Engineering and Urban Planning Solutions for Affordable Housing: Predicting Housing Choices Amidst Rapid Urbanisation

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https://doi.org/10.29227/IM-2025-02-02-120

Submission date: *2025-05-21* | Review date: *2025-06-17*

Abstract

Urban areas are the primary destinations for migration due to job opportunities, access to healthcare facilities, higher wages, a better quality of life, and increased educational opportunities. Affordable and available housing is in high demand in urban areas. Unaffordable housing is considered a primary concern in several European states, as it results in homelessness, financial strain, housing insecurity and becomes a social problem preventing younger people from leaving their parents' home [1]. As population and movement rates of people increase from rural areas to cities, housing rates rise, and specific problems related to rapid urbanisation also increase. In some cases, people must wait months and even years to obtain housing that suits their needs. This article will analyse how predicting the housing needs of people who will arrive in the city or are already in the town in need of housing will help solve the problem by creating an affordable and abundant housing option, supporting better urban planning and sustainable development. By using regression, the number of people expected to arrive in the future is estimated. Using agent-based modelling, individuals who migrate from rural to urban areas predict their housing choices based on their social, educational, and economic status. This result will aid the government, urban planners, and authorities in planning and creating housing that will be a viable option for people arriving in the city or, for those already living in urban areas, who require affordable housing. Better anticipation of housing demand contributes to effective urban management and infrastructure planning, helping to address the challenges of rapid urbanisation. This approach holds the promise of preventing the formation of slums and other problems caused by rapid urbanisation, offering a hopeful outlook for the future.

Keywords: Affordable, Urban, Predictive, Urbanisation, Regression

1. Introduction

Urban areas have long been the hotspots of migration due to several factors, including job opportunities, access to healthcare facilities, higher wages, a better quality of life, and opportunities for higher education [6]. Millions of people move from rural to urban areas worldwide every year. This process has both positive and negative effects. Some positive effects include economic developments in urban areas, growing urban populations, and thriving communities. Adverse effects include a lack of housing, unaffordable housing rates, the formation of slums, and several urbanisation problems, including a lack of resources and non-functioning services in urban areas, as the population exceeds capacity. The European Union estimates that 8 out of 10 people live between cities and towns[4]. Unaffordable housing is considered a primary concern in several European states, as it results in homelessness, financial strain, housing insecurity and becomes a social problem preventing younger people from leaving their parents' home [1]. According to the United Nations report, more than half of the world's population lives in urban areas. By 2030, it is expected that 6 out of 10 people will be living in urban areas [5], and by 2050, it is projected that this number will increase to two out of three people.[8]. This number is expected to increase according to the report. Solving the problems arising from migration is essential; otherwise, it will cause the city to fail to function, and specific issues will emerge.

An increase in demand will lead to unaffordable housing, resulting in the formation of informal settlements or slums. These slums are often developed in areas that are unsuitable for construction, such as wetlands and riverbanks, which can eventually lead to flooding. This poses significant challenges for urban planners and civil engineers in terms of risk mitigation and infrastructure development. It is estimated that approximately 1 billion people reside in informal settlements worldwide [2]. Moreover, these problems arise, strains on the drainage and sanitation result from the improper functioning of the waste management. The stressed-out infrastructure and congested traffic, as well as healthcare and education, will struggle significantly to meet the needs. Social unrest and poverty, many end up unemployed or in low-paying jobs, or illegal jobs, and end up being overexploited. Degradation of the environment and land deterioration, including deforestation and a lack of green areas, result from the overuse of land, highlighting the need for sustainable urban planning and resilient design strategies. This can lead to a heat island effect and other climate-related issues. Social inequality can arise from the socioeconomic gap between the local population and migrants, leading to these tensions.

Challenges arise in governance, as informal settlements are often neglected because they fall outside the jurisdiction of governance institutions. However, a lack of capacity and funding for local governments also occurs.

This article aims to bridge the research gap in the literature regarding the frequent problems that arise in urban areas due to overpopulation and propose solutions to address them. This will be achieved by determining the number of people who will arrive and identifying the type of accommodation they will choose. This will be achieved through the use of regression and agent-based modelling.

