A MULTI-SCALE DECISION SUPPORT FRAMEWORK FOR SUSTAINABLE URBAN RENEWAL IN HIGH-DENSITY CITIES: A CASE OF HONG KONG

ZHENG WEI

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Department of Building and Real Estate

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ZHENG Wei

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CERTIFICATE OF ORIGINALITY

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ZHENG Wei

Abstract

High-density cities, especially developed ones, are constantly facing challenges, such as urban decay, environmental deterioration, scarce land resources, insufficient housing and infrastructure, social problems, and economic decline. Urban renewal/regeneration is regarded as a potential strategy to address these challenges because it is aimed at resolving social, environmental, and economic problems in cities. Despite their potential advantages, renewal initiatives do not always realize their expected objectives. Urban renewal initiatives have received considerable criticism consisting of the destruction of local businesses, loss of local culture, profit-driven features, expulsion of residents with low income, and low quality of urban renewal stock. Effective decision-making is required before launching renewal programs to avoid or reduce the negative aspects of urban renewal initiatives.

An urban renewal system is embedded with complexity. Such a system involves different stakeholders whose interests must be balanced during the renewal process. The decision-making process involves various planning considerations including buildings, facilities, transportation, and land use. Urban renewal also has multiple solutions/strategies, such as rehabilitation, revitalization, redevelopment, land readjustment, and preservation. Additionally, urban renewal initiatives are related to different spatial scales, which include city, district, neighborhood, and building block. These different stakeholders, planning considerations, solutions, and scales increase uncertainty and complexity to the decision-making process in urban renewal.

A comprehensive review of existing research in decision support for urban renewal reveals several gaps. First, existing studies on decision support for urban renewal mainly focus on project scale. Decision support for other scales, including city, district,

and neighborhood scales, is rarely investigated. Existing research on decision support for urban renewal does not integrate multiple scales with a comprehensive perspective. Second, previous studies on decision-making support in urban renewal are limited to qualitative discussion. A framework with quantitative analysis that can support decision-making is a relatively neglected area. Third, an urban renewal system involves various interrelated variables. The dynamic analysis of an urban renewal system can contribute to improved decision-making, but this area has not been investigated by previous studies. Fourth, quantitative investigation on the mechanism of land use change in urban renewal at the district level has not been conducted in existing studies. Fifth, a comprehensive list of sustainability assessment that focuses on urban renewal decision-making at the neighborhood scale remains lacking.

To fill these research gaps, the present study aims to develop a multi-scale decision support framework for sustainable urban renewal. The following specific objectives are achieved in this research: (1) to identify major variables and their relationships in urban renewal systems and investigate existing theories and tools for decision support of urban renewal; (2) to conceptualize a multi-scale decision support framework for sustainable urban renewal and its associated modules in the framework based on theories, practice, tools, and technologies relating to urban planning, urban renewal, and land use; (3) to develop a system dynamics (SD) module at the city scale, a land use simulation (LUS) module at the district scale, and a neighborhood assessment (NA) module at the neighborhood scale in the framework; and (4) to validate and verify the effectiveness of the proposed framework in supporting decision-making of urban renewal.

Document analysis, expert interview, case study, simulation, and experimental study were adopted as main research methods in the process of achieving these objectives.

Literature review and document analysis were used to achieve Objective 1. Objective 2 was completed through literature review, document analysis, and expert interview. Case study and simulation were employed to realize Objective 3. Several tools were adopted during this phase, including system dynamics modeling, Markov chain prediction, conversion of land use and its effect through small-scale modeling, and spatial analysis in Geographic Information System. Objective 4 was accomplished through two expert interviews and an experimental study.

The main research output is a multi-scale decision support framework for sustainable urban renewal. This multi-scale decision support framework consists of a supporting database, an SD module, a land use simulation (LUS) module, and a neighborhood assessment (NA) module. The SD module works at the city scale. The LUS module explores changes of land use at the district scale. The NA module investigates current performance at the neighborhood scale. The integration of the three modules and the database can provide decision makers with comprehensive and objective references for realizing sustainable urban renewal. By using Hong Kong as the case study city, rehabilitation is suggested as the prior strategy based on the SD module. The probability maps for different land use types provide an explicit understanding of the probability of spatial land allocation, and scenario analysis reflects land use change under different policies in the LUS module. The decision matrix in the NA module proposes four strategies (minimum change, rehabilitation, revitalization, and redevelopment) for different neighborhoods in Kowloon of Hong Kong. Validation results show the effectiveness of this multi-scale framework in supporting urban renewal decision-making given its comprehensive and objective references.

This research contributes to new knowledge and practical decision-making processes. Specifically, this research has contributions in several aspects. First, this research provides a comprehensive understanding of sustainable urban renewal and its inherent dynamics from both spatial and temporal dimensions. Second, this research proposes a multi-scale framework to support urban renewal decision-making, which can be regarded as a prototype of a decision support system that supports comprehensive and objective analyses for sustainable urban renewal. The multi-scale framework is the first attempt to investigate urban renewal by integrating multi-scale (the city, district, and neighborhood scales) considerations. Third, land use simulation supporting decision-making at the urban renewal district is the first attempt in the field of land use simulation. Finally, from a practical point of view, the proposed framework is an effective and comprehensive tool for analyzing problems and policies in urban renewal before making decisions and implementing renewal strategies.

Publications

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1. **Zheng, H. W.**, Shen, G. Q., Song, Y., Sun, B., & Hong, J. (2016). Neighbourhood Sustainability in Urban Renewal: An Assessment Framework. *Environment and Planning B* (accepted)

2. **Zheng, W.**, Shen, G., Wang, H., & Lombardi, P. (2015). Critical issues in spatial distribution of public housing estates and their implications on urban renewal in Hong Kong. *Smart and Sustainable Built Environment*, 4(2), 172-187.

3. **Zheng, H. W.**, Shen, G. Q., Wang, H., & Hong, J. (2015). Simulating land use change in urban renewal areas: A case study in Hong Kong. *Habitat International*, 46, 23-34.

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1. **Zheng, W.**, Shen, G. Q., Sun, B., & Hong, J. (2016) An Indicator-based Approach to Neighborhood Sustainability Assessment for Urban Renewal Decision-making, *CIB World Building Congress 2016*, June 2016, Tampere, Finland.

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1. **Zheng, H. W.**, Shen, G. Q., Peng, Y., Hong, J., & Wang, H. (2016). A Spatial-temporal Framework to Support Strategic Urban Renewal Decision-making. *Journal of Planning Education and Research*.

2. **Zheng, H. W.**, Shen, G. Q., Wang, H., & Hong, J. (2016) Decision Support for Sustainable Urban Renewal: A Multi-scale Model. *Land Use Policy*.

3. Sun B., Shen, G. Q., Wang, D., **Zheng, W.** & Liang, X. (2016). An Intelligent Data Mining Approach for Detecting Individuals' Behaviour Patterns and its Applications in Sustainable Urban Planning and Route Optimization. *Landscape and Urban Planning*.

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Chapter 1 Introduction

1.1 Research Background

High-density cities, especially developed ones, are constantly facing various challenges, such as urban decay, environmental deterioration, scarce land resources, insufficient housing and infrastructure, social problems, and economic decline. Urban renewal/regeneration has emerged as a research agenda because it is aimed at clearing slums (Carmon, 1999; Chan, 2000; Zipp, 2012), solving urban decay issues (Chan & Lee, 2008; Larsen & Hansen, 2008), stimulating urban economies (Chan & Lee, 2008; Couch, 1990; Musterd & Ostendorf, 2008), resolving social problems (Lee & Chan, 2008a; Murgante, Las Casas, & Danese, 2012), optimizing and rationalizing land use (Adams & Hastings, 2001b; Couch, 1990; Ho, Yau, Poon, & Liusman, 2011), enhancing the reputation of cities (Kleinhans, 2004), and promoting the sustainable performance of cities (Mayer et al., 2005).

Urban renewal initiatives hold inspiring objectives, but such targets, especially those involving social goals, are not always realized (Hulsbergen & Stouten, 2001). Urban renewal projects are often regarded as a source of some social and economic problems, such as social network destruction, vulnerable group exclusion, and unpleasant living environment (Chan & Yung, 2004). A considerable number of existing studies regarded urban renewal as a driving force for dispossession and expulsion of residents from their current social networks (Karaman, 2013). For example, a number of regeneration efforts in Dublin of Ireland are considered unsustainable; such efforts lead to certain problems, including low quality of urban renewal stock, limited benefits for native residents, and displacement of local residents and businesses (Winston, 2010). Other negative comments include finance-driven issues and loss of local characteristics. Most urban renewal practices in Hong Kong are regarded as profit-driven rather than being focused on environmental and social needs (Chan & Lee, 2008; Ng, Cook, & Chui, 2001). Federal urban renewal programs in the United States were previously criticized for their monotonous forms and for folding the vitality of cities (Jacobs, 1961). The criticism on urban renewal did not originate from urban renewal itself but stemmed from the methods and strategies applied during the urban renewal process. Insufficient stakeholder participation and limited consideration of long-term spatial−temporal impacts are observed in the decision-making process. An informed decision-making process that ensures improved urban renewal initiatives should be implemented to avoid those negative issues and to achieve sustainability in urban renewal.

Complexity is inherently rooted in urban renewal initiatives that involve different issues and players (Zheng, Shen, & Wang, 2014) and provide multiple solutions (Mayer et al., 2005). Complexity adds a significant challenge to urban renewal decision-making. A considerable number of studies have been conducted to improve the decision-making and implementation of urban renewal. Land use, which is an essential issue that needs to be addressed in urban renewal, has been explored by many researchers (e.g., Zheng et al., 2015; Wang et al., 2014; Wang et al., 2013). The popularity of the sustainability concept also stimulates extensive studies on the integration of sustainability into urban renewal (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 studies have focused on housing (e.g., Zheng et al., 2015b; Winston, 2010), provision of public facilities (e.g., Brown and Barber, 2012; Burrage, 2011), and stakeholder relationships (e.g., Ruming, 2010; Van Bortel and Elsinga, 2007) in urban renewal.

In addition to complexity, the urban environment involves different spatial scales, such as city, district, neighborhood, and building blocks. Different scales face different challenges in the decision-making process of urban renewal. Relevant policies for urban renewal/regeneration are proposed at the city scale. In most cases, district, neighborhood, and building scales are at the implementation levels. For example, the Netherlands implemented the "Big Cities Policy" in 1994; specific policy actions are conducted at neighborhoods to attract the better-off, create opportunities, and restructure neighborhoods (Musterd & Ostendorf, 2008). If an urban renewal initiative is implemented at the building scale, it could only address the physical improvement of a specific building and may lead to an inharmonious condition with the surrounding area; an example of such a condition is the pencil development in Hong Kong. Past and present studies mainly focus on urban renewal at the project level (e.g., Mayer et al., 2005; Juan et al., 2010; Lee and Chan, 2008). Studies on other scales are rarely conducted in existing research. A multi-scale perspective of decision-making in urban renewal can contribute to the proposal of comprehensive and sustainable policies and actions. Therefore, the present study proposes a multi-scale decision support framework for sustainable urban renewal in high-density cities. This research focuses on previously ignored scales, namely, the city, district, and neighborhood scales. Spatial and temporal dimensions are considered in the framework for the following reasons: (1) the three scales involve multiple problems in space, and (2) the decision-making is a temporal problem that requires consideration of the past, present, and future. Theories, practice, tools, and technologies relating to planning, urban renewal, and land use are referred to and adopted in a comprehensive and dynamic way to conceptualize and develop this multi-scale decision support framework, including its associated modules and the supporting database. Decision-making for sustainable urban renewal is expected to be supported and promoted with the aid of the proposed framework.

1.2 Research Scope

Sustainable urban renewal and multi-scale decision support are the foci of this research. These two issues involve a wide range of research in relevant fields. However, this single research cannot cover all relevant aspects. High-density cities are the application foci. Therefore, the research scope must be articulated at the beginning of the thesis.

1.2.1 Sustainable urban renewal

Sustainable urban renewal is the ultimate pursuit for the implementation of urban renewal initiatives. Sustainable urban renewal largely depends on an informative and effective decision-making process. Urban renewal is always rooted in inspiring and positive desires of promoting urban performance in terms of social, economic, and environmental aspects. Given that reality does not always follow people's expected direction, practical urban renewal initiatives have been criticized. Additionally, the concept of sustainability possesses three pillars including social, environmental, and economic sustainability. It is therefore necessary to integrate sustainability into urban renewal.

In this study, sustainable urban renewal means that a city can realize sustainable development, including social, economic, and environmental sustainability, by conducting urban renewal activities.

1.2.2 The multi-scale decision framework

The concept of multi-scale decision support in this research therefore refers to decision support at the city, district, and neighborhood scales. In this framework, three modules including the system dynamics (SD) module, the land use simulation (LUS) module, and the neighborhood assessment (NA) module can support decision-making at the city, district, and neighborhood scales respectively. Different scales hold specific boundaries. The concept of a city is defined in a variety of ways. In the present study, a city refers to a large-scale, permanent human settlement with its own operation system within which diverse issues, such as housing, land use, facilities, transportation, and residents, are covered. Most cities employ and formulate planning frameworks on the basis of their administrative boundaries. The boundary of a city refers to the administrative boundary, which, in most circumstances, includes urban and suburban areas. A district is smaller than a city. Specifically, a district is a part of a city where some common features and facilities are shared for administrative purposes. Neighborhood is the smallest scale among the three scales. A neighborhood could be qualitatively described as a geographically delineated subarea with several blocks in a district of a city where residents sometimes share daily life services, facilities, or common interests. A neighborhood is not a separated area in a city but is connected to other areas of a city. A neighborhood is not necessarily delineated by a tangible boundary. A boundary is set in the present study because the case study city has similar administrative or planning boundaries for units that are close to the qualitative definition of a neighborhood. One district always comprises a certain number of neighborhood units.

This research cannot cover every issue at each scale. At the city scale, the focus is to propose a policy direction for urban renewal from a temporal dimension by exploring environmental, socio-economic, and building sub-systems in urban renewal. At the district scale, the land utilization issue is explored from spatial and temporal perspectives through considering bio-physical, economic, social, political, and neighborhood aspects. At the neighborhood scale, the focus lies on the current sustainability performance (social, economic, environmental, and land use form) and building condition of neighborhoods in the spatial dimension. As a response to the scope of sustainable urban renewal, three pillars of sustainability (social, economic, and environmental) and the urban renewal characteristics in the local context are considered when addressing issues at different scales. Figure 1.1 presents the considerations and development tools for different modules at the city, district, and neighborhood scales in the proposed framework.

The proposed multi-scale framework provides objective references to support urban renewal decision-making but not to solve decision-making problems. The framework is proposed from an urban planning perspective on the basis of planning-related theories and practice. In practice, decision makers should simultaneously consider other issues, but such issues are not considered in the present research. For example, financing and relocation, which are critical issues that need to be tackled, are not covered in this research.

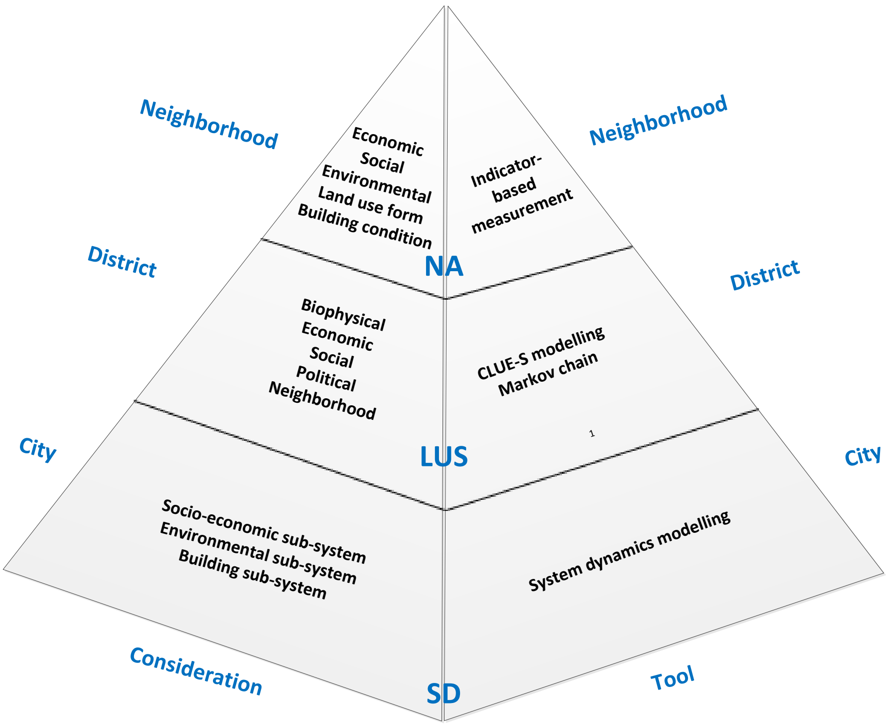

Figure 1.1 The multi-scale decision support framework

1.3 Research Questions

This study critically and comprehensively reviewed previous research regarding to relevant concepts in sustainable urban renewal, decision support theories and tools for urban renewal, and the urban renewal practice in four high-density cities. Past research on urban renewal decision support is characterized by a loose pattern that ranges from a single issue to various approaches. Expert interviews and reviews of urban renewal practices found that financing always plays a more important role than other factors in urban renewal decision-making. In consideration of long-term development, sustainability issues should be prioritized when making decisions. Adopting a comprehensive perspective for decision-making is especially important. In practice, a balance must also be established among different stakeholders. Addressing this issue requires the adoption of a quantitative and objective approach to support urban renewal decision-making. Five major gaps in the scope of existing research and practice are listed below.

1. Most studies on decision support for urban renewal mainly focus on the project level; other spatial scales (e.g., city, district, and neighborhood scales) are neglected.

2. A comprehensive decision support framework with quantitative and objective analysis that involves multiple spatial scales and multiple dimensions has yet to be developed.

3. A dynamic analysis of variables and their associated relationships in an urban renewal system has not been conducted.

4. Few existing studies have investigated the mechanism of land use change in urban renewal at the district scale.

5. A comprehensive list of considerations in sustainability assessment, with a focus on urban renewal decision-making at the neighborhood scale, is still lacking.

Given the research background and identified research gaps, several research questions are addressed in this research.

1. How does a multi-scale decision support framework for sustainable urban renewal decompose at different scales?

2. What are the variables and their relationships in an urban renewal system, and how do they affect urban renewal initiatives?

3. What is the land use mechanism in an urban renewal district, and how does it facilitate decision-making for urban renewal initiatives?

4. How can comprehensive urban renewal decisions at the neighborhood scale be supported in a clear and easy way?

5. How can a multi-scale framework support urban renewal decision-making in practice?

6. Can a multi-scale framework effectively support the decision-making process for sustainable urban renewal?

1.4 Research Aim and Objectives

To address the aforementioned research questions, we primarily aim this research toward the development of a decision support framework for sustainable urban renewal in a multi-scale perspective, with both spatial and temporal dimensions covered.

The specific objectives of this research are as follows:

(1) To identify major variables and their relationships in urban renewal systems and to investigate relevant supporting tools and methods for urban renewal decision-making;

(2) To conceptualize the multi-scale framework and its associated modules on the basis of theories, practice, tools, and technologies relating to planning, urban renewal, and land use;

(3) To develop to a system dynamics (SD) module at the city scale, a land use simulation (LUS) module at the district scale, and a neighborhood assessment (NA) module at the neighborhood scale in the framework;

(4) To validate and verify the effectiveness of the proposed framework in supporting decision-making for sustainable urban renewal.

The first objective was completed by a comprehensive literature review and document analysis. The second objective was realized by adopting methods of literature review, document analysis, and expert interview. The completion of the first and second objectives provides a theoretical foundation and guides the further development of the framework. The third objective was realized by using case studies of a real city at different scales. The city selected in this study is Hong Kong. The developed framework was validated via an experimental study and two expert interviews (Objective 4).

1.5 Research Process

To investigate the proposed research questions and to achieve specific research objectives, we apply qualitative and quantitative research methods in this research. This research is quantitatively dominant because quantitative methods are used for the core parts of this research. These methods involve the analysis and development of modules at different scales. Four phases are designed in conducting this research. Figure 1.1 shows the overall research process.

Literature review and document analysis were adopted to review the existing research on sustainable urban renewal, decision support for urban renewal, and urban renewal practice in four high-density cities. The research outputs at this stage include research trends and gaps, features of urban renewal systems, and difficulties in urban renewal decision-making. Research at this stage focused on realizing Objective 1. The details are shown in Chapters 2 and 3.

In the second phase, research was conducted by adopting methods of literature review, document analysis, and expert interview. The conceptualized framework includes four components, namely, an SD module at the city scale, a LUS module at the district scale, a NA module at the neighborhood scale, and a database that supports the development of these modules. The research outputs of this phase include the identification of the functions of the three modules, confirmation of steps for developing these modules, settings of the three modules, and details about how the database is established. Research in this phase was conducted to complete Objective 2. Chapter 5 presents the research in the second phase.

In the third phase, case study and simulation methods were employed to realize Objective 3, which is the development of different modules in the proposed multi-scale framework. An SD modeling approach was directly adopted in the development of the SD module. The development of the LUS module combined the conversion of land use and its effect at small scales (CLUE-S) modeling and Markov chain prediction. The development of the NA module employed an indicator-based approach. When developing the LUS module and the NA module, spatial analysis in Geographic Information System (GIS) was applied to conduct different analyses. Chapter 6 illustrates how real data were used in developing these modules in the context of Hong Kong.

The last stage involves the accomplishment of Objective 4, which is to validate and verify the effectiveness of the proposed framework. Two expert interviews and one experimental study were conducted to collect feedback. The qualitative and quantitative analyses of the collected feedback provide the research results. Chapter 7 presents the details of the validation stage.

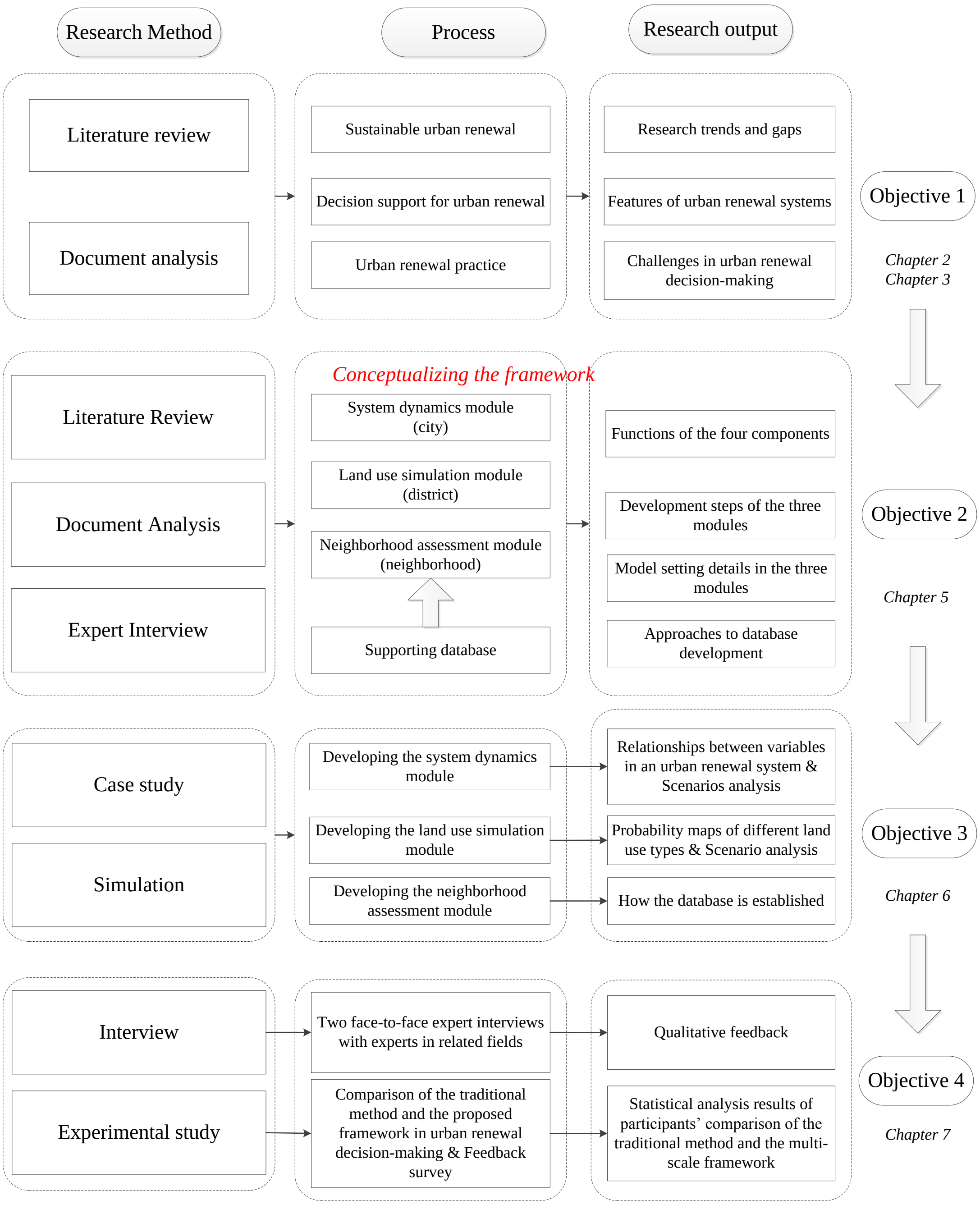

Figure 1.2 Overall research process of the thesis

1.6 Significance of the Research

This research proposes a multi-scale decision support framework for sustainable urban renewal. This framework includes an integrated supporting database and three modules at the city, district, and neighborhood scales. The SD module at the city scale can explore the relationships between various variables in an urban renewal system and explain how urban renewal initiatives are influenced by different variables. These initiatives can guide policymaking at the city level. In addition to analyzing the mechanism of land use change at the district scale, the LUS module can predict policy impacts through scenario analysis. The potential for urban renewal at the neighborhood scale can be identified based on the results of developing the NA module. Implementation strategies can also be proposed. Generally, this framework can be regarded as a prototype of a decision support system for urban renewal.

From an academic perspective, this research can enrich the theoretical development in urban planning, urban renewal, and decision-making fields. This research fills the gaps mentioned above. This research also provides a comprehensive understanding of sustainable urban renewal. The process of establishing different modules can contribute to the knowledge in specific fields, including the application of system dynamics in urban renewal, simulation of land use change, and neighborhood planning. A comprehensive analysis on an urban renewal system from a temporal perspective provides a dynamic understanding on urban renewal, which has not been investigated in existing research. Land use simulation at urban renewal district is the first attempt in the field of land use simulation. The NA module proposes a comprehensive list of indicators to support sustainability assessment on neighborhood units for urban renewal decision-making. From a practical point of view, the proposed framework is an effective and comprehensive tool to analyze problems and policies in urban renewal before making decisions and implementing renewal strategies.

1.7 Structure of the Thesis

The dissertation is organized into eight chapters.

Chapter 1 introduces the whole research picture, including the research background, research scope, research questions to be addressed, overall research aim and specific objectives, research process, and the significance and values of the research.

Chapter 2 provides a comprehensive literature review regarding related definitions and concepts in sustainable urban renewal, complexity of urban renewal, and rationale of integrating sustainability into urban renewal. Another important part of the literature review is the discussion of theories and tools for urban renewal decision-making, including neighborhood planning, urban renewal evaluation, sustainability assessment, and technical planning support. The theoretical foundation is established based on the critical review of existing literature. Research trends and gaps are also identified and discussed.

Chapter 3 reviews urban renewal practices of four high-density cities in Asia, namely, Hong Kong, Singapore, Tokyo, and Seoul. Urban renewal history, institutional arrangement, relevant laws, strategies/methods adopted, and stakeholders involved are discussed. A comparison of urban renewal practices in four cities is also conducted to provide a practical rationale for conducting this research and useful references for developing the framework.

Chapter 4 illustrates the research methodologies and detailed research process. The methods adopted include document analysis, expert interview, case study, simulation, and experimental study. These methods are described and explained in detail. Apart from these methods, several analytical tools were also employed in the development of various modules. These tools include the SD approach, Markov chain prediction, CLUE-S model, and spatial analysis in GIS. Why and how these tools were utilized in this research is also introduced in this chapter.

Chapter 5 conceptualizes the structure of the framework. The functions and development steps of the components in the proposed framework are then explained and discussed. The framework is composed of one supporting database and three modules, namely, the SD, LUS, and NA modules. The integration of these modules is then discussed. The case study city of Hong Kong is proposed, and the data preparation process (the development of the supporting database) is illustrated using the data of Hong Kong.

Chapter 6 illustrates the development process of the three modules. The module description, validation, simulation, and policy implications of the SD module are presented. The simulation area, data preparation, simulation process, model development, validation, simulation results, and policy implications of the LUS module are described and discussed. The indicator selection, overall assessment framework, assessment results, proposed strategies for neighborhood units, and validation stage are clarified for the NA module.

Chapter 7 presents the validation stage for this research. The overall picture of validation methods is described. The validation methods from expert interview and experimental study are explained in detail. The implementation details and results of two expert interviews are shown thereafter. Feedback from expert interviews is investigated qualitatively. A hypothesis is proposed for the experimental study. Feedback from a questionnaire survey in the experimental study is analyzed via descriptive statistics.

Chapter 8 summarizes the primary research findings and investigates the achievement of the research objectives proposed in Chapter 1. First, the research objectives proposed at the beginning of the thesis are reviewed. Second, the research findings from the literature review; practice review; development of the three modules at the city, district, and neighborhood scales; and validation phase are summarized. The contributions and limitations of this research and recommendations for future research are also provided.

1.8 Summary of the Chapter

This chapter outlines the overall picture of this research. Background information is introduced first. In the section of research scope, the definition of sustainable urban renewal in this research is proposed. Then the picture of the multi-scale decision framework concerning its various tools, factors, and scales is presented, followed by the application of the proposed framework in high-density cities. Afterwards, research questions, and research aim and objectives are proposed and explained. After presenting the research process, the significance of the research is summarized. The structure of the thesis is finally outlined.

Chapter 2 Literature Review

2.1 Introduction

Urban renewal or urban regeneration is regarded as a sound approach to increasing land values and enhancing environmental quality (Adams & Hastings, 2001b); mitigating the urban decay problem and achieving socioeconomic objectives (Lee & Chan, 2008a); promoting existing social networks, including vulnerable groups; and reversing negative impacts on the living environment (Chan & Yung, 2004). Many studies have been conducted in the field of urban renewal or urban regeneration because of the role of urban renewal in solving urban problems. Simultaneously, sustainable development corresponds to urban renewal because the inherent meaning of sustainable development includes the three pillars of social, economic, and environmental sustainability. Urban renewal and sustainability should be integrated for realizing better urban development. The urban renewal process involves various planning issues and different stakeholders whose relationships make the urban renewal process complicated. Sustainable urban renewal practice requires informed decisions and a meaningful understanding of underlying mechanisms. This chapter reviews the relevant theories related to urban renewal and planning theories for urban renewal decision-making.

2.2 Sustainable Urban Renewal

2.2.1 Definition of Urban Renewal

Urban renewal, urban regeneration, urban redevelopment, and urban rehabilitation are widely applied in planning. These concepts share similar meanings, but they are sometimes used in different scales, situations, and regions. Urban renewal and regeneration share the same meaning and scale, but they are used in various ways in different regions. In the 1990s, urban renewal was defined as "the physical change or change in the use or intensity of use of land and buildings" (Couch, 1990: p.1). Many dictionaries define urban renewal as the process of slum clearance and the physical redevelopment of urban areas (Couch et al., 2011). This term goes further in some contexts. Urban renewal may include other elements that need to be improved, such as heritage conservation and rehabilitation. Urban regeneration, which is widely used in western countries, has been recognized as a comprehensive and integrated vision and action to resolve the multi-faceted problems of urban areas and to improve the economic, physical, social, and environmental conditions of deprived areas (Akkar Ercan, 2011; Roberts & Sykes, 2000). These two terms are employed generally for large areas or scales, emphasizing the renewal of targeted regions or areas in many aspects (social, economic, and environmental). Redevelopment and rehabilitation are more specific than the two former terms. Redevelopment is defined as any new construction on a site with preexisting uses, such as the redevelopment of an industrial site into a mixed-use development or the redevelopment of a block of townhouses into a large apartment building (De Sousa, 2008). Rehabilitation is interpreted as the renovation of decaying buildings to sound condition, operation, or capacity through some methods (Zheng et al., 2014). In summary, urban renewal or urban regeneration focuses on the physical, socio-economic, and ecological improvement of developed or decaying areas in cities; such improvement is achieved through a series of approaches including redevelopment, rehabilitation, and heritage preservation (Zheng et al., 2014). Redevelopment and rehabilitation are important approaches for renewal or regeneration. Renewal or regeneration is the final goal.

2.2.2 Complexity of Urban Renewal

Cities are major consumers of natural resources and main sources of pollution and waste (Nijkamp & Pepping, 1998). Cities are also places where people live and where natural and social systems integrate and interact (Mayer et al., 2005). "Considering the city a spatial-constructional and social system, we may outline two large sub-systems: town planning and social sub-system. While the town-planning sub-system includes all material elements of a city, including environmental factors that form the territorial structure, the social sub-system consists of the number of inhabitants as beneficiaries of the whole system." (Ristea et al., 2010: 103) These two sub-systems can be used as a reference to improve the understanding of the complexity of urban renewal. Planning sub-systems in the urban renewal process involves various issues, which include land, housing, facilities, culture and heritage, and transportation. Urban design is crucial for addressing these complex issues for sustainable urban renewal. Social sub-systems involve different stakeholders and their relationships. The whole process of urban renewal involves multiple stakeholders, and the people who plan, construct, finance, operate, and live in neighborhoods have specific preferences and interests (Mayer et al., 2005). Urban renewal initiatives are also characterized by the complexity of potential solutions (Mayer et al., 2005). One major challenge in dealing with various planning issues among different stakeholders is how to establish a discussion while creating a consensus (Randolph & Freestone, 2012).

2.2.2.1 Planning issues for sustainable renewal

Various planning issues need to be considered in the urban renewal process. These considerations include land, housing, facilities, culture and heritage, transportation, and urban design. These considerations form the material elements of a city planning system.

Land use

Sustainable land use is an important aspect of achieving sustainable urban renewal because land redevelopment is one form of reusing resources. Some researchers have paid attention to the process of meeting the demand for land resources in urban renewal. Urban renewal is often discussed in terms of whether it can resolve the issue of inefficient land assembly, which involves many difficulties. The conclusions of O'Flaherty (1994) suggest that urban renewal can potentially address the difficulties of land assembly to some extent. Land readjustment (LR) is discussed widely in different contexts. LR is regarded as an attractive approach to address the cooperation of existing property owners (Li & Li, 2007). LR can facilitate the assembly of scattered and irregular parcels of agricultural lands, building roads, and infrastructure lands into sub-divided urban parcels (Sorensen, 1999). LR was originally applied in rural land renewal, but it has been extended to urban environment in recent years. For example, some of the few successful urban cases that adopted LR for urban renewal were examined in China from the perspective of transaction cost theory; these investigations focused on the rationale of adopting this model for urban renewal (Li & Li, 2007). Krabben and Needham (2008) investigated the important role of urban land readjustment in enhancing value capturing in urban redevelopment in the Netherlands.

Other studies related to land issues in urban renewal were also conducted. Abu-Dayyeh (2006) found that the processes of land succession could contribute to the creation of opportunities for development and redevelopment by freeing a considerable amount of available land. Wang et al. (2014) developed a GIS-based framework to support the suitability assessment of land use for urban renewal projects.

Housing

Housing policy and practice can positively or negatively affect the sustainable development of urban areas (Winston, 2010). On the one hand, housing is the home of residents and is crucial for residents' quality of life and sense of well-being. On the other hand, various aspects of housing can leave a significantly negative impact on the environment and eco-system (Winston, 2010). Some researchers focused their attention on this issue. Garner (1996) used a number of cases as basis for exploring the role of housing and social housing in improving a city's competitiveness, as well as the revitalization and reintegration of areas of economic and social exclusion in urban renewal. Winston (2010) proposed the key characteristics of sustainable housing in urban regeneration from the perspectives of location, construction and design, use, and regeneration. The spatial distribution of public housing estates and its implications on urban renewal in Hong Kong were explored, which focused on access to social resources and rent levels (Zheng et al., 2015).

Infrastructure

Infrastructure or facility is another necessary consideration in planning for urban renewal. The provision of social infrastructure was assessed using futures analysis in Lancaster city; equitable access for residents was emphasized in delivering social benefits of social infrastructure in urban regeneration (Brown & Barber, 2012a). Mell (2009) addressed how green infrastructure can be planned to enhance human integration, ecological sustainability, and economic regeneration in the UK. Green hubs were discussed in terms of their potential to enhance community sustainability, cohesion, and engagement in the context of the UK (H. Burrage, 2011). The territorial disparities of commercial facilities in Romania were studied using the "point method"; such a method quantifies the equipment levels reached and compares available spaces (Ristea et al., 2010).

Culture and heritage

Culture is an element of urban design. Culture has the potential to promote social cohesion and market a city's brand (Degen & García, 2012). Degen and García (2012) studied the dynamic relationships between urban regeneration and the use of culture and modes of governance in the "Barcelona model," which is a prominent example of cultural regeneration. After proposing the view that cultural heritage can greatly contribute to sustainable urban regeneration, Tweed and Sutherland (2007) presented the results of a survey that was conducted to assess people's perceptions of cultural heritage in urban regeneration. An improved understanding of how people interact with the urban environment and its heritage is important.

Urban design

Urban renewal involves changes in the physical aspects and functions of cities (Couch, 1990). These two issues are closely interrelated with urban design, which is a process of making decisions about the investment of the location and physical fabric in the built environment and the adaption of these decisions to functional and aesthetic ends (Couch, 1990). A series of studies have been conducted to explore urban design in terms of addressing sustainable urban renewal. Urban design considerations in the sustainable urban renewal of Hong Kong were shortlisted, and the critical factors for enhancing social, economic, and environmental sustainability were proposed (Chan and Lee, 2008a; Chan and Lee, 2008b; Lee and Chan, 2008b).

2.2.2.2 Stakeholders and community involvement in urban renewal

Apart from planning sub-systems, various stakeholders are also involved in the city system. These stakeholders and their relationships form the social sub-system of a city in urban renewal.

Stakeholders

Various stakeholders, both domestic and international, are involved in urban renewal. These stakeholders may be local, regional, and national officials in environmental and economic development institutions as well as institutional and individual private sectors, who aim to place capital, reduce risks, gain profits, and enhance their reputation. The affected adjacent public should be included because of concerns about their health and quality of life resulting from urban renewal activities. Urban renewal policy and project implementation are greatly influenced and determined by different stakeholders, the characteristics of different partnership modes, the relationships between stakeholders, and the power, mechanism, and operation of different agents. Different stakeholders guide urban renewal toward different directions. Stakeholders do not have equal rights and powers in the renewal process.

The government plays the most important role in the governance structure that directly influences urban renewal policies and planning strategies. For example, the transition of governance structure from a traditional hierarchical government to new forms of governance in the UK was discussed. The Thames Gateway regeneration project was examined in terms of its institutional context and the relationship between traditional and new forms of planning (Greenwood and Newman, 2010). The results suggested that traditional forms of planning influence urban regeneration and provide insights into new planning forms that favor sustainable development (Greenwood & Newman, 2010). Brownill and Carpenter (2009) used the case of the Thames Gateway regeneration project to probe the relationship between the emergence of new forms of networked governance and the increasing emphasis on the integration of social, economic, democratic, and environmental objectives with planning practice. Researchers have examined how planners and policymakers in Birmingham and Barcelona addressed the challenges in the creation of new urban districts; they found that the institutional context within which leaders operate and exercise their roles in the regeneration process, as well as the prevailing planning culture, explains the different experiences in these two cities (Barber & Pareja Eastaway, 2010).

