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Review

The emergence of slums: A contemporary view on simulation models☆

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ABSTRACT

The existence of slums or informal settlements is common to most cities of developing countries. Its role as single housing delivery mechanism has seriously challenged the popular notion held by policy makers, planners and architects. Today informality is a paradigm of city making and economic growth in Africa, Asia and Latin America. This paper discusses the role of computer simulation models to understand the emergence and growth of slums in developing countries. We have identified the key factors influencing the growth of slums and formulated a standardized set of criteria for evaluating slum models. The review of existing computer simulation models designed to understand slum formation and expansion enabled us to define model requirements and to identify new research questions with respect to exploring the dynamics of slums.

1. Introduction

Today, over half of the world's population lives in urban areas and by the middle of this century 7 out of 10 people will live in a city. This increased urbanization has also lead to more and more people residing in informal settlements generally known as slums. In India, for instance, roughly 13.7 million households, or 17.4% of urban Indian households, are considered to live in slums. In India alone this equates to over 200 million people. Over a third of India's slum population lives in 46 million-plus cities (Census Of India, 2011). Likewise, many other countries around the world offer similar statistics and in fact the world's most notorious slums span multiple continents: Neza-Chalco-Itza (Mexico), Orangi Town (Pakistan), Dharavi (India), Khayelitsha (South Africa), and Kibera (Kenya). The emergence of slums, and growing number of people living in slums, is now a very significant and intricate global challenge for our society (UN-HABITAT, 2011a; Patel et al., 2012). While there are many different definitions and classification criteria of what constitutes a slum (Richter et al., 2011), for residents the reality is often inadequate shelter, poor access to basic services such as water and sanitation, insufficient access to healthcare and in general a low quality of life. Slums are the byproduct of social and economic impact due to rapid urbanization. Many nations including developed and developing countries together are formulating and organizing strategies to eradicate this problem. For example, in 2011 the United States introduced a bill to increase aid for "Shelter, Land and Urban Management (SLUM)" in developing countries, while the eight Millennium Development Goals (MDG) aimed to improve the lives of slum dwellers by 2015 (UNDP, 2000). Policy intervention in slums is one of the key mechanisms adopted by various governments to enhance the quality of life of the urban poor. Slum policies have evolved and urban authorities have adopted different strategies, ranging from *in-situ* development in

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slums, relocation to the resettlement colonies, and to slum evictions. These strategies can be categorized in following order: "Laissez-Faire" in the 1950s (Bourgin, 1990), "Site and Service" in the 1970s (Linden, 1986; Pugh, 2001), "Slum Upgrading" in the 1980s (Banes et al., 2000), "Tenure and Enabling Approach" in the 1990s (Thahane, 1993) and "Slum-free cities" in 2000s (WorldBank, 2013). Several indigenous policies were also implemented across the world, for example "Slum Redevelopment Scheme" in Mumbai, India (Mukhija, 2001; Patel et al., 2012), or "Rio Favela Development" in Rio, Brazil. These policies were reviewed and found to be inefficient (Mehta et al., 2008; UN-HABITAT, 2011b). The reality, however, shows that the slum policies have been either *incremental* or *experimental* (Patel et al., 2012; Kundu, 2013). Incremental policy-making looks at existing programs or policies and uses the "Goodness of fit" criteria to implement change. They rely on past outcomes as a guide and are best suited to situations where there is high degree of continuity in the problem, which reduces the risks and costs of uncertainty. Experimental policy-making pertains to policies implemented without any substantial prior research. They are exploratory and are usually designed as part of government-sponsored pilot programs targeted at preselected groups. Both incremental and experimental policies have often been implemented without knowing their negative implications. There are numerous *ex-post* analyses of slum policies (Viratkapan and Perera, 2006; Takeuchi et al., 2008, e.g.) but very few attempts have been made to understand the impact of policies *ex-ante*. In India, a massive housing program for slum dwellers has been launched, called Rajiv Awas Yojana or RAY (Government of India, 2010). RAY aims to provide basic amenities such as water system, waste disposal, internal and access roads, street lamps and various social infrastructure facilities in slums adopting a 'whole city' approach. Under the mandate of the National Resources Centre in New Delhi, surveys are currently being carried out to understand the differences in slum typologies and how slums can be classified based on their deficiencies and access to resources. A key challenge for policy makers in implementing RAY is to understand the slum typology and underlying driving forces as there is unlikely a 'one-size fits all' solution to the problem. Slums, themselves are complex dynamic systems that have close symbiotic relationships with their encompassing cities. In order to identify the intricate consequences of particular policies, governments must consider a multitude of factors, and most importantly understand how these factors interact. The relationship between a slum and its parent city can be *commensalistic* or *parasitic*. Specifically, in some cases, the economic and political power of slums is so significant that cities need to maintain them. Hence, slums can be compared to a parasitic organism, thriving at the expense of the city and draining key urban resources. It grows and subdivides within itself much like an organism would when provided with restrictions. However, another view is that slum could also be commensalistic in nature as each slum in a city serves a specific function and provides cheap labor for the development of urban infrastructure. The traditional view of slums, certainly from a policy and research perspective, is that these were "controlled" systems, maintained in an equilibrium state by negative feedbacks. The new, complexity view, considers slums as dynamic, non-equilibrium systems that are constantly changing and adapting. It is clear that slums have emerged spontaneously from the interactions of the component parts (spatial components of shelter deprivation and the dynamics of slum development), not dictated in a top-down manner. Viewing and analysing slums as complex systems should therefore lead to new perspectives on what is an increasingly challenging problem.

