SUMMARY OF DOCTORAL THESIS

Studies on Urban Growth in Conakry, Guinea, Using Geo-Spatial Data
（地理空間データを用いたギニア，コナクリの都市拡大に関する研究）

Arafan TRAORE

1. Background

The unprecedented transformation of natural landscapes into urban settings significantly affects the ecosystems functioning. Conakry, capital of Guinea, is believed to have experienced a rapid urban growth over the last recent years. This growth is essentially the result of high natural population increase, and migration from rural zones. More than half of the Guinea's urban population currently resides in Conakry, which has 15 times the population of Kankan, the second-largest city. Moreover, Conakry's rapid urbanization can also be attributed to the concentration of the economic, administrative and cultural activities. Nevertheless, urban development in this city has taken place with only little planning. The authorities in charge of urban planning and management have met increasing difficulties to plan for spatial expansion and to identify, coordinate and carry out the most critically needed investments in basic infrastructure and service, hence, Conakry has become critically overcrowded, exerting considerable pressure on basic urban services and resulting in drastic degradation of the environment.

Nevertheless, while rapid urbanization is expected to exacerbate these problems, experiences from the developed countries showed that urbanization has the potential to boost national economy and improve the quality of life and social well-being. But, this requires accurate, consistent, and timely geospatial information on urban growth patterns to assess current and future urban growth process. Geospatial information will be important for setting policies that promote inclusive and equitable urban, environmental, and socioeconomic development.

The current study was therefore designed to provide insights into the spatial and temporal land-use and land-cover (LULC) change, especially an urban growth in Conakry in 1986, 2000 and 2016 using a Geographic Information System(GIS) and a Remote Sensing (RS) technique; to investigate the relationship between urban growth with two categories of drivers: (socioeconomic and physical) using Logistic Regression Model (LRM); to predict future land-use and land-cover (LULC) change in Conakry by 2025 using the integrated Cellular Automata (CA) and Markov model and to discuss in detailed the urban growth pattern in each of the five communes of Conakry by analyzing nighttime light data of the Defense Meteorological Satellite Program's Operational Lines-Scan System (DMSP/OLS) in 1992, 2000, 2005 and 2013.

2. Methodology

The first objective was to classify Land-use and land-cover (LULC) change using three Landsat images, Thematic Mapper (TM) acquired on January 3, 1986, Enhanced Thematic Mapper Plus (ETM+) on December 19, 2000, and the Operational Land Imager (OLI) on January 20, 2016. The image classification was conducted using the maximum likelihood classification (MLC) scheme. Based on the spectral characteristics of each Landsat image, image quality enhancement and the existing information on different LULC types in Conakry, four LULC categories namely: (1) Urban, (2) Water, (3) Vegetation, and (4) Bare ground were respectively identified and classified for 1986, 2000 and 2016 respectively.

In the second objective, the Logistic regression model (LRM) was used to investigate the relationship between urban growth with two categories of urban growth drivers. LRM is one of the most popular empirical approaches to modeling, and can be used for explaining the relationship of several x_i explanatory variables to a dichotomous single dependent variable y, which represents the occurrence or non-occurrence of an event. The socioeconomic drivers considered in this study consist: distances to active economic center (DAEC), to the urbanized area (DUA), to major roads (DMR) and population density (PD), and physical drivers include Slope and Elevation. The use of the LRM can determine the coefficients of the explanatory variables (both continuous and categorical). The model gives the probability of urban growth and non-urban growth occurrence.