Private sectors also possess crucial power in the regeneration process. In most cases, private sectors act as developers that function as builders and investors of renewal projects. Builders and investors greatly influence the landscape and urban fabric, supply of domestic space, appearance of urban landscape, and the lives of residents (Kriese & Scholz, 2011). The role of private sectors in property investment and financing has been praised, but their negative impacts have also been identified. The evolution of sustainability positioning in residential property marketing was studied to shed light on the specific role and responsibility of housing builders and investors in sustainable urban regeneration (Kriese & Scholz, 2011). In response to evolving sustainability agenda, Bryson and Lombardi (2009) investigated the activities of two UK-based property development companies that have integrated sustainability into their business models as a source of competitive advantage.

The public or residents are the end users of a renewed community. The sustainability of the urban renewal of a community influences the daily life of residents. Their behaviors and their preferences exert simultaneous impacts on the decision-making of governments and private sectors. Scholars have probed into this group of stakeholders under various contexts. Bromley et al. (2005) determined the contribution of residents in sustainable urban regeneration after exploring the residential redevelopment of the city centers of Bristol and Swansea. These residents are frequent shoppers who thus support the local daytime economy. They walk to the attractions in the city center and to their places of work. This situation shows reduced reliance on private cars. A study in Manchester and Glasgow examined the characteristics of new residents, including their reasons for choosing to live in the two districts and the factors that affect their satisfaction with their new place of residence, in the urban renewal process (Seo, 2002).

Community Involvement

Social inclusion has become a crucial objective in the current urban renewal context. Issues on “community involvement” or “public participation” cannot be avoided when discussing sustainable urban renewal. For example, an examination of the urban regeneration policy and programs of OECD member countries showed that the improved coordination of public programs, promotion of sustainable development, and involvement of local communities are indispensable factors for resolving urban problems (Fordham, 1993). Bagaeen (2006) compared the processes of redeveloping former military sites in three countries by focusing on whether citizens participate in sustainability promotion. The author concluded that the redevelopment of military bases must balance the interests of all parties involved to improve competitive advantages through revenue-generating activities. Public participation is not necessarily positive because it may fall into tokenism. In addition to examining the findings of a study on a major regeneration program in Merseyside, Jones (2003) investigated whether participatory and partnership approaches have become problematic as a result of the participation experience of the "developing world." Cinderby (2010) aimed to improve the participation of "hard-to-reach" groups by proposing an innovative participatory GIS method; the aim of such a method is to overcome the obstacles to the engagement experienced by these "hard-to-reach" groups. The application of this method was illustrated with reference to three case studies in cities of the UK. Under the participatory context, partnership is a positive aspect of sustainable urban renewal. Partnership is defined as "a dynamic relationship amongst diverse actors, based on mutually agreed objectives, pursued through a shared understanding of the most rational division of labor based on the respective comparative advantages of each partner" (Brinkerhoff, 2002: 21). The functions and relationships of a partnership within a group of institutions that comprise the development chain of the Catholic Church was demonstrated to be "patchy" at all levels (Morse & McNamara, 2009). Given this issue, solving multifaceted problems and bringing sufficient resources to the development of urban renewal remain a challenge in sustainable development.

2.2.2.3 Different strategies used for urban renewal

Various strategies should be embraced to realize sustainable urban renewal. Decisions must be made on whether to rehabilitate old buildings or to redevelop entire sites. The aim of redevelopment is to eradicate existing dilapidated areas or to prevent existing areas from being transformed into slums (Warren, 1965). Land sites can be rearranged through redevelopment, thereby removing substandard buildings, eliminating incompatible land uses, addressing environmental problems, and improving the use of land lots (Yau & Chan, 2008). Capital investment from redevelopment could benefit local communities in social and economic aspects; these benefits include reduced crime, improved environmental hygiene, job creation, and strengthened economy (Stevens, 1995). Despite these benefits, redevelopment initiatives constantly involve massive building demolitions and displaced residents (Arthurson, 1998), which result in negative effects; these negative effects include expelling low-income and deprived groups, destroying existing community networks, and influencing local businesses. According to Keating (2000), redevelopment could disrupt individuals and communities and decrease social capital. The continuation of "sense of place" may cause negative effects as well (Oakley, 2007). Apart from social and economic issues, redevelopment may have further influence on the environment. For example, comprehensive redevelopment projects in Hong Kong produce massive waste, which would soon occupy all available landfill sites (Tam & Tam, 2007).

Rehabilitation is occasionally regarded as socially friendly because it does not require the relocation of residents (Ho et al., 2012). Rehabilitation plays an important role in the renewal process of old urban areas (Hui, Wong, & Wan, 2008). The financial benefits of rehabilitation have been identified as motivators of rehabilitation initiatives in obsolescent districts (Hui et al., 2008). Upgrading building quality through rehabilitation is a rapid and inexpensive process (Yau, 2008) that could improve the value of rehabilitated properties and their surrounding areas (Yau et al., 2008). Rehabilitation offers social benefits, such as enhancing community identity and reducing social asymmetries (Mourão & Pedro, 2007). Rehabilitation activities could avoid lengthy land assembly processes (Yau & Chan, 2008) and are environmentally friendly because of the low consumption of energy and materials (Ho et al., 2012).

Adaptive re-use is considered a sound strategy in architectural conservation and urban regeneration (Zaman, 2011). Regeneration led by urban refurbishment is regarded to be a cheaper, faster, and less disruptive alternative to demolition and redevelopment (Turcu, 2012). Regeneration led by urban refurbishment can potentially meet the demand for land resources. For example, Zaman (2011) studied a case of adaptation of a residential building to understand the local adaptive re-use process. Power (2008) adopted a holistic perspective in discussing the social, economic, and environmental benefits of refurbishment in comparison with that of demolition.

2.2.3 Why Sustainable Urban Renewal

The term "sustainable development" dates back to the 1970s, but only in the 1990s did it emerge in the field of urban planning and become linked to urban policy for urban regeneration (Bromley et al., 2005). Sustainability has no commonly agreed definition (Bromley et al., 2005). "Sustainable development" is considered a complex and ambiguous concept (Weingaertner & Barber, 2010). To understand this concept, a considerable number of studies have attempted to conceptualize sustainability in urban renewal under different contexts. Lorr (2012) discussed three of the most commonly applied perspectives of sustainability, which include inter- and intra-generational equity and justice perspective, comprehensive environmental perspective, economic perspective, and equitable change perspective, as well as free-market "greening" perspective. The author applied these perspectives in the context of North American cities and provided a working definition of urban sustainability that emphasizes multiple scales. On the basis of the three pillars of sustainability and the weak–strong sustainability continuum, sustainability was conceptualized in a case study of the Eastside regeneration in Birmingham in the UK (Lorr, 2012).

Regardless of the concept of sustainability, the only widely accepted perspective is the concept of sustainability development that comprises three pillars, namely, social, economic, and environmental/ecological sustainability. Urban renewal or urban regeneration is closely related to these three pillars because it is often aimed at solving a series of urban problems, including the deterioration of urban functions, social exclusion in urban areas, and environmental pollution. Urban renewal or urban regeneration has been regarded as a useful approach to augmenting land values and promoting environmental quality (Adams & Hastings, 2001b), resolving the urban decay problem and realizing socioeconomic objectives (Lee & Chan, 2008a), revitalizing existing social networks (including unprivileged groups), and rectifying negative impacts on the living environment (Chan & Yung, 2004). Urban renewal projects are initiated to repair dilapidated buildings (Ho et al., 2012), improve the quality of housing and reduce health risks for communities (Krieger & Higgins, 2002), and promote the effective use of buildings and land resources in urban areas (Ho et al., 2012). These perspectives suggest that urban renewal can become a sword that will benefit sustainable urban development. However, urban renewal actions may lead to unexpected results if their implementation does not follow sustainable approaches. Couch and Dennemann (2000) identified one problem, that is, environmental or social regeneration is often neglected by urban regeneration policies, whereas economic regeneration is prioritized in the renewal process. For example, an exploration of the redevelopment of a military site in Jordan revealed that although the development was characterized as a political commitment to “sustainable” urban regeneration, it was more profit-driven than to promote social and environmental improvement. The relationship between sustainability and urban renewal is complex, but their linkage provides a potential direction for sustainable urban renewal.

2.3 Decision Support for Urban Renewal

2.3.1 Neighborhood Planning

Definition of neighborhood

The term "neighborhood" is commonly used in different contexts, especially in the field of urban studies, despite the lack of consensus on its definite meaning. "Community" is sometimes used as an alternative to neighborhood. These two terms are undefined and used interchangeably in most circumstances, but they have obvious differences. Before exploring the inherent meaning of neighborhood planning, the common interpretation of scholars, planners, and decision makers on the concept of neighborhood and the differences between a neighborhood and a community should be discussed.

Neighborhoods are places where people live; they concern urban residents the most because their daily life is largely influenced by what happens in their neighborhoods (Rohe, 2009). The size of a neighborhood is defined differently by different scholars, but one common recognition is that neighborhoods are sub-divisions of towns and cities with different physical or social features (Rohe, 2009). Previous research provides insights into the inherent characteristics of neighborhoods. Mumford (1954) defined neighborhood as an "important organ of urban life" where people are linked together and live interdependently. Keller (1968, p. 91) summarized four dimensions in the concept of neighborhood. The first dimension is "a physical delimited area having an ecological position in a larger area and particular physical characteristics." The second one is "an area containing such facilities as shops, clubs, schools, houses, and transportation that may be used by those living in the area or by outsiders." Third, it is "an area representing certain values both for the residents and for the larger community." The fourth dimension is "a field or cluster of forces working in and on an area to give it a special atmosphere." Clay and Hollister (1983, p. 6) applied the following three aspects to explore the nature of neighborhood: "(1) typologies, (2) stages, and (3) functions which comprise economic, administrative, political, as well as socialization and sociability functions." According to Hallman (1984, p. 12), "a neighborhood is a territory, a small area within a larger settlement. It contains dwellings occupied by people, and usually community facilities and buildings with other uses." According to Galster (2001, p. 2112), a neighborhood is "a bundle of spatially based attributes associated with clusters of residences, sometimes in conjunction with other land uses." Even though the definitions of neighborhood hold various elements, delineated neighborhoods as communities are one of the most predominant meanings (Martin, 2003). In summary, a neighborhood could be qualitatively described as a geographically delineated sub-area within a city where residents sometimes share services, facilities, and common interests. A neighborhood is not a separated area in a city, but it is connected to the other areas of the city. People, physical places, and social connections are the three most basic elements that define a neighborhood. The sizes of neighborhoods may vary because of different contexts and applications.

The meaning of community focuses on a group of people who share similar values, interests, culture, careers, and beliefs (Park & Rogers, 2015; Peterman, 2000). A number of studies have identified a connection between neighborhoods and homes. Local places are linked to homes with a nurturing familial identity and purpose (Aitken, 2000). This concept of home emphasizes neighborhoods as places where families gather together and communities thrive; this concept represents a connection between neighborhoods and communities (Martin, 2003). The concepts of community and neighborhood can be conflated to some extent, although some sociologists and geographers insist on the separation of these two concepts. They argue that equating communities to neighborhoods can obscure social connections at various scales and boundaries (McCann, 2003; Raco & Flint, 2001). Compared with the concept of community, the concept of neighborhood consists of another geographic dimension of bonding apart from the social dimension of bonding as a common understanding of both concepts. Geographic place or a spatially delineated place at the local scale is the most noticeable element in distinguishing a neighborhood from a community.

Neighborhood planning theories

The garden city model was proposed by Ebenezer Howard in 1898. This city model suggests the development of a self-sufficient village within a city to exclude the disadvantages of the city and to embrace the beauty of the countryside (Peterman, 2000). The model describes a section called a "ward" in a city that includes schools, religious institutions, or libraries in 1,000 acres of land with 5,000 people (Howard & Osborn, 1965). This model influences planning theories.

The most famous and earliest theory in neighborhood planning is Clarence Perry's neighborhood unit theory proposed in 1929. This theory specifies the ideal size and design guidelines for residential development at the urban neighborhood scale. Furthermore, this theory recommends the formation of a residential neighborhood with

160 acres of land and 5,000 (up to 9,000) people (Perry, 1929). Six principles were proposed for the formula of a neighborhood unit: (1) the size of each neighborhood should be large enough to sustain an elementary school, (2) trunk roads along neighborhood boundaries should be constructed to prevent cut-through traffic, (3) a central gathering place and small dispersed parks should be placed in each neighborhood, (4) schools and other institutions should be at the center of a neighborhood, (5) local shops should be set up at the margin of a neighborhood, and (6) traffic should be discouraged by designing the street system of the internal neighborhood (Perry, 1929).

Despite the disputes over the neighborhood unit theory, it has provided insights into neighborhood-based design concepts, including planned unit development (PUD), traditional neighborhood development (TND), and transportation-oriented development (TOD) (Park & Rogers, 2015).

Postwar suburban development in the USA was criticized in a series of problems, including long commuting distance, traffic congestion, reduced opportunities for recreation and walking, environmental pollution, decreased natural habitats, high infrastructure costs, and loss of communities (Arendt, 2012; Bookout, 1992a, 1992b; Mandelker, 2007). The concept of PUD was first introduced by a planner to respond to suburban development in the 1960s. PUD is “a land development project comprehensively planned as an entity via a unitary site plan which permits flexibility in building siting, mixtures of housing types and land uses, usable open spaces, and the preservation of significant natural features” (So et al., 1973, p. 2). PUD provides developers with an opportunity to initiate integrated development with various land use types and mixed housing types. Reduced compliance with rigid and highly specific development regulations was observed because the proposals can go through a review process with general standards (Rohe, 2009). However, typical PUD has been criticized on several aspects. For example, its use of wide, curvilinear, and cul-de-sac street patterns leads to unnecessary costs, limited connectivity, and lack of a sense of community. Many PUD designs have also been criticized because of the lack of pedestrian amenities (Rohe, 2009).

To respond to the shortcomings of PUDs, Duany et al. proposed TND in 1991. Thereafter, some municipalities adopted special TND ordinances from a model ordinance developed by Duany et al. (1992). TND could be summarized into the following elements: “1. Mixed uses including a range of housing types and costs, retail shops, schools and workplaces; 2. Moderate- to high-density development including small single-family lots, multifamily development, and multistory buildings; 3. A mixed-use community core within one quarter mile of all residents; 4. A grid or semi-grid street system with pedestrian amenities; 5. Single-family houses close to the street with unified setbacks and front porches; 6. Automobile parking and garages in the rear of the units, reached via rear service drives; 7. Common open spaces distributed throughout the neighborhood; 8. Common architectural and landscaping standards based on the climate and culture of the area; and 9. Convenient access to mass transit” (Rohe, 2009, p. 18).

TOD is a relative concept to TND (Calthorpe & Fulton, 2001). TOD principles have become fashionable in Western Europe and North America over the last few decades (Pojani & Stead, 2014). TOD emphasizes walkability, relatively high density, and compact and mixed land use (Rohe, 2009). The main difference between TOD and TND is that mixed-use development is near or oriented to mass transit facilities. In the

USA, TOD is regarded as a major part of a broad and smart growth approach to urban development (Goetz, 2013). TOD is not easy to implement in the places where car ownership is high and suburban development is predominant just like Britain and North America. By contrast, TOD has been delivered sufficiently in some mega cities in Asia, including Hong Kong, Singapore, and Tokyo, where urban development exists around rail transit stations (Loo et al., 2010; Murakami, 2011) .

Some organizations focus on neighborhood planning. For example, the Community Action Program (CAP) and the Model Cities Program in the USA are aimed at solving central neighborhood problems, involving citizens in design and implementation stages, as well as improving social, political, economic, and physical aspects (Rohe, 2009). Given the CAP's inadequate attention to economic development, many community development corporations (CDCs) were developed in the late 1960s (Perry, 1987) . These CDCs are nonprofit organizations developed by local communities that focus on the physical and economic improvement of neighborhoods (Rohe, 2009). The significant influence of the CDC approach on neighborhood planning can be seen in the recent number of CDCs, which is over 4,600 across all 50 states of the USA (Community-Wealth.org, 2015).

The term "urban renewal" has emerged as a response to dilapidated housing and infrastructure in central cities around the world. The concept is closely related to neighborhood planning because a number of urban renewal programs around the world focus on neighborhood betterment in central cities. Rohe (2009) discussed urban renewal as a form of neighborhood planning in the USA. The connection between urban renewal and neighborhood planning can also be observed in the influence of urban renewal initiatives on communities. For example, some urban renewal programs in the USA have been criticized for destroying existing communities and thereby causing segregation (Fried & Gleicher, 1961; Gans, 1962; Jacobs, 1961). Urban renewal could make a difference in a community if neighborhood planning is delivered effectively.

2.3.2 Evaluation of Urban Renewal

A policy perspective indicates the significance of early, persistent, and rigorous evaluation of regeneration initiatives because existing programs can be improved or be terminated (Hemphill et al., 2004). Achieving the most sustainable outcomes requires the monitoring of the urban regeneration process throughout its life cycle to propose other practical strategies (Cahantimur et al., 2010). In summary, the evaluation of urban renewal can provide stakeholders in urban renewal with an improved understanding of current or future performance and improve their strategies or solutions for sustainable urban renewal.

Evaluating the whole process of urban renewal

Renewal projects should be selected before making decisions. The combination of the fuzzy Delphi method, analytic network process, and zero-one goal programming was proposed for the selection of an urban renewal project in Taichung, Taiwan (Wey & Wu, 2008). The dilapidation index was presented in Hong Kong to assess building conditions; this index can reflect the need of renewal projects (Ho et al., 2011). The UK adopts a national metric called the index of multiple deprivations that measures the need for regeneration. Localization is emphasized to facilitate the implementation of this index (Greig, El-Haram, & Horner, 2010).

In the renewal process, some conflicts may exist between various stakeholders and risks because of the system and political complexities of urban renewal initiatives (Mayer et al., 2005). Researchers have paid close attention to overcoming these problems. A conflict−risk assessment model based on fuzzy-failure mode and effect analysis was proposed for an urban regeneration project in Korea. The case study shows that this model can aid the project manager in managing the risk of an urban regeneration project by identifying critical conflict−risk types that require immediate corrective actions (Yu & Lee, 2012). Kim (2010) presented a risk performance index to enhance the efficiency of the general performance measurement for mega urban regeneration projects. The effectiveness of community involvement in urban regeneration is another important issue. After examining the nature of community involvement in urban regeneration partnerships, the "wheel of involvement" model was proposed to analyze the effectiveness of community involvement (Smith & Beazley, 2000).

After initiating urban renewal projects, the approaches for assessing their performances and accompanying feedback should be selected. For instance, the largest urban redevelopment project in Hong Kong (Kwun Tong Town Center) was evaluated from the economic perspective by employing a risk-based option model, that is, the Samuelson−Mckean model (Hui, Ng, & Lo, 2010). An urban transformation project with multiple objectives in Turkey was evaluated using the analytic hierarchy process (Demir & Yilmaz, 2012).

Evaluating the three aspects of urban renewal

The evaluation of regeneration is generally performed from the perspective of area-based regeneration. Given that sustainability and urban renewal surround social, economic, and environmental aspects, the evaluation of sustainable urban renewal must be grounded on these three pillars. Some researchers focus on social and economic aspects. Bäing and Wong (2012) examined the impact of urban residential brownfield development on the most impoverished areas by evaluating their changing housing market, residential density, population growth, and economic deprivation. In the older parts of Sydney, housing, as well as investment characteristics and trends of household and housing, are explored by applying socio-demographic and development application data (Randolph & Freestone, 2012).

Some studies have focused on the environmental impacts of urban renewal areas or programs. Collier (2011) discussed how the changes caused by regeneration projects influence the quality of local weather and air in the Greater Manchester area in northwest England in the long term. The impacts of the proposed development on air quality were assessed in a 6.6 ha case study in Lancaster in the UK (Pugh et al., 2012). The environmental impacts of maintenance, consolidation, transformation, and redevelopment of two typical cases in Dutch urban renewal were compared by using the life cycle assessment method (Itard & Klunder, 2007).

Turcu (2012) adopted a holistic perspective to discuss the impacts at the local level in the UK; this study probed into three neighborhoods and considered several aspects, including housing and the built environment, economy and jobs, local communities, use of resources, and local services and facilities. In Budapest, the sustainability of property development in urban regeneration was evaluated in terms of physical, social, and economic aspects (Kauko, 2012).

Approaches for evaluating urban renewal

Urban regeneration is being increasingly evaluated following an indicator-based approach because of the consensus that indicators can contribute to the assessment of the combined performance of individual agencies/interventions, the overall effectiveness of partnerships in improving economic well-being, and the cost-effectiveness of main regeneration activities (Hemphill, et al., 2004). Despite the several sets of indicators or frameworks, no agreement has been reached on the application of this type of approach. Indicator-based methods of evaluating urban renewal include qualitative discussion and quantitative assessment. The key characteristics of sustainable housing in the city scale, which include *location, construction and design, use, and regeneration,* have been identified to assess housing and regeneration in Dublin since the early 1980s (Winston, 2010). On the basis of the principles of *encouraging participation, building community character, advancing equity, improving environment, and enlivening the economy*, Ng (2005) developed quality of life indicators for assessing sustainable urban regeneration in Hong Kong. Several papers have focused on the district level using an indicator-based approach or assessment framework (Berg et al., 2010; Boyko et al., 2012; Cahantimur et al., 2010; Cheng & Lin, 2011; Wedding & Crawford-Brown, 2007; Williams & Dair, 2007; Hemphill, et al., 2004a; Hemphill et al., 2004b), but the selection of factors in each study differs. For example, Hemphill et al. (2004a) developed an approach for measuring the performance of regeneration by using indicators related to *the economy and work, resource use, buildings and land use, transport and mobility, and community benefits*. In their later paper, they applied this approach to several case areas and conducted a sensitivity analysis (Hemphill et al., 2004b). To provide a reference for stakeholders in brownfield redevelopment, Wedding and Crawford-Brown (2007) proposed 40 indicators (involving four categories: *environment health, finance,* *livability, and social economic*) of successful brownfield redevelopments with their corresponding weights. In addition, a framework including *identifying the stakeholders in land reuse* and *assessing sustainability objectives to be achieved on reused sites* was presented to assess the sustainability of brownfield developments (Williams & Dair, 2007).

Planning follows the evaluation of current performance, prediction of the future, and proposal of corresponding strategies and solutions. Thus, future-based approaches are also applied to evaluate urban renewal. Future scenarios have not been applied in depth, but they can be a potentially helpful approach to scrutinizing existing and potential plans and providing valuable insights for decision-making in the name of sustainable development. For instance, a strategy for balancing the supply and demand of water resources at the local level of a proposed urban regeneration site in north west England was assessed using four future scenarios; this approach determined how current "sustainable solutions" can cope with the future (Farmani et al., 2012). Scenarios are sometimes combined with indicator-based methods. Urban Future, a toolkit developed in the UK, evaluates the performance of urban renewal. The toolkit comprises a group of indicators and a list of characteristics that describe four future scenarios (Boyko et al., 2012). Caputo et al. (2012) applied this toolkit to assess three energy conservation strategies for a flagship regeneration project. The analysis demonstrated that the solutions are vulnerable to unpredicted future events, and the conclusion provided insights into the improvement required at present. This toolkit has also been used to assess the sustainability of sub-surface environments (including infrastructure and utilities) through cases in the UK (Hunt et al., 2011).

2.3.3 Sustainability Assessment

Since the introduction of sustainable development in the Brundtland report, the concept has become an important policy objective around the world. Given its generous definition, sustainability must be discussed in different contexts. Over the past few decades, numerous assessment tools have been developed at different scales to facilitate decision-making and to improve the sustainable performance of the urban environment and the elements within it.

City sustainability assessment

The sustainability assessment of a city has become a significant research agenda because of the growing number of populations moving to cities (Grimm et al., 2008). Sustainability assessment is considered a technical approach to assessing the performance of sustainability and a favorable tool for mediating various stakeholders (Thomson et al., 2009). A comprehensive sustainability assessment of urban systems, particularly one that includes social, institutional, and cultural aspects, is the research frontier of this field (Chester et al., 2012). The methods of sustainability assessment range from single indicator (index), which focuses on one particular aspect of sustainability, to comprehensive composite indicators (Lin et al., 2010).

The human development index (HDI), index for sustainable economic welfare, ecological footprint (EF), and environmental pressure indicators are examples of single indicators (Nourry, 2008). Most case studies are conducted by integrating these indicators, including the HDI and EF. Lin et al. (2010) proposed a method of sustainability assessment based on urban eco-efficiency and applied it to assess the urban sustainability of Xiamen City in China from 2000 to 2006. Browne et al. (2012) applied energy flow accounting, ratio analysis of energy flow metabolism, and ecological foot-printing in the measurement of urban sustainability in an Irish city; they then compared the effectiveness of different methods in assessing urban sustainability.

Most studies use composite indicators. These holistic approaches can offer overall assessment (Lin et al., 2010), which corresponds to the concept of sustainability. For example, an integrated urban sustainability indicator model was proposed to evaluate urban sustainability through a hierarchical index system. The quantification of indicators requires traditional statistical methods and geospatial techniques (Shen et al., 2013). The compass index of sustainability was developed for Orlando, Florida, to assess city sustainability; the compass index was constructed by clustering indicators into nature (N), economy (E), society (S), and well-being (W), which relate to the four points on a compass (Atkisson & Lee Hatcher, 2001). An integrated index was selected for Taipei, Taiwan, to determine city sustainability; this index includes 51 sustainability indicators (Lee & Huang, 2007). The sustainability of four medium-sized cities in China were assessed (Van Dijk & Zhang, 2005) by referring to an urban sustainability index (Zhang, 2002). These integrated models or frameworks simultaneously focus on several aspects to provide references for developing other urban sustainability assessment tools.

Neighborhood (or community) sustainability assessment

Neighborhood is recognized as the scale at which land development and the construction of new buildings take place and a favorable point for building a sustainable community (Sharifi & Murayama, 2013). Unlike research on sustainability assessment at the city scale, only a few academic studies have focused on the neighborhood scale (Blum, 2007; Hurley & Horne, 2006), but they have developed some standard tools. The Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND), Comprehensive Assessment System for Building Environmental Efficiency (CASBEE), Building Research Establishment's Environmental Assessment Method (BREEAM), and Building Environmental Quality for Sustainability through Time are examples of well-known assessment tools for urban communities. These assessment tools were developed on the basis of different contexts worldwide. Locality is a crucial aspect of different tools. Some researchers have examined these tools accordingly. Garde (2009) studied LEED-ND pilot projects to explore the extent of inclusion of certain planning and design criteria; the effectiveness of this tool was further evaluated in terms of sustainability enhancement. Haapio (2012) recently examined LEED-ND, BREEAM Communities, and CASBEE for Urban Development. Two neighborhood assessment tools, namely, Sustainable Community Rating Tool and Enviro-Development, were examined with respect to their applications to residential estate development (Hurley, 2009).

Building sustainability assessment

A considerable number of studies on the sustainability assessment of construction projects have focused on the assessment of the environmental performance of buildings (e.g., Crawley & Aho, 1999; Cole, 1998; Ding, 2008). Performance-based approaches focus on the outcomes ("end") (Bragança et al., 2010) . The significance of sustainability in the context of building design and subsequent construction work is reflected in the assessment of environmental buildings (Ding, 2008). Examples of approaches to green building assessment include LEED, Green Building Tool (Cole & Larsson, 2002), and BREEAM (Baldwin et al., 1998). These methods assess building performance on the basis of the performance standards and physical features of buildings (Kaatz et al., 2006). Assessment methods for green buildings cannot fully meet the requirements of sustainable construction (Kaatz et al., 2006). Sustainable construction requires sustainability values to be reflected in the decisions of stakeholders (Kaatz et al., 2006). Sustainable values are realized through a life cycle process. Some methods of assessing building sustainability are produced based on construction processes. Eco-Quantum (Netherlands), Eco-Effect (Sweden), ENVEST (U.K.), BEES (U.S.), and ATHENA (Canada) are examples of life-cycle assessment (LCA)-based tools (Bragança et al., 2010).

2.3.4 Technical Planning Support

Information and communication technologies applied in urban renewal decision-making

The relationship between information and communication technologies (ICTs) and urban regeneration is highly complex. The perspectives of investigations within international contexts have been debated (e.g., Ghose, 2001; Graham, 2002; Kingston et al., 2005; Southern, 2002; Southern & Townsend, 2005). Advances in geo-information and visualization technology can facilitate urban renewal decision-making and community participation. Some researchers have discussed the potential of applying these tools to urban renewal decision-making. Deakin et al. (2011) examined whether information technology under the set of interoperable e-government services can support the crime, safety, and security initiatives of socially inclusive and participatory urban regeneration programs. The specifics of urban renewal processes in the Netherlands were studied to determine the extent to which recently developed 3D geo-information technology, specifically multiple 3D representations, can enhance the different phases of urban renewal (Zlatanova et al., 2010). Remote sensing was applied to decipher the spatial patterns of land use transformation and expansion with urban renewal in Pudong area of Shanghai. The result indicates that urban land use structure is gradually optimized during vigorous urban renewal and large-scale development; such a process exerts a positive effect on the urban space landscape and the quality of the ecological environment (Dai et al., 2010) .

The GIS tool, which was one of the most popular ICTs in the 1970s, is a new approach to organizing spatial data in computers and a tool for information processing (Ceccato & Snickars, 2000). GIS has been widely applied to solve many spatial problems. The impact of the development of residential brownfields on the most deprived urban areas of England from 2001 to 2008 was assessed under the context of urban renewal; the assessment was based on changing housing market, residential density, population growth, and economic deprivation through GIS analysis and variance test analysis (Bäing & Wong, 2012). The urban climate map system, which can enable compact cities to incorporate climate effects in planning processes, was developed through a GIS platform. This system is a useful platform of climatic information for the daily on-going work of local planners and policymakers (Smith & Beazley, 2000). Some articles explore the effectiveness of using GIS. Ceccato and Snickars (2000) studied an urban renewal project of a residential area in Stockholm of Sweden; they concluded that GIS, in combination with the Internet for social analysis in renewal planning, can promote involvement whilst identifying future challenges of using GIS techniques. Hui et al. (2010) explored the potential of a GIS-based approach (Baltimore's CitiStat e-government program) in city management to realize the goals of sustainable urban regeneration. In their work, CitiStat failed to provide a physical solution to urban problems. GIS is sometimes combined with other systems or tools to address community problems. For example, a prototype system called coordinator for rational arguments through nested substantiation was integrated with GIS; the effectiveness of this system in handling community conflicts was demonstrated through an actual consultation exercise of an urban regeneration scheme in London (Demir & Yilmaz, 2012).

Planning Support System (PSS)

(1) Definition of PSS

Planning support systems (PSSs) are defined as computer-based geo-information instruments that can assist urban planners in exploring their particular activities, foresee future alternatives, and propose an improved plan (Taleai, Sharifi, Sliuzas, & Mesgari, 2007). Most PSSs for storing, managing, and displaying spatial data are based on GIS (Geertman et al., 2013). These systems always support problem diagnosis, data collection, mining and extraction, spatial and temporal analysis, data modeling, visualization and display, scenario projection, plan formulation and evaluation, and collaborative decision-making (Taleai et al., 2007). Specifically, a PSS consists of three sets of components, namely, identification of planning tasks and current problems, system models, and methods that inform the planning process through analysis; projection and evaluation; and the conversion of basic data into information that in turn acts as basis for modeling and design (Pirrone et al., 2005). PSSs emerged in the field of planning in the mid-1990s when geo-information technologies were gradually applied to facilitate and promote planning performance (F. Dai, Lee, & Zhang, 2001).

Spatial decision support systems (SDSSs) are closely related to PSS. SDSS originated from decision support systems (DSSs). DSSs emerged in the late 1950s as a means of addressing decision-making processes by presenting and structuring large volumes of complex information in a simple and interactive way (Bäing & Wong, 2012). DSSs have been widely employed in the field of planning. An SDSS for tenants was developed for Australian public tenants to improve the outcomes of their forced relocation (Bäing & Wong, 2012). The simulation game is another promising tool for collaborative decision-making in urban renewal. Simulation is often combined with DSSs. The modeling environment for design impact assessment (MEDIA) is a DSS adapted from the Analysis of Interconnected Decision Areas. The combination of MEDIA with a simulation game to support sustainable urban renewal projects is positive for decision-making (Mayer & De Jong, 2004; Mayer et al., 2005). SDSSs are mainly designed for short-term operational decision-making, whereas PSSs are geared toward strategic planning activities. PSSs are valuable tools that support planners in addressing complex planning processes, producing plans with high quality, and accumulating savings in terms of time and resources (e.g., Stillwell et al., 1999; Geertman et al., 2013) .

(2) Application of PSS

The appearance and advantages of PSSs stimulate the investigation of their applications. "What if?" is a popular toolkit of PSSs; it includes geospatial visualization, collaborative decision-making, and scenario-based analysis (Klosterman, 1999). Several researchers used "What if?" as basis to address problems in land use planning and assessment, land use forecasting, evaluation of growth management strategies, and scenario analysis of sustainable urban development (Ludin et al., 2006; Pettit & Pullar, 2004; Pettit, 2005; McColl & Aggett, 2007). Other studies were conducted using other systems or models. The Land CONsolidation Integrated Support System for planning and decision-making is applied by integrating GIS, artificial intelligence techniques, and multi-criteria decision methods to resolve land consolidation problems (Demetriou et al., 2013). The LUPIS system (Ive, 1992; Ive &

Cocks, 1988) was applied in an area of the Valencian Mediterranean to create alternative land use plans and thereby solve the issue of the suitability of land areas in land use competition (Recatalá et al., 2000). The iCity software tool, which is an extension of the traditional cellular automata (CA) model, was proposed in GIS to predict urban growth (Stevens et al., 2007). UrbanSim was developed to correspond to linking planning of land use, transportation, and environmental quality; it can be applied to manage the negative effects of growth such as sprawl, congestion, housing affordability, and loss of open space (Waddell, 2002). Other PSSs include, but are not limited to, CommunityViz, Smart Places, MEPLAN, and SLEUTH. Some studies have applied and adapted these PSSs to facilitate decision-making. For example, EmiquonViz, adapted from the CommunityViz Scenario Construction extension, was proposed to facilitate examination of hypothetical scenarios related to recreational use and a lodging facility in a naturalized floodplain (Nedović-Budić, Kan, Johnston, Sparks, & White, 2006). SLEUTH-3r, as a new version of the SLEUTH cellular automata model, was developed to improve the capability of SLEUTH by incorporating economic, cultural, and policy information, opening up new avenues for the integration of SLEUTH with other land use change models (Jantz et al., 2010).

Different approaches to developing models for decision support

Qualitative and quantitative methods have been used recently to explore the mechanism of land use, transportation, and urban development. Various models are widely applied to facilitate the understanding of dynamics and to predict future alternatives to enhance decision-making. Land use models are helpful tools for understanding the complex mechanism of social, economic, and physical variables that influence the change and spatial distribution of land use and for evaluating the impacts of land use changes (Verburg et al., 2004; Braimoh & Onishi, 2007); they can provide informed decisions and further improve land use planning and land-related policies (Braimoh & Onishi, 2007). Some models can also be used to predict future scenarios (Verburg et al., 2004; Agarwal et al., 2002).

Urban development is often simulated by applying CA. The current state of a cell depends on its previous state and its neighborhood on the basis of a set of rules (Santé et al., 2010). A probability surface is obtained for future transitions of land use by analyzing historical changes. This process was first applied to geographic modeling problems in the 1970s (Tobler, 1979). In the 1980s, some researchers began to study urban expansion by applying CA-based models (Batty & Xie, 1994; Couclelis, 1985). This approach is appropriate for short-term predictions, but it cannot predict changes when the demands for different land use types change. This approach can only simulate the conversion of one land use type in most cases (Verburg et al., 2002).

Models at the micro-level are usually interpreted as a function of the behavior of individuals and the corresponding impact (Verburg et al., 2004). Multi-agent models are most widely applied at this level. This type of model analyzes the decision-making of key actors in the system (Parker et al., 2003). Agents are essential elements in this type of model, and their behaviors are based on their autonomous goals for the environment (Parker et al., 2003). An agent-based model considers individual decision-making agents, their interactions, and related social processes (Matthews et al., 2007). Most current multi-agent models only focus on simple systems because the number of interrelated agents and factors is large, thereby increasing the difficulty of developing comprehensive models (Verburg et al., 2004). Sufficient data at the individual/household level can improve the effectiveness of this type of model. However, such data are difficult to acquire from individuals at the micro-level.

Other models based on multidisciplinary considerations and various modeling techniques are classified into integrated models; this classification probably best explains the process of land use change (Guan et al., 2011). The CLUE modeling framework is a famous integrated model that was developed at Wageningen University and first published in 1996 (Veldkamp & Fresco, 1996). This model has been widely applied in different regions to address a wide range of issues, including agricultural intensification, deforestation, land abandonment, and urbanization (Verburg & Overmars, 2007).

In summary, these technical tools can be adopted in the decision-making process. Table 2.1 summarize the relevant technical tools for planning support, which can be analyzed for further application in the proposed framework.

Table 2.1 Technical tools to support planning

Category	**Example**
Information, Community, and Technologies	✧ Geographic Information System ✧ Remote Sensing ✧ 3D geo-information technology ✧ Building Information Modelling
Examples of Planning Support Systems	✧ What if? ✧ CommunityViz ✧ Smart Places ✧ UrbanSim ✧ MEPLAN ✧ SLEUTH ✧ NatureServe Vista
Approaches to developing models for decision support	✧ Cellular Automata Model ✧ Agent-based Model ✧ Other Integrated Models

2.4 Research Trends and Gaps

2.4.1 Research Trends

A literature review of sustainable urban renewal and decision support can reflect the complexity of urban renewal systems and implicate the path of decision-making that leads to sustainable urban renewal (see Figure 2.1). Urban renewal inherently involves different complex dimensions. Various issues, different stakeholders, multiple solutions, and diverse scales are closely related, which poses complexity and uncertainty to urban renewal. These issues include buildings, land use, facilities, transportation, and urban design. Stakeholders range from public and private agencies to community and individuals with different roles. Multiple strategies or solutions can be adopted in urban renewal. Examples of these strategies are redevelopment, rehabilitation, revitalization, land readjustment, adaptive re-use, and preservation. Diverse scales in urban renewal consist of city, district, neighborhood, and building block. To promote decision-making, these dimensions must be considered in the analysis and evaluation of urban renewal. Planning-related theories and technical tools (GIS, RS, and 3D) act as the basis and support of the analysis and evaluation of urban renewal. Decision-making can be supported through analysis and evaluation process to further contribute to the realization of sustainable urban renewal.

Previous and current literature can point out the research foci in several areas. Table 2.1 provides a summary of the research foci in decision-making for urban renewal. Research on the theoretical development of the urban planning field focuses on different issues in urban systems. In terms of decision support, optimization of land use is an area that attracts considerable attention. Urban design has been discussed in some studies, whereas neighborhood planning is not sufficiently investigated. The role and power of stakeholders and their relationships are explored sufficiently in the theoretical development of social systems. Community engagement has increasingly attracted the attention of scholars. Assessment is the most widely studied topic in urban sustainability. Some studies have explored the strategies and approaches to sustainable development. The current hotspots in technical applications are various simulation models and planning support systems. Technologies include building information modeling (BIM), GIS, and RS; 3D, in particular, has become increasingly popular in recent decades.

