A GIS-BASED FRAMEWORK FOR SUPPORTING SUSTAINABLE LAND USE PLANNING IN URBAN RENEWAL PROJECTS

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Declaration

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgement has been made in the text.

Signed

WANG Hao

Abstract

Land use planning plays an important role in improving land use patterns and conditions in cities. Land resources are very limited in many high-density cities such as Hong Kong and land supply is the major concern of local governments in these regions. Urban renewal is a topic emerging from some developed cities with a long history, and it aims to redevelop or revitalize the older districts/areas usually located in the central city to fit for the changing demands of urban development. Urban renewal provides an effective channel to adjusting land-use allocation and improving land-use efficiency (increasing land supply in a sense). In some developed cities with limited land and many older districts to be redeveloped, a big issue planners are facing for years is land use planning with sustainability considerations for urban renewal projects. Therefore, how to provide effective support to the planning process in these cities is a necessary research question.

As documented in literature, there are three major gaps in this research area. First, the studies on sustainable land use planning are mostly limited on the theoretical and qualitative level, whereas, quantitative approaches/methods incorporating the sustainability thinking into the planning practice are rare. Second, planning support systems (PSS) are seldom used in the planning practice for they do not usually receive enough attention from planners due mainly to the mismatch between the suppliers of PSS and the users during the system development, and the high complexity of the systems. Third, a general list of criteria for land-use suitability analysis has yet to be developed for urban land evaluation, and small-scale (street/site level) land suitability analysis is a relatively neglected topic.

In order to fill these research gaps and answer the research question, this research develops a GIS-based framework consisting of a planning support model and a land information database to support sustainable land use planning in urban renewal projects. Four main objectives of this research are achieved and they are (1) to identify criteria concerning sustainability (i.e. economic, social and environmental perspectives) in sustainable site planning, (2) to develop a general list of criteria (including the sustainability criteria) for land suitability assessment at the site level, (3) to conceptualize and develop a GIS-based framework (consisting of a planning support model and a land information database) as a prototype of PSS for supporting the decision-making process of land use planning in urban renewal projects, and (4) to validate the effectiveness of this framework in supporting the planning process.

In the process of achieving these objectives, six research methods are used in this research: document analysis, expert interview, focus group meeting, case study, experimental study and questionnaire survey. Literature review and document analysis are used to achieve Objective 1 and Objective 2 – Criteria Identification; literature review, expert interview, focus group meeting, and case study are conducted to achieve Objective 3 – Conceptualization and Development of the Framework based on the criteria identified; experimental study and questionnaire survey are employed to achieve Objective 4 – Framework Validation. The research conclusions include major findings from the document analysis, expert interviews, case study, and experimental studies. Ultimately, the results of this validation process prove that the framework developed in the research can support the decision-making process of land use planning in urban renewal projects by facilitating planners to analyze the land-use suitability, helping the other stakeholders understand the planning considerations of the planners, and further improving public engagement during the planning processes.

This research has contributed to new knowledge and improved the decision-making process of land use planning in urban renewal projects. The main contributions of this research are: (1) this research has identified general criteria for land-use decision-making in site planning (including sustainability criteria) and the sources of the associated data/information; (2) this research has developed a GIS-based framework which can be regarded as a prototype of a PSS for land use planning in Hong Kong; (3) this research has developed a quantitative approach to assessing land-use suitability for land sites to be redeveloped (i.e. the planning support model) and a standard means of providing the usable data for the model (i.e. the steps of the land-info database setup); (4) this research has demonstrated the usefulness of GIS visualization and spatial analysis in land use planning, in particular, site redevelopment planning, and expanded GIS applications to the planning practice.

Publications

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3. Wang, H., Shen, Q.P., Tang, B.S., Lu, C., Peng, Y. and Tang, L.Y.N. (2013). A framework of decision-making factors and supporting information for facilitating sustainable site planning in urban renewal projects. *Habitat International*, Under Review.
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8. Tang, L.Y.N., Shen, Q.P., Skitmore, M. and Wang, H. (2013). Procurement-related critical factors for briefing in Public Private Partnership projects. *Journal of Management in Engineering*, Under Review.

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Chapter 1 Introduction

1.1 Research Background

Land is the basis of urban activities. Without enough land, cities cannot be formed, let alone be developed. Especially in modern times, cities have been highly developed and the land in urban area is relatively insufficient for meeting the increasing demand from new urban residents. For example, Hong Kong is a world city playing an important role as the pole of development in the Pearl River Delta region and the hub of finance, information and logistics in Asia, even globally (Shen et al., 2009). However, it is a small city in terms of the territorial area, with only 1100 square kilometers, but has a population of over 7 million (Lee and Chan, 2008). This great contrast leads to an inevitable consequence, that is, the hyper-density of land development in the metropolitan areas of Hong Kong. Land issue is an inherent problem for Hong Kong. Under these circumstances, how to plan and manage the land use with a high sustainability is indeed a puzzle to be solved.

The current land use in Hong Kong has some drawbacks which have led to some complicated problems in terms of society, economy and environment. For instance, the uneven spatial distribution of land development is outstanding in Hong Kong: The land in the north of Hong Kong Island and the majority of Kowloon has been over-developed and land reclamation has taken place along the seashore. To the contrary, a large amount of land resource has not been developed in the New Territories due to the natural constraint and historical reasons. As a result, the over-development of land with a high plot ratio and the land reclamation from the harbour have worsened the living environment, and the limited housing conditions in general have also caused some social problems (CEDD, 2011). Until 1997, accompanying with the rapid economic development, a variety of environmental problems has emerged in Hong Kong: poor air quality, polluted beaches and declining marine water quality, excessive noise levels, increasingly serious waste disposal problems, and threatened habitats and ecosystems (Lee and Chan, 2008). In addition, Hong Kong is well-known for her high housing price which prevents many citizens from having their own homes (Housing Authority, 2011). These problems have increasingly lowered the sustainability of land use in Hong Kong.

Although the scarce land resource and unlimited demand for space are unchangeable, the conditions of current land use can be improved and the associated problems can be solved by optimizing land use planning and management. To achieve these improvements, one effective way is to re-plan the land utilization within the whole territory. Even though most construction land has been occupied and on which buildings/infrastructure have been completed for years, growing land redevelopment/urban renewal projects could be guided by the new land use plans. Urban renewal is a significant contemporary issue in Hong Kong, with over 50 redevelopment projects having been announced by the Urban Renewal Authority (URA) of the Hong Kong Government. Under the situation of severe land shortage, urban renewal can be a means of providing more available land and improving the efficiency of land use (Wang et al., 2013). In addition, the housing price has risen dramatically in recent years in Hong Kong due mainly to the shortage of land supply (Planning Department, 2007). To reasonably increase the land supply is a crucial therapy to the symptom of high housing price by lowering the land price indirectly.

In the current planning practice, the decisions of land use planning are made heavily based on the subjective and qualitative judgments from planners. This situation leads to two main shortcomings. Firstly, the planning decisions may not be reasonable because of various subjective ideas proposed by different planners without a general model and an objective set of standards for decision-making. Secondly, planning is always a long decision-making process due to much coordination work among the different voices of decision-makers and stakeholders. Particularly, in urban renewal projects, site re-planning including land use re-allocation for the developed sites expects a shorter time to reduce the impacts on affected residents and to accelerate the pace of urban regeneration. Therefore, a general model or tool with a quantitative approach to supporting decision-making processes for improving the rationality and efficiency of land use planning is highly in need.

The power of GIS has been widely recognized in spatial planning which is to combine geospatial information in unique and efficient ways – by symbols or layers, and extract something new. GIS has powerful capacity and great potential to be used in supporting land use planning. For example, a GIS analysis may include the location of a highway intersection and the average number of vehicles that pass through the intersection throughout a day, and extract useful information for locating a business (Folger, 2009). The GIS technology has made it easier to create and implement models for solving actual problems in geographic space. “GIS tools help not only to process, analyze and combine spatial data, but also to organize and integrate spatial processes into huge systems that model the real world" (ESRI, 2000).

In order to make good use of the limited land resource and enhance the sustainability of land use, a GIS-based framework, including a quantitative model for supporting sustainable land use planning in urban renewal projects, is highly needed. With the support of this framework, a general method in aid of land use planning could be formed for land-use suitability analysis (LUSA) in urban developed areas and site selection of different land uses.

1.2 Research Scope

Land use planning, sustainability considerations, and GIS-based tools are three key elements in this research and cover a broad research area. However, this single research cannot touch everything within the wide-ranging topic. Therefore, the scope of this research is demarcated at the beginning of the thesis.

Sustainable land use planning is defined as an ideal planning concept, which brings sustainability considerations (i.e. economic, social, and environmental needs) into the decision-making process of plans or arrangements of land resource. In the research, suitable land use is regarded as the premise of sustainable land use, and suitability analysis of land use becomes the basis of sustainable land use planning. Because of the growing urban renewal projects in recent years, land use planning for urban renewal becomes increasingly significant. To expand the study on sustainable land use planning, the way to sustainable land use planning for urban renewal is the niche of this research.

Although political system has great impact on land use planning in a city, but it is not the focus of this research. For an academic study can hardly affect the planning implementation through changing relevant political system, the research just focuses on the planning system itself. In view of the nature of planning (i.e. subjective judgments oriented), some factors extremely determining land use planning, such as prohibitions by law, political needs were not quantitatively examined in the framework for this research just aims to support land use planning with quantitative and objective LUSA, rather than changing the current mechanism (i.e. letting quantitative analyses replace qualitative and subjective decisions by planners).

Geographic information systems (GIS) technology is just used as a tool to facilitate the process of required information acquisition in land use planning. The aim of this research is to discover a possible way to solve a planning issue, and how to improve the efficiency and accuracy of geospatial data processing is another separate research in GIS field.

1.3 Research Question and Objectives

This research has comprehensively reviewed the literature regarding sustainable land use planning, and specifically focused on planning support systems (PSS) as well as land-use suitability analysis/assessment (LUSA). Three gaps in the scope of the existing research are identified as follows:

1. A set of criteria/factors for quantifying and measuring sustainability of land use planning has yet to be fully identified;

2. A framework/approach as a prototype of PSS or similar tools with an easy-to-understand rationale and adequate communication with the users during the PSS development needs to be developed;
3. A general list of criteria for assessing land suitability of urban land uses has yet to be developed, and small-scale (street/site level) land suitability analysis does not gain enough attention.

1.3.1 Research Question

Based on the research motivation described in the research background, this research puts forward and aims to address a research question:

Can a GIS-based framework consisting of a planning support model and a land information database support sustainable land use planning at the site level in urban renewal projects?

The proposed framework consists of a planning support model for LUSA and a procedure for developing the associated land information database established by GIS technology. The word "collaborative" means that the framework can serve not only for planners' decision-making, but also for public consultation by facilitating the other stakeholders to get familiar with the planning considerations from the point of view of the planners and participate in the planning processes. "Sustainable" requests a balanced development taking into account economic growth, social stability, and environmental protection together. Land use planning at the site level specially refers to site planning, i.e. a small-scale land use planning. Urban developed areas mean elder urban areas which have been developed for many years, where urban renewal projects often take place.

1.3.2 Research Aim and Objectives

In accordance with the research question above, the aim of this research is specified as:

To investigate whether a GIS-based framework consisting of a planning support model and a land information database can support sustainable land use planning at the site level in urban renewal projects.

Specifically, four research objectives are designed to achieve the aim as follows:

1. To identify criteria from economic, social and environmental perspectives for measuring the sustainability of land-use decisions in site planning (corresponding to Gap 1);
2. To develop a general list of criteria (including the sustainability criteria) for land suitability assessment at the site level by identifying planning factors affecting land-use decision-making in site planning (corresponding to Gap 3);
3. To conceptualize and develop a GIS-based framework as a prototype of PSS with an explicit rationale and adequate communication with planning practitioners for supporting the decision-making process of land use planning in urban renewal projects (corresponding to Gap 2 and Gap 3);
4. To test the viability of this framework and validate its effectiveness in supporting the planning process.

1.4 The Research Process

To investigate the research question and achieve the specific research objectives, a complete research process of this thesis is designed as Figure 1.1 shows. There are three phases in the research process: Research proposition, framework development, and framework validation. In Phase 1, research question and specific objectives are proposed based on comprehensive literature review and document analysis.

Phase 2 contains two processes of framework development: structure of the framework and development of the framework (through a case study). In the first process, tentative criteria often considered in the planning process and their supporting data sources were identified on the basis of in-depth literature review and document analysis. In the second process, the framework was practically developed through conducting a case study. A real urban developed area was studied to illustrate the process of framework development. In the case study, several expert interviews and one focus group meeting were used to determine the criteria, weightings, and rating standards. Meanwhile, required data were collected, processed and analyzed to establish a supporting database for the model use. The framework was further developed according to the steps and criteria described in the structure of the framework, and the detailed process of development of the framework (i.e. the case study) is elaborated in Chapter 6.

Phase 3 is the stage of research validation. An experimental study and a focus group meeting were employed to test the performance of the proposed framework in this phase, and survey method was used in both of them to mainly provide quantitative results for more convincing validation. The details are discussed in Chapter 7.

The specific research methods adopted during the whole process can be found in Chapter 4. In addition, land-use suitability assessment is the core part of the planning support model in the research, so that the model building can be basically regarded as evaluation research.

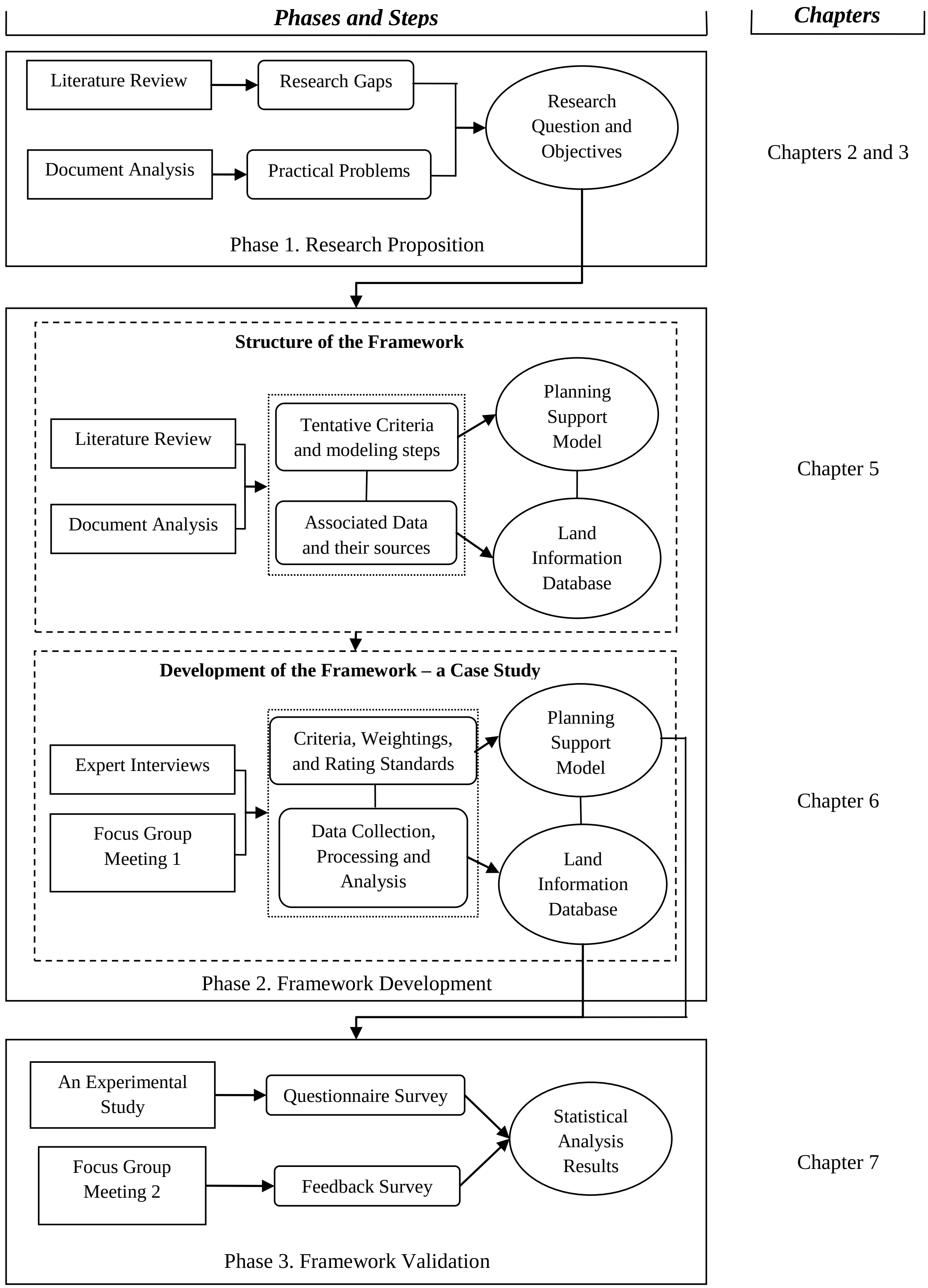


Figure 1.1 Research process of the thesis

1.5 Structure of the Thesis

The dissertation is organized into eight chapters. Chapter 1 introduces the research background, research scope, and research question to be investigated in this research, and addresses specific research objectives as well as the research process. Finally, thesis structure is also given.

Chapter 2 provides a comprehensive review on the whole research picture - sustainable land use planning covering several keywords: sustainable land use, urban land use planning, urban renewal (urban developed areas). The review involves a mass of literature on land use studies from two perspectives: theoretical development and technological application, and emphasizes the existing work in planning support systems and land use suitability analysis. Based on the overview of existing literature related to the research topic, research trends and gaps are discussed and identified.

Chapter 3 reviews the literature and governmental documents regarding land utilization and urban renewal in Hong Kong to address land use problems in the local practice. It discusses land demand and supply from internal driving forces and specific solutions, and analyzes the mechanism of land use allocation from two perspectives: land management and land use planning, as well as the current urban renewal strategy. Finally, problems in current land use practice are indicated based on the above discussions to identify the problem(s) to be solved or mitigated in this research.

Chapter 4 narrates the methodological strategy of the research and explains why particular research methods were adopted. The research methods include document analysis, expert interview, focus group meeting, case study, experimental study, and questionnaire survey. These methods are properly devised and used to achieve the four research objectives identified in Section 1.3.2.

Chapter 5 conceptualizes the structure of the framework for supporting sustainable land use planning (site-level). It explains why needs the framework again, and discusses sustainability issues in planning. Two major components of the framework: planning support model for LUSA and the associated land information database are described in detail about the steps of the development of them, in which the general criteria for sustainable site planning and the detailed information involved in the database are sorted and identified.

Chapter 6 illustrates the development process of the framework using a case study, and discusses the potential outcomes (including features) of the framework. Specifically, it introduces an overview of the case study, and demonstrates the detailed processes and workflows of developing the model and establishing the associated database. The semi-results of land-use suitability analysis (i.e. suitability maps) based on the available criteria are also presented.

Chapter 7 describes the stage of framework validation. Two experimental studies, a comparative experiment and a focus group meeting are conducted to test a hypothesis about the performance of the PSS-supported process (PSS-SP) based on the framework, followed by questionnaire surveys to collect the feedback of the participants. In addition to testing the hypothesis, the advantages and shortcomings of PSS-SP are also recognized from the surveys.

Chapter 8 concludes the thesis and summarizes the major research findings. In this chapter, the contributions of the research are highlighted, and the limitations are explained. Finally, the recommendations for further research are also suggested.

1.6 Summary of the Chapter

This chapter describes why and how to conduct this research. In the beginning, research background and scope are introduced. Then, research question and objectives are presented, followed by the process of this research. The structure of the thesis is also outlined.

Chapter 2 Land Use Planning in Urban Developed Areas

2.1 Introduction

Urban land use (ULU) is not an unfamiliar topic today. Because of the rapid urbanization process and urban expansion, land use has become a prominent and practical issue with increasing concern. The growing concern of sustainable development has led to a new challenge – what is sustainable urban land use and how to make land use plans appropriate, in particular, for land rezoning/redevelopment in urban renewal? Reviewing and summarizing the relevant existing literature helps solve such a puzzle. By far, a comprehensive review of the theme can hardly be found for the research scope is so broad and the existing literature is dispersed in this field.

To bridge this gap, this chapter provides a comprehensive review of existing research works on sustainable ULU from two major perspectives: theoretical development and technological applications. Specifically, an in-depth review is also given towards GIS-based planning support systems (PSS) and land-use suitability analysis (LUSA) with objectives of urban renewal/revitalization (sustainability considerations). The successes and shortcomings of current research in this broad area are analyzed, and the future directions or new research trends in ULU as well as PSS are provided. Finally, the research gaps to be filled are identified.

2.2 Related Definitions

For all studies, the first step is to identify the clear definitions of the research contents. In other words, it can hardly be a good study if the fundamental definitions are not identified at the beginning of the research process. Regarding ULU studies, some key terms need to be defined here.

2.2.1 Urban Land Use

Land use is a highly complex issue. It contains not only physical external patterns, but also socio-economic internal relationships. It means that the studies on land use should be focused both on land cover utilization and potential driving forces. According to Dale (2000), land use is defined as the purpose to which land is put by humans (e.g. protected areas, forestry for timber products, plantations, row-crop agriculture, pastures, or human settlements). And he also defined the land-use dynamics as the changes in patterns of land use over time. These changes were strongly influenced by population density, the infrastructure that humans established, and many aspects of lifestyle and standards of living. In addition, Cai (2001) believed that land use reflected the most direct and close relationships of mutual influence and interactions between human and nature. In planning a development, land use is the major concern of any activities involved.

Furthermore, land use has different levels, for example, global level, national level, regional level, local level, and more detailed levels. In this research, land use is discussed at the local/site level. Thinh et al. (2002) provided a definition of urban land-use structure (urban form) that is a framework of spatial relations between lands with differing uses. Therefore, urban land use can be defined as the arrangement or configuration of land resource with different utilizations according to the need of urban development within the urban boundary.

2.2.2 Sustainable Land Use

Nowadays, sustainable development becomes one of the hottest spots in academic world. Due to the excessive exploitation to natural resources, the world needs a strategy imbedded with "sustainable development" principles to ensure the normal demand of future development. The concept of sustainable development was initially proposed at the United Nations Conference on the Human and Environment in 1972, further developed by Bruntland Report named 'Our Common Future' in 1987 and the Rio Conference (United Nations Conference on Environment and Development) in 1992 (Shen et al., 2009). The United Nations World Commission on Environment and Development defines sustainable development as *meeting the needs of the present without compromising the ability of future generations to meet their own needs* (Yaakup et al., 2005). As a result of the political agenda of sustainable development, the significance and approaches to sustainable development have been extensively discussed in international literature (Breheny, 1992; Campbell, 1996; Fearnside, 1997; Bruff and Wood, 2000; Thinh et al., 2002; Du et al., 2006; Chan and Lee, 2008a; Li and Liu, 2008; Fischer and Amekudzi, 2011). In short, sustainable development requires us to take into account the social, environmental and economic consequences of our actions both at present and for future generations.

In terms of sustainable land use, Li and Liu (2008) claimed that sustainable land use should coordinate the land-use demand from multiple aspects and different interest groups, and a useful tool can be provided to alleviate land-use conflicts. The sustainability of land use implies not only the sustainability of land use model and biological production on the temporal scale, but also includes the optimization of land use patterns on the spatial scale (Peng et al., 2007). In this specific field – ULU in developed areas, the sustainability of land use can be reflected in the sustained capacity of supporting the urban future development with a comprehensive consideration in economic, social and environmental aspects.

2.2.3 Urban Renewal (Urban Developed Areas)

Urban renewal/urban redevelopment/urban revitalization is commonly adopted to deal with urban decay and change deteriorated built environment to meet current demand or better usage. Actually, the terms mentioned above have a similar meaning and are collectively referred to as ‘urban renewal’. It can be regarded as a process involving “physical change, or change in the intensity of use of land and buildings” stemming from the “social, economic and environmental forces” imposed on the urban areas (Couch, 1990). Urban renewal is a useful tool to cope with changing urban environment, aiming at meeting various social and economic objectives through regenerating the existing built environment.

Urban developed areas refer to built-up areas/districts where infrastructure such as road, water and electricity supply, and other service facilities have been established within the city boundaries. They usually situate in the central city, or the downtown of cities. In these urban areas, probably, many old buildings need to be redeveloped or revitalized for they are old and lack of maintenance.

2.3 Theories and Technologies in Land Use Studies

During the past decades, several classical theories such as land use pattern (urban form), land use planning, and land carrying capacity (urban ecology) have been developed in the field of land use studies as well as urban studies (Alberti, 2005). At the same time, based on the theoretical development in this area, some technologies are created and applied to the related research and practice. For example, land-use simulation models, planning support systems and land-use suitability assessment. Their involvement in land use studies makes a great contribution to the integration of theories with applications.

2.3.1 The Development of Major Theories

2.3.1.1 Land Use Pattern

Urban form is mainly formed by its land use pattern. As a result of this fact, the intangible land use mechanism could be investigated through looking into visible urban development forms. In other words, there is a close relationship between urban form and land use pattern. Many researchers have conducted their research focusing on the urban form or land use pattern to explore what sustainable land use is. Henderso (1974) emphasized his investigation on the size and types of cities, and attempted to give a reasonable urban size or type with high sustainability. Breheny (1992) presented a review paper on the contradiction inherent in compact cities, and deeply analyzed the close relationship between urban form and sustainable development. Welbank (1996) made a further search for a sustainable urban form, and thought that the compact city can be a sustainable form. Kombe (2005) paid attention to land use dynamics and its implications on the urban growth and form. Pichler-Milanović (2007) sought to understand recent trends in urban sprawl in European urban regions and examine the sustainability of cultures of urbanism or anti-urbanism and the hybrid landscapes.

In addition, land use and land cover change (LUCC) is another specific research interest which has been investigated by many geographers since 1995, for its starting point is interactive mechanism analysis on human driving forces – land use/cover changes – environmental responses (Chen et al., 2003). Weng (2002) analyzed land use changes using the techniques of GIS and remote sensing (RS) in the Zhujiang Delta of China. Deal and Schunk (2004) focused on the theoretical underpinnings and the practical application of spatial dynamic modeling and urban land-use transformation, and applied real cases to the cost assessment of urban sprawl in Kane County. Herold et al. (2005) developed a framework combining spatial metrics with RS to improve the analysis and modeling of urban growth and land use change. Perry and Enright (2006) reviewed the methods and applications of spatial modeling of dynamic vegetation change. Especially, an analysis on spatial and temporal changes of land use and land cover patterns in response to urbanization was conducted in a typical mountain forest area in Kastamonu, the western part of Turkey (Turan et al., 2010).

2.3.1.2 Land Use Planning

Urban land use planning controls urban future land-use development to a large extent. As a major part of urban planning, *land use planning is the systematic assessment of land and water potential, alternatives for land use and economic and social conditions in order to select and adopt the best land-use options* (FAO, 1993). Therefore, in order to achieve sustainable land use, in-depth studies on urban land use planning are necessary.

Urban planning has a long history, and the theory of urban planning should be discussed prior to urban land use planning. In the first half of the 19^{th} century, the theory of modern urban planning arose from western countries. From then on, many famous urban planners made contributions to the development of urban planning, such as Utopian Socialism by Moore, Garden City by Howard, and Modernist City by Le Corbusier. Because of the rapid urbanization and economic growth, urban planning is becoming increasingly complicated due to the increasingly complex urban system. From the classical economy-based planning theories such as concentric circles, sectors and growth poles to the environment-oriented urban sustainable development strategies, the theories of urban planning have experienced a series of changes (Burrows, 1980; Parr, 1999; Jepson, 2001; Markusen and Gadwa, 2010).

After a brief retrospect of urban planning theories, the focus should be switched back to urban land use planning. Since urban land is the carrier of all activities taking place within cities, many theoretical research studies have been conducted in this specific field. Bruff and Wood (2000) investigated the contribution of land use planning to modern local governments. Land suitability analysis has been emphasized as a useful tool to provide a suitable land use distribution for comprehensive urban planning (Collins et al., 2001; Joerin et al., 2001; Forster et al., 2008; Pourebrahim et al., 2011). In addition, the reasonable prediction for future demand of urban development such as population projection, proportion of occupation, and land-use demand is important for practical land use planning. Some urban scholars dedicated to improving the forecast techniques of urban future demand for better land use planning (Stephenson et al., 2003; Chi, 2009; Adam and Fritzsche, 2012).

2.3.1.3 Land Carrying Capacity

The research on land carrying capacity initially launched in the middle of the 20th century, however, the concept of urban land carrying capacity was formed later than the related studies (Yang et al., 2010). Waddell (2000) gave a descriptive interpretation on the concept: land carrying capacity can be regarded as the capability of land supply to supporting the required types and quantity of land development and human behaviors on the land. In addition, carrying capacity studies on urban land is just one specific part in the studies of land carrying capacity. Due to the complexity of urban systems, urban land aims to support more socio-economic activities such as large-scale constructions, public facilities, and infrastructure than suburban land. So far, a consensus concerning the definition of urban land carrying capacity has not been reached yet (Yang et al., 2010).

Urban scientists have conducted relevant research on land carrying capacity from different perspectives to improve the sustainability of urban land use. Fearnside (1997) estimated the human carrying capacity to recognize and think over the limits of carrying capacity in Brazilian Amazonia, and set the estimated results as a basis of land-use sustainable development. A typical research study aiming at developing an integrated framework for assessing urban carrying capacity was conducted to determine development density based on existing infrastructure and land use (Oh et al., 2005). Another study focused on the concept of physical carrying capacity, and developed a set of indicators including different elements in coastal areas, such as beach stability, coastal morpho-dynamics, land uses and land use changes, urban sprawl, beach quality, and landscape richness for the assessment of physical carrying capacity (Tejada et al., 2009). Furthermore, many scholars have paid attention to the urban land carrying capacity from a perspective of environment or ecology. Some of them applied the approach named 'ecological footprint' to evaluate the sustainability of land carrying capacity through assessing the ecological impact on the urban ecosystem (Rees and Wackernagel, 1996; Du et al., 2006). And some of them emphasized other broad aspects, such as the relationship between urban patterns and environmental performance, the effects of urban patterns on the function of ecosystem, the environmental carrying capacity of cities as well as evaluation and planning of urban green space (Alberti, 1999a; Alberti, 2005; Zhang et al., 2007; He et al., 2008; Liu and Borthwick, 2011).

2.3.2 The Application of Major Technologies

2.3.2.1 Land-use Simulation Models

As a recognized research frontier in urban studies, urban simulation has attracted most researchers' attention since it came out. The simulation model is a useful and advanced tool which can tell people what will happen and what will probably be in the future according to the current development trends or some specific control rules to help us observe, predict and manage our living surroundings. Wegener (1994) summarized the research progress of various simulation models which were used in urban studies, and defined a framework for urban modeling process. According to his review, in the late 1980s and early 1990s, there were mainly twenty active urban modeling centers all over the world. Afterwards, more pioneer researchers have shown their interests in urban simulation models in recent decades. In view of the diversity of research targets, some modelers wanted to simulate the future urban sprawl through understanding the dynamics of urban growth (Batty et al., 1999; Andersson et al., 2002; Fang et al., 2005; Vimal et al., 2012). Some of them paid more attention to urban environmental problems and conditions of urban ecosystem, aiming to improve the sustainability of urban development with the considerations on environmental protection via the urban ecological simulation models (Alberti, 1999b; Deal, 2001). There were also other modelers who built the simulation models to solve the problems generated in the process of urban development from other points of view such as modeling theories, economic models, and social impacts (Waddell, 2000; Guhathakurta, 2002; Hong et al., 2009). In terms of modeling tools, a number of well-verified algorithms or computer-based approaches have been used in urban simulation modeling, such as system dynamics (SD) (Forrester and Collins, 1969), cellular automata (CA) (Batty, 1997) and multi-agent systems (MAS) (Parker et al., 2003).

As the carrier of urban development, studies on urban land cannot get rid of simulation models. Instead, land use is the focus of urban modeling. Almost all urban models are related to urban land use, and the land-use transportation models can be the main body of land use models (Putman, 1975; Chang, 2006). Some modelers put their emphases on modeling the land use and transportation systems for urban simulation and monitoring (Waddell, 2002; Iacono et al., 2008; Bartholomew and Ewing, 2009; Campo, 2009). And others were interested in simulating the urban land-use change and evolution using GIS technique for visualizing the future land-use scenarios (Landis, 1995; Weng, 2002;

Pauleit et al., 2005; Svoray et al., 2005; Yang et al., 2008; Petrov et al., 2009; Irwin, 2010). In addition, some innovative modelers have switched their attentions to the application of new modeling tools, rather than being limited in an old modeling routine. In addition to the economic or policy-impact models of urban land use (Irwin and Geoghegan, 2001) and system dynamics models of urban land development simulation (Deng et al., 2008; Shen et al., 2009), the micro-simulation approaches have been widely used in urban land-use simulation (Waddell et al., 2003; Miller et al., 2004), such as the approaches of CA and MAS (Gruner, 2010; Haase et al., 2012). Particularly, combining with the visualization and spatial analysis tool – GIS, the CA and MAS models of urban land-use simulation have been popularly developed in recent years (Wu, 1996; Batty et al., 1999; Li and Yeh, 2000; Li and Yeh, 2002; Lau and Kam, 2005; Ligtenberg et al., 2001; Liu et al., 2006; Arentze et al., 2010).

2.3.2.2 Planning Support Systems (PSS)

The increasingly complex urban system and intricate interactions among urban residents make urban planning much more difficult than ever before. Owing to a large amount of spatial data involved in the process of urban planning (Brail, 1990), urban planners often encountered such a dilemma which was lack of effective and efficient measures to meet the growing technical requirements (Cheng et al., 2006). Thanks to the rapid development of computer and information technology as well as geospatial techniques, computer-aided approaches (i.e. PSS) with GIS spatial visualization and analysis have been developed. However, they have been applied slowly to real planning problems (Klosterman, 2005). Since the emergence of PSS for urban planning, they have been regarded as a sort of potential and promising tools in improving urban planning.

Nevertheless, most of them are at a laboratory stage and hardly used in planning practice (Vonk et al., 2007). The What if? could be considered as one of the most successful toolkits of PSS, including the functions of geospatial visualization, collaborative decision-making and scenario-based analysis (Klosterman, 1999b). Currently, scenario planning is a common tool used for dealing with uncertainties in rapidly changing situations (Pearson et al., 2010). As a result, some applied research projects were carried out to generate future scenarios for supporting urban land use planning based on the framework of software What if? (Pettit and Pullar, 2004; Pettit, 2005; McColl and Aggett, 2007). Apart from the software, other GIS-based PSS or models such as CommunityViz (Kwartler and Bernard, 2001), SLEUTH (Silva and Clarke, 2002), and UrbanSim (Waddell, 2002), were also developed to support urban land use planning and decision-making (Recatalá et al., 2000; Wang and Zou, 2010; Arciniegas and Janssen, 2012).

Since public participation and collaborative decision-making became the two necessities in urban land use planning, they have been noticed by urban planners for years. Public participation is very important to the success of a planning project, since any urban planning project will ultimately become part of the everyday life of the public (Wu et al., 2010). Several approaches recognized within participatory planning are effective in improving the participatory process, such as public surveys and participatory workshops combining with the use of support tools including cognitive mapping, statistical analysis, and suitability modeling (Golobic and Marusic, 2007). In order to achieve more reasonable and convincing decisions in urban land use planning, a collaborative expert system (ES) or knowledge-based system (KBS) should be one part of PSS to bringing the collaborative decision support from experts or experience for assisting the planning process (Alshuwaikhat and Nkwenti, 2002; Witlox, 2005; Garrido-Baserba et al., 2012). An in-depth review on PSS is given in Section 2.4, and the improvement in PSS accomplished by this research is explained in Section 2.6.2.

2.3.2.3 Urban Sustainability/Land-use Suitability Assessment

In line with the people's growing concern on sustainable development, the assessment of sustainability in urban development and urban land use is becoming a popular research direction in urban studies. At the beginning of the 21st century, urban scholars started to study the sustainability of urban system intensively. Ravetz (2000) looked at how to appraise the sustainability of a city, a region, a policy, or a program, and outlined a conceptual framework and a practical tool for the effective appraisal based on an integrated assessment (IA) approach. From the viewpoint of an experienced planner, Jepson (2001) provided an introduction to the sustainability framework in terms of its scientific basis and cultural interpretations, and identified conceptual associations that tend to tie it to the planning profession. Barredo and Demicheli (2003) investigated the urban sustainability in African countries by modeling and simulating future urban growth in these cities.

Narrowing the sustainability assessment down to urban land use, there is also much tentative research conducted in accordance with different objectives. Some appraisers put their attentions on sustainability assessment of urban land from a certain perspective, for example, theory and methodology of indicator system for sustainable land use (Fu et al., 1997), urban land-use structures (Thinh et al., 2002), urban land use and transport policies (Campo, 2009). Incorporating with the approaches of multi-criterion evaluation (MCE) and analytic hierarchy process (AHP), other appraisers paid attention to a comprehensive evaluation for the sustainability of urban land resource within the whole urban area (Banai, 2005). Meanwhile, some researchers focused their work on the suitability analysis of urban land use with the inspiration from the suitability assessment for agricultural land (Bojo ŕquez-Tapia et al., 2001; Dai et al., 2001; Malczewski, 2004; Aly et al., 2005; Malczewski, 2006b; Taleai et al., 2007), and land-use suitability assessment could also be a tool in assisting the site selection for specific land development (Jankowski and Richard, 1994; Zucca et al., 2008; Nas et al., 2010; Vasiljevic et al., 2012). An in-depth review on land-use suitability analysis/assessment is presented in Section 2.5.1, and the differences between the existing literature on LUSA and the work done by this research are discussed in Section 2.6.2.

2.4 Overview of PSS for Land Use Planning

2.4.1 Definition of PSS

Planning support systems (PSS) are a set of innovative tools which can assist the urban planners in foreseeing the potential scenarios of land utilization in future and make a better land use plan. So far, there have been several main definitions given by different scholars in this area. According to Batty (1995) and Klosterman (1997), PSS were regarded as relatively new phenomena, which emerged in the planning field in the mid-1990s as geo-information technologies were gradually utilized to support and improve the performance of specific planning tasks. In a sense, they have something to do with GIS, but the latter are general tools for capturing, storing, manipulating, analyzing and displaying geospatial data, which are applicable to various spatially-related problems. The PSS distinguish themselves by being focused on supporting specific planning tasks. In many cases, a PSS included a GIS, especially when geospatial data were required in the task. They were also related to spatial decision support systems (SDSS), although the former generally laid emphasis on long-range problems and strategic issues, while SDSS were commonly designed to support short-term policy making which involved individuals or business organizations (Clarke, 1990). *PSS are usually comprised of planning-related theory, data, information, knowledge, methods and instruments that take the form of an integrated framework with a shared graphic user interface* (Geertman and Stillwell, 2003).

Harris and Batty (1993) are recognized as the pioneers to associate the concept of PSS with a series of computer-based methods and models into an integrated system, used to support a particular planning function. In their opinion, a single PSS formed the framework in which three components were integrated: 'the specification of planning tasks and problems at hand, including the data assembly; the systematic models and methods that optimize the planning process through analysis, prediction and prescription; and the transformation of raw data into useful information which, in turn, provides the driving force for modeling and design'. Similarly, Klosterman (1997; 1999a) and Brail and Klosterman (2001) described PSS as a kind of information technologies that were used specifically by planners to undertake their unique professional missions. They indicated that PSS had evolved into frameworks of integrated systems of information and software that synthesize the three components of traditional decision support systems: information, models, and visualization, and deliver them into the public. At the earlier time, Batty (1995) suggested PSS to be a subset of geo-information technologies, dedicated to supporting those involved in practical planning to explore, represent, analyze, visualize, predict, prescribe, design, implement, monitor and discuss the issues associated with the need to plan. Geertman and Stillwell (2003) considered PSS to be geo-information technology-based instruments that incorporate a set of components (theories, data, information, knowledge, methods, tools, meta-information) which collectively support specific parts of a unique professional planning task. Brail (cited in Batty, 2005), specifically, paid attention to the fact that many PSS are developed to provide predictions of probable scenarios in the future or may involve estimations of the impacts that result from different patterns of development.

In a word, these kaleidoscopic reviews from different researchers indicate that there is no uniform definition of PSS so far. However, a further conclusion made by Klosterman and Pettit (2005) proves that "all definitions coincidentally tend to include or mention the same kind of required functionalities which are implemented in the supporting instruments". Many observers also regard PSS as capable of improving the handling of knowledge and information in the process of land use planning, and a great potential in providing assistance to those involved in dealing with the increasingly complex planning tasks in practice.

2.4.2 Components of PSS

The components of PSS represent the major theories and technologies applied to building PSS, such as related planning theories, GIS, and decision support systems (DSS) technologies.

Usually, a PSS is a combination of planning theories, GIS technology and computer-based DSS. Therefore, the improvement of PSS can be prompted by the respective development in these three aspects. The details include 1) the relevant theories and principles on urban planning or land use planning are the theoretical basis for building the planning support tools; 2) GIS technology facilitates the functions of geospatial analysis and visualization in the tools; and 3) computer-based DSS provide the main skeleton of the PSS for supporting the decision-making process of urban (land use) planning. In addition, the development of PSS has different characteristics in different times. In the middle of the 20th century, due to the increasing complexity of urban planning, people tended to seek a computer-aided method for more efficient and accurate decision-making process via computer technology. At that time, a PSS mainly looked like a DSS without geospatial visualization. Afterwards, from about the 1980s, geographic information technology was applied to the support systems when the Geographic Information Science was established. With the help of the geo-information processing ability of GIS, PSS can now visually and effectively support specific tasks of planning through geospatial data collection, analysis and display. PSS realize a transformation from non-spatial support, such as ordinary Expert Systems to spatial support with geographic visualization. This great progress opens a new page in the history of planning support tools.

2.4.2.1 Theory of Land Use Planning

Land use planning is a term used for an administrative and statutory activity which seeks to regulate and order the land utilization in an efficient and appropriate way, thus avoiding land use conflicts. The 'Canadian Institute of Planners' offered a definition of land use planning: *the scientific, aesthetic, and orderly disposition of land, resources, facilities and services with a view to securing the physical, economic and social efficiency, health and well-being of urban and rural communities* (CIP, 2010). According to another similar definition by Wang (2006), urban land use planning is a temporal-spatial plan or arrangement for the reasonable configuration and utilization of land resource in accordance with the social, economic and natural conditions within the urban area. The two definitions have the same principles and objectives of land use, and it is also indicated that land use planning can control and determine the future land utilization to a large extent in the planned areas.

Usually, local land use planning can be seen as a high-stake game of competition over a city's or region's future land-use pattern. In this game, land-use planners are central players and game managers as stewards of the public interest (Berke et al., 2006). Meanwhile, cities are highly complex systems due to all kinds of stakeholders and their activities involved in, such as all levels of governments, land developers, common residents, and also intensive money, material resources, manpower. These lead to the increasing complexity of urban planning or land use planning, and set a higher requirement for urban planners. Under such circumstances, an effective planner acts as a mediator to resolve all kinds of conflicts, a coalition builder to achieve multi-group benefits, and an advocate to advance the interests of underrepresented groups. The planners must be visionary thinkers who look beyond immediate concerns to the needs of future generations, and effective communicators of these visions of the future who inspire confidence in the reality of sustainable land use patterns (Berke et al., 2006).

Therefore, land use planning must be done by carefully watching, considering and responding to the interests, actions and alliances of other players.

In practice, the tasks of land use planning are confusing and frustrating even to experienced planners. It can be regarded as an arena or even ‘battlefield’ for different political groups such as central government, local governments, land developers and common residents to compete for their own interests. Rather than being an orderly and regular procedure of adopting land use plans derived from systematic studies aiming at certain major objectives and requirements, planning has become a special and complex process involving various requests and views from different interest groups and also uncertainties in reality. Therefore, theories of ideal urban form, urban economics, policy-intervention strategy and statistical modeling techniques taught in planning classes often carry less weight, in other words, they receive less attention than the actual demands or expectation of all parties in the process of land use planning practice. The land use planning and decision-making process can be treated as a high-stake contest with a series of requests to be taken into consideration over the future land use pattern in an area. However, the competitive process could be tempered by the presence of cooperation and collaboration amongst different players. In view of this reality, land use planning is a key and useful tool to coordinate community land utilization and development activities. Planning is not simply a process, but is a process guided by a plan (Berke et al., 2006). The plan fulfills many needs, from both traditional functions of guiding urban infrastructure and setting parameters for zoning and other land use regulations on private and public property, as well as the newer purposes with more collaboration and agreement amongst the different stakeholders.

Both the complexity and turbulence of land use planning pose a challenging decision-making environment to planners. At the same time, these characteristics offer an opportunity and incentive to build innovative and adaptive land use planning programs or systems, for example, PSS for land use planning. A conceptual framework of land use planning was formed by Berke et al. (2006) (Figure 2.1). This framework depicted relationships among land use values of different respective stakeholders, such that their planning schemes and outcomes constitute the game of land use planning. The emergence of the goal of sustainable community is also recognized as a new trend of considering the requirement of sustainable development. That goal aims to seek a sustainable land use pattern which can keep an appropriate balance among economic, social, environmental and livability values.