2. Methodology

This study utilises artificial data for simulation purposes. Due to a lack of data and limited access to empirical data, artificial data are employed, allowing the experiment to proceed without legal constraints. The application of artificial data will help to support the development of the methodology for using empirical real data in the future. These artificial data sets are created based on the data of people who migrated due to the economic crisis from one region to another. Certain assumptions are also made on the data, as there

are certain areas where there is not enough data. These data are used in the coding, which is done in Python for regression and agent-based modelling, and simulations are created. The artificial data is flexible, but there are limitations to the artificial data; it may not have the real data pattern and complexity. These simulations illustrate potential possibilities and show that this kind of simulation provides a framework for analysing real-life data in the future.

2.1 How the analysis is done

The analysis is done on regression and agent-based modelling.

2.1.1 Regression. A statistical model is developed to examine the relationship between a dependent variable and one or more independent variables [7]. A simple linear regression is employed in the article, where the dependent variable is the population and the independent variable is time.

2.1.2 Agent-based modelling. This modelling is used to simulate the actions and interactions of autonomous entities, which are agents, thereby producing aggregate emergent phenomena [3]. This computational modelling is primarily used in urban planning and economics. This model is dynamic and can reflect value changes as social, educational, and economic statuses change, providing valuable input for urban planners and architects to design adaptable housing solutions. The user can modify it according to their requirements and based on the data.

In agent-based modelling, it is divided into four parts: Agents, Environment, Interaction, and Emergence. The analysis of these four parts is presented in the following section.

- Agents-The migrants are considered agents.
- Environment- Spatial place where the agent lives, spatial data: Urban area
- Interaction - The agents interact based on their social, economic, and educational status.
- Emergence - How education, social, and economic status can affect complex patterns at the system level.

Data on the years and the migrants who arrived in the city from 2018 to 2024 are collected. Using regression, the number of people who arrived in the city in 2025 is determined. Statuses are given to them, statuses are given based on education qualification, how much money they are earning, and their economic and social status, whether they are single, married or living with a family. This status is assigned based on analysing previous migrant status data from 2018 to 2024. The number of people arriving in the year 2025 and their status, by using this combined data, a code in a Python environment is created with MESA. By running this code, an agent-based model simulation is developed. The accommodation choice assigned for this simulation is as follows.

The property types are given below:

- Luxury Apartment
- Standard apartment
- Shared housing type
- House type
- Public housing

2.2 Regression Analysis

Table 1 shows the number of people who migrated from rural to urban areas from 2018 to 2024; the number of people migrating from rural to urban areas increases every year.

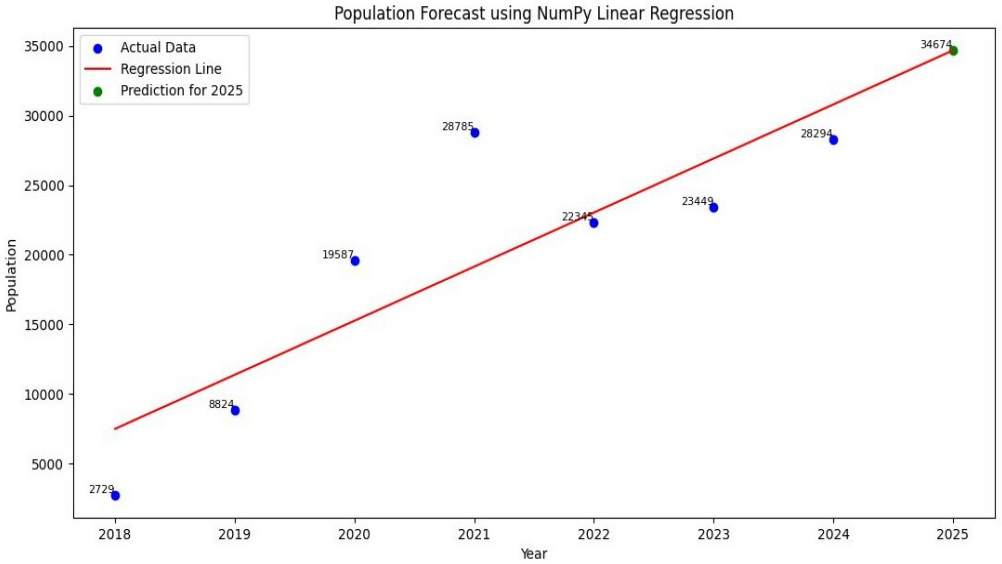

Fig. 1. Regression graph result- prediction of the number of migrants arriving in 2025

Tab. 1. Year and population

	Year	Migrants arrived
1	2018	2729
2	2019	8824
3	2020	19587
4	2021	28785
5	2022	22345
6	2023	23449
7	2024	28294

Regression analysis is performed in Table 1, where the number of people arrived in the years 2018 to 2024 is used to predict the number of people arriving in 2025. The regression analysis reveals that 34674 people will arrive in 2025.