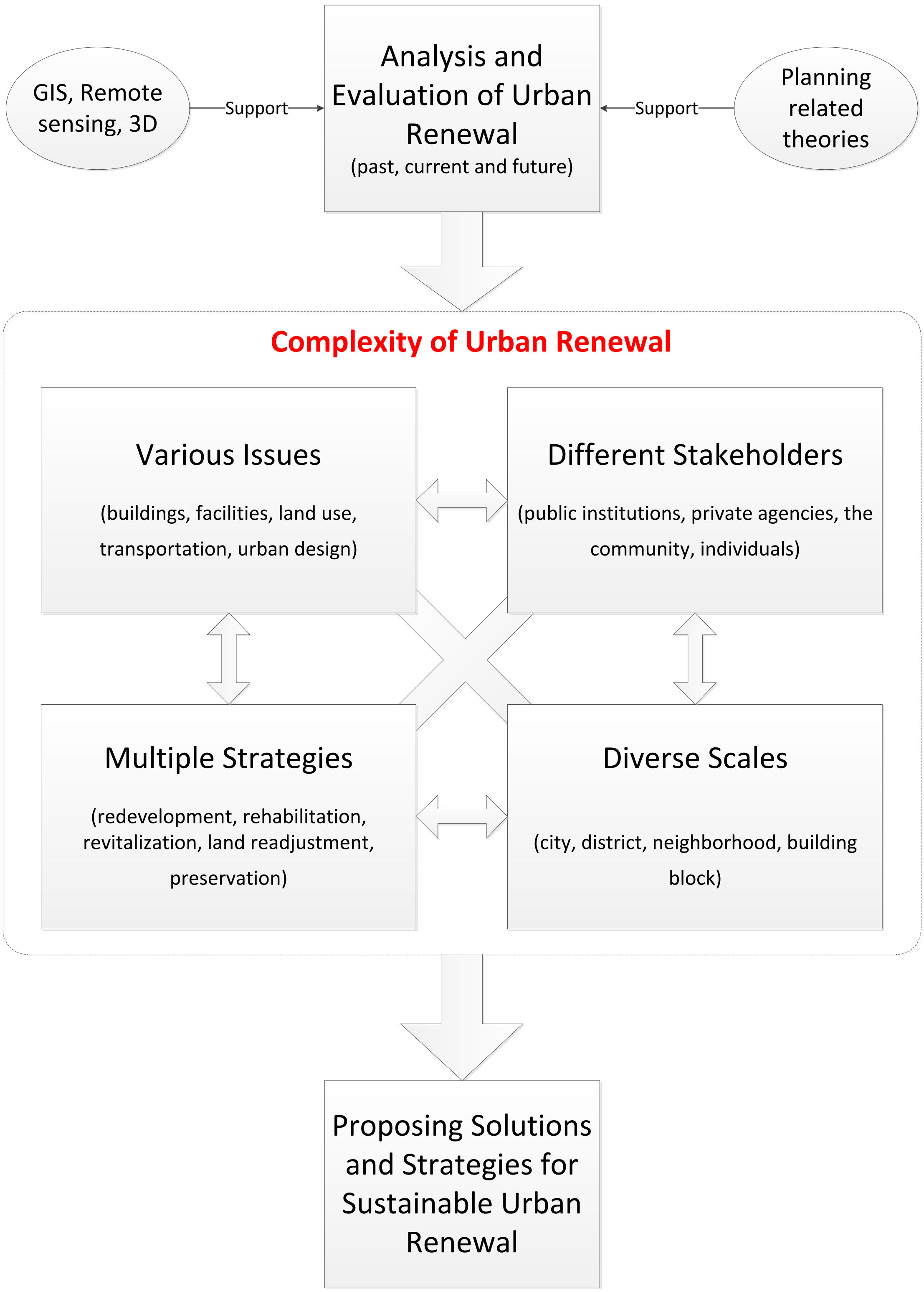

Figure 2.1 Path of decision-making leading to sustainable urban renewal

Table 2.2 Research trends in decision-making for urban renewal

Main Category	**Sub-category**	**Research focus**
Theoretical development	Urban planning	✧ Different issues in urban system ✧ Optimization of urban form ✧ Application of urban design ✧ Optimization of land utilization ✧ Neighborhood planning
	Social system	✧ The role and power of different stakeholders ✧ Various partnerships ✧ Community engagement
	Urban sustainability	✧ Sustainability assessment ✧ Sustainable strategies and development modes
Technical application	Simulation models	✧ Cellular automata (CA) model ✧ Agent-based model ✧ Integrated model ✧ System dynamics model
	Planning support system	✧ Integrated database development ✧ Spatial Decision Support Systems (SDSS) ✧ Scenario analysis ✧ Collaborative working
	Technology application	✧ The application of BIM, GIS, RS, and 3D

The new trends in decision-making for urban renewal are aligned with social aspects and new technology applications. Given that civic awareness is gaining attention, social issues in urban renewal are increasingly being emphasized in practice. Therefore, research on community engagement and public participation in the decision-making process has been recognized as significant. New methods and models for social simulation are considered new trends. Given that neighborhoods stand at the community scale, neighborhood development modes/approaches in neighborhood planning have also emerged as new trends. New modes of partnership are considered research frontiers. Another new research trend is the application of new technologies to support decision-making for urban renewal; such technologies include big data application, unmanned aerial vehicle (UAV), and virtual reality (VR). Improvement in PSSs also requires additional efforts because these systems enable decision makers and the community to capture various issues in the decision-making process. Qualitative GIS, participative GIS application, and 3D visualization can be integrated in PSSs. Table 2.2 presents the research trends in the area of decision-making support for urban renewal.

Table 2.3 Research trends in the field of decision-making support for urban renewal

Category	Sub-category	New trend
Theoretical development	Urban planning	✧ New modes for neighborhood development
	Social system	✧ New modes for partnership (e.g. crowdfunding) ✧ Community engagement
Technical application	Simulation of social system	✧ Agent-based simulation
	Improvement of PSS Integrated PSS	✧ Integration of data from different sources ✧ Dynamic scenario analysis ✧ 3D Visualization ✧ Collaborative platform ✧ Participative GIS ✧ Qualitative GIS ✧ Real-time interaction
	Application of new technologies	✧ Big data for data collection, information analysis and prediction ✧ Unmanned aerial vehicle (UAV) for data collection and evaluation ✧ Virtual reality (VR) application

2.4.2 Research Gaps

The critical review of previous research reflects research gaps in past research. Some of these gaps are filled in the current work.

First, PSSs and DSSs have been explored, but most existing studies focus on land use planning, environmental planning, and urban planning. Limited research has been conducted for urban renewal decision support. Research on decision-making for urban renewal mainly concentrates on urban renewal projects, whereas strategic decision-making in other broad scales is a rarely discussed topic. Existing PSSs and DSSs do not integrate multiple scales with a comprehensive perspective. In light of this deficiency, the present study proposes a multi-scale framework that focuses on ignored scales, including city, district, and neighborhood scales.

Second, urban renewal research at the city scale concentrates in the qualitative discussion of policies and strategies. Quantitative methods represent an untouched area. This research performs quantitative analysis, simulation, and prediction in the investigation of urban renewal decision-making at the city scale.

Third, land use in urban renewal has been discussed considerably in the past, but existing studies merely present a qualitative discussion. Quantitative investigation on land use issues in urban renewal is rarely performed in previous research. Land use simulation at the medium scale in urban renewal, which is a quantitative approach to supporting decisions, can reflect land use problems and policy reactions with additional details. The present study fills this gap by developing a module of land use simulation at the district scale to support decision-making for urban renewal.

Neighborhood planning is not a new concept, but it is not sufficiently discussed in the field of urban renewal. Given that the trend of urban renewal programs has changed to comprehensive development, the neighborhood scale has become important because of its implementation advantages. Sustainability assessment is not a new topic, but sustainability assessment that considers urban renewal indicators represents a research gap. This research gap is addressed by the present study by conducting a neighborhood assessment for urban renewal decision-making.

2.5 Summary of the Chapter

This chapter reviews related literature. First, relevant concepts in urban renewal are reviewed and analyzed. The complexity of urban renewal is illustrated on the basis of previous and current studies. The relation between sustainability and urban renewal and the reason why they should be integrated are also analyzed. This part implicates the importance of conducting this research. Second, different aspects of decision support in urban renewal are reviewed, including neighborhood planning theory, empirical research on evaluation of urban renewal, sustainability assessment, and technical planning support in the urban planning field. These aspects provide references for conceptualizing and developing the decision support framework. Research trends are also discussed on the basis of the review. Research gaps are proposed in this chapter. Generally, this chapter establishes a theoretical foundation for this research and provides different perspectives for a decision support framework for sustainable urban renewal.

Chapter 3 Urban Renewal Practice in High-Density Cities

3.1 Introduction

Urban renewal decision-making is complex and involves different issues and various players. Different contexts face different challenges. This research focuses on high-density cities. Given this focus, urban renewal practice and the relation of urban development to urban renewal initiatives and policies should be understood. Therefore, this chapter reviews major urban renewal practices and policies in selected high-density cities. Hong Kong, Singapore, Tokyo, and Seoul are selected because these four cities are the high-density cities in Asia. The urban renewal practices in these four cities have a long history. Furthermore, these four cities face limited land supply, a large population, and developed economy. Hong Kong, Singapore, and Seoul also experienced colonization of other countries. The interpretation of renewal initiatives and relevant policies in these cities can provide a clear picture of urban renewal in practice. The main issues that need to be explored are as follows: how history relates to population growth, how urban renewal activities relate to urban development and population growth, how modes of urban renewal change with time, how related laws or policies contribute to urban renewal, and how the complex characteristics of urban renewal are embedded in nature. Four sections present a review of the urban renewal practices in these four cities. A comparison of these practices in these four cities is summarized in the final part of this chapter.

3.2 Urban Renewal Practice in Hong Kong

3.2.1 Brief History

Hong Kong is located at the southeastern tip of mainland China and has a total land area of approximately 1104 square kilometers and a population of about 7 million. Hong Kong is the first Special Administrative Region of the People's Republic of China. This region consists of Hong Kong Island, Kowloon, and the New Territories.

Hong Kong became a British colony in the late 18th century. During World War II, the city was occupied by Japan until the resumption of British control in 1945. In 1997, the sovereignty of Hong Kong was transferred back to China according to the Sino-British Joint Declaration in 1984.

The population of Hong Kong Island was only 7,450 when British control began in 1841. In the 1850s, a large number of Chinese immigrants crossed the border to this safe shelter to escape from flooding, typhoons, famine, and other disasters (Thomson, 1874). Hong Kong experienced modest growth during the first half of the 20th century. The Chinese Civil War led to a wave of skilled migrants from China (Wiltshire, 1999). As the first of the Four Asian Tiger economies, Hong Kong underwent rapid industrialization in the 1950s. Such rapid industrialization was driven by textile exports, manufacturing industries, and re-export of goods to China. Labor costs remained low, but living standards began to rise steadily (Briscoe, 1975). Shek Kip Mei Estate marked the first public housing estate program for the poor to address the immigration influx. The manufacturing industry in Hong Kong began to decline because of the rising labor and property prices and the new development of southern China under the Open Door Policy in 1978. In the 1990s, Hong Kong become a global financial center under its laissez-faire market policy (Dodsworth & Mihaljek, 1997).

3.2.2 Efforts in Urban Renewal

Similar to other developed cities around the world, Hong Kong is always burdened with its urban decay problem, which includes traffic congestion, lack of amenities, aging urban fabric, and uncomfortable living conditions (Chan and Lee, 2008b). To respond to these issues, urban renewal projects were implemented in the past decades.

Before the 1960s

The urban transformation of Hong Kong from the British colony since the mid-19th century indicates that urban renewal practice in the earliest times can be attributed to typhoons, fires, inadequate sanitation, and epidemics (Cuthbert & Dimitriou, 1992). The earliest renewal activity dates back to the first slum clearance scheme in 1884 (Adams & Hastings, 2001b). Between 1884 and 1905, the slum clearance activities in the Lower Lascar Row and Kau U Fong were implemented to enhance hygiene conditions and the environment (URA, 2009). A number of redevelopment activities were introduced by the private sector in the 1950s and 1960s, but they were executed poorly and achieved piecemeal rebuilding (Jim, 1994).

The prevailing economic principle in Hong Kong was laissez-faire; this system enabled the government to control any systematic approach in city planning until 1939 when the Urban Planning Law in Hong Kong was established (Cuthbert & Dimitriou, 1992).

From the 1960s to the 1980s

The government's earliest urban renewal efforts can be traced back to the 1960s. In 1968, the Hong Kong Government proposed two major aims for urban renewal, namely, to promote comprehensive redevelopment and to prepare a program of urban environment improvement (Bristow, 1984). The first urban redevelopment project was launched in the Western District of Hong Kong Island; this program was not considered successful, and much of the eastern part was abandoned 14 years after the commencement of the program (Cuthbert & Dimitriou, 1992). Another government effort in urban revitalization was the release of the government's redevelopment responsibility in 1974 to the Housing Society (HS). With a loan of 100 million HKD, the HS started the Urban Improvement Scheme (Law, 2004).

Hong Kong's industries began to wane with the rising labor and land costs after the 1970s. Industries were gradually moved outside of Hong Kong, thus leaving a large number of derelict industrial powerhouses. The private sector played a more important role than the Government of Hong Kong in redeveloping those dilapidated dockyards, power stations, and oil depots into residential buildings (Ng, 2002). A portion of the urban renewal initiatives during this period could be attributed to the transition of low value-added industries to speculative financial and property developments. When developers were redeveloping these industrial land sites, they were required by the town planning authority to implement a development plan that included public facilities, open spaces, landscaping, and other elements of a favorable environment (Jim, 1994). A number of large-scale private housing estates developed during this period are good examples of private developers participating in comprehensive urban redevelopment activities (Jim, 1994). Apart from this success, other market-led redevelopments by private developers led to small-scale pencil redevelopments. Such efforts continue to exist at present, thereby increasing neighborhood density but contributing minimally to the improvement of the urban environment. Another issue that emerged during this period was the development of virgin land parcels into new towns by the private sector and their unwillingness to renew old areas when those sites became less financially attractive (Cuthbert & Dimitriou, 1992).

Establishment of the Land Development Corporation (LDC)

By the 1980s, urban renewal pressure in Hong Kong increased because of the sub-standard development of many buildings before the 1970s (Adams & Hastings, 2001b). On the one hand, the government recognized its previous failures in urban renewal because of the slow and cumbersome process (Adams & Hastings, 2001a; Cuthbert, 1998). On the other hand, public−private ownership in the 1980s became prominent for urban policies in the UK and the USA (Barnekov, Boyle, & Rich, 1989). Some relevant approaches were applied in the western world; an example of this approach is the Urban Development Corporations in the UK, which attempted to integrate private resources with urban policies. This experience was regarded relevant for addressing urban problems in Hong Kong. Therefore, when unattractive sites needed urgent renewal, the government decided to play an active role in promoting and facilitating renewal within the old urban areas by establishing its institutional authority through the Land Development Corporation (LDC) in 1988.

According to the Land Development Corporation Ordinance, the purposes of LDC were as follows: (1) to enhance housing standards and the environment through urban renewal, (2) to deliver activities and functions that may be helpful for the promotion of urban renewal, (3) to carry out other activities permitted or assigned by the Governor’s order (after consulting with the Corporation) published in the Gazette. The responsibilities of the LDC included identifying sites for urban renewal, preparing redevelopment schemes, acquiring and resuming lands, rehousing affected residents, and cooperating with private developers to implement urban renewal projects

(Cuthbert & Dimitriou, 1992; W.-m. R. Liu, 2002). Two phases were recognized as the LDC's engagement in urban renewal initiatives: (1) collaboration with leading private sectors and (2) direct development and owner participation (Adams & Hastings, 2001b). Phase 1 was criticized for its reliance on large developers. Without the support of large developers, LDC in Phase 2 only conducted small-scale pencil redevelopments (Adams & Hastings, 2001b). Only 12 projects were completed in about 2.8 ha of site area during the LDC's 12 years of operation (Land Development Corporation, 2002). The redeveloped area accounted for only 0.5% of the total target redevelopment areas proposed by the 1991 Metroplan (Ng & Cook, 1999). The whole process was slow and made little difference to the urban renewal of Hong Kong.

Transition from LDC to Urban Renewal Authority (URA)

To respond to the constraints of the LDC, the government accelerated the pace of urban renewal. The Urban Renewal Authority (URA) was established to replace the LDC in 2000 under a new piece of legislation, that is, the Urban Renewal Authority Ordinance (URAO). The URA applies a powerful way of integrating the overall machinery of the government and delivered a comprehensive approach (Adams & Hastings, 2001b). The "4Rs" approach was proposed with the establishment of the URA. At present, this approach is still applied as a strategy. Under this approach, "redevelopment" and "rehabilitation" are regarded as primary businesses, whereas heritage preservation and revitalization are equally important components of urban renewal (URS, 2011). The URA acts as an "implementer" or a "facilitator" on the basis of the different needs of redevelopment projects. The projects implemented by the URA always go through the whole process of planning, acquisition, land resumption, clearance, construction, and management. The URA provides services to owners who aim to redevelop their buildings. It also offers different schemes for rehabilitation by working with property owners, the government, and other partners (URA, 2016). Heritage preservation is also a part of the URA's work, but the agency only conducts self-standing heritage preservation outside its redevelopment projects when a policy support or a request from the Administration exists (Development Bureau of Hong Kong, 2011).

3.3 Urban Renewal Practice in Singapore

3.3.1 Brief History

Singapore, which is located over 1 degree north of the equator, is a city-state in Southeast Asia. Singapore was founded in 1819 and was a former British trading port for the British East India Company (Yuen, 2005). Singapore originated from a small fishing village with less than 150 people. In 1950, Singapore grew into a modern city with a population of 1 million (Yuen, 2005). By 2015, Singapore had a population of 5.535 million and a land area of 719.1 km^2.

Singapore was occupied by Portugal and the Netherlands in the 16^{th} and 17^{th} century, respectively. Singapore experienced British colonization from 1819 to 1942. The city-state was then occupied by Japan from 1942 to 1945. After the colonization of Japan, Singapore was ruled again by the British from 1945 to 1959. Before becoming an independent government after 1965, Singapore first merged with Malaysia. Singapore's unique history has resulted in the development of its indigenous and colonial built environment (Yuen & Hock, 2001).

3.3.2 Diverse Issues in Urban Renewal

From Demolition to Conservation

As a city-state with a large population and limited land supply, as well as insufficient and overcrowded housing, Singapore drafted a number of urban renewal initiatives. The urban renewal policy in Singapore changed from a domination by slum clearance and demolition to an increased focus on conservation (Kong & Yeoh, 1994; Yeoh & Huang, 1996).

Slums in Singapore are characterized by disorder, substandard housing, and lack of facilities. Slums were established and expanded during the Japanese occupation and a period after the end of the war. These slums continued to expand. Thus, overcrowding in the city center became particularly serious, especially given the high birth rates and continued rural–urban migration (Wardlaw, 1971). Since Singapore's independence in 1965, urban redevelopment has accompanied the process of economic restructure (Yuen & Hock, 2001). The earliest effort of urban renewal after the war can be traced back to the attempts of the Singapore Improvement Trust, but little progress was achieved at that instance (Kong & Yeoh, 1994). Urban renewal was introduced because the government aimed to clear slums and demolish the dilapidated shop houses in the city center (Western, Weldon, & Haung, 1973). The renewal policy was first proposed in 1964, and the first government department called the Urban Renewal Department of the Housing and Development Board was established in 1966 (Kong & Yeoh, 1994). The early aims toward urban renewal in Singapore were aimed at providing a healthy environment for residents and making good use of the land for different usages, including commercial, industrial, residential, and recreational purposes (Kong & Yeoh, 1994). As a response to the call for increased efforts, the Urban Redevelopment Authority was established in 1974 as a separate institution that would undertake renewal and redevelopment initiatives. Three critical elements were identified for urban renewal: rebuilding, rehabilitation, and conservation (Yeh, 1975). In its early years, the Urban Redevelopment Authority primarily focused on demolishing old buildings, clearing slums, resettling the population from the city center, and constructing new buildings (Kong & Yeoh, 1994).

Urban conservation became an important aspect of the urban planning agenda in the mid-1980s and urban planning was not confined to demolition and construction (Yeoh & Huang, 1996). The changed attitude of the government from its focus on demolition to the accommodation of conservation within the redevelopment framework can be captured by studying the URA's efforts to conserve and rehabilitate whole areas (Kong & Yeoh, 1994). This shift is symbolized by the appointment of a conservation authority, the designation of conservation areas, the implementation of conservation requirements, and the formulation of conservation guidelines, which were provided by the 1989 amendment to the Planning Act (Yuen, 2005). In the same year, the URA and the Planning Department and Research and Statistic Unit of the Ministry of National Development merged into the National Conservation and Central Planning Authority. During this period, the conservation practice in Singapore applied adaptive use toward an improved environment instead of employing the simple preservation of entire old districts with their original history, architectural style, and features (T. K. Liu, 1990). In the early 1990s, a large number of shop houses in historic districts were saved because of the conservation idea rooted in the urban renewal policy (Yuen, 2005).

The Urban Redevelopment Authority attempted to increase the transparency of their planning process through in-depth communication with various stakeholders and the public. Their role changed from a land sales agent involved in the urban renewal of the city center to an agent in charge of land use planning, land sales, place management, conservation, and urban design (URA, 2016). Public participation and transparency in decision-making was increasingly emphasized.

State-led development

The state plays a significant role in the urban planning of Singapore (Kong & Yeoh, 2003; Perry, Kong, & Yeoh, 1997; Savage & Pow, 2001). State-led development in Singapore lies in its control of scarce land sources. Land parcels were attained and assembled by the state under the Land Acquisition Act of 1967. Private developers bought those loose land parcels (Dale, 1999; Perry et al., 1997). The Act provides the government with the power to acquire lands for national development and to facilitate land acquisition on behalf of private developers (Pow, 2009). Given that the government is the largest landlord, it can significantly influence urban planning and real estate development in Singapore (Pow, 2009).

The physical appearance of Singapore holds the imprint of state policies and various plans, such as the Urban Redevelopment Authority concept plan, and the overall blueprint for guiding urban development in Singapore. The land shortage problem in Singapore resulted in the emergence of high-rise and high-density buildings that characterize much of the city's current urban landscape (Pow, 2009). In the 1960s, the government began to initiate vast public housing programs through the Housing and Development Board (HDB) (Pow, 2009). The government also introduced the Home Ownership for the People Scheme to provide residents with tangible properties; such scheme contributed to the country's stability (HDB, 2016). At present, HDB flats are home to more than 80% of the whole population (HDB, 2016). Private housing (condominium, other apartments, and landed properties) only accounts for about 20% (Singapore Department of Statistics, 2016).

Redevelopment and rehabilitation

Apart from redevelopment initiatives of the HDB, the redevelopment of private buildings in Singapore follows free market principles. Redevelopment initiatives should be consistent with the planning system of Singapore. Since the early 1990s, the URA has implemented a new two-tier planning system, which included the Revised Concept Plan as the upper tier and detailed plans called the Development Guide Plans (DGPs) as the lower tier. The Revised Concept Plan strategically presented the long-term physical development of the country. The DGPs were detailed local plans for 55 planning areas that covered land use zones, development density, transportation networks, open space, recreational areas, and conservation designations (Lum, Sim, & Malone-Lee, 2004). Under this new system, the density parameters for residential lands were revised upward, leading to the en bloc redevelopment of buildings with multiple owners (Christudason, 2004). A 100% consensus among owners was initially required. However, conflicts often occurred among strata-titled property owners, and such conflicts resulted in the difficulty in acquiring overall agreement on selling their units (Christudason, 2004). Such en bloc redevelopment was further accelerated because of amendments to the strata legislation in 1999 (Christudason, 2009). The unanimity agreement was replaced with the majority agreement. When the development was less than 10 years, the majority agreement indicated that not less than 90% of the owners should agree to the en bloc sale; when the development exceeded 10 years, the majority agreement indicated that at least 80% of the owners must agree to sell their units (Lum et al., 2004).

Lifting the rent control also contributes to the redevelopment of private housing. Rent control was adopted to avoid exorbitant rents charged on tenants (Chang, 2016), which may pose disincentive for maintaining their own houses. Lifting the rent control stimulated private landowners to rehabilitate their properties for new rentals or to sell their units for redevelopment (Chang, 2016). The waiver of building premium in 2008 aimed to remove the disincentive of improving buildings at the expiration of the lease (SLA, 2008).

3.4 Urban Renewal Practice in Tokyo

3.4.1 Brief History

The history of Tokyo stretches back to the Edo period 400 years ago. At present, Tokyo is both the capital and the largest city in Japan and is home to 13 million people (Tokyo Metropolitan Government, 2016).

The Edo period existed for approximately 260 years until the Meiji Restoration in 1868. During the Meiji era from 1868 to 1912, Japan initiated the process of learning western civilization. During that period, stones and bricks were the main materials used for building construction. From 1912 to 1926, the population working in urban areas in the Taisho era increased. Tokyo was devastated after the Great Kanto Earthquake and associated fires. Reconstruction plans were then formulated. The 1950s were another period for the nation to recover after the war. The 1964 Olympic Games in Tokyo was a significant event for urban rebranding. The economic growth of Tokyo accelerated in the 1980s because of global economic activity and the application of information in society. From the 1980s to the 1990s, Tokyo became a “bubble economy” with very slow development. Two successive financial reconstruction programs were initiated to overcome this financial crisis. The Great East Japan Earthquake in 2011 seriously affected Tokyo. The high probability of suffering from natural hazards explains why disaster redevelopment is emphasized in the country’s urban development.

3.4.2 Governmental Policies and Related Organizations

The earliest efforts of urban renewal in Japan could be traced back to the establishment of the Urban Renewal Bureau in 1880 under the Tokyo Metropolitan Government; the bureau responded to a series of disastrous events in Tokyo slums (Ishizuka, 1981). Urban renewal is an initiative of the Bureau of Urban Development, which is tasked to implement urban development planning, urban renewal, infrastructure development, housing policies, building administration, and disaster management (Bureau of Urban Development Tokyo Metropolitan Government, 2016b). The main tasks of the Bureau of Urban Development that are related to renewal include urban redevelopment and readjustment.

The Urban Redevelopment Law passed in 1969 signified the establishment of an urban redevelopment system in Japan. Redevelopment wholly or partially refers to the clearing of a large-scale dilapidated area for redevelopment to an area with improved environment and social quality (Sakamoto, 1998). The Urban Redevelopment Law guides urban redevelopment policies; it serves as a master plan to coordinate various measures for urban redevelopment from a long-term and comprehensive perspective (Bureau of Urban Development Tokyo Metropolitan Government, 2016a). The urban areas for redevelopment are categorized into three: (1) areas that require planned redevelopment, (2) redevelopment promotion districts that should be promoted comprehensively, and (3) redevelopment guidance districts that are expected to be developed but fail to satisfy the requirements for redevelopment promotion districts (Bureau of Urban Development Tokyo Metropolitan Government, 2016a). Depending on voluntary reconstruction to improve redevelopment is difficult and undesirable. The Urban Redevelopment Project is adopted as a crucial method for the redevelopment process. Two types of Urban Redevelopment Projects are implemented through the appropriate conversion method; the projects are also based on how executors purchase lands and buildings within project areas (Bureau of Urban Development Tokyo Metropolitan Government, 2016a). By the end of 2012, 199 urban redevelopment projects had been implemented in 199 areas in Tokyo (Bureau of Urban Development Tokyo Metropolitan Government, 2016a).

Land readjustment, which is also known as "land consolidation" in the literature, is widely adopted in Japan, Taiwan, and Korea (Agrawal, 2000). According to the Land Readjustment Act, readjustment projects should change the form or nature of land with the aim of enhancing public facilities and improving housing land use in urban planning areas. The Land Readjustment Act is a typical approach to urban development that facilitates the comprehensive development of public facilities and housing land (Bureau of Urban Development Tokyo Metropolitan Government, 2016a). Land readjustment projects aim to develop urban areas by changing the shapes and conditions of land sites and by constructing or reallocating public facilities; these projects could make good use of land parcels and promote public facilities (Nagamine, 1986). Land readjustment is a useful method in urban planning, in which various land owners can contribute to the development or redevelopment of lands (Sorensen, 1999). Readjustment projects in Japan involve several executors, including individuals, land readjustment associations, land readjustment companies, local governments, the Minister of Land, Infrastructure, Transport and Tourism (MLIT), Urban Renaissance Agency, and regional public housing corporations (Bureau of Urban Development Tokyo Metropolitan Government, 2016a). By the end of 2012, land readjustment projects with approximately 21,312 ha had been accomplished in 593 areas; projects covering 1,575 ha are in progress (Bureau of Urban Development Tokyo Metropolitan Government, 2016a).

In addition to statutory and institutional support, a wide range of financial programs are provided by the government. These programs include government loans, disposition of reserve lands, shared payment of public facilities by management authority, and tax preferential systems.

Urban renaissance is another term used in Japan relating to urban renewal. The Urban Renaissance Headquarters was set up in 2001 as a decision-making institution in charge of multi-staged urban regeneration projects and the implementation of the Urban Renaissance Special Measure Law, which was aimed at enhancing city functions and people’s standard of living (Chong, 2008). To promote urban renaissance initiatives, the Urban Renaissance Special Measure Law was enacted in 2002, and its associated Basic Policies for Urban Renaissance was established in 2004. This special law emphasizes the promotion of urban regeneration projects by private agencies in a limited period through financial assistance with some exemptions (Chong, 2008).

The Urban Renaissance Agency was established in 2004 by merging the Urban Development Corporation and the Regional City Development Division of the Japan Regional Development Corporation. Four fields are involved in the business of the Urban Renaissance Agency, namely, urban rejuvenation, living environment, disaster redevelopment, and suburban environment fields (UR, 2016). The field of urban renaissance is the most closely related to urban renewal. Urban renaissance has five crucial mandates: (1) revive idle lands to communities with multiple functions; (2) create new bases for future generations to integrate people, products, and culture; (3) realize safe cities that can address earthquakes and fires; (4) develop comfortable living and working space in close proximity; and (5) reconstruct old buildings for renewed cities and lifestyles (UR, 2016). The Urban Renaissance Agency acts as the main initiation body of each business. It has recently shifted its attention to its facilitating role in urban renewal (UR, 2016). The Urban Renaissance Agency supports community development in four ways: (1) to clear out and effectively use vacant industrial land, (2) to reenergize and revitalize the city, (3) to improve redevelopment projects, and (4) to enhance road development (UR, 2016b) .

3.5 Urban Renewal Practice in Seoul

3.5.1 Brief History

Seoul is located northwest of South Korea and is the capital and largest metropolis of South Korea. Seoul's history dates back to more than 2,000 years ago. Seoul maintained its population of approximately 200,000 people for several centuries before the Japanese colonization in 1910, which was followed by the establishment of its current spatial form in 1394 (Kim, 2003). The city of Seoul under the Chosun Dynasty did not grow significantly from 1392 to 1910 because the old Seoul (Hansung) was always surrounded by the wall (Rii & Ahn, 2002).

The urbanization process started during the period of Japanese occupation when the total population reached around 1 million. Traditional society and the spatial pattern of Seoul were disordered and destroyed during the Japanese occupation and the Korean War (Rii & Ahn, 2002). Seoul experienced a rapid population growth after the end of World War II. Since the beginning of modernization in the 1960s, South Korea had undergone rapid industrialization accompanied by rapid urbanization. The urbanization process in South Korea was characterized by intense concentration in a few large urban centers, such as those in Seoul (Lee, 2000). The population of Seoul dropped and stabilized in 1992; this period was considered a turning point (Choe, 2003). From 1992 to 1999, about 2 million of South Korea's population moved to satellite cities around Seoul. By 2010, the total population of Seoul had reached around 10 million.

3.5.2 Changing Modes of Urban Renewal

Urban renewal in South Korea is closely related to its population change and history, which can be classified into four periods on the basis of the main players involved and the strategies employed by the government (Lee, 1990). Changes in relevant policies and renewal approaches can be observed from 1950s to recent decades.

The first phase ran from the 1950s to the 1960s. This period followed the Japanese colonial control in 1945 and the Korean War in 1953. Given the massive migration into South Korea after the war, the state-led clearance of squatter settlements dominated urban renewal activities during this period. These activities were aimed to address the shanty settlements constructed by immigrants. The urban development policy was not sufficiently developed, and the demolition and relocation of shanty settlements for the benefit of residents were not addressed properly (Lee, 2000). The social and spatial segregation of the relocated squatters from the city center and the development of new squatter settlements at the periphery were the main characteristics of this period (Lee, 2000).

The second phase covered the period from the 1960s to the 1970s. During this period, rehabilitation activities in multi-dimensions and apartments for citizens played an important role in urban renewal. Effective policy tools were proposed in this period because the government recognized the social issues that emerged from demolition and relocation. The first policy was the legalization and rehabilitation of squatter settlements when housing conditions met certain requirements and associated requirements for renovation. The second policy was the citizen apartment building program, which funded the construction of low-rise apartment buildings allocated by the government and provided squatters with the opportunity to purchase units through a negotiable program (Lee, 2000). Squatters were prioritized, but the financial infeasibility of some residents passed the benefits intended for low-income groups to middle- or upper-lower income groups (Lee, 200).

The joint redevelopment project (JRP) proposed by the government in the 1980s aimed to solve the financing problems in housing redevelopment, especially in squatter settlements in Seoul (Ha, 2004). The representative point was the issuance of the Implementation Guidelines for Joint Redevelopment in January 1984. The essential characteristic of the JRP was its financing and management structure, which were greatly based on the developers' participation in partnership with housing owners (Choe, 2002). The feasibility of the JRP was attributed to the permission provided by the planning regulation to transfer low-rise substandard neighborhoods to high-rise commercial housing estates with maximum density (Shin, 2009). The gentrification of dilapidated low-income neighborhoods was the socio-spatial consequence of the JRP (Shin, 2009). The main profits of the JRP were returned not to the original residents and tenants but to the speculators and outside middle-income households who moved in (Ha, 2004). The 1986 Asian Games and the 1988 Olympic Games during this period accelerated the urban redevelopment process and historic conservation of Seoul.

Since the 1990s, community-led urban renewal has become popular in the promulgation of The Urban Poor's Housing Environment Improvement Act. This program encourages residents' participation in the improvement scheme and the public sector's participation in the clearance scheme. This program attempts to resettle an increased number of residents. Individual improvement and multi-family housing development are the two types of redevelopment schemes in this program. This program is not without its challenges because residents cannot afford the development cost and the financial support of the government is limited. Other problems include disagreements among residents when designating a program site and overcrowding in improved districts (Lee, 2000).

Apart from the four phases identified by Lee (2000), several other policies related to urban renewal were proposed in the 2000s. The project of Seoul Urban Regeneration through Creative Destruction of Public Space was initiated through Cheonggyecheon restoration and downtown revitalization because of the decline in downtown Seoul. This project aimed to restore a dilapidated public space to create a waterfront, enhance the environment, and recover its historical value. The government acted as the initiator for this project through public investment; this project was conducted in partnership with the private sector (Seoul Solution, 2014). The Housing Environment Advisory Committee was formed by the Housing Bureau in 2009 to facilitate housing improvement; the committee aims to implement Phase 3 of the housing policy by innovating housing refurbishment projects, which include redevelopment and reconstruction projects (Seoul Solution, 2014a). "New Town" projects were initiated in 2002 by redeveloping the old Gangbuk to support a balanced regional development (Hyeon, 2011). This project focused not on new town development but on changing an "old town" into a "new town." The new town project is an approach established by the public sector to deal with problems of the existing redevelopment method by targeting identical urban living zones with a concentration of old or poor residential areas (Hyeon, 2011). The first task of the government was to set up a new bureau that would lead the development by facilitating related authorities and public agencies (Lee, You, & Kwon, 2015). A legal framework, called the Special Act for the Promotion of Urban Regeneration, was established in 2005 to facilitate an organized, complex legal system and administrative process. Unlike past efforts on urban renewal, "New Town" projects were led by the government.

3.6 Comparison of Urban Renewal in the Four Cities

This section compares urban renewal in the four cities in terms of three major dimensions, namely, adopted urban renewal strategies, stakeholders involved, and changes over time.

These four cities share common features in urban renewal. First, these four cities utilized different strategies during their renewal process with different foci in different phases. Urban development in these four cities underwent a rapid process and became a source of poor living conditions. A transition from slum clearance or a bulldozing approach to an increased emphasis on conservation and combination of different approaches can be observed in these four cities. The cities adopted rehabilitation, redevelopment, and conservation strategies. Second, relevant institutions have been established in these cities to promote urban renewal initiatives, but the power and structure of these institutions vary. The mode of public–private partnership was adopted in Hong Kong, Tokyo, and Seoul. Community engagement was increasingly emphasized in these cities. Table 3.1 summarizes the major events and characteristics related to urban renewal in the four cities.

Differences can be identified by investigating the details of urban renewal in different countries. These differences include objectives, institutional structure, the focus given to different types of urban renewal, and power of different stakeholders. Table 3.2 presents a brief summary of a comparison of cities' objectives, types of urban renewal, and institutional arrangements.

Objective

Competitiveness, economic development, and improvement of living environment are the common themes among the four cities, but differences still exist. The main objective in Hong Kong has changed from addressing the issue of the housing shortage and provision of facilities to improving the urban environment for addressing the urban decay issue. The urban renewal objectives in Singapore are related to its national development. Conservation and tourism development have been given important roles in urban renewal. Seoul's urban renewal policies are mostly related to its goal to become a competitive global city. This finding means that Seoul's objective is to improve the appearance and quality of its urban environment. Unlike in other cities, contemporary urban renewal in Tokyo is related to the revitalization of the economy. Disaster prevention is another crucial component of urban renewal.

Institutional arrangement

The institutional arrangement for urban renewal in Hong Kong is the semi-governmental institution called the URA, which evolved from the Land Development Corporation. HS also participated in several projects with the URA. All initiatives must conform to related urban planning guidelines and restrictions. Singapore holds the simplest institutional arrangement for urban renewal initiatives. In Singapore, the Urban Redevelopment Authority under the Ministry of National Development is responsible for urban planning and conservation. Therefore, only one single authority takes charge of all issues.

Compared with Singapore and Hong Kong, Tokyo faces a complex situation. In 2001, the Japanese government established the Urban Renaissance Headquarters, which is a high-level institutional structure for legal issues and policy frameworks. The Urban Renaissance Headquarters are not implementation institutions for specific projects. Other governmental departments at the local level conduct different projects for urban renewal. The Urban Renaissance Agency (UR Agency) was set up in 2004, thereby changing the role of the projects proposed by the Urban Renaissance Headquarters from a direct role to a facilitating role. Land readjustment and redevelopment of urban areas in Tokyo are facilitated by the businesses of the Bureau of Urban Development (BUD) of the Tokyo Metropolitan Government.

Unlike other cities with special institutional arrangements for urban renewal, Seoul does not have an obvious institutional framework for urban renewal. The Seoul Metropolitan Government (SMG) plays a comparatively active role in developing relevant policies for urban renewal. Different institutions are involved in urban renewal activities.

Foci on different types of urban renewal

Although urban renewal at the early phases mainly focused on slum clearance, demolition, and total redevelopment, increased focus has been given to conservation and rehabilitation. Nevertheless, the four cities show obvious differences.

In Hong Kong, redevelopment dominated the main type of urban renewal, but progress was slow. Redevelopment, rehabilitation, revitalization, and heritage preservation became the four types of urban renewal in Hong Kong. A transition from demolition to conservation can be observed in the case of Hong Kong. Singapore changed from redevelopment to conservation possibly because of an efficient institution arrangement, in which only one authority is responsible for planning and conservation. The redevelopment in Singapore is related to public housing redevelopment, whereas private redevelopment only accounts for a small proportion. Urban renewal in Tokyo covered redevelopment, rehabilitation, and preservation. No obvious emphasis was placed on one aspect. In Seoul, redevelopment dominated the urban renewal process. Rehabilitation and preservation were not sufficiently adopted.