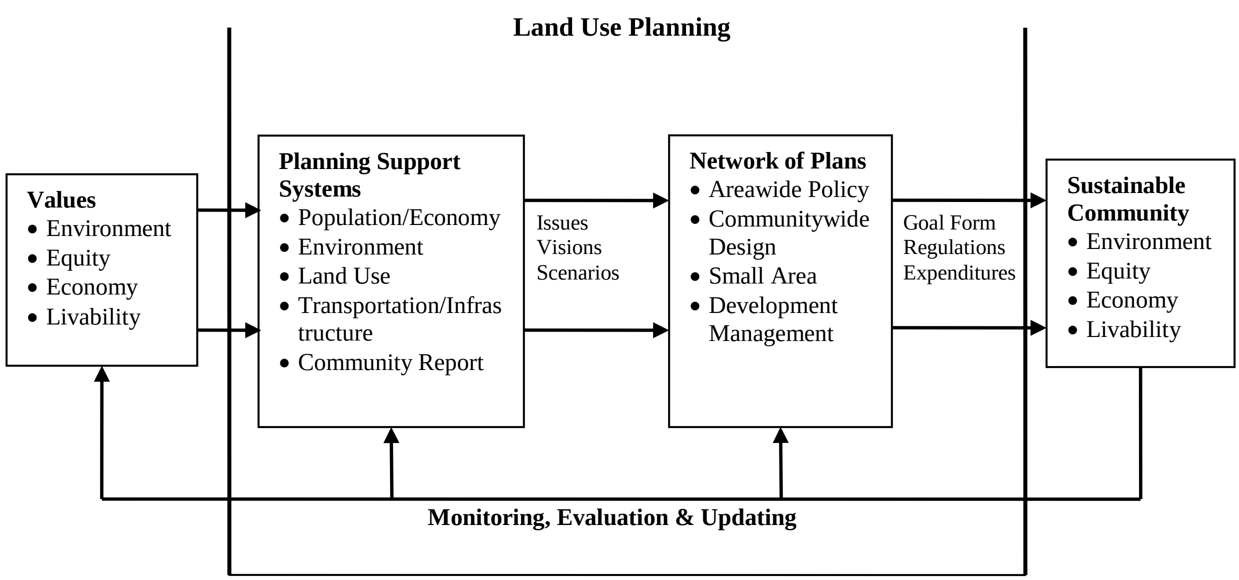


Figure 2.1 Conceptual framework of land use planning
(source: Berke et al., 2006)

2.4.2.2 Geographic Information Systems (GIS)

GIS are a set of tools or techniques which capture, store, analyze, manage and display spatial data that are related to location(s). Generally speaking, a GIS is a ‘compound’ which is the merging of cartography, statistical analysis, computation and database technology (Longley et al., 2001). Definitions of GIS were also given by some academics: “GIS are one kind of computer systems which are capable of capturing, storing, analyzing and displaying geographically referenced information — information attached to a location, such as latitude and longitude, or street location. The geographically referenced information is also known as geospatial information” (Folger, 2009). The geospatial information includes all kinds of geographic features such as road intersections, office buildings, rivers, railways, contour lines, or district boundaries. GIS are a kind of software that uses geographic (spatial) location as the organizing principle for collection, storage, analysis, and presentation of information in digital form. It began as a tool for planning, moved forward into engineering through computer aided drafting, and has rapidly developed into the best enterprise software available for management and decision support (NRC, 2003).

From the emergence of GIS theory to the present time, GIS have gradually been used in cartography, remote sensing, land surveying, public utility management, natural resource management, photogrammetry, geography, urban planning, emergency management, navigation, and localized search engines (Longley et al., 2001). In the past 30 years, GIS have developed rapidly, increasing its potential for effective use in both public and private sectors. In some developed countries, especially the U.S., GIS have been adopted as planning tools by the different governments for many years. However, GIS applications to urban simulation, urban planning practice, and the construction of geo-information infrastructure supporting urban and regional management are still at a relatively low level in most countries. In other words, although GIS was developed over three decades ago and has been recognized as an effective tool in geographic research area, these techniques were less applied to urban modeling and simulation due to insufficient technological interactions in the past two decades (Sui, 1998).

Some GIS products such as ArcGIS, MapInfo, SuperMap, adopt graphical manifestation of models (diagram toolbars), making it easy to create, edit and implement geoprocessing workflows. With the combination of global positioning system (GPS) and remote sensing (RS) technologies (GIS, GPS and RS are called '3S' as a rule), and also the internet, GIS technology – collection, processing, analysis and visualization of spatial data, will be better applied into practical land use planning, especially with the form of integrating into planning support instruments.

2.4.2.3 Spatial Decision Support Systems (SDSS)

SDSS are a kind of decision support systems (DSS) and they have been developing in accordance with the development of DSS. A DSS is *a computer-based information system which supports business or organizational decision-making activities* (Turban and Aronson, 2001). DSS serve the process of management, operation and planning, and help improve the planning level and make decisions, which may be rapidly changing without any rules and not easily specified in advance. Usually, DSS include knowledge-based systems. A well designed DSS is an interactive software-like system intending to help decision-makers compile useful information from a pool of raw data, relevant documents, personal knowledge, or business models to identify and resolve problems and finally make decisions (Turban and Aronson, 2001). Similarly, a SDSS is an interactive, computer-based system designed to support specified users in achieving a better and more effective decision-making while solving some problems at the spatial level (Sprague and Carlson, 1982). Sometimes, people consider the 'abbreviation' as the combination of the two typical components – GIS and DSS (i.e. GIS + DSS = SDSS).

In terms of SDSS for land use planning, they are designed to assist planners with guidance and reference in making land use decisions (Wang and Zou, 2010). For instance, when deciding where to build a new high-speed railway station, many criteria related to the location choice, such as noise and employment distributions, service radius, and surrounding impacts along the railways, make decision-making difficult and complicated. A SDSS tool which simulates varied scenarios based on different potential decisions can be used to help practitioners make better decisions. In some cases, especially in Europe, a SDSS can be treated as be equal to a PSS due to their similar functions in supporting decision-making with the powerful capability of spatial data processing and analysis. However, the two tools differ in three aspects (Long, 2007). Generally speaking, PSS are a kind of computer-based systems which are specially used for supporting the tasks related to planning, while a SDSS can be regarded as the technical frame of a PSS. In short, by solving the spatial problems based on the integrated expert knowledge and the ability for supporting spatial data, SDSS serves as the core processor in the decision-making process of these planning support instruments. Actually, the proposed framework in this research can also be considered as a SDSS in supporting land-use decision-making.

2.4.3 Applications of PSS

This part describes the variety of PSS applications not only to urban (land use) planning, but also to other specialized planning.

During the past 15 years, computer and GIS technologies have been both widely used in developing planning support tools, and several tight-coupled PSS software such as What if?, CommunityViz has been produced for planning support. It indicates that the advancement of planning support instruments is no longer represented by the computerizing techniques in terms of these tools development itself, but by some innovative technologies such as GIS spatial analysis and simulation models. These technological innovations are employed to tackle the practical planning problems and achieve goals in current planning processes. Examples include dynamic simulation for land use changes, real-life display for planning scenarios, and web-based public participation. On one hand, today's research on PSS focuses more on a series of specialized planning support tools to resolve the specific problems in urban or regional planning, for example, population and employment projection, land-use demand prediction, and alternative plans comparison. On the other hand, current PSS are prone to be used to assist all kinds of planning tasks, not only urban (land use) planning, but also specialized planning such as environmental planning, landscape planning, and redevelopment planning.

2.4.3.1 In Land Use Planning/Urban Planning

Planning support systems have increasingly drawn people's attention since they were brought about nearly two decades ago. These systems are developed to support, in an integrated form, the various planning-related tasks in the different stages of planning processes. Due to their planning-oriented nature, PSS have mostly been used in urban planning or land use planning. Generally, they provide a computer-based platform to apply land-use change or urban growth models to generate the scenarios of land use plans on the basis of a set of assumptions on future land use or urban development and policy choices in an area to be planned. Particularly, the systems are used to support interactive use of the models where users can change settings and possible future visions in the area can be shown correspondingly, rather than generating exact solutions to some existing problems and accurately predicting how a planned area should or will be. This so-called what-if analysis offers added value in particular in the systems where plan development is an outcome of a group planning process involving planners, local communities, and other possible stakeholders (Arentze et al., 2010). The above argument has also been widely supported in practice.

During the development of PSS, a large number of models for planning support purpose have been built and employed by planning academics and professionals. Meanwhile, a smaller number of commercial software or toolkits, serving as the planning support systems, have been developed and experimentally used, such as CommunityViz (http://www.communityviz.com), What if?™ (http://what-if-pss.com), SLEUTH (http://www.ncgia.ucsb.edu/projects/gig), UrbanSim (http://www.urbansim.org) and INDEX® (http://www.crit.com) (Klosterman and Pettit, 2005). Among them, What if? and CommunityViz are two well-known examples of PSS and can be regarded as the most successful computer-aided packages with potential practicality and effectiveness (Arentze et al., 2010). Some researchers working on urban planning have applied a toolkit – What if? into the studies on land use planning and assessment, land-use forecasting, evaluation of growth management strategies and scenarios of sustainable urban development (Pettit and Pullar, 2004; Pettit, 2005; Klosterman et al., 2006; Ludin and Yaakup, 2006; McColl and Aggett, 2007).

Many similar research studies have also been conducted by using other systems or models. For instance, Silva and Clarke (2002) were interested in the SLEUTH model (slope, land use, exclusion, urban extent, transportation and hill-shade), and calibrated the SLEUTH model by analyzing the simulation results of the urban growth model for two European cities. In order to solve land-use conflicts and environmental issues in the Valencian Mediterranean Region, Recatalá et al. (2000) applied the LUPIS system (Ive and Cocks, 1988; Ive, 1992) to generate alternative land-use plans by adjusting the relative importance given by multiple stakeholders to the preference and avoidance guidelines. They also found that, by using the LUPIS system, in a transparent and explicit way, the agreement between contending stakeholders as to how to develop areas of land suitable for competing land uses can be facilitated. Reginster and Rounsevell (2006) used a cellular automata (CA) based model (similar to White et al., 2004) to present the development of quantitative, spatially explicit, and alternative scenarios of future urban land use in Europe. In their paper, they identified and described the principal driving forces of the spatial pattern change that are specific to the European region and urban sectors on the basis of the theoretical principles of urban economy, and also suggested that 'scenario analysis is a useful tool for testing incentives, measures, or planning regulations according to different policy objectives'. Based on the above summary of related literature, new research trends in PSS for land use planning are deduced in Section 2.6.1.

In addition to the use of various planning support systems or models, the categorization of the typical PSS which have been developed for urban planning should also be discussed. According to the statement given by Klosterman and Pettit (2005), the systems or models can be categorized into two dimensions: 1) technique, the modeling approach that was used to develop the support systems; 2) task, the analytical task which the support systems help address. The details of the categorization are summarized in Table 2.1. The four modeling techniques are listed in the table by the time order in which they were applied to the field of planning. Taking the first modeling technique – Large-scale Urban Models for example, some research has been conducted by using the large-scale urban modeling and simulation methods integrated into those tools to assess the future outcomes of policy alternatives and guide future urban (land use) development (Deal and Pallathucheril, 2009; Nijs, 2009; Sudhira and Ramachandra, 2009), and Land-use/land-cover change has also been investigated and evaluated by adopting these planning support toolkits (Pettit and Wyatt, 2009). As the basis of spatial analysis models, geo-information databases are essential part of PSS and their integration with analysis models is a research hot spot in urban planning and management (Brail, 1990; 2008). In terms of 3D visualization, although a great deal of innovative work has been done in graphic visualization over the last decade (Batty et al., 2001; Langendorf, 2001; Pettit et al., 2004), the technology of 3D visualization is seldom incorporated into those PSS in practice. From the summary of the techniques and tasks associated with the typical PSS (Table 2.1), it is indicated that only one system supports 3D visualization, and recognized small-scale (site/street level) models are still rare.

Table 2.1 Categorization of typical planning support systems
(source: Klosterman and Pettit, 2005)

Technique	Task			
	Land-use/Land-Cover Change	Comprehensive Projection	3D Visualization	Impact Assessment
Large-scale Urban Models	METROPILUS	METROPILUS		
	SPARTACUS	SPARTACUS		
	TRANUS	TRANUS		
	URBANSIM	URBANSIM		
Rule-based Models	CUF	WHAT IF? 2.0	COMMUNITYVIZ	COMMUNITYVIZ
	WHAT IF? 1.1			INDEX®
				PLACE³S
State-change Models	CUF II			
	CURBA			
Cellular Automata Models	SLEUTH			
	DUEM			

Another function-dedicated classification was produced based on the function of a system with regard to handling information in the planning process. The six information-handling functions with their respective examples are listed in Table 2.2 (Vonk et al., 2007). In recent years, public participation has become a key requirement for urban planning. That is to say, a people-oriented development plan should reflect the adequate concern and viewpoints from the public sector. As a result, some researchers have attempted to include a collaborative way and integrate participatory techniques into the planning support tools to enhance public engagement in urban/land use planning and also develop more effective participation methods for this profession (Lieske et al., 2009; Miller et al., 2009; Kahila and Kyttä, 2009; Carver et al., 2009; Bourgoin et al., 2012).

Table 2.2 Function-based classification of PSS
(adapted from Vonk et al., 2007)

No.	Function	Example
1	Information Gathering	Traffic-monitoring systems
2	Information Storage and Retrieval	Geo-databases
3	Information Visualization	3D visualization kits
4	Information Communication (Collaboration between stakeholders)	Cognitive mapping systems, electronic brainstorming systems, electronic collaborative sketching systems
5	Information Analysis (To generate new information from existing information)	Multi-criterion analysis systems, statistical trend analysis systems
6	System Modeling (To simulate processes based on current information)	Land-use evolution models, physical process forecasting models

Note: the functions underlined are involved in the proposed framework.

PSS provide an environment in which land use models can be utilized to support the planning process. The effectiveness of these models is guaranteed by three essentials: an explicit representation of planning controls (defining what-if scenarios), short computation time (rapid feedback), and accuracy of predictions and solutions (quality of information).

2.4.3.2 In Other Specialized Planning

Planning support systems can also be used in other specialized planning such as solid waste planning, landscape planning, environmental planning, green space planning and tourism planning (MacDonald, 1996; Besio and Quadrelli, 2009; Pelizaro et al., 2009; Johnson and Sieber, 2009; Chrysochoou et al., 2012), rather than being limited in conventional urban or regional planning. Similar to the application of PSS in urban (land use) planning, in special areas, some new methods and technologies are also adopted in the specialized planning with PSS. For example, Simonovic and Bender (1996) introduced the concept of collaborative planning to water-resources planning, and indicated that a collaborative planning support system could integrate available computer technologies, together with modeling and analysis tools in a user-friendly environment. Shen and Kawakami (2005) studied the usable building space, which is the space generated according to the zone restrictions of a building implemented in a district plan. Gibin et al. (2009) described a successful geographic visualization tool which was implemented based on the framework of Google Maps application programming interface (API) for supporting public health service planning. Elsewhere, Schaller et al. (2009) focused their research on the development of GIS environmental modeling technology to provide new applications in the field of regional environmental planning and assessment. They have developed a series of new GIS software embedding effective tools and models for environmental planning and management over the past several years. Because of the increasing concern on habitat environment, PSS for specialized planning such as environmental planning and landscape planning become new research interests of some urbanists.

2.5 LUSA Linkage to Objectives of Urban Renewal

2.5.1 Overview of LUSA

LUSA is a tool used to identify the most suitable locations for future land use for specific purposes (Collins et al., 2001). It aims to comprehensively determine the most suitable pattern for future land use to meet the needs of land users (Malczewski, 2004). In a spatial planning process, identifying a suitable location for a specific future land use is a multi-objective decision task. Of course, it is difficult for planners to simultaneously consider several factors affecting land use selection. Currently, the relationship between land and other social or environmental factors has become more complicated in urban renewal projects. Taken together, the need for decision support in land use planning is clear.

Studies of LUSA have taken place since the second half of the 20th century (McDonald and Brown, 1984; Jankowski and Richard, 1994; Mendoza, 1997). These are based on the premise that LUSA is an appropriate means of quantifying land development constraints and opportunities, and is able to help in land use planning. For many, land-use suitability assessment is essentially a process involving multi-criteria decision analysis (MCDA). That is to say, LUSA is an evaluation/decision problem with multiple factors. According to Malczewski (2006a)'s survey of the literature relating to GIS-based multi-criterion decision analysis, GIS-MCDA approaches are the most popular in addressing land suitability problems. A general model of land/site suitability analysis is (McDonald and Brown, 1984; Mendoza, 1997)

$$S = F(x_1, x_2, \dots, x_n)$$

where S is suitability grade, F is rating function, and x_1, x_2, …, x_n are factors affecting the suitability of the land/site. As the equation suggests, LUSA also takes into account the different factors involved simultaneously in a standardized form.

With the widespread application of GIS technology and the development of multi-criterion analysis approaches, a great deal of research into LUSA has been conducted and much progress has been made over the last decade. A large percentage of land use suitability studies focus on agricultural land or meadowland in rural areas. Bojorquez-tapia et al. (2001) presented a GIS-based multivariate approach for land suitability assessment with a public participation base and identified nine environmental criteria for suitability assessment, including Brackish water, Distance to major roads, Distance to agriculture and cattle ranching land, Coastal lagoons, Mangrove, Deciduous forest and scrubland, Soil type, Flood prone zones and Riparian zones. Store and Kangas (2001) presented a GIS-based habitat suitability modeling method for improving habitat suitability evaluation in forest areas, providing seven habitat suitability criteria in terms of both vegetation and soil characteristics. Store (2009) extended this research to a more sustainable approach for promoting effective placement of different forest uses through the use of GIS tools and MCE methods. Burnside et al. (2002) developed a GIS-based habitat suitability model to support strategic landscape evaluation and to provide a method of identifying (most suitable) target sites for grassland restoration. Three topographic variables – Elevation, Slope and Aspect were assessed in the model. Similarly, Baja et al. (2002) introduced a GIS-based conceptual model for defining and assessing land management units from available biophysical information consisting of land suitability indices for a cropping land use type and soil loss indices of the land.

Ozcan et al. (2003) assessed land suitability for plantations according to climatic factors and soil characteristics, and monitored the spatial and temporal changes in land use types by using GIS. Samranpong et al. (2009) described a GIS-based system which supports the dynamic assessment of economic land suitability for major economic crops on the basis of a land evaluation of physical suitability and economic suitability. In addition, Cengiz and Akbulak (2009) used both the analytic hierarchy process (AHP) and GIS to make a LUSA for agriculture, meadow-pasture and forest alternative rural land uses, and determining three different sets of criteria for the three different land uses respectively. Bobade et al. (2010) carried out a land evaluation for agricultural planning based on soil survey data and GIS spatial analysis, generating suitability maps for agricultural land use according to the results of a soil-based land use suitability and fertility assessment. Jafari and Zaredar (2010) examined a relatively new method of MCE by using a spatial AHP method to determine the most suitable areas for rangelands, which involved 14 criteria, namely Erosion, Soil hydrology, Soil depth, Soil structure, Soil texture, Vegetation type, Vegetation density, Rainfall, Temperature, Slope, Elevation, Land use, Distance from population centers and Distance from surface water. The criteria were chosen for a comprehensive assessment from the perspective of environmental and economic land properties.

In addition to the suitability of agricultural land, the issue for other land uses and specific sites in urban areas has also been the subject of several studies. Dai et al. (2001) illustrated a GIS-aided geo-environmental evaluation for urban land use planning from the viewpoint of geological features of land. 13 factors for suitability evaluation - *Slope, Elevation, Surficial geology, Formation combination, Lithology of bearing layer, Depth* *to groundwater table, Corrosive potential of groundwater, Groundwater rise, Distance to debris flow, Distance to landsliding, Liquefaction potential and Distance to fault* were selected for high-rise buildings, multi-storey buildings, low-rise buildings, waste disposal and natural conservation urban land use categories. Aly et al. (2005) also considered suitability assessment for urban development from the perspective of engineering geology, by developing a GIS-based model that incorporates suitability factors such as *land use/cover, types of soil, Karst feature distribution, fracture densities, slopes, distances to major faults, streams and road network, and city boundaries*.

Different sets of criteria for suitability assessment were used according to the different land site uses. Joerin et al. (2001) described a decision support method for land use suitability assessment for housing by combining MCDA with GIS, identifying eight significant criteria. Gomes and Lins (2002) also applied the integration of GIS and MCDA methods to aid spatial decisions for municipal district evaluation in respect to quality of urban life. They defined 14 exclusion criteria for measuring the quality of urban life from the aspects of infrastructure, education, security, health and work. Yang et al. (2008) incorporated remote sensing, landscape ecological analysis and GIS into their land suitability modeling to develop a spatial analysis system for evaluating the suitability of urban expansion land. Eight factors were used, comprising *Surface water parameter, Normalized difference vegetation index (NDVI), Soil penetrability, Soil fertility, Slope, Foundation capacity, Resident land use information and Landscape value*. Dai et al. (2008) evaluated the suitability of industrial land use in the land use planning of industrial cities on the basis of ecological suitability evaluation, identifying seven factors: *Current land use, Slope, Distance to river, Density of green surface,* *Distribution of pollutant sources, Distance to road network and Distance to residential areas*. Wu et al. (2009) investigated urban land use patterns by modeling the spatial autocorrelation of land use types, with the purpose of deriving better spatial land use pattern on the basis of terrain characteristics and infrastructural conditions. In their study, the land uses were divided into four types - cultivated land, forest land, construction land and virgin land - and 12 driving factors, including *distance to town, distance to river, distance to road, population density, digital elevation model (DEM), slope and aspect to represent the geophysical and socio-economic conditions* involved.

In addition, land sites were subjected to suitability analysis by integrating GIS and MCDA/MCE for the selection of sites for waste landfills, parks and route selection (Jankowski and Richard, 1994; Zucca et al., 2008; Sharifi et al., 2009; Nas et al., 2010). The improvement/differences of the work focusing on LUSA presented in this research in comparison with the above work of others are clarified in Section 2.6.2.

2.5.2 Objectives of Urban Renewal (Sustainability Thinking)

Urban renewal or land redevelopment is one kind of resources re-use intrinsically reflecting sustainable development. In pace with the urban development and the increasing demands of living environment, the target of urban renewal has moved from oversimplified clearance of large-scale slums to improvement and rehabilitation of older areas (Couch, 1990). Housing improvement has become an element of urban renewal policy for several decades for improving sustainability of urban services development.

2.5.2.1 Economic Perspective

To discuss urban renewal processes with traditional economic theory, the general demand for buildings or land can be regarded as the derivative of the needs of producers and consumers for urban space and their payment ability for such space (Couch, 1990). From this viewpoint, internal mechanism and dynamics of urban space allocation can be examined based on economic concerns, such as the economic life of a building and the timing of redevelopment, the economics of urban vacant and derelict land, and the economics of urban regeneration. Regarding economic considerations of urban renewal in high-density cities, six factors affecting economic sustainability were identified by Lee and Chan (2008). They are Quality welfare planning and provisions, Conservation and preservation, Land strategic utilization, Community contributions, Integrated design, and Transport arrangement.

2.5.2.2 Social Perspective

The aims of urban renewal are ultimately to improve the environment of certain urban areas where people live densely and to bring about changes in the use of urban land and buildings. People are the principal concern of urban renewal and the outcomes of renewal projects serve mainly for living condition improvement. Therefore, the population trends, household structures, community and neighborhood changes, and social needs of certain vulnerable groups including women, minor races and the elderly often need to be discussed to examine the social impacts of urban renewal. As urban renewal projects take place in the older areas, the preservation of historical and cultural heritage is one of the greatest concerns in urban renewal/regeneration. In terms of social considerations of urban renewal, Lee and Chan (2008) recognized underlying factors such as Image building, Daily living provisions, and Open space design and provisions for looking into social sustainability of urban renewal projects. Six critical factors including Satisfaction of welfare requirements, Conservation of resources and surroundings, Creation of harmonious living environment, Provisions facilitating daily life operations, Form of development, and Availability of open space for improving social sustainability of urban renewal projects were also identified (Chan and Lee, 2008b).

2.5.2.3 Physical/Functional Perspective (Urban Design)

Urban renewal makes changes in the physical fabric of cities. These changes may make the city look better or worse and may make the urban function better or worse (Couch, 1990). Urban design plays an important role in both building and rebuilding urban environment. In terms of urban design in the built environment, two issues are often highlighted: aesthetical appearance of a city, and the efficiency of urban physical infrastructure. To explore the physical potential of existing buildings and areas, re-designing the city in urban renewal or rehabilitation is an effective tool. During the process of urban design, design guidance and development control including both physical criteria and visual criteria regulate the implementation of the design to ensure a more livable and ecological urban space. Chan and Lee (2008a) highlighted a list of urban design considerations contributing to sustainable development and identified key design factors improving economic sustainability of a special issue – urban renewal projects in Hong Kong.

By linking the multi-objective decision tool of LUSA to the specific objectives of urban renewal, a new approach can be developed to support the decision-making process of land use planning in urban renewal projects.

2.6 Research Trends and Gaps

2.6.1 Research Trends

Table 2.3 gives a summary of research frontiers in several areas. Because of the increasing demand of urban space and capacity, the concept of sustainable development will still serve for a guideline for the relevant studies in the near future. Specifically, urban land carrying capacity could be a hotspot for theoretical research with environmental concern in the coming years. In terms of technological applications, urban land-use simulation models are still a powerful and useful tool for land use planning and development through predicting the future land use development. Particularly, PSS for land use planning can be another research focus in the future. By using these computer-aided tools, different scenarios of future land use can be generated according to different planning policies, so that urban planners can be assisted in optimizing decision-making in the process of land use planning practice, particularly, land rezoning/redevelopment in urban renewal.

Table 2.3 Research hotspots in urban land use studies

Main Category	Sub-category	Research Hotspot
	Urban Form/Land Use Patterns	• Internal mechanism of urban sprawl; • Land use dynamics; • Spatial and temporal changes of land use and land cover;

Theoretical Development		(based on urban complex system)
	<u>Urban Land Use Planning</u>	• Overall <u>land-use suitability analysis for urban land</u>; • Land-use demand analysis; • Arts and culture in urban land use planning;
	Urban Land Carrying Capacity	• Up-to-date meanings of urban land carrying capacity; • Assessment of land carrying capacity using 'ecological footprint'; • Urban environmental carrying capacity/Urban ecosystem;
Technological Application	Urban Land-use Simulation Models	• Urban sprawl simulation; • GIS-based land-use evolution models; • Micro-simulation approaches (e.g. CA, MAS models);
	<u>Land-use Planning Support Systems (PSS)</u>	• <u>Integrated spatial database</u>; • Scenario-based PSS application; • <u>Approach of public participation</u>; • <u>Collaborative ES/KBS modules</u>;
	<u>Land-use Sustainability/Suitability Assessment</u>	• <u>Appraisal from economy, society and environment</u>; • <u>Evaluation system with MCE</u>; • <u>GIS-based suitability assessment of urban land use</u>.

Note: the items underlined are directly related to this research.

Many people regard PSS as valuable supporting tools which enable planners to better handle the complexity of planning processes, leading to a satisfactory situation in which plans are completed with better quality and saving time and resources. In this respect, it seems that a fresh, more positive view concerning PSS has emerged since the beginning of this century. Currently, much more attention is focused on planning support and its technological instruments than the case was in the past (Geertman and Stillwell, 2009). However, drawbacks of current PSS such as lack of design standards, weak proliferation capacity, and limited use in practice, indicate that their application is still in an early and exploratory stage (Vonk et al., 2007). In order to improve the situation, many researchers are dedicated to improve PSS development technologies, such as dynamic modeling technology, comprehensive geo-databases integration, 3D dynamic visualization, and collaborative channel for public participation, so that several new research trends in this area, for example, specialized PSS for LUSA serving for urban renewal projects are given (Table 2.4).

Table 2.4 New research trends in PSS

No.	New Trend	Example & Description
1	Dynamic scenario-generated PSS	CA, Agent-based modeling with GIS
2	Real-life visualization PSS	3D, Google Earth-combined display
3	Real-time user interactive PSS	Virtual city model with real-time data and mobile avatars
4	Collaborative PSS	Collaboration among stakeholders in planning processes
5	Public engagement PSS	Using Web-based technology for enhancing public participation
6	ArcGIS processing models for multiple spatial analysis	Modeling based on ModelBuilder application in "ArcGIS"
7	Environmental & landscape planning support tools	Developing PSS for specialized planning, emphasis on environmental sustainability
8	Integrated framework for supporting decision-making process of planning	Spatial & non-spatial databases integration, multi-level suitability analysis of land use (e.g. site-level)

Note: the trends underlined are involved in this research.

2.6.2 Research Gaps

There are still some gaps left in the research trends underlined in the above tables, part of them are discussed and filled by the research.

Sustainable development is not readily measurable, whereas sustainable planning usually searches for a compromise among different parts of society (Zander and Kachele, 1999). A great number of scholars have attempted to answer the question - How to make a sustainable land use plan for many years. From the end of the 20th century, some researchers began to explore this area from the perspective of agricultural land in rural areas (Senes and Toccolini, 1998; Herrmann and Osinski, 1999; Zander and Kachele, 1999). When the focus was switched from rural areas to urban areas, some researchers paid close attention to the relationship between sustainability and land-use structure (urban form) (Thinh et al., 2002), geological environment evaluation for urban land use planning (Dai et al., 2001), and integrating the concept and principles of sustainable development into land use planning through the multi-criterion analysis in the planning process (Nijkamp et al., 2007). Although a big step forward has been achieved in the theoretical development of sustainable land use planning, a generally recognized approach to quantifying and measuring the sustainability of urban land use can hardly be found. In other words, the studies on sustainable land use planning are mostly limited on the theoretical and qualitative level, and consequently, technological and quantitative approaches/methods incorporating the sustainability thinking into the planning practice are rare. In addition, in traditional land use planning, the top-down central planning system has some shortcomings which brings obstacles to the context of sustainable development (Wit and Verheye, 2003). Taking two major weaknesses for example, 1) planning decisions are often made with the deviation from the actual demands of the public, and 2) effective communication among the different stakeholders is usually insufficient in the planning process. Therefore, a set of criteria/factors concerning sustainability (i.e. economic, social and environmental aspects) for quantifying and measuring sustainability of land use planning is needed.

Although PSS have a bright future and great potential in land use planning, they are far from being a set of standardized toolkits. According to an investigation on the usage of PSS conducted by Vonk et al. (2005), some bottlenecks blocking the adoption of PSS in planning practice were found. The main bottleneck is that planners are not aware of PSS and their potential, and have limited experience and little interest in the use of these tools. An appropriate and successful PSS should be developed aiming at the requirements of planning tasks and fitting the demands of end users. To eliminate the mismatch between the suppliers of PSS and the demand of planning support (users of PSS), better communication between system developers and planning practitioners during the process of PSS development is required. In addition, the technologies for building PSS, user interfaces, and complexity in operational processes ultimately affect the acceptance of PSS. Planning practitioners (i.e. PSS users) usually consider that the instruments are too complicated to use and too many data or information are required to make decisions. Therefore, a framework/approach as a prototype of PSS or similar tools is needed to be developed with an easy-to-understand rationale and adequate communication with the users during the development process.

Land evaluation is a process which examines both current and changing land performance, by considering the physical and economical factors associated with the land (FAO, 1976). Land suitability assessment can be regarded as one form of land evaluation. Although there have been many studies on LUSA, the majority still focus on agricultural land or forest/grassland. In 1976, the Food and Agriculture Organization of the United Nations (FAO) proposed a framework of land evaluation for agricultural use, followed by land evaluation guidelines for irrigated agriculture in 1985. In contrast, any recognized framework or guidebook for urban land evaluation can hardly be found so far. As urban land involves more complex relationships between nature and humans (and different users), the urban LUSA should have socio-economic criteria excluding geological or soil properties of the land. In addition, studies examining land suitability for urban uses (such as residential, industrial and open spaces) are invariably carried out on a large scale (district level or above), leaving small-scale (street/site-level) analysis a relatively neglected topic (Wang et al., 2013). However, small-scale LUSA directly works on site analysis and is capable of supporting land-use decisions for land redevelopment in urban renewal projects. Therefore, a general list of criteria for LUSA (i.e. factors affecting land-use decision-making) and general land classification in urban developed areas, particularly, land sites in urban renewal projects are necessary to enrich urban land evaluation.

2.7 Summary of the Chapter

Sustainable land use planning is a big issue to existing and future community environment. Planners always attempt to achieve a sustainable way of land use planning to build a better future living environment. However, it is not an effortless job. There are still some problems and limitations blocking planners' expectation in the planning practice. Particularly, in urban developed areas or urban renewal projects, the situation of plan-making becomes more complicated since more stakeholders and relationships are involved. According to Berke et al. (2006), a redevelopment plan is one type of small-area plans which are one part of urban land use planning. In the redevelopment area plan, LUSA and land-use re-allocation for the redeveloped sites is the main task of land use planning (site-level) and a practical problem encountered by today's planners.

This chapter presents a big picture of sustainable land use planning from both theoretical development and technological applications, including relevant theories of land use planning, planning support systems and LUSA, and then narrows the topic down to land use planning in urban developed areas/urban renewal. The new research trends in sustainable land use planning as well as PSS are discussed and several research gaps in the scope of the existing literature on sustainable land use planning, PSS and LUSA are indicated.

Chapter 3 Land Utilization and Urban Renewal in Hong Kong

3.1 Introduction

Land utilization varies among different cities due to varied characteristics of terrain conditions, population, legal restrictions, and culture, etc. For example, in a city with high population density, the pattern of land use is always compact, mixed and efficient. In contrast, if a city has low population density or hilly terrain, a reasonable land-use layout (urban form) which can provide convenient living services to the citizens is usually more important than exploring the potential of efficient land use. Land use policies should be made according to local characteristics of land use and development in different countries and even cities. Although the policies may differ in specific standards and regulations, they have a common objective – to adapt the practical land-use conditions and serve for building a sound legal system of land development and management. In metropolises, basically, large population and employment are continuously being attracted there and the land becomes relatively scarce due to increasing demands of urban development. Hong Kong is a quite unique case because of its high population density but very limited space. As a result, land utilization in Hong Kong is much different from many large cities. In order to better support land use planning in such a high-density city, current land-use conditions and policies in Hong Kong need to be reviewed.

This chapter describes the land use condition of Hong Kong from both demand and supply, and reviews the statutory and administrative procedures of land development and allocation as well as the urban renewal practice in Hong Kong. The analysis on land demand and supply aims to explore the driving forces of land use changes. The summary of statutory procedures for land management helps locate the main aspects which are affecting the land-use allocation in practice. In addition, problems in current land use planning and management such as the difficulties in urban renewal are also analyzed.

3.2 Land Demand and Supply

3.2.1 Land Demand

As a world city in Asia, Hong Kong is an international financial and service center, serving as a hub for logistics and information services, and a premier tourist destination in the world (Shen et al., 2009). However, contradicting to its important role and huge demands from the world, Hong Kong has very limited land resources (approximately 1,100 km^2). It consists of Hong Kong Island, Kowloon Peninsula and New Territories with many small islands, which are all dominated by hilly terrain, including 84% slope areas, unfavorable for urban and agricultural development, and only 16% small plains (Ye, 1998). On the other hand, Hong Kong has over 7 million people and average population density reaches 6,500 persons/km^2 (over 20,000 persons/km^2 in metropolitan areas). How to accommodate the increasing demand of the large population and also a large number of travelers in such limited space is a long-standing question faced by the Hong Kong government.

Before discussing the land use policies in Hong Kong, two questions should be looked into: how much land is basically needed for maintaining the normal development and how much land could be continuously provided by the government.

According to the population projection made by Census and Statistics Department of Hong Kong (Figure 3.1), the population of Hong Kong will keep a steady increase in the next 30 years (0.7% average annual rate). Taking employment into consideration as well, under these assumptions of annual growth rate (population: 0.7%, GDP: 4.0-3.0%, employment: 0.6-1.2%), working population (referring to workers who are also Hong Kong residents) and employment (including the jobs filled by cross-boundary commuting workers) will both keep going up in the future (Table 3.1). As a result, more land will be needed to meet the demand of the population change.

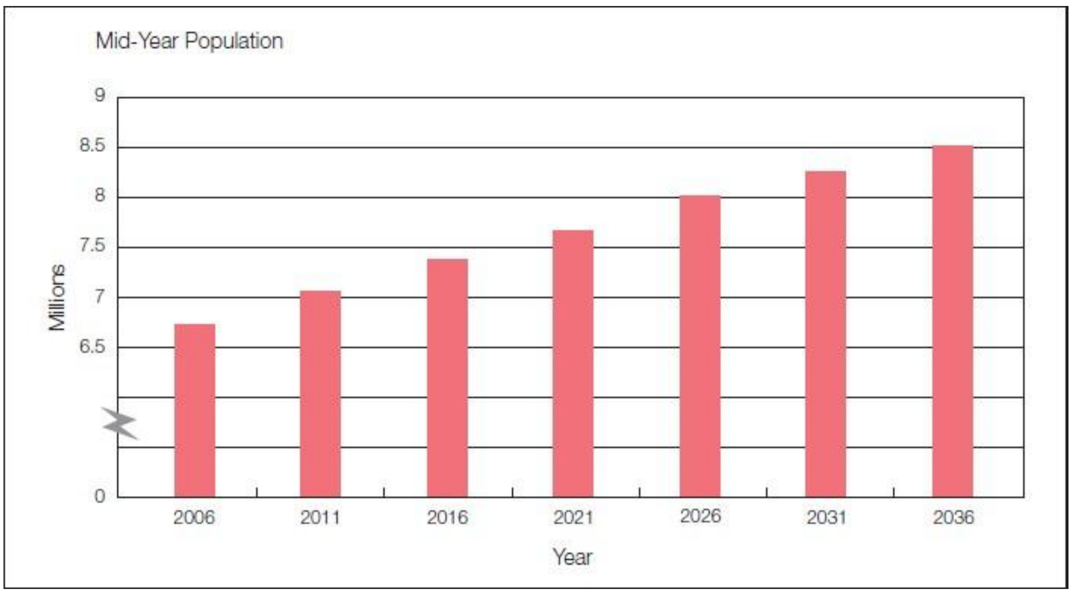


Figure 3.1 Projected population growth (2006-based)
(source: Planning Department, 2007)

Table 3.1 Population and employment projection
(adapted from Planning Department, 2007)

	Base Year (2003)	2010	2020	2030
Resident Population	6.8	7.2	7.8	8.4
Working Population	3.2	3.6	3.8	3.9

Employment	3.0	3.5	3.7	4.0

(Unit: million)

To meet the needs of a growing population, one basic land demand is from housing. Housing problem is one of biggest troubles in Hong Kong for many years. Up to 2011, in contrast to mainland China's 31.6 m^2 in urban areas, the average living space (in GFA) per capita was less than 14 m^2 in Hong Kong (Wong, 2011). Contradicting to the goal of provision of better living environment, Hong Kong faces a big challenge in providing adequate space for the larger and better housing. Not only should the quality of housing be improved, but also more houses need to be built for the increasing population. In the period between 2003 and 2030, a total housing demand of about 924,000 units (averaging about 34,000 per year) is assumed in the HK2030 Study (Table 3.2). In addition, as a financial hub in the world, Hong Kong needs a durative land provision for economic activities serving both the local and global market. Corresponding with the characteristics of modern economic activities, the economic land use can be classified into three broad categories: (i) CBD Grade A Offices, (ii) General Business and (iii) Special Industries. According to an econometric model established to assess future floorspace demand in the HK 2030 Study, the total employment-related floorspace demand will amount to about 10.5 million m^2 in GFA in 2030. Taking into account the existing surplus stock and the need to accommodate a "natural vacancy" (referring to a level of vacancy that is normally present in the property market), the total requirement will be around 11.0 million m^2 in GFA. The details are displayed in Table 3.3.

Table 3.2 Housing demand assumption
(adapted from Planning Department, 2007)

	Base Year (2003)	2010	2020	2030
Housing stock	2,394	2,642	2,948	3,319
Accumulative Requirement	-	248	553	924

(Unit: thousand)

Table 3.3 Assumed floorspace demand and requirements
(adapted from Planning Department, 2007)

	Base Year (2003)	**2010**	**2020**	**2030**	**Demand 2003-2030**	**Requirement 2003-2030**
CBD Grade A Offices	4.1 (10%)	5.1 (11%)	5.8 (12%)	6.7 (13%)	2.6	2.7
General Business	33.0 (80%)	35.5 (77%)	36.2 (76%)	38.2 (74%)	5.2	5.4
Special Industries	4.0 (10%)	5.5 (12%)	6.0 (13%)	6.7 (13%)	2.7	2.9
Total	**41.1 (100%)**	**46.2 (100%)**	**47.9 (100%)**	**51.6 (100%)**	**10.5**	**11.0**

(GFA in million m^2)

In addition to the land demand for housing and economic activities, much land is also needed for transportation and infrastructure development. The total land demand is really high due to the important role the metropolis plays. The figures estimated in the above are not easy to fill up because of limited land available.

3.2.2 Land Supply

Unlike most of world cities, the built-up (developed) area in Hong Kong is only about 25% (less than 300 km^2) of the whole territory. Geographically, nearly 66% land is woodland/shrubland/grassland/wetland, including 46% country parks and special areas under statutory control. The land distributes in major ten types of land use, for example, residential, commercial, industrial, institution/open space and transportation (Table 3.4). These land uses consist of the whole territory of Hong Kong and the area of each sub class changed slightly from 2006 to 2010.

Table 3.4 Broad land use distribution in Hong Kong
(tabulated from Planning Department, 2011)

Class	**Sub-class**	**Approximate Area (sq.km)**				
		2006	**2007**	**2008**	**2009**	**2010**
Developed Lands						
Residential		75	75	75	76	76
	Private Residential	25	25	25	25	25
	Public Residential	16	16	16	16	16
	Rural Settlement	34	34	34	35	35
Commercial		3	3	4	4	4
	Commercial/Business and Office	3	3	4	4	4
Industrial		24	24	25	25	26
	Industrial Land	7	7	7	7	7
	Industrial Estates	3	3	3	3	3
	Warehouse and Storage	14	14	15	15	16
Institution/Open Space		46	47	48	48	49
	Government, Institution and Community Facilities	24	24	24	24	25
	Open Space	22	23	24	24	24

Transportation		55	57	57	58	56
	Roads	39	41	41	42	40
	Railways	3	3	3	3	3
	Airport	13	13	13	13	13
Other Urban or Built-up Land		55	53	52	52	52
	Cemeteries and crematoriums	7	7	7	8	8
	Utilities	7	7	7	7	7
	Vacant Development Land/Construction in Progress	20	19	17	16	16
	Others	21	20	21	21	21
Sub-total		258	259	261	263	263
Non-built-up Lands						
Agriculture		68	67	68	68	68
	Agricultural Land	51	51	52	51	51
	Fish Ponds/Gei Wais	17	16	16	17	17
Woodland/Shrubland/Grassland/Wetland		744	744	742	740	740
	Woodland	245	247	241	234	254
	Shrubland	228	237	238	241	303
	Grassland	266	255	258	260	178
	Mangrove and Swamp	5	5	5	5	5
Barren Land		9	9	8	8	7
	Badland	5	5	5	5	2
	Quarries	2	2	1	1	1
	Rocky Shore	2	2	2	2	4
Water Bodies		29	29	29	29	30

	Reservoirs	24	24	24	24	25
	Streams and Nullahs	5	5	5	5	5
Sub-total		850	849	847	845	845
Total		**1108**	**1108**	**1108**	**1108**	**1108**

Note: above figures updated on 2011

Because of the land scarcity, Hong Kong government has to face challenge in land supply and to search for solutions to provide adequate land to meet the demand. By far, there are two main sources of land supply in the city: government land and private sources (Legislative Council, 2004b). Government land is provided by the government through land sales to general developers, and private treaty grants to approved bodies for specified uses. Developers can also procure land from other private land owners in the open market. In addition, private land owners can redevelop their own land according to the town plan and land lease conditions. As displayed in Table 3.5, from 2005 to 2010, the majority of government land was provided through the means of private treaty grants for specified uses, usually public utilities or non-profit-making purposes. Land exchange and lease modification, to some extent, reflect the frequency of activities of land redevelopment and reutilization, and indicate the vibrancy and stability of the land (real estate) market. Actions of lease modification and land exchange are driven by market forces and private developers can achieve their development plans through seeking lease modifications or land exchanges in the market. Table 3.6 shows the number changes in the two kinds of approved transactions from 2005 to 2011. The two ways may be chosen by private developers complement the source of land supply by the government.

Table 3.5 Supply records of Government land in two means (2005-2011)

Year	Auction/Tender		Private Treaty Grant		Total Land Area (ha.)
	Land area (ha.)	Percentage	Land area (ha.)	Percentage	
2005/2006	3.30	2	138.30	98	141.60
2006/2007	7.79	8	94.67	92	102.46
2007/2008	11.46	6	167.20	94	178.66
2008/2009	2.45	2	151.46	98	153.91
2009/2010	5.97	3	180.13	97	186.10
2010/2011	15.04	9	147.14	91	162.18
2011/2012	35.71	89	4.50	11	40.21

Note: raw statistics from Lands Department

Table 3.6 The number of approved applications of land exchange/lease modification (2005-2011)

Year	Land Exchange	Lease Modification	Total No.
2005/2006	25	72	97
2006/2007	15	104	119
2007/2008	13	128	141
2008/2009	15	224	239
2009/2010	12	127	139
2010/2011	20	108	128
2011/2012	12	77	89

Note: raw statistics from Lands Department

Currently, there are six land supply options provided by the government: Rezoning land, Land resumption, Rock cavern development, Redevelopment, Reclamation and Reuse of ex-quarry sites. The existing land supply approaches are selectively adopted to maintain the land provision for increasing land demands every year. In fact, they have both advantages and disadvantages for land development. For example, Rezoning and

Redevelopment are market-driven but unpredictable. Resumption may disturb the local residents and Reclamation may cause some environmental issues. The details about the six options are discussed in Table 3.7. In the past, reclamation was one of the main solutions to the land shortage problem, and it can produce new flat land along the coast. In recent years, the pace of reclamation has dropped dramatically. One of the main reasons is strong public aspiration of protecting and preserving Victoria Harbour as a special public asset and a natural heritage. The general public protest against the reclamation inside or near the harbor because the excessive reclamation may lead to environmental and landscape deterioration.

