



The pitfalls of regional delineations in land use modeling: Implications for Mumbai region and its planners



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ABSTRACT

In this article we use the SLEUTH model and publicly available datasets to develop a stylized planning application for Mumbai, India. We use two sets of model specifications that reflect the two regional extents at which Mumbai region is planned: (1) the jurisdiction of the Municipal Corporation of Greater Mumbai (MCGM), which is responsible for the central city and surrounding suburbs, and (2) the planning area of Mumbai Metropolitan Regional Development Authority (MMRDA), which is a loose collection of a much larger set of municipalities and districts. Using these, we illustrate how urban models can be limiting as a predictive tool but useful as an assessment mechanism, especially when additional considerations of scale and institutional roles are applied. We compare the outcomes for the overlapping geographic area between the two planning agencies and find considerable variations in the location and amount of growth and discuss why and how the differences in the spatial extents affect the model results. Through a discussion on the implications for modelers and planners, especially in light of the ongoing initiatives in India, we highlight the value of consideration of multiple model outcomes and highlight the importance of coordination of planning efforts taking place in spatially overlapping or nested jurisdictions.

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Introduction

While urban modeling is increasingly common in developing countries to understand the processes of growth and change (Wilson & Chakraborty, 2013), its influence on policy analysis and decision-making has been limited. This disconnect can be attributed to a lack of reliable information (Barredo & Demicheli, 2003), an inability of modelers to communicate the functioning of models to decision makers, and an overemphasis on improving the predictive abilities of the models at the expense of its analytical potential (Couclelis, 2005; Waddell, 2011). This paper employs a land use modeling framework and harnesses publicly available data sources to present a stylized planning application for Mumbai, India. Using two spatial extents that reflect the actual regional jurisdictions of two different but overlapping planning agencies, we illustrate how urban models can be limiting as a predictive tool but useful as an assessment mechanism, especially

when additional considerations of scale and institutional roles are applied.

Land use and land cover (LULC) models capture the relationship between components of the built environment such as land use, topography, infrastructure, and urban extents, and project the outcomes of these relationships into the future. These qualities make land use models useful for decisions makers and planners in anticipating future challenges, particularly the consequences of present day decisions and impact of uncertainties. Prior research indicates that the availability of information derived from computer analyses and simulations contributes to higher rates of communication and interaction between participants in the planning process (Appleton & Lovett, 2005; Shiffer, 1992) and models of LULC change are particularly promising in the social sciences, and in urban planning in particular, as a way to test theory and evaluate the likely effects of proposed policies and interventions.

But the models are tools and their value depends as much on the validity of the modeled relationships as they do on a number of other factors such as data quality, purpose, assumptions, and the parameters specified by the modeler. Another factor can be the spatial extent of the study area modeled, which is of particular importance in metropolitan regions where there are often multiple agencies operating at different scales with overlapping responsibilities. Modeling efforts undertaken by one agency at

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one scale can lead to a different outcome compared to modeling by another agency at a different scale, frustrating attempts to coordinate and synchronize decisions. It is, therefore, important that the impact of these 'external' and typically ignored parameters be understood and made useful for the planning process.

In this paper, we demonstrate how the regional extent used in forecasting urban growth and land use can play a critical role in determining the types of development and underlying processes that can be captured in a model and that ultimately shape the results. This research also underscores the importance of coordinating planning efforts in spatially overlapping or nested jurisdictions. Using the SLEUTH model (Clarke, Hoppen, & Gaydos, 1997), we forecast the extent of urban growth for the jurisdictional areas of (1) the Municipal Commission of Greater Mumbai (MCGM), which is responsible for the central city and surrounding suburbs, and (2) the Mumbai Metropolitan Regional Development Authority (MMRDA), which is a loose collection of a much larger set of municipalities and districts. We then compare the outcomes for the *common area* between these two regional delineations and discuss how differences in the spatial extent administered by the two lead planning agencies in the region might affect planning efforts, in addition to reflecting on the technical aspects and performance of SLEUTH at differing scales.

For modelers, our analysis shows that in addition to spatial resolution (Jantz & Goetz, 2005), neighborhood definition (Menard and Marceau, 2005), and temporal resolution (Liu & Andersson, 2004), the spatial extent of the study area matters a great deal when forecasting land use change. While the Modifiable Areal Unit Problem (MAUP) is well-studied (Dark & Bram, 2007; Openshaw, 1984) and its effects are widely known (Bailey & Gatrell, 1995; Fotheringham & Wong, 1991), the ways in which spatial extents and other input parameters (Syphard, Clarke, Franklin, Regan, & McGinnis, 2011; Menard and Griffith, 1983; Marceau, 2005) impact land use modeling are less understood.