Power of different stakeholders

In Hong Kong, the URA acts as the initiator of urban redevelopment projects and facilitator of urban redevelopment. The URA is a semi-governmental institution, but it has to support itself financially with the initial capital injection of $10 billion from the government and other institutions. Given its structure, the URA sometimes share similarities with private developers, which might explain the criticism against profit-driven redevelopment. In terms of rehabilitation, the URA always works with other stakeholders, including property owners, the government, and other organizations. Private developers play a less important role in accelerating the redevelopment process. They conduct redevelopment activities only when they can profit from the project. Therefore, a large number of pencil buildings (one-story buildings) can be easily found in old districts of Hong Kong. Property owners can contribute to urban renewal because they can initiate demand-led redevelopment and participate in rehabilitation activities with the help of the URA and relevant institutions. Owners and tenants are the most affected groups because they always face the issue of relocation.

The URA in Singapore exhibits governance characteristics and plays a significant role in urban redevelopment as the planning and endorsement authority, but the agency does not play an active role in financing. Private developers primarily lead redevelopment projects in terms of financial provision. The public/community does not participate in redevelopment projects. Rehabilitation is often regarded as owners' work.

In Tokyo, the government is in charge of setting up a legal and policy framework and providing financial incentives. The implementation of projects always involves the public sector, owners, and developers. These parties work together to establish an association for redevelopment or land readjustment projects. In some instances, private developers buy off lands from owners to implement redevelopment on their own. The Urban Renaissance Agency has changed its role from project facilitator to an initiator. With respect to financing issues, private sectors are primary players for financing redevelopment. The government facilitates redevelopment through different forms of support, such as interest-free loans, sharing of the cost for public facilities, relaxing of floor area ratios, and tax exemptions.

Before the New Town Project, the government's role was mainly to facilitate redevelopment, whereas private developers led redevelopment; the financing issue was dealt with by the private sectors. Specifically, the government provided loans and additional plot ratios to promote redevelopment projects. The New Town Projects then increased the engagement of the public sector. The PPP mode has increasingly become popular. Owners do not play an important role in urban development projects because of the inadequate compensation and frequent conflicts among tenants, shop operators, and project implementers.

Table 3.1 Major events and characteristics of urban renewal in four cities

	Major Events and Characteristics
Hong Kong	✧ The first slum clearance scheme was in 1884. ✧ There were some redevelopment activities by private sector in the 1950s and

	1960s (mainly pencil development). ✧ Two major aims for urban renewal by the government (1968): to promote comprehensive redevelopment and to prepare a program of urban environment improvement ✧ In the 1970s, private sectors played a more important role in redeveloping dilapidated dockyards, power stations, and oil depots into residential buildings. ✧ The Land Development Corporation (LDC) was established in 1988 ✧ URA was established to replace LDC in 2000 under the Urban Renewal Authority Ordinance (URAO). ✧ Currently, the four "4Rs" approach (redevelopment, rehabilitation, revitalization, and heritage preservation) was adopted in urban renewal of Hong Kong
Singapore	✧ The establishment of Urban Renewal Department (URD) was in 1966 ✧ The URD was turn into Urban Redevelopment Authority in 1974 (the Urban Redevelopment Authority is both the planning and conservation authority) ✧ Most of the redevelopment was primarily related to the public housing managed by the Housing and Development Board (HDB) ✧ Government facilitates redevelopment in private housing though different methods such as the en bloc sale, lifting of rent control, and waiver of building premium
Tokyo	✧ The Urban Renewal Bureau was launched in the year 1880 at the Tokyo Metropolitan Government (the earliest attempt of urban renewal in Japan) ✧ The Urban Redevelopment Law was established in 1969 (overall policy directives) ✧ The Urban Renaissance (UR) Headquarters was set up in 2001 (UR aims at advancing city functions) ✧ Public-private partnership could be mostly achieved models of urban redevelopment
Seoul	✧ Urban renewal between the 1950s and 1970s was primarily related to the clearance of squatters and upgrading of substandard housing ✧ The Implementation Guidelines for Joint Redevelopment in 1980s (model of owners' led redevelopment) ✧ Two types of programs to support old and deteriorated housing of low-income groups: the designated housing redevelopment districts and the Residential Environment Improvement Project ✧ The 1986 Asian Games & The 1988 Olympic Games speeded up the urban redevelopment in downtown

	✧ Special Act for the promotion of urban regeneration was enacted in 2005 ✧ Gentrification occurs after redevelopment

Table 3.2 Issues being compared

	Current Objective	Type of urban renewal	Institutional arrangement
Hong Kong	To tackle the urban decay problem	Redevelopment Rehabilitation Revitalization Heritage preservation	The Land Development Corporation; Urban Renewal Authority
Singapore	To make Singapore a great city to live (corresponding to national development)	Redevelopment Conservation	Urban Redevelopment Authority
Tokyo	To revitalize the economy and prevent disasters	Redevelopment Rehabilitation Preservation Land readjustment	Urban Renaissance Headquarters; Urban Renaissance Agency; The Bureau of Urban Development (BUD) of the Tokyo Metropolitan Government
Seoul	To improve the appearance and quality of urban environment	Redevelopment	No specific institutions (The Seoul Metropolitan Government)

3.7 Summary of the Chapter

This chapter reviews the urban renewal practices in four high-density cities in Asia. The analysis and comparison of the urban renewal practices in these four cities show common characteristics: (1) the involvement of multiple stakeholders, (2) transition from slum clearance to increased focus on rehabilitation or preservation, (3) selection of various approaches in urban renewal, and (4) community engagement being increasingly emphasized in these cities. Differences of the four cities were also identified in terms of their objectives, institutional structure, the focus given to different types of urban renewal, and power of different stakeholders. Urban renewal practice is embedded with complex features, which pose a significant challenge for urban renewal decision-making. This situation implicates the significance of conducting this research. The results from reviewing urban renewal practice correspond to the findings from literature review in Chapter 2. In summary, this chapter presents a review of urban renewal practices in different countries, providing references for a decision-making framework for urban renewal. Lessons learned from the four cities can be applied in practice. Different contexts have different social, economic, and environmental conditions so that specific factors must be included in their decision-making considerations. Therefore, the proposed decision support framework must be adapted under various contexts.

Chapter 4 Research Design and Methodology

4.1 Introduction

This chapter presents the research design, specific research methods, and analysis techniques employed in this study. To realize the research objectives, this study adopts a combination of qualitative and quantitative research methodologies. Section 4.2 provides an overview of the research methodologies. Section 4.3 presents the entire research process. Sections 4.4 and 4.5 introduce the different research methods and analysis techniques used in this research, respectively.

4.2 Overview of Research Methodologies

Research is defined as “a careful study of a subject, especially in order to discover new facts or information about it” (Oxford Advanced Learner’s Dictionary). Two inherent features are identified as “contribution to knowledge” and “a learning process” (Fellows & Liu, 2015). Research methodology is “a way to systematically solve the research problem” (Kothari, 2004). Research methods and styles are not usually exclusive (Fellows & Liu, 2015). Two basic research approaches include qualitative and quantitative approaches. The differences between different approaches lie in the data collection and analysis, but does not lie in the investigation of theory and literature (Fellows & Liu, 2015).

Quantitative approaches are related to data generation in the quantitative form, which could be analyzed through a rigorous quantitative manner (Kothari, 2004). This approach could be further categorized into inferential, experimental, and simulation approaches (Kothari, 2004). A qualitative approach involves a subjective assessment of attitudes, opinions, and behaviors (Kothari, 2004). This approach aims to capture insights and to understand people's perceptions of individuals, groups, and "the world" (Fellows & Liu, 2015). The three approaches to analyzing quantitative data are language-based, descriptive or interpretive, and theory-building approaches (Tesch, 1991). These approaches exhibit different attributes. Table 4.1 presents the attributes of quantitative and qualitative approaches.

Table 4.1 Typology of attributes of quantitative and qualitative evaluation

(Source: Steckler et al., 1992)

Qualitative	**Quantitative**
Inductive Discovery and process	Deductive Verification and outcome oriented
Measurement tends to be subjective	Measurement tends to be objective
Valid Self as instrument (the evaluator is close to the data)	Reliable Technology as instrument (the evaluator is removed from the data)
Ungeneralizable The insider's perspective Case oriented	Generalizable The outsider's perspective Population oriented

Given that these approaches have strengths and weaknesses, a triangulated research methodology is undertaken in the present study. In a triangulated study, two or more research techniques are adopted. Qualitative and quantitative approaches are applied to reduce the disadvantages of each approach and to improve their advantages (Fellows & Liu, 2015). In the present study, a qualitative approach is necessary to capture the decision-making objectives, challenges, relevant issues, and stakeholders during the urban renewal process. It can obtain people's perspectives since this study aims to improve decision-making which is finally implemented by people. Quantitative analysis, assessment, and prediction are indispensable for proposing objective decision support for urban renewal. By combining both quantitative and qualitative approaches, the references provided for decision-making are more comprehensive with a multi-dimensional perspective. Therefore, a triangulated methodology that combines quantitative and qualitative approaches is adopted for this research.

4.3 Research Process

The research process comprises a range of required actions or steps to effectively conduct research, including the desired order of these steps (Kothari, 2004). The detailed research process is shown in Figure 4.1. After defining the research problem, relevant concepts, theories, previous research findings, and related documents were reviewed in the library research process. The decision support framework was conceptualized by reviewing the literature, analyzing documents, and interviewing experts. Simulation and case study are the main research methods adopted in the development of the three modules in the framework. Various analytical tools were also used in developing the three modules in the framework. These tools included the SD model, CLUE-S, Markov chain prediction, and spatial analysis in GIS. In the development process of the three modules, internal validation of the three modules was conducted from the technical perspective. To enhance the rigor of this study, validation was also conducted from the people's perspective. An experimental study and two expert interviews were employed to validate the decision support framework. Validation was aimed at obtaining feedback that could further enhance the multi-scale framework and modify its associated modules.

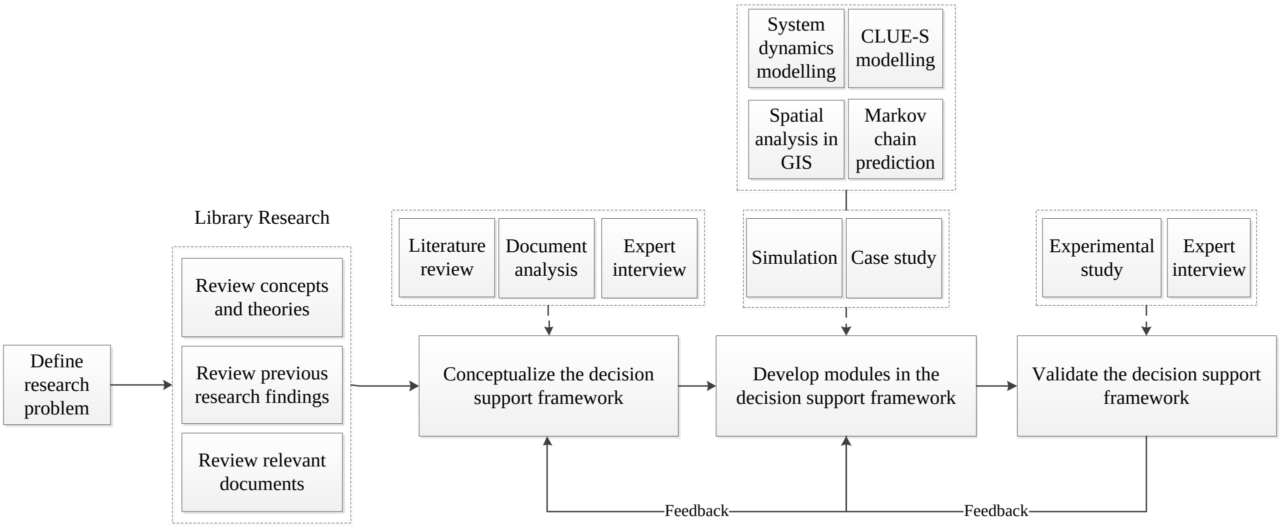

Figure 4.1 Flow chart of the research process

4.4 Research Methods

4.4.1 Document analysis

Document analysis is a type of archival research that can address research problems by investigating various groups of documents. Archival research is any research that involves public records as an analysis unit (Dane, 1990). Document analysis can supplement the information obtained through other methods, such as interviews and questionnaire survey under some circumstances (Bell, 2014). Document analysis is a qualitative method that includes content analysis and review of existing data. Content analysis is defined as "any technique for making inferences by objectively and systematically identifying specified characteristics of messages" (Holsti, 1969: 14).

Caulley (1983) identified some advantages of document analysis. First, document analysis can collect some types of retrospective data. Second, document analysis is the most efficient way of collecting certain types of data, such as background information. Third, information acquired from documents is more reliable than that obtained from observations and interviews. Fourth, some people may be unwilling to provide certain information. Document analysis may be the only way to obtain such type of information. Fifth, document analysis is more convenient to perform than questionnaires, interviews, and observations. Sixth, document analysis is inexpensive. Seventh, this method does not need reactivity. Eighth, this method saves time and money. Ninth, some information from agencies is collected repeatedly through this method, which can provide continual trends. Tenth, documents could defend themselves because they are public records. Eleventh, documents can trace back information that may have been recorded in the past.

In the present research, document analysis was applied to explore the official documents issued in the case study area and other high-density cities, such as the relevant policies on urban renewal, urban development, land use issues, and previous renewal cases. Document analysis can identify current problems in urban renewal practice, renewal decision-making problems, and useful experiences in urban renewal. When facilitating the development of the modules in the framework, this method can investigate the local conditions, which is required for module development. Existing data from the statistical records of government institutions were analyzed to identify the past trends of urban renewal practice.

4.4.2 Expert interview

An interview is defined as a survey conducted through a structured conversation for the purpose of collecting data (Dane, 1990). A skillful interviewer can obtain ideas, probe responses, and explore the motives and feelings of respondents (Bell, 2010). A personal interview can be conducted through a detailed schedule with open and closed questions (Kothari, 2004). The three types of interviews are structured, unstructured, and semi-structured interviews (Longhurst, 2003). Structured interviews should follow a pre-designed list of questions, whereas unstructured interviews are guided by the informant (Dunn & Interviewing, 2005). Semi-structured interviews could provide participants with flexibility to explore issues they feel are important (Longhurst, 2003). Expert interviews, in which the interviewees are experts in a certain field, are effective in capturing professional information and comments.

Urban renewal initiatives for decision-making require professional input. Four expert interviews were adopted in this research to collect suggestions for the conceptualization and development of the framework and its associated modules. Two expert interviews were conducted during the validation stage as a supplemental approach to collect experts' comments on the effectiveness of the proposed framework. Experts refer to experienced planning practitioners and researchers in relevant institutions, such as the Lands Department, Planning Department, Urban Renewal Authority, and planning-related departments in universities. Considering the strict confidentiality of the specific profiles of the interviewees, only general information is presented in Table 4.1.

Table 4.1 Information on interviewees

Interviewee	**Working experience**	**Purpose**
1	now is an assistant professor in one university in Hong Kong, used to work in a private real estate firm in Hong Kong and three governmental departments in Hong Kong (the Lands Department, the Housing Department and the Rating & Valuation Department)	conceptualizing the framework
2	now is an assistant professor in one university in Hong Kong, used to work in two architectural firms in Hong Kong and a NGO	conceptualizing the framework

3	now is a famous professor in urban planning field of the U.S.	conceptualizing the framework
4	now is a professional in Urban Renewal Authority of Hong Kong	conceptualizing the framework
5	now is a planner in Planning Department of Hong Kong	validating the framework
6	now is both a senior lecturer in one university in Hong Kong and a professional in Urban Renewal Authority of Hong Kong	validating the framework

4.4.3 Case study

Case study is defined as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used" (Yin, 1984:23). The following three features could be obtained from the definition: (1) the approach is context-based, (2) contextual conditions are not specific, and (3) the case study method is always combined with other methods because it can use different data sources collected by qualitative and quantitative methods. The case study approach facilitates the investigation of phenomena within a certain context, in which no single survey or data collection approach can be applied to collect information about those numerous variables (Bell, 2014). A case study could provide an opportunity to explore particular conditions of a phenomenon (Bell, 2014; Fellows & Liu, 2015). A case study comprises four stages: (1) design, (2) implementation, (3) analysis of evidence, and (4) drawing of conclusions, recommendations, and implications (Yin, 1984).

In the current research, case studies were adopted to develop different modules in the framework. Through case studies, the conceptual framework could be applied into practice. Given the typical characteristics of Hong Kong as a high-density city, it was chosen as the case study area. Cases at different scales were used to develop the different modules.

4.4.4 Simulation

Simulation is defined as the application of a model to represent the crucial characteristics of a reality of a system or a process (Fellows & Liu, 2015). Simulation facilitates the prediction of behavior in reality and improvement of the predictive accuracy or capability of a model (Fellows & Liu, 2015). Simulation involves a dynamic process (Fellows and Liu, 2015). The main objectives of a simulation include imitating a model's behavior, exploring the performance of various techniques, examining complex analytic models, and assessing the complex behavior of random variables (Morgan, 1984).

In this research, the method of simulation was adopted in the development of certain modules in the framework. The SD module simulates the relationships between different variables in the urban renewal system and the changes of different variables in the future. A simulation method was also adopted in the LUS module to simulate land use change in the future under various scenarios.

4.4.5 Experimental study

Experiments are tests to explore any relationship between the activities conducted and the results (Fellows & Liu, 2015). Hicks and Turner (1999) defined an experiment as a study in which independent variables are controlled, their effects on one or more dependent variables are determined, and the levels of these independent variables are randomly appointed to the experimental units in the experiment. Testing cause−effect relationships is the main feature of an experimental study. Researchers apply this method to investigate research hypotheses relating to the cause−effect relationships proposed at the beginning of an experimental study.

This method was adopted in the validation stage. An experiment was designed and conducted to enable participants to experience the traditional method and the proposed framework in decision-making process, which facilitated the validation of the effectiveness of the proposed framework. The details are presented in Chapter 7.

4.5 Analytical Tools

4.5.1 System dynamics

In this research, the SD model was applied to identify the features of the different variables of the urban renewal system and to analyze the relationships between such variables in the SD module. The characteristics of the urban renewal system and the requirements for applying the SD model are considered.

SD is widely applied to capture the characteristics of variables and their interrelationships within a complex and dynamic system. The methodology was first developed in industrial and business systems management by Jay Wright Forrester (1961). Other applications were then proposed (Forrester, 1969; Forrester, 1971) . SD was extended to a considerable amount of research, including that in sustainable development (e.g., Forrester, 1971; Meadows et al., 1992; van den Bergh & Nijkamp, 1994), environmental systems (e.g., Deaton & Winebrake, 1997; Chang et al., 2008), urban planning (e.g., Xu & Coors, 2012), and ecological modeling (e.g., Costanza &

Gottlieb, 1998; Arquitt & Johnstone, 2008). This approach is realized as a function of feedback loops, variables, and equations.

SD models comprise three types of variables, namely, stock, rate, and auxiliary; these variables are related through physical/material and information flows (Q. Shen et al., 2009). The structure of an SD model is displayed as causal loop diagrams that can be interpreted as stock flow diagrams. Feedback mechanisms can be captured and depicted in these diagrams. Causal loop diagrams are drawn in arrows and words with the aim of interpreting problems qualitatively, whereas stock flow diagrams are written as equations for quantitative analysis (Yuan et al., 2011). Simulation in SD is interpreted as temporal modeling that follows the passage of time (Coyle, 1977). The application of SD always aims to understand internal relationships among system variables (Wolstenholme, 1990) and, in most cases, to explore "what-if" scenarios over time to search for effective managerial policies (Güneralp & Barlas, 2003; Han, Bhandari, & Hayashi, 2010).

4.5.2 Markov chain prediction

The Markov chain model was adopted to develop the LUS module in the framework. "Markov chain models are essentially projection models that describe the probabilistic movements an individual in a system comprised of discrete states." (Iacono et al., 2012: 4) Markov chain prediction can be used to calculate temporal land use demand in the future. Markov chain prediction has been widely applied to the temporal prediction of land use change in a considerable number of studies (e.g., Muller & Middleton, 1994; Reveshty, 2011; Xia et al., 2013). In the dynamic process of land use change, different land types may change in a certain region, and many incidents that are difficult to be captured may be included. The transition rate of land use patterns is comparatively stable.

Considering the characteristics mentioned above, a Markov chain can be used to analyze temporal land use changes (Guan et al., 2011).

The matrix of the transition probability of land use types should be provided before applying the Markov chain. The mathematical expression of the Markov chain is given as

$$p = (p_{ij}) = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1n} \\ p_{21} & p_{22} & \cdots & p_{2n} \\ \cdots & & & \\ p_{n1} & p_{n2} & \cdots & p_{nn} \end{bmatrix}.$$

In the above matrix, P_{ij} represents the transformation probability of the i th land use type into the j th land use type from the previous status to the next status; n is the land use type of the study area. P_{ij} should meet the following requirements:

$$0 \le p_{ij} \le 1(i, j = 1, 2, 3 \cdots, n)$$

$$\sum_{i=1}^{n} p_{ij} = 1(i, j = 1, 2, 3 \cdots, n).$$

On the basis of a transition probability matrix and Bayes' theorem of conditional probabilities, the Markov chain prediction model is defined as $P_{(n)} = P_{(n-1)} P_{ij}$, where $P_{(n)}$ is the state probability of any period and $P_{(n-1)}$ is the previous state probability (Chen & Zhang, 2011; Guan et al., 2011).

4.5.3 CLUE-S model

The CLUE-S model is used to predict the spatial land use changes in the future; its results can be valuable inputs for land use decision-making. CLUE-S was developed at Wageningen University and was first published in 1996 (A Veldkamp & Fresco, 1996). CLUE-S is used for the spatially explicit simulation of land use changes based on locational suitability and dynamic modeling of competition and interactions between different land use types (Verburg et al., 2002). Spatial considerations (including spatial pattern of land use, driving factors for location, conversion elasticity and matrix, as well as spatial policies and restrictions) determine spatial land allocation, which should be consistent with the temporal land demand calculated through other methods (e.g., Markov chain prediction).

Logistic regression for land use is an essential step in the simulation process. Logistic regression aims to identify the relationships between location factors and different land use types. Land allocation probability depends not only on location factors but also on the conversion capability of different land use types. In the conversion settings of the model, conversion elasticity and conversion matrix should be set accordingly. Conversion elasticity reflects the relative elasticity of changing one land use type into any other land use type in the model (Verburg et al., 2002). The conversion matrix shows whether one type of land can be changed into another type (Verburg et al., 2002). Spatial policies can also be considered in the model. For example, some particular sites cannot be changed into other uses because of policy restrictions that are reflected in the simulation. Land allocation must be equal to the land demand calculated by other methods. The adaptive simulation process of CLUE-S is shown in Figure 4.2.

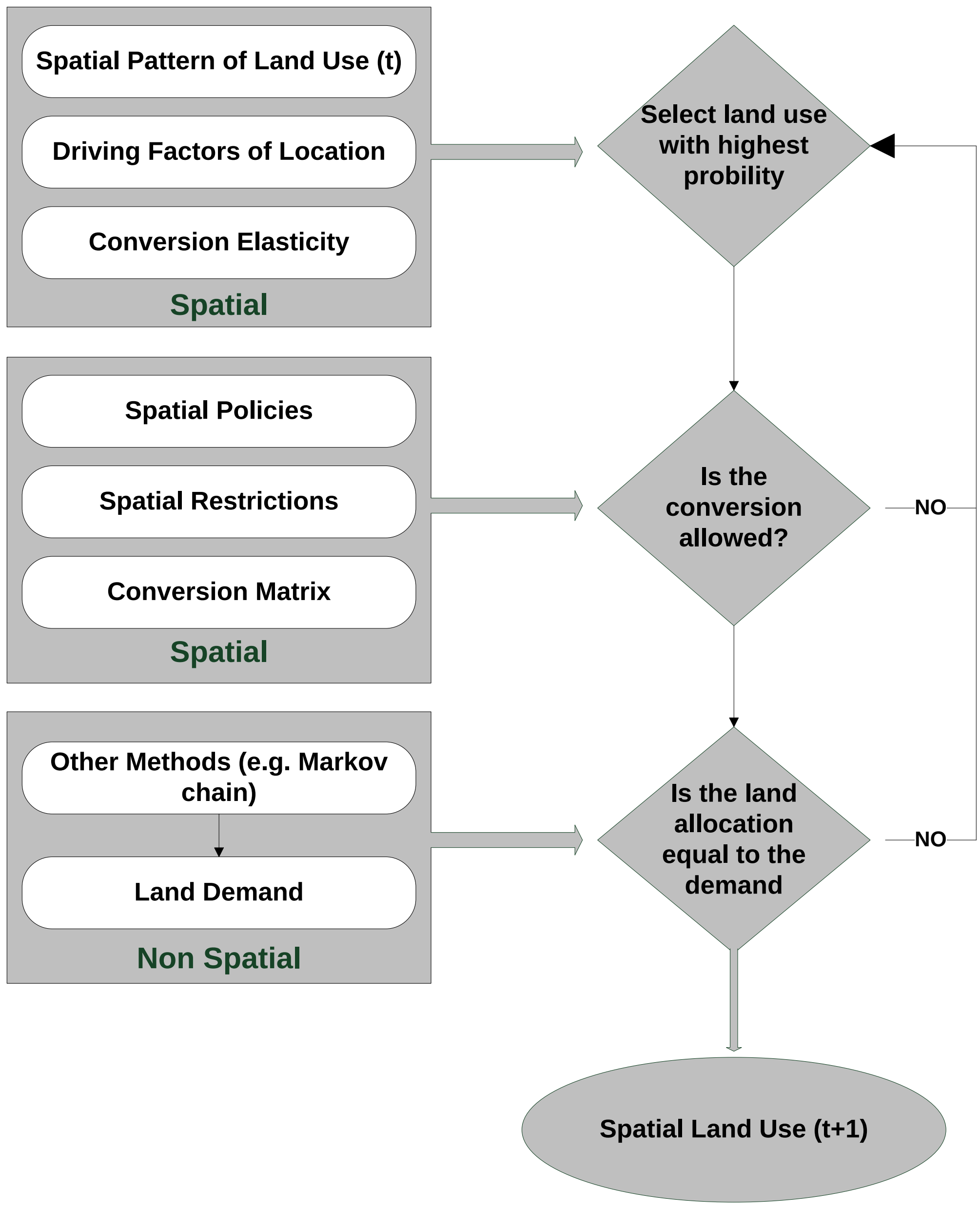

Figure 4.2 Land allocation process adapted from Verburg (2008)

4.5.4 Spatial analysis in GIS

Spatial analysis is defined as a set of analytic techniques, the results of which are based on a two-dimensional frame and could change following the change of the frame (Goodchild & Longley, 1999). Spatial analysis processes two types of information, namely, the attributes of spatial objects and the locational information about spatial objects (Goodchild, 1986). GIS is crucial for spatial analysis because it increases the accessibility of spatial analysis to users, facilitates effective decision-making, and supports scientific research (Goodchild & Longley, 1999).

Spatial analysis in GIS is the main analytical technique for processing spatial data and developing the LUS and SA modules. ArcGIS 10.2 serves as the platform for conducting spatial analysis. A group of spatial analysis and modeling tools were used for raster (cell-based) and feature (vector) data. Tool sets that include density, extraction, generalization, interpolation, mathematics, overlay, joints and relates, projections and transformations, and data conversion in ArcGIS were applied during the research.

4.6 Summary of the Chapter

This chapter introduces the research methodologies adopted in this study including both qualitative and quantitative methodologies. The overall research design is then illustrated. The main research methods, which include document analysis, expert interview, case study, simulation, and experimental study, are discussed separately. Four analytical tools for developing the three modules are introduced: SD, Markov chain prediction, CLUE-S model, and spatial analysis in GIS. These research methods and analytical tools are organized to accomplish the research objectives.

Chapter 5 Conceptualized Framework

5.1 Introduction

The multi-scale framework is conceptualized in this chapter to support urban renewal decision-making. This framework comprises three modules and an associated supporting database that enables decision makers to understand renewal issues at the city, district, and neighborhood scales. The steps for developing the different modules and database can be regarded as the prototype of a decision support system for urban renewal. The functions of the different modules and their integration for decision support are discussed in detail in this chapter, which can be applied in different high-density cities. Hong Kong is selected as the pilot city for the further development of different modules. Therefore, this chapter introduces the rationale of using Hong Kong as the case study area and the data preparation in the preliminary stage of developing the three modules.

5.2 Overview of the Framework

The SD, LUS, and NA modules are the three modules in the framework that support urban renewal decision-making at the city, district, and neighborhood scales, respectively. An associated database is also required. Figure 5.1 presents an overview of the framework, including the steps for developing the three modules and their associated functions for decision-making.

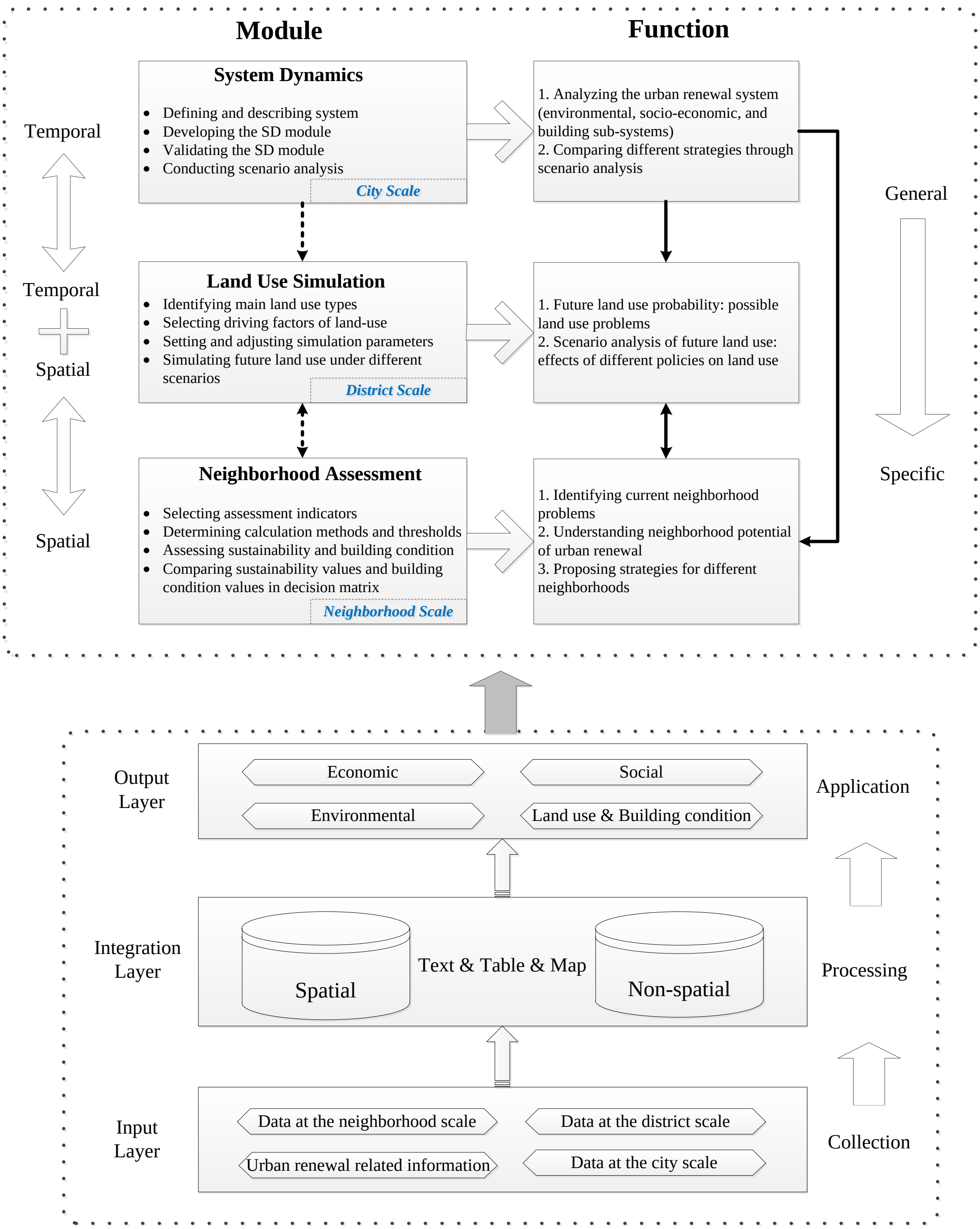

Figure 5.1 An overview of the framework

5.2.1 Supporting Database

To support urban renewal decision-making, crucial information should be collected to establish a supporting database. The establishment of a supporting database comprises three steps, namely, data collection, storage and retrieval, and analysis. First, data at the three scales and urban renewal-related information are collected. Different forms of data exist because information is collected from different sources. The supporting database should ensure that all information could be transferred in a comprehensive and transmissible form. Second, a proper environment is required for data storage and retrieval. A database is usually established with the help of computer technology. Given that this research involves spatial and non-spatial data, different software packages are used for data storage and retrieval. Excel is used to store non-spatial data in the form of tables. ArcCatalog 10.2 stores spatial data and their associated attributes. The supporting database contains economic, social, and environmental information. Land use data and building condition data are also included in the output layer. Decision support modules can be established by analyzing and interpreting the data stored in the database; the results become references for decision makers. Spatial data are mainly analyzed with the ArcGIS 10.2 package. Other software packages used in this research include Microsoft Excel, SPSS, Vensim, MATLAB, and ENVI.

5.2.2 System Dynamics Module

The SD module is aimed at investigating the urban renewal system of a city with consideration of social, economic, and environmental variables; variables related to urban renewal initiatives are also included. The development of the SD module involves four steps. Figure 5.2 shows the details of developing the SD module. First, the boundary of the urban renewal system should be defined, the variables in the system should be identified, and the system should be described through causal loop and stock flow diagrams. Second, the relationships between different variables in the SD module should be set through different expressions. Third, the SD module is validated through different approaches, including a comparison of historical data and simulated data as well as a sensitivity analysis. Fourth, the validated SD module is applied to conduct simulations (scenario analysis). Urban renewal decision-making can be supported from two main aspects: (1) exploration of sub-systems and variables in urban renewal process to provide an improved and comprehensive understanding of urban renewal at the city scale; (2) analysis of the influence of different strategies (e.g., rehabilitation and revitalization) on realizing the objective of urban renewal.

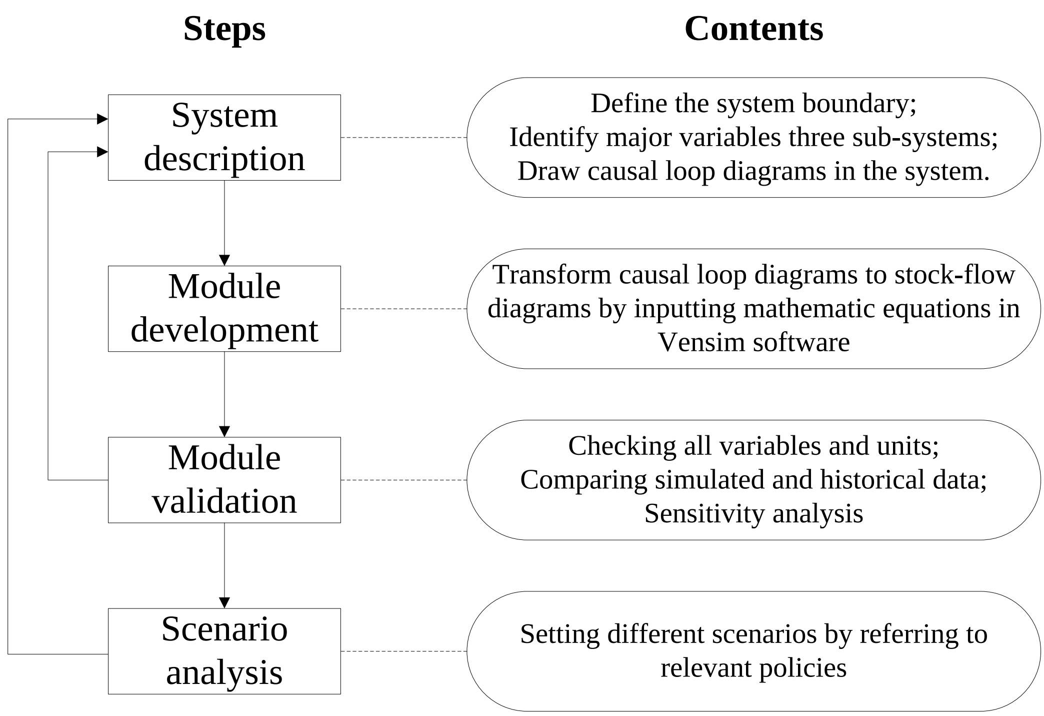

Figure 5.2 Process for constructing the model

5.2.3 Land Use Simulation Module

The LUS module is aimed at providing decision support at the district scale by simulating future land use at the district scale. Four main steps are involved in the module development process: (1) identifying main types of land use for further analysis, (2) analyzing and confirming driving forces/factors in model settings, (3) setting and adjusting the model parameters on the basis of historical change, and (4) simulating future land use and conducting scenario analysis. The driving forces of land use change obtained during the development of the LUS module become valuable references for decision makers tackling land use issues. Land use probability maps and different land use scenarios in the future are the main products of the LUS module. These outputs could indicate land use problems and the future effects of policies.

The identification of factors that affect land use is an essential part of the development of the LUS module. The following paragraphs review previous studies that discussed this issue. Table 5.1 summarizes the factors that influence urban land use. These factors can be referred to in the development of the LUS module and its further applications.

Factors that affect land development

The factors that affect the location of development or redevelopment are complex. These factors have evolved over time as land management has increased in complexity. For example, housing development was first determined by physical conditions, especially in ancient times when technology was not developed. Social development has increased the influence of economic and social factors. Specific influencing factors vary in different contexts. At present, these factors can be classified into several groups, namely biophysical, economic, social, political, and locational factors. This classification is based on related literature.

DEM and slope are two common physical variables that influence urban land development (e.g., Duan et al., 2004; Huang et al., 2009; Liao et al., 2014). A number of studies have considered water (e.g., Maria de Almeida et al., 2003), soil (e.g., van Vliet et al., 2013), and vegetation conditions (e.g., Wang et al., 2013). Economic factors play a key role in the development of urban land use because economic value is regarded as one of the most important values for land resources (Zhang et al., 2002). In areas where land resource is limited and land use is dynamic, land use is likely to be converted to that with economic purpose (Torrens, 2011). For example, given the profitability of urban development projects, they are often implemented in agricultural lands even though the soil is fertile and productive. The specific economic factors mentioned in the literature always include GDP, investment, employment, income, and land price or rent (e.g., Deng et al., 2009; Huang et al., 2009; Jjumba & Dragićević, 2011; Wang et al., 2014). Another influential variable for the location of urban land is a social factor that comprises demographic factors, human attitude and values, cultural factors, and the availability of services (e.g., Huang et al., 2009; Jjumba & Dragićević, 2011; Wang et al., 2014). City growth is often associated with population increase; residential lands appear in areas with enough facilities and commercial centers (Huang et al., 2009). Given that urban land development is space-related and is significantly influenced by the neighborhood environment, location/accessibility and neighborhood factors are considered as the most important variables. These factors can also be interpreted as neighborhood effects, which reflect the attraction or repulsion of surrounding land uses (Anas et al., 1998; van Vliet et al., 2013). These factors are often represented by distance to neighborhood elements, such as water bodies, roads, town centers, facilities, and commercial centers (Haller, 2014; van Vliet et al., 2013; Huang et al., 2013; Feng & Liu, 2013; Maria de Almeida et al., 2003; Huang et al., 2009). For instance, agricultural lands converted to urban lands are always located on the edge of existing urban lands. Industrial lands are always located far from residential lands. Political factors cannot be ignored in such cases (van Vliet et al., 2013; Torrens, 2011) .

