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Modelling the impact of household life cycle on slums in Bangalore

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ABSTRACT

According to the United Nations Human Settlements Program (UNHSP), the number of slum households in developing countries continues to grow by a higher proportion as compared to its encompassing city. Traditionally, policy makers have concentrated on population control strategies by focussing on birth rates and rural–urban migration to stem the growth and emergence of slums. However, these strategies have often failed to achieve the desired results. In the present paper we find the key underlying processes that explains the observed differences in household life cycle between slum and non-slum households. We find that the slum households when compared to nonslum urban households, exhibit a large variation in the household size over the course of their life cycle, which in turn leads to inefficiency while building slum resettlement colonies. We have developed an agent based model, namely *DynaSlum*, to identify the key social determinants that impact the behaviour of a slum household. We use a novel and unique dataset based on the field work from 37 slums in Bangalore combined with the NFHS data to calibrate *DynaSlum* and validate our findings. This paper presents two major insights to address the challenges. First, we find that high rate of home leaving among young adults is the key determinants for the large variation in the life cycle of slum households. Second, we show that reducing home leaving among young adults will reduce the formation number of new slum households and contribute to a higher but stable household size. This will lead to efficiency and higher per capita resource consumption when building capacity for slum development (resettlement colonies) as policy makers would be able to plan for a stable household size.

1. Introduction

Today, approximately a third of the urban population in developing countries are living in slums (UN-HABITAT, 2010). Although slums differ in size and other characteristics from city to city, most slums are characterised by organic growth because of high rate of rural–urban migration, high population density and low birth control measures. It is unclear whether there are context specific solutions to the problem of slums given their extraordinary organic growth rates and the lack of political will to implement effective policies (Greater Pacific Capital, 2013; Nijman, 2015). In India, 14 million households live in slum settlements and addressing slums requires a rethink of the design and governance of cities and a deeper understanding of the household dynamics of slum dwellers (Roy, Lees, Palavalli, Pfeffer, & Sloot, 2014; UN-HABITAT, 2010). Amitabh Kundu argued that 'the vision of slum-free Indian cities is hindered by poor urban planning and the failure to make adequate land and capital provisions for affordable housing' (Kundu, 2007, November). There are numerous ex-post analyses of slum policies; however, very few attempts have been made to understand the impact of policies ex-ante (A. Patel, Crooks, & Koizumi, 2012; Roy et al., 2014). The challenge is to provide context-specific information to enable effective policy interventions. To design low-cost housing strategies, the policy makers and the urban planners need to have an understanding of how slum households make residential choices. In general, one of the most important factors accounting for relocation, has been a fundamental change in household composition and size. Individual life events such as marriage (and divorce), births and deaths, transition to adulthood and home leaving of adults may initiate a household's decision to relocate depending on the level of dissatisfaction from its current housing (Montgomery & Curtis, 2006). The analysis of household life cycle (HLC) attempts to describe the effect of time on the household size through individual life events and also helps to understand the behaviour of individuals

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in context, which enables more effective interventions (Bearden & Wilder, 2007; Malan, 206; Wilkes, 1995). However, the HLC may vary across different sections of the society. It is therefore important to understand how the HLC of slum households evolves as compared to that of non-slum households, as it will help explain at what stage of the HLC new households emerge from existing ones (or when they do not) and this in turn will indicate when new slums may emerge.

In the case of slums, the age structure, religion, language and composition of a household play an important role in building a social network that may influence how slum dwellers settle in various slums in a city (Carpenter, Daniere, & Takahashi, 2004; McCarthy, 1976). Therefore, understanding the various social determinants that impact the behaviour of slum dwellers, and how they might influence slum households, can help us understand the demographic processes and patterns of slum settlements and forecast how these settlements will change over time. In turn, these insights may lead to effective low-cost housing strategies. Individual life events such as marriage (and divorce), births and deaths, transition to adulthood and home leaving of adults may initiate a household's decision to relocate depending on the level of dissatisfaction from its current housing (Montgomery & Curtis, 2006). In the case of relocation of an entire slum, the collective movement involves households in different stages of their respective life cycles. Apart from the emerging household dynamics developing from discrete lifecycle events, the traditional composition of slum households has experienced dramatic changes over the past decade because of increased urbanisation, improving health care, and changing social values (Kirk, 1996; Murphy, 2011). The impact of such changes on the behaviour of slum dwellers is not yet well understood. A recent survey of existing slum growth models showed that the impact of change in household structure and composition is not included in the analysis of slum dynamics (Roy et al., 2014). Therefore, the key objective of the present paper is to understand why slum households are different from non-slum urban households and identify the key factors that drive this difference.

