POST-EARTHQUAKE HOUSING RECOVERY AND POPULATION DISPLACEMENTS IN VANCOUVER, CA

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1. Introduction

An agent-based object-oriented model for housing recovery and population displacements is presented and used to analyze post-earthquake recovery in the City of Vancouver, Canada. Building recovery is modeled in the context of a community, contrasting with the practice of assessing the recovery of buildings in isolation. This approach better captures the effect of competition for resources, infrastructure disruptions, and socioeconomic factors on recovery. The analyses include models for damage, inspection, financing, power infrastructure, and labor/materials for repairs. The presented approach is applied to simulate the impact of a M7.3 earthquake on 114,832 buildings in the 22 neighborhoods in Vancouver.

2. Models

Computer models were developed to represent the entities of real-world community. Buildings, infrastructure, resource suppliers, and households are the agents which are represented by models defined in C++ classes. Instances of classes are called objects. For example, only one Power Substation class is implemented but many power substation objects are instantiated at run-time. The functionality of the objects reflects the behaviors of the agents. These are defined through "data members," which store information, and "member functions," which carry out operations on the data. Specifically, data members represent attributes of infrastructure objects and member functions define the actions that an object can perform, such as providing electrical power. In this “bottom-up” approach, complex phenomena emerge from the interactions between relatively simple agents, e.g. households competing for scarce resources for recovery.

