemporal pattern of LUC changes using the satellite-based monitoring method in the period 1988-2013. Shanghai has been transformed physically, as indicated the developed area had increased from 6.8% to 44.9% by an almost 6-fold. Distinct regional differences in the urbanization are observed, especially for the southern and eastern inner suburbs. Owing to its geographical location (gate and hub of the expressway to the mainland), Shanghai is listed as one of the priority areas in the early stages of the second Chinese economic reform. The rapid development of urbanization in Shanghai is forced by the urban development plans and policies, population growth, economic activities and the development of transportation systems. Specifically, the preferential policies of urban development for priority areas, rural-urban inequality, and "hukou" system of managing the migration are identified to influence the growth of population, economy and urban development of Shanghai.

Secondly, a new geospatial predictive model (MLP-EAI) is developed to predict the future urban development of Shanghai in 2020, 2030 and 2040. Both the collaboration with linear (Logistic Regression) and non-linear (Multi-Layer Perceptron Artificial Neural Network) algorithms are utilized to exam the new model. The model calibration and validation results show that the developed

model provides more accurate predictions than the traditional models. The examined model is used to optimize spatial patterns of future urban growth allocation under three designed future urban growth scenarios, viz. spontaneous scenario (SS), planned scenario (PS), and environment-protecting scenario (EPS).

Thirdly, the scenario analysis demonstrates that Shanghai is expanding rapidly, and showing high building density and lack of green open spaces in the urban core area. Increasing the green open spaces in dense urban areas is recommended to restore the urban ecosystem services. Scenario analysis results reveal that without applying intervention, the SS (i.e., no controls) achieving sustainable urban development will be difficult. The PS scenario predicts that the negative impact of the urbanization under the SS can partly be mitigated, although not adequate to achieve sustainability (loss of a lot of green space will still occur). Thus, from a long-term sustainable development standpoint, i.e., achieving finding a balance between environmental protection and sustainable socioeconomic urban development, the EPS is a more desirable way forward.

Fourthly, based on the simulation results of scenario analysis, the following recommendations are provided that can be considered to implement the sustainable urban development successfully: (1) conservation of land through mixed-use and densification rather than expansion, (2) increasing the green spaces in urban core areas, and (3) establishing zoning structure and refinement functions of zoning areas. Moreover, the observation and simulation results show that Shanghai has already formed a metropolitan area that links other neighboring

provinces and cities. From a short-term shift to long-term sustainable development thinking, future urban development of Shanghai can focus more on urban redevelopment and upgrading while assigning more functions with neighboring cities.

Keywords: Geospatial Predictive Modeling, GIS, LUC Change, Nighttime Light, Remote Sensing, Scenario-based Analysis, Shanghai, Urbanization.

Contents

List of Tables

List of Figures

List of Photos

Acronyms/Abbreviations

ANN	Artificial Neural Network
BU	Built-Up
CBD	Central Business District
DEM	Digital Elevation Model
DN	Digital Number
EAI	Economic Activities Intensity
GIS	Geographic Information Science
LCM	Land Change Modeler
LR	Logistic Regression
LUC	Land Use/Cover
LUCC	Land Use/Cover Change
MLP	Multi-Layer Perceptron
NBU	Non Built-Up
NTL	Night Time Light
OBIA	Object-Based Image Analysis
ROC	Receiver Operating Characteristic
RS	Remote Sensing

TOD	Transit-Oriented Development
TTA	Training and Test Area
WA	Water Body