Table 3.7 Six existing land supply options
(tabulated from CEDD, 2011)

Option	Definition	Key Limitation/Challenge
Rezoning Land	Rezone under-utilized sites and lands that no longer perform their original functions for housing or other uses	• A longer process may be required due to the involvement of private owners and developers or different Government departments • Timing of development is less predictable because the actual development hinges on market response
Redevelopment	Redevelop the older urban areas or individual buildings through re-planning and re-building to improve the local environment and better utilize the land	• Less predictable because private owners and developers take the leading role comparing with other options implemented by the government
Land Resumption	Exercise statutory power to compulsorily take over private lands for public purposes	• Local resentment may be caused if residents wish to maintain their rural lifestyle or are not satisfied with the compensation or re-housing arrangement • Low flexibility in land use due to only designated purposes for the land

		acquisition
Reclamation	Create usable land over the foreshore or sea-bed	• Much more emphasis is placed on reducing and mitigating the impact on marine ecology
Rock Cavern Development	Place new facilities inside caverns and relocate suitable existing government facilities into rock cavern to release the sites for housing or other uses	• May be applicable to many uses only if the public can accept daily activities inside cavern
Reuse of Ex-quarry Sites	Rehabilitate the platforms formed in ex-quarry sites as a source of new land	• Limited sources and only be available upon quarry closure

To ensure a sufficient land supply for Hong Kong's development, several government departments collaborate with each other and each of them takes specific responsibilities (Table 3.8). In 2011, a study titled 'Enhancing Land Supply Strategy: Reclamation outside Victoria Harbour and Rock Cavern Development' was conducted by a consultant firm (ARUP) who was commissioned by Civil Engineering and Development Department (CEDD), and the first stage of this study - Public Engagement was arranged by multiple hosts: Development Bureau, Planning Department and CEDD. The government also plans to allocate a large amount of fund (about HKD 300 million) for public engagement exercise to examine the options of reclamation outside the harbour and rock cavern development in the following few years. It can be believed that the two kinds of land supply options will play an important role in new land provision after the feasibility study on them as well as public consultation.

Table 3.8 Government departments/bureaux involved and their roles in land supply

Government Department/Bureau	Major roles/responsibilities
Development Bureau	• Facilitate effective land use planning as well as a steady and sufficient supply of land • Achieve the optimum use of land resources and maintain an effective land administration system • Manage an efficient system for registration of land
Environment Bureau	• Develop policies covering environmental protection • Facilitate the integration of sustainable development into new government initiatives and programs (e.g. sustainability assessment)
Transport and Housing Bureau	• Make policies on matters relating to Hong Kong's internal and external transportation • Maintain a fair and stable environment to enable sustained and healthy development of the property market by ensuring adequate land supply and the provision of an efficient supporting infrastructure
The Land Registry	• Ensure secure, customer friendly land registration and information services • Advocate reform of Hong Kong's land registration system
Planning Department	• Coordinate planning matters • Prepare OZP, ODP • Carry out necessary land rezoning
Lands Department	• Process land resumption • Coordinate clearance matters • Issue possession license
Civil Engineering and Development Department	• Prepare and handle site formation and infrastructural work contracts including gazettal actions • Coordinate fill management • Comment on slope stability and geotechnical matters • Advise on blasting matters
Buildings Department	• Provide services to owners and occupants in both existing and new buildings in the private sector • Make the built environment of existing buildings safe and healthy • Approve building plans, audit construction works and site safety, and issue occupation permits upon

	completion of new buildings
Transport Department	• Coordinate major traffic planning matters • Comment on Traffic Impact Assessment (TIA) • Advise on road layout and capacity
Environmental Protection Department	• Comment on Environmental Impact Assessment (EIA) • Advise on environmental nuisance control requirements • Control marine dumping
Highways Department	• Advise on road construction materials and maintenance responsibilities • Comment on road drainage design • Prepare gazettal actions under the Roads Ordinance
Water Supplies Department	• Advise and make provision for water supply
Drainage Services Department	• Advise and make provision of drainage connections • Advise on drainage design and maintenance responsibility • Comment on Drainage Impact Assessment (DIA)

Note: ODP refers to Outline Development Plans.

In the long run, more land is required to accommodate the population growth and economic development, and to cope with rising public desire for quality living and heritage conservation. Meanwhile, under the circumstance of decline in reclamation, a more flexible and resilient land supply strategy is needed to respond to the changing demand stemming from the complex uncertainties in society and the challenges faced by the land supply options. Land reserve is an effective approach to ensuring timely supply of land. At present, land reserve can be established in three forms: 1) land is formed first for ready use when the needs arise; 2) potential sites are identified with the necessary studies and design work; 3) potential sites meeting the criteria of site selection are reserved. With the presence of land reserve, land can be provided flexibly in correspondence with three establishing forms: 1) land in the land bank can be allocated for temporary use before a permanent land use is determined; 2) construction works can commence immediately when the need is confirmed; 3) further studies to make certain the feasibility of the potential sites and design works can be conducted directly and pertinently after the need is proposed.

3.3 Mechanism of Land-use Allocation

As stated in the Basic Law of the Hong Kong Special Administrative Region of the People's Republic of China (CAB, 2006), "The land and natural resources within the Hong Kong Special Administrative Region (the SAR) shall be State property. The government of the SAR shall be responsible for their management, use and development and for their lease or grant to individuals, legal persons or organizations for use or development. The revenues derived therefrom shall be exclusively at the disposal of the government of the Region." (Article 7) In practice, the duties stipulated in Article 7 of the Basic Law, including managing, developing and leasing land in Hong Kong are discharged by the Chief Executive and officials authorized by him, on behalf of the Hong Kong SAR Government.

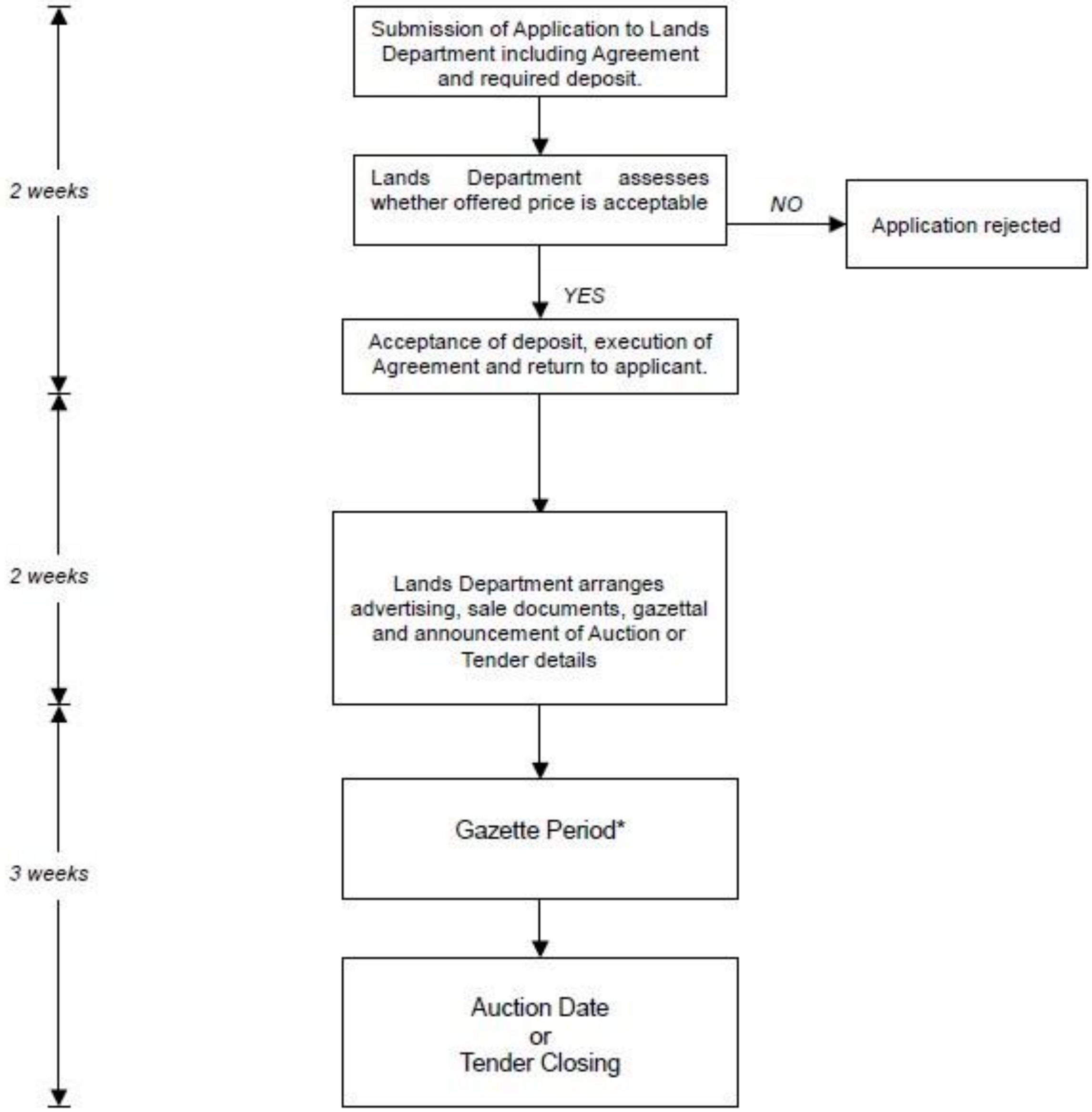
Over the years, Hong Kong government has attempted to optimize land use and promoted economic development with a vision to enhancing the living environment for the Hong Kong residents. Given the scarcity of land in Hong Kong, land grant is adopted by the government. In order to fully utilize such precious natural resources, land use planning should be determined in line with the development needs of whole society. Under these circumstances, the government will then develop the planned uses in regard to the resource availability and development priorities, or will lease the land to individuals, legal persons or organizations for their use or development.

In addition to maximizing the provision of land, Hong Kong government should regularly review its policy of using land resources and timely provide more available land by improving the efficiency of land-use management. For example, the government has been urged to subsidize commercially operated infrastructural projects through financing arrangements, and supply land through market mechanism and fair competition. Land is also reserved for other developments which are compatible with the public interest, apart from reserving sufficient land for public housing development.

3.3.1 Application List System for Land Sales (Perspective of Land Management)

The government's land allocation policy is based on the principle of fairness and transparency. Here the term of “land sale” is not actually selling the land but the land use right. In Hong Kong, the core of the land system is that land users pay for the right of land use within certain periods on the principle of the separation of land use rights and land ownership. The land can be granted mainly through open bidding (such as land auction and tender) for commercial, residential and other private developments. The land grants system experienced a series of changes over time. Before 1997, land was mainly granted through scheduled land auctions and tenders following the one-year land sale program (LSP). In 1999, an application list system (ALS) was introduced as a supplement to the LSP to enable the market to flexibly determine the amount, timing and type of additional land required (Legislative Council, 2004a). Under the ALS, a developer with interest in any land site on the application list can apply for buying this site from the government by offering his/her minimum price first. If the government thinks that the minimum price offered is reasonable and acceptable, the site will be put up for sale by tender or auction as appropriate. The offered price will be taken as the upset price and the site will be sold to the highest bidder ultimately.

Under the annual LSP, the Lands Department of Hong Kong publishes a list of sites available for sale upon application (Application List). The Application List includes information about lot number, location, use, site area and the estimated earliest available date for each of the sites. The application procedure for land sale is described in Figure 3.2. After the open bidding, the land provided by the Lands Department goes to the highest bidder and the bidder can hold the land use right for a certain lease term (up to 2047 for the lease newly signed after 1997). The price at which the land is sold reflects the prevailing market value of the land concerned. It is government's policy that the land will not be sold at a pathetic price. It means that, if the land site cannot be sold at the upset price or above in the public auction, the government would withdraw the land sale. Actually, there have been two temporary suspensions of land sales with the Application List since 1997; one was nine months from June 1998 to March 1999 and the other from November 2002 to the end of 2003. After the last suspension in 2002-03, the land sales were regularly conducted from 2004 to now.



* (two consecutive weeks)

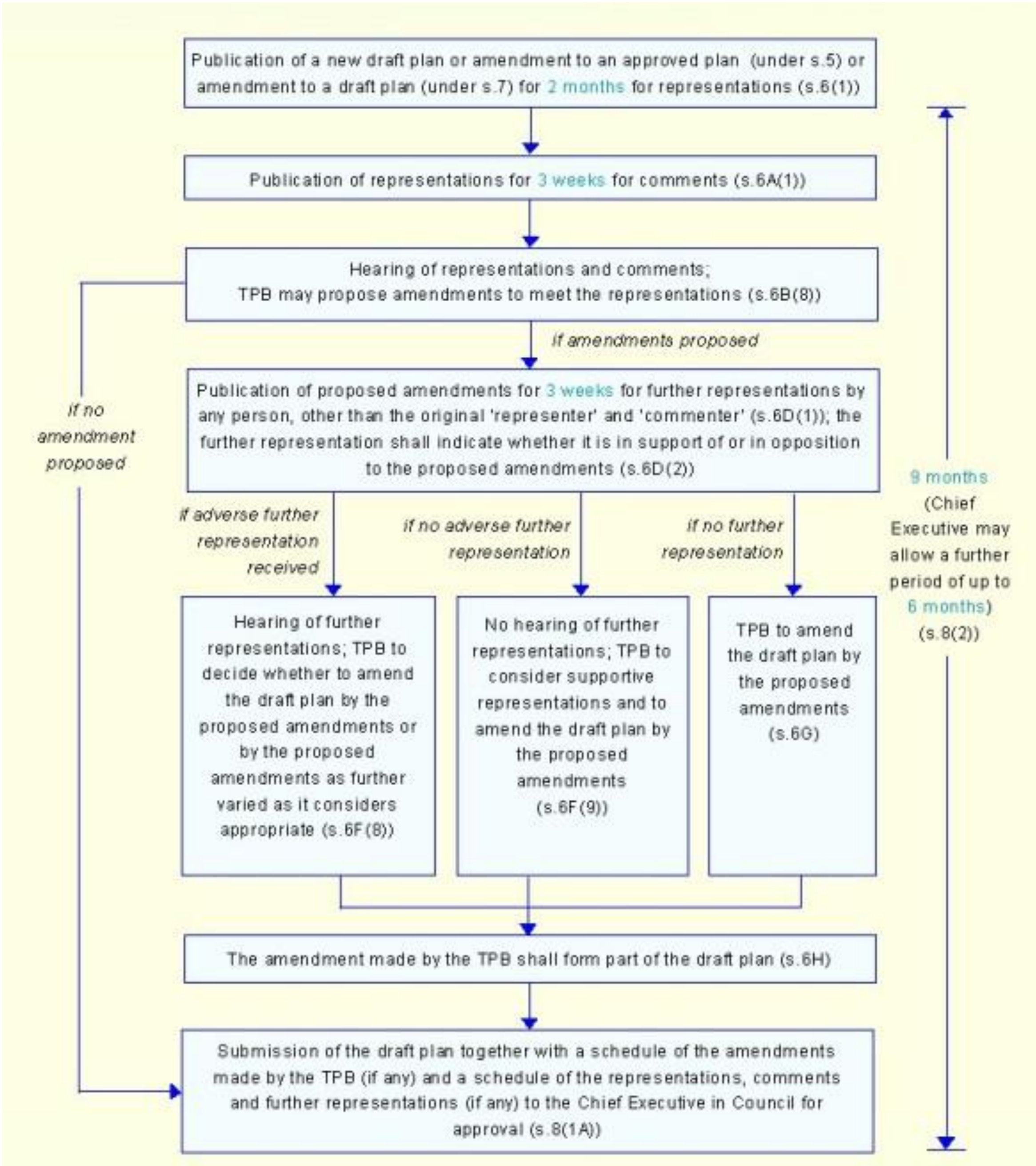
Figure 3.2 Application procedure for land sale
(source: Lands Department, 2005)

In addition to open bidding, the government also grants land by means of private treaty to non-government or private organizations under certain circumstances. This way of granting land has been in use for a long time for the purpose of meeting social needs. It is mainly adopted for land assigned to community use or for public utility purposes.

Examples include non-profit making community uses such as schools, welfare and charitable organizations, as well as land for essential public utility services like power station and land for certain policy promotion like Science Park. The level of land premium charged on the land grants depends on the uses of the land (Legislative Council, 2005). For instance, nominal or concessionary premium is normally charged for non-profit-making community/public uses, and full market premium is usually charged for commercial land uses such as power station.

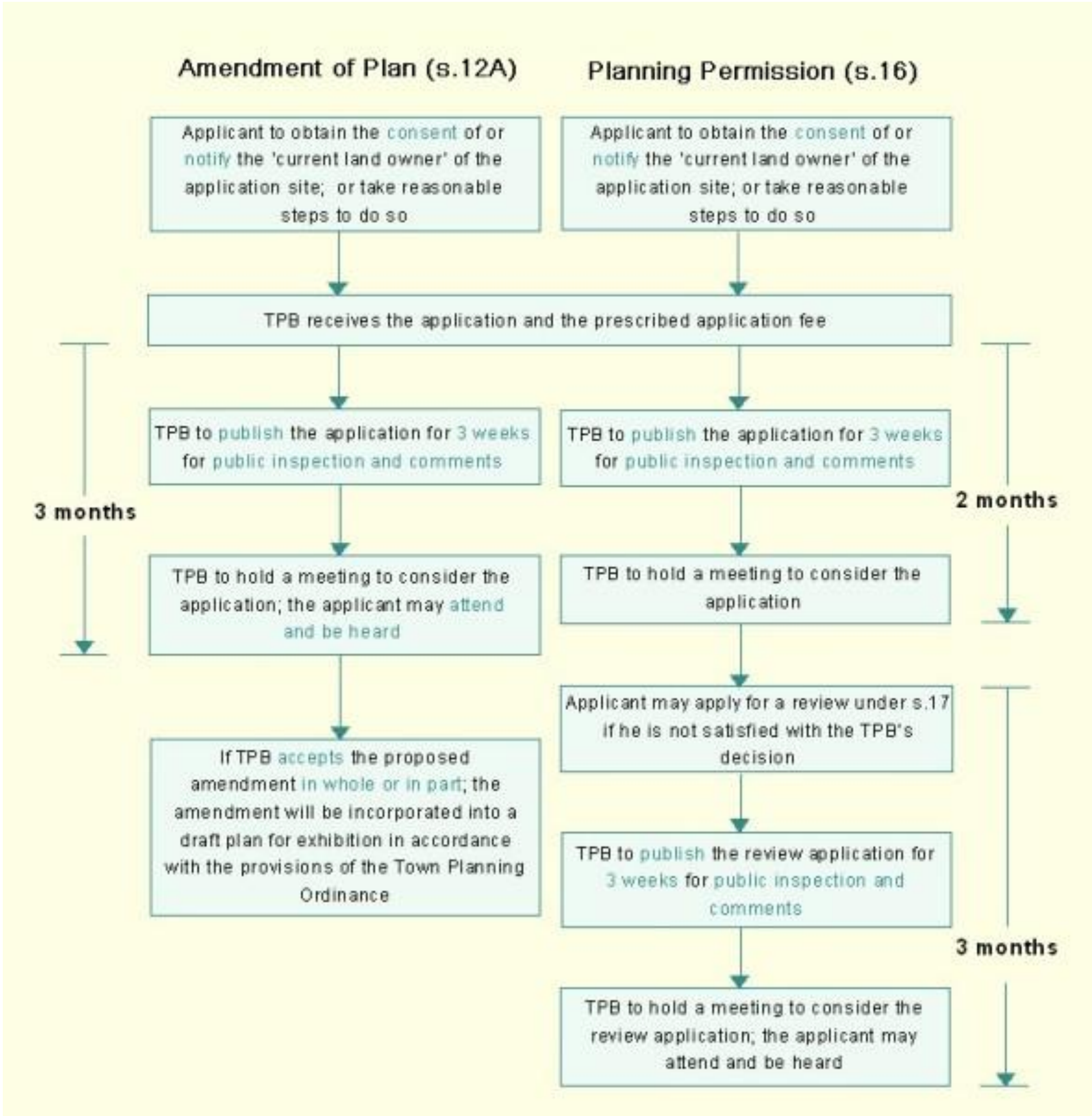
3.3.2 Control System for Land Development (Perspective of Land Planning)

The objective of town planning of Hong Kong is to provide a living environment which is comfortable and safe. It meets the needs of social development, achieves sustainable development and benefits the next generation (Legislative Council, 2005). In Hong Kong, Town Planning Ordinance (TPO) stipulates Town Planning Board (TPB) to make statutory plans including Outline Zoning Plans (OZP) and Development Permission Area (DPA) Plans. During the plan-making process, if necessary, specific studies serving the planning are required to finalize the plans. Similar to planning applications, requests for changing land use zoning submitted by the public are also processed by the TPB. This administrative practice is formalized and enhanced in the Amendment Ordinance (Planning Department, 2004). A new plan or amendment is made strictly following an elaborate and long process (Figure 3.3), and an application for plan amendment and planning permission is also regulated by a strict procedure (Figure 3.4).



Note: details refer to 'Town Planning (Amendment) Ordinance 2004'.

Figure 3.3 The process of making a new plan or amendment
(source: Planning Department, 2004)



Note: details refer to 'Town Planning (Amendment) Ordinance 2004'.

Figure 3.4 Application procedure for plan amendment and planning permission
(source: Planning Department, 2004)

According to the nature of uses, land in Hong Kong is classified into 18 broad categories including residential use, commercial use, industrial use, etc. The details of them are listed in Table 3.9 (TPB, 2008). These categories enable greater flexibility in the use of land, and facilitate the interchange of the land uses under the same broad use granted by planning permission. On the whole, the 18 land use categories relate to several main aspects of society, such as residence, manufacturing (including industry and agriculture), services sector (including commerce, recreation, education, medical service and other public utilities), and transportation, etc. In Hong Kong, land use planning and control is carried out at two levels: territorial/strategic and district/local (site level). As a result, types of plans are implemented at different levels (Figure 3.5). During the territorial planning, the main task is to predict the land demand and supply for all kinds of land uses and plan the land use allocation correspondingly. In contrast, analyses on the quantity (area) of land demand and supply do not make sense for site-level planning. Site selection for specific land uses is the major work in this level.

Table 3.9 Broad land use categories in Hong Kong
(tabulated from TPB, 2008)

No.	Land Category	Specific Uses
1	Residential Use	Flat, House, Residential Institution
2	Commercial Use	Broadcasting, Television and Film Studio, Commercial Bathhouse/Massage Establishment, Eating place, Exhibition or Convention Hall, Hotel, Market, Off-course Betting Center, Office, Shop and Services, Wholesale Trade
3	Industrial Use	Cargo Handling and Forwarding Facilities, Cement Manufacturing, Concrete Batching Plant, Container Vehicle Park/Container Vehicle Repair Yard, Container Storage/Repair Yard, Dangerous Goods Godown, Industrial Use, Information Technology and Telecommunication Industries, Offensive Trades, Open Storage, Research Design and Development Center, Rural Workshop, Service Industries, Ship-building, Ship-breaking and Ship-repairing Yard, Vehicle Repair Workshop, Vehicle Stripping/Breaking Yard, Warehouse
4	Other Special Uses and Installations	Abattoir, Bus Depot, Chemical and Biochemical Plant, Electric Power Station, Gas Works, Resource Recovery Park, Mine and Quarry, Oil Depot, Oil Refinery and Petro-chemical Plant, Refuse Disposal Installation, Sewage Treatment/Screening Plant
5	Recreation and	Field Study/Education/Visitor Center, Golf Course, Holiday Camp, Private Club, Place of Entertainment, Place of Recreation, Sports or Culture,

	Leisure	Theme Park, Zoo
6	Education	Educational Institution, School, Training Center
7	Medical Facility	Ambulance Depot, Hospital, Public Clinic
8	Government Use	Animal Quarantine Center, Correctional Institution, Firing Range, Government Refuse Collection Point, Government Use, Library, Public Convenience, Service Reservoir
9	Social/Community /Institution Use	Social Welfare Facility, Institutional Use
10	Religious Use	Religious Institution
11	Funeral Related Facility	Burial Ground, Columbarium, Crematorium, Funeral Facility, Grave
12	Agricultural Use	Agricultural Use, On-farm Domestic Structure
13	Open Space	Amenity Planting, Open Space
14	Conservation	Country Park, Nature Reserve, Nature Trail, Wetland Habitat, Wild Animals Protection Area
15	Public Transport Facility	Cable Car Route and Terminal Building, Mass Transit Railway Vent Shaft and Other Structure above Ground Level, People Mover, Pier, Public Vehicle Park, Public Transport Terminus or Station
16	Airport Related Use	Air Cargo Handling System and Facility, Air Catering Facility and Service, Aircraft Maintenance and Repair Plant, Airfield, Air Mail Center, Air Passenger and Freight Handling and Processing System/Facility, Air Passenger Terminal and Concourse, Airport Apron, Airport Runway, Airport Supporting and Servicing Facility, Airport Taxiway, Air Traffic Control Tower and Center, Apron Control Center, Aviation Fuel Pipeline Reserve, Aviation Fuel Storage Facility, Radar, Navigational Aid and Communication Devices, Sea Rescue Station, Vehicle Staging
17	Utility Installation	Public utility Installation, Radar, Telecommunications Electronic Microwave Repeater, Television and Radio Transmitter Installation, Utility Installation for private Projects
18	Miscellaneous	Animal Boarding Establishment, Driving School, Helicopter Fuelling Station, Helicopter Landing Pad, Marina and its Fuelling Station, Petrol Filling Station, Recyclable Collection Center

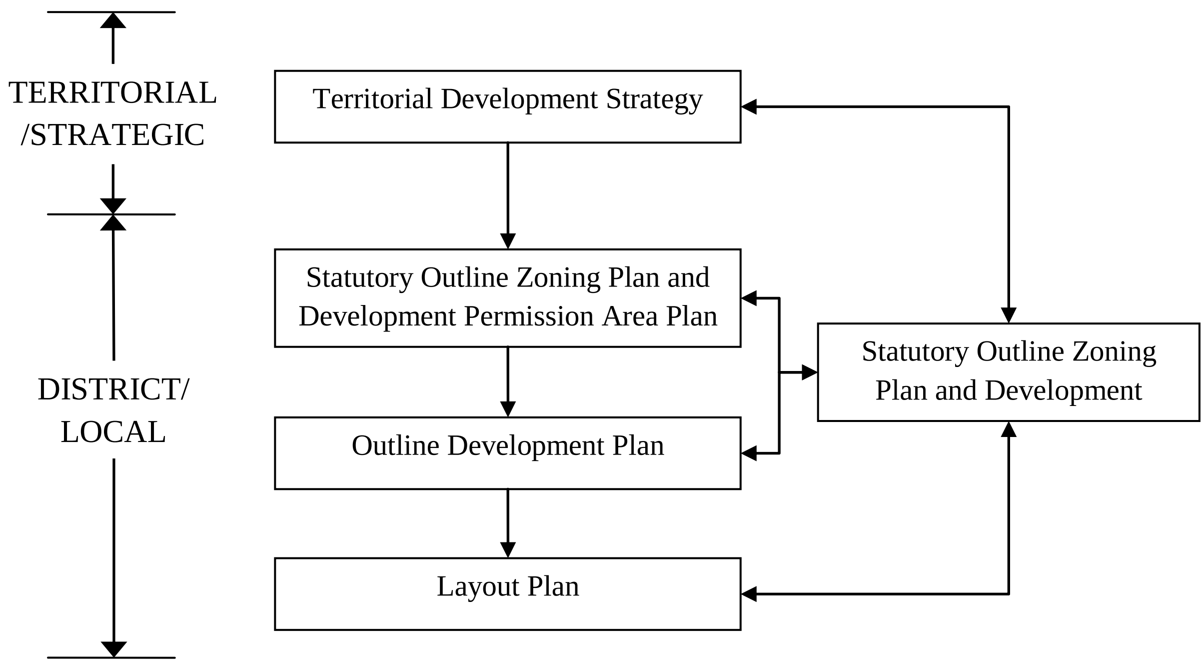


Figure 3.5 Plans involved in the two-level planning process

When a piece of land is selected for development, it must comply with the OZP in which the site is located. Figure 3.6 shows the application process of land development. As depicted in the diagram, sites with different land uses have different development processes. TPB sets the development requirements and controls the development processes. The varied procedures enable a more flexible environment for developers. If the plans made by developers are classified into usually permitted utilization, they can be proceeded to get other approvals such as land lease modification and building plan submission instead of waiting for the approvals from TPB. It makes the development process more efficient by reducing the cost and time.

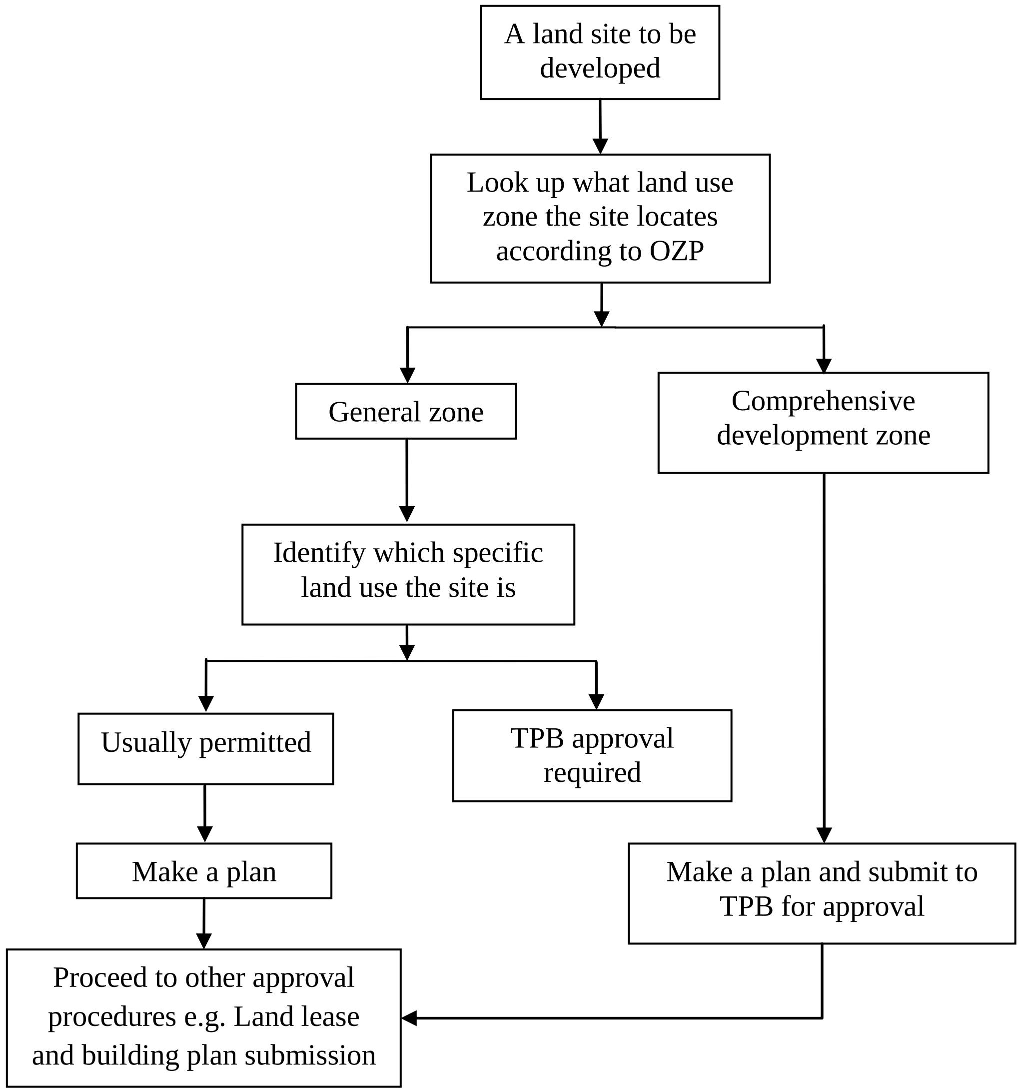


Figure 3.6 Application process of land development for specific uses

3.3.3 Continuous Public Engagement

Public participation and support is the key to success in any planning process/system (Legislative Council, 2005). In Hong Kong, major strategic and development plans drafted by the government are required to be reviewed by the public from time to time to collect the views from the citizens and merge the public needs into the plan revision. It is an effective way to cope with the changing environment and the desire of the public for the development in different regions or areas. Kai Tak Planning Review is a good example. Kai Tak airport was closed in 1998 and left a large piece of land to be redeveloped in the metropolitan area of Hong Kong. The redevelopment of Kai Tak is a big issue for the government and surrounding residents. Since the planning for Kai Tak started over ten years ago, many rounds of public consultation have been conducted to gather the views from the public. Public consultations in the form of forums and community workshops aim to ensure that the development proposal to be carried out will not only take into account the local characteristics of the area/zone to be developed but also meet the public aspiration. Like Kai Tak redevelopment project, planning reviews for other projects are similar and successful in collaborating with different stakeholders for the better future of the community. In the future, this planning policy will continue to actively engage the public in every planning process to ensure that the current planning system/mode not only satisfies the physical demand of land in quantity, but also reflects the common desires of the public with regard to the certain development projects and also the future landscape of Hong Kong.

3.4 Urban Renewal Practice

Urban renewal is a hot topic in today's Hong Kong. Like other cities which have a long history in city construction, many old buildings and sites in the developed area need to be redeveloped or revitalized to fit the changing demands.

3.4.1 Transition of Governing Agency of Renewal Projects

Large-scale urban renewal has taken place in Hong Kong for over 40 years (Drakakis-Smith, 1976). During these years, building stock of Hong Kong is ageing rapidly: about 4,000 buildings aged 50 years or above at present, and the number will increase by 500 per year over the next decade (Development Bureau, 2011). Renewal/redevelopment projects are urgent to be carried out to deal with the serious problems of urban decay and poor living conditions. In order to officially undertake, encourage, promote and facilitate renewal projects in the older urban areas, Land Development Corporation (LDC) was established in Hong Kong on 1988 (Adams and Hastings, 2001). LDC operates as a self-financing commercial organization and its main objective is to promote urban renewal through cooperating with private developers in implementing urban renewal projects. Although LDC is more flexible than governmental departments in utilizing private resources, it has radical weaknesses in coordinating both the government and private developers, and subjecting to a time-consuming process for government approval (Adams and Hastings, 2001).

Before the sovereignty handover of Hong Kong to China in 1997, urban renewal projects in Hong Kong had been carried out under the control of LDC for almost ten years. Despite efforts of the government in the decade, the conditions of old buildings in Hong Kong were still unsatisfactory and posing threats to public safety (Development Bureau, 2011). To address the problem of urban decay and speed up the pace of urban renewal, the Urban Renewal Authority Ordinance (Chapter 563) (URAO) was enacted in 2000. Under this guideline, Urban Renewal Authority (URA) was established as a new governing agency replacing the LDC for improving the implementation of urban renewal projects on 2001. The URA plays more flexible roles in redevelopment projects since it can redevelop on its own (as "implementer") or thorough joint-venture partnership (as "implementer"), and can also dispose project sites upon land resumption in the open market for private development (as "facilitator"). "Redevelopment" and "Rehabilitation" are two core businesses of URA, including redevelopment, rehabilitation, heritage preservation and revitalization (i.e. the 4Rs). The detailed introduction to the 4Rs is summarized in Table 3.10.

Table 3.10 Functions and difficulties in the 4Rs

4Rs	Functions	Difficulties
Redevelopment	• Targets old, dilapidated buildings with poor living conditions; • Replan and rebuild these sites and buildings to achieve environmental and social benefits, such as open space and community facilities	• Land resumption under multiple land ownership; • Land assembly for comprehensive planning
Rehabilitation	• Prevents the decay of the built environment by promoting and facilitating the proper repair and maintenance of buildings; • Extends the useful life of buildings to alleviate the urgency of redevelopment	• Mortgage lending on older properties; • Owner attitudes on maintenance; • Public perceptions on older buildings
Revitalization	• Deploys appropriate means to revive and strengthen the economic and environmental fabric of different districts	• Absence of empowered local district authority; • Coordination of stakeholders' contributions and project programs; • Few experienced business associations
Preservation	• Preserves buildings, sites and structures of historical, cultural or architectural interest; • Retains the local color of the community and the historical characteristics of	• Identification of few buildings worthy of preservation; • Limited public support; • Absence of dedicated

	different districts	funding support

3.4.2 Urban Renewal Strategy

The urban renewal strategy (URS) in Hong Kong is a government strategy initially published in 2001, which aims at expediting the urban renewal process. Under this strategy, a comprehensive and holistic approach is adopted to rejuvenate older urban areas by means of redevelopment, rehabilitation, revitalization and heritage preservation (Development Bureau, 2011). As highlighted in the latest strategy revised on the basis of public comments received from public consultation review on the former version, implementation of URS is undertaken by the URA, as well as all the other stakeholders/participants in order to achieve a better balance and coordination among the 4Rs. The main objectives of urban renewal are stated in URS as follows (Development Bureau, 2011):

- To restructure and re-plan concerned urban areas;
- To design more effective and environmentally-friendly local transport and road networks within the concerned urban areas;
- To rationalize land uses within the concerned urban areas;
- To redevelop dilapidated buildings into new buildings of modern standard and environmentally-friendly design;
- To promote sustainable development in the urban areas and the timely maintenance and rehabilitation of buildings in need of repair;

- To preserve buildings, sites and structures of historical, cultural or architectural value;
- To preserve as far as practicable local characteristics and the social networks of the local community;
- To provide purpose-built housing for groups with special needs and more open space and community/welfare facilities;
- To enhance the townscape with attractive landscape and urban design.

To strengthen urban renewal planning at the district level, a new advisory platform, District Urban Renewal Forum (DURF) is proposed in the new URS which calls for the adoption of a “People First, District-based, Public Participatory” approach at the stage of urban renewal planning. DURF is appointed by the government. The chairman of each DURF will be a professional familiar with urban renewal issues and its members will be drawn from a wide cross-section in the local community. In addition, the Planning Department provides secretariat and professional support to DURF (Development Bureau, 2011). DURF advises the government on district-based urban renewal initiatives in an integrated way (including the 4Rs), and conducts broad-based public engagement activities and planning related studies.

The URA implements renewal projects by way of a development project or a development scheme under the guidance of the URAO. During the planning process of an urban renewal project, the URA has to prepare a draft corporate plan and a draft business plan, and submit both of them to the Financial Secretary (FS) for approval (Development Bureau, 2011). Specifically, 1) the URA should conduct a freezing survey to determine eligibility for ex gratia allowances and rehousing on the commencement day of the implementation of a project; 2) social impact assessments should be initiated and conducted by DURF before any specific redevelopment project is implemented by the URA; and 3) An urban renewal trust fund with endowment from the URA should be established to provide financial aid for various activities to be conducted by DURF and social service teams.

In accordance to outline zoning plans (OZP), statutory development scheme plans (DSP) are prepared for the URA to control its redevelopment projects. The OZP is a sort of statutory plans developed by the Planning Department, in which the proposed land uses and major road systems are given for individual planning areas. Such plans cover almost all planning scheme areas in Hong Kong territory, and the areas are zoned for specific uses such as residential, commercial, government, institution and community (G/IC), and open space. In order to make the development plans more appropriate with the changing demand, an OZP needs to be continuously amended over time and approved by Town Planning Board. Consequently, redevelopment projects can be carried out subject to the control of DSP which are derived from the dynamic OZP.

3.5 Problems in Current Land Use System

To ensure economic growth in the long term, a flexible land provision mechanism should be developed and adopted by the government. Although six land supply options have been identified and land reserve is being established for adequate and flexible land provision, some problems still exist in the current land use system.

3.5.1 Inherent Shortage of Land

The fact that Hong Kong has a small territory but a large population cannot be changed, so that the government must efficiently utilize the land available to accommodate the increasing demand from population growth and economic development. In view of this inherent constraint, the government should not only create new space through reclamation or rock cavern development, but also explore land potential and improve the efficiency of land use by rezoning and redeveloping the under-utilized sites and old areas. Only increasing the land in quantity/amount is not enough to catch up with the pace of land demand, and an efficient land use/reuse mechanism managing the land resource in quality is required. Land reuse in urban renewal is an effective way to maximize land use efficiency and improve the built environment.

Regarding the housing issue, the objective of Hong Kong government is to ensure timely provision of adequate land and infrastructure for the development of housing and community facilities. However, the supply of affordable housing is still lagging behind the public needs. According to an annual report published by Housing Authority (2011), the waiting list for public housing application is becoming longer during the past ten years (increasing from 108,000 live applicants in 2000/01 to 152,000 in 2010/11), and the average waiting time for the applicants to be allocated with public housing in 2010/11 was about 2 years. Comparing with other cities in mainland China, average living space per person for public housing is much smaller. It had only 2.1 sq.m increase from 2001 (10.7 sq.m) to 2011 (12.8 sq.m).

3.5.2 Difficulties in Urban Renewal

The redevelopment works are not easy to accomplish because of some difficulties in urban renewal, such as resumption of land, coordination between governmental departments, and public protest and problems of social equity. For example, urban redevelopment in Hong Kong is mainly restricted to the multiple ownership of the land and buildings within potential redevelopment sites, and most of the sites on which sporadic high-rise old buildings (commonly called “pencil development”) stand are small (Adams and Hastings, 2001). This constraint leads to lengthy negotiations for land resumption of a number of small lots assembling into a larger site for redevelopment. During the implementation of urban renewal projects, many stakeholders are involved in the planning process, such as governments, developers and local residents. They have their own aspirations in the renewal projects and interact with each other for frequent negotiations. It is really a difficult task to reach a consensus among the different parties. Under these circumstances, an urban renewal project often takes a long time to complete starting from the feasibility study of the proposal, and the timing of redevelopment is always unpredictable. In addition, the impact on surrounding residents is also an unavoidable issue. People who live in the renewal area are affected, and sometimes are disturbed more or less. Anyway, urban renewal plays a key role in improving living environment in urban developed areas and reshaping the image/landscape of cities. The government needs a way to shorten the time of redevelopment and improve the communication among the different stakeholders for reducing the impacts on local residents.

3.5.3 Procedure and Regulation Amendments

Although Hong Kong has a set of existing statutory procedures and codes in managing land planning and development, some of them may be out of date and some can be simplified. In many cases, large projects need a long time, usually over 10 years to be completed partially due to the outdated regulations in an increasingly complicated land administration system. Particularly, it often takes a long time for the feasibility analysis in urban renewal projects. Therefore, simplifying and shortening some procedures are necessary for the government to improve the efficiency of management and further benefit the investment environment for Hong Kong. The point for the regulation updates is to facilitate a balance which can both meet adequate public participation and time saving during the projects. Last but not least, as discussed in the previous paragraphs, the coordination of different governmental departments which are involved in land planning and development with different responsibilities is also a key issue in terms of the efficiency improvement for town planning and land development.

3.6 Summary of the Chapter

Over the years, Hong Kong government has attempted to ensure an adequate supply of land together with the necessary supporting infrastructure to meet market demands in a timely manner. It is a big challenge for the government to continually supply sufficient land to meet the changing market demands and the needs of the prevailing market conditions.

This chapter comprehensively introduces land use practice in Hong Kong. The picture of Hong Kong’s land utilization is shown from both land demand and supply: the demand from different land uses and the land supply measures are described respectively. In addition, the mechanism of current land-use allocation is analyzed from two perspectives: land management and land use planning. And the urban renewal practice in Hong Kong is also discussed. Finally, major problems in the current land use, in particular, urban renewal projects are identified to make this research serve for problem solving in practice.

Chapter 4 Research Design and Methodology

4.1 Introduction

This chapter introduces the methodological design and specific research methods adopted in the research. To examine the research question and achieve the four specific research objectives discussed in Section 1.3, the research framework is well-designed by mixing qualitative and quantitative methodologies, selecting appropriate research methods, and formalizing a logical research process. Six main research methods are chosen in the research, including document analysis, expert interview, focus group meeting, case study, experimental study, and questionnaire survey. Among them, literature review and document analysis are used to achieve Objective 1 and Objective 2; literature review, expert interview, focus group meeting, and case study are employed to achieve Objective 3; experimental study and questionnaire survey are adopted to achieve Objective 4.

4.2 Research Design

4.2.1 Overview of Qualitative and Quantitative Methodologies

Research can be categorized into several paradigms, such as developing new knowledge, testing a theory, and building a model/framework. Development of knowledge is a fundamental paradigm of research that develops scientific theories to explain natural phenomena, and critically discusses and questions those theories. *A theory is a system of ideas for explaining something* (Fellows and Liu, 2008) which can be tested (corroborated or falsified) by empirically evaluating a scientific hypothesis deduced from the theory. Researchers build a model to show how the variables of a theory interact in a particular situation hypothesized, or develop, modify and validate a theoretical framework for providing both the adopted views/ideas and the approach to questioning and discovery.

In this research, a methodology is designed and employed to explain and solve issues and problems related to the real life. Specifically, an applied framework is conceptualized, developed, and validated for offering an adoptable tool to support a process of the planning practice. In view of the nature of the methodological paradigm, empirical methods/approaches commonly used in the social sciences such as surveys, case studies, and experiments, are inevitably applied to the research.

To fill the gaps identified by the literature review in the previous two chapters, this research aims to quantitatively analyze and support the decision-making process in a subject highly related to the social sciences – urban land use planning, in which the qualitative description of planning issues is indispensable to reflect the planning goals of social interests. Therefore, a mixed research methodology including both quantitative and qualitative methods is needed for the research.