Modeling and simulation is one useful way to understand complex slum dynamics, and knowledge derived through such tools could assist planners and policy makers in decision-making processes. The paradigm shift to a bottom-up modeling approach captures the interaction and processes at a finer scale. Agent based Modeling and Simulation (ABMS) has proved useful in representing the processes underlying a particular phenomenon. The advantage of an agent based model (ABM) lies in its capacity to simulate individual behavior and their interactions with their environment and other individuals (Kelly et al., 2013). Geographical Information Systems (GIS) can be used to spatially represent the pattern of the phenomenon, and identify the key spatial structures which influence the micro-scale behavior and interactions. The integration of simulation models with a GIS environment has been successfully implemented in various studies to represent spatially explicit environments in ABMS (Gimblett, 2002; Goodchild, 2003). Thus, ABMS of slum dynamics coupled with the spatial representation of the geographical region would provide a promising tool to model the emergence and growth of slums as well as the processes and patterns within slums.

The contribution of this paper to slum research is four-fold. First, this paper proposes a set of universal factors which determine the emergence and growth of slums. Second, based on these factors, we define an evaluation framework for computer simulation models designed to study slum dynamics. Third, we apply this evaluation framework to existing literature and review the existing simulation models focusing on slum formation and growth. However, we exclude general urban models from our review as the evaluation criteria we propose are designed specifically for slums and may not be applicable to general urban models. Sietchiping presents a valuable review of various urban dynamics model (Sietchiping, 2004). Finally, this paper identifies key open research questions in the context of slum modeling. The remainder of this paper is organized as follows. The characterization of slums and its impact on human wellbeing is explained in Section 2. The factors influencing the emergence and growth of slums are discussed in Section 3. Literature review of existing slum models is presented in Section 4. Finally, in Section 5, this paper concludes with a summary of the current state-of-art in modeling of slum dynamics and a way forward. This paper is part of a larger research project with a focus on India, and lot of statistics used in this paper have been collected from Asia. However the facts derived out of these statistics may be still applicable to other developing countries across the world.

2. Characterization and impact of slums

In this section we provide a short characterization of slums and identify the key impacts of slums on human wellbeing, particularly on slum dwellers and the poor. As mentioned in Section 1, there are numerous slum definitions and classification criteria. In our study we rely on the more general definition of UN-Habitat which defines a slum household as a group of individuals living under the same roof in an urban area, who lack one or more of the following conditions: (a) security of tenure; (b) structural quality; (c) durability of dwellings; (d) access to safe water; (e) access to sanitation facilities; and (f) sufficient living area[1]. Slums are heterogeneous and each slum in a city suffers from varying degrees of depravity. The degree of deprivation depends on how many of the conditions that define slums are prevalent within a slum household. A UN-HABITAT analysis shows that in Sub-Saharan Africa over 80% of the slum households have one or two shelter deprivations, but almost half suffer from at least two shelter deprivations (UN-HABITAT, 2006). From gender inequality to all aspects of health and quality of life, living in a slum significantly impacts upon many lives. Most of the

[1] Which means not more than three people sharing the same room: UN-HABITAT.