move by actively seek women for job opportunities and creating a working environment where women will stay and be treated with respect.

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Modeling the Dynamics of Housing and Population Growth in Kampala City

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ABSTRACT
Kampala city is experiencing rapid population growth of 5.61% per annum largely due to rural-urban migration and high fertility rates. The city's resident population increased from 774,221 in 1991 to 1,208,544 in 2002 and to 1,600,000 in 2008. Meanwhile, records by Uganda Bureau of Statistics show that by 2008, Kampala had about 274,000 housing units with a housing deficit of 100,000 dwellings. This large deficit in the housing sector resulted from continued growth of the city's population without matching housing facilities. The aim of this study was to develop a computer model to forecast the city's population and housing needs in the medium term period of 27 years (i.e. 2008-2035). The model was developed using system dynamics methodology and validated using historical population and housing data. The results of the study show that by 2035, the city's population will be 5,284,664 and the housing stock will be 700,858units resulting into a deficit of 148,081 housing units. This paper recommends policies that preserve the life-cycle of houses and therefore increase the housing stock, and those that control rural-urban migration rates especially through developing regional mini-cities, as a step towards containing the housing crisis in Kampala city.

Keywords: housing, modelling, population growth, system dynamics.

1. 0 INTRODUCTION

The 2002 Population and Housing Census in Uganda was the most comprehensive census ever conducted in Uganda (UBOS, 2007). This census put the Ugandan population at 24.2 million in that year. The total fertility rate (the number of children, given the current age-specific birth-rates, women will have in their life time) stood at 6.9 much higher than in the neighbouring countries e.g. Kenya at 4.7 and Tanzania at 5.6 (Klasen and Lawson, 2007). Largely as a result of the high fertility rate, the population growth rate in Uganda was 3.6% per year on average making Uganda a country with the fourth highest population growth rate in the world following closely to Liberia:3.7%, United Arab Emirates:3.8% and Maldives:5.6% (CIA World Fact Book, 2008).

Meanwhile, the population of Kampala city like that of other urban centres in the country has been increasing rapidly over the past 20years. This has mainly been due to high fertility, decline in mortality and migrations (Nyakana *et al*., 2007). The city's population has more than doubled in the past 15 years raising from 774,241 in 1991 to 1,479,741 in 2006 (see Table 1 below) with a population density of 51people per hectare.

Table 1: Population Dynamics in Kampala City

	1969	1980	1991	2002	2006	2010
City population	330,700	458,503	774,241	1,208,544	1,479,741	1,811,794
Growth rate	-	3.2%	4.76%	5.61%	5.6%	5.6%
National urban population	747,400	938,503	1,889,622	2,921,981	5,000,000	7,500,000
Kampala as % of National Urban Population	44.2%	48.9%	41%	41.4%	29.6%	24.2%
National population	9,535,051	12,636,179	16,671,705	24,200,000	27,400,000	32,900,000
Kampala as % of national population	3.5%	3.6%	4.6%	4.9%	5.4%	5.5%

Source: National Population Census Reports 1969-2002 and Projections

The continued growth of Kampala's population has resulted in a large expanse of the housing sector over the past 20years. By 2008, the city had about 274,000 housing units mostly obtained from the informal sector (Giddings, 2009). However, the construction of new housing has lagged significantly behind population growth and it is estimated that by 2008 there was a housing deficit of 100,000 units in Kampala city (ibid). With a standard occupancy of 4.8 persons per housing unit, close to half a million people are not housed adequately in Kampala. Evidence on ground suggests that this housing deficit is bound to increase in the coming years unless appropriate interventions are designed by the government and the private sector to control the situation. To this effect, this study was undertaken to develop a computer model to forecast the city's population and housing needs in the medium term period of 27 years (i.e. 2008-2035), and to propose appropriate strategies to contain the housing crisis in Kampala city.

2.0 METHODOLOGY

This study was undertaken through secondary data collection and computer modelling. The secondary data consisting of population statistics and housing data was obtained from census reports by the Uganda Bureau of Statistics, and from selected research papers. Meanwhile, the computer model was developed using system dynamics methodology in Stella 8.1.1 software environment and validated using historical population and housing data. The process of model formulation and validation is illustrated below.