Respective attributes of qualitative and quantitative research paradigms were summarized by Cook and Reichardt (1979) (Table 4.1). According to this attribute summary, qualitative research is a subjective, exploratory, process-oriented research methodology, which was employed to collect expert opinions through interviews and narrative description; meanwhile, quantitative research is good at objective, confirmatory, outcome-oriented measurement, and it was applied to quantitatively assessing land-use suitability and testing the effectiveness of the framework by conducting experiments and feedback surveys.

Table 4.1 Attributes of qualitative and quantitative paradigms
(source: Cook and Reichardt, 1979)

Qualitative Paradigm	Quantitative Paradigm
Advocates the use of qualitative methods	Advocates the use of quantitative methods
Phenomonologism and verstehen; "concerned with understanding human behavior from the actor's own frame of reference"	Logical-positivism; "seeks the facts or causes of social phenomena with little regard for the subjective states of individuals"
Naturalistic and uncontrolled observation	Obtrusive and controlled measurement
Subjective	Objective
Close to the data; the "insider" perspective	Removed from the data; the "outsider" perspective
Grounded, discovery-oriented, exploratory, expansionist, descriptive, and inductive	Ungrounded, verification-oriented, confirmatory, reductionist, inferential, and hypothetico-deductive
Process-oriented	Outcome-oriented
Valid; "real, rich, and deep" data	Reliable; "hard", replicable data
Ungeneralizable; single case studies	Generalizable; multiple case studies
Holistic	Particularistic
Assumes a dynamic reality	Assumes a stable reality

In terms of qualitative data collection, the types of data involved in data collection procedures are listed in Table 4.2, and the advantages as well as limitations of different collection types are also indicated (Creswell, 2003). In this research, two types of qualitative data collection were adopted: interviews and documents. With reference to the advantages and limitations of certain data collection types given in Table 4.2, interviews and documents can provide researchers with firsthand, time-series, and thoughtful information without much time and money for transcribing; however, they fail to deal with some probable problems that are born with qualitative research such as response bias, unequal perceptions from people, long time for communicating with interviewees and searching for useful documents, and inaccurate information collection.

Table 4.2 Qualitative data collection types, options, advantages, and limitations
(source: Creswell, 2003)

Data Collection Types	Options Within Types	Advantages of the Type	Limitations of the Type
Observations	• Complete participant: researcher conceals role • Observer as participant: role of researcher is known • Participant as observer: observation role secondary to participant role • Complete observe: research observes without participating	• Researcher has a firsthand experience with participants • Research can record information as it is revealed • Unusual aspects can be noticed during observation • Useful in exploring topics that may be uncomfortable for participants to discuss	• Researcher may be seen as intrusive • 'Private' information may be observed that the researcher cannot report • Researcher may not have good attending and observing skills • Certain participants (e.g. children) may present special problems in gaining rapport
<u>Interviews</u>	• Face-to-face: one on one, in-person interview • Telephone: researcher interviews by phone • Group: researcher interviews participants in a group	• Useful when participants cannot be observed directly • Participants can provide historical information • Allows researcher 'control' over the line of questioning	• Provides 'indirect' information filtered through the views of interviewees • Provides information in a designated 'place' rather that the natural field setting • Researcher's presence may bias responses • People are not equally articulate and perceptive
<u>Documents</u>	• Public documents such as minutes of	• Enables a researcher to obtain the language and	• May be protected information unavailable

	meetings, and newspapers • Private documents such as journals, diaries, and letters • Email discussions	words of participants • Can be accessed at a time convenient to the researcher – an unobtrusive source of information • Represents data that are thoughtful, in that participants have given attention to compiling • As written evidence, it saves a researcher the time and expense of transcribing	to public or private access • Requires the researcher to search out the information in hard-to-find places • Requires transcribing or optically scanning for computer entry • Materials may be incomplete • The documents may not be authentic or accurate
Audiovisual materials	• Photographs • Videotapes • Art objects • Computer software • Film	• May be an unobtrusive method of collecting data • Provides an opportunity for participants to directly share their 'reality' • Creative in that it captures attention visually	• May be difficult to interpret • May not be accessible publicly or privately • The presence of an observer (e.g. photographer) may be disruptive and affect responses

Note: 'Interviews' and 'Documents' are two main qualitative data sources in the research.

In contrast, quantitative research can provide confirmatory measurements/ratings for research objects without the subjective influence from investigators or respondents. It seems to be good news for confirmatory research that concludes with measuring or rating results of research questions. However, quantitative research cannot help solve such problems relating to psychological activities. For example, social sciences cannot only be explained by quantitative measurements, but also qualitative narration of people's perception. In regard to this research, a quantitative and objective method is designed to support a qualitatively oriented planning process. Apparently, either one of the two types of research methodologies cannot solely achieve the research aim. To successfully address the research question and aim, a mixed research methodology including both quantitative and qualitative methods should be adopted and elaborately designed. Table 4.3 shows the procedures of data collection and analysis in the three types of research methodologies: qualitative, quantitative, and the mixed.

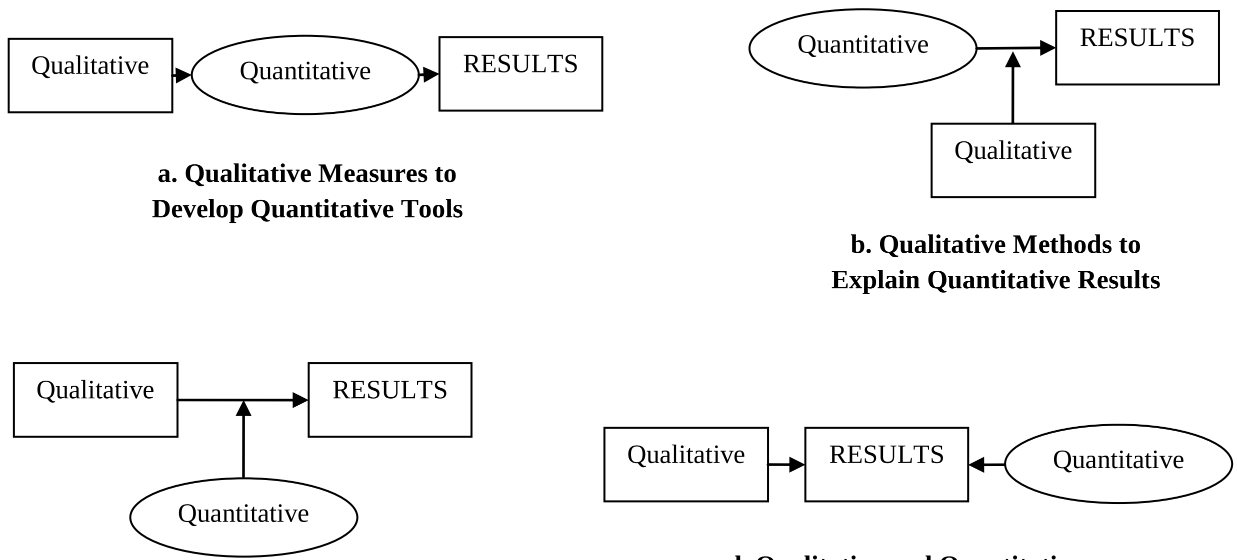
Table 4.3 Qualitative, quantitative, and mixed methods procedures
(source: Creswell, 2003)

Qualitative Research Methods	**Quantitative Research Methods**	**Mixed Research Methods**
• Emerging methods • <u>Open-ended questions</u> • <u>Interview data, observation data, document data, and audiovisual data</u> • Text and image analysis	• Predetermined • Instrument based questions • <u>Performance data, attitude data, observational data, and census data</u> • <u>Statistical analysis</u>	• Both predetermined and emerging methods • <u>Both open- and close-ended questions</u> • Multiple forms of data drawing on all possibilities • <u>Statistical and text analysis</u>

Note: items underlined indicate the procedures involved in the research.

4.2.2 Methodological Strategy of the Research

Qualitative research and quantitative research can be combined in different forms according to varied research targets. For instance, in qualitatively dominant research, quantitative methods are usually used to enrich and complement the qualitative descriptions with solid numeric data; in quantitatively dominant research, qualitative methods are often adopted to collect empirical data and explain the results of quantitative analysis; in equivalent/paralleled research, the two methods are equally and simultaneously employed to produce the mixed results. Figure 4.1 illustrates four scenarios for a combination of qualitative and quantitative methods.



a. Qualitative Measures to Develop Quantitative Tools

b. Qualitative Methods to Explain Quantitative Results

c. Quantitative Methods to Enlarge on Qualitative Studies

d. Qualitative and Quantitative Methods Equal and Parallel

Figure 4.1 Four scenarios for combination of qualitative and quantitative methods
(source: Tashakkori and Teddlie, 1998)

Specifically, combination scenarios a and c are useful for this research. Land use planning is a qualitatively based decision-making process. In that context, scenario a – ‘quantitative tools are developed in qualitative analysis processes’ was followed to build a land-use suitability model to quantitatively assess site suitability in the planning process; and scenario c – ‘quantitative methods to complement qualitative analysis’ was represented by using a quantitative land-use suitability model to facilitate and support the qualitatively oriented decision-making process of land use planning.

In terms of specific methods for both research methodologies, Creswell (2003) gave a roadmap for method/approach selection in qualitative, quantitative, and mixed research (Table 4.4). With reference to the roadmap, this research adopted both proper qualitative and quantitative approaches to form a mixed research rationale, which includes both qualitative data collection methods such as interviews, open-ended questions, and case study, and quantitative data collection methods such as surveys, closed-ended questions (numeric data), and experiments. The methods of data analysis in the research were also determined based on the research objectives and by referring to the approach selection guide. They included participants' view collection, research findings validation in the qualitative part; variables identification, numeric information measurement, and statistical analysis in the quantitative part.

Table 4.4 Qualitative, quantitative, and mixed research approaches
(source: Creswell, 2003)

Tend to or Typically	Qualitative Approach	Quantitative Approach	Mixed Research Approach
Use these philosophical assumptions, or Employ these strategies of inquiry	• Constructivist/advocacy/ participatory knowledge claims • Phenomenology, grounded theory, ethnography, case study and narrative	• Postpositivist knowledge claims • Surveys and experiments	• Pragmatic knowledge claims • Sequential, concurrent, and transformative
Employ these methods	• Open-ended questions, emerging approaches, text or image data	• Closed-ended questions, predetermined approaches, numeric data	• Both open- and closed-ended questions, both emerging and predetermined approaches, and both qualitative and quantitative data and analysis
Use these practices of research, as the researcher	• Positions himself or herself • Collects participant meanings • Focuses on a single concept or phenomenon • Brings personal values into the study • Studies the context or setting of participants • Validates the accuracy of findings • Makes interpretations of	• Tests or verifies theories or explanations • Identifies variables to study • Relates variables in questions or hypotheses • Uses standards of validity and reliability • Observes and	• Collects both qualitative and quantitative data • Develops a rationale for mixing • Integrates the data at different stages of inquiry • Presents visual pictures of the procedures in the study • Employs the practices

	the data • Creates an agenda for change or reform • Collaborates with the participants	measures information numerically • Uses unbiased approaches • Employs statistical procedures	of both qualitative and quantitative research

Note: items underlined highlight the approaches involved in the research.

4.3 Research Methods Adopted

4.3.1 Document Analysis

Document analysis is one kind of archival research, in which the data sources are various types of documentation. Archival research is *any research in which a public record is the unit of analysis* (Dane, 1990). It attempts to interpret the phenomena or problems stemming from people's activities by investigating a portion of the continuously recorded information they create. Systematic archival research can be classified into two categories: content analysis and existing data analysis. In content analysis, any communication medium such as written materials, pictures, and audiovisual records may be involved. A formal definition of content analysis is *a research method used to make objective and systematic inferences about theoretically relevant messages* (Dane, 1990). Similarly, document analysis is also an important research method in social studies, in which documentary works contain all kinds of written/visual documents such as personal biographies, corporation/community yearbooks, and official documents which relate to some certain issues of society.

In the research, documents to be analyzed mainly referred to official documents issued in Hong Kong including relevant policies on land use and urban development, land use administrative regulations, and planning standards and guidelines. Document analysis was used to investigate existing problems in the planning practice, investigate the land use mechanism and problems in practice, and help identify key factors/criteria affecting decision-making in land use/urban planning. It mainly served as a qualitative research method here.

4.3.2 Expert Interview

An interview can be described as a conversation with a purpose (Bingham and Moore, 1924). Dane (1990) defined an interview as *a structured conversation used to complete a survey*, in which the survey devises the structure of the conversation with the purpose of data collection. It can be conducted in different ways, such as face-to-face interviews, telephone interviews, and mail surveys. When the inquiries/questions regarding the research topic are addressed, a well-structured interview is one of the most effective ways to collect firsthand data if only interviewees can respond based on an accurate understanding of the questions. Among the various interview types, expert interviews, in which the interviewees are experts or experienced practitioners within the research areas, is an effective and widely used means to directly collect the in-depth, practical and up-to-date information.

“Experts” in the research referred to experienced planning practitioners in land use planning. In-depth interviews were conducted in face-to-face form and supplemented with telephone or email. The method of expert interview was used to adjust and finalize the key factors/criteria which were tentatively identified by literature review and document analysis, and discover practical problems existing in current planning processes. It was also adopted as a qualitative research method here.

4.3.3 Focus Group Meeting

In another name, focus group interview is defined by Khan and Manderson (1992) as follows: a qualitative method *with the primary aim of describing and understanding perceptions, interpretations, and beliefs of a select population to gain understanding of a particular issue from the perspective of the group's participants*. Usually, a focus group is comprised of six to ten people who are all familiar with the research topic and who come from similar social and educational backgrounds or have similar experiences or concerns regarding the research problems. They gather to discuss specific issues and collaboratively conclude their answers to the predetermined questions with the assistance of a moderator/facilitator. The moderator must make sure that every participant feels comfortable to engage in the dynamic discussion and the meeting should not last more than two hours in principle (Liamputtong and Ezzy, 2005). Like focused interviews, in which interviewers mainly put a few predetermined questions to discuss but ask interviewees follow-up questions with considerable flexibility, focus group meeting is typically used when several respondents (who are chosen as the qualified representatives) consist of a specific group for the sake of collecting group decisions/opinions concerning the research problems. The primary goal of a focus group meeting is to acquire information about the subjective judgments/perceptions of respondents.

In short, focus group meeting is a useful research tool when the researcher needs more in-depth information or common perceptions from the participants. The most important feature of focus groups could be that the group discussion relies on the interaction between participants and the results of the discussion are obtained based on the consensus/common view of the group members. In this research, two separate focus group meetings were conducted for different purposes. One focus group which is composed of planning stakeholders (i.e. planners, developers and residents) aimed to determine the weightings of criteria finalized by expert interviews with the help of AHP method, and verify the rating standards of each criterion; the other focus group (like an experience workshop) in which the participants are all experienced urban planners or planning practitioners in Hong Kong was used to validate the effectiveness of the GIS-based framework through a feedback survey which was completed together by the group members at the end of the workshop. This research method was employed to gather the subjective perceptions/judgments from focus groups with the form of quantifiable scaling.

Sometimes, one issue with respect to expert interview and focus group meeting may be how many participants should be involved in expert interviews and focus group meetings to ensure the reliability of the results. Liamputtong and Ezzy (2005) clarified this issue as follows. When researchers feel satisfied that, the data collected from the participants are rich enough and can cover all of the dimensions they are concerned, the sample could be large enough. In other words, the number of participants is less important than the richness of the data, and the sample will be large enough when it can support the expected analyses with sufficient data.

4.3.4 Case Study

Case study is a valuable research method, which can accommodate many kinds of investigations and has been widely used since its flexible applicability is gradually recognized by researchers (Tellis, 1997a). It is usually employed in combination with other research methods, such as archival analysis, interviews, and survey. Case studies emphasize detailed contextual analysis of a limited number of events or situations and their relationships instead of the conceptual or theoretical studies on the unlimited conditions (Soy, 1997). Zonabend (1992) stated that case studies are designed for paying attention to typical cases to represent and practise the context of complete study by observing, reconstructing, and analyzing the cases adopted. On the other hand, they are designed to bring out the details from the in-depth investigations with a full circle on the selected cases by using multiple sources of data (Tellis, 1997b). According to Yin (1994), normally, case study has four stages: 1) design the case study, 2) conduct the case study, 3) analyze the case study evidence, and 4) develop the conclusions, recommendations and implications, and he also identified three types of case studies: exploratory, explanatory and descriptive.

As a research tool, case study was used in the research to practically develop the framework consisting of two major components: a model and a database, based on the structure of the framework conceptualized previously. Basically, this one can be categorized into exploratory case studies. Actual data and practical concerns were involved in the case study, which aimed to present the whole research process of a real case and validated the viability of the framework. In fact, the case study mingled with some other specific methods including expert interview, focus group meeting, and document analysis.

4.3.5 Experimental Study

According to Dane (1990), experimental research is *the general label applied to methods developed for the specific purpose of testing causal relationships*, and it is the only way to directly test causal-effect hypotheses. Specifically, researchers use this method to test research hypotheses concerning cause-effect relationships posed by themselves. In general, causal-effect analysis contains three elements: temporal priority, control over variables, and random assignment, which combine together to achieve hypotheses test. In the research, experimental study was used to test a research hypothesis that is associated with a causal-effect relationship: the proposed framework providing planning support is the reason for better feeling and performance of planning practitioners (participants in the experiment) during the decision-making process. Specifically, two experiments were designed to help participants perceive the differences between the two kinds of planning processes. This research method was applied to the validation of the research framework, and questionnaire survey was combined to collect feedback from the experimental participants for quantitative and qualitative analysis. The details are discussed in Chapter 7 – Framework Validation.

4.3.6 Questionnaire Survey

Survey research is in a universal form in which respondents are asked questions directly. In other words, it aims to obtain information directly from a group of individuals by posing questions. The questions may be raised in an interview or listed in a questionnaire (Dane, 1990). In questionnaire surveys, normally, participants are asked to complete a questionnaire through answering questions. Mostly, questionnaire survey is employed to collect quantitative data (numeric information) scaled by respondents, and the data can be used for statistical analysis later. In the research, this research method was applied to collecting the feedback of experimental participants on the PSS-supported process for the quantitative and qualitative analyses. One questionnaire survey was conducted at the end of each experimental study, and it served as a tool for feedback collection from the participants to fully validate the research framework.

4.4 Summary of the Chapter

This chapter describes and justifies the design and methodology of the research, which are applied to achieving the research objectives introduced in Chapter 1. A mixed methodology is carefully designed for the research by combining both qualitative and quantitative methodologies. Six specific research methods, including document analysis, expert interview, focus group meeting, case study, experimental study, and questionnaire survey are adopted and well organized to accomplish the aim of this research.

Chapter 5 Structure of the Framework

5.1 Introduction

In this chapter, the framework which can be treated as a prototype of one sort of planning support systems, in essence, an integrated approach to supporting land use planning (site-level) is conceptualized to improve the application of PSS. This framework is systematically comprised of two major components, a planning support model and its associated land information database, which enables planners to easily understand the rationale and encourages them to follow the framework as a guideline for sustainable land use planning in urban developed areas/urban renewal projects.

To ensure that the framework can work for sustainable land use planning, sustainability considerations in planning are discussed. Based on theories and existing studies on sustainability indicators and site planning (analysis), general criteria for LUSA in site planning and land information required for planning preparation are identified in the chapter.

5.2 How the Framework Works in Dynamic Planning

Planning should be a dynamic process. Three phases of dynamic planning were defined and depicted in Lennertz and Lutzenhiser (2006). Phase one: Research, education, charrette preparation. This phase aims to establish the information and people infrastructure for a planning project. Information infrastructure includes all base data necessary to perform project planning and design during the charrette and people infrastructure contains people whose involvement is necessary to produce a feasible outcome that will be supported by the community. The land information database of this framework can provide base data for charrette preparation. Phase two: Launching the charrette. It plays a catalytic role in the dynamic planning process. The objective of the charrette is to generate a feasible plan that benefits from the support of all stakeholders through its implementation. A multidisciplinary charrette team, consisting of consultants (specialists) and sponsor staff, produces the plan. A charrette is regarded as the process of decision-making in planning projects here, and this framework can support the decision-making process. Phase three: Plan implementation. It is not the end when a 4-7 day charrette finishes. Two major processes still follow the charrette. One of them is product refinement, during which the charrette team tests and refines the final plan to make sure it is feasible and efficient. The other is that the project sponsor continues to work with the stakeholders to maintain their support of the plan. Usually no more than 4 or 6 weeks after the charrette, the dynamic planning process completes with a post-charrette public consultation, during which the refined plans are presented for collecting final public review and comments. This framework can also improve the process of public engagement by facilitating the other stakeholders/the public to fully understand the reasons of planning decisions made by planners.

True collaboration requires that participants are asked for their input before the design work begins because their contributions will have an impact on the outcome (Lennertz and Lutzenhiser, 2006). In the stage of charrette preparation, the project sponsors need to ensure that the plan would be feasible in terms of financial and engineering, and appropriate for future development. This requires the collection and analysis of base data necessary to provide the charrette team with the detailed information required for feasibility tests. Normally, the base data include transportation and economic existing conditions as well as analyses of the site and its subsurface condition. A marketing study specially determines the demand for housing, retail, and other uses on the site. In this research, a framework including a general list of factors affecting the feasibility analysis of the site and the data sources of required information as well as the procedure of data processing aims to facilitate the process of charrette preparation.

Although producing a feasible plan is one of the most important strategies of dynamic planning, further testing and refinement of the plan are also required in the whole planning process before it can be finalized. At the implementation stage, a follow-up meeting for public consultation is usually held one month after the charrette. During this meeting, amendments in the plan and the revised version are presented and further input from the public was collected and about to be incorporated into the final plan. The level of the public understanding on the charrette plan to a large extent impacts the effectiveness of the plan implementation. This proposed framework can, on the one hand, support planners in making land-use decisions by providing comprehensive and quantitative LUSA; on the other hand, assist the public (the other stakeholders) in understanding the plan from the perspective of a layman by providing a set of well-explained factors which are usually considered in land use planning and showing the decision-making process of the expert group/charrette.

5.3 Sustainability in Planning

5.3.1 Sustainability and Environment

"Environment" is one element of the Three Es (Environment, Economy, and Equity) as increasing concerns on environmental protection have been highlighted since the last century, such as air and water quality, chemical hazards, energy use, environmental justice, urban growth, and global climate change. In terms of planning practice, incorporating environmental goals with planning activities implies that plans are made based on as many considerations as possible about local ecosystems and their environmental laws and regulations, as well as environmental planning tools such as Environmental Impact Assessment, ecological planning and restoration. In respect of urban development, environmental principles associated with sustainability include compact urban form, transit-oriented development, close-loop resource cycles, environmental justice, pollution prevention, and the restoration of streams, coastlines, habitat, visual corridors, and other ecosystem components within cities (Wheeler, 2004).

5.3.2 Sustainability and Economics

From a sustainable point of view, a market-based economic system can be regarded as a sustainable way of economic development for it is good at regulating market demand and supply, allocating all kinds of resources, and providing incentives for entrepreneurship and innovation. However, market-based capitalist economics has some drawbacks from a sustainability perspective, such as difficulties in valuation for public goods and examination for externalities which are highly related to social and environmental impacts of production and consumption, inflation discounting the future, concentration of wealth and monopoly of power undermining social equity, and continuous expansion in material consumption conflicting with the environmental notion of “limit” (Wheeler, 2004). Environmental economics was proposed in the 1970s to reconcile environmental and economic goals, aiming to use economic measures to reduce pollution, resource consumption, and other environmental impacts of production. Furthermore, ecological economics can be seen as a more fundamental reform within the field of economics that observes a larger context of ecological interactions with economic activities using economic tools and the language of neoclassical economics. In addition to environmental concerns, other economic approaches such as local self-reliance and socially/collectively responsible investment are incorporated into economic mechanisms to improve social sustainability. In the long run, changes and adjustments in economic values and processes are necessary to accommodate environmental and equity goals (Wheeler, 2004). It is still a long journey to reach a better balance with other two Es and simultaneously motivate an efficient growth-oriented economy without displacing values of environmental protection and social equity.

5.3.3 Sustainability and Equity

Social equity is by far the least well-developed and the farthest from sustainability amongst the three Es (Wheeler, 2004). Unlike concerns laid on environmental or economic development, equity goals are often neglected and poorly understood by decision-makers. Under this circumstance, equity concerns usually take a back seat in planning and administrative discussions. In general, growing imbalance in resource occupancy between rich and poor communities is a prominent case which has become the root of social disparities. To improve the living condition of poor communities, more resources are needed to provide social services for vulnerable groups, repair ageing infrastructure, and deal with problems happening in urban renewal projects such as brownfield treatment, provision of affordable housing, and distribution of public transportation. The imbalance in resource occupancy is a contradiction inevitably existing in social development. In terms of planning processes, another inequity, that some lower-income or minority groups have not been thoroughly involved in public participation/consultation, occurs in the public decision-making stage. In short, the biggest question of promoting social equity is how to advance equity objectives while the political and economic leadership is not paying enough attention to them.

5.4 Process of Structuring the Framework

5.4.1 Planning Support Model

To make a feasible plan for future land use, a SWOT analysis (e.g. strengths, weaknesses, opportunities and threats) is often performed in the planning project. In the SWOT analysis, the project is usually examined by categories such as site, transportation, economics/market, politics, environment and design (Lennertz and Lutzenhiser, 2006). It means that planners need to take into consideration the internal and external conditions of the planning project from these perspectives. However, SWOT analysis inherently lacks quantitative information in comprehensive examination of conditions of the project (Kurttila et al., 2000). One of the limitations of traditional SWOT analysis is that, any one element in the four, for example, the strengths may be overestimated over the other three. That may lead to overestimations or neglects of major considerations in the feasibility analysis of the planning project. Therefore, a quantitative approach to synthetically examining the planning project (e.g. urban renewal projects) with multiple considerations in SWOT analysis is necessary for supporting decision-makers to make more accurate and reasonable choices.

Analytic hierarchy process (AHP) is an effective method to quantify the importance of all considerations. It is a mathematical method for analyzing complex decision problems with multiple criteria (Kurttila et al., 2000). Like the planning process, many factors affecting the feasibility of a plan should be examined at the same time, and a final decision needs to be made based on the comprehensive assessment of the multiple criteria. AHP was originally created by Satty (1980), and initially stemmed from mathematics and psychology. Afterwards, due to the strength in dealing with quantitative attributes as well as qualitative ones, AHP has been widely used in all kinds of decision situations, such as business, government, medicine, and education. In this model, AHP is employed to determine the relative importance (weightings) of each factor affecting planning decision-making.

5.4.1.1 Criterion Identification

Identifying the criteria for LUSA in sustainable site planning is the first step in model development. In fact, one criterion can be regarded as one affecting factor considered in the decision-making process. When the model is practically developed, the criteria should be identified based not only on existing literature from planning theories, but also on expert interviews from planning practice.

Criteria equaling to factors or indicators, refer to a set of key factors affecting decision-making in the planning process. As indicators for urban planning described in Wong

(2006), indicators/criteria play an important role in the measurement and quantitative analysis in the planning fields. The relationship between planning theory, measurement and policy-making was described as a tangled triangle. That means there is a close tie among the three items: the measurement should be guided by theories and the indicators are developed to achieve the quantitative or qualitative measurement for facilitating policy-making. For example, a study aiming at tackling the problems encountered in local economic development (LED) decisions provided a list of key factors considered to be important to LED (Table 5.1) (Wong, 1998).

Table 5.1 Key factors of local economic development
(source: Wong, 1998)

Traditional Factor	• Physical Factors • Location • Human Resources • Finance and Capital • Infrastructure • Knowledge and Technology • Industrial Structure
Intangible Factor	• Institutional Capacity • Business Culture • Community Identity • Quality of Life

In terms of sustainability indicators, Ambiente Italia (2003) identified ten common local sustainability indicator groups by integrating local actions into sustainability measurement (Table 5.2). In fact, the interpretation of sustainability at the local level (small-scale) is quite different from the large-scale sustainability analysis. For local communities, it is much more difficult to measure and relate social attributes (e.g. local employment demand), environmental concerns (e.g. local air quality), and abstract perceptions like aesthetics to the concept of sustainability.

Table 5.2 The European common sustainability indicator groups
(source: Ambiente Italia, 2003)

No.	Indicator Group
1	Citizen satisfaction with the local community
2	Local contribution to global climate change
3	Local mobility and passenger transportation
4	Availability of local public open areas and services
5	Quality of local air
6	Children's journeys to and from school
7	Sustainable management of the local authority and local businesses
8	Noise pollution
9	Sustainable land use
10	Products promoting sustainability

Normally, neighborhood planning and site planning can be regarded as the two smallest-scale land use planning. There is no strict definition for "Neighborhood". In respect of acreage, it may be larger or smaller. But typically the term refers to a relatively small area where residents can easily travel around on foot, and such an area has its unique characteristics of society, economy, architecture, history, or physical condition so as to be distinguished from surrounding neighborhoods. Within neighborhoods, small-scale planning or design decisions such as the width and layout of streets, the size of blocks, the mix of land uses, and the location of public services have great influences on urban livability and sustainability (Wheeler, 2004). With respect to sustainability, certain planning issues which are particularly important at the neighborhood scale, such as compact and mixed land uses, mix of jobs and housing, integration of public transit, and preservation of natural features and historical structures are often faced in such kind of planning.

To be more detailed, site planning represents the smallest scale of urban development controlled by the corresponding planning. Lynch (1971) gave a definition of site planning as follows: *Site planning is the art of arranging the external physical environment to support human behavior. It lies along the boundaries of architecture, engineering, landscape architecture, and city planning, and it is practiced by members of all these professions. Site plans locate structures and activities in three-dimensional space and, when appropriate, in time.* It is an active domain overlapping with planning, design/architecture and engineering, in which the outcomes of design decisions of site and building are directly experienced by people every day. At the site level, the concern regarding sustainability emphasizes "design with nature", that raises some issues in sustainable site design including how development affects the landscape, how it influences the neighborhood interaction, and how it affects the daily lives of residents (Wheeler, 2004). In this research, land use planning refers specifically to site planning because land-use decisions are made for site redevelopment, in other words, LUSA is conducted for sites to be reused in urban renewal projects.

In Wheeler (2004), the role of planning and the relationship between planning and sustainability were discussed. Generally, the word "Planning" refers to a wide range of systematic activities designed to make sure that goals can be achieved. These goals may include urban development, environmental protection, forms of economic activity, social justice, and many other expectations consisting of the sustainability. According to the theory of sustainability planning, five elements of the approach to sustainability planning are: 1) A long-term perspective, 2) A holistic outlook, 3) Acceptance of limits, 4) A focus on place, and 5) Active involvement in problem-solving.

At the site level of land use planning, neighborhood development is highly related to planning implementation. According to LEED rating system for neighborhood development (USGBC, 2009a), indicators for assessing the sustainability of neighborhood development are listed in Table 5.3. From the viewpoint of buildings on the site, LEED rating systems also provided two sets of indicators for rating green/sustainable buildings, one for new construction and major renovations (USGBC, 2009b) and the other for existing building maintenance (USGBC, 2009c) (Table 5.4 and 5.5).

Table 5.3 Sustainability indicators for neighborhood development
(source: USGBC, 2009a)

Smart Location and Linkage	Smart location	*Prerequisite*
	Imperiled species and ecological communities	*Prerequisite*
	Wetland and water body conservation	*Prerequisite*
	Agricultural land conservation	*Prerequisite*
	Floodplain avoidance	*Prerequisite*
	Preferred locations	-
	Brownfield redevelopment	-
	Locations with reduced automobile dependence	-
	Bicycle network and storage	-

	Housing and jobs proximity	-
	Steep slope protection	-
	Site design for habitat or wetland and water body conservation	-
	Restoration of habitat or wetlands and water bodies	-
	Long-term conservation management of habitat or wetlands and water bodies	-
Neighborhood Pattern and Design	Walkable streets	*Prerequisite*
	Compact development	*Prerequisite*
	Connected and open community	*Prerequisite*
	Mixed-use neighborhood centers	-
	Mixed-income diverse communities	-
	Reduced parking footprint	-
	Street network	-
	Transit facilities	-
	Transportation demand management	-
	Access to civic and public spaces	-
	Access to recreation facilities	-
	Visitability and universal design	-
	Community outreach and involvement	-
	Local food production	-
	Tree-lined and shaded streets	-
	Neighborhood schools	-
Green Infrastructure and Buildings	Certified green building	*Prerequisite*
	Minimum building energy efficiency	*Prerequisite*
	Minimum building water efficiency	*Prerequisite*

	Construction activity pollution prevention	*Prerequisite*
	Building energy efficiency	-
	Building water efficiency	-
	Water-efficient landscaping	-
	Existing building reuse	-
	Historic resource preservation and adaptive use	-
	Minimized site disturbance in design and construction	-
	Stormwater management	-
	Heat island reduction	-
	Solar orientation	-
	On-site renewable energy sources	-
	District heating and cooling	-
	Infrastructure energy efficiency	-
	Wastewater management	-
	Recycled content in infrastructure	-
	Solid waste management infrastructure	-
	Light pollution reduction	-
Innovation and Design Process	Innovation and exemplary performance	-
	LEED accredited professional	-
Regional Priority Credit	Regional priority	-

Table 5.4 Indicators for sustainable sites in new construction and major renovations
(adapted from USGBC, 2009b)

Sustainable Sites	Construction activity pollution prevention	*Prerequisite*
	Site selection	-

	Development density and community connectivity	-
	Brownfield redevelopment	-
	Alternative transportation – Public transportation access	-
	Alternative transportation – Bicycle storage and changing rooms	-
	Alternative transportation – Low-emitting and fuel-efficient vehicles	-
	Alternative transportation – parking capacity	-
	Site development – protect or restore habitat	-
	Site development – maximize open space	-
	Stormwater design – Quantity control	-
	Stormwater design – Quality control	-
	Heat island effect – Nonroof	-
	Heat island effect – Roof	-
	Light pollution reduction	-

Note: only the first section – "Sustainable sites" is listed here.

Table 5.5 Indicators for sustainable sites in existing building maintenance
(adapted from USGBC, 2009c)

Sustainable Sites	LEED certified design and construction
	Building exterior and hardscape management plan
	Integrated pest management, erosion control, and landscape management plan
	Alternative commuting transportation
	Site development – Protect or restore open habitat
	Stormwater Quantity control
	Heat island reduction – Nonroof
	Heat island reduction – Roof

	Light pollution reduction

Note: only the first section – "Sustainable sites" is listed here.

According to the planning factors normally considered in site analysis and existing sustainability indicators given in the above literature, a general list of criteria for land-use decision-making in site planning is identified to assess land-use suitability and measure the sustainability of certain land use (Table 5.6).

Table 5.6 Criteria for land-use decision-making in site planning

Category	**Sub-category**	**Criterion**
Environmental/ Ecological	Vegetation	Vegetation rate
	Environmental indicators	Local air quality
		Local water quality
		Noise pollution
		Light pollution
Social	-	Local population
	-	Local employment
	-	Neighborhood identity
Economic	-	Local GDP
	-	Property values
	-	Rents
Political/Legal	Property legality	Political boundaries
		Land ownership
		Easements and deed restrictions
	Land use regulations	Statutory requirements for development
Utilities/	Land use	Former land uses

Accessibility (locational)		Current land uses
		Neighboring land uses
	Transportation	Road network
		Traffic volume
		Internal circulation
	Service utilities	Access to major living services (e.g. transport hub, medical center, open space)
		Utilities for basic housing (e.g. sewer, electric, gas)
Cultural/Historic	Sensory satisfaction	Aesthetics
		Visibility
		Visual quality
		Odors
	Historical features	Heritage landmarks
	Local built environment	Architectural/landscape uniqueness
Physical	Topography	Elevation
		Slope gradient
		Slope aspect
	Climate	Solar access
		Wind direction
	Geology	Terrain
		Seismic hazards
		Landslide hazards

Note: criterion categories underlined contain sustainability criteria.

5.4.1.2 Weighting Determination

Weightings of each criterion are determined by using the AHP method, and importance scores (the weightings) are automatically calculated in a software toolkit developed on the principle of AHP theory. AHP is a powerful and commonly used tool for decision-making in land use suitability issues, involving social, environmental and economic factors (Jafari and Zaredar, 2010). In combination with GIS technology, the Spatial AHP (SAHP) method was introduced for spatial multi-criterion analysis and has become a new feature in LUSA. AHP has several advantages over conventional LUSA techniques (Mendoza, 1997). Firstly, it relies less on the completeness of the data, and more on expert opinions or preferences concerning the factors of land suitability. Secondly, it allows both planners and the other stakeholders to provide their views in making land use suitability measurements. Without the AHP method, the land suitability mapping technique cannot incorporate the preferences and considerations of different stakeholders. Thirdly, it is more transparent and more likely to be accepted, especially when the results of LUSA serve as a reference to land use decisions in practice.

To achieve this process, a focus group meeting (like a charrette) is conducted to collect the opinions of decision-makers. The focus group consists of six to ten stakeholders of specific land use planning (e.g. urban planners, land developers, and surrounding residents). During the meeting, the comparison matrices used in the AHP process are filled up according to the views of the focus group rather than individual participants of the group. This process reflects and improves collaborative/participatory planning by involving different stakeholders in decision-making. The details are depicted in the next chapter.

5.4.1.3 Rating Standard Formulation

Even though criteria and their weightings are ready, a complete assessment cannot be achieved without rating standards. In this model, the rating standards are formulated on the basis of planning standards, land development regulations and expert opinions, and are verified by the focus group of decision-making stakeholders according to the specific planning projects. The approach of multi-criterion evaluation/decision analysis (MCE/MCDA) is applied in the whole process of LUSA. Detailed information is found in the next chapter.

5.4.2 Land Information Database

When the planning support model is built, base data/information associated with the categories in the model need to be gathered and prepared prior to the comprehensive analysis. Here the database is digitally built in "ArcGIS" with the form of "Geodatabase".

5.4.2.1 How is information involved

As the information collected during planning processes is the basis of decision-making and actions, the complete process of information which complements and supports such planning activities contains three phase: Collection, Storage and Retrieval, and Analysis. The first step is collecting all kinds of information required. One important issue in this stage is to make sure that all collected information can be translated into a comprehensible, transmissible and transferable form. This is because one most adapted form/format of collected information needs to be chosen when the information is linked and coordinated with the others as well as the other phases of data processing. The second step is establishing an environment to store and retrieve information. To efficiently make use of information, it must be kept with a ready accessibility. A database is usually used to keep such information with the help of computer technology. Even though too much information is involved in planning tasks, in particular, every piece of information can still be identified and retrieved in a quick response. The third step is analyzing and interpreting information for providing references to decision-making. Information is gathered ultimately for assisting and advancing people's understanding on certain problems/issues.

In terms of urban planning, four steps are included in the planning process: setting a goal, proposing standards, providing a design and implementation. Firstly, the goal of planning is the spirit of these planning activities. No matter which level of the goal is, such as national goal, local goal, it can only be turned into reality by setting the holistic goal into specific standards. Secondly, standards in planning are a series of specific statements of planning conditions/requirements which a region or a city (local level) adopts. The local standards need to be translated into a program/formula of urban development by virtue of a design. Thirdly, to achieve the planning standards in practice, a detailed design for tomorrow's city needs to be provided. The design is both spatial/visual and functional, defining and showing what the city will look like and how it will work. Design is also a process of action involving three necessary steps: 1) building a model comprised of realistic standards, 2) paying attention to the construction and application in detail, and 3) design evaluation (Campbell and LeBlanc, 1967). Lastly, implementation is the final stage of the whole process of planning. Any design can only be beneficial to society if it can well be put into effect. In practice, implementation is an administrative process in which planners convince different stakeholders of their plans and work with political leaders to achieve the planning goals.

When the processes of data processing and planning are figured out and prepared, a process of database establishment for planning information will be worked out. Three steps are involved in this process: specifying data required, associating the data with specific methods of data processing, and evaluating the practicability and applicability of the database. The three steps look like a simple procedure composed of the three sequential stages, however, the steps are intercrossed by each other and each step may be adjusted at any time due to the complex and dynamic urban system.

5.4.2.2 What is information involved

Specifying required information for planning is the first stage of the process of database establishment. At this stage, crucial information required in urban planning is identified and defined. According to the description of planning data needs in Campbell and LeBlanc (1967), five sorts of information are usually involved: 1) statistics related to local population, 2) financial conditions of citizens and government, 3) physical conditions of the land/location, 4) internal structure and functional relationships within the city, and 5) relationship between the city and other ones.

The population-related information means the current and projected demographic information such as population, employment, number of households. The financial condition of people and government include income characteristics of the population, property values, GDP, etc. Physical conditions of the location refer to the topographic and spatial information of the land such as slope, terrain, and soil. Urban internal structure and functional relationships are the most complex information required in the planning, which are a series of considerations and criteria in terms of internal accessibility and functional distribution for identifying particular uses for each piece of land according to its size, value and location. The relationship between the city and others focuses on the impacts of economic activities from other surrounding cities and the coordinated development among the cities.

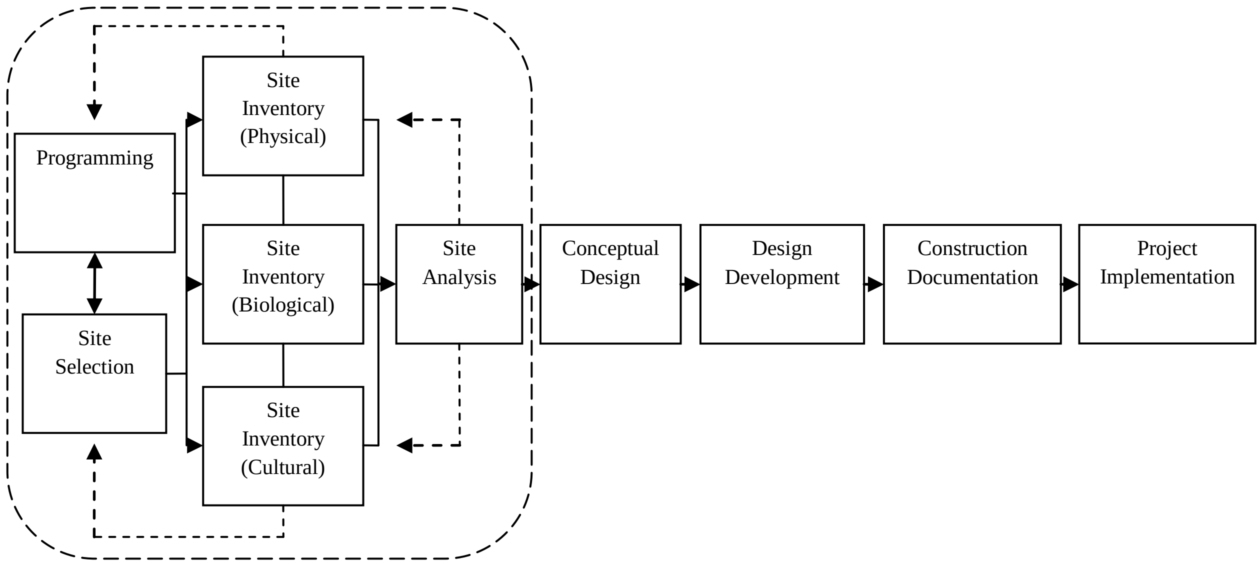
According to the description of categories of base data in Lennertz and Lutzenhiser (2006), a list of specific data commonly involved is summarized in Table 5.7. During the period of data preparation, the planning project manager has the responsibility to initially request and collect all existing reports, plans and studies from the project sponsor, local planning agencies, local universities, and possible community advocacy groups. Then the project management team will analyze this information and decide if new studies are necessary or if existing studies can be updated to cater for the feasibility analysis.

Table 5.7 Common categories of base data
(source: Lennertz and Lutzenhiser, 2006)

Category	Base data
Site	Existing conditions map, geotechnical study, base maps, aerial photographs
Transportation	Traffic counts, future projects planned, transportation system plan (TSP)
Market	Demographics, buyer profiles, demand analysis, housing types
Economics	Financial pro forma model
Politics	Decision-making process, relevant organizations and positions
Environment	Government regulations, analysis models/data for impact analyses
Planning	Previous plans, regulations and standards, policies (including previous

	attempts to develop the property)
History	Local built environment, culture
Project Program	Mix of uses: housing types, commercial types, public users, open space

Land use planning at the site level is actually called "site planning", which is the smallest-scale land use planning organizing the development of each single piece of land by determining specific land uses (i.e. locating buildings and facilities) on the site, arranging for roads, water, and other inside infrastructure, and developing detailed plans for grading, landscaping, and other site improvements (Wheeler, 2004). A process of site planning and design was introduced in LaGro (2008), and its implementation ensures that land use planning moves towards sustainable built environments (Figure 5.1). During the process of site planning or design, in many cases, site analysis can be the first and the most important step as it aims to collect information related to the site, assess the land-use suitability of the site and the compatibility with the proposed land use and surrounding environment, and understand the administrative requirements of the on-site project(s) such as building permits and other approvals. In the phase of site assessment, Russ (2002) gave a checklist of information involved in site analysis (Table 5.8).



Note: the area circled by dashed line is investigated intensively in this research.

