Decision support for sustainable urban renewal: A multi-scale model

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ABSTRACT

Developed cities are troubled by various challenges, including urban dilapidation, environmental pollution, traffic congestion, lack of facility provision, and economic decline. Urban renewal, as an important agenda in most countries, holds the aim of addressing these urban problems. With the inherent complexity of urban renewal, renewal initiatives do not always follow an unsustainable path, which has obtained much criticism from both academia and the public. Therefore, an informative decision-making process would contribute to better renewal outcomes. Previous research has mainly focused on one aspect of urban renewal, in which a comprehensive perspective is lacking. The multi-scale feature of urban renewal initiatives also adds complexity and uncertainty to decision-making. Therefore, this paper proposes a multi-scale model that supports decision-making on realizing sustainable urban renewal. Three sub-modules and a supporting database are included in the model. City, district, and neighborhood scales are the foci of the three sub-modules. Both temporal and spatial data are included in the database. Through experimental study and expert interview, the effectiveness of this model is validated.

1. Introduction

Cities, especially developed cities, are constantly facing various challenges such as urban decay, environmental deterioration, lack of infrastructure, social problems, and economic decline. Urban renewal/regeneration has therefore become part of the research agenda because it has aims that include clearing slums (Zipp, 2013), solving the urban decay issue (Chan and Lee, 2008a; Larsen and Hansen, 2008), improving urban economy (Musterd and Ostendorf, 2008), rectifying social problems (Murgante et al., 2012), and enhancing a city's reputation (Kleinhans, 2004). However, urban renewal initiatives sometimes have not realized their objectives, with some even receiving criticism such as, promoting a source of social exclusion, leading to loss of community identity and only considering profit. These comments implicate the need for better decision-making on and implementation of urban renewal.

Complexity is inherently rooted in urban renewal initiatives, in which different issues and players are involved (Zheng et al., 2014), as well as multiple solutions being provided (Mayer et al., 2005). By

adding to this complexity, the urban environment involves different spatial scales such as city, district, neighborhood, and building blocks. This inherent complexity indicates that informed decision-making is crucial for successful urban renewal initiatives. To improve decision-making and implementation for urban renewal, a considerable number of studies have been conducted. Land use, as an essential issue to be addressed in urban renewal, has been explored by many researchers (e.g. Zheng et al., 2015; Wang et al., 2015, 2013). The popularity of the sustainability concept also stimulates much research on the integration of sustainability into urban renewal initiatives (e.g. Lee and Chan, 2010; Colantonio et al., 2009; Chan and Lee, 2008a; Chan and Lee, 2008b; Lee and Chan, 2008; Hemphill et al., 2004a; Hemphill et al., 2004b). Other research focuses on the following issues, but is not limited to, housing (e.g. Zheng et al., 2015b; Winston, 2010), provision of public facilities (e.g. Brown and Barber, 2012; Burrage, 2011) and also stakeholder relationships (e.g. Ruming, 2010; Van Bortel and Elsinga, 2007) in urban renewal actions.

However, a multi-scale perspective, which is one important aspect in the complexity of urban renewal decision-making, has been ignored

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in previous research. Initiatives at different scales involve different issues and problems. At city scale, relevant policies for urban renewal/regeneration are proposed. In most cases, district, neighborhood, and building scales are at implementation levels. For example, the Netherlands has had a policy, called the "Big Cities Policy", since 1994, and specific policy actions are conducted at neighborhood levels to attract better-off residents, create opportunities, and improve neighborhood restructuring (Musterd and Ostendorf, 2008). Sometimes, if urban renewal initiative is implemented at the building scale, it can only address the physical improvement of that specific building, but may lead to inharmonious relationships with the surrounding area, such as "pencil development" in Hong Kong. A multi-scale perspective of decision-making in urban renewal can contribute to proposing more comprehensive and sustainable policies and actions. Therefore, the current research is to propose a multi-scale model to support urban renewal decision-making. Hong Kong, with its multiple urban problems (e.g. urban decay, land shortage, and pollution), is employed as the case study city to develop three sub-modules and the supporting database. Section 2 reviews research on decision support for urban renewal. Details of model development are introduced in Section 3. Section 4 presents how the proposed model was validated. Section 5 concludes the paper.

2. Decision support for urban renewal

Urban renewal initiatives are beset by complexity (Zheng et al., 2014; Mayer et al., 2005). Urban renewal requires addressing the urban system and the stakeholder-involved social system (Zheng et al., 2014). By adding to these two dimensions, it also involves the technological complexity of potential solutions (Mayer et al., 2005). Considering that various issues, stakeholders, and solutions require balance, decision support is necessary for realizing sustainable urban renewal. Studies have been conducted to explore how to improve urban renewal decision-making.