2.3 Agent-based modelling simulation

Simulation is conducted, utilising these assumptions for the migrant data, which are based on real data.

49.6% women and 50.4% men. 46% of immigrants from rural areas were travelling alone to Urban areas, and 54% of migrants travelled with family members. The educational status of these migrants is as follows: approximately 5% of individuals have no formal academic background, 30% have completed elementary education, 50% have completed secondary education, 5% hold technical degrees, and about 10% have a college education. Economic status is used for this analysis, based on a monthly minimum wage of $300 and the average salary of a post-secondary school-educated Venezuelan migrant in Colombia, which is $644. By combining real and artificial data, a hypothesis is proposed. A minimum salary of 0 dollars, people are living with state benefits, individuals with no education and those with elementary education earn about $300, $450 for people with secondary education and technical education. The highest pay is $700, the maximum amount for people with a college education or higher. The framework is given below.

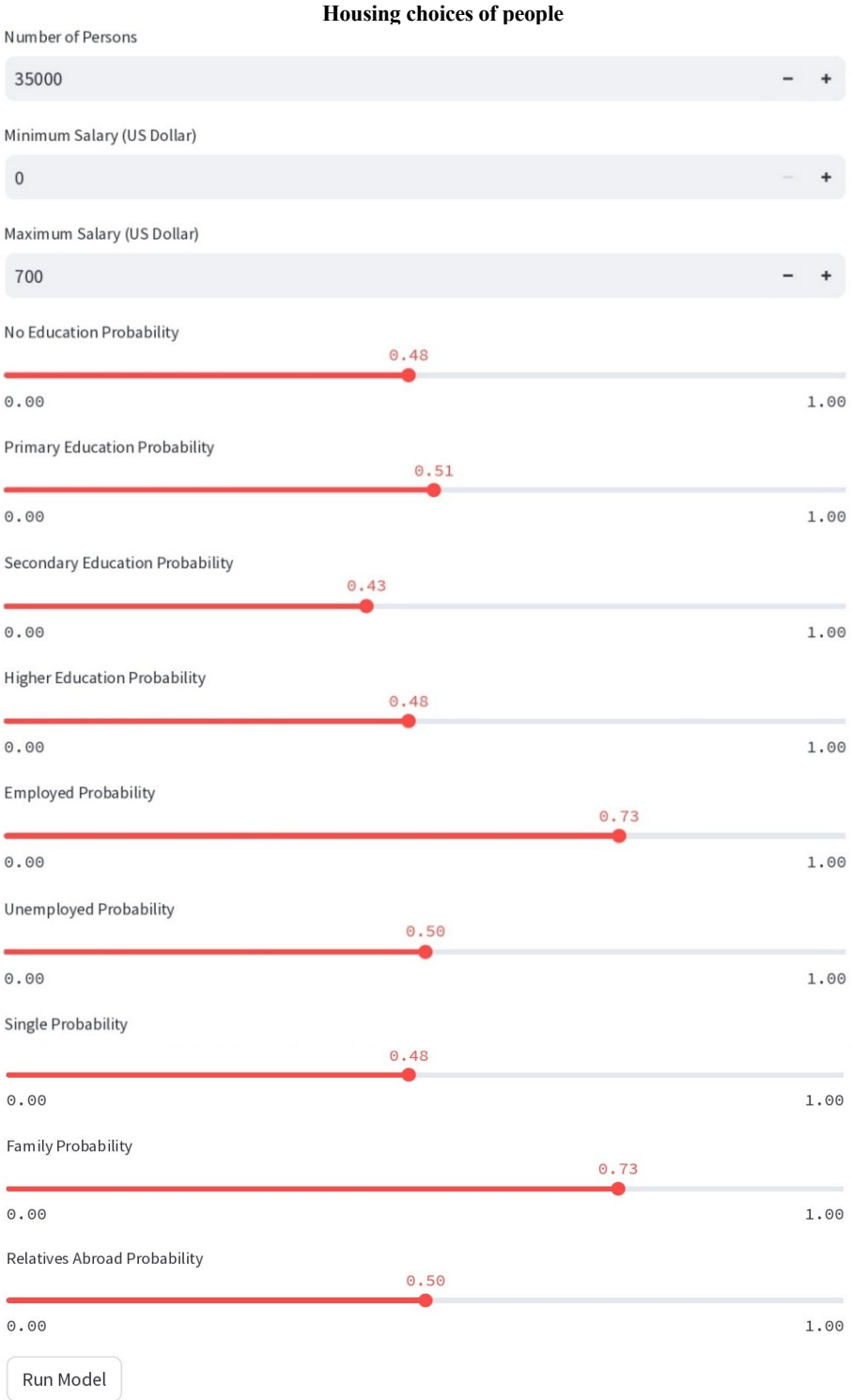

Fig. 2. Framework created from agent-based modelling, which is dynamic, adjusted based on preference