Table 5.1 Summarized influencing factors for urban land development

Category	**Sub-category**
Biophysical factors	DEM
	Slope

	Water
	Vegetation
	Solar condition
Economic factors	GDP
	Investment
	Employment
	Income
	Land price/rent
Social factors	Population
	Human attitude and values
	Cultural factors
	Availability of services
Political factors	Land use regulations (e.g. zoning)
	Land ownership (e.g. tenure)
Neighborhood factors	Distance to water bodies
	Distance to roads
	Distance to town centers
	Distance to facilities
	Distance to commercial centers
	Distance to nuisance (noise, light pollution, air pollution)

5.2.4 Neighborhood Assessment Module

The NA module is aimed at providing decision-making support at the neighborhood scale. A general list of assessment indicators should be proposed in this module. Indicators related to sustainability and urban renewal issues are included for assessment. Calculation methods, thresholds of indicators, and final assessment are confirmed through the methods of literature review and expert interview. Neighborhood performance is assessed by two dimensions, namely, sustainability and building condition. The two dimensions are compared to propose preferential strategies for different neighborhood units. The NA module can be used to identify current neighborhood problems, investigate urban renewal potential in the neighborhood, and propose relevant strategies.

Assessment indicators are crucial for the development of the NA module. Before confirming indicators via expert interview, an initial list of indicators should be proposed. A literature review is performed to summarize relevant indicators. Tables 5.2 and 5.3 show the important tools or studies on neighborhood sustainability assessment and urban renewal/regeneration evaluation. These tools and studies serve as the basic references for indicator selection and categorization.

Table 5.2 Summary of important tools for neighborhood sustainability assessment

Theme	Criteria	Neighborhood sustainability assessment						
		LEED-ND	ECC	BREEAM Communities	CASBEE-UD	HQE^2R	Eco city	SCR
Resources and environment	Water	Y	Y	Y	Y	Y	Y	Y
	Energy	Y	Y	Y	Y	Y	Y	Y
	Resources	Y	Y	Y	Y	Y	Y	Y
Social	Housing	Y	Y	Y	N	Y	Y	Y
	Inclusive communities	Y	Y	Y	N	Y	Y	Y
	Community well-being	Y	Y	Y	Y	Y	Y	Y
Economic	Employment, business, economy	Y	Y	Y	N	Y	Y	Y
Land use form	Mixed use	Y	Y	Y	N	Y	Y	Y
	Access, infrastructure	Y	Y	Y	Y	Y	Y	Y

Note: LEED-ND, ECC, BREEAM Communities, CASBEE-UD, HOE^2R, Ecocity, and SCR are major neighborhood sustainability assessment tools applied in different regions around the world. Y means that the specific tool applies to this criterion. N means that the specific tool does not use this criterion.

Table 5.3 Summary of studies on urban renewal/regeneration evaluation

Urban renewal/regeneration evaluation		
Theme	**Tool/Method**	**Source**
Income, Employment, Health and disability, Education, Skill and training, Barriers to housing and services, Crime	Deprivation indices in regeneration	Greig et al. (2010)
Building conditions, Building management	The dilapidation index	Ho et al. (2012)
Water and soil resources, Site and architecture, Comfort and health, Land and landscape, Infrastructure, Building concept, Community, Viability, Safety, Energy, Domestic water and waste, Operating costs	A multi-criteria approach to compare urban renewal scenarios for an existing neighborhood	Pérez and Rey (2013)
Economy & work, Resource use, Building & land use, Transport & mobility, Community benefits	An indicator-based approach to measuring sustainable urban regeneration performance;	Hemphill et al. (2004)
	An aggregated weighting system for evaluating sustainable urban regeneration	Hemphill et al. (2002)
Social (user comfort, form and space, access, amenity, inclusion), Economy (social benefits and cost, transport, employment, competition effects, viability), Environment (air quality, land use, water, ecology and cultural heritage, design and operation, transport), Natural resources (materials, water, energy, land utilization, waste hierarchy)	Sustainability indicators in decision-making processes for urban regeneration projects	Hunt et al. (2008)

5.2.5 Integration of the Three Modules

These three sub-modules are not isolated. The SD module provides a general direction for urban renewal. Under this general direction, the LUS module can provide guidance on land use issues, including the possible problems and effects of different policies/strategies based on the simulation of future land use change at the district scale.

Neighborhood problems can be found on the basis of the NA results, and a specific strategy can be proposed accordingly. By combining the LUS and NA modules, specific strategies and approaches can be raised. The references provided by the SD, LUS, and NA modules range from a general direction to specific strategies and from a macro perspective to a micro perspective. The SD module explores the urban renewal system from a temporal dimension, the LUS module explores the land use issue from both spatial and temporal dimensions, and the NA module explores neighborhood issues in a spatial dimension. The factors in the three modules involve three aspects of sustainability. There is a building sub-system in the SD module, which is related to the indicator category of building condition in the NA module. The connection between the SD module and the NA module is also shown in some variables relating to social and economic aspects. Some factors especially factors concerning the spatial pattern of land use in the LUS module can be found in the NA module, but are expressed in different ways for two scales. The integration of the three modules can reflect current issues and predict future alternatives. Comprehensive and multi-scale references can be provided to facilitate objective decision-making.

5.3 Data Preparation

To realize the functions of different modules in the framework, a real case should be applied. In Chapter 3, urban renewal practices in four high density cities including Hong Kong, Singapore, Tokyo, and Seoul are reviewed and compared in terms of their strategies, stakeholders, and the changes over time. The findings from the review on urban renewal practices in the aforementioned four cities indicate the complexity of urban renewal in practice. To realize sustainable urban renewal, it is essential to provide objective and comprehensive decision support. The proposed multi-scale decision support framework therefore can be applied to these high-density cities with its comprehensive considerations from multiple dimensions.

Given the serious urban decay problem in Hong Kong, the city is selected as the case study area to illustrate the application of the proposed framework to support decision-making at different scales. Due to time limitation, this research did not choose other cities for the application of the proposed framework.

The basic condition of Hong Kong and the necessity of improving urban renewal decision-making in Hong Kong are stated as follows. Hong Kong has a population of about 7.2 million and a land area of 1,104 km^2. Hong Kong is one of the world's most densely populated metropolises. Only 25% of land in Hong Kong is suitable for urban development. Hong Kong has three regions, namely, Hong Kong Island, Kowloon, and the New Territories. Hong Kong has continually faced issues that include land supply shortage, urban decay, and unpleasant living environment. In terms of the urban decay issue, Hong Kong has approximately 4,000 buildings that are aged 50 years or above. This figure will increase by 500 each year over the next decade (Development Bureau, 2011: 1). To solve the urban problems in Hong Kong, urban renewal was proposed as a crucial policy agenda after the establishment of the LDC, which was later replaced by the URA. Urban renewal initiatives in Hong Kong have been criticized because of fading local culture, profit-driven features, expulsion of local residents and businesses, and lack of comprehensive design. Expert interviews indicate that finance is the main consideration for decision-making in the URA. This finding is another source of criticism. Given these comments, decision-making related to urban renewal in Hong Kong should be improved by focusing on other important aspects for sustainable development.

Hong Kong is used as the basis for the development of the SD module. The Yau Tsim Mong (YTM) district in Hong Kong is adopted to illustrate the LUS module. Nine tertiary planning units in Kowloon, Hong Kong, are evaluated in the NA module. Data are prepared on the basis of the requirements of the three modules.

Data collection

Raw data at the city scale are provided as statistical tables that relate to society, economy, environment, and real estate. Given that the focus of this study is Hong Kong, data are collected from the Census and Statistics Department, Urban Renewal Authority, and Buildings Department in Hong Kong. Raw data at the district scale are obtained from digital topographic maps of Hong Kong, Hong Kong land utilization maps (for years 2000, 2003, 2006, and 2009), remote sensing images, governmental documents, and property transaction records. These data are collected from the Planning Department, Lands Department, and the website of Centamap of Hong Kong. Raw data at the neighborhood scale are digital topographic maps, current land utilization maps, statistical tables of tertiary planning units (neighborhood scale), and spatial maps of buildings. These data are collected from the Planning Department, Lands Department, Census and Statistics Department, and Buildings Department.

Data processing

After collecting the raw data from different sources, they are processed and integrated in the supporting database. Data at the city scale are stored as tables in temporal dimension (from 2001 to 2012). Data at the district scale are stored in spatial form with year-based information (temporal dimension). Data at the neighborhood scale are stored as spatial data including their associated attributes. Data processing activities comprise the digitalization of land use maps, derivation of different information from digital maps, spatial analysis of some information, integration of some non-spatial attributes with spatial data, and transformation between different data forms.

5.4 Summary of the Chapter

This chapter introduces the conceptualized framework (see Figure 5.1), including its database and the three modules. The steps for developing the three modules and the references they can provide are described. The conceptualized framework also illustrates the relations and integration of different modules. The three modules and supporting database cannot be isolated from one another. Only an effective integration of the three modules and a proper application of the database in the decision-making process can ensure the sustainability of urban renewal activities. Additionally, Hong Kong, as one high-density city, is selected as the case study city, drawing on the similarities among the aforementioned four cities in Chapter 3. Data preparation for further module development focusing Hong Kong is therefore discussed in this chapter.

Chapter 6 Development of Three Modules

6.1 Introduction

After conceptualizing the framework and preparing relevant data, the three modules were constructed respectively. The whole city of Hong Kong is used for developing the SD module; YTM district is selected for developing the LUS module; and several neighborhood units are chosen for establishing the NA module. This chapter presents the details of developing the SD, LUS, and NA modules respectively by using case studies.

6.2 System Dynamics Module

SD modeling always follows a four-step approach, as proposed by many scholars (e.g. Coyle, 1996; Sterman, 2000). These steps include model description, causal loop diagram, stock-flow diagram, and model validation (Yuan et al., 2011). Vensim, a SD software package, was employed to construct the SD module in the framework. Hong Kong is chosen as the case study area. This section introduces module description through causal loop and stock-flow diagrams, module validation, simulation results, and policy implications.

6.2.1 Module Description

The time range of the SD module is 24 years, from 2001 to 2024. The data from 2001 to 2012 were obtained and processed from statistical data. The scope of the SD is the urban renewal system in Hong Kong, especially focusing on the interrelationships within the system and required area of urban renewal projects. Three pillars (society, economy, and environment) of sustainable development are closely linked with common objectives of urban renewal (Zheng et al., 2014); urban renewal projects involve many old buildings, including their affected society and environment. Therefore, three sub-systems are conceptualized in the SD module, namely, building sub-system, socio-economic sub-system, and environmental sub-system. The interactions/causal-effective relationships among these three sub-systems are established based on existing literature (e.g., Xu & Coors, 2012) and analysis of existing data. The data sources are the Hong Kong Annual Digest of Statistics from 2001 to 2012 and Urban Renewal Authority Annual Report. The details of each sub-system are described below, and their causal loop and stock-flow diagrams are presented in Figure 6.1.

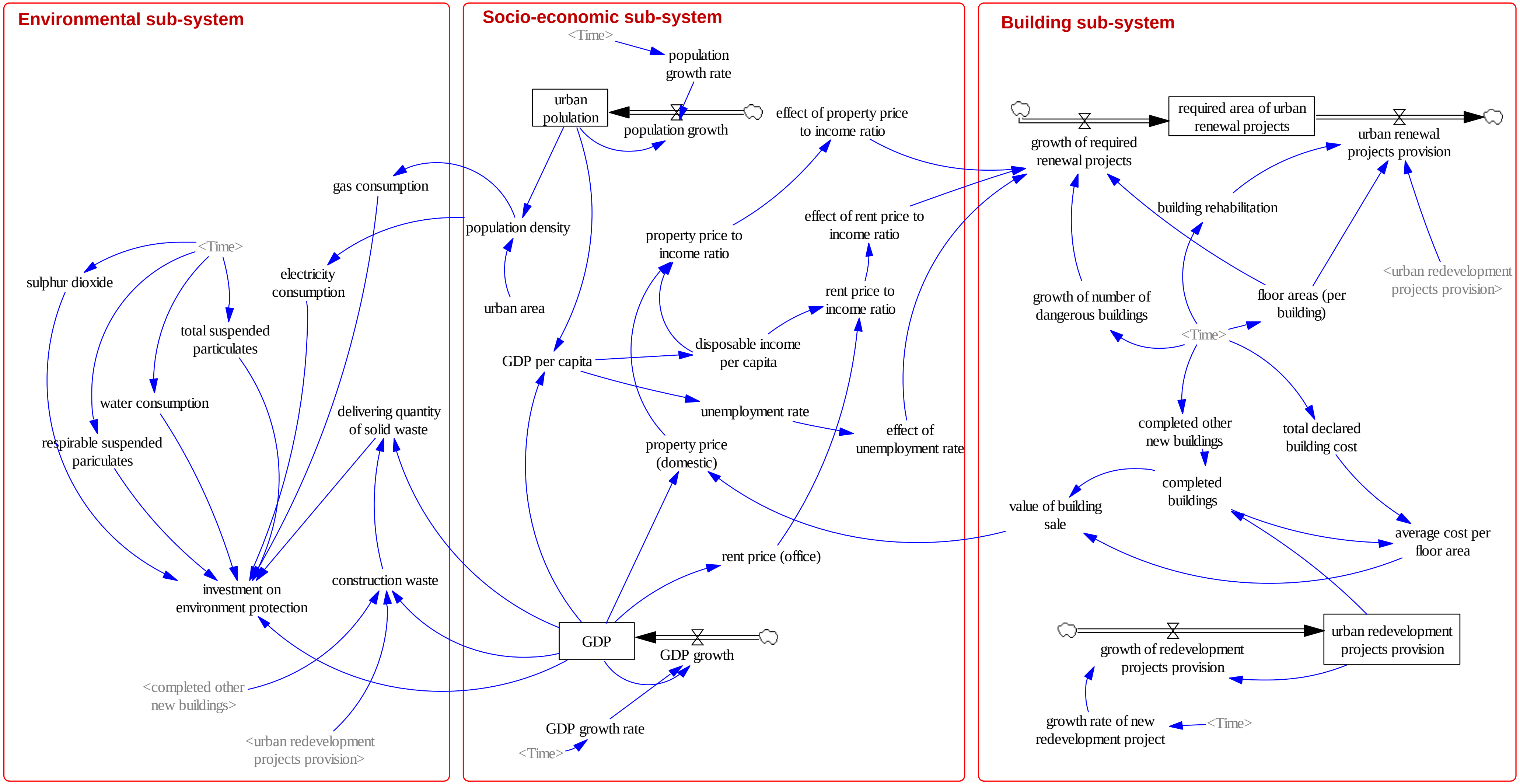

Figure 6.1 Causal-loop and stock-flow diagrams of three sub-systems in Vensim

Building sub-system

Building sub-system is the core sub-system in the SD module because it involves two essential stocks in the system, namely, "required area of urban renewal project" and "urban redevelopment project provision." Required area of urban renewal project means the total gross floor area of urban renewal projects that are needed in order to address urban decay issue. Furthermore, it is the simulation target of scenario analysis because it is an important consideration for urban renewal decision. Three rate variables used include "growth of required renewal projects," "urban renewal project provision," and "growth of redevelopment project provision." Growth of required area of urban renewal projects is influenced by the situation of dangerous buildings and some variables in the socio-economic sub-system, such as "the effect of rent price to income ratio," "the effect of property price to income ratio," and "the effect of employment rate," from which the connection between socio-economic and building sub-systems is established. Urban renewal project provision is affected by both the initiatives of building rehabilitation and urban redevelopment project provision, which reflect two main approaches of urban renewal in Hong Kong. This sub-system influences the socio-economic sub-system through the variable of "value of building sale." The environmental sub-system is connected with building sub-system through the variables of "completed other buildings" and "urban redevelopment projects provision," which are two sources of construction waste.

Socio-economic sub-system

The socio-economic sub-system is important because any changes in this sub-system will significantly cause changes in the other two sub-systems. Two stock variables exist, "urban population" and "GDP," both of which influence other essential variables in the socio-economic sub-system, including “property price of domestic housing,” “rent price of office estates,” “unemployment rate,” and “disposable income per capita.” Considering that the two stock variables are decided by complex factors (which are beyond the scope of this research), their influencing rate variables in the SD module are simplified as “population growth” and “GDP growth,” both of which are the functions of time.

Urban population and GDP further act as indispensable variables to connect socio-economic and environmental sub-systems because they significantly decide the performances of many aspects in the environmental sub-system. The driving forces, pressures, states, impacts, and responses (DPSIR) framework proposed by the Organization of Economic Cooperation and Development (OECD) is capable of illustrating the relationships within the social, economic, and environmental systems (Xu & Coors, 2012). Consistent with this DPSIR framework, the stock variables “urban population” and “GDP” act as the driving forces that lead to the pressures of the environment, and then affect urban pollution (e.g., air pollution and water consumption) reflected in the environmental sub-system.

Environmental sub-system

Although the environmental sub-system does not directly influence the other two sub-systems in the SD module, the change of variables within the sub-system is directly decided by other two sub-systems. Furthermore, the environmental sub-system is an essential part for the entire urban renewal system, and the variables in it play a significant role in the sustainable performance of urban renewal. Therefore, the environmental sub-system is further considered and depicted in the SD module. Within it, different aspects of environmental impacts (e.g., “sulphur dioxide,” “total suspended particulates," "water consumption," "electricity consumption," and "delivering quantity of solid waste") are displayed as different variables that influence the variable of "investment on environmental protection."

6.2.2 Module Validation

Before conducting quantitative analysis and simulation, it is necessary to test the credibility of the SD module through validation (Sterman, 2000). Model validation is the procedure of testing and developing the credibility of a model (Sterman, 2000) and then illustrating whether that model satisfies the internal requirements on the methods applied and the results acquired (Zheng et al., 2012). Using a single testing approach to fit the historical data cannot validate models (Musango et al., 2014). Hence, to verify the SD module, the current study utilized two approaches including sensitivity analysis and comparison between historical data and simulated results.

Comparison of simulated and historical data

To test whether the model is consistent with historical behavior, calculating the relative error (Wu et al., 2011; Xu & Coors, 2012) and mean square deviation of the indicators (Oliva, 2003; Xu & Coors, 2012) is commonly performed. Their formulas are expressed by

$$e_i = \left| y'_{it} - y_{it} \right| / y_{it} \quad (1)$$

$$MSEi = \sqrt{\sum_{1}^{n} e_{it}^2 / n} \quad (2)$$

in the formulas above, y'_{it} represents the simulated data of the indicator i in year t, y_{it} is the historical data of the indicator i in year t, e_i refers to the relative error of the indicator i, $MSEi$ stands for mean square deviation of the indicator i, and n is the number of selected historical data for verification of the indicator i. Table 6.1 shows the results of the comparison on historical data and simulated data for selected nine variables. Approximately 73% of the values have an error of less than 5%. For most indicators, $MSEi$ is less than 10%. Although “unemployment rate”, “construction waste” and “investment on environmental protection” have values of $MSEi$ more than 10%, these values are still within the range of 10% to 12.5%. Additionally, these three indicators are not crucial variables in this research. Hence, this model meets the accuracy requirements from a theoretical standpoint.

Sensitivity analysis

Sensitivity analysis is done to test how the behavior of the developed model responds to the changes of the variable values over a reasonable range (Maani & Cavana, 2000). For the developed SD module, “required area of urban renewal projects” was selected for sensitivity analysis because it is the most important variable. Given that GDP and urban population influence most variables in the whole system, while “growth of number of dangerous buildings” and “building rehabilitation” are direct influencing variables for “required area of urban renewal projects,” changes were made to “GDP growth rate,” “population growth rate,” “growth of number of dangerous buildings,” and “building rehabilitation.” The change ranges with negative and positive 10% and 20% were chosen to investigate the sensitivity of the stock variable “required area of urban renewal projects.” Sensitivity values were calculated through the formula given by

$$S_M = \left| \frac{\Delta M_t}{M_t} \times \frac{\Delta P_t}{P_t} \right| \quad (3)$$

In this formula, t refers to time, S_M represents the sensitivity of M to P, M_t is the value of stock M at the time t, P_t is the value of P at time t, and ΔM_t and ΔP_t refer to changes in M and P at time t, respectively.

Figure 6.2, 6.3, 6.4, and 6.5 show the results of these four auxiliary variables, respectively. Sensitivity values of "required area of urban renewal projects" to "GDP growth rate," "population growth rate," "growth of number of dangerous buildings," and "building repairs" are less than 0.003, 0.0001, 0.03 and 0.06 respectively, all of which indicate the steady changes of "required area of urban renewal projects" under different conditions. Comparatively, the variables of "growth of number of dangerous buildings" and "building rehabilitation" have greater influences on "required area of urban renewal projects" because they are direct factors for the changes of rate variables. Meanwhile, "GDP growth rate" has the minimal impact on "required area of urban renewal projects."

Table 6.1 Comparison table of historical data and simulation results

Indicators	Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	MSE
Disposable income per capita	Simulated data	147.61	147.74	148.08	147.65	147.89	149.47	156.60	159.21	155.71	162.87	177.56	187.02	0.014
	Historic data	152.10	149.70	146.60	144.70	145.80	148.90	155.20	156.60	157.90	163.10	178.30	187.50	
	Relative error	0.03	0.01	0.01	0.02	0.01	0.00	0.01	0.02	0.01	0.00	0.00	0.00	
Property price of domestic estates	Simulated data	76.55	73.18	75.72	79.55	82.95	84.40	110.87	116.44	130.55	145.83	172.92	197.75	0.087
	Historic data	78.70	69.90	61.60	78.00	92.00	92.70	103.50	120.50	121.30	150.90	182.10	206.20	
	Relative error	0.03	0.05	0.23	0.02	0.10	0.09	0.07	0.03	0.08	0.03	0.05	0.04	
Rent price of offices	Simulated data	87.19	83.36	77.67	86.83	100.00	113.70	137.77	144.27	137.58	152.56	172.21	183.58	0.061
	Historic data	101.00	85.40	74.60	78.10	96.40	117.40	131.90	155.50	135.70	147.60	169.90	188.30	
	Relative error	0.14	0.02	0.04	0.11	0.04	0.03	0.04	0.07	0.01	0.03	0.01	0.03	
Unemployment rate	Simulated data	6.12	6.77	8.03	6.40	5.38	4.89	4.27	4.14	4.32	3.99	3.53	3.32	0.104
	Historic data	5.10	7.30	7.90	6.80	5.60	4.80	4.00	3.50	5.30	4.30	3.40	3.30	
	Relative error	0.20	0.07	0.02	0.06	0.04	0.02	0.07	0.18	0.18	0.07	0.04	0.00	
Electricity consumption	Simulated data	135318	137401	136487	139971	141772	144212	147089	148821	149389	151098	152348	153780	0.011
	Historic data	134139	134112	138435	141201	144172	145204	147072	147345	149366	150705	151432	154911	
	Relative error	0.01	0.02	0.01	0.01	0.02	0.01	0.00	0.01	0.00	0.00	0.01	0.01	
Gas consumption	Simulated data	26670	26770	26726	26902	27002	27151	27353	27495	27547	27725	27891	28184	0.008
	Historic data	26564	26641	27002	27137	27261	27034	27041	27583	27274	27578	28147	28360	
	Relative error	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	
Delivering quantity of solid waste	Simulated data	3450.8	3498.3	3498.1	3462.9	3469.1	3476.6	3391.9	3427.0	3409.1	3400.9	3146.6	3458.8	0.025
	Historic data	3395.0	3439.0	3446.0	3400.0	3423.0	3387.0	3352.0	3301.0	3271.0	3326.0	3283.0	3395.0	
	Relative error	0.02	0.02	0.02	0.02	0.01	0.03	0.01	0.04	0.04	0.02	0.04	0.02	
Quantity of	Simulated data	2279.5	3707.1	2336.7	2582.6	2102.9	1637.0	1196.3	1359.0	1246.2	1356.7	840.5	1323.7	0.123

construction	Historic data	2339.7	3723.0	2456.5	2409.0	2394.4	1507.5	1153.4	1127.9	1138.8	1306.7	1215.5	1255.6	
waste	Relative error	0.03	0.00	0.05	0.07	0.12	0.09	0.04	0.20	0.09	0.04	0.31	0.05	
Investment on	Simulated data	2330.2	1839.3	1624.7	1673.2	1292.1	1163.8	1380.5	1821.9	3748.9	4652.8	6383.4	7079.5	0.108
environmental	Historic data	2252.0	1625.0	1587.0	1495.0	1361.0	1581.0	1323.0	1711.0	3272.0	4942.0	6390.0	6712.0	
protection	Relative error	0.03	0.13	0.02	0.12	0.05	0.26	0.04	0.06	0.15	0.06	0.00	0.05	

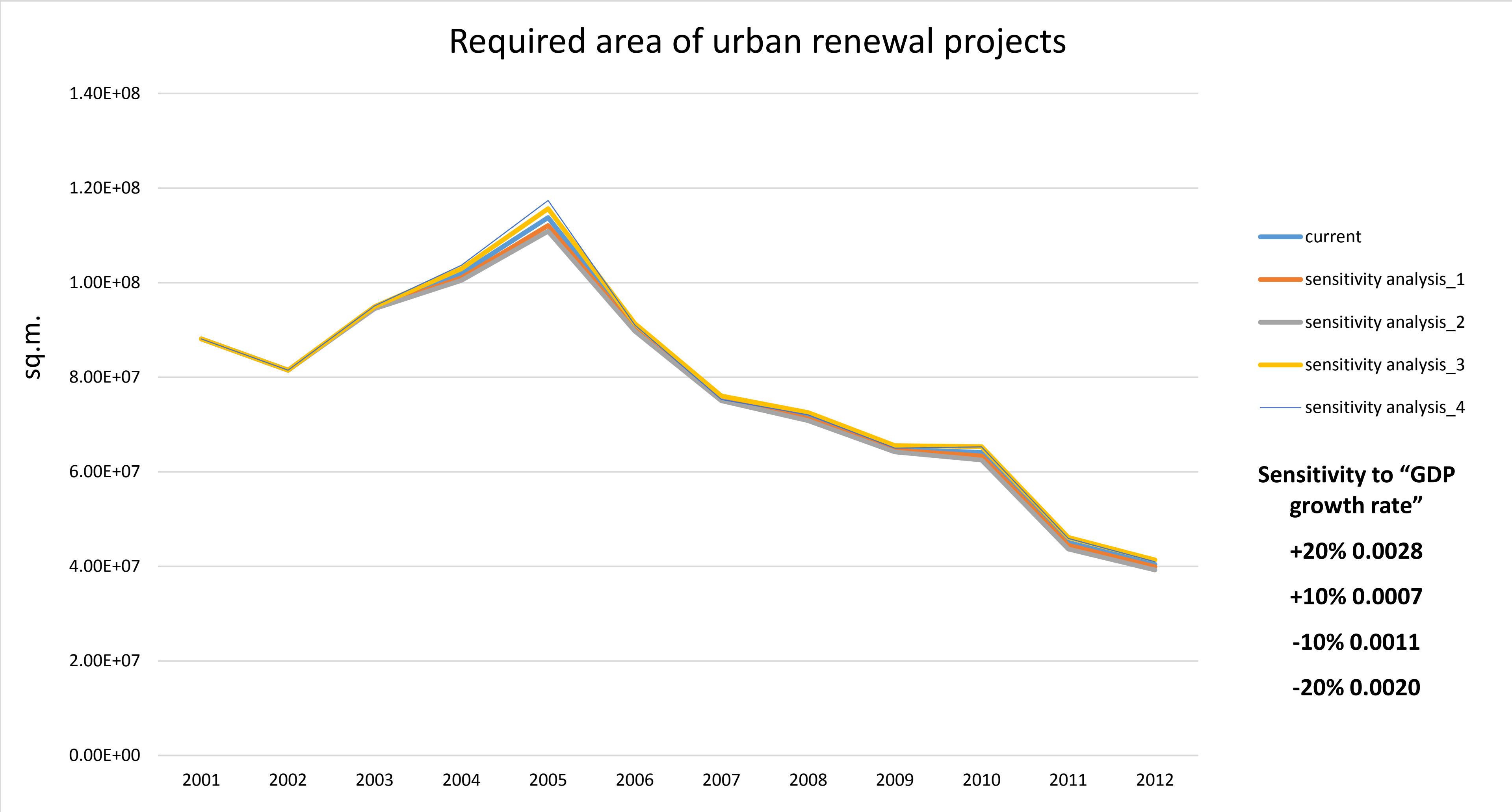

Figure 6.2 Sensitivity of "required area of urban renewal projects" to "GDP growth rate"

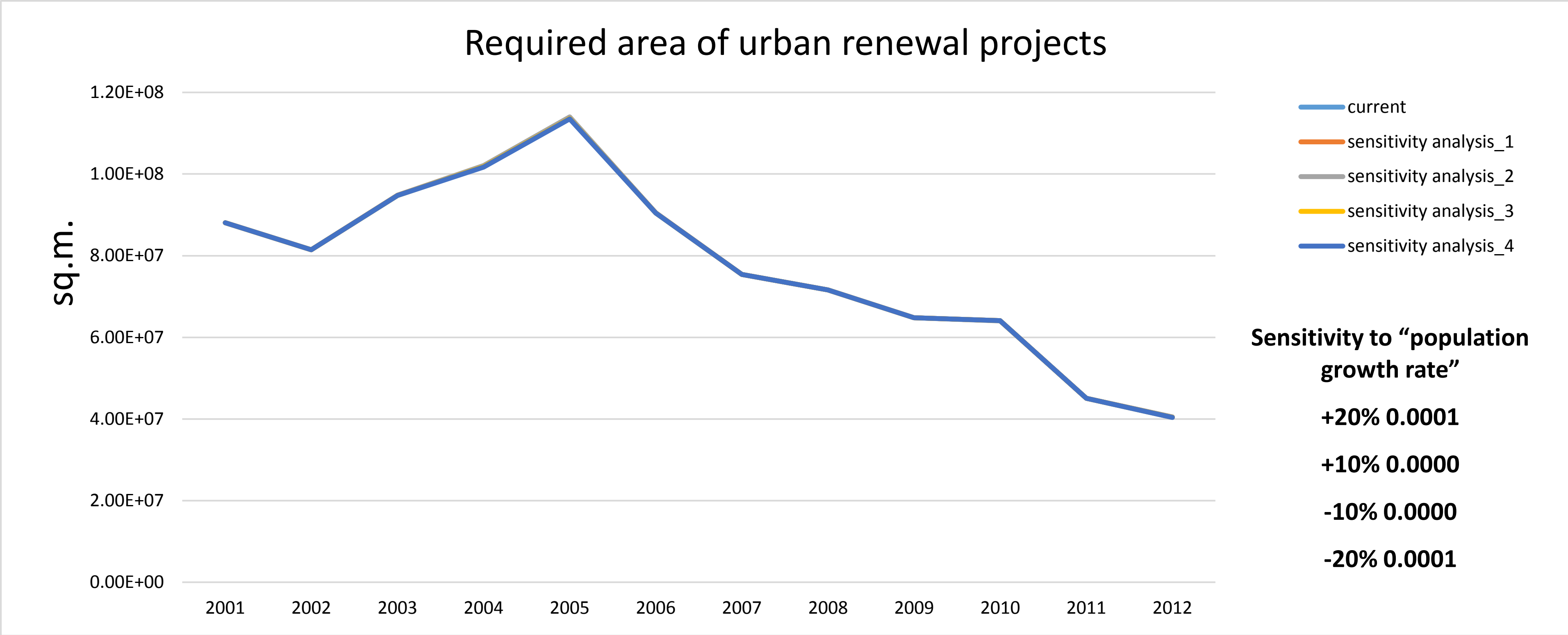

Figure 6.3 Sensitivity of "required area urban renewal projects" to "population growth rate"

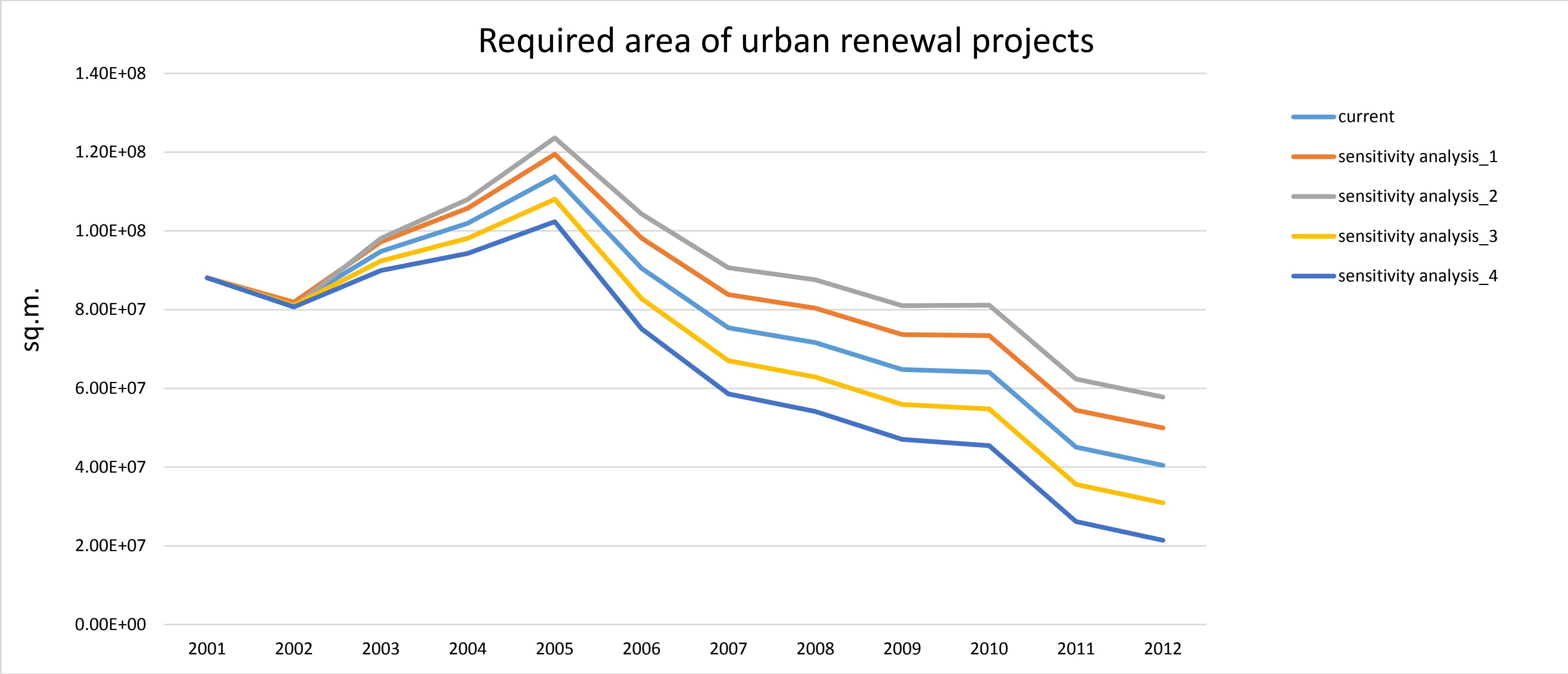

Figure 6.4 Sensitivity of “required area of urban renewal projects” to “growth of number of dangerous buildings”

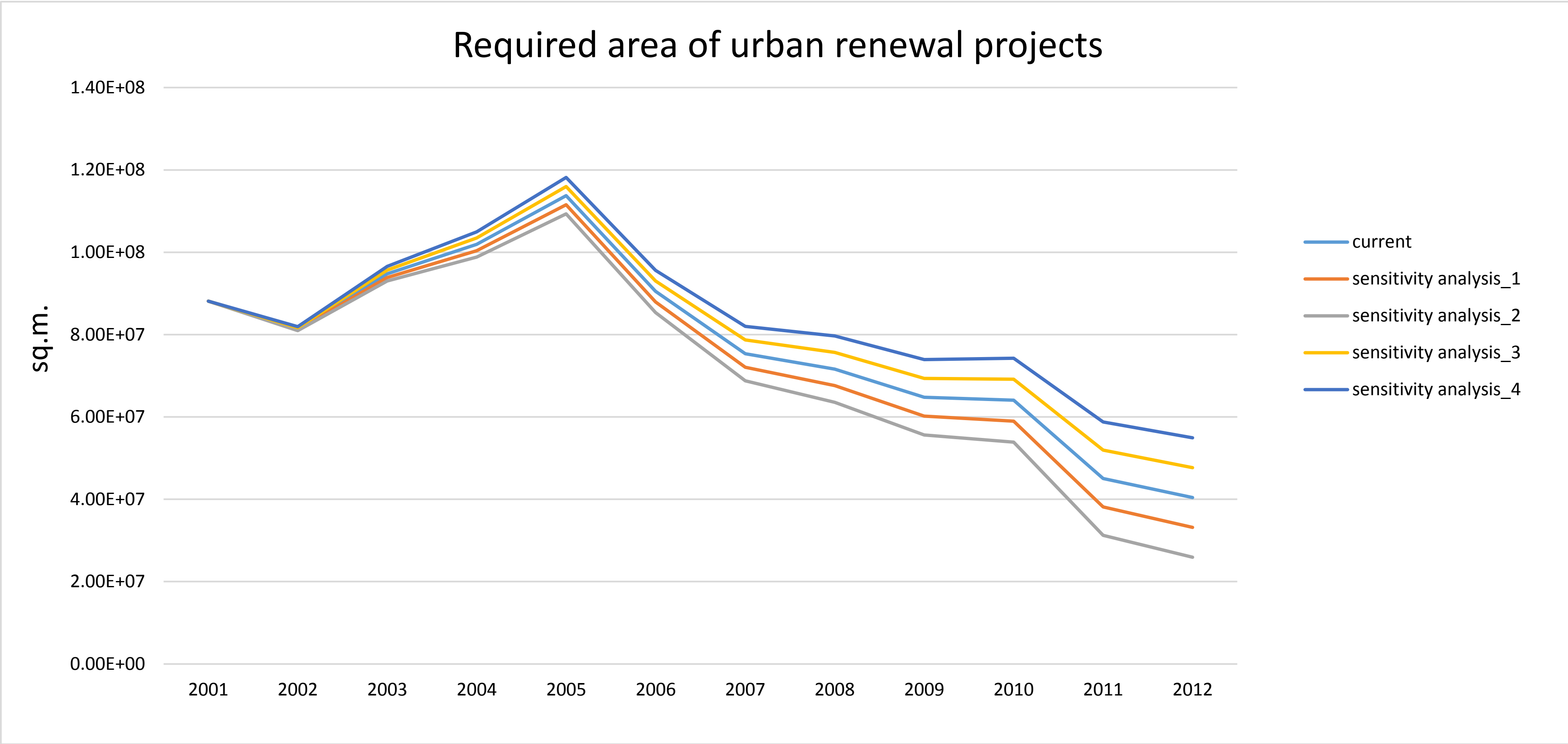

Figure 6.5 Sensitivity of "required area of urban renewal projects" to "building rehabilitation"

Note: Current: the base run simulation; Sensitivity analysis_1: the result of testing variable value with 10% increase; Sensitivity analysis_2: the result of variable value having the change of positive 20%; Sensitivity analysis_3: the result of variable value with 10% decrease; Sensitivity analysis_4: the result of variable value with the change of negative 20%

6.2.3 Simulation Results

After verifying the SD module structure, simulation and quantitative analysis under six scenarios are conducted. Results of scenario analysis are displayed and discussed in this section. In terms of values for some time functions in this module, grey prediction is applied to obtain the values in the future. Grey theory is a multidisciplinary and generic theory addressing systems that are featured by poor information and/or in which information is lacking (Hsu & Chen, 2003). Contrary to statistical methods, the potency of the original time series grey model GM (1,1) has been proven to be more than four (Deng, 2002). Additionally, it is not necessary to have the assumptions in relation to the statistical distribution of data when applying grey prediction (Hsu & Chen, 2003). As the historical changes of time functions meet the rules of applying grey prediction, grey theory was utilized to make the prediction in the SD module. When setting different scenarios, "growth of number of dangerous buildings," "building rehabilitation," and "growth rate of new redevelopment projects" were changed to represent different scenarios. Table 6.2 summarizes the comparison of scenarios. Table 6.3 and Figure 6.6 display the detailed results under different scenarios.