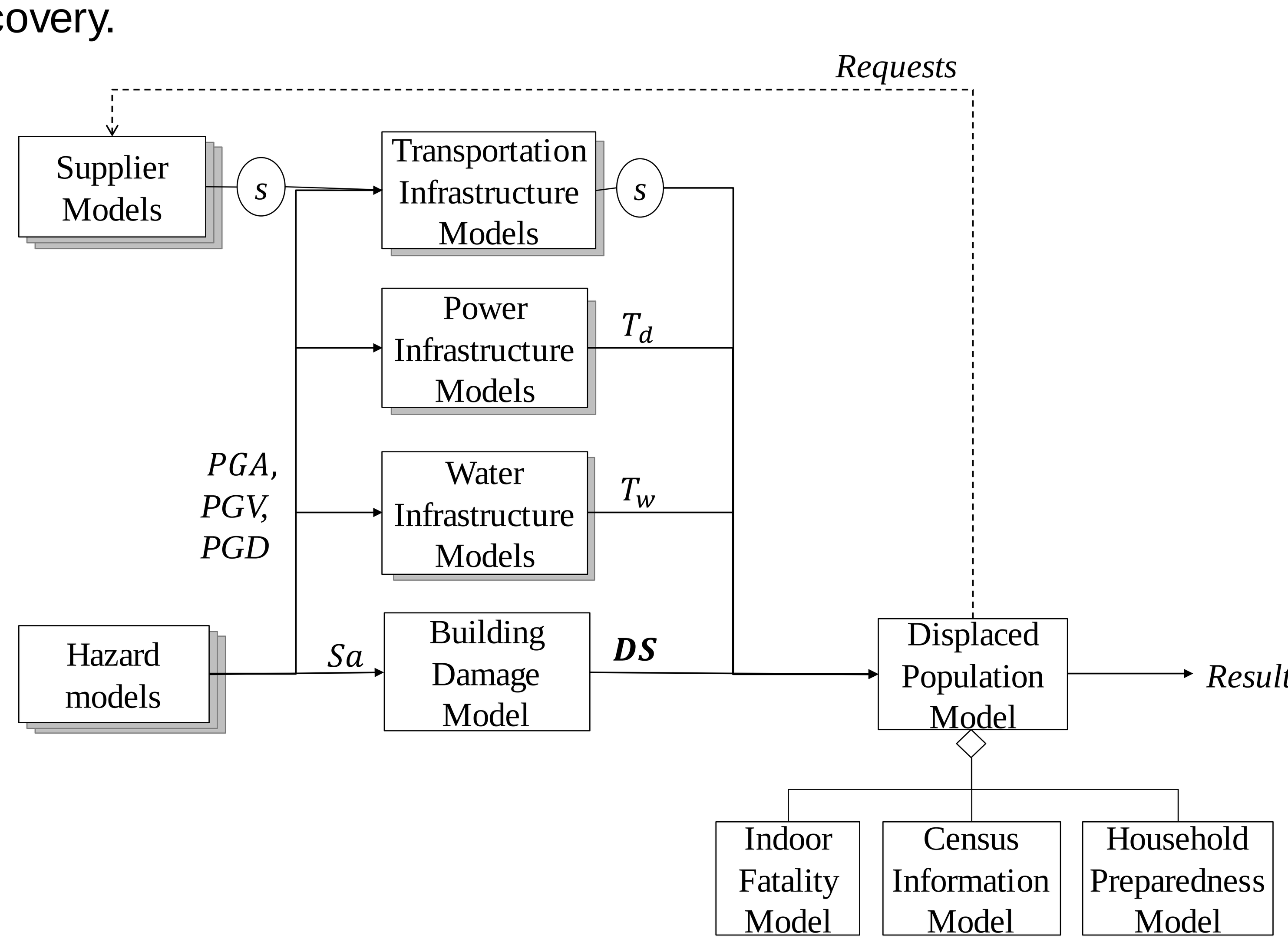

Figure 1. Flowchart of models

3. Housing Recovery

Figure 2 shows the recovery curves for 22 neighborhoods indicating that repairs extend over two years, and in some cases over four years. The extent of initial damage is higher for neighborhoods containing many multi-story buildings. The density of multi-family old buildings, renters, and the income and immigration status of the homeowners are shown to be good predictors of the speed of recovery for a neighborhood. The effective of selected mitigation measures was also evaluated. Facilitating the access to financial resources without increasing the number of worker crews was not effective at improving recovery capacity. Conversely, retrofitting the most vulnerable buildings or doubling the number of worker crews in the city during recovery, were demonstrated to be efficient in reducing housing recovery times and improving equity in recovery. The most efficient strategy was a combination of the three actions above, showing that they can interact in a synergistic fashion.

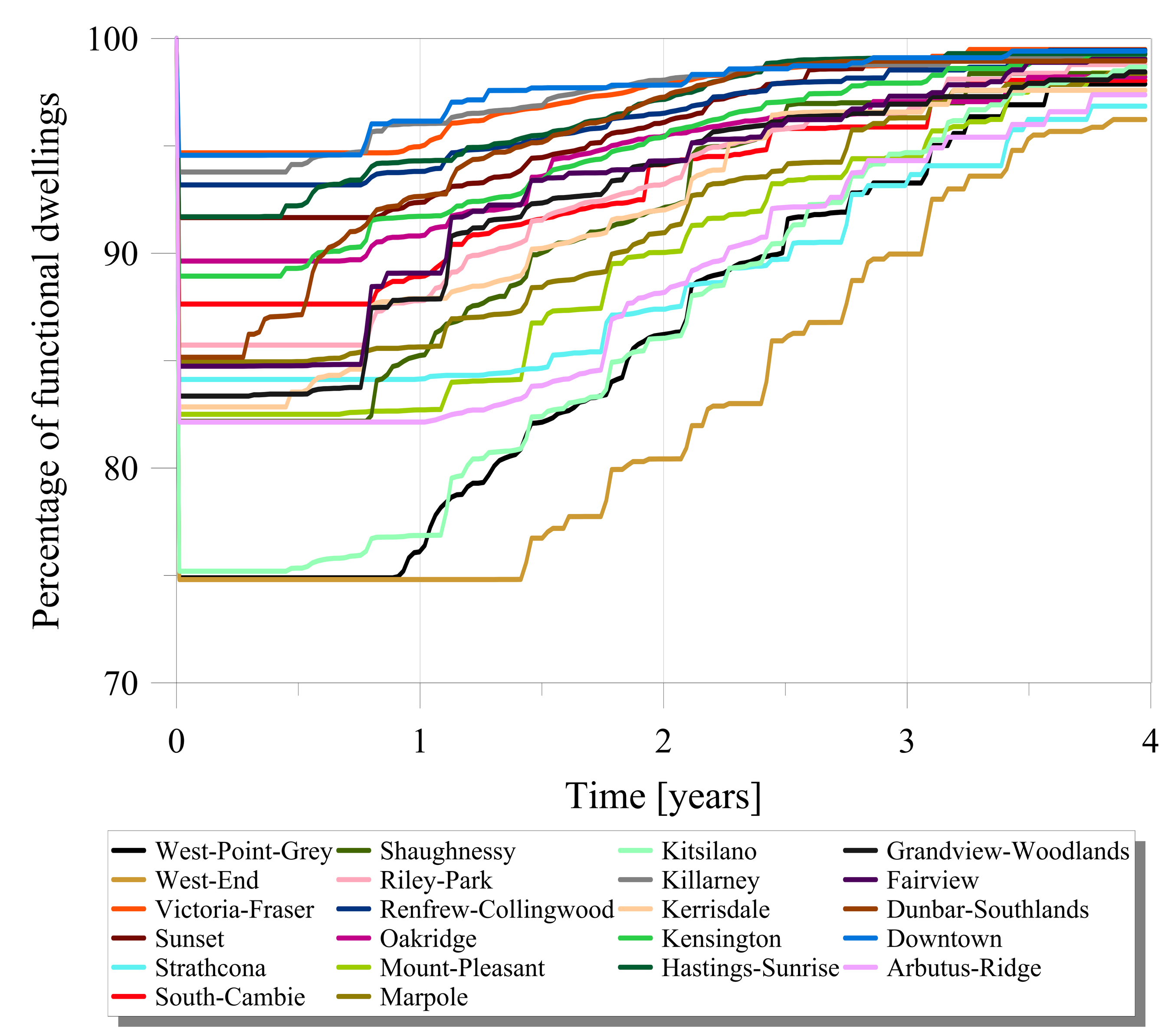

Figure 2. Housing recovery in Vancouver (CA)

4. Population Displacements

Figure 3 shows the socioeconomic demographics of the population of Vancouver (black), of the population temporarily displaced (yellow), and of the population that decide to permanently relocate (red). Results indicate that nearly 70,000 persons are expected to be displaced by the M7.3 earthquake. Of those, close to 19,000 will need public sheltering. It is also shown that nearly 40,000 persons are expected to relocate in the two years following the M7.3 earthquake investigated. Among those needing public sheltering or relocating, there is a disproportionally high number of renters and low-income dwellings.