Figure 5.1 Site planning and design process
(source: LaGro, 2008)

Table 5.8 Information checklist of site analysis
(source: Russ, 2002)

Site Condition	Developed
	Existing buildings or structures
	Former uses
	Known site conditions
	Character and/or condition of existing roads
	Points of access and exit (approximate site distances)
	Expected road improvements
	Visibility into and out of site
	Security considerations
	Neighboring property uses
	Existing rights of way or easements on property
	Other obstructions (condominium or community association)

Land Development Regulations	Street profile requirements
	Site distance requirements
	Slope restrictions
	Storm water requirements
	Landscaping requirements
	Lighting requirements
Utilities (Access and/or distance to and connection requirements)	Natural gas
	Telephone
	Electricity
	Cable television
	Public water
	Sanitary sewage
	Traffic
	Condition of local roads
	Access to site
	Internal circulation constraints
	Impact on neighborhood
Topography	General topographic characters of site
	Areas of steep slope
	Aspect and/or orientation of slopes
	Site access
	Slope stability
Vegetation and/or Wildlife	General types of existing vegetation
	Quality of vegetation
	Presence of known protected species

	Presence of valuable specimens or communities
	Presence of exotic and/or invasive species
Historic or Cultural Features and/or Community Interests	Known historical features
	Unique natural features or characters
	Existing parks or public areas
	Existing informal public access and/or use on the site
	Community character such as architectural style and/or conventions
	Local landscaping
	Local materials
Environmental Concerns	Past site uses
	Neighboring site uses
	Evidence of fill, dumping, or disposal
	Evidence of contamination (e.g. stained soils, stressed and/or dead vegetation)
	On-site storage
	Impact of site development on local water and air quality

Note: Zoning Regulations, Soils and/or Geology, and Hydrology aspects are omitted because this research focuses only on site redevelopment (excluding detailed design) in urban developed areas.

Similarly, Brooks (1988) provided a checklist of information required in site planning which was divided into three categories including legal considerations, planning data, and environmental concerns (Table 5.9). According to Brooks (1988), site planning is a non-short-circuit process, and every piece of crucial information should be collected and studied in depth as if we are ignorant of the site.

Table 5.9 Information checklist in site planning
(source: Brooks, 1988)

Legal	Plat or boundary line survey	Easements

Considerations		Right-of-way lines
		Acreage
		Oil and gas transmission lines
	Restrictive covenants or deed restrictions	-
	Existing land uses and buildings	-
	Zoning (existing and proposed)	Permitted uses or special exceptions
		Density
		Setbacks/height limits
		Coverage
Planning Data	Adjacent land uses	-
	Utilities	Water
		Sewer (storm and sanitary)
		Gas
		Electric
	Roads, alignment, and right-of-way (existing and proposed)	Major thoroughfares and freeways
		Primary arterials
		Secondary collectors
		Tertiary streets
		Service drives
	Public parks and open space	-
Environmental concerns	Topography: minimal 2-ft interval	Slope analysis
	Drainage	Off-site considerations
		On-site drainage characteristics
	Hydrology	Surface water
		Subsurface: water table and aquifer

	Vegetation	Tree cover: types and species
		Understory
		Ground cover
	Geology and soils	-
	Climate	Annual rainfall and seasonal variations
		Solar analysis
		Wind: direction and velocity

To provide sufficient information for site analysis, according to Figure 5.1, three types of site inventories are involved. They are physical, biological, and cultural attributes of the site (Table 5.10). The relationship between three attribute mapping and land use (site) suitability analysis is that, the three sorts of inventory maps of site containing site information will be synthesized to create land-use suitability maps for site analysis. Based on the existing literature and site planning standards, a tentative list of information/data involved in the database associated with the planning support model proposed in this research is given (Table 5.11).

Table 5.10 Three types of information inventory of site attributes
(adapted from LaGro, 2008)

Category	**Sub-category**	**Attribute**
Physical	Soils	Bearing capacity
		Porosity
		Stability
		Erodibility

		Fertility
		Acidity (PH)
	Topography	Elevation
		Slope
		Aspect
	Hydrology	Surface drainage
		Water chemistry
		Depth to seasonal water table
		Aquifer recharge areas
		Seeps and springs
	Geology	Landforms
		Seismic hazards
		Depth to bedrock
		Solar access
		Winds
		Fog pockets
Biological	Vegetation	Plant communities
		Specimen trees
		Exotic invasive species
	Wildlife	Habitats for endangered or threatened species
Cultural	Land use	Prior land use
		Land use on adjoining properties
	Legal	Political boundaries
		Land ownership
		Land use regulations

		Easements and deed restrictions
	Utilities	Sanitary sewer
		Storm sewer
		Electric
		Gas
		Water
		Telecommunications
	Circulation	Street function
		Traffic volume
	Historic	Buildings and landmarks
		Archaeological sites
	Sensory	Visibility
		Visual quality
		Noise
		Odors

Note: the attributes may be mapped if necessary.

Table 5.11 Information/data involved in the database

Category	**Sub-category**	**Information/Data**	**Data Source**
Physical	Topography	Elevation	Topographic maps
		Slope gradient	Topographic maps
		Slope aspect	Topographic maps
	Geology	Terrain	Topographic maps
		Seismic hazards	Geological report
		Landslide hazards	Geological report
		Depth to bedrock	Geological report

	Climate	Solar access	Local climate study
		Wind direction (prevailing)	Local climate study
	Soil	-	-
	Hydrology	Depth to water table	Hydrological report
		Drainage patterns	Hydrological report
<u>Ecological/ Environmental</u>	Vegetation	Vegetation rate	Remote sensing images
	Wildlife	-	-
	Environmental impacts	Air quality	Environmental assessment report
		Water quality	Environmental assessment report
		Noise	Environmental assessment report
		Light pollution	Environmental assessment report
Political/Legal	Legal properties	Political boundaries	Land registry
		Land ownership	Land registry
		Easements and deed restrictions	Land registry
	Land use regulations	Statutory requirements for development	Statutory regulations
<u>Social</u>	Local population	Population trends	Census projection
		Household size	Census statistics
	Local employment	Employment structures	Census statistics
		Employment needs	Employment prediction
	Neighborhood/ Community changes	Community characteristics	Archives/Survey
		Neighborhood identity	Archives/Survey

Economic	Production	Local GDP	Socio-economic statistics
	Consumption	Property values	Transaction records
		Rents	Lease records
Cultural/Historic	Sensory satisfaction	Aesthetics	Survey
		Visibility	Survey
		Visual quality (e.g. corridor)	Survey
		Odors	Survey
	Local built environment	Architectural styles	Archives/expert interviews
		Unique landscape	Archives/expert interviews
	Historical features	Historical buildings/landmarks	Heritage study
		Archaeological sites	Heritage study
Utilities/ Accessibility (locational)	Land use	Former and current land uses	Land registry and survey
		Neighboring land uses	Land registry and survey
	Transportation	Road function	Traffic design
		Internal circulation	Traffic design
		Traffic volume	Traffic survey
	Service utilities	Utilities for basic housing (e.g. sewer, electric, gas)	Detailed location maps
		Access to major living services (e.g. transport hub, medical center, open space)	Detailed location maps

Note: “Soil” and “Wildlife” are not considered in land redevelopment within urban developed areas; categories underlined relate to the data of sustainability criteria.

The data involved in the planning process are complex and in a huge amount. To improve the efficiency of data processing and management, database is a good way to store, convert and manage the large volumes of data. GIS mapping is becoming an indispensable and popular tool for base data gathering and analysis throughout the dynamic planning process. With the capability in geographic statistics and visualization, it can be used to provide a comprehensive picture of an existing community in terms of terrain, landscape, transportation, energy consumption, housing types, demographics, air quality, and other measures.

In general, information required in the database serving for the planning support model is in line with the general criteria for site analysis identified in the model. That is to say, the information/data gathered in the database should cover all aspects of planning considerations and can support the analysis of each criterion. Therefore, it should be a synchronized process in which the information will be collected simultaneously with the development process of the model.

5.5 Components of the Framework

In the framework, two major components which are planning support model and land information database work together to support land use planning in site redevelopment (Figure 5.2). Specifically, planning support model recognizes data/information required for the database build-up, and then land information database provides an assembly of adapted data to the model for land suitability analysis at the site level. The model offers a quantitative approach to assessing land-use suitability for urban land in regard to five types of land use: residential, commercial, industrial, government, institution and community (G/IC), and open space, and sustainability considerations are integrated in the suitability analysis. The database can be established by using GIS technology ("ArcGIS" toolkit) to collect, process, and analyze data, and useful information required in land use planning are extracted from the raw data.

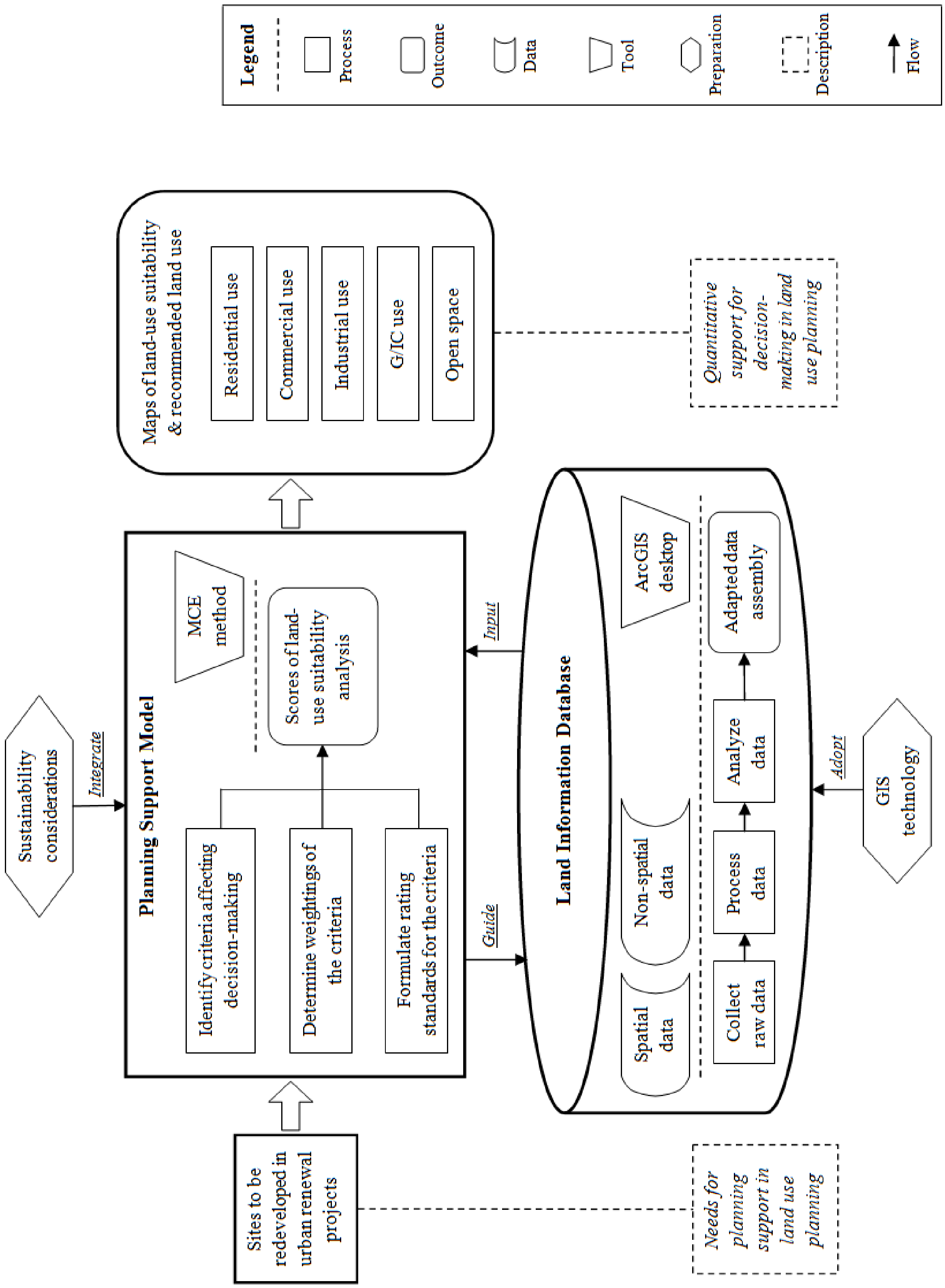


Figure 5.2 An overview of the framework

5.6 Summary of the Chapter

This chapter describes the structure of the framework for supporting sustainable land use planning (site-level) in land redevelopment. Two major components, planning support model and land information database are introduced respectively. Sustainability considerations (the Three Es) are also discussed in the planning process. Basically, the framework can serve as a manual for supporting planners in making decisions in land redevelopment, and it provides a general paradigm (Figure 5.2) for guiding real model development and database establishment in practice.

Chapter 6 Development of the Framework – A Case Study

6.1 Introduction

In this chapter, the framework which can serve as the prototype of a particular planning support system, in essence, an integrated approach to supporting land use planning (site-level) in urban renewal projects is developed, and the development process is illustrated using a case study in Hong Kong. An overview of the case study is introduced first. The detailed processes and workflows of building the planning support model and establishing the associated database are depicted then. After developing the whole framework, a more open environment for user customization can be provided through changing the criteria and/or their weightings for LUSA by users (stakeholders in the planning).

6.2 Overview of a Case Study

6.2.1 Study Area

Land is one kind of scarce and precious resource in Hong Kong and the case Yau Tsim Mong district (Figure 6.1) was elaborately selected due to data availability and its level of land development. Yau Tsim Mong is one of the older districts of Hong Kong, having been developed over a period of one hundred years. It is located in the Kowloon peninsula - one of Hong Kong's metropolitan areas - spanning over 114° 09' – 114° 11' E and 22° 17' – 22° 19' N. The area covers 7 km^2 and with a current population of 304, 900. The land in this district is highly developed and infrastructure such as roads, railways, and main service facilities are already provided. Therefore, the study area serves as a good case for the research because of its location and development level.

Currently, many older buildings located in the area are too old to maintain their original function and need to be redeveloped for future use. Urban renewal is a major contemporary issue in Hong Kong. Until 2011, 46 redevelopment projects have been announced by the Urban Renewal Authority (URA) of Hong Kong and the issue of land use decisions for redevelopment projects has become an increasing problem for urban planners from the perspective of sustainable town (land use) planning. Thus, this area is most appropriate for an empirical study of land use planning in urban renewal and can reflect the characteristics and merits of the proposed framework.

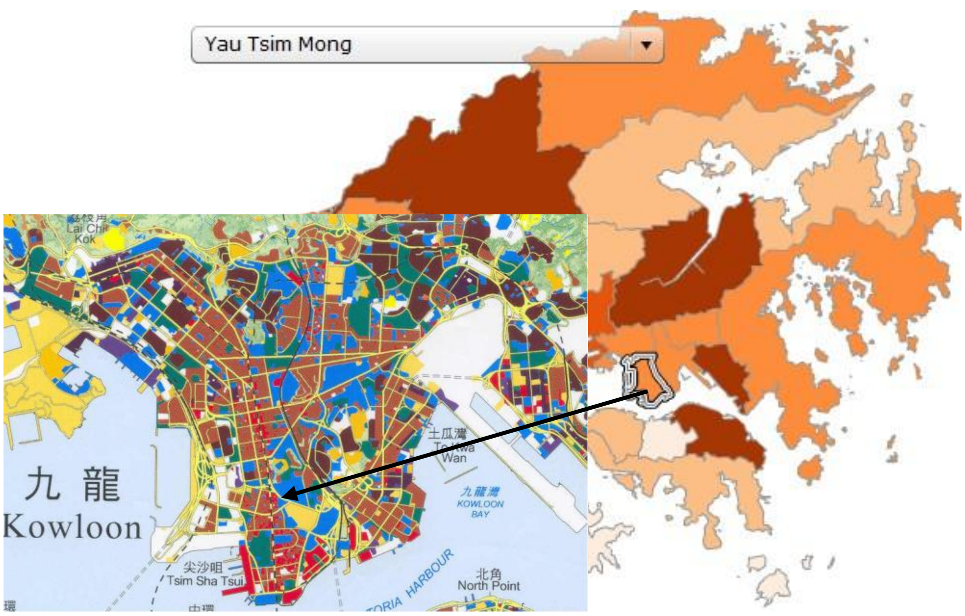


Figure 6.1 Study area

6.2.2 Current Land Use

According to the map of land utilization in Hong Kong provided by the Lands Department of the government, current land use for the existing sites in the study area can be categorized into six broad types: residential (orange diagonal), commercial (yellow diagonal), industrial (red), G/IC (green circle), open space (blue curve) and vacant/under construction/others (black point) (Figure 6.2). The total area of residential land is 2, 205, 956 sq. m (40.8%), with 580, 797 sq. m (10.7%) of commercial land, 52, 394 sq. m (1%) industrial land, 1, 070, 752 sq. m (19.8%) G/IC use, 506, 323 sq. m (9.4%) open space and 987, 073 sq. m (18.3%) vacant/under construction land or others. The residential land occupies two fifths of total area of the land sites. As the study area is a very high-density urban district (containing 304, 900 people in an area of 7.24 sq. km), sufficient residential land is necessary to sustain the large population. Because a well-known tourist attraction for shopping, Tsim Sha Tsui, is located within the study area, additional commercial land is also required to support a large number of commercial activities. In Yau Tsim Mong district, conventional industry is rare, and little land is needed for industrial use. G/IC land is another main land use in this district as, due to the hub location and convenient transportation, many governmental offices and institutions are situated in this area. Open space covers nearly one tenth of the total study area, indicating that the local government is acting in the interest of the general public by providing a reasonable amount of land for open space and recreational facilities in the area.

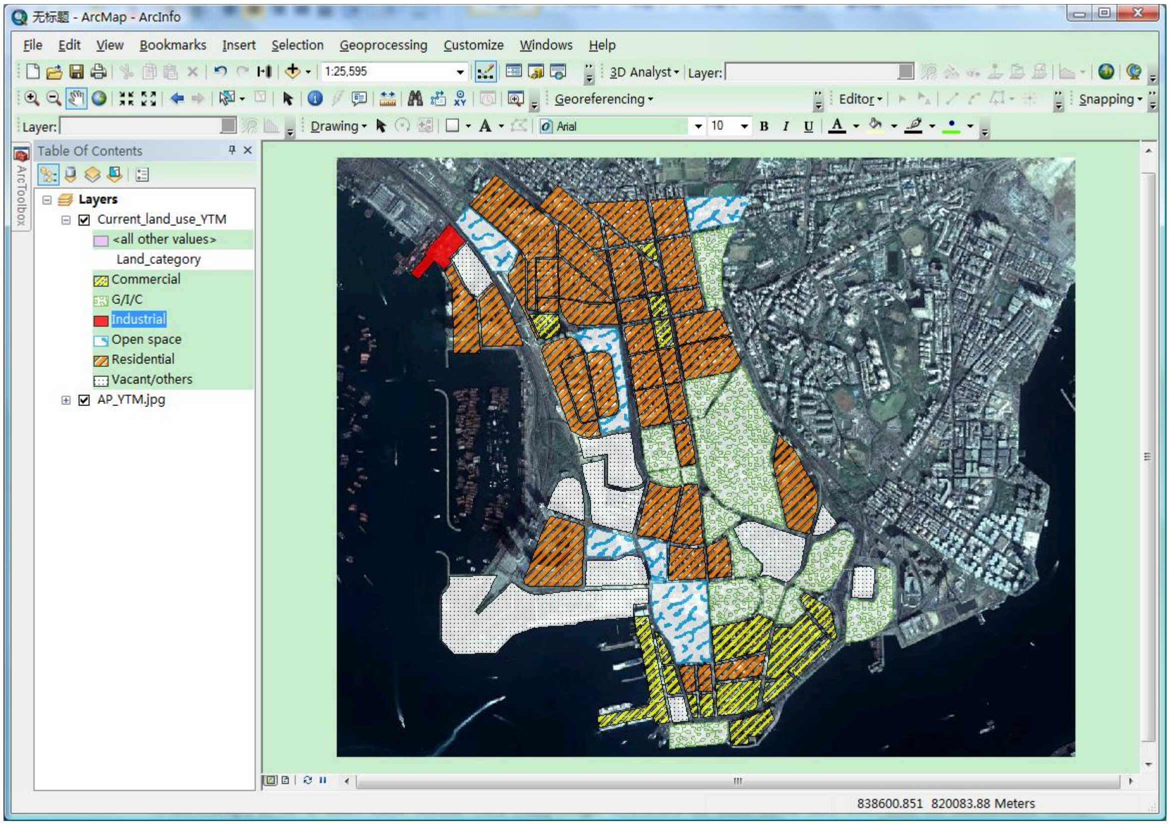


Figure 6.2 Current land use of the area

6.3 Model Development

According to the procedures and methods for developing the framework described in Chapter 5, the planning support model containing three parts: criteria for land-use suitability analysis, weightings of the criteria, and rating standards of the criteria was practically built for Hong Kong.

6.3.1 Identification of Factors affecting Land-use Decision-making

To support land-use decision-making during land use planning processes, factors which are mainly affecting the decision process should be identified. These factors can also be regarded as the criteria for LUSA.

6.3.1.1 Findings from Empirical Studies in Hong Kong: Expert Interviews

Expert interviews were conducted with five town planners who work in the Planning Department of Hong Kong, and two committee members of Town Planning Board of the government (i.e. seven interviewees in total). They all have more than ten-year working experience and comprehensive knowledge in the planning practice. These interviews aimed to address the problems occurring in Hong Kong's planning practice and collect the specific opinions of key factors affecting land-use decision-making from the planning practitioners. An interview sheet was prepared in advance for facilitating the interviews in which two parts were designed: open-ended questions and identification of key factors. Details of the interview sheet refer to Appendix 1.

During the interviews, every interviewee indicated that land use planning is a very complex process in which many stakeholders are involved. In current planning practice, land-use decisions for land lots are made based on qualitative analysis of planners. Particularly, in urban developed areas, it is more difficult for planners to make decisions on land use re-allocation. The main problem in land-use decision-making, especially in urban renewal is how to balance multiple interests of different stakeholders. All of them suggested that transportation (accessibility) and land use compatibility are the most important considerations in site planning for urban renewal projects. Environmental concerns are also emphasized in the planning process. Some of them suggested that land use planning is a dynamic process which cannot be determined simply by an objective, quantitative land-use suitability assessment but also many social values in terms of political, community and the public interests. And the information of existing buildings is necessary for site planning in the case of urban renewal. In detail, several factors were proposed by the interviewees, such as “Distance to bad-neighbor use” and “Distance to community center” in the Locational attributes, “Air ventilation” and “Visual corridor” in the Environmental attributes.

By summing up the findings of these interviews, one problem the planning practitioners encounter for many years was found, that is decisions of land use are made, relying heavily on the subjective and qualitative judgments from planners, and without a necessary objective and quantitative method to support the decision-making process. In addition, the public often cannot be effectively engaged in public consultation sessions due to their shortage of planning knowledge to fully understand planners’ considerations. Specifically, site planning containing land-use decisions for land redevelopment in urban renewal projects is more complicated and difficult for the practitioners, so that an effective method/tool to support the planning process is desired. In terms of GIS application in planning processes, although GIS technologies are increasingly applied to planning tasks, for example, the geospatial information hub (GIH) being built by Hong Kong Government in these years, specialized and direct applications for problem-solving or finding answers in several stages of planning are still underutilized.

6.3.1.2 Key factors identified in Hong Kong

Based on the criteria listed in the general list identified from the literature review (refer to Table 5.6 in Chapter 5), combining with the findings of the interviews conducted in Hong Kong, the key factors affecting land-use decision-making in Hong Kong’s planning practice were identified (Tables 6.1 and 6.2).

Table 6.1 Factors affecting land-use decision-making in Hong Kong

Factor Type	No.	Factor Name
I. Inherent/Physical attributes	1	Slope
	2	Elevation
	3	Vegetation
	4	Current land use
II. Locational attributes (accessibility/compatibility)	5	Connection to road network
	6	Connection to pedestrian route
	7	Distance to sensitive use (e.g. bad-neighbor)
	8	Distance to CBD/BCCs
	9	Distance to airport
	10	Distance to railway stations/MTR
	11	Distance to bus terminus
	12	Distance to ocean/streams
	13	Distance to nearest hospital
	14	Distance to nearest primary/high school
	15	Distance to open space
	16	Distance to trunk roads
	17	Distance to historic sites (preservation)
III. Social attributes	18	Population density
	19	Employment density
IV. Economic attributes	20	Output potential per land unit
	21	Property average price/rent
V. Environmental attributes	22	Air ventilation
	23	Visual permeability (harborfront)
	24	Air quality
	25	Traffic noise
VI. Political/Legal	26	Land lease

factors	27	Policy constraints
VII. Community/Cultural factors	28	Historic corridor (heritage)
	29	Compatibility with neighbors

Note: BCC means Business and Commercial Cluster.

Table 6.2 Additional factors considered in land redevelopment

I. Characteristics of buildings	Building age
	Building height
	Building condition
	Building surrounding
	Population density in each building
II. Parameters of development	Building density
	Plot ratio
III. Special needs for local redevelopment	Specified use of a redeveloped site
	Employment resettlement

6.3.2 Criteria for LUSA

According to the factors identified in the above context, key criteria for LUSA were finalized accordingly. In the case study, however, due to data and time constraints, part of the criteria (20 of 29) were available to be examined so far. In addition, the political and cultural factors were not involved in the case study because they are qualitative descriptions and cannot be quantitatively analyzed in a direct way. The 20 available criteria (Table 6.3) were examined following the general list of criteria (Table 5.6) to illustrate the practical process of framework development.

Table 6.3 Criteria examined in the case study

Criterion type	No.	Criterion name
I. Physical/Inherent attributes	1	Current land use
	2	Slope
	3	Elevation (relative)
	4	Vegetation
II. Locational attributes (Accessibility/compatibility)	5	Distance to CBD/BCCs
	6	Distance to airport
	7	Distance to railway/MTR stations
	8	Distance to bus terminus
	9	Distance to ocean/streams
	10	Distance to historic sites (Preservation)
	11	Distance to nearest hospital
	12	Distance to nearest primary/high school
	13	Distance to open space
	14	Distance to trunk roads
III. Social attributes	15	Population density
	16	Employment density
IV. Economic attributes	17	Unit price of land sale
	18	Property average price/rent
V. Environmental attributes	19	Air quality
	20	Traffic noise

These 20 criteria of urban land suitability were classified into five categories of physical/inherent attributes, locational attributes (accessibility/compatibility), social attributes, economic attributes and environmental attributes. Physical/inherent attributes refer to the physical or existing conditions of land tracts, such as *slope, elevation and* *current land use*. These restrict the usage of land sites in the perspective of inherent conditions of the land. Locational attributes represent spatial accessibility and compatibility, and they are currently regarded as the most important factors affecting land use decisions in urban renewal projects. Ten of the twenty suitability criteria were locational criteria, such as *distance to MTR, distance to open space, and distance to historic sites*. These distances were measured based on factual road network and automatically calculated by using GIS network analysis. And the road distance can also be converted to time distance through combining speed estimation. For example, the average speed of walking is about 5 km/h (84 m/min), and for driving in urban areas is around 50 km/h (840 m/min). In addition, social attributes, economic attributes and environmental attributes were identified as reflecting the sustainability of land use. Six criteria were chosen for the three attributes, with each category having two criteria. The six criteria including *population density, property average price and traffic noise* covered the main issues of land use sustainability in accordance with the three elements of sustainable development and also suggested a more effective and convenient way to quantify land use sustainability.

6.3.3 Weightings and Rating Standards for LUSA: Focus Group Meeting 1

A focus group meeting was conducted in Hong Kong Polytechnic University to determine weightings of the criteria involved in the case study and verify the rating standards of each criterion. The focus group was comprised of 8 participants (planning stakeholders in the specific case) who were 4 town planners working in the Planning Department and URA, 2 developers working in local companies and 2 residents living in the study area. The involvement of the participants from the Planning Department, URA, and the public contributes to participatory planning with different stakeholders and public engagement in the planning practice. The meeting consisted of four sessions lasting about two hours (Table 6.4). Two tasks were involved: the first was weighting determination with an AHP process and the second was the verification of rating standards.

Table 6.4 The rundown of Focus Group Meeting 1

No.	Duration	Session
1	20 mins	Meeting Briefing & Warm-up Activity
2	60 mins	Task 1 - Weighting Determination
3	10 mins	Tea Break
4	40 mins	Task 2 - Verification of Rating Standards

6.3.3.1 Weighting Determination: An Application of AHP Method

The first objective of the focus group meeting was to determine the weightings of considered criteria according to the views of planning decision-makers (including different stakeholders). Focus group is a good means to achieve a consensus/agreement of different stakeholders when making decisions in land use planning. In fact, different criteria may be applicable to different land uses; in other words, land use decisions are made according to different sets of criteria when specific land uses are different. For example, the criterion of traffic noise is sensitive to residential use but commercial use. In this study, five types of land use were defined and considered for LUSA. They were residential, commercial, industrial, G/IC and open space, and their definitions are given in Table 6.5.

Table 6.5 Definitions of the five land uses

No.	Category	Definition
1	Residential	Land sites for residential use, including private housing, public housing and staff/student hostels
2	Commercial	Land sites for commercial use, including offices, shopping malls, markets, hotels, car parks
3	Industrial	Land sites for industrial use, including industrial land, industrial estates, warehouses
4	G/IC	Land sites for Government, Institutional and Community use and other public purposes, i.e. utilities
5	Open Space	Land use zones for the provision of open space and recreation facilities for the enjoyment of the general public, including parks, playgrounds, gardens

Therefore, before determining the weightings, the specific sets of criteria which are really affecting decision-making for the five different land uses needed to be identified. Based on the 20 criteria discussed in Table 6.3, the participants of the focus group were asked to discuss and select the specific criteria for five particular land uses at the beginning of the session 2. According to the group opinions, five sets of criteria were selected from the 20 available criteria (Table 6.6).

Table 6.6 The selected criteria of for five land uses

Criterion name	Residential	Commercial	Industrial	G/IC	Open space
Current land use	✓	✓	✓	✓	✓
Slope		✓	✓		✓
Elevation		✓	✓	✓	
Vegetation				✓	✓
Distance to CBD/BCCs		✓			
Distance to airport			✓		

Distance to railway/MTR stations	✓	✓	✓	✓	
Distance to bus terminus	✓	✓		✓	
Distance to ocean/streams	✓		✓		✓
Distance to historic sites (Preservation)	✓	✓	✓	✓	✓
Distance to nearest hospital	✓			✓	
Distance to nearest primary/high school	✓			✓	✓
Distance to open space	✓			✓	✓
Distance to trunk roads	✓	✓	✓	✓	
Population density	✓	✓	✓	✓	✓
Employment density	✓	✓	✓	✓	✓
Unit price of land sale		✓	✓	✓	✓
Property average price/rent	✓	✓	✓		
Air quality	✓	✓	✓	✓	✓
Traffic noise	✓			✓	✓

Note: '✓' means the item is selected.

1-9 scale AHP

During the process of weighting determination, the AHP method was employed to calculate the weighting of each criterion. As discussed in Chapter 5, AHP is an appropriate and effective method for weighting determination in this study because it describes the relative importance based on decision-makers' views (nature of planning issues) and its explicit rationale is much easier to understand for all stakeholders in land use planning. The traditional 1-9 scale AHP method was used to compare the relative importance of every two criteria. The relative importance is ranked by number 1 to 9, and the explanation is provided below (Table 6.7).

Table 6.7 Instruction of 1-9 scale AHP

Value	Meaning
1	Criterion i and Criterion j with equal importance
3	Criterion i is moderately more important than Criterion j
5	Criterion i is strongly more important than Criterion j
7	Criterion i is very strongly more important than Criterion j
9	Criterion i is extremely more important than Criterion j
2、4、6、8	Medians between importance values shown above

Note: the reciprocal of above values if Criterion i is less important than Criterion j.

Hierarchy structure of LUSA criteria

Actually, some criteria cannot be directly compared because they were not in the same attribute. For instance, ‘Slope’ in physical attribute cannot be simply compared with ‘Distance to MTR’ in locational attribute to distinguish which is more important for land use decisions. Therefore, the criteria must be put into different categories, and at least two levels (hierarchy structure) were formed according to the criteria and their attributes so that their importance was only compared within each level. Figures 6.3 – 6.7 show the hierarchy structures of LUSA criteria for five land uses. During this session, the moderator distributed related documents to each participant and facilitated the group discussion.

Level 1 – Criterion attribute	Level 2 – Criterion (No.)
Physical/inherent	1
Locational	7 - 14
Social	15, 16
Economic	18
Environmental	19, 20

Figure 6.3 Hierarchy of LUSA criteria for residential land use

Level 1 – Criterion attribute	Level 2 – Criterion (No.)
Physical/inherent	1 - 3
Locational	5, 7, 8, 10, 14
Social	15, 16
Economic	17, 18
Environmental	19

Figure 6.4 Hierarchy of LUSA criteria for commercial land use

Level 1 – Criterion attribute	Level 2 – Criterion (No.)
Physical/inherent	1 - 3
Locational	6, 7, 9, 10, 14
Social	15, 16
Economic	17, 18
Environmental	19

Figure 6.5 Hierarchy of LUSA criteria for industrial land use

Level 1 – Criterion attribute	Level 2 – Criterion (No.)
Physical/inherent	1, 3, 4
Locational	7, 8, 10 - 14
Social	15, 16
Economic	17
Environmental	19, 20

Figure 6.6 Hierarchy of LUSA criteria for G/IC land use

Level 1 – Criterion attribute	Level 2 – Criterion (No.)
Physical/inherent	1, 2, 4
Locational	9, 10, 12, 13
Social	15, 16
Economic	17
Environmental	19, 20

Figure 6.7 Hierarchy of LUSA criteria for open space

Matrices of importance comparison

As discussed in the above context, the matrices of importance comparison were formed in accordance with two levels: criterion attributes and the criteria. Taking residential land use as an example, the first matrix was tabulated on Level 1 (Table 6.8) and then other matrices were formed within each criterion attribute. Table 6.9 illustrates the matrix for locational criteria, and it indicates that the importance weighting of locational attribute included the weightings of eight specific criteria. By filling up these matrices based on the views of the focus group, the weightings of each criterion were calculated and the total of all criteria applied in each land use was 1.0. Details of the calculated weightings are presented in Section 6.3.4.

Table 6.8 Matrix for criterion attributes

Criterion attributes A*j* / *Ai*	A1 (Physical/ inherent)	A2 (Locational)	A3 (Social)	A4 (Economic)	A5 (Environmental)
A1	1				
A2		1			
A3			1		
A4				1	
A5					1

Note: the blank cells are filled following 1-9 scale AHP method (refer to Table 6.7).

Table 6.9 Matrix for locational criteria

Criteria (Locational)*Cj* / *Ci*	C7	C8	C9	C10	C11	C12	C13	C14
C7	1							
C8		1						
C9			1					
C10				1				
C11					1			
C12						1		
C13							1	
C14								1

Note: the blank cells are filled following 1-9 scale AHP method (refer to Table 6.7).

6.3.3.2 Verification of rating standards

The second objective of the focus group meeting was to adjust and verify the rating standards for LUSA. A tentative set of rating standards was formed based on Hong Kong planning standards and guidelines, other regulations of land development and design requirements of urban renewal before the meeting. During the second half of the meeting, eight participants were asked to discuss the applicability of the tentative rating standards (Table 6.10) and make some adjustments if necessary. This session of group discussion lasted for about 40 minutes to allow the focus group to verify the rating standards, and the facilitator aimed to make every participant active in the discussion.

Table 6.10 Tentative rating standards of each criterion

Criterion	**Land uses**	**Rating standards**			
		Highly suitable	Suitable	Unsuitable	Very unsuitable
		3	*2*	*1*	*0*
Current land use	Residential	R	C, G/IC, V/O	I	O
	Commercial	C	R, G/IC, I, V/O	O	-
	Industrial	I	G/IC, V/O	R, C	O
	G/IC	G/IC	C, I, R, V/O	O	-
	Open space	O, V/O	I, R, G/IC	C	-
Slope (%)	Residential	0.2-12	12-25	< 0.2 or 25-30	> 30
	Commercial	0.2-10	10-20	< 0.2 or 20-25	> 25
	Industrial	0.2-5	5-10	< 0.2 or 10-15	> 15
	G/IC	0.2-10	10-20	< 0.2 or 20-25	> 25
	Open space	< 15	15-30	> 30	-
Elevation <relative elevation in study area> (m)	Residential	< 25	25-50	50-60	> 60
	Commercial	< 15	15-30	30-40	> 40
	Industrial	< 10	10-20	20-30	> 30
	G/IC	< 15	15-30	30-40	> 40
	Open space	< 20	20-40	40-50	> 50

Vegetation (percent)	Residential	> 30	< 30	-	-
	Commercial	-	-	-	-
	Industrial	-	-	-	-
	G/IC	> 20	15-20	10-15	< 10
	Open space	> 30	25-30	20-25	< 20
Distance to CBD/BCCs (km)	Residential	-	-	-	-
	Commercial	< 2; < 1 (sub)	2-3; 1-2 (sub)	3-4; 2-3 (sub)	> 4; > 3 (sub)
	Industrial	-	-	-	-
	G/IC	-	-	-	-
	Open space	-	-	-	-
Distance to airport (km)	Residential	-	-	-	-
	Commercial	-	-	-	-
	Industrial	< 20	20-25	25-30	> 30
	G/IC	-	-	-	-
	Open space	-	-	-	-
Distance to railway/MTR stations (m)	Residential	< 300	300-600	600-900	> 900
	Commercial	< 250	250-500	500-750	> 750
	Industrial (freight)	< 1000	1000-2000	2000-3000	> 3000
	G/IC	< 400	400-500	500-600	> 600
	Open space	-	-	-	-
Distance to bus terminus (m)	Residential	< 300	300-400	400-500	> 500
	Commercial	< 300	300-400	400-500	> 500
	Industrial	-	-	-	-
	G/IC	< 300	300-400	400-500	> 500
	Open space	-	-	-	-

Distance to ocean/streams (m)	Residential	< 200	> 200	-	-
	Commercial	-	-	-	-
	Industrial (port)	< 1000	1000-2000	2000-3000	> 3000
	G/IC	-	-	-	-
	Open space	< 100	> 100	-	-
Distance to historic sites <Preservation> (m)	Residential	> 50 (nearest)	30-50 (nearest)	20-30 (nearest)	< 20 (nearest)
	Commercial	>70 (nearest)	50-70 (nearest)	30-50 (nearest)	< 30 (nearest)
	Industrial	> 300 (nearest)	200-300 (nearest)	100-200 (nearest)	< 100 (nearest)
	G/IC	> 60 (nearest)	40-60 (nearest)	30-40 (nearest)	< 30 (nearest)
	Open space	< 100 (nearest)	> 100 (nearest)	-	-
Distance to nearest hospital (m)	Residential	50 (nearest)-450	450-900	< 50 (nearest) or 900-1200	> 1200
	Commercial	-	-	-	-
	Industrial	> 800 (pollutive)	500-800 (pollutive)	200-500 (pollutive)	< 200 (pollutive)
	G/IC	< 500	500-1000	1000-1500	> 1500
	Open space	-	-	-	-
Distance to nearest primary/high school (m)	Residential	50 (nearest)-300	300-600	< 50 (nearest) or 600-900	> 900
	Commercial	-	-	-	-
	Industrial	> 700	500-700	300-500	< 300
	G/IC	< 400	400-800	800-1000	> 1000
	Open space	< 250	> 250	-	-
Distance to open space (m)	Residential	< 300	300-600	600-900	> 900
	Commercial	< 400	400-800	800-1200	> 1200
	Industrial	-	-	-	-

	G/IC	< 350	350-700	700-1000	> 1000
	Open space	-	> 300 (neighbor O)	< 300 (neighbor O)	-
Distance to trunk roads (m)	Residential	50 (nearest)-200	200-400	< 50 (nearest) or 400-600	> 600
	Commercial	< 100	100-200	200-300	> 300
	Industrial	< 100	100-150	150-200	> 200
	G/IC	< 150	150-300	300-450	> 450
	Open space	-	-	-	-
Population density (persons/km^2)	Residential	20000-40000	10000-20000 or 40000-50000	< 10000 or > 50000	-
	Commercial	> 20000	10000-20000	< 10000	-
	Industrial	-	< 8000	> 8000	-
	G/IC	-	> 15000	< 15000	-
	Open space	> 15000	8000-15000	< 8000	-
Employment density (persons/km^2)	Residential	5000-20000 and ‘Employment density’ < ‘Population density’	‘Employment density’ < ‘Population density’	‘Employment density’ > ‘Population density’	-
	Commercial	> 20000	15000-20000	< 15000	-
	Industrial	-	< 5000 (non-industrial)	> 5000 (non-industrial)	-
	G/IC	-	> 10000	< 10000	-
	Open space	> 10000	5000-10000	< 5000	-
Unit price of land sale (thousand HK dollars/m^2)	Residential	-	> 200	< 200	-
	Commercial	> 300	250-300	200-250	< 200
	Industrial	< 100	100-150	150-200	> 200

	G/IC	< 300	300-500	> 500	-
	Open space	< 400	400-500	> 500	-
Property average price/rent (HK dollars/sq.ft)	Residential (average price)	> 6000	5000-6000	4000-5000	< 4000
	Commercial (rent per month)	> 23 (office); > 100 (retail)	18-23 (office); 90-100 (retail)	13-18 (office); 80-90 (retail)	< 13 (office); < 80 (retail)
	Industrial (rent per month)	> 11 (flatted factory)	9-11 (flatted factory)	7-9 (flatted factory)	< 7 (flatted factory)
	G/IC	-	-	-	-
	Open space	-	-	-	-
Air quality (API)	Residential	< 25	25-75	75-125	> 125
	Commercial	< 50	50-100	100-150	> 150
	Industrial	< 75	75-125	125-175	> 175
	G/IC	< 50	50-100	100-150	> 150
	Open space	< 75	75-100	100-150	> 150
Traffic noise (dB)	Residential	< 55	55-70	70-75	> 75
	Commercial	< 65	65-75	75-80	> 80
	Industrial	< 70	70-75	75-80	> 80
	G/IC	< 60	60-70	70-80	> 80
	Open space	< 60	60-75	75-80	> 80

Note: R – Residential, C – Commercial, I – Industrial, O – Open space, V/O – Vacant/ Under Construction/Others;

The road distance can be simply converted to time distance through dividing by average speed of walking or driving.

6.3.4 Importance Weightings of Considered Criteria

After the five sets of criteria were finalized, the weightings for each criterion were determined in accordance with the different land uses considered. Each criterion was weighted by the AHP method on the basis of the group opinions of different stakeholders. By using AHP software - ‘Expert Choice’, the weightings of five sets of criteria were calculated based on the comparison matrices presented in Section 6.3.3.1. Figures 6.8 – 6.12 show tree structures (hierarchy) of the criteria and their attributes in the software and the five sets of weightings for different land uses are displayed in Table 6.11.