Scenario 1

The first scenario is the base run simulation that follows the historical trend. The simulation results show a gentle yearly decrease of the value of "required area of urban renewal projects." The value of "required area of urban renewal projects" will decrease to 16.9 million m^2 in 2024, yet the provision of urban renewal projects still cannot reduce to zero. This scenario implies that the time of reducing the value of "required area of urban renewal projects" to zero need more than a decade after 2024 if the policy and action of urban renewal follow the current path.

Scenario 2

In order to explore how the value of “required area of urban renewal projects” will change when the number of dangerous buildings increase at a rapid speed, this scenario is therefore set as the scenario in which the number of dangerous buildings increases in extremely rapid rate. The number of buildings with age of 50 years or above in Hong Kong will increase by 500 each year in the next ten years, according to the Urban Renewal Strategy (2011). Under this scenario, the growth in the number of dangerous buildings is set at 500, assuming that all buildings aged 50 years or above become dangerous buildings. The result shows that the value of “required area of urban renewal projects” will decrease slowly over time, implying that more time is required for reducing it to none. In 2024, the area of required area of urban renewal projects will be about 26.5 million m^2, nearly double that under scenario 1.

Scenario 3

In recent years, the Urban Renewal Authority has been positively involved in the urban renewal process of Hong Kong, although it has faced several obstructions along the way. Scenario 3 aims to explore the situation of more actively implementing urban renewal activities, including redevelopment and rehabilitation. Thus, the value of “growth rate of new redevelopment project” is set to double the average value of historical data and the value of “building rehabilitation” is also set to double the average value in history. The decrease of the value of “required area of urban renewal projects” is at the highest speed among the four scenarios. Only under this scenario can the value of “required area of urban renewal projects” reduce to zero within the next decade. In 2020, the value of “required area of urban renewal projects” will reduce to zero if positive urban renewal policies and actions are carried out during the next decade.

Scenario 4

To compare the situation of moderate urban renewal action with that in Scenario 3, the values of “growth rate of new redevelopment project” and “building rehabilitation” under Scenario 4 are set to half those in Scenario 1. With the smallest decreasing rate, the area of required area of urban renewal projects will decrease to 53.7 million m^2 in 2024, implying that at least another decade is required to achieve the objective of addressing urban decay issue following this trend.

Scenario 5

Urban development and rehabilitation are two main approaches to improving old buildings in Hong Kong. In order to explore how the balance can be achieved between urban redevelopment projects and urban rehabilitation projects, two other scenarios (Scenario 5 and Scenario 6) are established to investigate the influences of initiating building rehabilitation and redevelopment projects on reducing the value of “required area of urban renewal projects” respectively. Under Scenario 5, “growth rate of new redevelopment projects” is set to be same as that in Scenario 3 while “building rehabilitation” is the same as that in scenario 1. The result indicates that the value of “required area of urban renewal projects” will reduce to zero in 2024.

Scenario 6

This scenario is set to make the comparison with scenario 5. Under Scenario 6, the value of “growth rate of new redevelopment projects” is set to be the same as that in Scenario 1, while the value of “building rehabilitation” is the same as that in scenario 3.

The result shows that the value of “required area of urban renewal projects” will reduce to zero in year of 2020 under this scenario. Obviously, “building rehabilitation” has a greater influence on resolving urban decay issue.

6.2.4 Findings and Policy Implications

The environmental, socio-economic, and building sub-systems are quantitatively constructed in the SD module. From causal loop and stock-flow diagrams, the interrelationships underlying different variables suggest that the social, environmental, and economic aspects are closely interrelated in the urban renewal system, indicating the potential of urban renewal to enhance sustainable development of cities because these three aspects are cores for sustainability.

Based on scenario analysis, it is concluded that required area of urban renewal projects follows the declining trend gradually but with various rates. The results also show that changing urban renewal strategies have a greater impact on reducing the value of “required area of urban renewal projects” compared with changing the value of “growth rate of dangerous buildings.” Additionally, the value of “growth rate of dangerous buildings” cannot be changed subjectively, thus implying that active policy for urban renewal initiatives can play a more important role in solving the urban decay problem of Hong Kong. By comparing the Scenario 5 and Scenario 6, we find that building rehabilitation can better contribute to reducing the value of “required area of urban renewal projects.” Therefore, it is suggested that urban rehabilitation initiatives should be planned and conducted more positively, although redevelopment projects are still required for the future urban renewal agenda. Currently, adaptive reuse of existing buildings and retrofitting existing buildings have been widely recognized to contribute to sustainable development (Bullen & Love, 2010; Ma et al., 2012). City planners can prioritize the use of these two approaches in the urban renewal process of Hong Kong.

Table 6.2 Comparison of scenarios

Scenarios	**Contents**	**Remarks**
Scenario 1 (S1)	This scenario follows the historical trend	
Scenario 2 (S2)	This scenario is concerned with whether extreme increase of dangerous buildings would influence "required area of urban renewal projects"	
Scenario 3 (S3)	This scenario is to investigate the effect of implementing active renewal activities (both rehabilitation and redevelopment) on reducing "required area of urban renewal projects"	S3 and S4 can be used to compare the differences between positive and moderate urban renewal policies.
Scenario 4 (S4)	This scenario aims at exploring the effect of implementing moderate renewal activities (both rehabilitation and redevelopment) on reducing "required area of urban renewal projects"	
Scenario 5 (S5)	This scenario is to simulate the influence of increasing urban redevelopment projects on reducing "required area of urban renewal projects"	S5 and S6 can be applied to investigate the different effects of carrying out redevelopment and rehabilitation on urban renewal.
Scenario 6 (S6)	This scenario is with the purpose of finding out the influence of increasing rehabilitation activities on reducing "required area of urban renewal projects"	

Table 6.3 Simulation results of required area of urban renewal projects

Time (Year)	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
2001	8.81E+07	8.81E+07	8.81E+07	8.81E+07	8.81E+07	8.81E+07
2002	7.64E+07	7.64E+07	7.64E+07	7.64E+07	7.64E+07	7.64E+07
2003	1.21E+08	1.21E+08	1.21E+08	1.21E+08	1.21E+08	1.21E+08
2004	1.48E+08	1.48E+08	1.48E+08	1.48E+08	1.48E+08	1.48E+08
2005	1.83E+08	1.83E+08	1.83E+08	1.83E+08	1.83E+08	1.83E+08
2006	1.45E+08	1.45E+08	1.45E+08	1.45E+08	1.45E+08	1.45E+08
2007	1.25E+08	1.25E+08	1.25E+08	1.25E+08	1.25E+08	1.25E+08
2008	1.23E+08	1.23E+08	1.23E+08	1.23E+08	1.23E+08	1.23E+08
2009	1.16E+08	1.16E+08	1.16E+08	1.16E+08	1.16E+08	1.16E+08
2010	1.16E+08	1.16E+08	1.16E+08	1.16E+08	1.16E+08	1.16E+08
2011	9.68E+07	9.68E+07	9.68E+07	9.68E+07	9.68E+07	9.68E+07
2012	9.17E+07	9.17E+07	9.17E+07	9.17E+07	9.17E+07	9.17E+07
2013	8.89E+07	8.89E+07	8.89E+07	8.89E+07	8.89E+07	8.89E+07
2014	8.26E+07	8.37E+07	7.62E+07	8.58E+07	8.26E+07	7.62E+07
2015	7.63E+07	7.85E+07	6.36E+07	8.27E+07	7.63E+07	6.36E+07
2016	7.00E+07	7.31E+07	5.08E+07	7.96E+07	6.99E+07	5.09E+07
2017	6.36E+07	6.76E+07	3.80E+07	7.64E+07	6.35E+07	3.81E+07
2018	5.72E+07	6.20E+07	2.50E+07	7.33E+07	5.69E+07	2.53E+07
2019	5.07E+07	5.63E+07	1.18E+07	7.01E+07	5.00E+07	1.25E+07

2020	4.42E+07	5.05E+07	-1.93E+06	6.68E+07	4.27E+07	-449427
2021	3.76E+07	4.46E+07	-1.63E+07	6.36E+07	3.47E+07	-1.34E+07
2022	3.08E+07	3.87E+07	-3.19E+07	6.03E+07	2.55E+07	-2.66E+07
2023	2.39E+07	3.26E+07	-4.94E+07	5.70E+07	1.44E+07	-3.98E+07
2024	1.69E+07	2.65E+07	-7.03E+07	5.37E+07	-146459	-5.33E+07

Note: the unit for "required area of urban renewal projects" is m^2 gross floor area

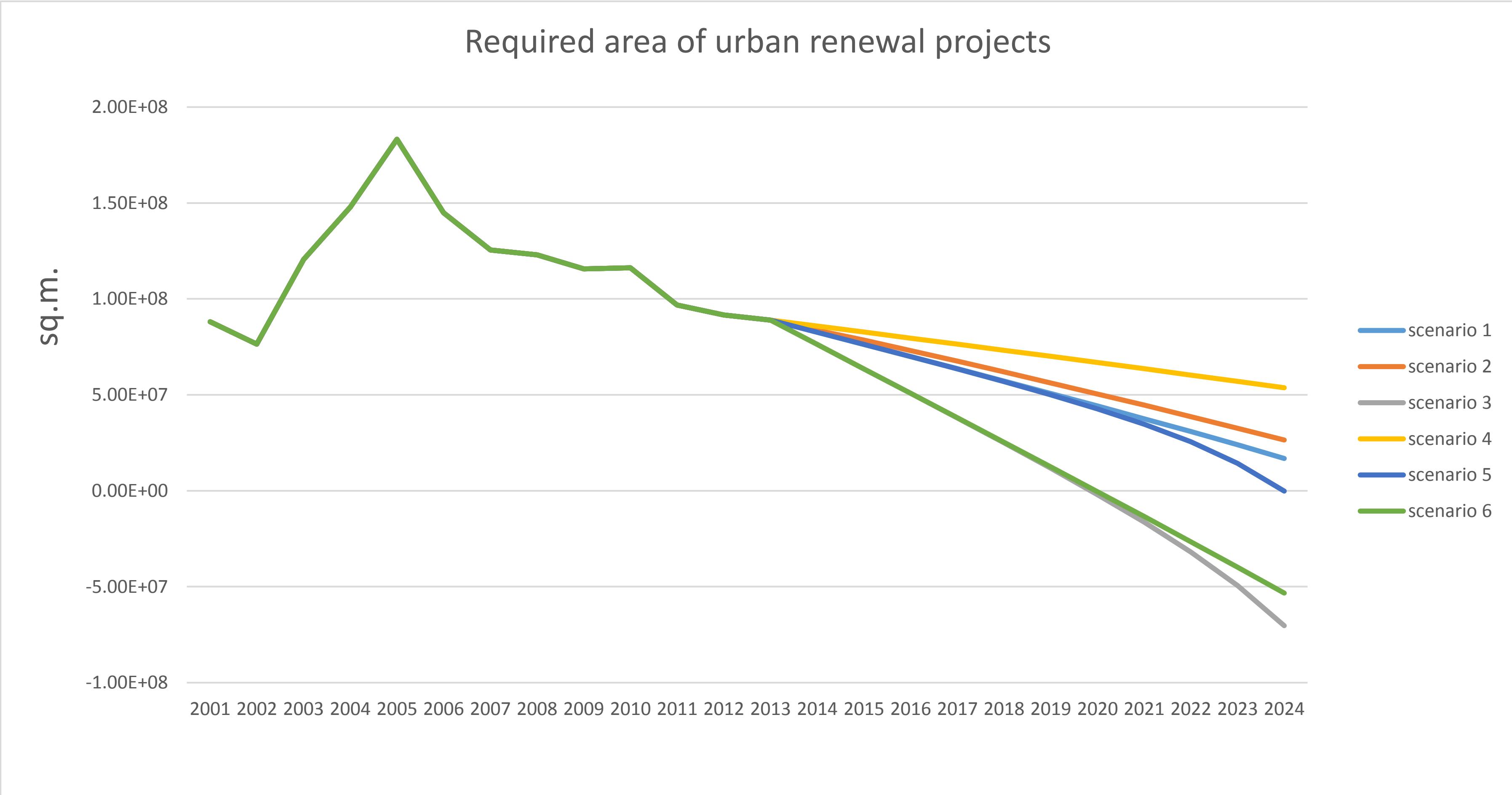

Figure 6.6 Scenario analysis on required area of urban renewal projects

6.3 Land Use Simulation Module

The LUS module provides decision support at the district scale, which simulates future land use. Firstly, the main land use types need to be confirmed. Secondly, the driving factors of each land use need to be identified and confirmed through analysis of past land use change. Thirdly, parameters in the LUS module should be set to simulate historical land use change. Based on comparison of real data and simulated data, the LUS module setting can be adjusted. Afterwards, the adjusted setting could be adopted to simulate future land use and conduct scenario analysis. The results of the LUS module comprise land use probability maps of different land use types and maps of future land use under different scenarios. These maps can facilitate identifying possible land use problems, which could provide decision-makers with some references. This section shows the details of developing the LUS module, including data preparation, module setting, and validation. The results and associated policy implications are also shown in this part.

6.3.1 Simulation Area and Data Preparation

The simulation area for the LUS module is the Yau Tsim Mong (YTM) district of Kowloon, Hong Kong, which is a highly developed area with scarce land resources. It is located on the Kowloon peninsula, spanning 114°09′-114°11′E and 22°17′-22°19′N. It is bounded by the East Rail Line of the Mass Transit Railway (MTR) to the east, the waterfront to the south and the west, and Boundary Street to the north. Figure 6.7 shows the location of YTM district. The land area of this district is approximately eight km² and the current population is around 301,800. Economic activities in YTM are mainly commercial, supplemented by tourism and light industries. Land use types in this district include commercial, residential, industrial, government, institutional and community facilities (G/IC), open space[1], vacant land, and others. Although this district is highly developed in most areas, land use still probably changes because vacant land accounts for a large portion of the total area (approximately 15.3% in 2009) and some old areas need to be redeveloped because of decaying conditions.

The raw spatial data was collected from the Lands Department of Hong Kong, including land utilization maps of the study area in 2000, 2003, 2006, and 2009, as well as digital topographic maps. The spatial dataset provides the information of natural conditions, land utilization, facilities, transportation, neighborhood, and some social and economic aspects. Non-spatial data includes documents on social and economic aspects including population, historical property price, and policies such as District Aspiration Study for Urban Renewal in Yau Tsim Mong and Projections of Population Distribution by the Planning Department.

[1] Open space here represents a statutory land use zoning for providing open space and recreation facilities for the entertainment of the public according to the definition of Planning Department in Hong Kong.

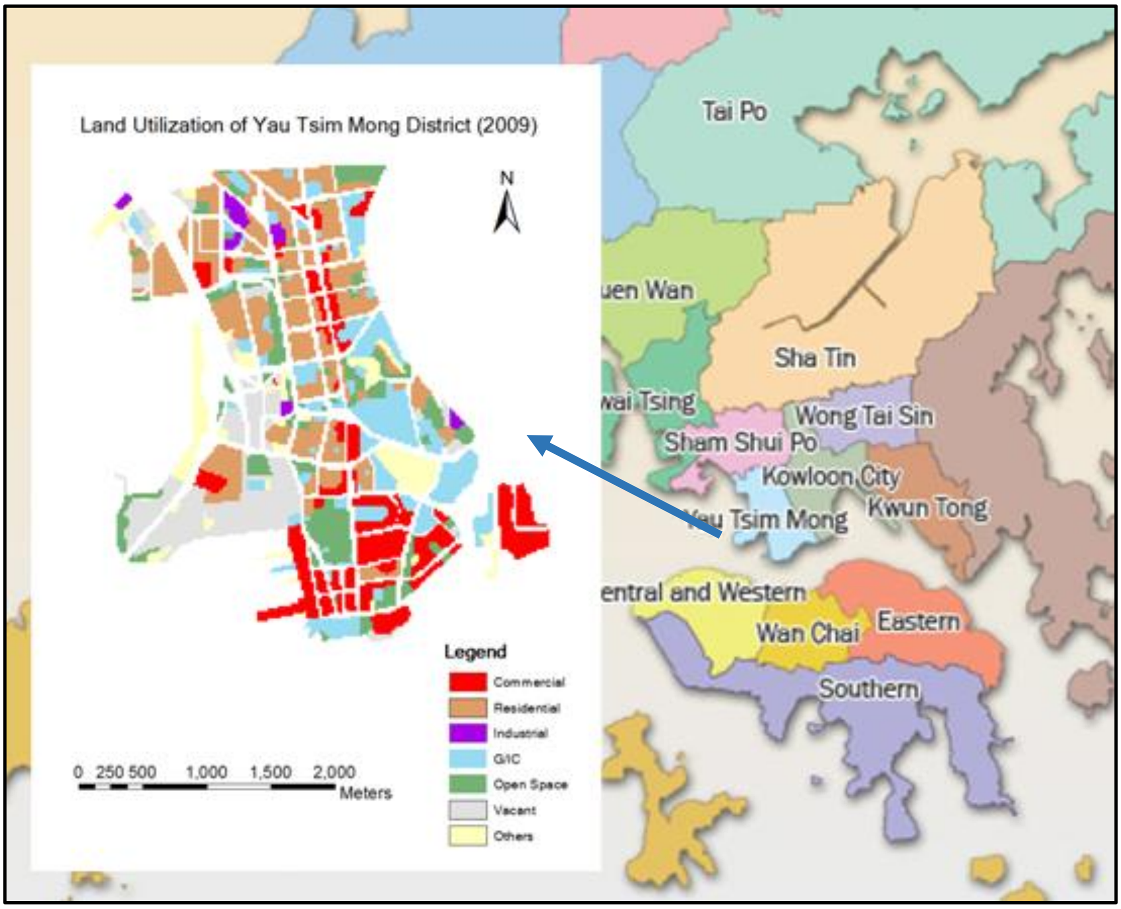

Figure 6.7 Location of the Yau Tsim Mong district

6.3.2 Simulation Process

The LUS module simulates land use changes from 2000 to 2009 based on historical changes of land uses during this period. Since the Planning Department in Hong Kong updates land utilization maps every three years, data of 2000, 2003, 2006, and 2009 are utilized. By comparing the real land utilization map with the simulated land utilization map in the year 2009, the proposed simulation model can be calibrated and validated. Finally, several future scenarios in 2018 are developed based on various development policies or directions. The LUS module applies two simulation approaches: the Markov chain prediction model and the CLUE-S model. The Markov chain prediction model works on the issue of temporal land use change, namely when and how much land use change will happen, while the CLUE-S model addresses the issue of where these changes will happen. The two models are connected to keep the balance between temporal land demand and spatial allocation. The flowchart of the simulation process is shown in Figure 6.8.

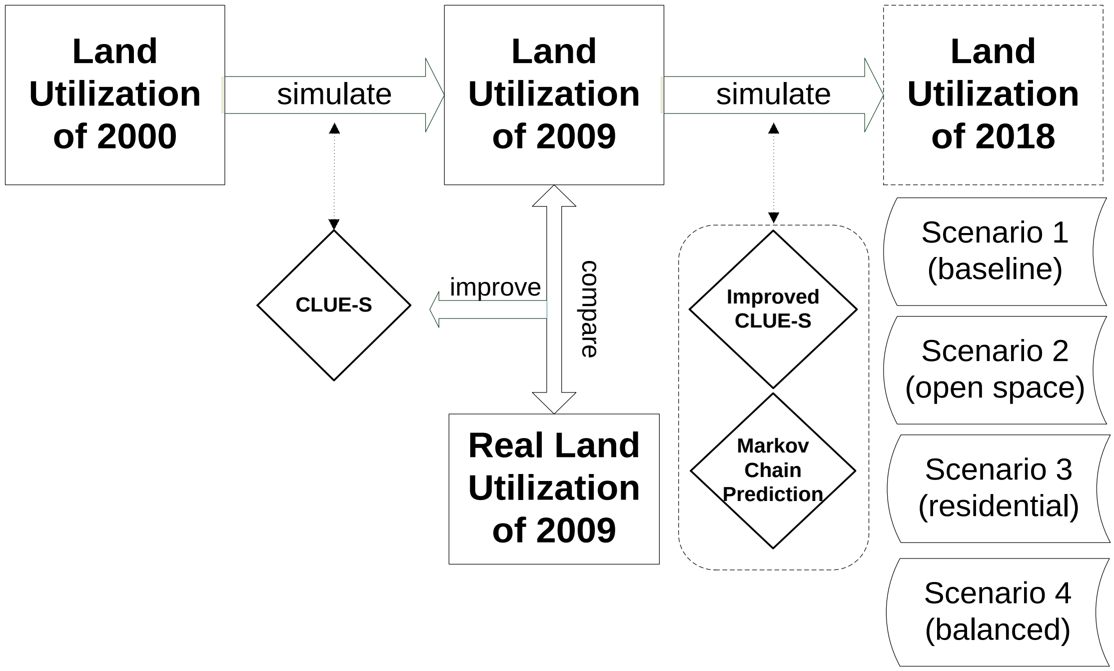

Figure 6.8 Flowchart of simulation process in the LUS module

6.3.3 Module Development

There are two main components when conducting the parameter settings in the LUS module. One is the spatial component, which includes the considerations of spatial pattern of land use, driving factors of land use location, conversion elasticity, conversion matrix, spatial policies, and spatial restrictions. Another is the non-spatial component relating to land use demand calculated by other methods. Therefore, the parameter settings were based on the aforementioned considerations. Details concerning module settings will be elaborated through three aspects: (1) important considerations in the LUS module; (2) the implementation of Markov chain prediction; and (3) regression analysis of land use in CLUE-S model.

Important considerations in the LUS module

Future scenario is the speculation about how the future might unfold, which can be expressed in both words and numbers (Lead et al., 2005). These scenarios provide images of the future through exploring drivers of change, past and current tracks, and opportunities for engagement (Raskin et al., 1998). The aim of scenario analysis is not predicting the future, but getting a better understanding of uncertainties that can provide a robust basis for decision-making. In the LUS module, four scenarios were produced in the simulation process. The first scenario is the baseline scenario, which means following the historical process of land use change and not taking into account any future measures to limit or encourage land use change. Land demand under the baseline scenario was calculated using the Markov chain model. The other three scenarios are policy-based scenarios.

Supplying more housing and improving the quality of the environment are the two main objectives proposed by the government. One of the urban renewal objectives in Hong Kong is "to offer more open space for the benefit of our urban communities" (URS, 2011). The second scenario (open space scenario) is thus to provide more open space at the district level. According to the projections made by the Planning Department in November 2008, there would be 3.39 m^2 per person provision of open space if all sites planned as open space were developed. Therefore, the demand of open space was calculated based on 3.39 m^2 per person and the projected population of 345,900 in 2018 by the Planning Department. The balance of open space is compensated by vacant land and other land use under this scenario. The third scenario is the residential scenario, which is assumed to provide more land for residential use in YTM. Based on the maximum plot ratio (7.5) assigned for Kowloon by the Planning Department and the average floor space per capita in the UK (35 m^2) in 2007

(Rector, 2007), the demand for residential land was determined accordingly. The balance of residential land is compensated by vacant land. The fourth scenario aims at achieving the balance of the improvement of housing and the sufficient provision of open space; therefore, the demands of open space and residential land were calculated based on the standards in scenario 2 and scenario 3 respectively. Moreover, the increased land supply of residential land and open space is from G/IC, vacant land, and others.

The precondition of developing the LUS module is to restrict land use change of historical sites because heritage preservation is one of the most important considerations for urban renewal in Hong Kong. There are four historical sites in YTM, the land use changes of which were restricted in the simulation process. Similarly, some particular sites were restricted due to the redevelopment of residential sites. As YTM is a district of Kowloon, it is necessary to consider neighborhood effects on the land use. Therefore, data of neighborhood facilities were included in the analysis of location factors.

The implementation of Markov chain prediction

In order to supplement spatial simulation, temporal changes of land use need to be predicted. Markov chain was used to project the demand of the baseline scenario from 2009 to 2018. The demands of other scenarios were calculated by taking into account the baseline scenario and future policies in the study area.

Transition matrix is a crucial process for Markov chain prediction. Table 6.4 shows the matrix of transition probability calculated from land use change from 2000 to 2009. P_{ij} presents the probability of one land use type changing into another from 2000 to 2009. Table 6.5 displays the historical land demand calculated by the software package

ArcGIS 10.2. From 2000 to 2009, the areas of commercial land, residential land, open space, and other land increased while industrial land and vacant land decreased; the area of G/IC remained stable. Table 6.6 presents the land demands under four different scenarios in 2018. Markov chain prediction for the baseline scenario shows that commercial, residential, and other land uses will increase continuously by taking up vacant land. The decreasing rate of industrial land is low since industrial land only takes up small areas of YTM.

Table 6.4 Matrix of transition probability from the 2000 to 2009

2000	**2009**						
p_{ij}	**Commercial**	**Residential**	**Industrial**	**G/IC**	**Open space**	**Vacant**	**Others**
Commercial	0.95	0.05	0.00	0.00	0.00	0.00	0.00
Residential	0.01	0.96	0.00	0.01	0.01	0.01	0.00
Industrial	0.03	0.31	0.66	0.00	0.00	0.00	0.00
G/IC	0.06	0.04	0.00	0.81	0.02	0.04	0.03
Open space	0.00	0.00	0.00	0.22	0.75	0.00	0.03
Vacant	0.11	0.14	0.00	0.04	0.14	0.50	0.07
Others	0.00	0.00	0.03	0.00	0.07	0.00	0.90

Table 6.5 Areas for various land types in history (Unit: ha)

Year	**commercial**	**residential**	**industrial**	**G/IC**	**open space**	**vacant**	**Others**
2000	70.2617	106.4684	12.1246	87.3023	51.4901	149.3220	34.2637
2003	64.8760	128.6287	6.9258	93.9278	48.8408	130.2163	37.8174
2006	84.0548	131.8941	10.8074	90.7033	51.5202	97.4870	44.7660
2009	89.1069	133.8881	9.0288	89.8417	64.7818	78.4262	46.1593

Note:G/IC means government, institutional and community facilities.

Table 6.6 Land demand areas of four scenarios in 2018 (Unit: ha)

2018	**Commercial**	**Residential**	**Industrial**	**G/IC**	**Open space**	**Vacant**	**Others**
S1	99.621	150.2993	7.3063	92.1780	66.0249	43.5243	52.2790
S2	99.621	150.2993	7.3063	92.1780	117.2600	17.9072	26.6610
S3	99.621	161.4200	7.3063	92.1780	66.0249	32.4036	52.2790

S4	99.621	161.4200	7.3063	80.2300	117.2600	17.9072	27.4883

Note: G/IC means government, institutional and community facilities. S1 means the scenario 1. S2 means the scenario 2. S3 means the scenario 3. S4 means the scenario 4

Regression analysis of land use in CLUE-S model

The CLUE-S model requires setting the relationship of location factors and different land uses. Typical driving factors were chosen to analyze the location suitability of these seven land use types. These factors were selected based on relevant literature, including physical, socioeconomic attributes and proxy variables (Wang et al., 2013; Zondag & Borsboom, 2009; Braimoh & Onishi, 2007; Veldkamp & Lambin, 2001). Table 6.7 shows the selected location factors in CLUE-S model and the analyzed coefficients for the logistic regression. Each land use type has different factors contributing to its location. For example, the location of residential land is related to factors including slope, distance to MTR stations, distance to historical sites, distance to road, distance to school, distance to open space, and population density.

To validate the reliability of the logistic regression, the ROC curve was used. The ROC is used to measure the goodness of fit of the logistic regression model (Baldwin et al., 1998). All the ROC values in the Table 6.7 are above 0.78, which indicate that these location variables preferably explain the location of land use.

Table 6.7 Estimated coefficients of binary logistic regression for seven land use types

Driving Factors	Commercial	Residential	Industrial	G/IC	Open Space	Vacant	Others
Slope		0.1599	0.3967	0.0987			
Elevation	0.1135		0.1288	-0.0679	-0.0371	-0.1794	0.1028
Distance to CBD	-0.0181			-0.0032			0.0071
Distance to airport							-1.0436
Distance to MTR stations		-0.0047	0.0071			0.0064	
Distance to bus terminus				-0.0017	0.0016	0.0011	0.0034
Distance to coastline				0.0027			-0.0077
Distance to historic sites		0.0007	0.0033	-0.0010			0.0022
Distance to schools		-0.0024			-0.0009		
Distance to open space		0.0006	-0.0068		-0.0932	-0.0014	
Distance to road		-0.0280	-0.0171		0.0314	-0.0097	
Distance to hospital	0.0020		0.0060	-0.0003			-0.0081
Population density	-20.9384	17.5029		-21.9404		-11.8701	
Property price						0.0001	0.0001
Roc Value	0.9230	0.8580	0.9580	0.7810	0.8700	0.9070	0.8130

6.3.4 Module Validation

Module parameters were set based on the historical data from 2000 to 2009. The simulated land use pattern of 2009 was achieved based on land utilization map in 2000. Figure 4a shows the land utilization map of 2000. The simulated land utilization map of 2009 (Figure 6.9 (b)) was achieved based on Figure 6.9 (a) in the CLUE-S model, and the real land utilization of YTM in 2009 is displayed in Figure 6.9 (c). The overall accuracy is 81.53%, which shows the percent of the number of pixels simulated correctly to the total number of pixels. Kappa value calculated by the ENVI 4.7 software is 0.7753, representing a substantial agreement, which indicates the effectiveness of the module setting to conduct the future simulation. Table 6.8 shows the contingency table, which is the basis for calculating the kappa value.

Table 6.8 Contingency table

Simulation (unit: percent)	Reality (unit: percent)						
	0	**1**	**2**	**3**	**4**	**5**	**6**
0	86.47	6.59	0.00	1.21	1.77	0.00	2.36
1	4.67	85.43	1.34	3.85	11.03	1.28	6.98
2	0.22	1.40	77.68	0.00	0.00	0.00	0.00
3	4.00	4.29	0.00	79.25	6.09	4.66	4.54
4	4.31	1.49	9.82	12.46	64.53	0.31	9.42
5	0.04	0.00	0.00	1.30	3.35	92.68	5.67
6	0.27	0.80	11.16	1.93	13.22	1.08	71.03

Note: 0 represents commercial land, 1 represents residential land, 2 represents industrial land, 3 represents the zone of government, institutional and community facilities, 4 represents open space, 5 represents vacant land, 6 represents other land uses.

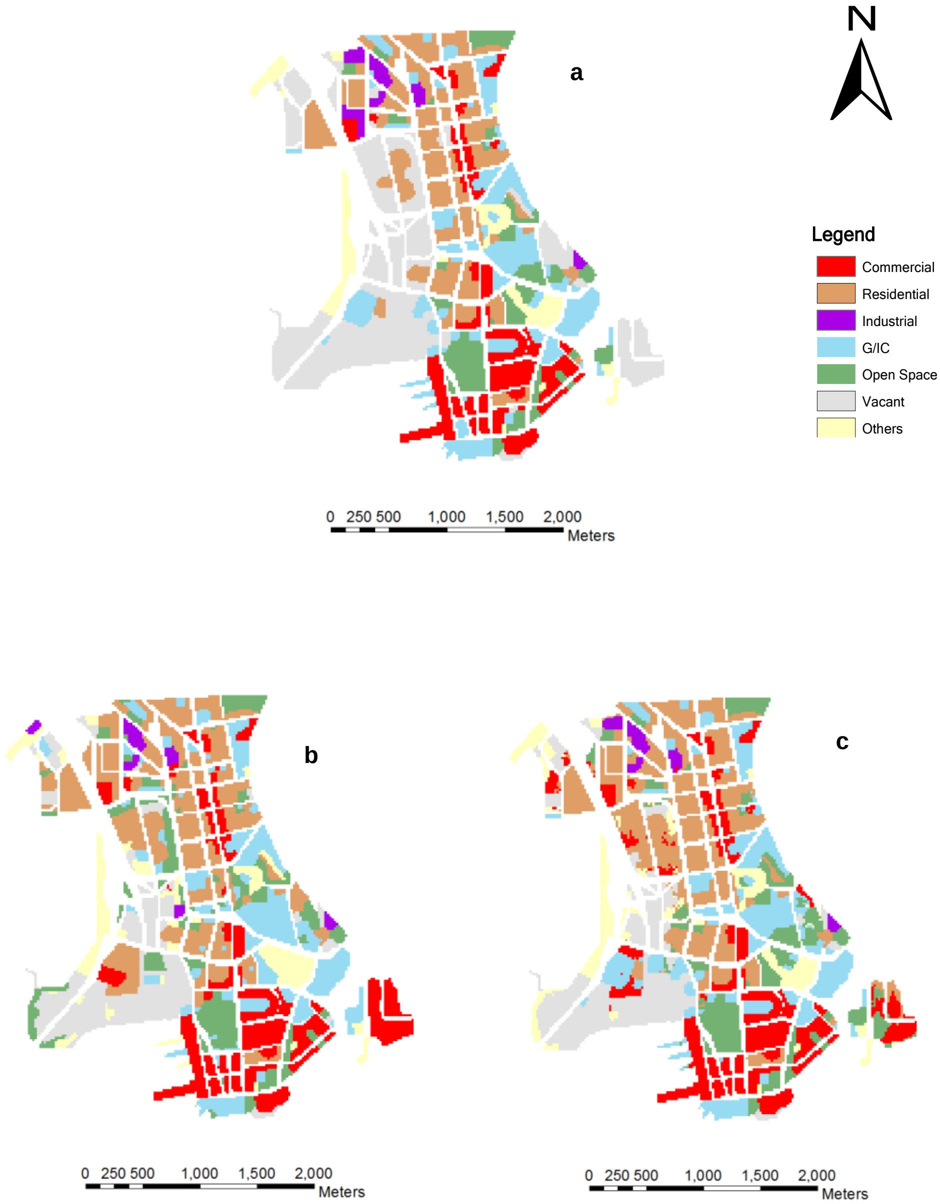

Figure 6.9 (a) Real land utilization map of year 2000, (b) Real land utilization map of year 2009, and (c) Simulated land utilization map of year 2009

6.3.5 Results of LUS

Probability maps of different land use types

After validating the LUS module, the validated setting was used to simulate future land use in 2018. By using the function of calculating probability maps in the CLUE-S model, seven probability maps for different land use types (commercial, residential, industrial, G/IC, open space, vacant, and others) were produced accordingly (see Figure 6.10). Commercial land has a higher probability of being located at the south part of YTM, which is near the coastline, while residential land is more likely to be located at the north part of YTM, which is the old district of Kowloon. Industrial land has a low probability of being located at most parts of YTM, except in a small part near Tai Kok Tsui in the northwest of YTM. G/IC is more likely to be located at districts near King's Park and Kowloon Park. Open space has a comparatively even-distributed probability of location except the northwest part with a lower probability, which implies a need for open space in these districts. Vacant land has a higher probability of locating at the west part of YTM, which is associated with the reality that developed land may not change back to vacant land in the long term.

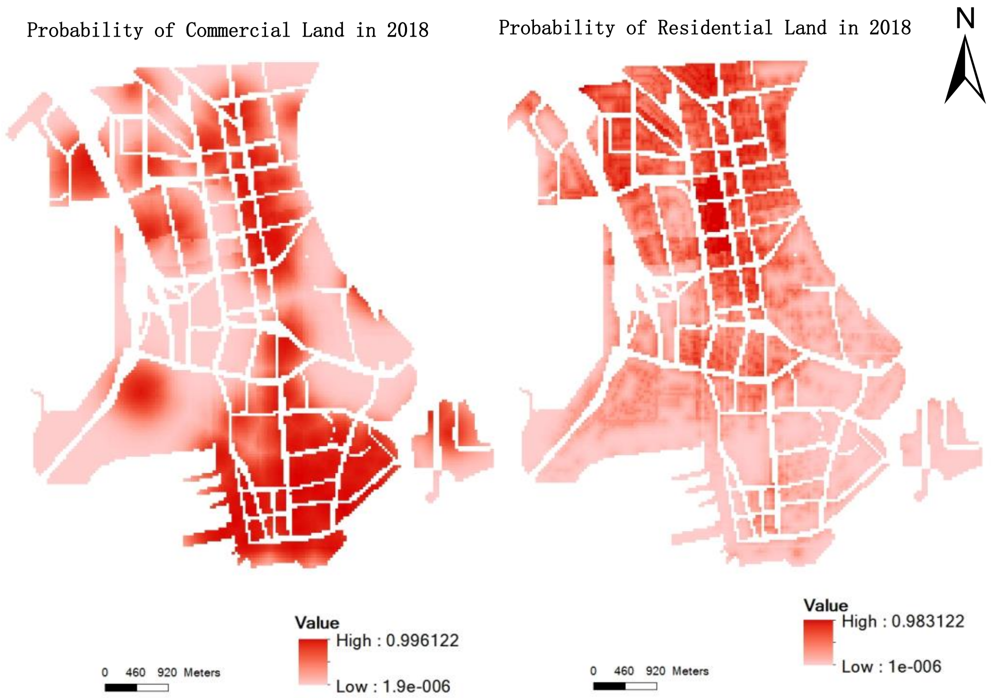

Figure 6.10 Probability maps of different land use types in 2018

Simulation maps

The land use demands in 2018 for four scenarios were input into the CLUE-S model separately (see Table 6.6). After running the CLUE-S model with the calibrated model settings, land use patterns under four scenarios were simulated (see Figure 6.11). The baseline scenario indicates that the supply of new land is from vacant land mainly in West Kowloon. The simulation results display the differences between the four scenarios. There are more open space areas in western Kowloon by taking up vacant land and other land uses under the open space scenario. More areas of residential land are located in the west part of YTM under the residential scenario compared with that under the baseline scenario. Compared with the historical data in 2009, the increased residential land supply is mainly from some vacant land and G/IC land. For the scenario four, the location of open space is similar compared with that under the open space scenario. There are more areas of residential land in the northwest part than that under the second scenario.

Figure 6.11 Simulated scenarios of land use in 2018

6.3.6 Findings and Policy Implications

The LUS module considers land use allocation factors including physical, locational, social, and economic attributes, which are comparatively comprehensive. Policy factors, which are difficult to be captured and expressed in some other models, are reflected in this module. In Hong Kong, policy plays a crucial role in land use allocation. For example, in order to solve the problem of residential land shortage, the government proposed “Hong Kong land for Hong Kong people”, which means one specific parcel of land is restricted to residential use for Hong Kong permanent residents. In the simulation, historical sites and parks were restricted from being changed. Similarly, some particular sites were restricted due to spatial policies, such as urban redevelopment of residential sites. This shows the possibility of using models to simulate land use change in urban renewal areas instead of simply discussing or analyzing land use change qualitatively.

Temporal land use change in history is associated with the fact that there is more commercial and residential land supply in YTM after the handover of Hong Kong to China. There are three possible reasons. First, more immigrants move to Hong Kong, stimulating developers to construct more residential housing with rising property price in Hong Kong. Second, government has been being striving to provide more residential housing during the past decade. Third, the growth of tourism after the handover of Hong Kong to China explains why there are more areas of commercial land.