2.1 Model Formulation

The developed model consists of two subsystems: the housing subsystem and the population subsystem (see Figures 1-2 below). It is made up of four stocks: the infant population, child population and adult population which define the population subsystem; and the housing stock which defines the housing subsystem. The infant population is increased by birth rate and decreased by infant mortality rate. The infant population matures into the child population at the age of 1 year and the child population matures into the adult population at the age of 18years. In addition to maturity of child population, the mature population is increased through migration (based on the assumption that most migrants are adults) and decimated by death rate resulting from natural causes and other incidences including accidents. On the other hand, the housing stock is increased through market driven housing investment by real estate developers and also based on improved per capita income which stimulates personal investment in housing development. The stock of housing in the city is decimated by demolitions resulting from old age and through demolitions by law enforcement agents.

By studying the structure of the model, it is evident that an increase in the adult population results into an increase in adult females leading to an increase in the birth rate. The high

fertility rate of 6.9 also significantly contributes to the growth of the child population. The above trend of events lead to a rapid growth of the city population which imposes pressure on the limited housing facilities. On a positive note, this expanded housing market has led to a proliferation of real estate developers over the past 15years including major players such as Akright Projects, Jomayi Estates Ltd and Canaan Sites Properties Ltd, amongst others. The state co-owned National Housing and Construction Corporation have also increased their presence on the market. However, the increased housing pressure has contributed to the growth of informal settlements in the city and by 2007, 54% of the city population were living in tenements "mizigo" and 12% in stores and garages (Mukiibi, 2007). In general, the housing environment in Kampala is characterised by shortage of decent housing.