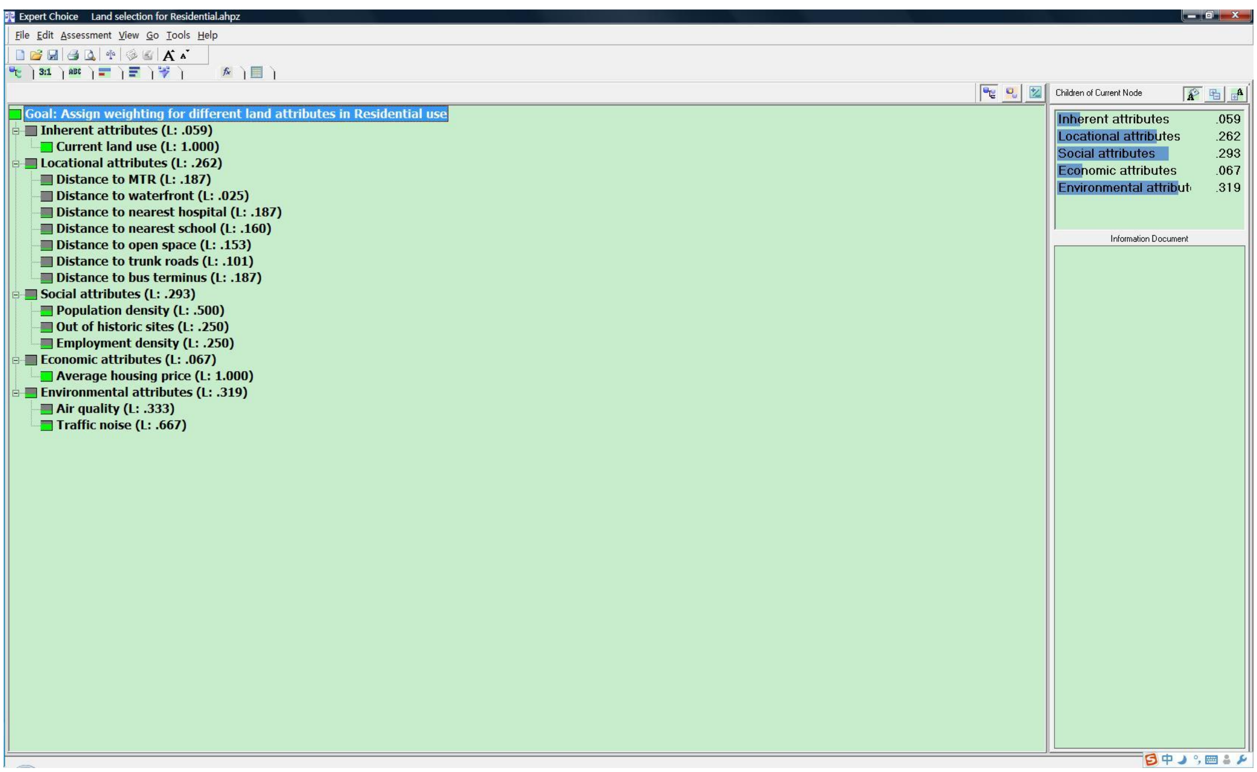


Figure 6.8 Weighting tree of residential use

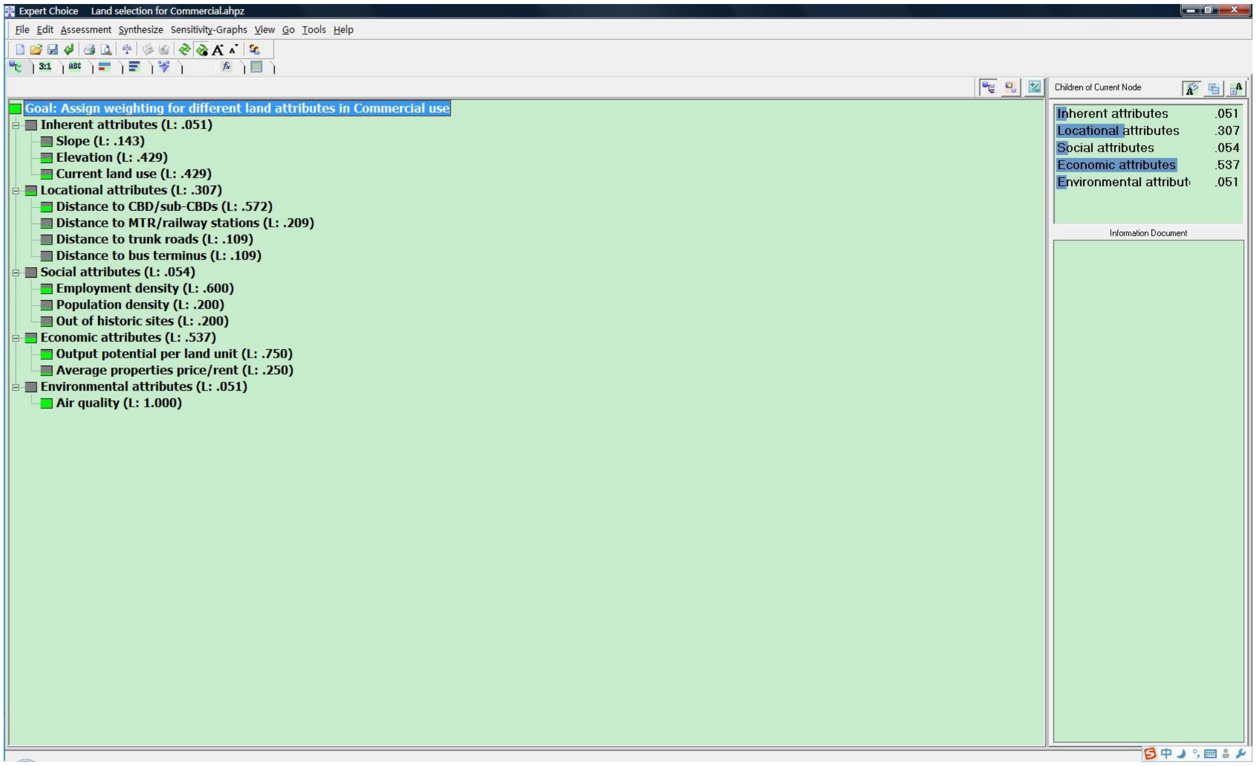


Figure 6.9 Weighting tree of commercial use

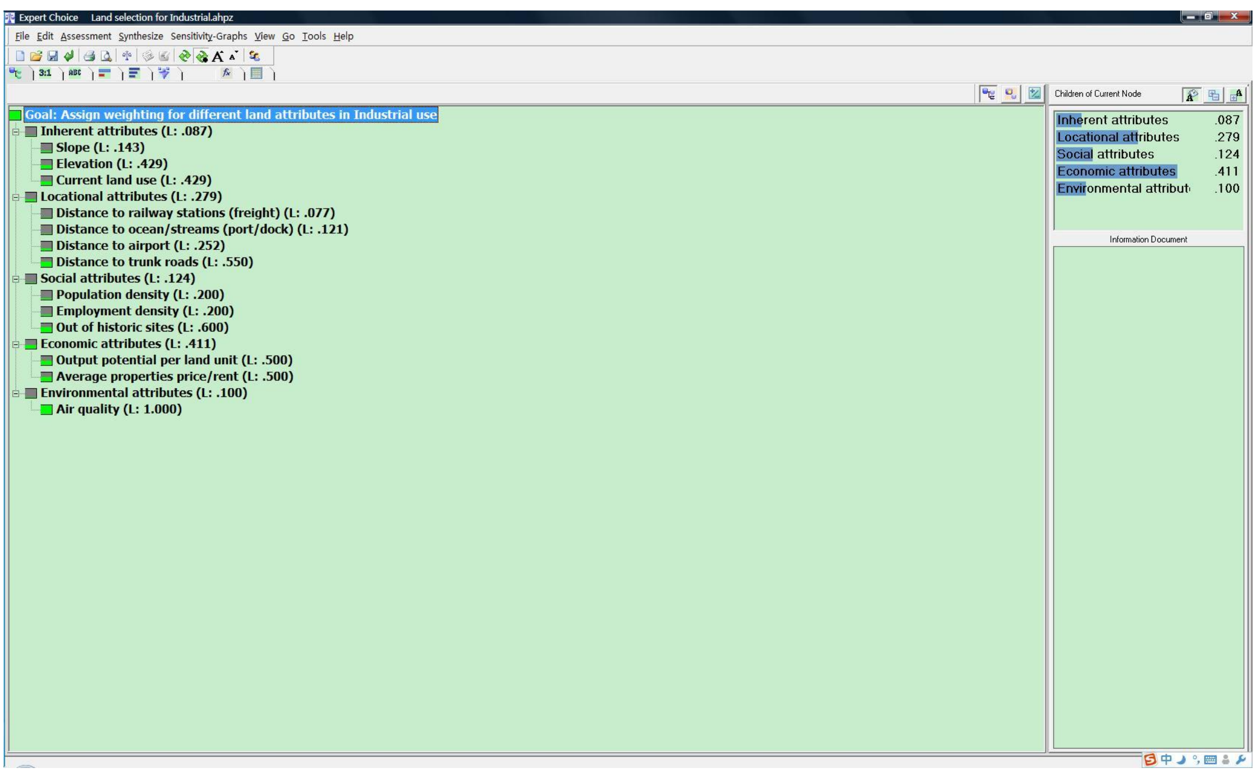


Figure 6.10 Weighting tree of industrial use

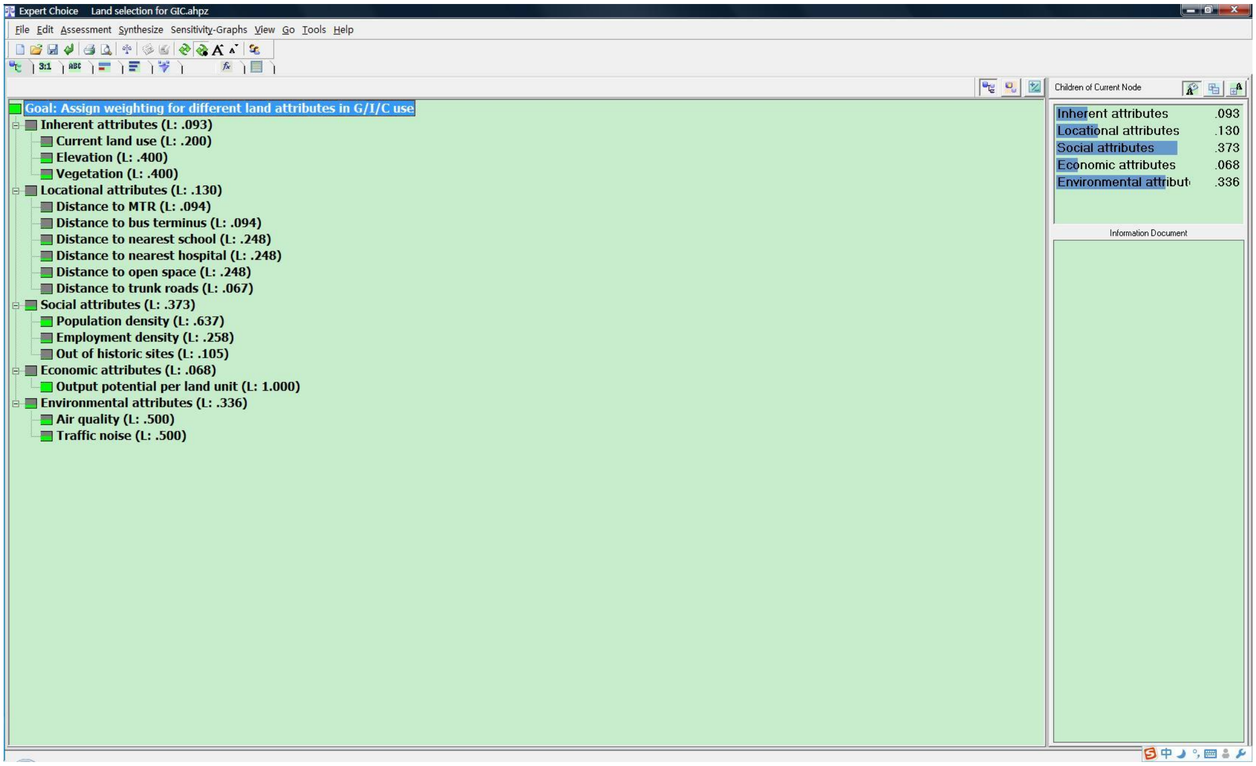


Figure 6.11 Weighting tree of G/IC use

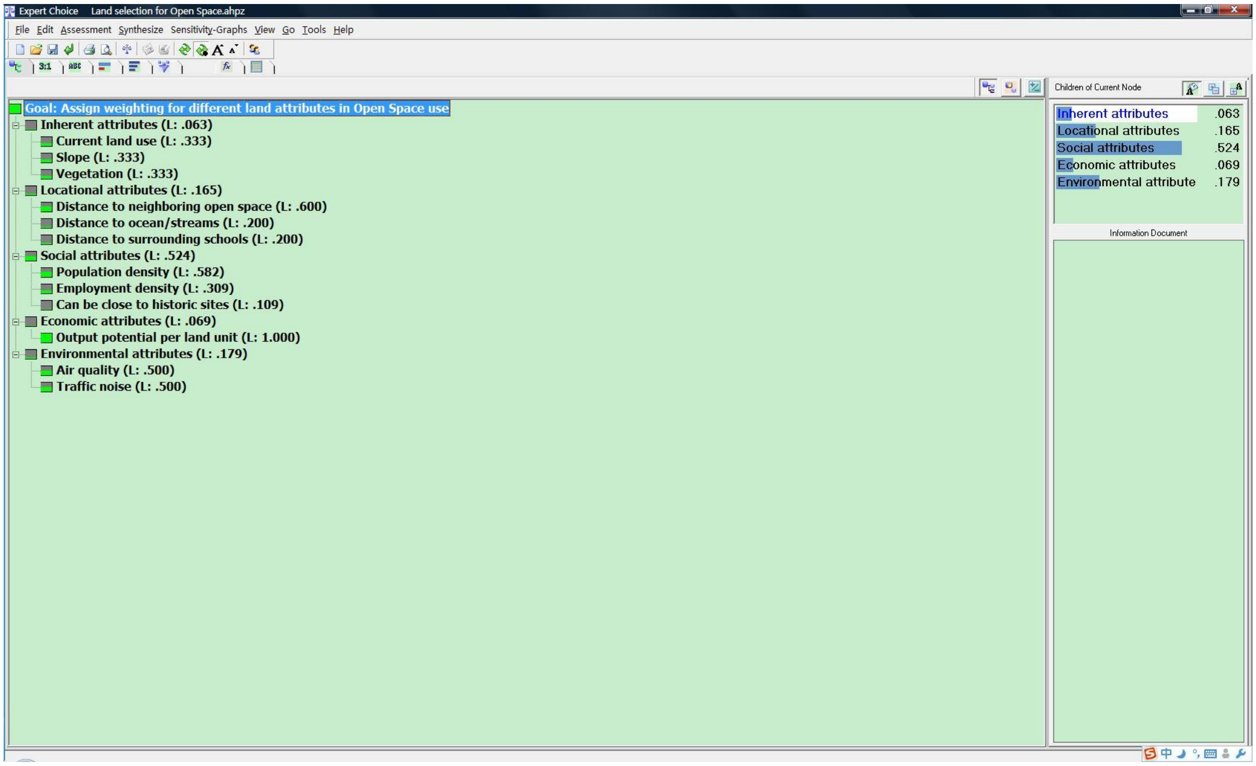


Figure 6.12 Weighting tree of open space

Table 6.11 The weightings of considered criteria for five land uses

Criterion name	Weighting of criterion				
	Residential	Commercial	Industrial	G/IC	Open space
Current land use	0.059	0.007	0.012	0.019	0.021
Slope	0	0.022	0.037	0	0.021
Elevation	0	0.022	0.037	0.037	0
Vegetation	0	0	0	0.037	0.021
Distance to CBD/BCCs	0	0.176	0	0	0
Distance to airport	0	0	0.07	0	0
Distance to railway/MTR stations	0.049	0.064	0.022 (Freight)	0.012	0
Distance to bus terminus	0.049	0.034	0	0.012	0
Distance to ocean/streams	0.007	0	0.034 (Port)	0	0.033
Distance to historic sites (Preservation)	0.073	0.011	0.074	0.039	0.057
Distance to nearest hospital	0.049	0	0	0.032	0
Distance to nearest primary/high school	0.042	0	0	0.032	0.033
Distance to open space	0.04	0	0	0.032	0.099 (Neighbor)
Distance to trunk roads	0.026	0.034	0.153	0.009	0
Population density	0.147	0.011	0.025	0.238	0.305
Employment density	0.073	0.032	0.025	0.096	0.162
Unit price of land sale	0	0.403	0.206	0.068	0.069
Property average price/rent	0.067	0.134	0.206	0	0
Air quality	0.106	0.051	0.1	0.168	0.09
Traffic noise	0.213	0	0	0.168	0.09
Total	1.0	1.0	1.0	1.0	1.0

Note: “0” represents that the criterion is not considered in certain land use.

6.3.5 Rating Standards of Considered Criteria

According to the planning standards and guidelines and other regulations of town planning and land development in Hong Kong, rating standards of the 20 criteria with five different land uses were tentatively proposed by the author. As described in Section 6.3.3.2, after combining the views of the focus group, the rating standards were finalized by the stakeholders of decision-making as Table 6.12 shows.

Table 6.12 Suitability classification and rating standards of selected criteria

Criterion	**Land uses**	**Rating standards**			
		Highly suitable	Suitable	Unsuitable	Very unsuitable
		3	*2*	*1*	*0*
Current land use	Residential	R	C, G/IC, V/O	I	O
	Commercial	C	R, G/IC, I, V/O	O	-
	Industrial	I	G/IC, V/O	R, C	O
	G/IC	G/IC	C, I, R, V/O	O	-
	Open space	O, V/O	I, R, G/IC	C	-
Slope (%)	Residential	-	-	-	-
	Commercial	[0.2-10]	(10-20]	< 0.2 or (20-25]	> 25
	Industrial	[0.2-5]	(5-10]	< 0.2 or (10-15]	> 15
	G/IC	-	-	-	-
	Open space	<= 15	(15-30]	> 30	-
Elevation <relative elevation in study area> (m)	Residential	-	-	-	-
	Commercial	<= 15	(15-30]	(30-40]	> 40
	Industrial	<= 10	(10-20]	(20-30]	> 30
	G/IC	<= 15	(15-30]	(30-40]	> 40

	Open space	-	-	-	-
Vegetation (percent)	Residential	-	-	-	-
	Commercial	-	-	-	-
	Industrial	-	-	-	-
	G/IC	>= 20	[15-20)	[10-15)	< 10
	Open space	>= 30	[25-30)	[20-25)	< 20
Distance to CBD/BCCs (km)	Residential	-	-	-	-
	Commercial	<= 2; <= 1 (sub)	(2-3]; (1-2] (sub)	(3-4]; (2-3] (sub)	> 4; > 3 (sub)
	Industrial	-	-	-	-
	G/IC	-	-	-	-
	Open space	-	-	-	-
Distance to airport (km)	Residential	-	-	-	-
	Commercial	-	-	-	-
	Industrial	<= 20	(20-25]	(25-30]	> 30
	G/IC	-	-	-	-
	Open space	-	-	-	-
Distance to railway/MTR stations (m)	Residential	<= 300	(300-600]	(600-900]	> 900
	Commercial	<= 250	(250-500]	(500-750]	> 750
	Industrial (freight)	<= 1000	(1000-2000]	(2000-3000]	> 3000
	G/IC	<= 400	(400-500]	(500-600]	> 600
	Open space	-	-	-	-
Distance to bus terminus (m)	Residential	<= 300	(300-450]	(450-600]	> 600
	Commercial	<= 300	(300-400]	(400-500]	> 500
	Industrial	-	-	-	-
	G/IC	<= 300	(300-400]	(400-500]	> 500
	Open space	-	-	-	-
Distance to	Residential	<= 200	> 200	-	-

ocean/streams (m)	(waterfront)				
	Commercial	-	-	-	-
	Industrial (port)	<= 1000	(1000-2000]	(2000-3000]	> 3000
	G/IC	-	-	-	-
	Open space	<= 150	> 150	-	-
Distance to historic sites <Preservation> (m)	Residential	>= 50 (nearest)	[30-50) (nearest)	[20-30) (nearest)	< 20 (nearest)
	Commercial	>= 70 (nearest)	[50-70) (nearest)	[30-50) (nearest)	< 30 (nearest)
	Industrial	>= 300 (nearest)	[200-300) (nearest)	[100-200) (nearest)	< 100 (nearest)
	G/IC	>= 60 (nearest)	[40-60) (nearest)	[30-40) (nearest)	< 30 (nearest)
	Open space	<= 100 (nearest)	> 100 (nearest)	-	-
Distance to nearest hospital (m)	Residential	[50 (nearest)-450]	(450-900]	< 50 (nearest) or (900-1200]	> 1200
	Commercial	-	-	-	-
	Industrial	-	-	-	-
	G/IC	<= 500	(500-1000]	(1000-1500]	> 1500
	Open space	-	-	-	-
Distance to nearest primary/high school (m)	Residential	[50 (nearest)-300]	(300-600]	< 50 (nearest) or (600-900]	> 900
	Commercial	-	-	-	-
	Industrial	-	-	-	-
	G/IC	<= 400	(400-800]	(800-1000]	> 1000
	Open space	<= 250	> 250	-	-
Distance to open space (m)	Residential	<= 300	(300-600]	(600-900]	> 900
	Commercial	-	-	-	-
	Industrial	-	-	-	-
	G/IC	<= 350	(350-700]	(700-1000]	> 1000

	Open space	-	>= 300 (neighbor O)	< 300 (neighbor O)	-
Distance to trunk roads (m)	Residential	[50 (nearest)-200]	(200-400]	< 50 (nearest) or (400-600]	> 600
	Commercial	<= 100	(100-250]	(250-350]	> 350
	Industrial	<= 100	(100-150]	(150-250]	> 250
	G/IC	<= 150	(150-300]	(300-450]	> 450
	Open space	-	-	-	-
Population density (persons/km^2)	Residential	[20000-40000]	[10000-20000) or (40000-50000]	< 10000 or > 50000	-
	Commercial	>= 20000	[10000-20000)	< 10000	-
	Industrial	-	<= 8000	> 8000	-
	G/IC	-	>= 15000	< 15000	-
	Open space	>= 15000	[8000-15000)	< 8000	-
Employment density (persons/km^2)	Residential	[5000-20000] and ‘Employment density’ <= ‘Population density’	‘Employment density’ <= ‘Population density’	‘Employment density’ > ‘Population density’	-
	Commercial	>= 20000	[10000-20000)	< 10000	-
	Industrial	-	<= 5000 (non-industrial)	> 5000 (non-industrial)	-
	G/IC	-	>= 10000	< 10000	-
	Open space	>= 10000	[5000-10000)	< 5000	-
Unit price of land sale (thousand HK dollars/m^2)	Residential	-	-	-	-
	Commercial	>= 300	[250-300)	[200-250)	< 200
	Industrial	<= 100	(100-150]	(150-200]	> 200
	G/IC	<= 300	(300-500]	> 500	-
	Open space	<= 400	(400-500]	> 500	-
Property average	Residential (average	>= 6000	[5000-6000)	[4000-5000)	< 4000

price/rent (HK dollars/sq.ft)	price)				
	Commercial (rent per month)	>= 23 (office); >= 100 (retail)	[18-23) (office); [90-100) (retail)	[13-18) (office); [80-90) (retail)	< 13 (office); < 80 (retail)
	Industrial (rent per month)	>= 11 (flatted factory)	[9-11) (flatted factory)	[7-9) (flatted factory)	< 7 (flatted factory)
	G/IC	-	-	-	-
	Open space	-	-	-	-
Air quality (API)	Residential	<= 25	(25-75]	(75-125]	> 125
	Commercial	<= 50	(50-100]	(100-150]	> 150
	Industrial	<= 75	(75-125]	(125-175]	> 175
	G/IC	<= 50	(50-100]	(100-150]	> 150
	Open space	<= 75	(75-100]	(100-150]	> 150
Traffic noise (dB)	Residential	<= 50	(50-60]	(60-70]	> 70
	Commercial	-	-	-	-
	Industrial	-	-	-	-
	G/IC	<= 55	(55-65]	(65-75]	> 75
	Open space	<= 60	(60-70]	(70-80]	> 80

Note: R – Residential, C – Commercial, I – Industrial, O – Open space, V/O – Vacant/Under Construction/Others;
The road distance can be simply converted to time distance through dividing by average speed of walking or driving.

To carry out land-use suitability assessment in the study, criterion standardization, weighting and composite scoring were accomplished with the help of MCE. This model provided a quantitative approach to the assessment, including the classification of land use suitability, rating of criterion values, and scoring for multi-criterion analysis. Firstly, land use suitability was classified into four levels - *very unsuitable*, *unsuitable*, *suitable* and *highly suitable* classes - and integers ranging from 0 to 3 were assigned accordingly (refer to Table 6.12). Secondly, the value of each criterion was obtained from the land-info database, and each criterion was correspondingly assigned a certain suitability level according to the rating standards. These ratings standards are a crucial part of the model and were determined by referring to the literature, Hong Kong planning standards and guidelines, and the views of the decision-makers in certain planning projects. Thirdly, a linear scoring formula was used, in the form of

$$S_i = \sum_{j=1}^{n} R_i(j) \times W(j)$$

where S_i denotes the land use suitability of land site *i*, *i* is the number of land sites; *j*=1, 2, …, n is the number of criteria; $R_i(j)$ refers to the rating of criterion *j* of the land site *i*; and *W*(*j*) is the weighting of criterion *j*. By overlaying map layers (which can be found in Section 6.4) of the selected criteria with their respective weightings, the final scores of each land site are calculated. The suitability grade of each land site is also divided into four levels according to the final scores: *very unsuitable* (0-0.75), *unsuitable* (0.75-1.5), *suitable* (1.5-2.25) and *highly suitable* (2.25-3).

6.4 Database Development

6.4.1 The Process of the Database Development

Firstly, raw data were collected in accordance with the criteria considered in the model. Secondly, the collected data were processed through digitization, format conversion, and spatial analysis to prepare usable input data for the model. Finally, the directly usable data were stored in the database with the form of map layers. Figure 6.13 shows the process of the database development.

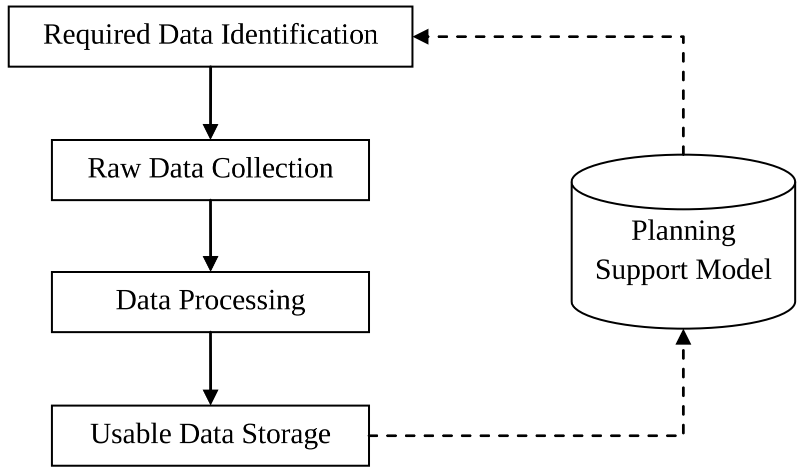


Figure 6.13 The process of the database development

6.4.2 Environment of Data Storage

The database was built in the environment of "ArcGIS" – a powerful GIS toolkit. The collected data were processed in one module of the software – ArcMap (ArcInfo), and the database was created with the form of File Geodatabase in another module of the software – ArcCatalog and all data were stored in the File Geodatabase. The interface of the database created as a File Geodatabase in "ArcGIS" is displayed in Figure 6.14.

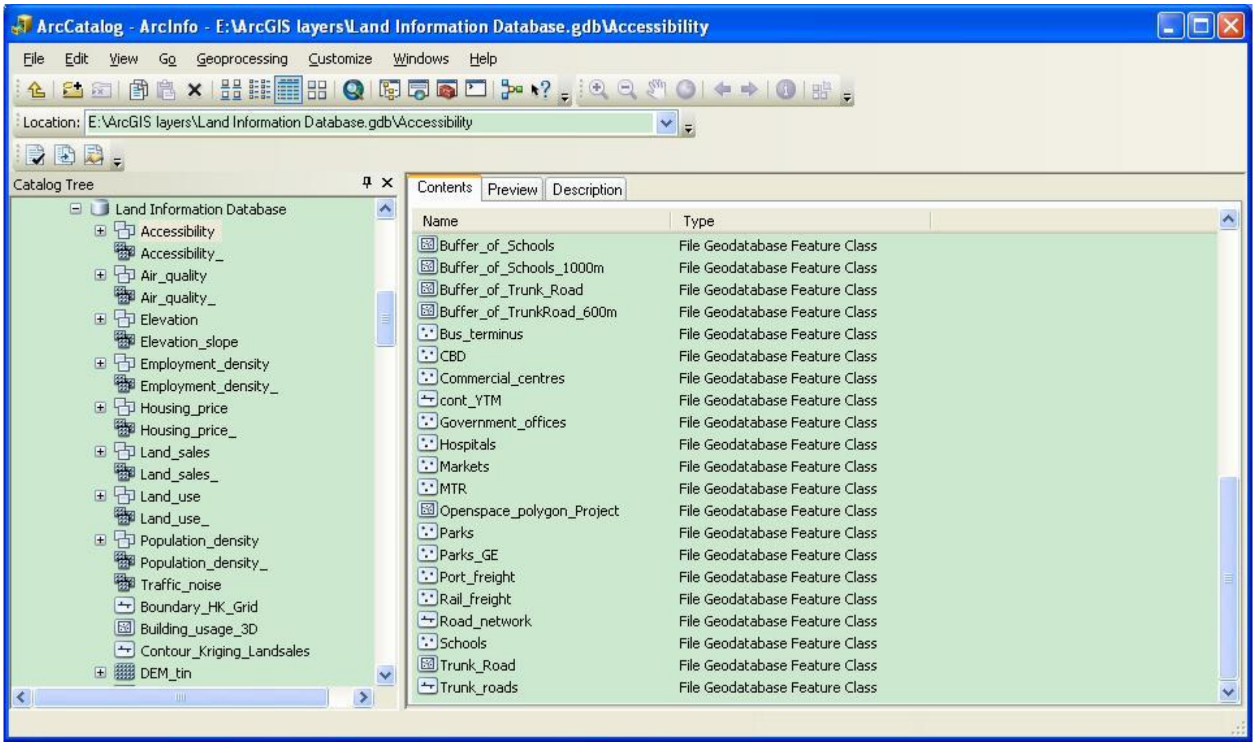


Figure 6.14 A screenshot of the database in "ArcGIS"

6.4.3 Data Collection

Before data collection, the required data/information was identified according to the criteria for LUSA given in the planning support model. To provide the information needed for LUSA in the model, volumes of raw spatial data such as digital topographic maps, aerial photos, and land utilization map and also many non-spatial data such as statistical tables recording the information of population, employment, and housing price were collected for this database. The details of raw data are listed in Table 6.13. Some of the raw data could be obtained from the governmental websites, for example, Outline Zoning Plan (OZP), traffic noise distribution, population distribution, API, and some needed to be purchased from government offices or relevant institutions, such as topographic maps, aerial photos, and transaction records of housing prices. Figure 6.15

shows an aerial photo as an example of raw spatial data. The assembly of raw data is the foundation of planning support, and it can provide sufficient information for decision-making in the planning process and land management on a geospatial visualization platform.

Table 6.13 Raw data forms

Spatial data	Non-spatial data
• Topographic maps	• Population distribution
• Aerial photos	• Employment distribution
• Current land utilization map	• Air pollution index (API)
• Land use plan (Outline Zoning Plan)	• Records of land sales
• Roads network	• Records of housing price
• Railways (MTR) network	• Records of office rent
• Location map of public facilities (e.g. hospitals, schools, parks)	• Records of industrial rent
• Location map of historic sites	
• Distribution map of traffic noise	
• Vegetation coverage map	
• Buildings information map	

Figure 6.15 An aerial photo of the study area

The quality of data collection restricts the completeness of criteria examined in MCDA. In this case study, due to data availability, partial criteria (20 out of 29) were considered with the support of available data. In addition, the validity of the collected data (e.g. accuracy, data update) influences the results of LUSA. Data collection is a very important step of the database development, and the quality of raw data and the data sources must be verified during the collection process.

6.4.4 Data Processing

The raw data cannot be directly used in the model, and they must be processed to fit for the model. The data processing included two steps: (1) GIS digitization and format conversion, and (2) spatial analysis for criterion-value generation.

In the first step, some raw data which were not GIS digital format were digitized in "ArcGIS". During the process of digitization, several kinds of jobs may be involved:

hardcopy scan, statistics input to the computer, and digitization in “ArcGIS”. For instance, a hardcopy of map needs to be scanned to be a digital map, and be further digitized into GIS format with appropriate geographic coordinates. Statistical data such as records of housing price need to be input into a table (e.g. Excel file) on the computer, and be linked to certain map layers in “ArcGIS”. In terms of format conversion, all digital data stored on the computer with whatever original format need to be converted into the file format of File Geodatabase in “ArcGIS”. After the first step, all raw data were digitized and/or converted into the storage format of File Geodatabase.

In the second step, the GIS digitized data were further processed through GIS spatial analysis in “ArcGIS” to provide criterion values for the model. During this step, many tools integrated in the ArcToolbox of ArcInfo for all kinds of spatial analyses such as Create TIN, Slope, and Kriging were used to generate the desired input data for the model. A Geoprocessing model was created using ModelBuilder in “ArcGIS” to automatically generate the values of the 20 considered criteria (i.e. the 20 map layers). The ModelBuilder is an application used to create, edit and manage Geoprocessing models for spatial data analysis. A Geoprocessing model is a set of spatial processes that converts input data into an output map using a specific function in ArcToolbox such as Buffer and Overlay, and large models can be built by linking several processes together (Esri, 2000).

Specifically, the 20 map layers with corresponding values of the 20 criteria were generated using different raw data and processing techniques. The layer of Current land use was a shapefile (vector format) containing the information of current land use of 86 land sites to be examined in the study area. The layers of Slope and Elevation were both raster maps created from digital elevation model (DEM) of the study area, and they recorded the Mean of slope and relative elevation of the 86 sites. The layer of vegetation was also a raster containing the Mean of vegetation coverage of the 86 sites, and the data of vegetation coverage in the study area originated from a remote sensing (RS) map (IKONOS). Most of the layers of locational attributes such as Distance to MTR stations, Distance to hospitals, and Distance to historic sites were all vector maps with location points of sites and all kinds of facilities, and the shortest road/time distances of the 86 sites to main facilities and sensitive uses were measured by building a dataset of road network analysis in "ArcGIS". The layers of Population density and Employment density contained the statistical information of population and employment density in the study area, and the values of the 86 sites were calculated after converting vector to raster. The layers of Unit price of land sale and Property average price/rent were both raster maps produced by using Spatial Interpolation based on distribution points with the information of land sale price and property average price/rent. They reflected the spatial distribution of land price as well as property price/rent, and provided the values of the 86 sites in terms of the two criteria. The layers of Air quality and Traffic noise were made based on the air pollution index (API) and the results (raster format) of a study "Spatial distribution of traffic noise problem in Hong Kong" conducted by Environmental Protection Department of Hong Kong, and they provided the information of air quality and traffic noise for the 86 sites in the study area. Details of data format, processing techniques and steps of the 20 criteria are shown in Table 6.14.

Table 6.14 Format, processing techniques and steps of data for the 20 criteria

Criterion No.	Data format	Processing techniques	Processing steps

1	Vector	Digitization/Vectorization in "ArcGIS"	1. Create polygons of 86 sites in a shapefile; 2. Add information of current land use of the 86 sites in Attribute Table of the shapefile.
2	Raster	'Kriging' interpolation, 'Create TIN', and surface 'Slope' in ArcToolbox	1. Create a raster using Kriging interpolation based on elevation points; 2. Create a TIN (DEM) based on the raster; 3. Create a raster of slope information from the TIN.
3	Raster	'Kriging' interpolation, 'Create TIN' in 3D Analyst Tools	1. Create a raster using Kriging interpolation based on elevation points; 2. Create a TIN (DEM) (containing elevation information).
4	Raster	'Reclassify', 'Zonal statistics as table' in Spatial Analyst Tools	1. Reclassify a RS map containing pixel values of vegetation coverage; 2. Calculate the Mean of vegetation coverage of the 86 sites.
5	Raster	'Multiple ring buffer' in Analysis Tools, 'Polygon to raster' in Conversion Tools and 'Tabulate area' in Spatial Analyst Tools	1. Create multiple ring buffer based on the spatial center of CBD/BCCs; 2. Convert polygons of the buffer rings (vector) to raster; 3. Calculate average distance of the 86 sites to the center of CBD/BCCs.
6	Vector	'Feature to point' in Data Management Tools, 'Near' in Analysis Tools	1. Locate the geometric center of the 86 sites and airport; 2. Identify the nearest point (foot of a perpendicular) on the roads from the geometric centers; 3. Calculate road/time distance from the center of the sites to the airport based on real-life road network.
7	Vector	'Feature to point', 'Near'	1. Locate the geometric center of the 86 sites and MTR/railway stations; 2. Identify the nearest point on the roads from the geometric centers; 3. Calculate road/time distance from the center of the sites to the stations.
8	Vector	'Feature to point', 'Near'	1. Locate the geometric center of the 86 sites and bus terminus; 2. Identify the nearest point on the roads from the geometric centers; 3. Calculate road/time distance from the center of the sites to the terminus.
9	Raster	'Multiple ring buffer', 'Polygon to raster', and 'Tabulate area'	1. Create multiple ring buffer based on the polyline of coastline within the study area; 2. Convert polygons of the buffer rings to raster; 3. Calculate average distance of the 86 sites to the coastline.
10	Raster	'Multiple ring buffer', 'Polygon to raster', 'Tabulate area' and 'Near'	1. Create multiple ring buffer based on the geometric center of historic sites; 2. Convert polygons of the buffer rings to raster; 3. Calculate average distance of the 86 sites to the historic sites; 4. Determine the nearest distance from the boundary of the 86 sites to the geometric center of the historic sites.
11	Vector	'Feature to point', 'Near'	1. Locate the geometric center of the 86 sites and hospitals; 2. Identify the nearest point on the roads from the geometric centers; 3. Calculate road/time distance from the center of the sites to

			the hospitals; 4. Determine the nearest distance from the boundary of the 86 sites to the center of the hospitals.
12	Vector	‘Feature to point’, ‘Near’	1. Locate the geometric center of the 86 sites and primary/high schools; 2. Identify the nearest point on the roads from the geometric centers; 3. Calculate road/time distance from the center of the sites to the schools; 4. Determine the nearest distance from the boundary of the 86 sites to the center of the schools.
13	Vector	‘Feature to point’, ‘Near’	1. Locate the geometric center of the 86 sites and open spaces; 2. Identify the nearest point on the roads from the geometric centers; 3. Calculate road/time distance from the center of the sites to the open spaces.
14	Vector	‘Feature to point’, ‘Near’	1. Identify trunk roads and their junctions with other roads in the road network; 2. Locate the geometric center of the 86 sites; 3. Calculate road/time distance from the geometric centers to the trunk roads; 4. Determine the nearest distance from the boundary of the 86 sites to the sideline of the trunk roads.
15	Raster	Vectorization, ‘Polygon to raster’, and ‘Zonal statistics as table’	1. Create district polygons indicating the distribution of population density in a shapefile; 2. Convert the polygons to raster; 3. Calculate the Mean of population density of the 86 sites.
16	Raster	Vectorization, ‘Polygon to raster’, and ‘Zonal statistics as table’	1. Create district polygons indicating the distribution of employment density in a shapefile; 2. Convert the polygons to raster; 3. Calculate the Mean of employment density of the 86 sites.
17	Raster	Vectorization, ‘Kriging’ interpolation	1. Create location points of sold land sites containing the sale price in a shapefile; 2. Create a raster using Kriging interpolation based on the price information of the points.
18	Raster	Vectorization, ‘Kriging’ interpolation	1. Create location points of real properties containing the average price/rent in a shapefile; 2. Create a raster using Kriging interpolation based on the price/rent information of the points.
19	Raster	Vectorization, ‘Polygon to raster’, and ‘Zonal statistics as table’	1. Create polygons of monitoring areas recording the API in a shapefile; 2. Convert the polygons to raster; 3. Calculate the Mean of API of the 86 sites.
20	Raster	‘Reclassify’, ‘Zonal statistics as table’	1. Reclassify a raster map containing spatial distribution of traffic noise; 2. Calculate the Mean of traffic noise level of the 86 sites.

With the help of ModelBuilder, the values of each criterion could be acquired for LUSA from the output maps which were automatically generated based on the spatial analysis of the input data. For instance, slope information of these sites was obtained from the DEM which was made from elevation information by running spatial analysis processes; and the shortest or nearest distances were measured on the basis of some specific spatial analyses on target facility locations such as MTR stations, hospitals and schools. When using and linking the specific tools for spatial analysis in ModelBuilder, some simple programming/coding in the 'Attribute Table' of each map layer was necessary. Since 20 map layers were involved in this study, the Geoprocessing model was huge and complex. A snapshot of the Geoprocessing model built in ModelBuilder is shown in Figure 6.16.

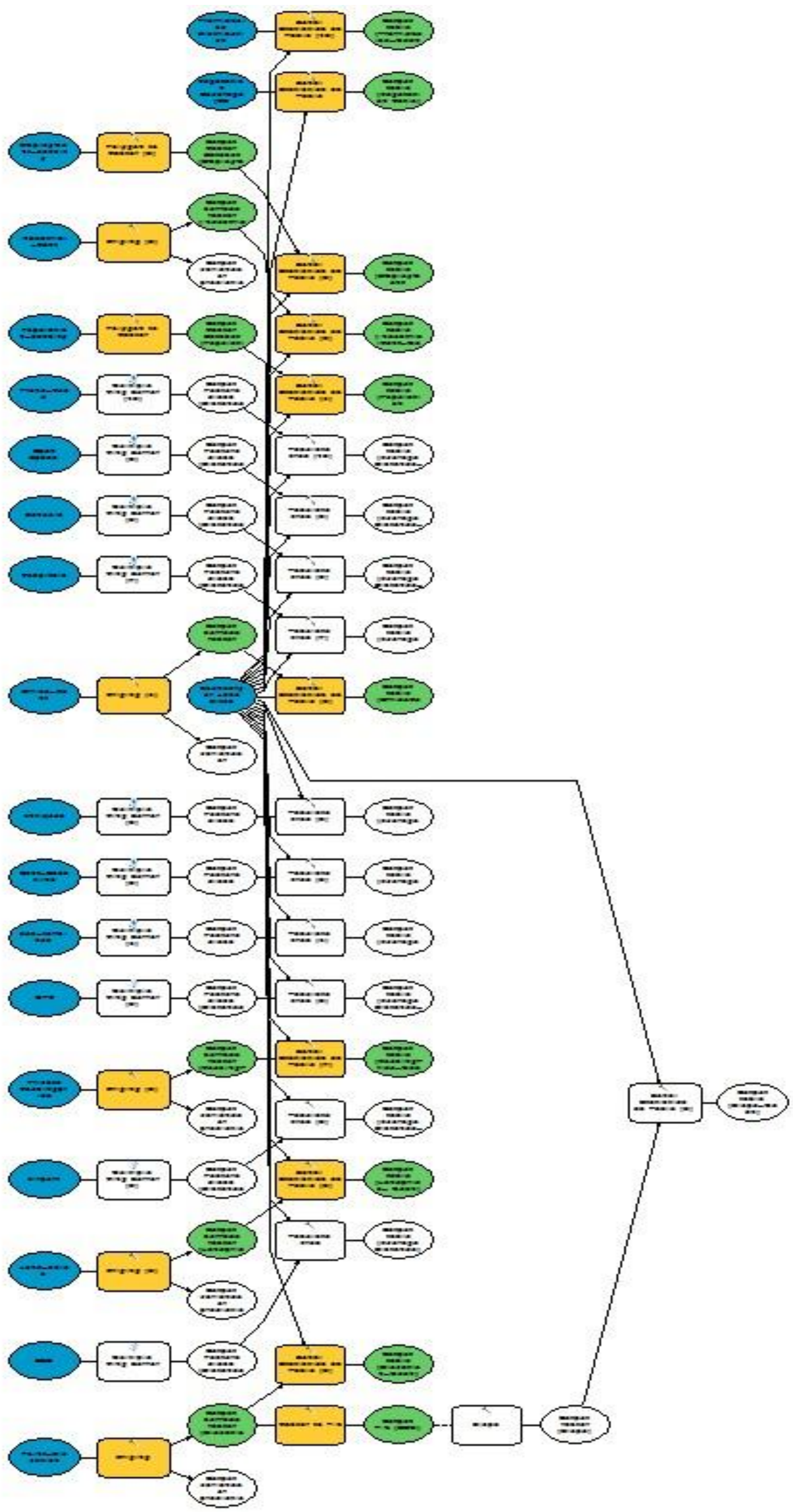


Figure 6.16 The Geoprocessing model in ModelBuilder

By running this Geoprocessing model, the 20 map layers containing the values of 20 criteria were generated in batch and stored in the database. Regarding file format of the map layers in GIS (vector/raster), except for the first criterion – current land use and most of locational criteria (vector maps), other criteria were all raster maps (10×10 m grids). The purpose of establishing this database was to provide usable input data for LUSA and a geospatial visualization platform, which can be regarded as the physical basis of the whole framework.

6.5 Semi-results of LUSA ONLY based on Available Criteria

Land-use suitability maps for five land uses were generated based on 20 available criteria. For each type of land use, every land site located in the study area was classified into four suitability grades as described in Section 6.3 Model Development. In the case study, 86 land sites with six broad land uses were investigated based on the required information provided by the database. Although the results of suitability analysis were not comprehensive due to the partial criteria included, they could illustrate the potential outcomes of using this framework. In addition, the results also quantified the land-use suitability based on the available criteria, and they could serve as a reference for land-use decision-making through combining more considerations on other factors which were not involved in this time.

As displayed in the land suitability maps corresponding to the five land uses (Figures 6.17 – 6.21), the 86 land sites were assessed and classified into three different levels for residential use – highly suitable (orange diagonal), suitable (green point) and unsuitable (white), two levels for commercial use and open space – highly suitable and suitable, two levels for industrial use - suitable and unsuitable, and only one level for G/IC use – suitable. The different suitability levels were categorized on the basis of the integrative consideration of the multiple attributes of each land site, such as physical conditions, locational (accessibility/compatibility), economic and traffic noise assessment. These results of the LUSA indicated that, in the study area, almost all land sites were suitable for residential, commercial, G/IC use and open space, and part of the land sites were unsuitable for industrial use. Although they were semi-results based only on incomprehensive criteria of LUSA, the maps could still show the part of land-use suitability of each site based on the partial criteria due to incomplete data supported. By using this GIS-based approach, the specific land sites can be easily found and located on the maps.