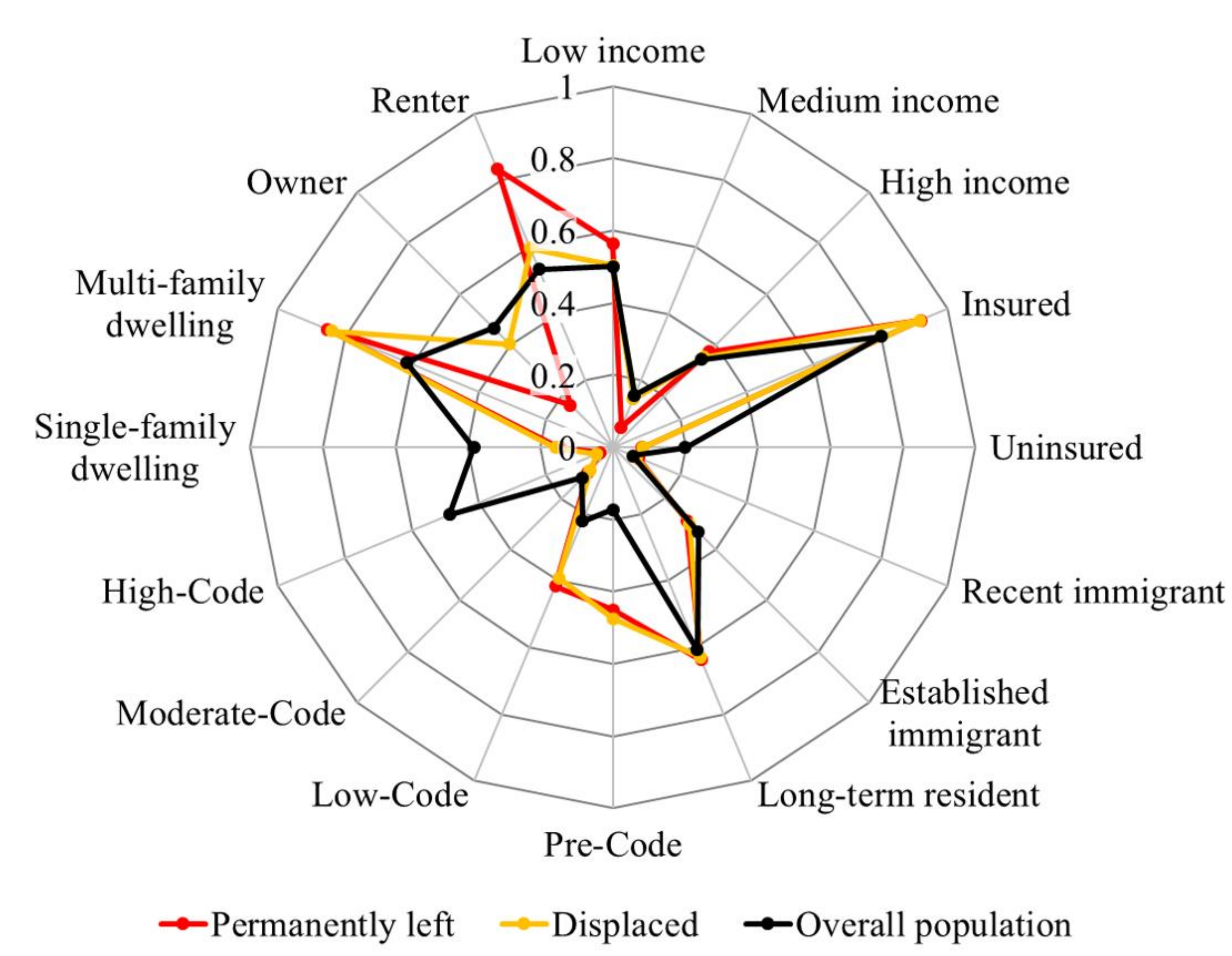

Figure 3. Socioeconomic demographics of displaced population

5. Conclusions

An integrated approach was employed in this research. Power, water, and transportation infrastructure, as well as buildings and dwellings are included in the analyses. This integrated approach is versatile and allows for the assessment of the benefits of mitigation measures to one system on other systems. Please contact rccosta@stanford.edu if interested in more information.

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