For planners, our analysis suggests that if close coordination among organizations actively engaged in planning for a given region itself cannot be achieved, then one of the roles that planners must adopt is to maintain an awareness of how geographic scale and the spatial extent at which plans are being made by others can impact their own work (Hopkins, 2001; Hopkins, Kaza, & Pallathucherial, 2005).

Planning context

Mumbai is the largest urban agglomeration in India and one of the largest in the world (United Nations, 2013). The Mumbai Metropolitan Region (MMR) is home to 18.41 million people living in 4355 km² as of 2011 (Census of India, 2011a). The MMR encompasses 995 villages, 7 non-municipal urban centers, 15 municipal towns, and 8 municipal corporations including Greater Mumbai. In 2011 Greater Mumbai had a population of 12.47 million and a land area of 438 km² (Census of India, 2011b). There exist a number of planning agencies in the region, of which two are of particular significance: the Municipal Commission of Greater Mumbai (MCGM) which is responsible for the central city and surrounding suburbs and the Mumbai Metropolitan Regional Development Authority (MMRDA) which as noted above, is a loose collection of a much larger set of municipalities and districts. The jurisdiction of the each of these planning agencies is depicted in Fig. 1.

Significant planning efforts are ongoing in the Mumbai region and since 2011 the Municipal Corporation of Greater Mumbai (MCGM) has been updating its development plan with a 20-year horizon and an intended completion date of 2015. The last plan update was prepared in 1981 and formally adopted over a decade later in 1994. The existing conditions report of the forthcoming

plan highlights the severity of many challenges including traffic congestion, housing affordability, environmental protection, and vulnerability to natural hazards. Major changes expected from this process include a near doubling of the citywide allowable floor area ratios (FAR), a new inclusionary housing program and more environmentally sound management of coastal resources. MMRDA has its own planning process that has a significant overlap in substantive and geographic coverage with MCGM's plan. Its Second Regional Plan for 1996–2011 sought to create "...a polynucleated structure through development of Growth Centres" (Regional Plan, 1996) and a Third Regional Plan for 2014–2034 is under development.

These policy initiatives and planning activities are occurring alongside larger shifts in governance and regulatory frameworks (Nandi & Gamkhar, 2013; Phadke, 2014). Institutional reform efforts in India starting with the 74th Constitutional Amendment Act of 1992 have promoted devolution of state powers – including planning authority – to urban local bodies. In the last decade, a number of central government funding programs such as Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and its close associate National Urban Transport Policy have added requirements for municipalities to make and update City Development Plans (CDPs) and for regional planning agencies to develop Detailed Project Reports, especially for large-scale infrastructure investments. These changes are expected to bring broader and better technical analyses to planning and decision-making. Furthermore, new administrative bodies such as the Unified Metropolitan Transportation Authority (UMTA) are being envisioned in some urban regions of India – including Mumbai – that will coordinate cross-jurisdictional planning efforts with technical assistance from regional agencies like the MMRDA. Many ideas for such assistance abound, such as the 2011 Ahluwalia Committee's Report on Indian Urban Infrastructure and Services, which recommends that municipalities should estimate demands in different sectors using econometric forecasting methods and use these to make planning decisions.

The above discussion suggests a growing need for analytical tools to inform planning in developing countries, and particularly in the largest and most rapidly growing cities. The sheer magnitude and rate of urban growth in places like Mumbai compresses the time horizon of planning processes and demands a broader regional perspective. Metropolitan scale land use models tailored to the needs of cities like Mumbai will be able to decompose the growth projections in a region, allocate it in a spatially explicit manner at more local scales, and estimate its implications for land demand, traffic conditions and coastal resources. While many complex, quantitative urban models have been used for research purposes in the developing country contexts (see, for example, Mir, Rao, and Hunt (2010)), their incorporation into planning processes is less common (Couclelis, 2005; Waddell, 2011). Building models that are more capable to capturing urban development processes (Rafiee, Mahiny, Khorasani, Darvishsefat, & Danekar, 2009) as well as impact of policies (Munshi, Zuidgeest, Brussel, & van Maarseveen, 2014) can help facilitate decision-making.

Land use models and plan making

Land use models have been used in urban planning for some time (Harris, 1985; Hunt, Kriger, & Miller, 2005; Lee, 1973; Wegener, 1994), both as a stand-alone tool and as part of a broader toolbox for planning support. Consequently, considerable effort has gone toward improving the models as well as the planning support systems that use them. These efforts can be organized into research that is focused on exposing a model's limitations and improving its predictive ability (Chaudhuri & Clarke, 2014),

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