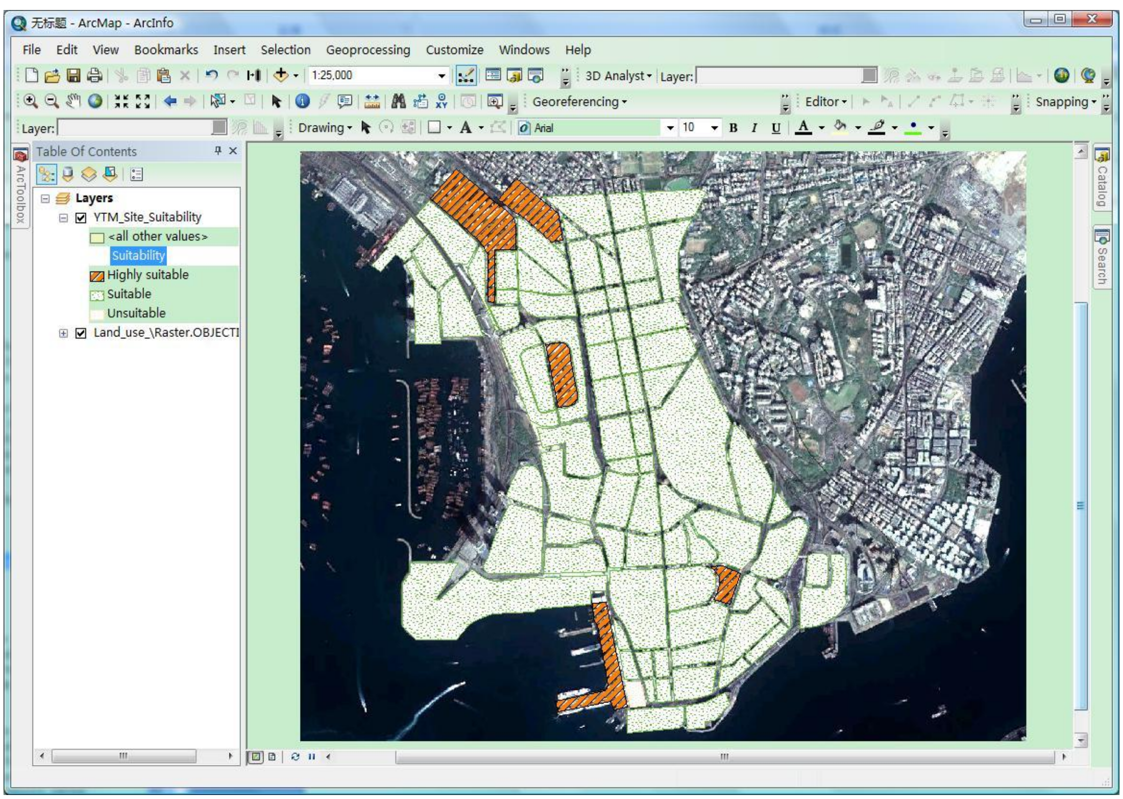


Figure 6.17 Land suitability map for residential use

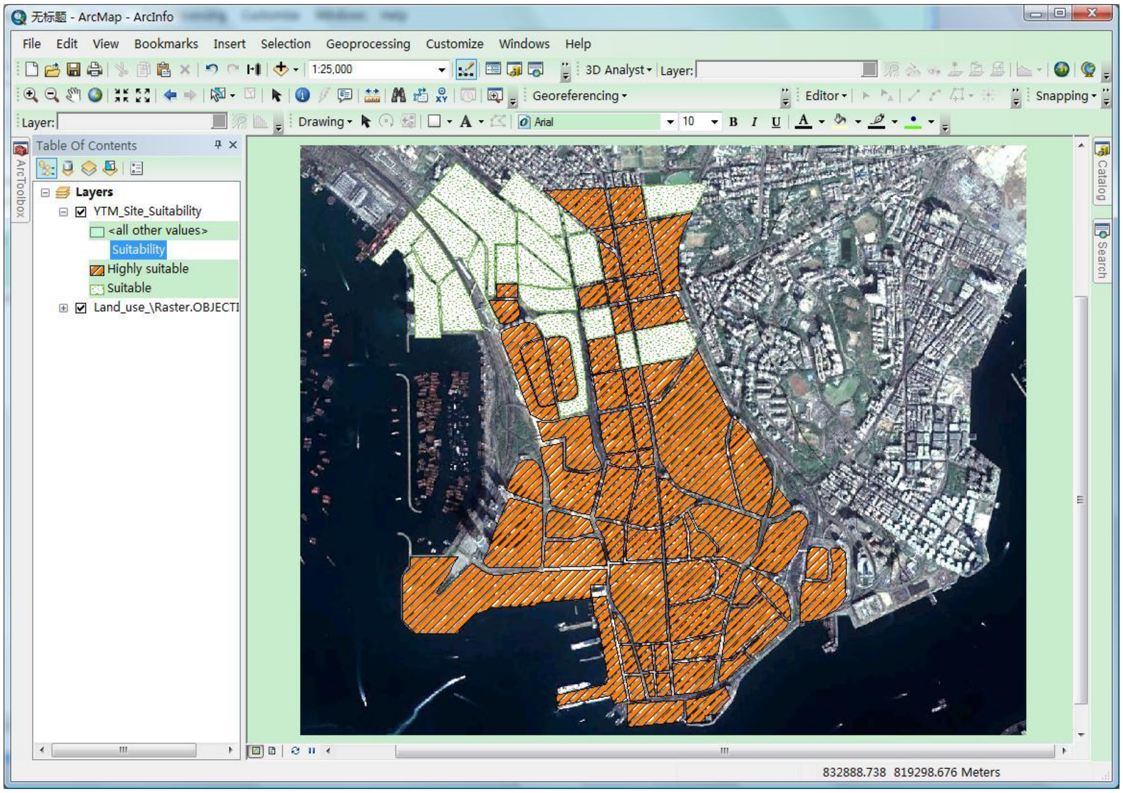


Figure 6.18 Land suitability map for commercial use

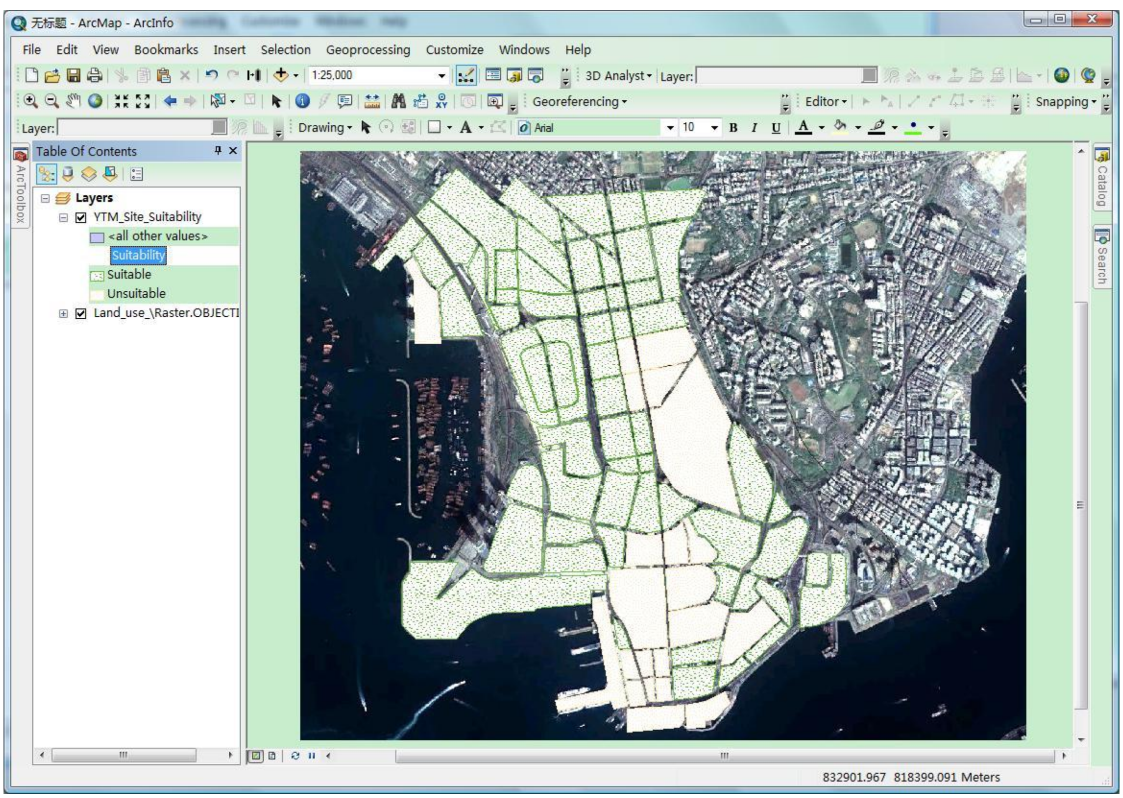


Figure 6.19 Land suitability map for industrial use

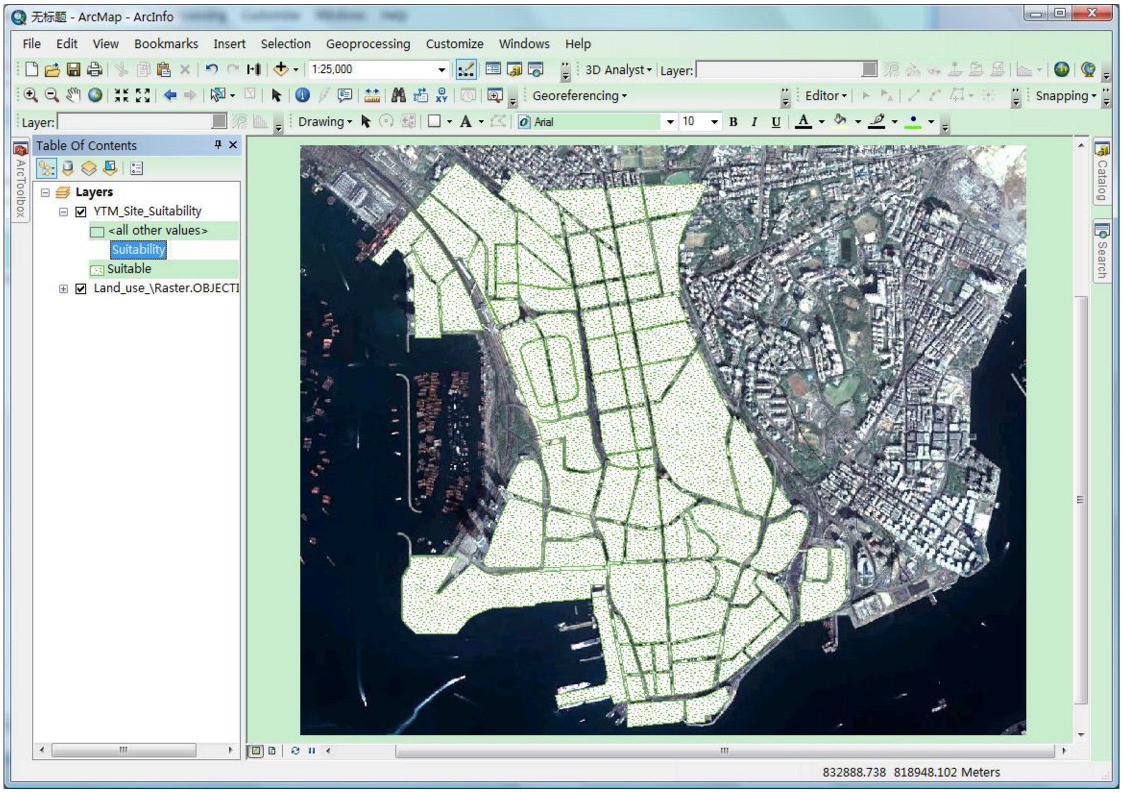


Figure 6.20 Land suitability map for G/IC use

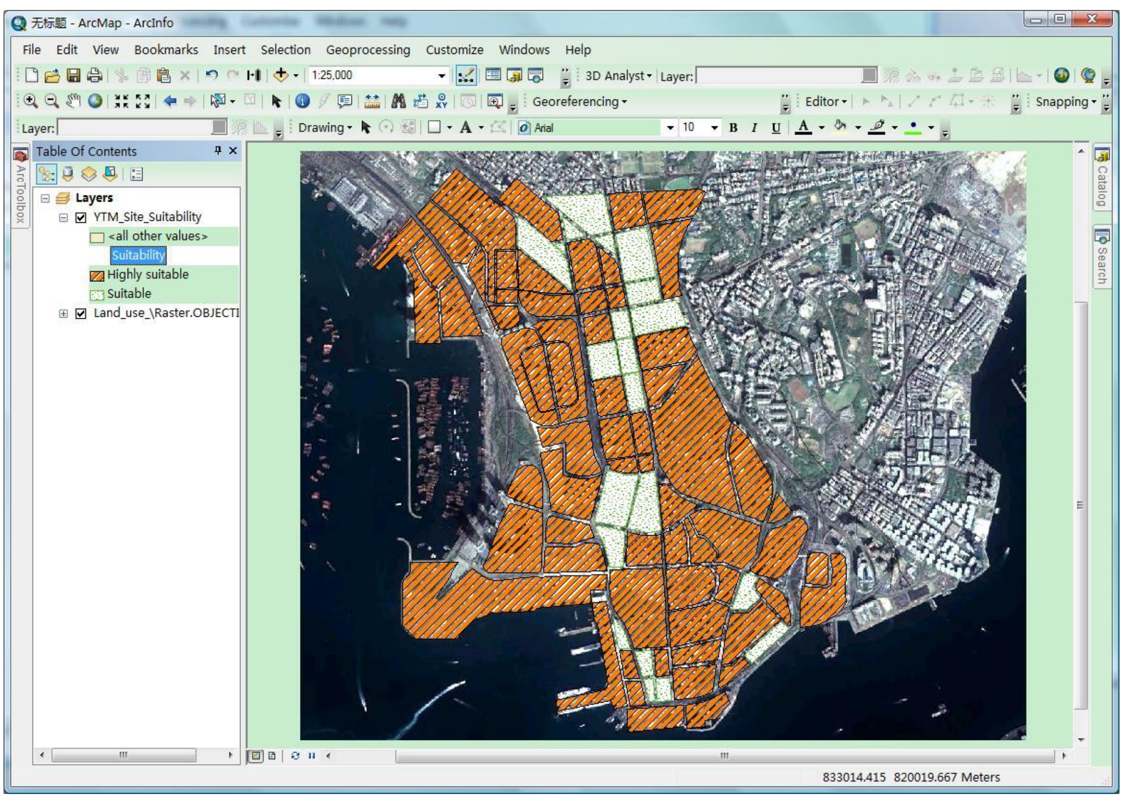


Figure 6.21 Land suitability map for open space

Based on the final scores of land-use suitability calculated by the model, the most recommended land use was assigned to each site (i.e. land use with the highest score was considered as the most recommended type). Figure 6.22 shows the most recommended land-use pattern in the study area, which can be used as a reference for decision-makers in the process of land use planning (Residential – orange diagonal, Commercial – yellow diagonal, G/IC – green circle, Open space – blue curve).

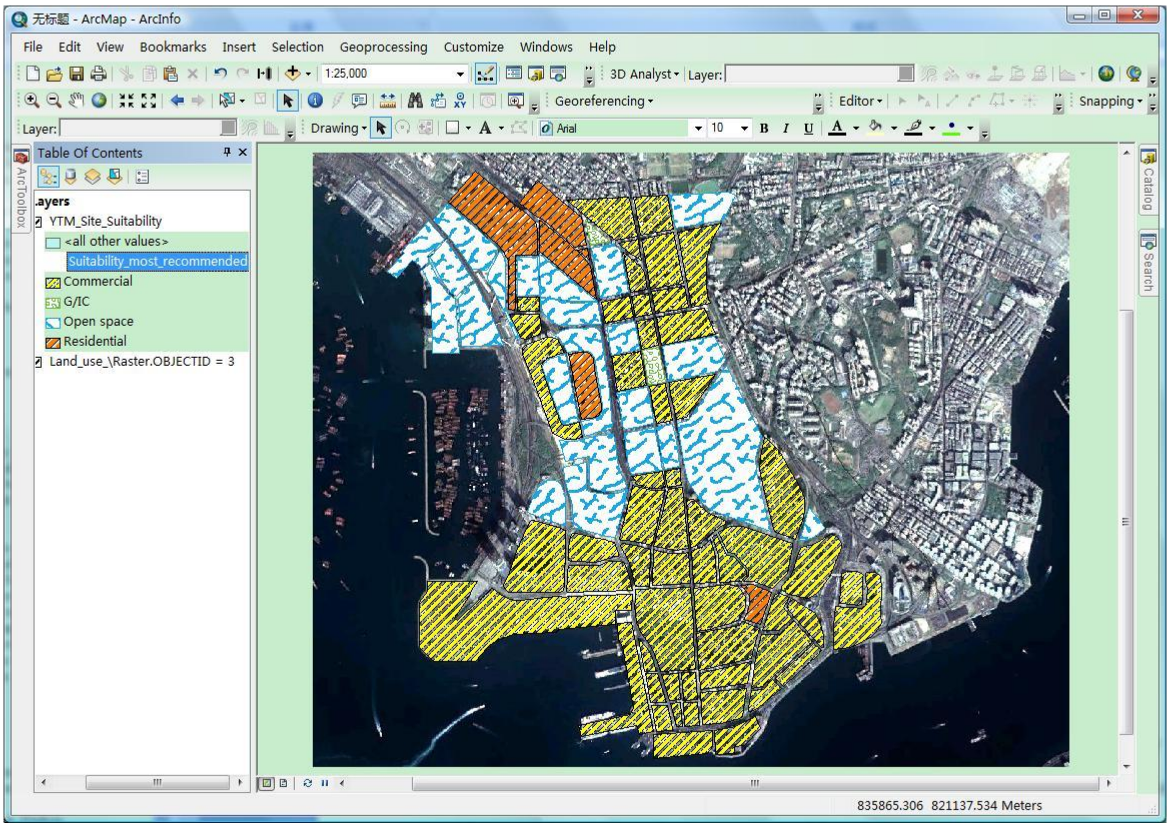
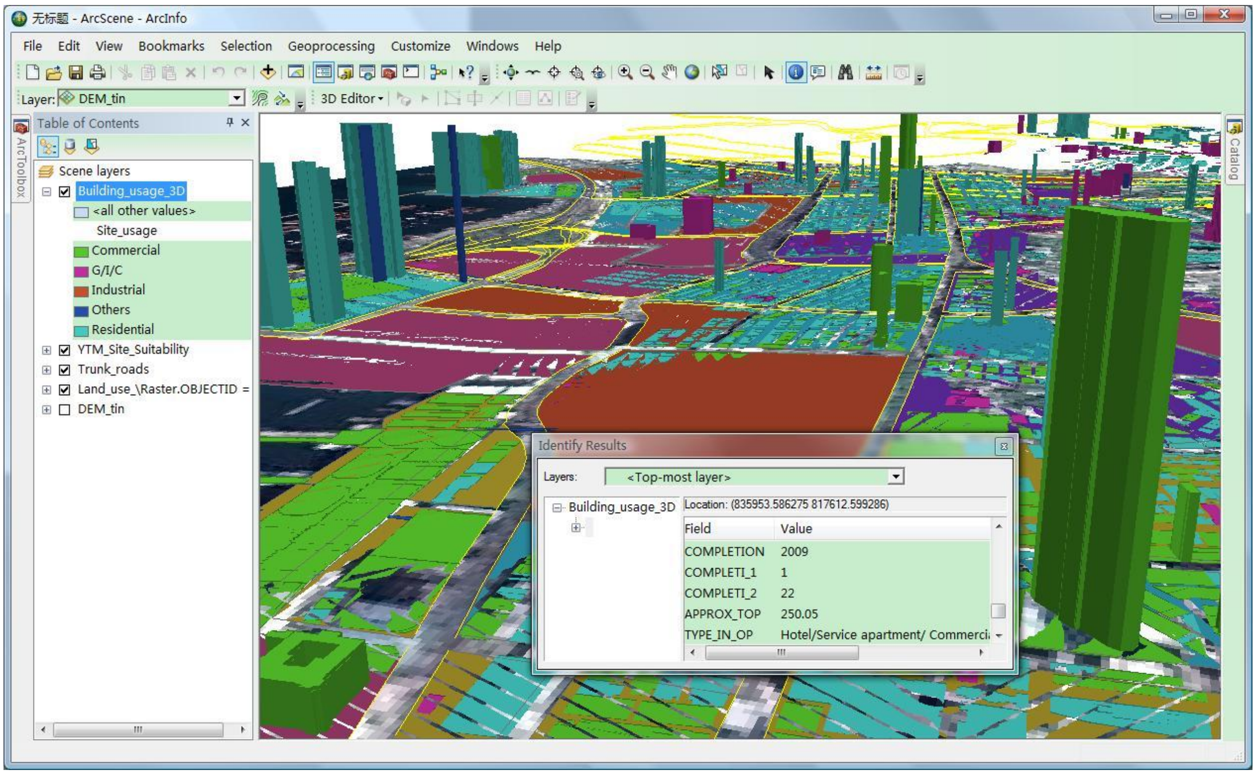


Figure 6.22 The most recommended land use for the sites

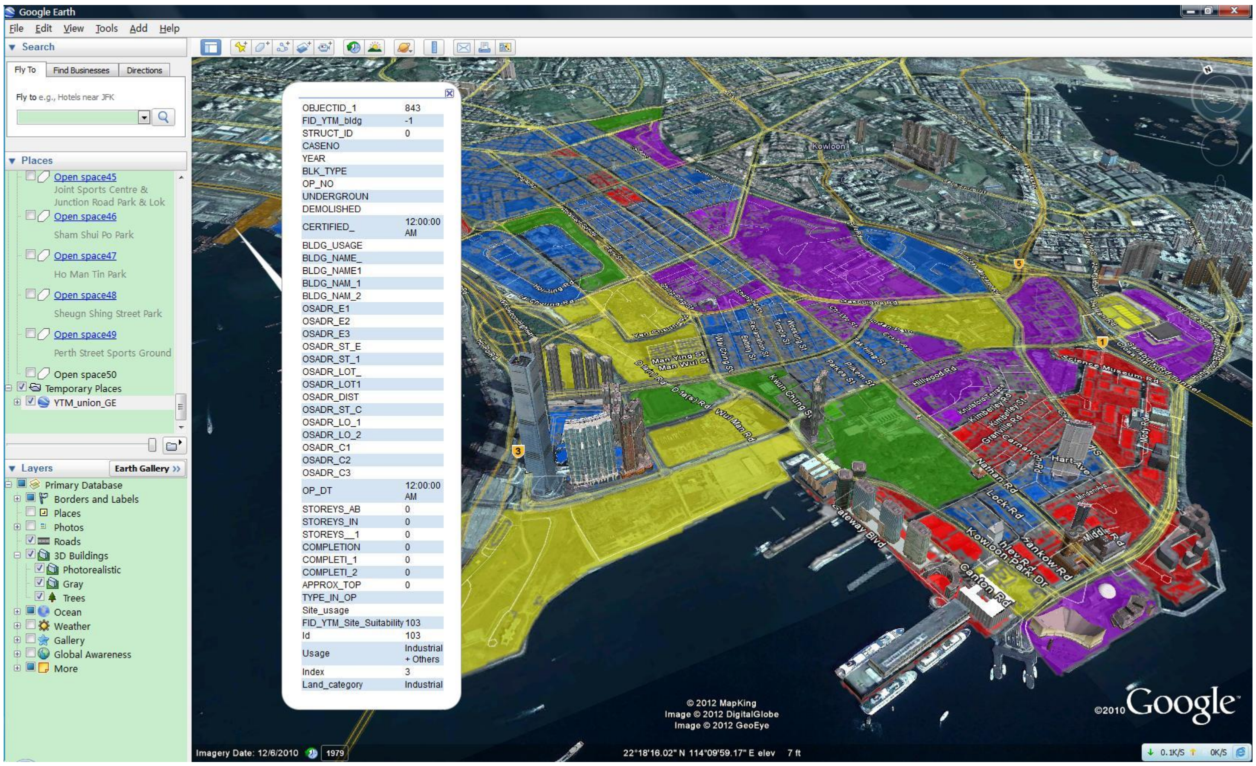
In addition, this framework (in the database) provides a function of 3D visualization to assist the decision-making process. 3D visualization of the real environment of planning areas can better display the details of the surroundings and current conditions of planning tasks than 2D conventional maps. With the help of 3D visualization, buildings can be displayed with their actual shape on the land and the information of the buildings such as building age, building height can also be involved in the maps if such information is available. An example of the study area with 3D visualization in "ArcGIS" is presented to show this feature (Figure 6.22).



Note: the pop-up window shows the information of the building sideward.

Figure 6.23 The study area with 3D visualization in "ArcGIS"

In order to improve the process of collaborative/participatory planning and enable more stakeholders of planning can access to the information of the conditions and environment of planning tasks without professional skills in GIS, this framework integrates a feature of Web-based geo-information display and enquiry. Specifically, the geospatial information stored in the database can be browsed and queried on "Google Earth", which is a virtual global, map and geographical information program developed by "Google". By virtue of this feature, every stakeholder can freely access to the geospatial information of planning tasks online and read the information on a global and public platform of general geographic information. Figure 6.23 shows a screenshot of the study area (Yau Tsim Mong) displayed on the interface of “Google Earth”.



Note: the pop-up window contains the detailed information of a site and its buildings.

Figure 6.24 The study area spatially displayed on “Google Earth”

6.6 Summary of the Chapter

This chapter illustrates how the framework has been practically developed following the instruction of the structure of the framework via a case study. This case study shows that the framework provides a feasible way to support land use planning in urban renewal projects. Details of the model and database development are described to interpret the detailed steps of framework development to the readers, and this illustration can be used as a guide to redevelop a set of model and database by others in other places. LUSA results produced by the framework based on the available criteria and data in the case study are also presented.

Chapter 7 Framework Validation

7.1 Introduction

This chapter describes the validation stage of the proposed framework. The validation contains two parts: a comparative experiment and a focus group meeting. They are separately organized to test the performance of the PSS-supported process (PSS-SP) based on the framework in two different ways. The comparative experiment is designed to compare the PSS-SP with the conventional process in site planning, and the focus group meeting is conducted to solicit feedback of using the PSS-SP from planning practitioners. Questionnaire surveys are combined with both of them to collect not only qualitative feeling of the PSS-SP but also quantitative scoring of different perception levels. Based on these data collected from the survey, statistical results are analyzed to verify the effectiveness of the framework.

7.2 Overview of Validation Measures

In order to test the performance of a framework or model serving for practical problem-solving purposes, it cannot be better to put the outcomes into practice. In this research, due to the time and resource constraints, an experimental study is designed to simulate and build an environment of planning charrettes instead of a real planning project, and a focus group meeting (like an experience workshop) is arranged to complement the validation.

In general, validation measures used in the research are experimental studies with questionnaire surveys. In fact, the focus group meeting can be seen as another experiment. As discussed in Chapter 1 – methodology part, experimental study is an effective tool to directly validate research outcomes by testing hypotheses. Two experimental studies are conducted separately to serve for the framework validation, and they are devised to approximate planning practice by using real places and real data. Firstly, the framework developed in the case study provides real-life data for validation preparation. Secondly, two experimental studies are conducted separately ending with questionnaire surveys. Finally, the data collected from the questionnaire surveys are analyzed quantitatively and qualitatively for the validation. The validation measures and process are displayed in Figure 7.1.

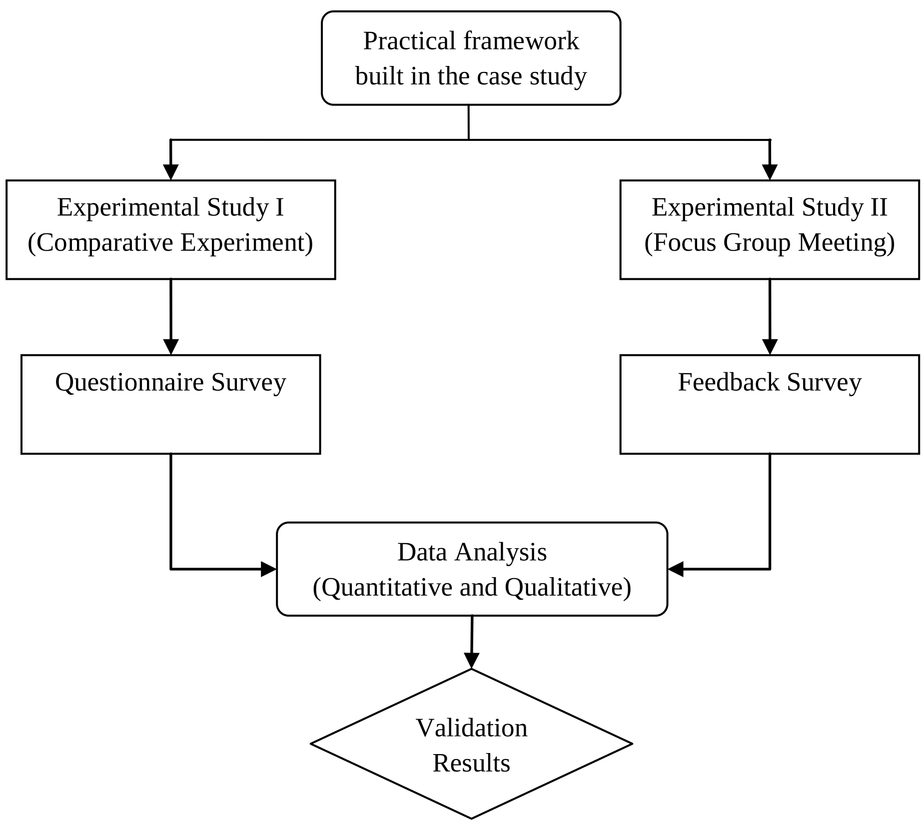


Figure 7.1 The process of framework validation

7.3 Experimental Study I (Comparative Experiment)

7.3.1 Hypothesis of the Experimental Study

As discussed in previous chapters, the proposed framework consisting of planning support model and associated land-info database has the potential to enhance the understanding and engagement of participants in planning charrettes, and the PSS-SP derived from the framework can facilitate the process of land use planning by enabling planners to readily acquire the information they need and make decisions in a shorter time and in a more objective way.

Therefore, the primary hypothesis to be tested in the experimental study is:

The planning strategy with the help of PSS-SP can support planners to make decisions more objectively and efficiently, and enable planning participants (stakeholders in planning) to better understand the planning needs and concerns than the case when conventional planning process runs.

PSS-SP refers to the planning process supported by the proposed framework, and the conventional planning process is specified as the current decision-making process employed in Hong Kong's planning practice, which goes without any universal planning support measures.

7.3.2 Design of the Experimental Study

7.3.2.1 Participants of the Study

30 participants were invited to the experimental study, and they were randomly divided into 6 groups (five people in each group). The participants were a class of Master students in the subject of Urban Planning and Urban Design offered by The Hong Kong Polytechnic University, and they all had educational background in relevant majors such as urban planning, land management, construction management, environmental science, and economics. Some of them even had working experience in planning-related fields. More importantly, this experiment was conducted at the end of the semester, and they had been taught the complete theory of urban planning and also the planning practice (including urban renewal) in Hong Kong. The knowledge background of the participants ensured that they were qualified to be involved in the experimental study.

In addition, the selection of experimental participants complies with the principle of random selection. They were a class of Master students with rich knowledge in urban planning theory and practice, and had nothing to do with the research before. In short, the participants had two outstanding features: abundant knowledge of urban planning and ignorance of the research before the experiment.

7.3.2.2 Experimental Tasks

There were two individual tasks to be finished in the experiment. In brief, the two tasks were to allow each group to make land-use decisions of site redevelopment based on the provided information of the sites. Each group was asked to give its answer to the MOST suitable land use for site redevelopment and provide specific reasons. As indicated in

Table 7.1, Site A was investigated in Task 1 and Site B was examined in Task 2. The two sites were chosen from the ones investigated in the case study illustrated in Chapter 6. The details of Tasks 1 and 2 refer to Appendices 2 and 3.

7.3.2.3 Questionnaire Design

A questionnaire survey was conducted at the end of the experiment. The questionnaire aimed to collect feedback from the participants after experiencing the two planning processes (i.e. PSS-SP and Conventional Process). Two types of questions (i.e. structured and open-ended) were included in the questionnaire to gather specific perceptions from the participants. Specifically, all questions were sorted into four sections: background information of respondent, comparison between the two processes, what participants like MOST and LEAST about PSS-SP. In the section of comparison between the two processes, nine structured questions were elaborately designed to reflect the potential benefits of PSS-SP, and its advantages over the conventional process. A sample of the questionnaire is attached as Appendix 4.

7.3.2.4 Experimental Arrangements

The experiment (with a form of workshop) was conducted for about two hours. The two tasks requiring the six groups to make land-use decisions for redeveloping one piece of land in an urban developed area (Yau Tsim Mong district of Hong Kong) were assigned to each group. Both of them are similar in terms of the target of tasks and the format of answer sheets, but different two individual sites planned for redevelopment.

For Task 1, Groups 1, 2 and 3 used the conventional process adopted in the current planning practice, in which decision-makers consider and assess land-use suitability mainly relying on their qualitative judgments, using basic information of the planning area (e.g. hardcopy of a 2D draft plan, current land utilization, existing planning-related studies). Meanwhile, Groups 4, 5 and 6 applied the PSS-SP to finishing the same task. Firstly, key planning factors which are usually taken into consideration during the planning process were given. Secondly, a GIS-based visualization platform (i.e. the land information database) which can vividly demonstrate all kinds of information displayed on 3D maps, such as geographic locations of each site and building, topographic map including slope, elevation information, and surrounding environment of each site and building was provided. Thirdly, a quantitative model for land-use suitability analysis was introduced to support the participants to make final land-use decisions through comprehensively examining land-use suitability of each piece of land based not only on the non-quantifiable factors such as political, cultural and public demands considered by subjective judgments of participants, but also on the quantifiable factors considered objectively in the model.

For Task 2, Groups 1, 2 and 3 turned to the PSS-SP, and Groups 4, 5 and 6 went with the conventional process (Table 7.1). Here cross-comparison method was adopted in the experiment to ensure two points: 1) every group can experience both planning processes with similar tasks and 2) any one group will not take the same task more than once. The two points are crucial to the reliability of the experimental study. If half of the groups went with only the PSS-SP and the other half of them used only the conventional process, the comparison results might probably be affected by the different perceptive levels of each group by nature. Therefore, each group must carry out both of planning processes before the questionnaire surveys. On the other hand, if a task was carried out twice by the same group, the participants might conduct the second process much easier because they had got familiar with the task by finishing it before. To avoid the influence of the adoptive sequence of the two planning processes, two similar tasks were arranged in the cross-comparison experiment to ensure that one task can only be conducted once by one group.

Table 7.1 Cross-comparison experimental scheme

Venue	Room 1			Room 2		
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Task 1 (Site A)	*Conventional Process*			*PSS-SP*		
Task 2 (Site B)	*PSS-SP*			*Conventional Process*		

Four sessions were organized in the experimental study. The first session was workshop briefing, in which land use planning (site-level) in urban renewal and the two kinds of planning processes were introduced to all participants and six groups were randomly formed. The second session was for group task 1 in which each group discussed and finished Task 1 with two different processes. Similarly, the third session was for group task 2, in which Task 2 was assigned to each group like session 2. During the group discussion, in order to ensure the independent discussion of different groups and avoid the mutual impacts of different planning processes, Groups 4, 5 and 6 were separated from other three groups by moving to another room. Finally, all participants were requested to fill out individual questionnaire about the feeling after participating in this workshop. The agenda of the workshop is arranged as Table 7.2 shows.

Table 7.2 Timetable of Experimental Study I

No.	Duration	Session
1	20 mins	Workshop Briefing
2	30 mins	Task 1
3	30 mins	Task 2
4	15 mins	Questionnaire Survey

Note: a 5-min break was placed between Tasks 1 and 2.

7.3.3 Procedures of the Experimental Study

The experimental study took place in the Hong Kong Polytechnic University. 30 Master students of Department of Building and Real Estate who were registered in the subject of Urban Planning and Urban Design were invited as experimental participants. In the briefing session, they gathered in Room 1 to be informed about the agenda and steps of the workshop. At the beginning of the brief session, site rezoning/redevelopment in urban renewal and the two planning processes were introduced to all participants. After the brief introduction to the workshop, 30 participants were randomly divided into 6 groups (five students in each group).

Before the task discussion session, Groups 4, 5 and 6 were relocated into Room 2 to avoid any interactions between the two kinds of processes. Task 1 was first assigned to six groups, in which Groups 1, 2 and 3 were asked to finish the task with Conventional Process and Groups 4, 5 and 6 went through the task with PSS-SP. During the group discussion, one facilitator was in charge of Groups 1, 2 and 3 (those used Conventional Process) by distributing the background information of Site A to each group and answering participants' queries about Task 1. At the same time, three facilitators worked for three groups (Groups 4, 5 and 6) respectively. Each of them operated a computer on which the land information database was installed to provide background information of Site A and other information each group enquired in digital format, and also dealt with the problems raised by each group. Members of each group worked together to discuss and answer questions in the task paper in 30 minutes, acting as six planning charrettes to make decisions for a plan individually.

After Task 1, a 5-min break was arranged before Task 2 started. In the five minutes, all participants could take a short rest and the facilitators changed rooms. During the Task 2 session, Groups 1, 2 and 3 in Room 1 employed PSS-SP to examine Site B, and other three groups investigated Site B with Conventional Process in Room 2 vice versa. The steps and details were similar to the context depicted in Task 1. Figures 7.2 and 7.3 show the sessions of Task 1 and Task 2 – group discussion with PSS-SP.

Figure 7.2 Group discussion in Task 1 – Group 5

Figure 7.3 Group discussion in Task 2 – Group 2

In the final session, every participant was asked to fill out a questionnaire about the feedback of experiencing the two kinds of planning processes in the workshop. After completing and returning questionnaire to the facilitators, they could leave the rooms and the workshop was closed.

7.3.4 Results of the Experimental Study

There were two sources of the experimental results: Answer sheets of the two tasks and the questionnaires collected. Findings from the answer sheets show the different considerations/concerns determining the land use selection in the group discussions by qualitatively analyzing the reasons written down in the answer sheets. Findings from the questionnaire survey indicate the comparative results between Conventional Process and PSS-SP in serving for the tasks by quantitatively analyzing the scaled information gathered from the respondents.

7.3.4.1 Findings from answer sheets of the tasks

In Task 1, participants were asked to choose a most suitable land use for redeveloping Site A in case of the need of urban renewal. Groups 1, 2 and 3 finished the task with Conventional Process and Groups 4, 5 and 6 completed it with PSS-SP. By analyzing the specific reasons supporting each group's decisions written down in the answer sheets, differences between the two processes in guiding the decision-making process and providing the information required in site planning can be identified. The decision-making factors (i.e. planning elements) considered by each group are summarized in Table 7.3 below.

Table 7.3 Summary of planning elements considered in Task 1

Category	**Conventional Process**			**PSS-SP**		
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Current land use					√	
Neighboring land uses	√	√	√	√	√	√
Physical conditions		√		√		√
Transportation (Accessibility)	√	√	√	√	√	√
Economic feasibility	√		√	√	√	√
Environmental protection	√	√		√	√	√
Social/Community impacts	√	√	√	√	√	√
Legal						√

constraints						
Total	5	5	4	6	6	7

Similarly, Site B was examined in the same way in Task 2. Groups 1, 2 and 3 used PSS-SP and Groups 4, 5 and 6 adopted Conventional Process. The planning elements considered in Task 2 are also summarized (Table 7.4).

Table 7.4 Summary of planning elements considered in Task 2

Category	**PSS-SP**			**Conventional Process**		
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Current land use	√		√			
Neighboring land uses	√	√	√	√	√	√
Physical conditions		√				
Transportation (Accessibility)	√	√	√		√	
Economic feasibility	√	√	√		√	√
Environmental protection	√	√	√	√	√	√
Social/Community impacts	√	√	√	√	√	√
Legal constraints						
Total	6	6	6	3	5	4

According to the summaries shown above, it is indicated that the groups which used PSS-SP in the tasks considered more decision-making factors (planning considerations) than the counterparts which went through with Conventional Process. Almost all of the PSS-SP groups considered 6 factors and the factors covered almost the same aspects since the groups followed a uniform framework for decision-making in the tasks. In addition to the difference in number, the reasons given by the PSS-SP groups were more detailed and measurable than the counterparts. For example, they took into account the actual distances for accessibility analysis, land price distribution for economic feasibility analysis, and traffic noise level for environmental analysis, whereas the Conventional Process groups only raised the descriptive and qualitative considerations for their reasons of decision-making. The decision-making factors considered in the PSS-SP groups are more comprehensive and operable, and the decision-making process of them is more objective and convincing.

No matter whether it was Task 1 or Task 2, the difference in terms of the reasons given from two kinds of planning processes tended towards the same direction. What lead to this stable difference? Basically, because of the similar background of each participant and the randomly-selected principle, each group had no difference from each other in planning knowledge and experience, and they were "born" together as six identical babies. In principle, they should have similar outcomes in doing the same tasks. However, the findings derived from answer sheets of six groups showed the stable difference in the number of planning elements considered. Therefore, the planning process employed by each group can be the only explanation to the different results. In short, based on the findings from the answer sheets, it is suggested that PSS-SP can make planning practitioners take into account more planning elements so as to ensure more comprehensive and reasonable land use planning.

7.3.4.2 Findings from the questionnaire survey

There are three sections in the questionnaire (15 questions in all): Background information of respondents (4 structured questions), comparison between PSS-SP and Conventional Process (9 structured questions), and satisfaction and dissatisfaction about PSS-SP (two open-ended questions). Section 1 concerned the educational background and experience of participants in urban/land use planning and public consultation activities. Sections 2 and 3 were designed to examine whether the PSS-SP has advantages over the conventional process in site planning based on the participants' overall perception of experiencing PSS-SP.

30 completed questionnaires were collected after the experimental study. In Section 1, answers to Q1 – Q4 are summarized in Table 7.5. According to the answer summary, all of the participants were familiar with urban/land use planning and urban renewal/land redevelopment, and most of them had knowledge about public consultation in the planning process (27 out of 30) and experienced group discussion/decision-making before (29 out of 30).

Table 7.5 Summary of background information of 30 respondents

Section 1	Yes	No	Total
Q1. I have knowledge in urban/land use planning	30	0	30
Q2. I have knowledge in urban renewal/redevelopment	30	0	30
Q3. I have knowledge about public consultation in the planning process	27	3	30

Q4. I have experience in group discussion and decision-making	29	1	30

In section 2, the responses to Q5 – Q13 were statistically analyzed and the means and standard deviations of the answers are displayed in Table 7.6. Scores from 1 to 4 refer to Strongly disagree, Disagree, Agree, and Strongly agree accordingly. The means and standard deviations were used to test whether most of the participants agreed or disagreed with the statements involved in the questions and whether they felt mostly the same with respect to the issues reflected by the questions.

Table 7.6 Summary of the survey results in Section 2

Section 2	**Standard Deviation**	**Mean**	**Agree/Disagree** with the statements in the questions
Q5. PSS-SP enables me to get familiar with the planning area more quickly	0.490	3.40	Agree
Q6. PSS-SP enables me to have better understanding of the attributes of each site	0.458	3.30	Agree
Q7. PSS-SP enables me to have better understanding of land-use suitability of each site	0.522	3.17	Agree
Q8. The quantitative analysis of land-use suitability facilitates me to make better decisions during the planning process	0.473	3.10	Agree
Q9. The key factors affecting land use planning facilitate decision-makers/planners to better examine the planning needs	0.512	3.27	Agree
Q10. The information provided by PSS-SP is more useful for decision-makers/planners to make decisions during the planning process	0.539	3.10	Agree
Q11. The information provided by PSS-SP is more comprehensive and easy to understand for non-professionals during public consultation	0.473	3.10	Agree

Q12. The geospatial information visualized via GIS helps me understand the land conditions and the site surroundings	0.537	3.33	Agree
Q13. PSS-SP can support the planning process in urban renewal	0.373	3.17	Agree

Note: more details refer to Appendix 4 (4: Strongly agree, 3: Agree, 2: Disagree, 1: Strongly disagree).

According to the statistical analysis in the above table, all of the means are larger than 3, and most of the standard deviations are around 0.5. It means that the participants basically agreed with all the statements raised in the questions. Specifically, they agreed that PSS-SP enables users to better understand the planning area and the attributes of sites (Q5 – Q7), and the key factors affecting land use planning and quantitative analysis of land-use suitability analysis facilitate users make better decisions during the planning process (Q8 – Q9). In addition, they also agreed that the information provided by PSS-SP is more comprehensive, useful and easy to understand for both planners and non-professionals (Q10 – Q12). For the overall question Q13, all participants consented to the statement “PSS-SP can support the planning process in urban renewal” with the lowest standard deviation (0.373). In detail, the statement “PSS-SP enables me to get familiar with the planning area more quickly” got the highest score (3.40), and statements in Q8, Q10 and Q11 had relatively lower scores (3.10). These results reflected the features and advantages of PSS-SP, which aims to support planners to make decisions and facilitate non-professionals to understand the planning. In a word, based on the feedback of the respondents, it is proved that PSS-SP has a better performance in making land use plans than the conventional planning process.

In section 3, two open-ended questions were asked at the end of the questionnaire: "what do you like MOST about PSS-SP" and "what do you like LEAST about PSS-SP". By summarizing the answers to each question, the characteristics of PSS-SP users like most were: the key factors affecting land use planning, the quantitative analysis of land-use suitability, the comprehensive and detailed information provided with GIS, and easy to understand for non-professionals; meanwhile, the aspects users like least were: the quality of part of raw data, a little difficult to operate (unlike typical software), and only quantitative/objective information stored in the database. In addition to the strengths of PSS-SP, it also has some shortcomings, which need to be improved such as adding qualitative information into the database, shortening the time of data collection, and developing the framework into typical software.

In short, the results of this experimental study showed that, in general, PSS-SP can support the process of site planning in urban renewal. It means that the hypothesis made at the beginning of the experimental study was supported.

7.4 Experimental Study II (Focus Group Meeting 2)

The second experimental study – focus group meeting 2 is used to validate the framework based on the feedback from experienced planning practitioners as a complement of the validation stage.

7.4.1 Design of the Focus Group Meeting

The experimental study aims to test the hypothesis which is the same as the one in the first experimental study. Unlike the previous one, participants in this experimental study were all experienced planning practitioners. Due to the difficulties in participant recruitment in this session, a focus group meeting consisting of 6 experienced experts in Hong Kong's planning practice was designed to achieve the experimental study II. They were all registered town planners in Hong Kong and all have more than ten-year working experience in planning practice (those were not the same participants in Focus Group Meeting I and did not have any idea about the research before). In accordance with the design principles of focus group discussed in Chapter 4, the six participants were selected based on two key points: they must have similar experience and knowledge background towards the group topic, and must not have differences in position level. That is to say, the participants were invited to the focus group meeting since they have similar adequate experience towards the experimental topic, and are equal and independent from each other.

During the experimental study (about 1.5 hours), the participants were asked to finish a task which is one of the same tasks assigned in Experimental Study I. The differences from the previous one are that, this study is not a comparative experiment and the task involved is to select land-use type once by only using PSS-SP (Details of the task refer to Appendix 5). Because the participants were all experienced planners working in urban and land use planning for more than ten years, they were familiar with the conventional process of decision-making in the planning. Therefore, there is no need to let them experience Conventional Process described in Experimental Study I. After their group discussion and task completion, a feedback questionnaire was finished by the group (not each participant), during which they worked together as a team for not only the task but also the feedback survey.

