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Spatial determinants of urban land use change in Lagos, Nigeria

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Abstract

The objective of this research was to identify the factors responsible for residential and industrial/commercial land development in Lagos between 1984 and 2000. Land use changes were mapped using satellite images, while binary logistic regression was used to model the probability of observing urban development as a function of spatially explicit independent variables. Accessibility, spatial interaction effects and policy variables were the major determinants of land use change. Variables that influenced residential development were not necessarily those responsible for the expansion of industrial/commercial land areas. The evidence of frontier residential development calls for land tenure and housing development reforms, and land use controls to minimize the environmental consequences of unplanned urban expansion.

Keywords: Urbanization; Land use change; Africa; Nigeria

Introduction

There has been a renewed focus on the study of urban systems in the last few years, as urbanization remains a major development challenge exerting awesome pressure on social, economic and environmental sustainability (Pickett et al., 2001). The world's urban population experienced a 15-fold increase from 200 million in 1900 to about 2.9 billion in 2000, and is estimated to increase to about 5 billion by 2030 (United Nations, 2002). In developing countries, urbanization is associated with natural population growth, rural–urban migration, convergence in rural and urban lifestyles, and the economic and political processes associated with globalization (Cohen, 2004).

Though urban areas currently account for about 3% of the Earth's surface, the ecological footprint associated with urban expansion has important environmental consequences. Urbanization often occurs on agricultural land and forests, and is generally accompanied by an increase in energy use, and air, water and noise pollution. The increase in impervious surface associated with urban land conversion also leads to a decrease in infiltration and an increase in surface runoff, sedimentation, and eutrophication of wetlands. Uncontrolled urban expansion also leads to the fragmentation of landscapes, destruction of wildlife habitat, and reduction in biodiversity. These impacts make an understanding of the factors driving urban expansion essential to global environmental change research.

Africa's urban transition is partially accompanied by economic growth derived mainly from non-agricultural value-added (Kessides, 2005). However, the growth is largely un-sustained, and far below the level required to significantly reduce poverty levels. As the urban areas sprawl at their peripheries and the core areas break down with the burden from increasing demand for social services by the population, they consequently become homes of the poor, and the sites and sources of environmental pollution. This phenomenon makes the study of urbanization patterns more crucial in the development agenda of African countries.

Nowhere in West Africa is the rate of urbanization in the last few years as unprecedented as Lagos City-State, the

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economic focal point of Nigeria. Lagos occupies a unique position in the economic processes of the West African sub-region for several reasons. As the economic and financial nerve-center, it accounts for over 70% of Nigeria's industrial and commercial establishments that account for up to 70% of the country's manufacturing value-added. It has extensive infrastructural facilities—the busiest international airport, seaport, and the most extensive road and telecommunication networks in Nigeria. It is also the host to the most active Stock Exchange in West Africa.

These same reasons have made the conurbation of Lagos the hub of intense settlement, and the prime destination of local and international migrants. The remarkable population growth translates to ever increasing pressure on land for housing and business premises with profound environmental implications.

Despite its economic importance, the environmental sustainability of Lagos has not received the kind of attention it requires in development research. Inadequate housing leading to the emergence of slums, spatial inequity in access to land and infrastructure, haphazard land development, infrastructure decay, incessant flooding, widespread poverty and unemployment are some of the symptoms of unsustainable expansion of the city requiring the intervention of land use planners and managers. In order to prevent grave urban crises, ensure future livability of the city, and minimize environmental impacts, land use planners require information about the location, spatial extent, rate and driving factors of urban expansion.

This study uses spatial, statistical models to investigate the factors associated with urban land use change between 1984 and 2000, the period Lagos experienced the most rapid population growth and economic transformation. Spatial models of land use change are important to identify the variables explaining land use change, the rate at which land use change occurs and the locations affected by change. Thus, they are useful tools for land use planning and the development of land-related policies. We used Landsat Thematic Mapper images to detect land cover changes. We also generated a set of spatially explicit variables and modeled urban land use changes as a function of these variables using logistic regression. Research and policy implications of the findings are thereafter highlighted.

Background

Land-use pattern (that is, the spatial configuration of land-use) is a reflection of the decisions made by different land users/managers. Many processes that influence land-use change interact at different levels of organization, and in a highly dynamic manner to produce complex patterns. Models of land use change can either be prescriptive or descriptive in scope. Prescriptive models aim at the determination of the optimum land-use patterns that satisfy a set of goals and objectives, whereas descriptive models aim at the simulation of current and near-future land-use patterns. In line with the aims of this study, attention is focused on descriptive models of land use change.

Several predictive modeling techniques have been used to model urbanization. One such technique is the monocentric model based on the land rent theory of von Thunen and Ricardo. In its original form, the model describes the spatial pattern of land use relative to a central business district to which residents commute. Other landscape features are not considered as determinants of land use pattern. The model has however been improved by incorporating other variables (e.g. infrastructure) in analyzing land use patterns. A major limitation of the monocentric model is that it is a static representation of an equilibrium land use pattern for either a fixed population or a utility level (Irwin and Geoghegan, 2001). Furthermore, the primary assumption of the model that land use decisions are based on utility-maximization tendency does not always apply to all categories of land developers. Some researchers therefore suggest the need to consider other factors such as cultural values, preferences and income, site characteristics such as housing prices, tenure conditions, access to public supplied infrastructure, and historical events due to the path-dependency of choices (Geoghegan et al., 2001).

Another urbanization modeling technique is the Cellular Automata (CA) approach (e.g. White and Engelen, 2000), in which the behavior of the land use system is determined by a set of analyst-imposed deterministic or probabilistic rules. CA approaches are particularly useful in assessing spatial interaction effects on land use. Spatial interaction connotes that urban land use development in a particular location depends on the neighborhood characteristics of that location. For instance, certain factors (e.g. economies of scale) can lead to the concentration of industries in a particular area. Furthermore, CA could be used to evaluate the effects of spatial policy on urban land use, but it often requires large amounts of data for calibration. Besides, the "growth rules" imposed by the analyst, rather than the actual driving factors of change, govern land-use transitions and model outcomes. This may therefore lead to the wrong policy conclusions.

Another modeling approach is spatial, statistical model of land use change. It consists of three components: multitemporal land-cover maps, a multivariate function of the hypothesized driving factors of change, and the resulting prediction map of land-cover change (Lambin, 1994). Changes in land cover are classified from remotely sensed data, and their spatial occurrence is correlated with location attributes using multivariate statistics. We used this method in this study first, because it allows the inclusion of several variables in modeling urban land use change. This is plausible, as land users generally respond to a wide range of biophysical, socioeconomic and institutional factors. Second, spatial, statistical models help to identify the set of variables that explain land use change