The framework developed from the agent-based model illustrated in Fig. 2 is dynamic and provides numerous options that are adjusted according to user preferences. These include the number of individuals, salary, educational background, social status, and whether they are single or have a family. The estimated number of individuals in need of housing is 35,000. For this framework, a minimum amount of $0 and a maximum amount of $700 are utilised. Additional assumptions are also based on educational data: 48% of the group possesses no education, while 51% have primary education and 43% have higher education. The employment rate is set at 73%, while unemployment is considered at 50% due to many employed individuals not earning sufficient income to afford housing. To enhance the probability, 50% is allocated. Individuals with single status constitute 51%, and those with relatives abroad account for 48%. Families are represented at 73%, given that there is a possibility that single individuals and those with relatives abroad could bring their families. Based on this data result is generated.

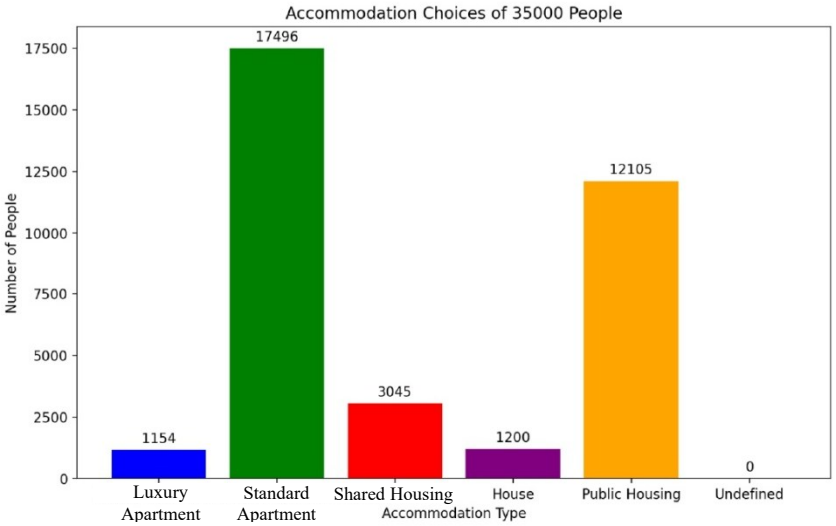

Fig. 3. Housing choice of people predicted using an agent-based modelling

3. Result

According to the results, the majority of people prefer standard apartments, while luxury apartments are the least popular option. A considerable number of people also prefer public housing as their second choice. The main reason for this preference stems from their lower salaries, the higher number of single individuals, and an increased unemployment rate reflected in the data set. As this framework is dynamic, urban planners can utilise the model for forecasting. This dynamic model helps to predict new accommodation choices for urban planners by incorporating additional people or input data based on their educational, economic, and social status. This enables forecasting of accommodation choices and allows for preparation based on those forecasts. These typologies reflect the diversity of housing needs and are essential considerations in urban design and civil engineering projects focused on affordable housing.

Tab. 2. Result from agent-based modelling, housing choices of the migrants

Number	Housing choices	Number of people chosen
1	Luxury apartment	1154
2	Standard apartment	17496
3	Shared housing type	3045
4	House type	1200
5	Public housing	12105

4. Conclusions

This result reveals the potential accommodation choices of people arriving in 2025, providing an overview of the accommodation choices required in the city. Decision-makers, city officials, and urban planners can consider this information and plan accordingly, integrating perspective models into comprehensive housing and infrastructure strategies. This will not only help migrants find affordable housing but also prevent the formation of illegal settlements and related problems, allowing city officials to continue running the urban area efficiently without strain on services, infrastructure, and resources. Further research possibilities, including considering the number of people who need housing and are already in the city, will provide a more accurate calculation of the total number of housing requirements the city has to provide. The data on the number of people who require housing and are already residing in urban informal settlements can be collected from officials or city authorities to obtain a clear picture of the total housing requirements.

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