The questionnaire was designed on the basis of the one used in the previous experiment, and it was adjusted to fit for opinion collection from experienced practitioners, particularly, town planners. A sample of the questionnaire is shown in Appendix 6. Unlike the questionnaire used in Experimental Study I, background information of respondents was not needed to collect due to the group decision-making for the questionnaire. There were only two parts in the questionnaire: structured statements and open-ended questions for collecting group perception after experiencing PSS-SP during the decision-making process.

7.4.2 Procedures of the Focus Group Meeting

The focus group meeting was also held in the Hong Kong Polytechnic University. The six experienced town planners working in Planning Department of Hong Kong and the URA were invited to come for a group meeting lasting about one and a half hours and a facilitator was arranged to make sure every participant can fully understand the task and PSS-SP, and can comfortably communicate with each other during the group discussion. In the beginning, the facilitator used fifteen minutes to give a brief introduction to the focus group meeting to let them know the topic of the meeting and its purpose and agenda. The rundown of the experimental study is shown in Table 7.7.

Table 7.7 The rundown of Experimental Study II

No.	Duration	Session
1	15 mins	Meeting Briefing
2	10 mins	Warm-up Activity
3	40 mins	Group Task

4	20 mins	Feedback Survey

Note: a 5-min break was set between Sessions 2 and 3.

Before the facilitator sent the task to the participants, they were required to know each other by joining a warm-up activity. This session was important because the familiarity with each other is the basis of effective communication in a focus group. After the necessary preparations, a planning task with required information was given to the group and they were asked to discuss the issue and make planning decisions together in 40 minutes. During this session, the facilitator operated the database and explained details about PSS-SP to make them fully experience the proposed process and the facilitator also had the responsibility to enhance and keep their interactions in the group discussion. By the end of the group task session, they reached a consensus as the answers to the questions raised in the task sheets.

When the task was finished, like the second round of group decision-making, they were requested to work together as a panel to fill out the feedback questionnaire. Based on the last group decision-making for the task, this group decision-making for the questionnaire was more efficient and effective. After the feedback survey session, the focus group meeting (Experimental Study II) was closed.

7.4.3 Findings from the Focus Group Meeting

In this focus group meeting, the aim of the task was to make the participants work together to experience PSS-SP in a planning-like process, and the answers to the questions of the task were not important to the research. However, the feedback collected from the questionnaire reflected expert opinions towards PSS-SP and these views from them could test its viability and effectiveness in the planning process.

According to the completed questionnaire, the scores given by the focus group for the first part – structured statements (Q1 – Q9) are shown in Figure 7.4. The figure indicates that all of the scores are not less than 3, and Q1, Q5, Q7 and Q8 got the highest score 4. It means that the focus group agreed with all of the statements given in the questionnaire, and particularly, they strongly agreed with the following statements: "PSS-SP enables us to get familiar with the planning area more quickly", "key factors affecting decision-making in land use planning facilitate us to better consider the planning needs", "the information provided by PSS-SP is more detailed and easy to understand for non-professionals participating in public consultation" and "the geospatial information visualized via GIS helps us recognize the land itself and surroundings of planned sites".

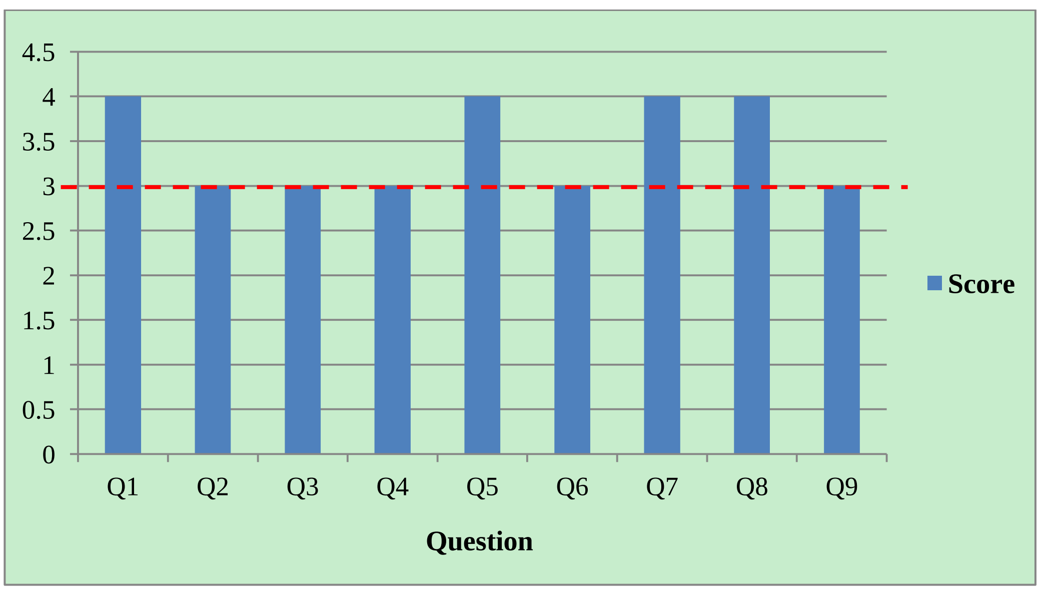


Figure 7.4 The scores of Q1 – Q9 given by the focus group
(4: Strongly agree, 3: Agree, 2: Disagree, 1: Strongly disagree)

Note:

Q1: PSS-SP enables us to get familiar with the planning area more quickly.

Q2: PSS-SP enables us to have better understanding of the attributes of each piece of land.

Q3: PSS-SP enables us to have better understanding of land-use suitability of each piece of land.

Q4: The quantitative analysis of land-use suitability facilitates us to make better decisions during the planning process.

Q5: The list of key factors affecting decision-making in land use planning is a practical reference for planners/decision-makers to better consider the planning needs.

Q6: The information provided by PSS-SP is more useful for planners/decision-makers to make decisions during the planning process.

Q7: The information provided by PSS-SP is more comprehensive and easy to understand for non-professionals to deliver their ideas during public consultation activities.

Q8: The geospatial information visualized through GIS technologies helps us understand the condition of land and surroundings of planned sites.

Q9: PSS-SP can support the process of site planning in urban renewal.

In addition to the structured statements, two open-ended questions were answered by the focus group. First, what they like MOST about PSS-SP were: an integrated database storing required information for land use planning, a list of key factors affecting decision-making in land use planning, and an approach to quantitative analysis of land-use suitability for site planning in urban renewal. The focus group thought that PSS-SP would allow decision makers to go through a guided and consistent approach, and retrieve related information through one single platform. PSS-SP can serve as an effective tool in public consultation because of its simplicity in logic and process. Second, what they like LEAST about PSS-SP were: lack of qualitative analysis of land-use suitability (community/legal/political sides), the issue of data collection and update, and the operation and interface of the planning support tool. The focus group indicated that not all factors affecting planning decisions on land use can be quantified, and PSS-SP cannot replace the existing delicate planning process although it can be treated as a complementary technical tool. Their dissatisfaction was also due to the lack of analysis on economic feasibility of site redevelopment. The merits of PSS-SP highlighted by the focus group confirm the significance of the framework and its effectiveness in the planning practice. The deficiencies of PSS-SP also direct future work for the framework improvement.

In one word, the focus group gave positive comments to PSS-SP and agreed that PSS-SP can support the planning process of site rezoning/redevelopment in urban renewal. Consequently, the hypothesis set before the experiment was supported.

7.5 Summary of the Chapter

This chapter presents the validation stage of this research. Two experimental studies are involved in the framework validation and they are depicted in detail from experimental design, procedure and findings. Experimental Study I aims to test the hypothesis by comparing PSS-SP with Conventional Process in land use planning (actually, an experimental environment was established to simulate the process of real planning). Experimental Study II serves for complementing the hypothesis test by collecting feedback from practitioners/experts in planning practice. In addition to testing the hypothesis through analyzing the information collected in the questionnaires, the advantages and shortcomings of PSS-SP are also indicated from the questionnaire survey.

Chapter 8 Conclusions

8.1 Introduction

This chapter concludes this research by summarizing the research findings and how the research propositions have been addressed. Firstly, the research objectives are reviewed to present how they are achieved through the research. Secondly, main research findings are summarized from document analysis, expert interviews, framework development and framework validation. Thirdly, a summary of the contributions to knowledge in the interdisciplinary field is given. Last but not least, limitations of the research and recommendations for further research are discussed.

8.2 Review of Research Objectives

As stated in Chapter 1, the aim of this research is to develop a GIS-based framework which consists of Model for LUSA and supported Land Information Database, and to investigate whether it can support sustainable land use planning (site-level) in urban renewal projects. To achieve this aim, four specific objectives were addressed: 1) to identify criteria from economic, social and environmental perspectives for measuring the sustainability of land-use decisions in site planning; 2) to develop a general list of criteria (including the sustainability criteria) for land suitability assessment at the site level by identifying planning factors affecting land-use decision-making in site planning; 3) to conceptualize and develop a GIS-based framework as a prototype of PSS for supporting the decision-making process of land use planning in urban renewal projects;

4) to test the viability of this framework and validate its effectiveness in supporting the planning process.

To achieve Objective 1 and Objective 2, literature review and document analysis were used in the research. Chapter 2 provides a comprehensive review of existing research works on sustainable urban land use and planning support systems, as well as LUSA. Three research gaps were identified through the literature review: 1) a set of criteria/factors for quantifying and measuring sustainability of land use planning has yet to be fully identified; 2) a framework as a prototype of PSS developed with an explicit rationale and adequate communication between the system developers and planning practitioners during the process of framework development has yet to be developed; 3) a general list of criteria for LUSA (i.e. factors affecting land-use decision-making) needs to be developed for urban land evaluation, and site-level land suitability analysis is a relatively neglected topic.

This research was designed aiming at filling these gaps. The model for quantitative LUSA in which the criteria regarding sustainability were incorporated was developed to fill Gap 1 and Gap 3 partially. The sustainability criteria are innovative for they are decisive factors from the perspectives of environmental, economic and social considerations in site planning/analysis. To fill Gap 2, the framework proposed in the research was devised as a prototype of a PSS. In the case study, it was developed in accordance with the demands of town planners in Hong Kong through fully communicating with the practitioners (via in-depth interviews) during the process of the framework development. And the framework was developed using explicit methods (e.g. AHP, MCE) to make the PSS users including all the stakeholders easily understand. The site-level LUSA containing a list of evaluation criteria, general land classification and specific suitability standards was conducted in the case study to support land-use decisions for site redevelopment in urban renewal. By doing so, Gap 3 was further filled.

The literature review in Chapter 2 also provides specific methods or tools such as MCDA, AHP and GIS to fulfill this research. Chapter 3 reviews Hong Kong's practice in land utilization and urban renewal, in which the driving forces of land demand and supply, the mechanism of land-use allocation, and urban renewal strategy are discussed. Based on the review/analysis on Hong Kong's land use practice, main problems occurred in current land use are identified: 1) inherent shortage of land resources; 2) difficulties in urban renewal projects; 3) procedure and regulation amendments. The details are discussed in Section 3.4. This research helps alleviate the difficulties in urban renewal projects by supporting land-use decisions in site reuse. In detail, the framework was able to facilitate the other stakeholders to understand the planning considerations of planners and improve the process of public engagement. Chapter 5 reviews the literature and industry standards on sustainability indicators/factors in planning and site development to help achieve Objective 1.

To achieve Objective 3, a GIS-based framework consisting of a model and a database was conceptualized and developed in Chapters 5 and 6. Chapter 5 introduces the rationale, structure, and the components of the framework including how to design the two modules – the Model and Database. Regarding how to build the model, the methods of criterion identification, weighting determination, and rating standard formulation were described. In terms of the steps of the database establishment, how and what information/data involved were discussed. Chapter 6 illustrates how the framework consisting of the model and database has been developed via a case study. The detailed steps of the model and database development are depicted in Sections 6.3 and 6.4. These provide a useful reference for framework redevelopment in other cities. Land-use suitability maps generated based on the existing criteria and data were presented to show the potential outcomes of planning support model. These suitability maps provide quantitative and objective reference for decision-making in land use planning. The case study conducted following the structure of the framework also indicates the viability and applicability of the framework proposed in the research.

To achieve Objective 4, two experimental studies were designed and conducted to validate this framework (Chapter 7). A comparative experiment was conducted to compare the performance between the planning process (PSS-SP) derived from the framework and the conventional planning process used in the current planning practice. This experiment aimed to simulate an environment of group decision-making in land use planning, and two similar planning tasks were cross-completed by two separate parts of six groups (3 in one part) with the two different planning processes at one time. A focus group meeting consisting of experienced planners was conducted to verify the effectiveness of the framework from the views of planning practitioners. The focus group was asked to finish a planning task using PSS-SP, and the task and experimental process were similar to the first experiment (Section 7.4). The conventional planning process was not involved in this experimental study as the participants of the focus group were experts in the current planning practice. The results of the two experimental studies were reflected from two rounds of questionnaire survey conducted at the end of the two studies, and the quantitative and qualitative analyses of the data collected from the questionnaire tested the hypothesis posed at the beginning of the experimental studies.

8.3 Research Conclusions

By doing this research on the use of planning support in land-use decisions for site redevelopment in urban renewal projects, the research question concerning how to develop a framework to support land use planning in urban renewal projects has been answered through showing that the framework developed in the research can support the decision-making process of land use planning in urban renewal projects by facilitating the planners to analyze the land-use suitability, helping the other stakeholders understand the planning considerations of planners so as to improve public engagement during the planning process. According to the research process and particular methods outlined in Chapters 1 and 4, the conclusions of this research are drawn from the document analysis, expert interviews, case study, and experimental studies (questionnaire survey).

8.3.1 Conclusions from the Document Analysis

To understand the practice of the land use planning and management and address the real problems in Hong Kong's land utilization, current land-use conditions and related policies and regulations of land use planning in Hong Kong were reviewed, so that the research can be designed aiming at solving these problems. The land-use issues related to this research were pointed out as follows:

- Due to the inherent shortage of land in Hong Kong, one of effective solutions to increasing land supply is land resource reuse, such as land rezoning, land redevelopment and land resumption.
- Following the increase of land rezoning/redevelopment projects, some difficulties emerged in urban renewal processes. For instance, it is difficult to reach a consensus/balance among the different voices of stakeholders involved in the projects. Therefore, the projects often take a long time to complete starting from the feasibility study of the proposal, and the timing of redevelopment is always unpredictable.
- Some outdated regulations or procedures of land use planning and development should be amended and simplified to shorten the duration of a project and improve the efficiency of land development/redevelopment. This research provides a planning support tool to help adjust the planning process of land redevelopment in urban renewal projects.

8.3.2 Conclusions from the Expert Interviews

Seven in-depth interviews were conducted to address the problems occurring in Hong Kong's planning practice and collect the specific opinions of key factors affecting land-use decision-making from the experienced planning practitioners. Details are described in Section 6.3.1.1. The problems identified from the interviews are summarized as follows:

- One problem the planning practitioners encounter for many years is that, land-use decisions are made relying heavily on the subjective and qualitative judgments from planners, and without an objective and quantitative method to support the decision-making process.

- The public often cannot be effectively engaged in public consultation sessions due to their shortage of planning knowledge to fully understand planners' considerations.
- Site planning/analysis containing land-use decisions for land redevelopment in urban renewal projects is more complicated and difficult to eventually finish in a predictable time because of the multiple interests of different stakeholders involved.

Regarding the key factors affecting land-use decisions, the interviewees indicated that transportation (accessibility) and land use compatibility are the most important considerations in site planning for urban renewal projects. Environmental concerns are also emphasized in the planning process. Some feasibility studies proposed by Planning Department of Hong Kong specially investigate planning issues on environmental concerns such as air ventilation, wind/thermal environment, and harbour-front protection during the planning process. The interviewees also suggested that land use planning is a dynamic process which cannot be determined simply by an objective, quantitative land-use suitability assessment but more social values in terms of political, community and the public interests. And the information of existing buildings such as building age, building density, and maintenance condition is necessary for site planning in the case of urban renewal. Based on the criteria given in the general list (Table 5.6), the key factors affecting land-use decisions in Hong Kong were identified by combining the opinions of the interviewees (refer to Section 6.3.1.2).

8.3.3 Conclusions from the Case Study

The proposed framework was developed via this case study. Due to data availability and time constraints, partial criteria (20 of 29) were involved in the model and the associated data were collected and processed in the database. The detailed processes of the framework development including the model and database were illustrated in the case study to show the viability of the framework proposed in the research. Although the land-use suitability was analyzed on the basis of incomplete criteria by far, the land-use suitability maps were still generated based on the criteria considered in the study to demonstrate the potential outcomes of the framework. Details of the results of LUSA and land-use suitability maps for five land uses are shown in Section 6.5. The case study is a good case for the research because of its location and development level of the study area. This successful case study reflects the good applicability of the framework, and implies that the same methodology can be applied to other urban renewal studies in the similar context.

8.3.4 Conclusions from the Experimental Studies

In order to investigate whether the use of a GIS-based framework providing planning support can facilitate the decision-making process of land reuse in urban renewal projects and improve public engagement by enabling the other stakeholders to fully understand the planning considerations of planners, two experimental studies were designed and conducted. The common settings of the two experiments are shown as follows:

- The planning process supported by the framework (PSS-SP) was employed;

- Groups with a face-to-face setting for decision discussion were used;
- A PSS-SP facilitator was provided for each task.

Experimental Study I aimed to compare the PSS-SP with the conventional process by involving six groups consisting of 30 participants with planning knowledge to simulate the environment of planning charrettes which were normally comprised of stakeholders in the planning projects. The experimental results were derived from two sources: answer sheets of the tasks and the questionnaires collected. As indicated from the answer sheets, the groups which used PSS-SP in the tasks considered more decision-making factors (planning concerns) than the counterparts which went through with the conventional process. In addition to the difference in number, the reasons given by PSS-SP groups were more detailed and measurable than the counterparts. Regarding the results of the questionnaires, the statistical analysis of the data collected showed that the participants generally agreed with the statements involved in the questions (Section 7.3.4.2 – Table 7.6). That is to say, they agreed that PSS-SP has a better performance in making land use plans than the conventional process. In addition, the advantages and shortcomings of PSS-SP and what can be done to improve PSS-SP were suggested from the open-ended questions in the questionnaires. The advantages of PSS-SP were highlighted as PSS-SP is easy for non-professionals to understand and provides the key factors affecting land use planning, quantitative analysis of land-use suitability, and comprehensive and detailed geospatial information. Meanwhile, the shortcomings to be improved were pointed out in the data quality and update, difficulties in operation (unlike typical software), and lack of qualitative information stored in the database.

Experimental Study II was conducted with a form of focus group meeting. The focus group was composed of six experienced planners in Hong Kong and it aimed to validate PSS-SP based on the feedback from experienced planning practitioners. The participants were asked to work on a task and finish a feedback questionnaire as a group. According to the filled questionnaire, the feedback of the focus group was highlighted that the experts gave positive comments to PSS-SP and agreed that PSS-SP can support the planning process of land redevelopment in urban renewal projects. Regarding the 'Good' and 'Bad' of PSS-SP given by the focus group, the participants advocated PSS-SP as it provides an integrated database storing required information for land use planning, a list of key factors affecting decision-making in land use planning, and an approach to quantitative analysis of land-use suitability for site planning in urban renewal; but then, they revealed the same defects as the ones indicated in Experimental Study I.

Through conducting the two experimental studies, the results of the experiments (including questionnaire survey) showed that the same hypothesis regarding the effectiveness of PSS-SP in planning support (refer to Section 7.3.1) posed at the beginning of the studies was supported by both of them.

8.4 Contributions of the Research

In terms of contributions to knowledge, this research has contributed to the fields spanning across land use planning/urban planning, urban renewal/site redevelopment and GIS. The issue of land-use decisions in site planning/analysis is in the field of land use planning, and the decision-making process is a part of planning processes. Urban renewal is a hot topic in urban planning and management, and site redevelopment/reuse in urban renewal projects increasingly emerges in the planning practice. The framework was developed combining with GIS technology, and the data preparation in the database for the model included in the framework belongs to the field of GIS. This research has explored an approach to planning support for land use planning (land-use decision-making) in a new specific field: urban renewal projects. The main research outcomes reflecting the contributions include new knowledge on key factors affecting land-use decisions in site planning, an approach to quantitative LUSA with sustainability thinking, and a framework providing planning support in making land-use decisions for site redevelopment and improving public engagement in the planning process. They indicate that the GIS-based framework can be one possible solution to the difficulties frequently encountered by planners when making land use planning for urban renewal projects. To sum up, four main points of contributions dedicated to this research are highlighted as follows:

Firstly, this research has identified a general list of criteria for land-use decision-making in site planning (including sustainability criteria) and the sources of the associated data/information. The list of criteria helps decision-makers pick out key factors affecting decision-making in the planning process so as to make a land use plan based on comprehensive considerations including sustainability elements. And key factors affecting land-use decisions in Hong Kong were identified during the development of the model. In fact, these factors can also be regarded as criteria for quantitative LUSA in land/site redevelopment. These findings provide a reference for making land-use decisions in site reuse planning and an assessment tool to evaluate the suitability including sustainability of particular land uses, and can help planners take into account multiple objectives (i.e. criteria) during the planning process.

Secondly, this research has developed a framework which can be regarded as a prototype of a PSS for land use planning. This PSS prototype was designed based on full communication with planning practitioners during the process of framework development, and developed by using easy-to-understand methods or tools such as MCDA, AHP and GIS to keep its low complexity (i.e. relatively simple rationale). This outcome can be used as a guideline to support planning practitioners in making land-use decisions in site planning, particularly in urban renewal projects, and attempt to improve the PSS adoption in the planning practice.

Thirdly, this research has developed a quantitative approach to assessing land-use suitability for land sites to be redeveloped/reused (i.e. the planning support model) and a standard means of providing the usable data for the model (i.e. the steps of the land-info database setup). These outcomes make up of the framework, and enrich the studies on urban LUSA and data processing in GIS respectively. The quantitative approach provides planners with a more objective way to support the decision-making process of land use planning. In addition, the key factors usually considered by planners provided by the model and the GIS visualization platform provided by the database can help the other stakeholders better understand the planning concerns and conditions so as to improve public engagement in the process of public consultation (participatory planning).

Lastly, this research has demonstrated the usefulness of GIS visualization and spatial analysis in land use planning, in particular, site reuse planning, and expanded GIS applications to the planning practice. These findings indicate that GIS is a powerful tool to facilitate planning processes in accurate data acquisition, advanced spatial analysis, and virtual geospatial visualization.

8.5 Limitations of the Research

Three key aspects of limitations of the research are acknowledged as follows. Firstly, the framework was developed in a loosely coupled form rather than a software package, which integrates all components automatically. The main reason of this limitation is due to time and technical limits.

Secondly, not all of the criteria identified for LUSA were quantitatively examined in the case study, and the land-use suitability maps generated by the framework were just semi-results of LUSA. The reason of this limitation is due mainly to data availability. Specifically, the data/information for some criteria such as air ventilation, visual permeability are unavailable and some qualitative (feeling-based) criteria such as community, cultural concerns have to be converted to quantitative (scaled) ones to fit for the model. This conversion (i.e. criterion quantifying) needs more time and more expert opinions, and it could be follow-up research.

Finally, the development of the land information database was a time-consuming process as much data/information was collected and processed during this process. But the process could be shortened if the data are accessible and the techniques of database development are improved. In addition, the technologies of spatial analysis on the data (i.e. data processing in “ArcGIS”) are not the most advanced and updated in the GIS world.

8.6 Recommendations for Future Research

In order to refine this research, suggestions for future research are proposed as follows:

1. A sort of “system” running on the computer could be developed based on the framework (a prototype of PSS) to improve the efficiency of the planning support. The potential system can provide a more user-friendly interface and an automatic connection between the model and the database, so that the data flow between both does not need to be transferred manually.
2. The complete results of LUSA based on all criteria identified in the existing case study should be produced to fully demonstrate the outcomes of this framework. The further work includes special studies on certain criteria (i.e. input data for LUSA) and qualitative criterion quantification, such as feeling-based cultural concerns.
3. More advanced technologies for data processing and analysis in GIS field could be employed to shorten the time of obtaining usable information. For example, virtual reality modeling of 3D buildings containing building’s real-time information could be applied to the database development. In addition, a module/sub-system specially assessing economic feasibility of site redevelopment could be incorporated in the integrated framework.

Appendix 1: Sample of Interview Sheet

Thank you for joining this interview!

I. **Open-ended questions**:
1. How to determine the future land use of each piece of land during the process of town planning? If some factors are commonly considered, what are they?
2. Is there a quantitative method/tool to synthetically assess land-use suitability in planning processes?
3. How about the application of GIS analysis and visualization in the planning process?
4. What's main problem(s) in land-use decision-making in planning practice, in particular, land redevelopment in urban renewal projects?

II. **Identification of key factors**

This part aims to investigate, in the experts' opinion, key factors which are affecting land-use decision-making for land/site redevelopment in urban renewal projects. A set of general criteria are listed below for your reference, please give your answers based on the practice of Hong Kong. After that, you can also leave some comments or suggestions.

Criteria for land-use decision-making in site redevelopment

Category	Sub-category	Criterion
Environmental/ Ecological	Vegetation	Vegetation rate
	Environmental indicators	Local air quality
		Local water quality
		Noise pollution
		Light pollution
Social	-	Local population
	-	Local employment
	-	Neighborhood identity
Economic	-	Local GDP

	-	Property values
	-	Rents
Political/Legal	Legal properties	Political boundaries
		Land ownership
		Easements and deed restrictions
	Land use regulations	Statutory requirements for development
Utilities/ Accessibility (locational)	Land use	Former land uses
		Current land uses
		Neighboring land uses
	Transportation	Road network
		Traffic volume
		Internal circulation
	Service utilities	Access to major living services (e.g. transport hub, medical center, open space)
		Utilities for basic housing (e.g. sewer, electric, gas)
Cultural/Historic	Sensory satisfaction	Aesthetics
		Visibility
		Visual quality
		Odors
	Historical features	Heritage landmarks
	Local built environment	Architectural/landscape uniqueness
Physical	Topography	Elevation

		Slope gradient
		Slope aspect
	Climate	Solar access
		Wind direction
	Geology	Terrain
		Seismic hazards
		Landslide hazards

Please leave your specific comments if you like:

Appendix 2: Task 1 in Experimental Study I

Determine the most suitable land use of site A

1. Your task

Please look at the piece of land which is circled by black line (map is attached in the next page). The site is located in a developed urban area where urban renewal projects usually take place. **If the piece of land needs to be redeveloped to fit for today's demands in urban renewal, which one of the following is the MOST suitable?**

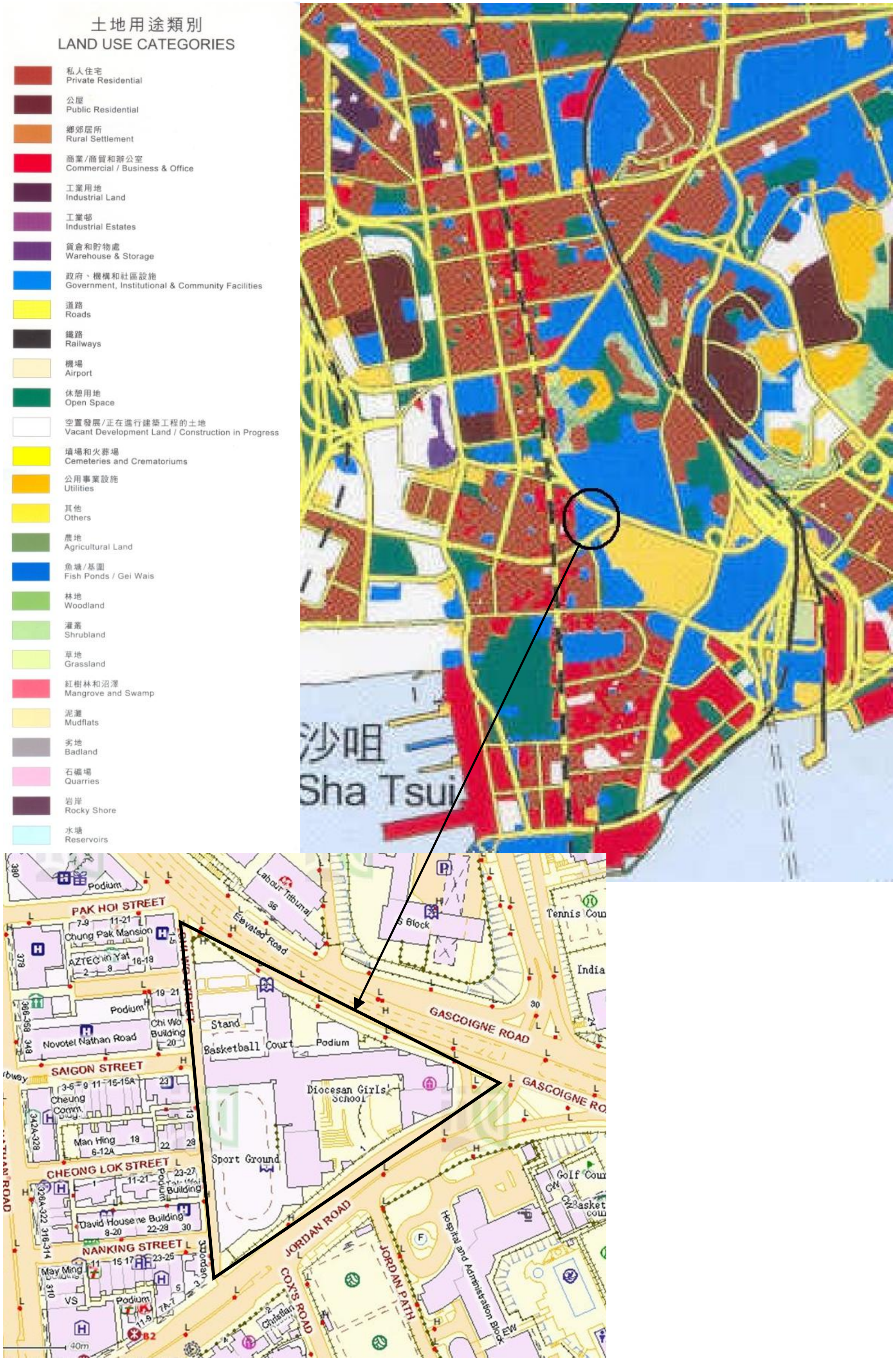
No.	Category	Definition
1	Residential	Land sites for residential use, including private housing, public housing and staff/student hostels
2	Commercial	Land sites for commercial use, including offices, shopping malls, markets, hotels, car parks
3	Industrial	Land sites for industrial use, including industrial land, industrial estates, warehouses
4	G/IC	Land sites for Government, Institutional and Community use and other public purposes, i.e. utilities
5	Open Space	Land use zones for the provision of open space and recreation facilities for the enjoyment of the general public, including parks, playgrounds, gardens

The task aims to simulate a decision-making process in land use planning. Please give your reasons and results of land-use decisions in 30 minutes.

2. Background Information of Site A

- Current land utilization: Government/Institution/Community (G/IC) use.
- Area of the site: About 13,000 sq.m
- Buildings usage: School (Diocesan Girl's School)
- Detailed surrounding and geospatial information:
  a. Basic topographic map
  b. Aerial photo
  c. Outline Zoning Plan (OZP)

Land utilization map



1. Which one of land use is MOST suitable for site A?

a. Residential b. Commercial c. Industrial d. G/IC e. Open space f. Others, please specify: _______________

2. Reasons for making this land-use decision (please list the detailed considerations/ factors examined during the discussion):

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Appendix 3: Task 2 in Experimental Study I

Determine the most suitable land use of site B

1. Your task

Please look at the piece of land which is circled by black line (map is attached in the next page). The site is located in a developed urban area where urban renewal projects usually take place. **If the piece of land needs to be redeveloped to fit for today's demands in urban renewal, which one of the following is the MOST suitable?**

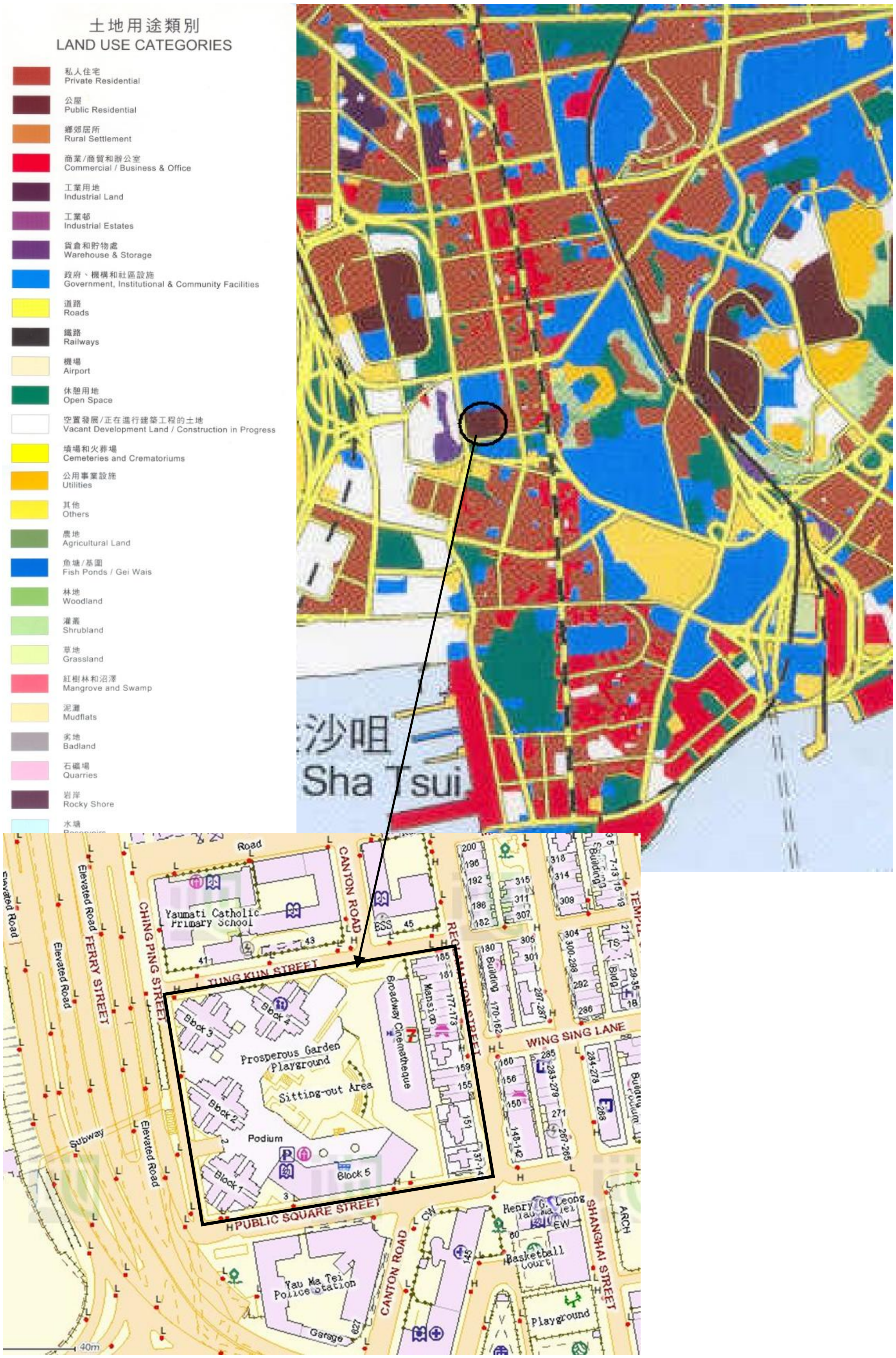
No.	Category	Definition
1	Residential	Land sites for residential use, including private housing, public housing and staff/student hostels
2	Commercial	Land sites for commercial use, including offices, shopping malls, markets, hotels, car parks
3	Industrial	Land sites for industrial use, including industrial land, industrial estates, warehouses
4	G/IC	Land sites for Government, Institutional and Community use and other public purposes, i.e. utilities
5	Open Space	Land use zones for the provision of open space and recreation facilities for the enjoyment of the general public, including parks, playgrounds, gardens

The task aims to simulate a decision-making process in land use planning. Please give your reasons and results of land-use decisions in <u>30 minutes</u>.

2. Background Information of Site B

- Current land utilization: Residential use (public housing).
- Area of the site: About 17,000 sq.m
- Buildings usage: Composite building (R/C)
- Detailed surrounding and geospatial information:
  a. Basic topographic map
  b. Aerial photo
  c. Outline Zoning Plan (OZP)

Land utilization map



1. Which one of land use is MOST suitable for site B?

a. Residential b. Commercial c. Industrial d. G/IC e. Open space f. Others, please specify: _______________

2. Reasons for making this land-use decision (please list the detailed considerations/ factors examined during the discussion):

Appendix 4: Sample of Questionnaire for Experimental Study I

Feedback Questionnaire

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

1. Background Information

	Y	N
Q1. I have knowledge in urban/land use planning		
Q2. I have knowledge in urban renewal/redevelopment		
Q3. I have knowledge about public consultation in the planning process		
Q4. I have experience in group discussion and decision-making		

(Y: Yes N: No)

2. Comparison between Conventional Process and PSS-supported Process (PSS-SP)

	SA	A	D	SD
Q5. PSS-SP enables me to get familiar with the planning area more quickly (e.g. location, surroundings, development information)				
Q6. PSS-SP enables me to have better understanding of the properties/attributes of each piece of land (e.g. slope, elevation, vegetation)				
Q7. PSS-SP enables me to have better understanding of land-use suitability of each piece of land (i.e. the suitability of residential, commercial, industrial, G/IC, and open space use)				
Q8. The quantitative analysis of land-use suitability facilitates me to make better decisions during the planning process				
Q9. The key factors affecting land-use planning facilitate decision-makers/planners to better examine the planning needs				
Q10. The information provided by PSS-SP is more useful for planners/decision-makers to make decisions during the planning process				
Q11. The information provided by PSS-SP is more comprehensive and easy to understand for non-professionals to deliver their ideas during public consultation activities				
Q12. The geospatial information (e.g. distance between facilities, area of sites, location of sites and buildings) visualized via GIS helps me understand the land conditions and the site surroundings				
Q13. PSS-SP can support the planning process in urban renewal				

(SA: Strongly Agree A: Agree D: Disagree SD: Strongly Disagree)

3. What do you like <u>MOST</u> about PSS-SP?

a. ____

b. ____

4. What do you like LEAST about PSS-SP?

a. ____

b. ____

Personal Particulars (optional)

Name: ____________________ Occupation: ____________________

Thank you very much for completing this questionnaire!

- THE END -

Appendix 5: Experimental Task in Experimental Study II

Determine the most suitable land use for site reuse

1. Your task

Please look at the piece of land which is circled by black line (map is attached in the next page). The site is located in a developed urban area where urban renewal projects usually take place. **If the piece of land needs to be redeveloped to fit for today's demands in urban renewal, which one of the following is the MOST suitable?**

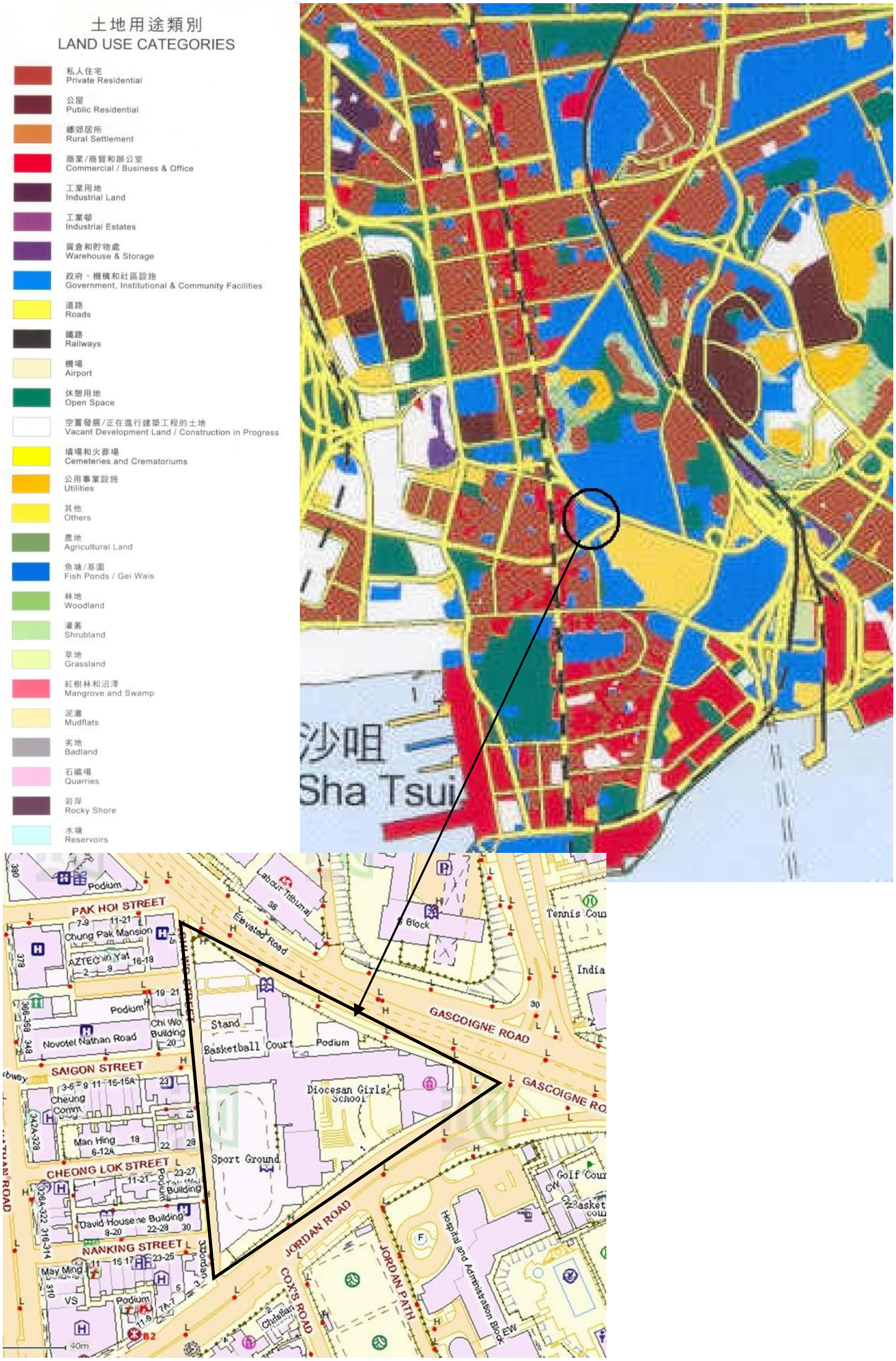
No.	Category	Definition
1	Residential	Land sites for residential use, including private housing, public housing and staff/student hostels
2	Commercial	Land sites for commercial use, including offices, shopping malls, markets, hotels, car parks
3	Industrial	Land sites for industrial use, including industrial land, industrial estates, warehouses
4	G/IC	Land sites for Government, Institutional and Community use and other public purposes, i.e. utilities
5	Open Space	Land use zones for the provision of open space and recreation facilities for the enjoyment of the general public, including parks, playgrounds, gardens

The task aims to simulate a decision-making process in land use planning. Please give your reasons and results of land-use decisions in 30 minutes.

2. Background Information of the Site

- Current land utilization: Government/Institution/Community (G/IC) use.
- Area of the site: About 13,000 sq.m
- Buildings usage: School (Diocesan Girl's School)
- Detailed surrounding and geospatial information:
  a. Basic topographic map
  b. Aerial photo
  c. Outline Zoning Plan (OZP)

Land utilization map



1. Which one of land use is MOST suitable for the site?

a. Residential b. Commercial c. Industrial d. G/IC e. Open space f. Others, please specify: ________________

2. Reasons for making this land-use decision (please list the detailed considerations/ factors examined during the discussion):

Appendix 6: Sample of Questionnaire for Experimental Study II

Feedback Questionnaire

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

1. Please tick the options matching your perception about PSS-supported Process (PSS-SP)

	SA	A	D	SD
Q1. PSS-SP enables us to get familiar with the planning area more quickly (e.g. location, surroundings, development information)				
Q2. PSS-SP enables us to have better understanding of the properties/attributes of each piece of land (e.g. slope, elevation, vegetation)				
Q3. PSS-SP enables us to have better understanding of land-use suitability of each piece of land (i.e. the suitability of residential, commercial, industrial, G/IC, and open space use)				
Q4. The quantitative analysis of land-use suitability facilitates us to make better decisions during the planning process				
Q5. The list of key factors affecting decision-making in land-use planning is a practical reference for planners/decision-makers to better evaluate/examine the planning needs				
Q6. The information provided by PSS-SP is more useful for planners/decision-makers to make decisions during the planning process				
Q7. The information provided by PSS-SP is more comprehensive and easy to understand for non-professionals to deliver their ideas during public consultation activities				
Q8. The geospatial information (e.g. distance between facilities, area of sites, location of sites and buildings) visualized through GIS technologies helps us understand the condition of land and surroundings of planned sites				
Q9. PSS-SP can support the process of site planning in urban renewal				

(SA: Strongly Agree A: Agree D: Disagree SD: Strongly Disagree)

2. Open-ended Questions

Q10. What do you like MOST about PSS-SP?

a. ____

b. ____

c. ____

Q11. What do you like LEAST about PSS-SP?

a. ____

b. ____

c. ____

Thank you very much for completing this questionnaire!

- THE END -

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