Based on Markov chain prediction, which means following the historical trend, there will be more supply of commercial and residential land in 2018. The simulated scenarios show that the land development in YTM often takes place by occupying vacant land or industrial land. The results are reasonable for two reasons: (1) developed land always has constant inertia, which means that it tends to follow its original use; (2) land use change occurs when new land use type is able to provide more value especially economic value in a free market.

The probability maps for different land use types provide an explicit understanding of land allocation probability spatially. Decision-makers for urban renewal could understand the direction of future land use, discover possible problems of land use, and then make decisions that are more informed. For instance, the probability value of open space is low in the northwest region, indicating that attention should be paid to this area for sustainability.

From a practical perspective, the main benefits of simulated scenarios can reveal problems resulting from interventions of different policies, indicate the trend of land use change, and provide a more comprehensive understanding of land use mechanisms in urban renewal areas. The results can serve as important references for decision-making of sustainable land use in the urban renewal process. For example, from scenario 2, open space is not distributed evenly in space, with a low proportion in the northern part of YTM. Residential land accounts for the largest proportion of the northern part, in which more areas of open space should be provided.

6.4 Neighborhood Assessment Module

The NA module is to explore current problems of neighborhood units. The first step for assessment is to identify indicators that can represent sustainability performance of neighborhood units. Then calculation method for neighborhood assessment is confirmed by expert interview and literature review. Afterwards, the potential neighborhood units are selected to implement NA. Strategies for neighborhood renewal in the future can be proposed finally. This part discusses the details of developing the NA module.

6.4.1 Indicator Selection in NA

Based on literature on the sustainability assessment of neighborhoods, studies on measurement of sustainable urban renewal performance, special considerations on urban renewal in Hong Kong, and interview results, a general list of indicators is proposed to assess the current conditions of land use in neighborhoods. These indicators are classified into five categories, namely, social aspect, economy and work, resources and environment, land use form, and building condition. Twenty-five indicators were initially proposed. Three additional indicators ("Density of small business with local characteristics," "Conservation of built heritage resources," and "Fragment level of property rights") were added after expert interviews. Table 6.9 provides a modified list of indicators for sustainability assessment and their calculation formulas.

Table 6.9 Indicators of sustainability assessment for neighborhood in urban renewal

No	Category	Indicator	Measurement	Remarks
1 (S1)	Social aspect	Population density	Population/Area of the planning unit	
2 (S2)	Social aspect	Diversity of ages	$\frac{1}{cat}\sum_{i=1}^{cat}(1-\frac{n_{cat\_age\_i}}{n_{cat\_age\_i}^{obj}})^2$	cat means the number of age groups, $n_{cat\_age\_i}$ is the number of people belonging to age group of i category, $n_{cat\_age\_i}^{obj}$ refers to the objective number of people in age group of i category
3 (S3)	Social aspect	Residential floor area per capita	Residential floor area/Population	
4 (S4)	Social aspect	Diversity of public transport	$\frac{1}{cat}\sum_{i=1}^{cat}(1-\frac{n_{cat\_trans\_i}}{n_{cat\_trans\_i}^{obj}})^2$	cat refers to the number of public transport types, $n_{cat\_trans\_i}$ is the number of transportation points (stops/stations) in type i, $n_{cat\_trans\_i}^{obj}$ is the objective number of transportation points in type i.
5 (S5)	Social aspect	Diversity of public facilities	$\frac{1}{cat}\sum_{i=1}^{cat}(1-\frac{n_{cat\_faci\_i}}{n_{cat\_faci\_i}^{obj}})^2$	cat means the number of facility types, $n_{cat\_faci\_i}$ is the number of facility i, $n_{cat\_faci\_i}^{obj}$ is the

				objective number of facility i
6 (S6)	Social aspect	Conservation of built heritage resources		
7 (E1)	Economy and work	Labor force participation rate	Labor force participation rate	Data can be obtained directly from statistics
8 (E2)	Economy and work	Disposable income per capita	Disposable income per capita	Data can be obtained directly from statistics
9 (E3)	Economy and work	Diversity of business activities	$\frac{1}{cat}\sum_{i=1}^{cat}(1-\frac{n_{cat\_busi\_i}}{n_{cat\_busi\_i}^{obj}})^2$	cat means the number of different business groups, $n_{cat\_busi\_i}$ is the number of people belonging to business category i , $n_{cat\_busi\_i}^{obj}$ refers to the objective number of people in business category i
10 (E4)	Economy and work	Density of Small businesses with local characteristics	The trade of small business with local characteristics/the area of planning unit	NA
11 (R1)	Resources and environment	Waste generation	Total waste generation/population	
12 (R2)	Resources and environment	Waste recycling	Number of waste recycling facilities/area the planning unit	
13 (R3)	Resources and environment	Electricity consumption	Total electricity consumption/population	NA

14 (R4)	Resources and environment	Air quality	Air quality index	NA
15 (R5)	Resources and environment	Water consumption	Total water consumption/population	NA
16 (L1)	Land use form	Land use mix	$-\sum_{i=1}^{n} l_i \ln l_i \big/ \ln n$	l_i is the area of land use type i , n means the number of land use types.
17 (L2)	Land use form	Accessibility to cultural facilities	Number of cultural facilities within 300 meters	Spatial analysis in GIS
18 (L3)	Land use form	Accessibility to education services	Number of education facilities within 300 meters	Spatial analysis in GIS
19 (L4)	Land use form	Accessibility to health care services	Number of health care facilities within 300 meters	Spatial analysis in GIS
20 (L5)	Land use form	Accessibility to sport and leisure facilities	Number of sport and leisure facilities within 300 meters	Spatial analysis in GIS
21 (L6)	Land use form	Accessibility to other facilities	Number of other facilities within 300 meters	Spatial analysis in GIS
22 (L7)	Land use form	Accessibility to public transport	Number of public transport points within 300 meters	Spatial analysis in GIS
23 (L8)	Land use form	Open space coverage ratio	Area of open space/Area of the planning unit	Spatial analysis in GIS
24 (B1)	Building condition	Average building age	$\sum_{i}^{n} age_i \big/ n$	

25 (B2)	Building condition	Number of buildings aged above 50 years	Number of buildings aged above 50 years	Data can be obtained directly from statistics
26 (B3)	Building condition	Building repair	Number of building repair cases/Number of buildings aged above 50 years	
27 (B4)	Building condition	Building density	Floor area/Area of the planning unit	
28 (B5)	Building condition	The fragment level of property rights	The fragment level of property rights	NA

Note: NA means the data is not available at the study scale. Values of some indicators can be obtained directly from statistics or some data sources, and they are noted as "Data can be obtained directly from statistics."

6.4.2 Assessment Process

The NA module includes two components (see Figure 6.12). The first component is the sustainability scores of different neighborhoods and the scores of their building conditions, respectively. The second one is the comparison of different neighborhoods in the decision-making matrix using four quadrants that indicate different strategies for urban renewal.

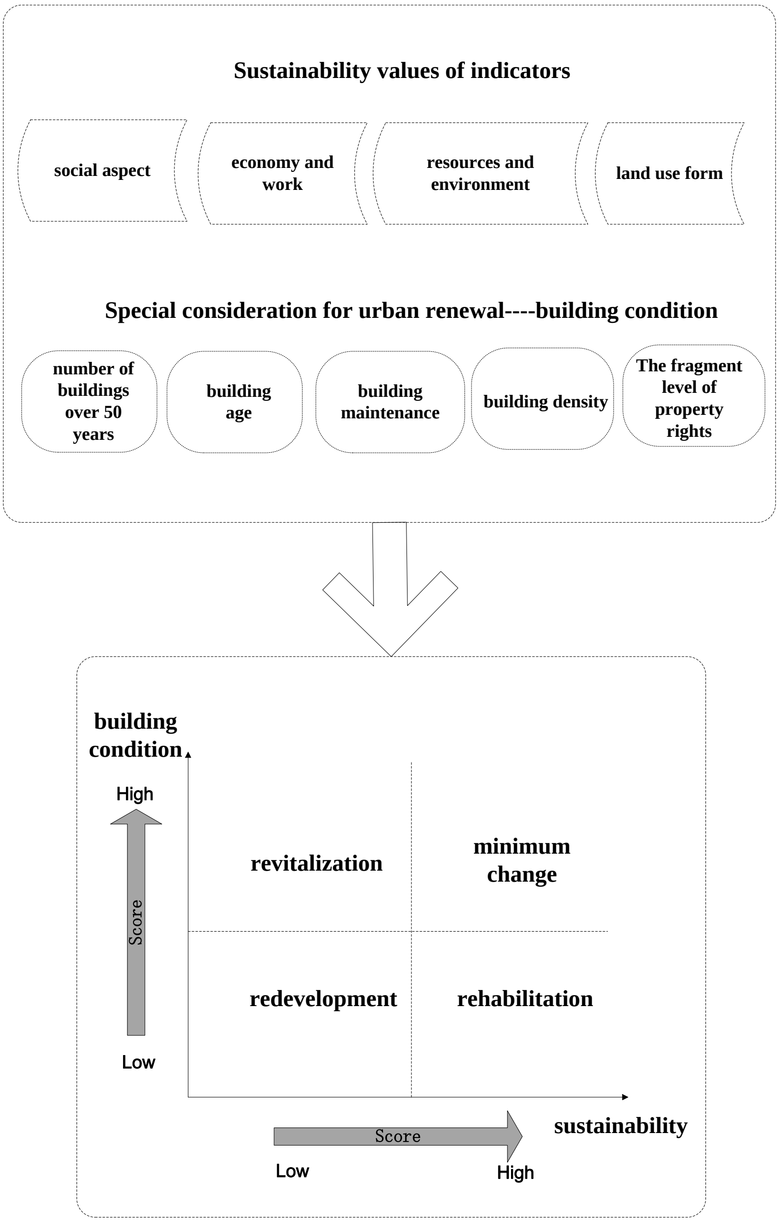

Figure 6.12 Assessment process for neighborhood renewal decision-making

Sustainability score calculation and building condition measurement

Each indicator has a unique calculation method. After calculating the values of the indicators, the initial evaluation results of indicators are obtained by using different units, which cannot be compared directly. Thus, standardization is required. Considering the positive and negative effects of various indicators on the overall sustainability value, two equations were applied (Pirrone et al., 2005; Wang et al., 2010).

Positive indicator: $$y_{ij} = (x_{ij} - \min x_{ij}) / (\max x_{ij} - \min x_{ij}) \quad (1 \le i \le m, 1 \le j \le n) \qquad (1)$$

Negative indicator: $$y_{ij} = (\max x_{ij} - x_{ij}) / (\max x_{ij} - \min x_{ij}) \quad (1 \le i \le m, 1 \le j \le n) \qquad (2)$$

After standardizing the values of each indicator, the overall points scoring introduced by Balaban (2013) is applied to calculate the overall sustainability score. A summary of the overall points scoring is shown in Table 6.10.

Utilizing this scoring system, the overall sustainability scores of neighborhoods are calculated by summarizing the scores of Categories 1, 2, 3, and 4. The scores of building condition are measured independently.

Table 6.10 Overall points scoring

Category	Performance category	Number of indicators	Maximum possible total score
1	Social aspects	6	6
2	Economy and work	4	4
3	Resources and environment	5	5
4	Land use form	8	8
5	Building condition	5	5

Note: this table is adapted from the overall evaluation method by Balaban (2013)

Decision-making matrix

The decision-making quadrant is drawn to facilitate decision-making and is based on the sustainability scores and the scores of building conditions for different neighborhood units. When both sustainability and building condition have high scores, minimum change is favored for the neighborhood. Conversely, when both have low scores, redevelopment projects should be implemented. When the sustainability score is high and the score of building condition is low, a rehabilitation approach is suggested. If the sustainability score is low and building condition score is high, revitalizing the neighborhood is strongly recommended. The decision matrix can be adapted to other contexts. The definition of the demarcation lines between the four quadrants can be defined in other contexts through two possible approaches. Firstly, more cases are to be conducted by using this matrix. Then different cases are to be trained through artificial intelligence in order to find out an optimum definition of the demarcation lines between the four quadrants. Secondly, experts and local people are to be consulted to define the lines under different contexts.

6.4.3 Neighborhood Assessment: Case Study

Study Area and Data

Nine tertiary planning units (TPUs[2]) were selected as the cases to develop the NA module (See Figure 6.13). The nine TPUs are located in Kowloon, a developed area in Hong Kong with a serious urban decay problem. Five TPUs (2.1.4, 2.2.1, 2.2.5, 2.2.7, and 2.2.9) belong to Yau Tsim Mong District, where many commercial activities take place. The other four TPUs (2.4.1, 2.4.2, 2.4.4, and 2.8.5) are located in Kowloon City, where residential buildings are concentrated.

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[2] The territory of Hong Kong is separated into 289 tertiary planning units by the Planning Department for town planning purpose.

Both spatial and non-spatial data are included. Spatial data are comprised of land utilization map, road network map, location map of public facilities, and distribution map of buildings. Non-spatial data cover information on environment and resources as well as social aspect for nine TPUs. Data are obtained from different governmental departments. Thus, an integration process in the database is necessary before assessment. The land utilization map was digitalized in the stage of spatial data processing. The road network and location of facilities were extracted from the Hong Kong digital topographic map. Building information was extracted from the building information map. Information on building repair was processed manually in space from the addresses of buildings and their spatial orientations. Table 6.11 shows the details of data preparation.

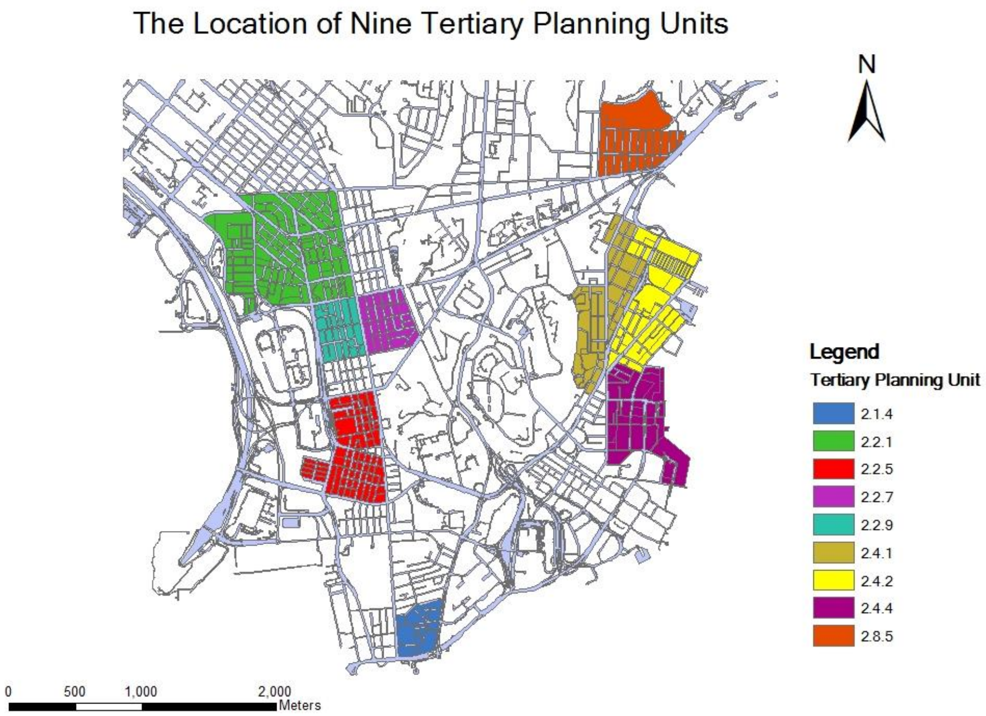


Figure 6.13 Location of nine tertiary planning units in Kowloon District

Table 6.11 Data preparation

Information	Raw Data	Source
Land utilization	Hong Kong land utilization map	Planning department
Road network	Hong Kong digital topographic map (1:5000)	Lands department
Location map of public facilities (e.g. hospitals, schools, parks)	Hong Kong digital topographic map (1:5000)	Lands department
Basic information of buildings (e.g. building age, building name, floor)	Building information map	Buildings department
Building repairs	List of buildings being repaired	Hong Kong Housing society
Information about environment and resources	Statistics and governmental documents	Environmental protection department
Information about social aspects	Statistics and governmental reports	Census and statistics department

Assessment Results

Among the 28 indicators, "density of small businesses with local characteristics," "electricity consumption," "air quality," "water consumption," "conservation of built heritage resources," and "fragment level of property rights" are not included in the results because of data limitations at the neighborhood scale. For the value of "Social aspect," TPU of 2.2.1 has the best performance, whereas TPU of 2.1.4 has the worst performance. TPU of 2.1.4 has the highest score, whereas TPU of 2.2.9 has the lowest score for "Economy and work." In terms of "Environment and resources," TPU of 2.2.7 performs best, and TPU of 2.1.4 performs worst. As for score of "Land use form," TPU of 2.8.5 obtains the highest score. Sustainability score is calculated based on the four categories mentioned above. TPU of 2.2.9 is assessed as the most sustainable unit, whereas TPU of 2.4.1 is the most unsustainable. Focusing on

"Building condition," TPU of 2.1.4 has the best condition, and TPU of 2.8.5 bears the worst condition.

Table 6.12 and Figure 6.14 show the final scores of nine planning units on different categories (social aspect, economy and work, environment and resources, land use form, and building condition) by calculating the indicators of each category. The purpose of drawing radar figures (see Figure 6.14) is to provide decision-makers with more direct results. One the one hand, radar figure clearly compares different TPUs in terms of their performance on a specific category (e.g., Land use form). For example, practitioners can easily capture information that TPU of 2.1.4 performs best in "Economy and work" from the radar figure. On the other hand, practitioners can easily compare the performance of each TPU on the scoress of different categories. By taking TPU of 2.1.4 as the example, its scores on social aspect, as well as environment and resources are obviously very low, whereas its performance on economy and work is satisfactory, which further indicates the unbalanced development of this neighborhood. By referring to the assessment results, the following information can be extracted for further discussion. Additionally, Figure 6.15 and Figure 6.16 show score maps of sustainability and building condition respectively, both of which can provide better visualization of the results.

Table 6.12 Comparison of TPUs on their Values of Different Categories

TPU	social	economy and work	land use form	environment and resources	sustainability	building condition
2.1.4	1.528433	2.742574	3.155004	0.258893	7.684905	2.390327537
2.2.1	3.092454	0.784653	1.852921	1.064077	6.794105	2.012146412
2.2.5	1.914598	0.78096	2.844678	1.074522	6.614758	1.413385656
2.2.7	2.47602	0.527444	4.110659	1.799541	8.913664	2.294361199
2.2.9	2.846517	0.405355	4.827838	1.441507	9.521217	1.987517766

2.4.1	1.616239	0.709447	2.150377	1.276244	5.752307	1.861886544
2.4.2	2.099314	0.593426	3.458709	1.181474	7.332923	1.227028608
2.4.4	2.509216	1.800826	4.043575	0.88173	9.235348	1.563592596
2.8.5	1.939181	0.72668	4.973897	0.792792	8.43255	1.145785703

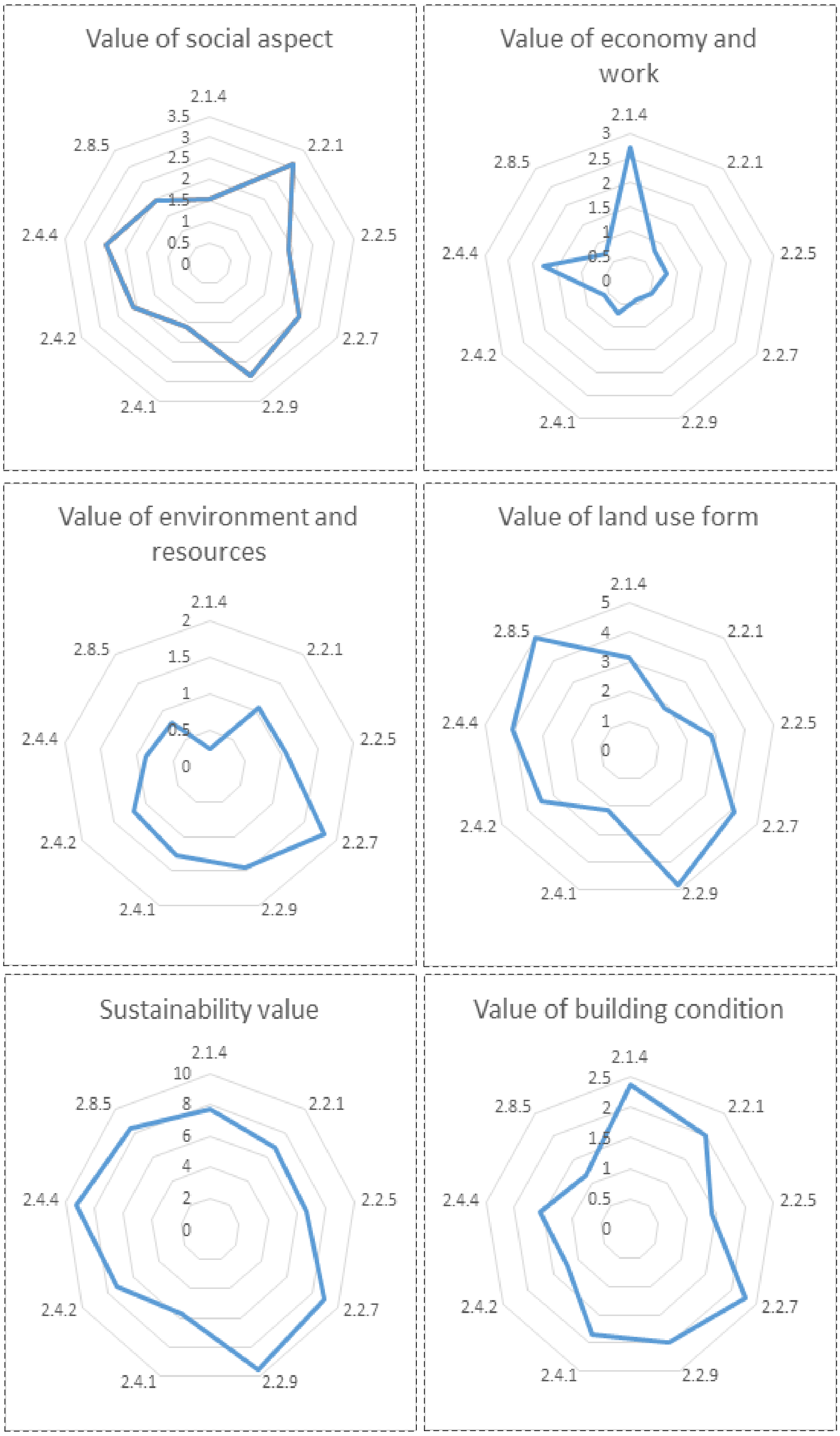


Figure 6.14 Values of different categories, sustainability, and building condition

Sustainability map for neighborhoods

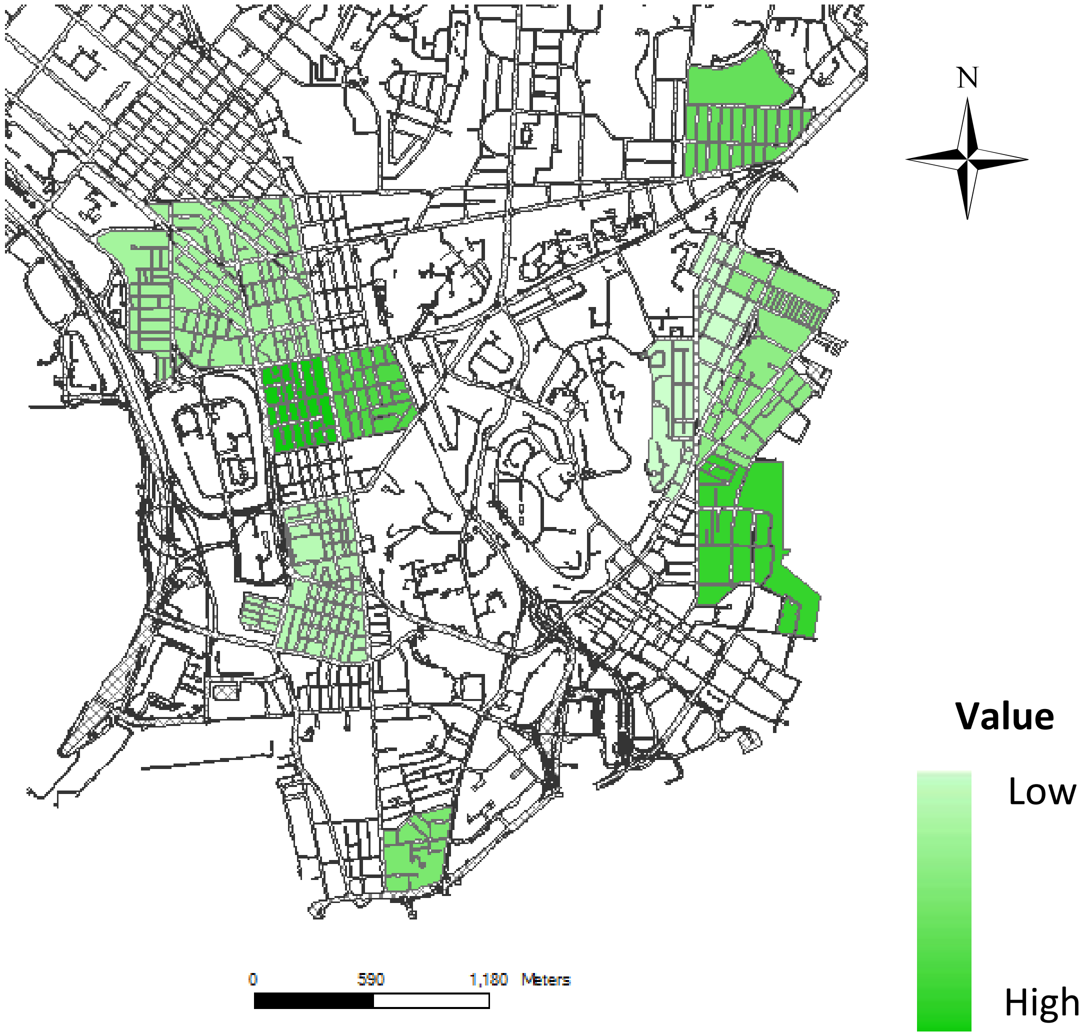


Figure 6.15 Sustainability map for neighborhoods

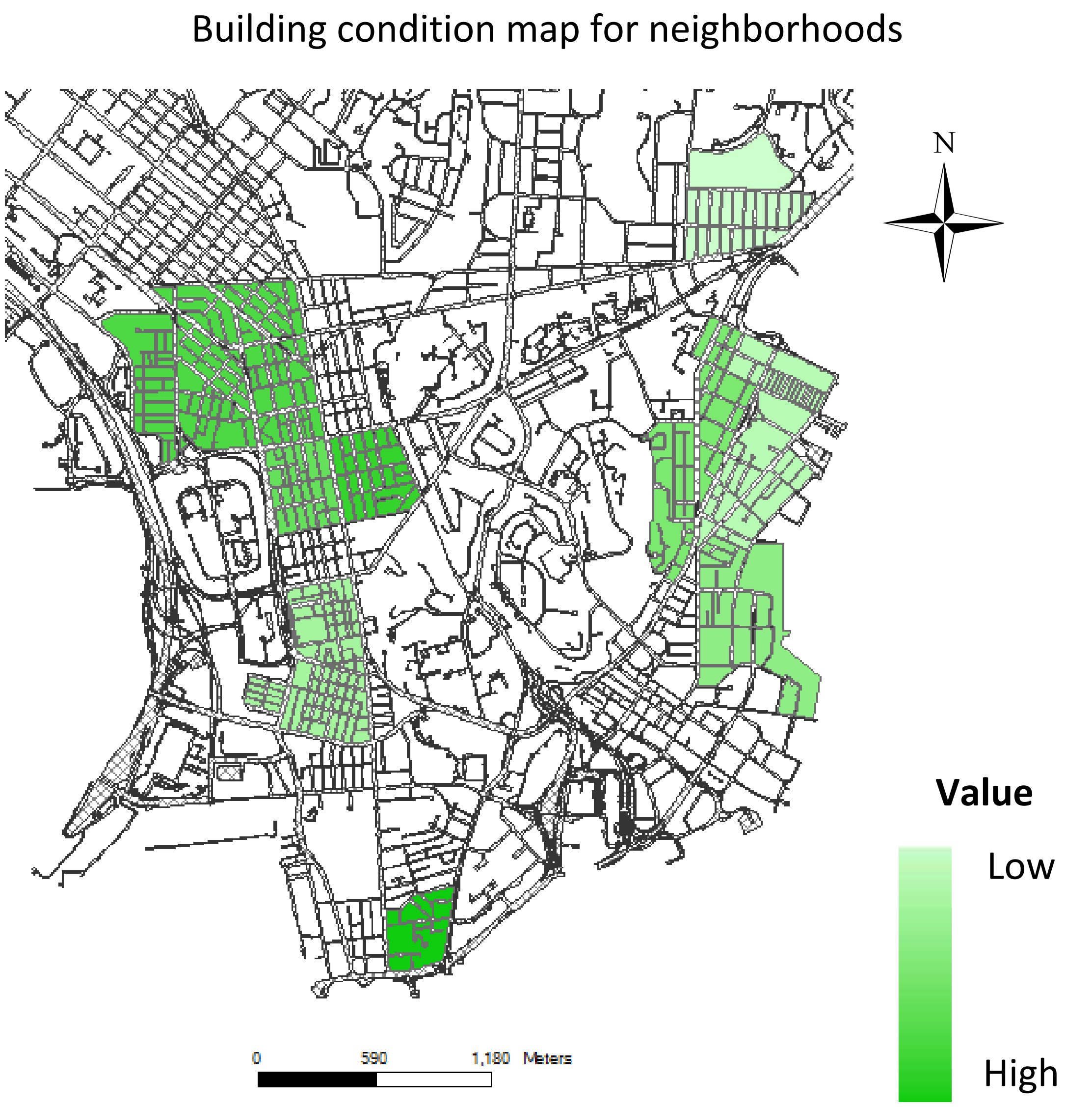


Figure 6.16 Building condition map for neighborhoods

6.4.4 Findings and Strategies Proposed in NA

Current issues of TPUs

A dilemma may exist if we only refer to the final sustainability scores of different planning units because the scores of various indicators are replaceable. Thus, when referring to assessment results, further comparisons of the different aspects must be conducted.

Issues of each TPU can be found in the assessment results, which can serve as references for policy makers for the specific unit. This finding may indicate that there exist certain problems for each TPU because no TPU is in the quadrant of minimum change. For example, 2.4.1 (the most unsustainable TPU) has low values in land use form and economy and work. Specifically, its land use form is comparatively simple and residential land use accounts for most areas. The diversity of public transport and facilities also has a low level of performance. Performance on accessibility to public transport and other facilities also ranks behind most TPUs, which serves to remind decision-makers that they need to increase the provision of certain facilities and public transportation points within or near this neighborhood. This area has a low value of diversity of business incomes and a considerably low level of disposable income per capita, indicating that it may have a segregation problem with only one income group.

1.1.1 Priority of strategies

Based on the decision-making matrix (see Figure 6.15), no TPU can be categorized into the quadrant in which minimum change is favored. TPUs of 2.1.4, 2.2.1, and 2.2.7 should revitalize their neighborhoods because their sustainability values are comparatively low. TPUs of 2.2.9 and 2.4.4 should prioritize rehabilitation strategy. The rest of the TPUs belong to the redevelopment quadrant. These TPUs could be considered first when allocating redevelopment projects.

Relevant strategies can be identified for TPUs from the decision-making matrix. TPUs in the revitalization quadrant have comparatively good building conditions. Therefore, initiatives aimed at enhancing the entire neighborhood are recommended by referring to its specific problems. The methods may include upgrading facilities, improving green environment, and enhancing social integration through community activities. As for TPUs in the rehabilitation quadrant, the neighborhoods face a severe problem of their building conditions. Decision-makers can investigate detailed problems of buildings in the neighborhood. Repairing dilapidated buildings and upgrading building facilities can address the decay problem. Compared with redevelopment, rehabilitation can save on economic costs and reduce its impact on the environment and residents. Most TPUs belong to the redevelopment quadrant, which implies that redevelopment may be the most appropriate method for long-term development. Comprehensive redevelopment[3] is suggested because it can address the problem of building decay and enhance sustainable performance of the neighborhood by considering every aspect of sustainability. The redevelopment process involves complex aspects and stakeholders. These results only serve as references for decision-makers. Decision-makers should consider other factors, such as the feasibility of finances, compensation, and resettlement of residents.

[3] Comprehensive redevelopment indicates that the redevelopment project includes various land use types, and that providing facilities and upgrading the surrounding environment are involved in this process.

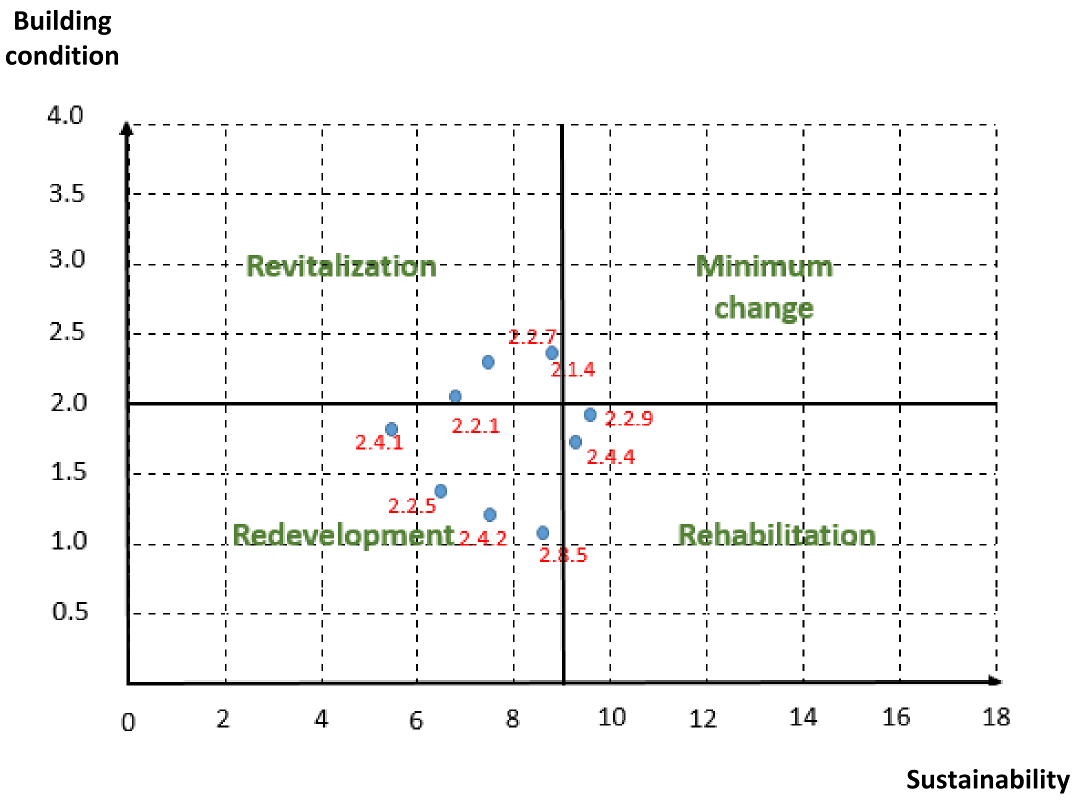


Figure 6.17 Priority of strategies for neighborhood units

6.4.5 Validation of the Proposed Strategies

The Urban Renewal Strategy (URS) is a governmental strategy of the Hong Kong Development Bureau, which suggests a comprehensive and holistic approach for urban renewal through redevelopment, rehabilitation, revitalization, and heritage preservation. In our matrix, redevelopment, rehabilitation, and revitalization have been included, which further justify the practical advantages of applying the proposed framework.

A comparison between current urban renewal projects initiated by URA and the proposed strategies can validate the proposed framework. Table 6.13 summarizes the urban redevelopment and revitalization projects initiated by URA in recent years. Figure 6.16 shows the boundary of rehabilitation activities by URA. Comparing the proposed strategies with projects by URA, the proposed strategies are mostly consistent with those proposed or developed by URA. For example, the results of the assessment suggest the redevelopment projects in TPUs of 2.2.5, 2.4.1, 2.4.2, and 2.8.5. URA has already implemented several projects in TPUs of 2.2.5, 2.4.1, and 2.4.2. However, total GFA of these projects is comparatively small, indicating the necessity of more redevelopment projects. Assessment results also suggest revitalization projects in TPUs of 2.1.4, 2.2.1, and 2.2.7, whereas the revitalization projects have been initiated by URA in TPUs of 2.2.1 and 2.2.7. Most of the selected TPUs are included in the boundary of rehabilitation activities of URA. The comparison demonstrates the reliability of the proposed framework in supporting urban renewal decision-making.

Table 6.13 Urban redevelopment projects and revitalization projects by URA

Planning Unit	Number of redevelopment projects	Total GFA of redevelopment projects (m^2)	Revitalization projects
2.1.4	1	102625	N
2.2.1	9	122773	Y
2.2.5	1	32012	N
2.2.7	2	46952	Y
2.2.9	2	179933	N
2.4.1	3	27261	N
2.4.2	3	29695	N
2.4.4	2	28666	N
2.8.5	0	0	N

Note: The information of this table is summarized based on the information posted in URA website. Y means there are revitalization projects in that TPU; N means there is no revitalization project in the TPU.

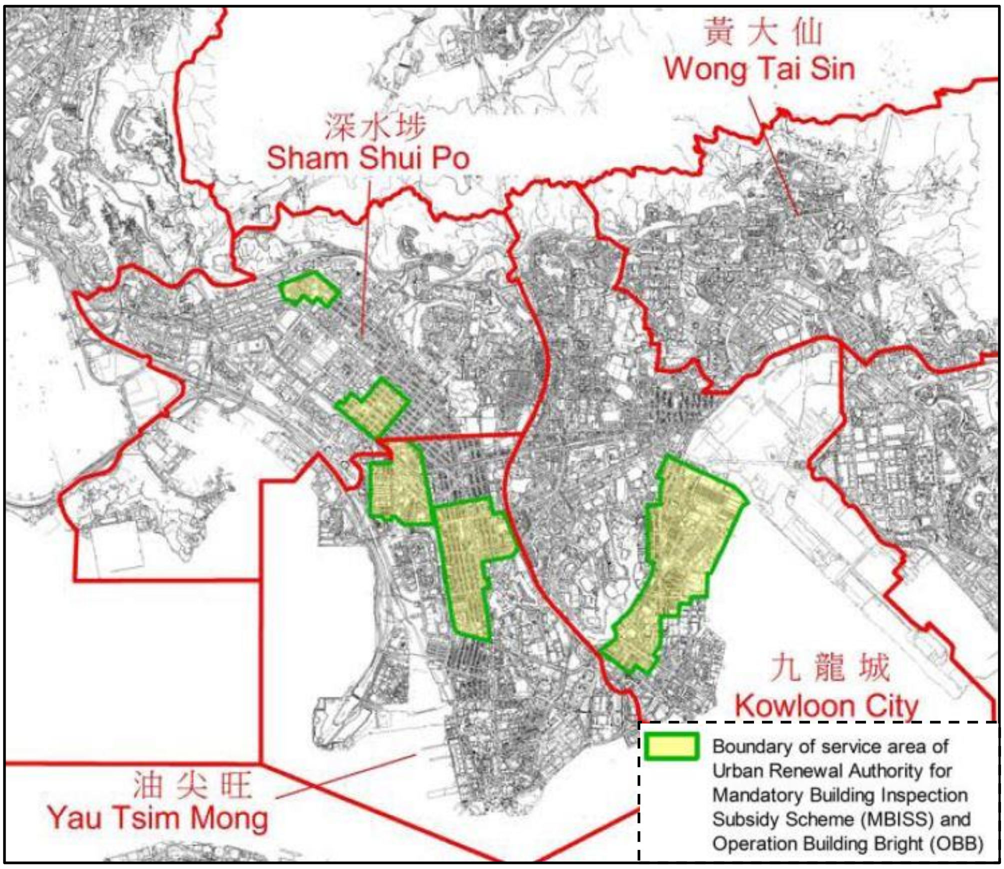


Figure 6.18 URA scheme area for building rehabilitation

(Adapted from the open information of official website of URA)

6.5 Summary of the Chapter

This chapter illustrates how the three modules have been developed following their development processes via the case study method. Cases at different scales show that the framework can provide a feasible way to support urban renewal decision-making with a multi-scale perspective. This illustration is useful for applying the multi-scale framework in other contexts since it is regarded as the pilot study. Validation is conducted for each module; the focus is the inherent robustness of three modules. Further validation from the perspective of practice will be discussed in the next chapter.