To answer the above question, we adopt a computational approach to develop an agent-based model ABM, namely *DynaSlum*, which can also be used by policy makers for various *What-If* scenarios. One common assumption included in most of the existing population models (Ball & Neal, 2002a; Becker, Glass, Li, & Aldis, 2005) is that the structure and composition of a household do not change over time. Many population dynamics models have been developed and applied to different research domains (infectious disease and transportation) in the context of developed countries; however, these models may not be suitable for analysing slum settlements in developing countries because they do not include the key cultural factors such as religion, language, origin and social beliefs (see Section 2). Hence, it is important to capture the changing patterns of slum settlements as a result of the complex, multi-dimensional relationships that emanate from the HLC (Rindfuss, Walsh, Turner, Fox, & Mishra, 2004). *DynaSlum* was designed to generate a synthetic population of slums and to describe household structure and composition in slums by including individual life events (see Section 3). We chose Bangalore, India as our case study as it has experienced considerable urbanisation and immigration of young adults from other parts of the country to engage in off-farm employment. We used survey and census data from the city of Bangalore, India, to validate the demographic characteristics of *DynaSlum*. Bangalore has 21.5% of the total slum population in the state of Karnataka, and every fifth person within the Bruhat Bangalore Mahanagara Palike (BBMP) limits lives in a slum. The population living in urban slums in Bangalore has doubled in a decade, and this poses a serious challenge to urban planners and policy makers. The present case study is representative of a society in a developing country characterised by multiple religions and languages.

The remainder of this paper is organised as follows. The literature review of existing population models is presented in Section 2. The design of *DynaSlum*, execution steps and calibration of the model are discussed in Section 3. The validation of *DynaSlum* and the sensitivity analysis with respect to HLC are discussed in Section 4. In Section 5, we present the key findings of *DynaSlum* and the difference in HLC between a slum and a non-slum household. Finally, the paper concludes with a discussion on the findings and their implication.

2. Related work

In the past, different methodologies have been developed for creating synthetic populations from the historical data in the field of healthcare, demography and social science. Understanding the impact of HLC on settlement choices is crucial for forecasting emerging land use. Individuals or households as a social entity and migration as a driver of population change have been central to population studies (Fox, 2003; Liu, Daily, Ehrlich, & Luck, 2003; Ranade, 1990). Research articles on ecology and geography that have addressed the impacts of population on land use change and planning are available in literature (Allen & Barnes, 1985; Skole, Chomentowski, Salas, & Nobre, 1994; Turner, Geoghegan, & Foster, 2004). However, some approaches in ecology are not based on accurate data and are forced to make strong assumptions about human behaviour. Furthermore, while there are various approaches for population modelling and forecasting in demography (Spielauer, 2011; Stillwell & Clarke, 2011), studies on the impacts on land change and planning are scarce in this discipline (Pebley, 1998). In the past, various HLC models (Gilly & Enis, 1982; Lpez-Ospina, Martnez, & Corts, 2016) have been developed in the field of consumer behaviour based on the age of the children and the marital status of adult members of a household. Gilly and Enis argued that earlier models had an overly inflated other category and do not incorporate a number of non-traditional household structures such as 'childless households, remarriage, middle-aged and older bachelors, never married or widowed single parents, and mature nest families' (Gilly & Enis, 1982). Previous reviews of the above HLC models showed that the models are not appropriate in dealing with non-traditional households (Rooyen & Plessis, 2003).

Mathematical models have also been used to study demography by dividing population according to age or gender (Ball, Mollison, & Scalia-Tomba, 1997; Ball & Neal, 2002b, 2008; Becker et al., 2005; Glass, McCaw, & McVernon, 2011). These models have also been proposed to incorporate household structure based on empirical distributions for household size. However, the household size distribution is static and these models do not show emerging household compositions. Another methodology using modelling and simulation was used to study the impact of population dynamics on land use; however, the role of micro level processes was not included. The state of population research has changed as more researchers are now actively involved in analysing population at the micro level using tools such as ABM (Ettema, Jong, Timmermans, & Bakema, 2007; Ferguson & Cummings, 2005; Geard, McCaw, Dorin, Korb, & McVernon, 2013). Many micro-simulation models have also been developed for predicting future population growth from past settlement patterns (Murphy, 2011). These models have adopted empirical methodologies to capture household composition. The initial population is generated using the Monte Carlo method; and thereafter the birth and death rates are calculated based on empirical data. The childbirths are assigned to households to fit the observed household size distributions. The household composition does not evolve over time and these models do not capture the impact of religion, language and origin. Despite the importance of population in slum settlements and land use change (Holdren & Ehrlich, 1974), population and household dynamics have not been central in slum