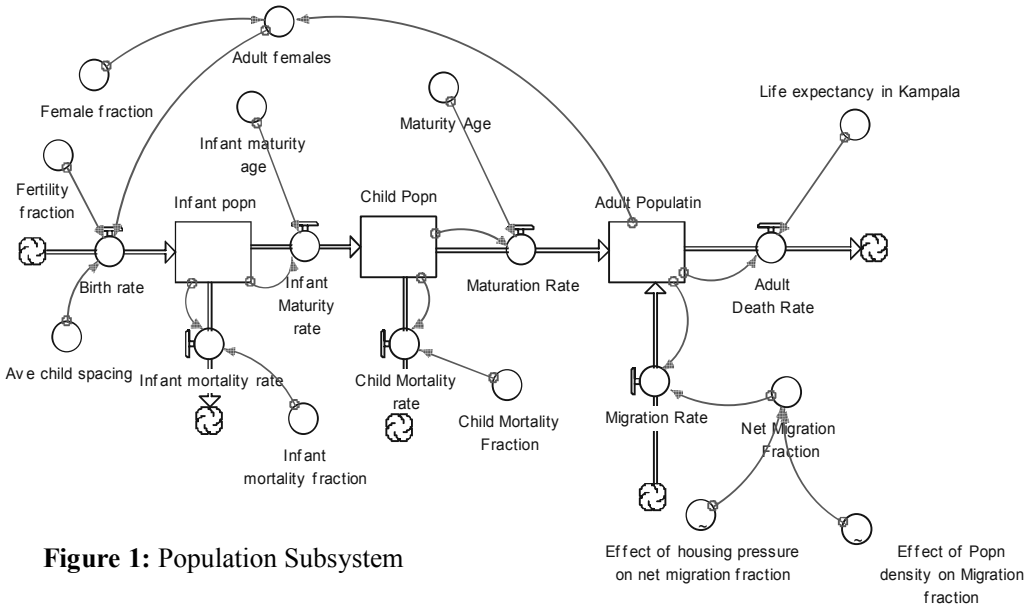

Figure 1: Population Subsystem

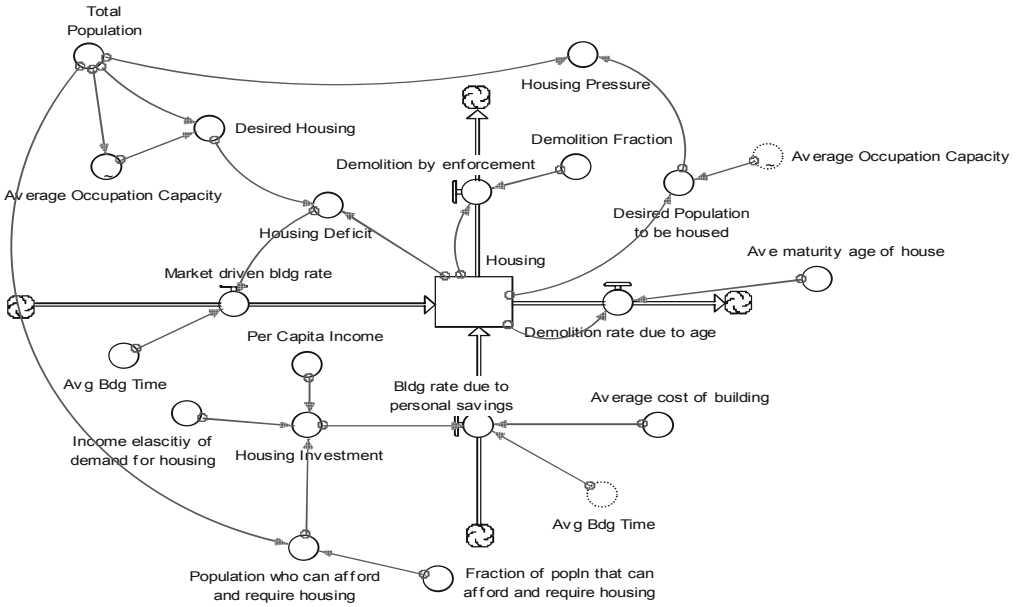

Figure 2: Housing Subsystem

2.2 Model Validation

Model validation is a vital and yet controversial aspect of any model-based methodology in general, and system dynamics in particular. It is a process that deals with building confidence in the usefulness of a model (Barlas, 1996). In model validation, the sequence is to first test the internal structure of a model and then test the output. The model is valid if its output matches the "real" output within some specified range of accuracy, without any questioning of the validity of the individual relationships that exist within the model (Barlas, 1996).

In this study, the structure of the model was validated through deactivating the key loops responsible for behaviour. As expected, the test results show that when the loops responsible for birth-rate and for building rate are deactivated, the city's population and housing stock significantly drops from 5,284,664 to 1,695,415 and from 700,858 to 154,834 respectively, by 2035. On the other hand, the outputs of the model were validated by comparing model results with historical population and housing statistics. For example, in 2008, it was observed that the model results predict a city population of 1,600,267 and a housing deficit of 100,076 units compared to the Uganda Bureau of Statistics record of 1,600,000 and 100,000 respectively. This amounts to a marginal error of 267 and 76 units in population and housing deficit projections respectively.

3.0 DISCUSSION OF RESULTS

Population and housing projections are vital for planning at the international, national and regional levels for both the private and the public sectors. These projections help planners to efficiently allocate the scarce resources and to design policies aimed at attaining sustainable economic development.

The results of this study reveal that by 2015, the city population will grow from 1,600,000 [value for 2008] to 2,182,269, to 3,390,858 in 2025 and to 5,284,664 in 2035 at an average growth rate of 5.6% per annum. Similarly, the housing stock will grow from 274,000 units [value for 2008] to 373,426 units by 2015 largely due to the ongoing boom in the real estate and construction sector. This housing stock will further increase to 528,795 by 2025 and to 700,858 by 2035 at an average annual growth rate of 3.7% strikingly much lower than the observed 5.6% annual growth rate in population. As result of a faster growth of population in relation to housing, the housing deficit will increase from 100,000 units [value for 2008] to 109,526 in 2015, to 144,285 in 2025 and to 148,081 in 2035 (see Figure 3 below for trends in housing and population growth over the period 2008-2035).