Some studies only focus on decision support on one critical issue in urban renewal initiatives. For example, Wang et al. (2015) developed a GIS-based framework to support land use planning in urban renewal with three modules of a land information database, planning/policy control mechanism, and land use suitability analysis. Housing, as an essential issue in renewal, has attracted much attention. Housing rehabilitation and redevelopment has been compared with a focus on economic feasibility by Schaaf (1969). These two strategies for housing improvement, both of which hold various advantages and disadvantages, have been widely discussed by researchers (e.g. Yau and Chan, 2008; Ho et al., 2012). To obtain a better understanding of building conditions, the Dilapidation Index in Hong Kong was proposed to assess the potential of urban renewal projects in decision-making (Ho et al., 2011).

The sustainability concept is widely applied in a large number of studies to conduct decision support. An indicator-based approach, with its sustainability indicators, was conceptualized and developed by using a case study to measure urban regeneration performance (Hemphill et al., 2004a; Hemphill et al., 2004b). In the Budapest region, sustainability of property development in urban regeneration was evaluated on physical, social and economic aspects (Kauko, 2012). Peng et al. (2015) integrates a set of sustainability indicators into their proposed model to measure sustainability of urban regeneration. Another indicator-based system, entitled SIPRIUS, was developed to assess sustainability in urban renewal, within which the project dynamics of regeneration of disused urban areas were included (Laprise et al., 2015).

Apart from various issues in urban renewal, the complexity of stakeholders also adds difficulties and uncertainties to urban renewal decision-making. When assessing brownfield developments, Williams and Dair (2007) proposed stakeholder identification in land reuse as one essential part in their framework, in which the assessment of

sustainability objectives is another important part. The unlisted property fund sector's investment style was studied with the focus on its impact on decision making in urban renewal/regeneration property in the UK (Haran et al., 2008). Nine types of public-private partnership in Dutch urban land use and revitalization projects within the framework of deregulated land markets were evaluated through a comparative study (Nijkamp et al., 2002).

Scenario analysis can be applied to support decision-making because it can scrutinize future potential plans, evaluate possible effects from policies, and provide valuable references for decision-makers. For example, Boyko et al. (2012) proposed a toolkit entitled Urban Future to assess urban renewal performance with four future scenarios (*urban market forces, urban policy reform, urban new sustainability paradigm, and urban fortress world*). A structured sustainability assessment of an existing neighborhood and comparison of three possible scenarios (*building improvement, densification according to the legal principles, and densification with adaptation of legal bases*) were integrated to evaluate an existing neighborhood in Switzerland to support the urban renewal decision-making process (Pérez and Rey, 2013).

Urban renewal initiatives are proposed in multiple scales. At city scale, renewal direction and policies are proposed. At district and neighborhood scales, specific programs can be implemented, because they are small enough to implement detailed plans. Compared with building scale, these two scales can better address issues for the community and even the whole city, because they are large enough to address other issues in urban renewal such as land use, urban design, and facility provision. Previous research mainly focuses on one project or neighborhood. Research from a multi-scale perspective has not been touched. Multi-scale analysis could provide a more comprehensive understanding on urban renewal for better decision-making. Hence, this research will fill this gap.

3. Model development

3.1. Process and methods

Several research methods were adopted to develop and validate the proposed model, including literature review, document analysis, expert interview, simulation, case study, and experimental study. The detailed research process is shown in Fig. 1. After defining the research problem, relevant theories, previous research findings, and related documents were reviewed in the library research process. Then, the multi-scale model was conceptualized through reviewing literature, analyzing documents and interviewing experts. When developing different sub-modules, simulation and case study were the main research methods adopted. Various techniques were also used, including system dynamics modelling, conversion of land use and its effect at small scale (CLUE-S) modelling developed by Verburg et al. (2002), Markov chain prediction, indicator-based approach, and spatial analysis in GIS. To validate this multi-scale model, experimental study and expert interview were employed. During the validation stage, feedback was collected, to further enhance the conceptualized model and modify the sub-modules.

3.2. Conceptualization of model development

Three sub-modules are included in this model, which are system dynamics (SD) sub-module, land use simulation (LUS) sub-module, and sustainability assessment (SA) sub-module. An overview of these three sub-modules is shown in Fig. 2. Three sub-modules involve three different scales (city, district, and neighborhood).

SD sub-module development generally involves four main steps (see Fig. 2): (1) defining and describing system; (2) developing model; (3) validating model and (4) conducting scenario analysis. Urban renewal decision-making can be supported from two main aspects: (1) it could explore sub-systems and variables in the urban renewal process, which provides a better and more comprehensive understanding of urban