Chapter 7 Framework Validation

7.1 Introduction

This chapter presents the validation stage of the study. The modules were validated through technical validation approaches, but the proposed framework should be validated from the perspective of practical application. The validation process involved two expert interviews and an experimental study, both of which are described in this chapter. The expert interviews were aimed at collecting comments on the application of the proposed framework. An experimental study was designed to compare the traditional method and the proposed framework in urban renewal decision-making. The results of both validation methods show the effectiveness of the proposed framework.

7.2 Overview of the Validation Methods

To test the effectiveness of the proposed framework in supporting urban renewal decision-making, the framework should be applied in practice. Two expert interviews and an experimental study were designed to investigate the performance of this framework. The two methods can supplement each to improve the rigor of this study. The outcomes of the framework are used as the basis of validation.

Experts have practical experiences. They can provide comments on the proposed framework immediately after the author illustrates the proposed framework and the results of the case study are obtained. As a validation method, an experimental study is performed to investigate the effectiveness of the framework by comparing the traditional decision method with the application of the proposed framework. The experimental study is designed to simulate decision-making using real places and actual data. Before conducting the experimental study, a number of preparation tasks should be completed, including the designing of experimental study process, devising and testing the questionnaire, and recruiting proper participants. In the present work, the experimental study was organized in the form of a workshop. After conducting the experimental study, a questionnaire survey was conducted to determine the perception of the participants toward the application of the proposed framework. The sets of feedback from the interviews and experimental study were analyzed qualitatively and quantitatively. The validation methods and process are displayed in Figure 7.1.

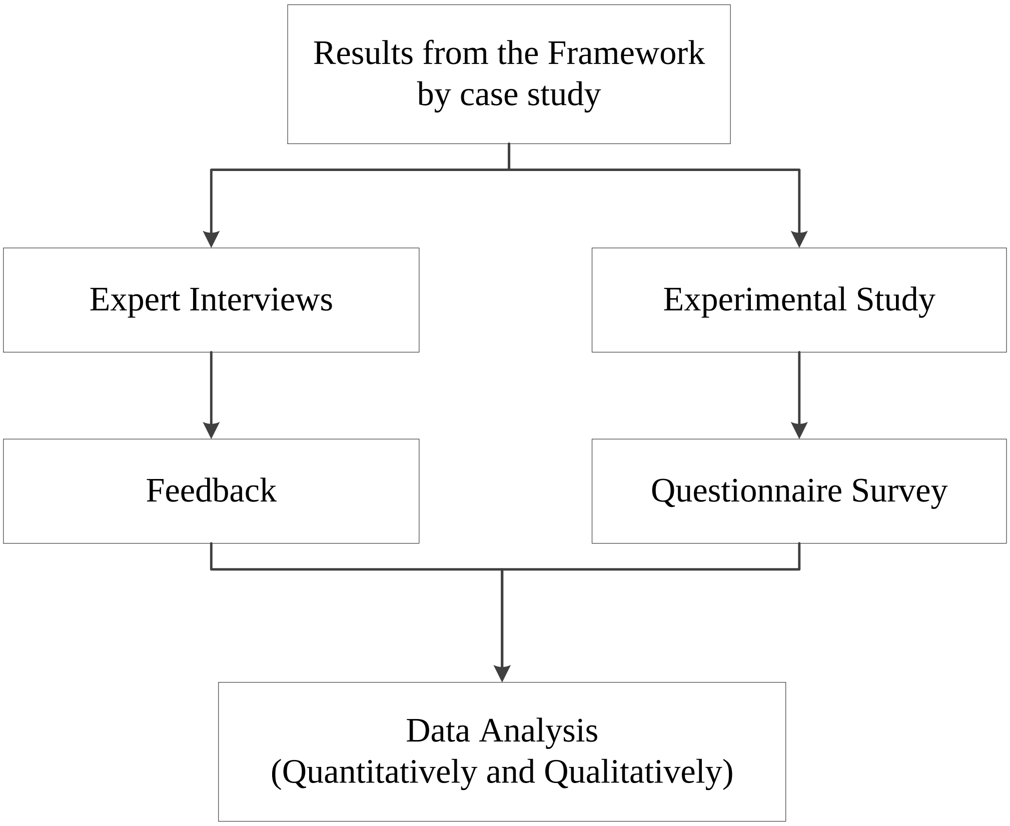


Figure 7.1 Process of framework validation

7.3 Expert Interviews

After developing the three modules based on Hong Kong as the case study area, two expert interviews were conducted to collect opinions on the proposed framework. One expert is both a non-executive director in the URA Board and a senior lecturer in one university in Hong Kong. Another expert is a senior town planner in the Planning Department of Hong Kong. Both interviewees are experts in the fields of planning and urban renewal with more than ten-year's practice in decision support. The selection of the two experts was based on two key points: they must have deep background knowledge and rich experience concerning decision-making of urban renewal, and their positions must be in the senior level. The purpose of setting the two selection criteria is to ensure the reliability of experts' comments concerning the effectiveness of the proposed framework.

In interviews, the proposed framework was first explained to the professionals, and then six questions pertaining to the effectiveness of the framework were raised. The first question explored the effectiveness of the SD module. The second question collected comments on the LUS module. The third and fourth questions were designed for the NA module. The fifth question explored the usefulness of the overall framework in supporting decision-making. The final question collected other suggestions and comments that were not included in the previous questions. Ideas relevant to urban renewal were also discussed during the entire process.

The experts made positive comments on the framework and the three modules. They also provided suggestions on how to improve the framework further. Their suggestions included the revision of some terms in the SD and NA modules to avoid confusion. The terms shown in the dissertation and the experimental study have been modified accordingly. Another suggestion is that when decision makers refer to the probability maps, maps of different land use types in the LUS module should be jointly considered.

7.4 Experimental Study

7.4.1 Purpose of the experimental study

The experimental study is to test whether the proposed multi-scale framework can provide decision makers with useful references for urban renewal decision-making and facilitate objective and effective decision-making.

7.4.2 Preparation of the experimental study

The experimental study compared the effects of using the traditional decision method and applying the proposed decision support framework in decision-making. Eighteen graduate students with similar educational backgrounds, such as urban planning, land management, and construction management, were recruited as participants in the experimental study. The participants were from a class of Master course in urban planning theory and practice, in which they had conducted team-based projects concerning decision-making and planning. Some of the participants had working experience or are working in planning-related fields. Additionally, none of the participants had prior understanding of the characteristics of the experiment and the contents of the study. In short, the participants had two characteristics: abundant knowledge of urban planning and urban renewal and possessing no prior understanding of the proposed framework. These two features can ensure the reliability of their comments on the comparison between the proposed framework and the traditional approach in decision-making.

Relevant information from the results of the framework were selected and integrated for the experimental study. Results from the three modules were also selected for future implementation. The results used in the workshop comprised the results of the scenario analysis in the SD module, the land use probability maps and the results of the scenario analysis in the LUS module, and the results of the NA module (see Table 6.2 and Figures 6.6, 6.10, 6.11, 6.14, and 6.15).

The duration of the experiment (in a form of a workshop) was designed to last for one-and-a-half hours. The participants need to be divided randomly and equally into two groups. Each group was designed to perform tasks of deciding on the overall direction of urban renewal in Hong Kong, strategies for two neighborhood units (A and B), and associated approaches.

In Section 1, Group 1 participants were designed to use the traditional method to make decisions on the overall direction of urban renewal in Hong Kong, strategies for neighborhood A, and some associated approaches (Task 1). Group 2 were also designed to use the traditional method in Section 1 but to focus on neighborhood B (Task 2). The participants could surf the Internet and search for the information that they need while conducting the designated task.

In Section 2, the multi-scale framework for decision-making should be introduced to the two groups firstly. Group 1 was designed to decide on a general direction of urban renewal in Hong Kong and to provide a strategy for neighborhood B (Task 2) by referring to the results of the proposed framework; Group 2 was designed to do the same but with a focus on neighborhood A by applying the multi-scale decision support framework. Both groups could search for related information through the Internet.

The effectiveness of the experimental study was ensured because of the following reasons. First, every group could experience a traditional method and the application of the decision support framework. Second, every group was designed to perform the same task once to ensure not being influenced by a prior decision. Appendix III shows the location of the tasks. Table 7.1 presents the design of the experimental study.

A semi-structured questionnaire was designed and tested before the workshop. The questionnaire comprises three parts: (1) background information, (2) comparison of traditional method and the multi-scale framework, and (3) open-ended questions on the effectiveness of the multi-scale framework. The first part explores whether the participants hold relevant background and knowledge in urban planning, land use, urban renewal, and public participation. The second part investigates whether the proposed framework is more effective than the traditional method. The final part asks about the opinions of the participants in terms of their satisfaction on the proposed framework.

Table 7.1 Design of experimental study

	Method	**Group 1**	**Group 2**
Section 1	Traditional method	Task 1 (Policy direction & site A)	Task 2 (Policy direction & site B)
Section 2	With the help of the proposed framework	Task 2 (Policy direction & site B)	Task 1 (Policy direction & site A)

Note:

Task 1: making decisions on the overall direction of urban renewal in Hong Kong, strategies for neighborhood A, and some associated approaches.

Task 2: making decisions on the overall direction of urban renewal in Hong Kong, strategies for neighborhood B, and some associated approaches.

7.4.3 Implementation of the experimental study

The experimental study was conducted in Hong Kong Polytechnic University in the form of a workshop. Before the workshop formally started, light lunch meals were provided to the participants to warm them up and to familiarize them with the coordinators. The workshop was divided into three parts. The first part was the workshop briefing. A general description of urban problems and urban renewal in Hong Kong, brief introductions to neighborhoods A and B, and a number of associated spatial maps and statistical tables were provided to the participants. In the second part, 18 participants from the two groups were initially asked to complete the tasks prepared in the preparation phase. A five-minute break followed Section 1. Then the decision support framework was briefly introduced, and the prepared results were displayed for them. The two groups were asked to complete their own tasks in Section 2. During the process of performing the tasks, they could freely surf the Internet and search for different resources. The questionnaire survey was conducted to the participants in the final part. All participants were asked to fill in the prepared questionnaire to collect their feedback about the application of the multi-scale framework in the decision-making process. Table 7.2 shows the timetable of the workshop. Figure 7.3 shows the group discussion in the experimental study.

Table 7.2 Timetable of the workshop

No.	**Duration**	**Session**
1	20 mins	Workshop Briefing
2	30 mins	Section 1
	5 mins	Break
	20 mins	Introduction to the framework
	30 mins	Section 2

3	15 mins	Questionnaire Survey

Figure 7.2 Group discussion in experimental study

7.4.4 Questionnaire survey for the participants

Eighteen questionnaires were completed after Section 2. The results of the first part showed that all the participants were familiar with the issues related to urban planning, land use, and urban renewal. Most of them had previous knowledge of focus group decision-making and public participation.

Table 7.3 shows the results from the second part, wherein questions were asked about the extent of the participants' agreement or disagreement with several statements. A four-point scale was used to gauge their responses (strongly agree, agree, disagree, and strongly disagree). The participants agreed that the proposed framework could contribute to improved decision-making on urban renewal compared with the traditional method. The standard deviation value for Question 8 was high because two participants disagreed with the statement. This result implies the existence of controversy that the proposed model can be easily understood by non-professionals.

The final part involved open-ended questions that asked the participants about their most and least favorite aspects of the proposed framework. The comments varied. Most participants mentioned that the logic was clear and that the NA module was particularly helpful. In terms of the question that asked for the participants' suggestions, some mentioned that the quality of the data might be a cause for concern.

The results from the experimental study implies that the proposed framework and its associated modules can benefit urban renewal decision-making with objective and comprehensive references.

Table 7.3 Results of part two of the questionnaire survey

Questions	**Mean**	**Standard deviation**
Q5. The proposed framework makes me have a better understanding of the case study sites	3.67	0.47
Q6. The proposed framework provides me with more useful information for decision-making of urban renewal	3.78	0.42
Q7. The proposed framework enables me to better make decisions during the decision process	3.50	0.50
Q8. The information provided by the proposed framework is easy to understand even for non-professionals to express their opinions during the public participation process	3.11	0.99
Q9. The probability maps provided by land use change simulation can reveal some problems relating to land use	3.33	0.47
Q10. The sustainability assessment enables me to better understand specific conditions of each neighborhood	3.44	0.60
Q11. The sustainability matrix is useful for me to make better decisions	3.50	0.50

Note: 4: strongly agree, 3: agree, 2: disagree, 1: strongly disagree

7.5 Summary of the Chapter

This chapter presents the validation stage of this research from the people's perspective. Two validation methods were used in the process: two expert interviews and an experimental study; both methods were described firstly. The expert interviews were aimed at collecting the feedback of experts on the proposed framework based on their practical experiences. The questions asked were open-ended. The details of two expert interviews were given in this chapter. Additionally, this chapter introduces the preparation, implementation, and questionnaire survey of the experimental study. The application of the multi-scale framework in urban renewal decision-making was compared with that of the traditional method. The results show that the proposed framework can effectively facilitate decision-making with its comprehensive and objective analysis, evaluation, and prediction.

Chapter 8 Conclusion

8.1 Introduction

This chapter concludes the study by summarizing the research findings and suggesting future research directions. The overall research aim and objectives are reviewed to determine whether they were achieved through the research. The key research findings are summarized from the literature review, and the development of three modules in the framework. Research contributions, limitations, and future directions are finally discussed.

8.2 Review of Research Objectives

Urban renewal, which is considered the sword for solving urban problems, has attracted research efforts in the academia and practice. The inherent feature of urban renewal is its complexity in different dimensions, which poses a significant challenge for urban renewal decision-making. Previous research on urban renewal decision support primarily focuses on the project level. Limited attention has been given to large scales (e.g., city, district, and neighborhood). Quantitative and subjective decision support can help balance different interests and improve the performance of urban renewal initiatives. As clarified in Chapter 1, the overall aim of this research is to develop a decision support framework for sustainable urban renewal in a multi-scale (city, district, and neighborhood) perspective. The framework covers spatial and temporal dimensions. To realize the research aim, four specific objectives were addressed:

(1) To identify major variables and their relationships in the urban renewal system and to explore relevant supporting tools and methods for urban renewal decision-making;

(2) To conceptualize a multi-scale decision support framework for sustainable urban renewal and its associated modules in the framework based on theories, practice, tools, and technologies relating to urban planning, urban renewal, and land use;

(3) To develop a system dynamics (SD) module at the city scale, a land use simulation (LUS) module at the district scale, and a neighborhood assessment (NA) module at the neighborhood scale in the framework;

(4) To test and validate the effectiveness of the proposed framework in supporting urban renewal decision-making.

To address Objective 1, a literature review and document analysis were conducted. Chapter 2 provides a comprehensive review of existing research on sustainable urban renewal and decision support for urban renewal. Chapter 3 presents past and current urban renewal practices in four high-density cities (Hong Kong, Singapore, Tokyo, and Seoul). These two chapters contribute to addressing Objective 1 and serve as the theoretical and practical foundation for the further conceptualization and development of the framework. The conceptualization of the framework was completed through the literature review, document analysis, and expert interviews. Chapter 4 presents the structure of the conceptualized framework, the four components including the supporting database and the three modules (SD, LUS, and NA), and the process of city selection and data preparation. These processes illustrate the completion of Objective 2. To realize Objective 3, the three modules were developed on the basis of real data and cases. The SD module was developed by using Hong Kong as the case city. The LUS module was developed using the YTM district in Hong Kong as the case study area. The NA module was completed through the neighborhood assessment on nine tertiary planning units in Kowloon of Hong Kong. SD modelling was used in the SD module.

CLUE-S model and Markov chain prediction were integrated to complete the LUS module. An indicator-based approach was adopted for the NA module. Spatial analysis in GIS played a significant role in the development of the LUS and NA modules. The details of the development of the three modules (SD, LUS, and NA) are illustrated in Chapter 6. The validation of the proposed framework was completed through two expert interviews and one experimental study in a workshop. Chapter 7 introduces the validation phase of the research and explains how Objective 4 was addressed.

8.3 Research Conclusions

The research questions raised in Chapter 1 were answered in different chapters of this thesis. This research completed the proposed objectives. The results show that the proposed framework, which comprises one supporting database and three modules, can address different issues at different scales by incorporating various considerations/factors and tools. Based on the case study, the proposed framework has the potential to be applied in other high-density cities. The conclusions of this research are drawn from the literature review, the review of urban renewal practice, and the conceptualization, development, and validation of the framework.

8.3.1 Conclusions from the Literature Review

To establish the theoretical foundation of this research, existing studies were reviewed. These studies included those that explored sustainable urban renewal and decision support for urban renewal. The literature review provides insights into the difficulties and complexities in urban renewal decision-making. The literature review also identified the following research gaps:

(1) The research on urban renewal decision-making mainly concentrates on urban renewal projects. Strategic decision-making at other scales (city, district, and neighborhood) has rarely been discussed in existing research.

(2) Urban renewal research at the city scale concentrates on the qualitative discussion of policies and strategies. A dynamic analysis of variables and their associated relationships in an urban renewal system through quantitative method has not been conducted.

(3) Land issue in urban renewal in most studies has been qualitatively discussed, but land use simulation in urban renewal district has rarely been carried out in previous research. The existing research on urban land use simulation mainly concentrates on large scales and urban sprawl processes. Simulation on urban renewal districts represents an untouched field.

(4) Neighborhood planning is not a new concept, but it has been rarely discussed in relation to urban renewal. The trend of urban renewal programs has shifted to comprehensive development, but neighborhoods have become increasingly important because of its implementation advantage. Sustainability assessment is not a new topic, but sustainability assessment that considers urban renewal indicators is a research gap.

Apart from these research gaps, the literature review also facilitated the achievement of the first objective of identifying the major variables and their relationships in the urban renewal system and exploring relevant supporting tools and methods for urban renewal decision-making.

Urban renewal is inherently complex at different dimensions. Various issues, different stakeholders, multiple solutions, and diverse scales are closely related and increase the complexity and uncertainty of urban renewal. Various issues include buildings, land use, facilities, transportation, culture and heritage, and urban design. Stakeholders range from public and private agencies to community and individuals with different roles. Multiple strategies or solutions can be adopted in urban renewal. These strategies include redevelopment, rehabilitation, revitalization, land readjustment, and preservation. The diverse scales in urban renewal consist of city, district, neighborhood, and building blocks.

To promote decision-making, these dimensions must be considered in the analysis and evaluation of urban renewal. Planning-related theories and technical tools (such as GIS, RS, and 3D) act as the basis and support for the analysis and evaluation of urban renewal. Decision-making can be supported by analysis and evaluation. These approaches further contribute to the achievement of sustainable urban renewal.

8.3.2 Conclusions from the Review of Urban Renewal Practice

The review of urban renewal practice further illustrated the complexity of an urban renewal system. Urban renewal practices in the four cities (Hong Kong, Singapore, Tokyo, and Seoul) reveal the complexity of urban renewal as a result of the involvement of multiple stakeholders, various issues, different approaches, and different scales.

Four common features can be identified from the analysis and comparison of the urban renewal practices in the four cities: (1) involvement of multiple stakeholders, (2) the transition from slum clearance to increased focus on rehabilitation or preservation, (3) selection of various approaches, and (4) community engagement has attracted more attention recently.

Urban renewal practice is embedded with complexity, which is a considerable challenge for urban renewal decision-making. The lessons learned can be utilized in practice. Different contexts have different conditions. Therefore, the proposed framework for decision support must be able to adapt to various contexts.

8.3.3 Conclusions from the Development of the Three Modules

Modules at different scales address different goals. Conclusions can be obtained from the development of the three modules.

SD module

Considerable research efforts have been made to explore issues and solutions related to urban renewal. Despite these efforts, a general analysis of the system and its inherent dynamics remains lacking. The SD module can offer insights into the dynamics and interrelationships in the urban renewal system through the application of the said module. The SD module consists of environmental, socio-economic, and building sub-systems. Another essential result of the SD module includes the simulations of required area of urban renewal projects in six different scenarios. Such simulations are crucial inputs in urban renewal decision-making.

The causal loop and stock flow diagrams developed in this module depict the feedback relationships underlying the important variables involved in the urban renewal system, such as required area of urban renewal projects, urban redevelopment project provision, and building rehabilitation.

Environmental, socio-economic, and building sub-systems are interrelated in the entire urban renewal system. This interrelation indicates that urban renewal can provide opportunities for the sustainable development of a city.

Positive urban renewal policies are suggested based on the simulation of required area of urban renewal projects under different scenarios. In order to promote the sustainability of cities, urban rehabilitation activities are suggested as the priority.

LUS module

A comprehensive understanding of the mechanisms and directions of land use change is crucial in land use planning. Land use planning for urban renewal areas differs from the planning of new towns because land sites in renewal areas are developed for many existing uses (Wang et al., 2013). The LUS module explores the mechanism of land use change in a developed district in Hong Kong to support urban renewal decision-making at the district scale. The development and validation of the LUS module consider spatial and temporal dimensions. The LUS module (combination of the CLUE-S model and the Markov chain prediction model) was developed and validated to simulate four land use scenarios in 2018.

The simulation results indicate that land use change is influenced by physical, locational, socio-economical, and political factors. The 14 driving factors selected in this module can explain land use allocation. The simulation result can be a significant complement to the qualitative analysis of the mechanism of land use change in urban renewal districts.

The probability maps for different land use types provide an explicit understanding of the probability of spatial land allocation. Decision makers for urban renewal could understand the direction of future land use, discover possible problems of land use, and make informed decisions.

Scenario analysis reflects land use change under different policies. Simulation results show that vacant land parcels are prioritized for utilization when development is required. To facilitate sustainability, the redevelopment of decaying sites should be considered instead of developing new lands.

NA module

The evaluation of urban renewal is necessary for decision-making. Current studies have rarely explored the neighborhood scale of urban renewal assessment. The NA module develops a systematic framework to support urban renewal decision-making at the neighborhood scale. The NA module comprises two components. The first component is sustainability scores and the building condition scores of different neighborhoods. The second component is a decision-making matrix for potential strategies. The development of the NA module using the nine TPUs in Chapter 6 is a pilot study of NA in urban renewal decision-making at the neighborhood scale.

The NA module considers four approaches in urban renewal/regeneration through a decision matrix, which is a new concept of urban renewal decision-making. The selected indicators of NA can be considered as references for practice. These indicators can contribute to the theoretical development of NA by focusing on urban renewal decision-making. The indicators and matrix in this framework are not fixed. Hence, the conditions of specific contexts must be considered to facilitate the improved application of the framework in practice.

Decision-making is a complicated process. The proposed assessment framework does not propose the final strategies for urban renewal, but provides decision makers with objective references. The final decisions should consider other factors, such as those that cannot be quantified.

8.3.4 Conclusions from the Validation of the Framework

To determine whether the proposed framework can support urban renewal decision-making, two expert interviews and one experimental study were designed and conducted.

Both experts held positive comments on the framework and the three modules. They commented that the proposed framework is useful for urban renewal decision-making. They also offered suggestions about minor modifications of the multi-scale decision support framework. According to the results of the experimental study, the proposed framework can support urban renewal decision-making because of the multi-scale perspective and objective results.

8.4 Contributions of the Research

8.4.1 Contributions to Current Knowledge

From an academic perspective, this research can enrich theoretical development in the fields of urban planning, urban renewal, land use and decision-making.

First, the multi-scale framework is the first attempt to investigate urban renewal from a multi-scale perspective while previous research only focuses on one scale of urban renewal, especially the project scale. A multi-scale approach can better address the paradox of problems at different scales. This framework explores the scales that were ignored in previous studies. This framework also addresses different aspects in urban renewal in an integrated way.

Second, the present study reviews existing research on sustainable urban renewal and decision support tools and methods for urban renewal. This study provides a comprehensive understanding of sustainable urban renewal and the decision support for realizing it. The research findings and gaps identified in previous studies could serve as basis for recommending future research in relevant fields.

The development process and results from the three modules at different scales also contribute to current knowledge in specific fields, including the application of SD in urban renewal, land use change simulation, and neighborhood planning.

The contributions of the SD module are twofold. First, the causal loop and stock flow diagrams, which were constructed to interpret the internal relationships among major variables, enrich the research by providing a comprehensive and dynamic understanding of urban renewal. Second, the SD module contributes to the research on decision support for urban renewal because it proposes a quantitative and dynamic model through which decision makers can make informed decisions with the quantitative and systematic understanding.

The LUS module at the district scale is the first attempt to simulate land use change in urban renewal districts. This attempt contributes to fields of urban renewal and land use simulation. The land use mechanisms identified and validated in this module can serve as important references for future research on land issues in urban renewal.

The contributions of the NA module comprise two aspects. First, this framework considers four approaches in urban renewal/regeneration through a decision matrix, which is a new concept in urban renewal decision-making. Second, the selected indicators for sustainability assessment can be considered as references for other contexts. The indicators selected can contribute to the theoretical development of sustainability assessment at the neighborhood scale for neighborhood renewal decision-making.

8.4.2 Contributions to Practice

From a practical point of view, the proposed framework is an effective and comprehensive tool to analyze problems and policies in urban renewal before making decisions and implementing renewal strategies. It can be referred by statutory bodies whose aim is to promote urban renewal initiatives. It provides a perspective of making decisions with more sustainability-related considerations. At the city scale, the SD module can present the relationships among various variables in the urban renewal system and explore how urban renewal initiatives are influenced by different variables. This process can guide policymaking at the city level. The proposed framework can serve as a platform for simulating other scenarios to provide information on different policies. In addition to analyzing the mechanism of land use change at the district scale, the module can also predict policy impacts through scenario analyses. The potential for urban renewal can be identified through development of the NA module at the neighborhood scale; implementation strategies can also be proposed in the NA module. The integration of the three modules in decision-making can facilitate the analysis of current conditions and predict future issues with a spatial−temporal perspective. This approach can offer comprehensive decision-making references. This framework can be regarded as a prototype of a decision support system for sustainable urban renewal.

In summary, the proposed multi-scale decision support framework is an effective framework for evaluating current problems and predicting the future before urban renewal. The proposed framework can be used in the decision-making process for implementing sustainable urban renewal initiatives.

8.5 Limitations of the Research

Despite the theoretical and practical contributions to existing studies, this research is still subject to a number of limitations. First, the three modules within the framework were developed loosely. The integration of the three modules is limited to a qualitative discussion. This limitation is attributed to time limits and technical difficulties. Second, the development process of the supporting database was time consuming because considerable data/information were involved and obtained from different sources. This limitation can be addressed with improved data integration and management technologies or approaches. Third, the validation from the people's perspective by using expert interview and experimental study has the limitation in terms of the number of expert interviews and participants in the experimental study. This limitation can be addressed by applying the multi-scale decision support framework in real cases.

Each module has some individual limitations. The SD module has two main limitations. First, the variables included in the SD model are limited. Additional variables should be considered to improve the SD module further. Second, the required area of urban renewal projects is likely to be influenced by other factors, in addition to those in the SD module. Additional factors could be considered for further study. The LUS module is subject to two limitations. First, some social and economic data cannot be obtained at the district scale. These data include the economic output of each land unit and employment density. Given this limitation, some variables of land allocation were ignored. Second, some qualitative factors, such as land ownership and land lease, cannot be reflected in this type of model. Therefore, the combination of qualitative and quantitative analyses is a potential direction for future research. The development of the NA has two limitations. First, six indicators were excluded in the assessment process because of the unavailability of data. This limitation might influence the accuracy of the results to some extent. Second, the weights of the indicators were considered evenly distributed, whereas some indicators may be more important for deciding neighborhood performance.

8.6 Recommendations for Future Research

To improve this research, some suggestions for further studies are proposed:

1. This research considers city, district, and neighborhood scales in its framework. Future research can add the building scale for more comprehensive decision support.

2. An efficient approach to integrate the modules is a direction for future research. For example, a "system" can be developed to integrate the modules into one platform. The current framework could be regarded as a prototype.

3. Additional case studies should be conducted in the future to refine this framework and promote the adaptability of the multi-scale framework.

4. Other advanced technologies can be applied for efficient data collection, processing, and analysis. For example, UAV can be adopted to obtain updated information on building conditions.

5. Additional variables could be considered for further study of the SD module. A detailed analysis on sub-systems in urban renewal can be another direction for future studies. Urban renewal in high-density cities is associated with changes in land use density, in addition to changes in land use types. An investigation of this issue can provide an improved understanding of urban renewal in high-density cities. Therefore, this issue should be explored in future research. Weights for different indicators

should be developed for the NA on the basis of the local context. Several methods are suggested, including the analytic hierarchy process and analytic network process. Alternatives should be explored to address the data limitation of some indicators.

Appendix I: Sample of Interview Sheet I

Thank you for joining this interview!

Title of Research Project:

A Multi-scale Decision Support Framework for Sustainable Urban Renewal in High Density Cities

Brief Introduction:

This research aims at developing a multi-scale decision support framework that utilizes the potential and functions of a geographic information system, system dynamics models, and other simulation models to support decision-makers for realizing the sustainability performance of urban renewal. This framework will address the complexity and major aspects of sustainable urban renewal. It will assess sustainability based on the relationships between various variables in urban system, predict future land use under different scenarios, optimize land utilization, and conduct neighborhood assessment. It is envisaged that the proposed framework in this research has the potential to improve the efficiency and effectiveness of the urban renewal related services provided by government.

Open-ended Questions:

1. What are the most challenged issues for decision-making of urban renewal?

2. URA established District Urban Renewal Forum (DURF) to improve public participation. How to integrate various voices from professionals and different people?

3. We know that public participation is considered as an important part in decision-making of URA. The URA will carry out social impact assessment before and

after the publication of any proposed redevelopment projects. How are these projects decided? In addition, who make decisions and what methods do they use?

4. Do you know whether there is any GIS application or 3D application for urban renewal decision-making? If yes, how does it influence decision-making in urban renewal?

5. Do you know whether there is any assessment after redevelopment? If there is, how does it integrate with previous social impact assessment? Could you suggest us some successful redevelopment cases in the past decade?

6. What are your suggestions on decision-making at city, district, and neighborhood scales?

7. What are the most important factors for land use change in Hong Kong? What about high-density area of Hong Kong like Kowloon District?

8. What are your suggestions on the proposed framework for urban renewal decision-making?

9. What are your suggestions on sustainability assessment for urban renewal decision-making?

Identification of factors for land use change in LUS:

In your opinion, which of the following factors will contribute to land use change in Hong Kong? Please click √ in the right column.

Biophysical	**Slope**	
	Elevation	

	Terrain
	Solar access
	Vegetation rate
	Others (Please specify):
Locational (accessibility)	Distance to CBDs
	Distance to airport
	Distance to bus terminus
	Distance to coastline
	Distance to historic sites
	Distance to schools
	Distance to open space
	Distance to road
	Distance to hospital
	Traffic volume
	Others (Please specify):
Socio-economic	Population density
	Property price
	Local GDP

	Heritage preservation
	Local uniqueness preservation
	Others (Please specify):
Environmental	Local Air quality
	Noise pollution
	Light pollution
	Local water quality
	Others (Please specify):
Political	Land use regulations
	Land ownership
	Development projects or schemes
	Others (Please specify):
Others	Former/Current land use
	Neighborhood effects
	Others (Please specify):

Identification of indicators for sustainability assessment

This part aims to investigate, in the experts' opinion, indicators for sustainability assessment in land use decision-making of urban renewal. A set of tentative criteria are listed below for your reference. Please give your suggestions and comments in terms of these indicators.

No	Category	Indicator	Remarks
1 (S1)	Social	Human density	
2 (S2)	Social	Diversity of ages	
3 (S3)	Social	Residential floor area per capita	
4 (S4)	Social	Diversity of public transport	
5 (S5)	Social	Diversity of facilities	
6 (E1)	Economy and work	Labor force participation rate	
7 (E2)	Economy and work	Disposable income per capita	
8 (E3)	Economy and work	Diversity of business income	
9 (R1)	Resources and environment	Water consumption	
11 (R2)	Resources and environment	Waste generation	
12 (R3)	Resources and environment	Waste recycling	
13 (R4)	Resources and environment	Electricity consumption	
14 (R5)	Resources and environment	Air quality	
15 (L1)	Land use form	Land use mix	
16 (L2)	Land use form	Accessibility to cultural facilities	
17 (L3)	Land use form	Accessibility to education services	

18 (L4)	Land use form	Accessibility to health care services
19 (L5)	Land use form	Accessibility to sport and leisure facilities
20 (L6)	Land use form	Accessibility to other facilities
21 (L7)	Land use form	Accessibility to public transport
22 (L8)	Land use form	Open space coverage ratio
23 (B1)	Building condition	Average building age
24 (B2)	Building condition	Number of buildings aged above 50 years
25 (B3)	Building condition	Building maintenance
26 (B4)	Building condition	Building density

Please leave your specific comments if you have:

Appendix II Sample of Interview Sheet II

Thank you for joining this interview!

This interview is to collect some suggestions on the proposed framework and evaluate the effectiveness of using the three modules in the proposed framework to support urban renewal decision-making. Attachment is a brief introduction to the framework results.

Open-ended questions

1. Do you think the scenarios set in the simulation of required renewal projects are reasonable? What kind of improvement can be made?

2. What do you think about the probability maps in land use change simulation model?

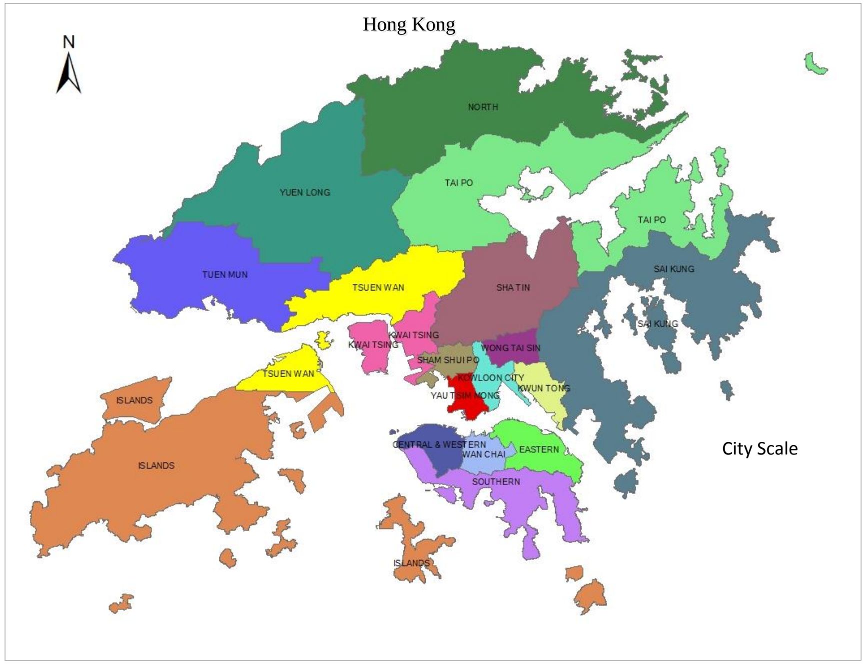
3. Are the proposed categories in sustainability assessment appropriate or not? If not, from which aspects can it be improved?

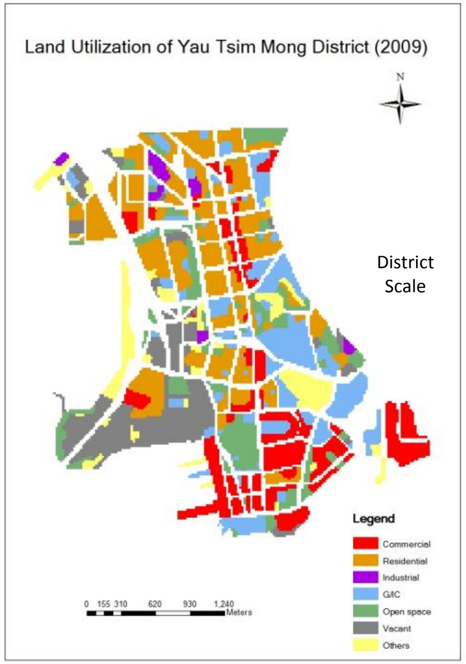
4. Is the approach sustainability matrix for supporting decision-making appropriate? What kind of improvement can be made?

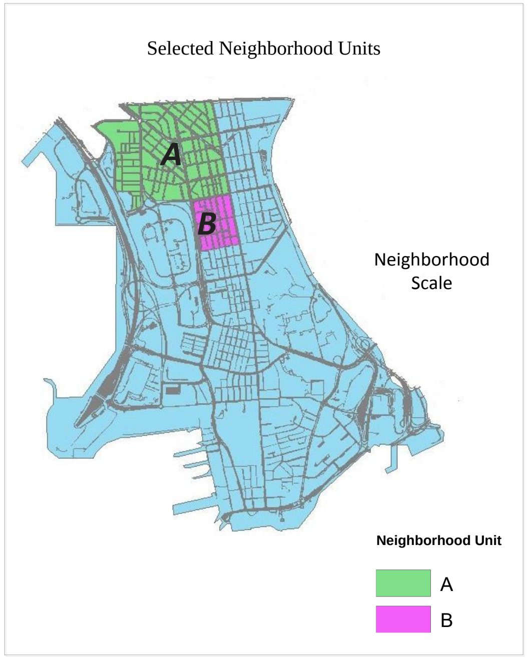
5. Is the proposed framework useful for strategic decision-making of urban renewal?

6. Do you have any suggestions on this framework?

Appendix III Location of Case Study and Task Areas in the Experimental Study







Appendix IV Sample of Questionnaire Survey

Feedback Questionnaire

Thank you very much in advance for your kind help in completing this questionnaire.

1. Background Information

	Yes	No
Q1. I have basic knowledge in urban/land use planning		
Q2. I have basic knowledge in urban renewal/regeneration		
Q3. I have basic knowledge in public participation in the planning process		
Q4. I have experience in group discussion and decision-making		

2. Comparison between conventional approach and the proposed framework

	Strong disagree	disagree	agree	Strong agree
Q5. The proposed framework makes me have a better understanding of the case study sites				
Q6. The proposed framework provides me with more useful information for decision-making of urban renewal				
Q7. The proposed framework enables me to better make decisions during the decision process				
Q8. The information provided by the proposed				

framework is easy to understand even for non-professionals to express their opinions during the public participation process				
Q9. The probability maps provided by land use change simulation models can reveal some problems relating to land use				
Q10. The sustainability assessment enables me to better understand specific conditions of each neighborhood				
Q11. The sustainability matrix is useful for me to make better decisions				

3. Open-ended questions

(1) What do you like MOST about the proposed framework?

(2) What do you like LEST about the proposed framework?

(3) What suggestions do you have for this proposed framework?

Name (optional) _______________

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