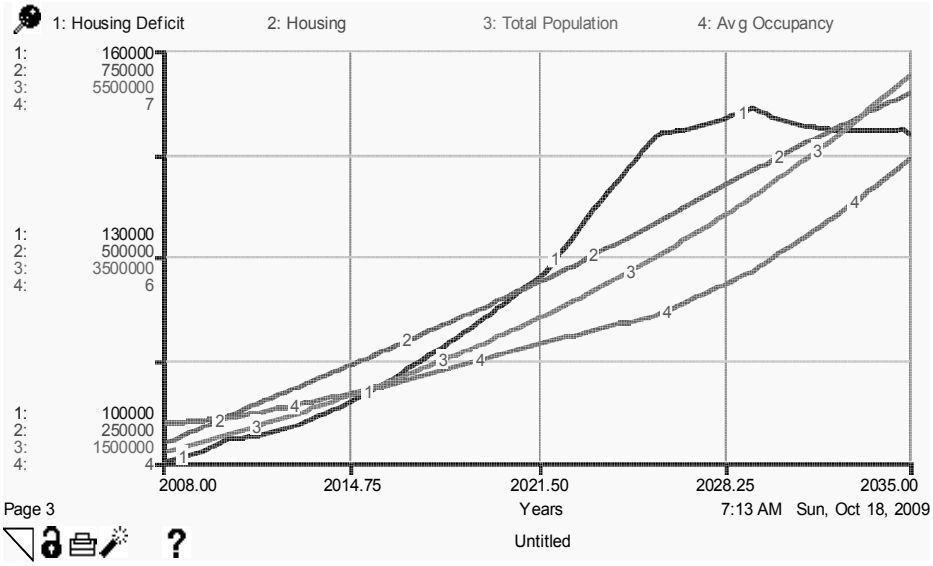

Figure 3: Trends in housing and population growth (2008-2035)

From Figure 3 above, it is evident that with a faster growth in population, the average occupancy of houses in Kampala will increase from 4.8 to 6.3 persons per unit after 2020. Although not sustainable, the increased occupancy of houses will temporarily contain a rapid growth in housing deficit.

4.0 STRATEGIES OF CONTAINING THE HOUSING CRISIS IN KAMPALA CITY

The projections of population and housing stock as discussed in section 3.0 above have affirmed the position presented by Mukiibi (2007) and Giddings (2009) that Kampala is experiencing a housing crisis. Many strategies can be adopted by the public and the private sector to contain the housing crisis including those related to legislation of the sector and the provision of incentives for housing development. In particular, this study has proposed and tested (in a modelling environment) two policies: the internal migration policy and the housing life cycle preservation policy.

4.1 Internal Migration Policy

Rural-urban migration is one of the major factors that contribute to rapid population growth in Kampala city (Nyakana *et al*., 2007). Migrants are both temporary and permanent with a resident population of almost half of the daily transient population (ibid.). People move to urban areas in search of opportunities including employment, good schools, health facilities and other amenities. A possible solution is to develop regional mini-cities so that the rural population do not have to unnecessarily move to Kampala in search of opportunities.

To test the internal migration policy, the migration ratio of 0.125 for Kampala city (see UBOS, 2006) was reduced by half to a value of 0.0625. The resultant effect was a drop in population from 5,284,664 to 4,500,010 by 2035 and a drop in housing deficit from 148,081 to 138,127 during the same period. Thus, a 50% reduction in the migration ratio has potential of reducing the city population by 15% and the housing deficit by 6.7%.

4.2 Housing Life-Cycle Preservation Policy

The policy on life-cycle preservation advocates for the improvement of quality of housing in the city so that houses can have a longer life-cycle. This can be achieved by adopting building technologies and construction materials that preserve the life-cycle of houses. It should be noted that Kampala city and its neighbourhood lie along a seismically active zone and therefore, the mandatory enforcement of reinforced concrete technology has potential of producing buildings with a longer life-cycle. The adoption of appropriate building technologies will not only serve to preserve the life cycle of buildings but also to ensure safety on site and during occupation. Indeed, as noted by Irumba *et al*. (2010), Uganda has a high incidence of construction accidents in excess of 50 major injuries per annum and 6 fatal accidents per annum, the majority of which are registered in Kampala.

To test the life-cycle preservation policy, the average life cycle of a house was increased by 10years from 82 to 92years. The resultant effect was an increase in the housing stock from 700,858 to 705,171 units by 2035 or 4,313 units. Given a standard occupancy of 4.8 persons per housing unit, an extra 2070 people can be housed adequately by 2035.

5.0 CONCLUSION

This paper has discussed a system dynamics modelling approach to forecasting population and housing growth in urban areas using Kampala City, Uganda as a case study. The developed model has revealed that over a period of 27years effective 2008, the population of Kampala city will increase from 1,600,000 to 5,284,664 at an average growth rate of 5.6% per annum and the housing stock will increase from 274,000 to 700,858 units at an average growth rate of 3.7% per annum. The housing deficit will increase by 48% from 100,000 to 148,081 housing units during the same period, worsening the already visible housing crisis.

As a step towards containing the crisis, this paper has recommended policies that preserve the life-cycle of houses and therefore increase the housing stock, and those that control rural-urban migration especially through developing regional mini-cities.

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