The third objective was to integrate Cellular Automata (CA) and Markov model to project future land-use and land-cover (LULC) change in Conakry by 2025, This was accomplished by analyzing a pair of LULC maps of 1986 and 2000 using Markov module in Idrisi software, which will then output a transition probability matrix, a transition areas matrix and a set of conditional probability images. The transition probability matrix records the probability that each LULC category will change to every other category. However, one inherent problem with the Markov model is that it provides no sense of geography. The transition probability may be accurate on a per category basis, but there is no knowledge of the spatial distribution of occurrences within each LULC category, in other word, there is no spatial component in the modeling outcome. The combination of Markov chain and Cellular Automata (CA-Markov) allows simulating the evolution of the geographical area represented by pixels. Each pixel can take a value from finite set of states. All pixels are affected by a transition function that takes an argument the measured values and values of the neighboring pixels as a function of time. In this study, the transition function was determined based on the difference between 2000 and 2016. CA-Markov then used this transition function to predict the urban growth for 2025. In order words, the transition probability matrix, created from the changes observed between 2000 and 2016, the transition probability maps of 2016 and each scenario were used to produce maps of the urban growth of 2025.

Finally, the nighttime light data from the Defense Meteorological Satellite Program(DMSP) were used to extract a nighttime light information in each of the five communes of Conakry by computing the Vegetation Adjusted Night Light (VANUI). The choice of this approach is because, it provides a relatively good technique in reducing the saturation and blooming effects and, it reflects the dynamics of urban population size, economic of scale, and urban expansion simultaneous.

3. Results

From the overall trends, the intense LULC occurred in Conakry over the period of study, was mainly characterized by a significant increase in urban area and a substantial decrease in vegetation and bare ground cover respectively. The area under vegetation decreased from 52% (217.48 km^2) in 1986 to 35% (147.32km^2) in 2016, with an annual decrease rate of 0.57% in the first period (1986-2000) and 0.50% in the second period (2000-2016) respectively. The area under bare ground area decreased from 27% (114.76 km^2) in 1986 to 9% (39.88km^2) in 2016, with an annual decrease rate of 0.35%, in the first period (1986-2000) and 0.81% in the second period (2000-2016). The area under urban has increased from15% (63.03 km^2) in 1986 to 49% (206.58 km^2) in 2016 with an annual increase rate of 1% in the first period (1986-2000) and 1.25% in the second period (2000-2016) respectively. The area under water showed a slight increase 5% (24.63 km^2) from 1986 to 6% (26.10 km^2) in 2016 due to seasonal variation and the geographical location of the study area, as a coastal city.

LRM has revealed that the variables of elevation, population density, distance to major roads, distance to existing urbanized areas and slope have resulted in the model with the best fit and high statistical significance, suggesting that these variables influence urban growth in Conakry. The LRM model was validated based on the Relative Operating Characteristic (ROC), method which showed a high agreement (0.89) between the simulated urban growth probability map and the actual one.

The integrated CA-Markov chain revealed that based on the current growth probabilities, urban area will continue to increase at the expense of vegetation and bare ground cover. The proportion of the urban area was 49% in 2016, and it is expected to increase to 52% by 2025, while vegetation will decrease from 35% in 2016 to 32% in 2025.

The Vegetation Adjusted Nighttime Urban Index (VANUI) indicator of urban growth showed increasing pattern in each commune of Conakry. However, there was a difference in the spatial and temporal VANUI distribution at the commune level. The urban core communes (Dixinn and Matam) showed rapid increase and large VANUI values (0.81-0.83). The active economic and administrative center, the Kaloum commune showed values (0.31-0.42), while the sub-urban communes (Ratoma and Matoto) exhibited values (0.09-0.27). This difference in VANUI is explained by the difference of the historical development of the city, which is strongly related to the topography (horizontal distance to the port).

4. Discussion

This study discussed that the rapid urban growth has been led by both rapid population growth and extreme poverty in rural areas, which have resulted in migration into Conakry. This study provides useful information on further urban development in Conakry. Given that urban growth has occurred mainly due to population growth and migration from rural areas, population 0,10n111.

growth in Conakry is expected to continue at an accelerated rate. Therefore, better management plans are needed not only for Conakry but also for the entire country. The results of this study will provide bases for assessing the sustainability and the management of the urban area and for taking actions to mitigate the degradation of the urban environment.