PLANNING SUPPORT FOR URBAN SPATIAL DEVELOPMENT

A Case Study of Zhenning County

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---A case study of Zhenning County

By

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ABSTRACT

Urbanization has a strong impact on urban spatial development and land use changes. With the process of urbanization, the occupation of agricultural and green space around urban area in China is arising conflicts between stakeholders.

The current planning support approach (LE) in China is not effective and comprehensive: Not better considering stakeholders' interests (social, political); Not considering demand criteria (demographic); and Not providing allocation scenarios of the different land use types. Therefore the result of this computer-based method is hard to support urban gaining sustainable development.

The main objective of this study is to investigate if the current planning support approach can be improved by creating allocation scenarios that considers stakeholders' interests and multiple criteria

This target is achieved by understanding the concept of land use planning and sustainable development; the concept of stakeholders' involvement and scenario planning in urban planning; analysing the limits of current planning support practice in China; introducing the worldwide planning support practice (MCE, GIS and PSS) and their inner linkage.

Because the alternatives need to be proposed by diverse stakeholders, criteria and factors also need to be identified, multiple criteria evaluation (MCE) is used. Geographic information system (GIS/ARC VIEW) is employed to provide GIS date set and spatial operation, in which major stakeholders' concerns and key planning elements involved. *What if?* Planning support system is used to provide operational interface, which links MCE, GIS with participatory planning support and identify what will happen based on the provided criteria and assumption.

The study area for this research is a County named Zhenning in China. Two major kinds of stakeholders are identified and their interests are presented and considered into development of the stakeholders' criteria. The resulting maps and tables of analyses provide four land allocation alternatives (ALT) for residential, industrial, office/retail and green space constructions.

The study has discussed around the focused stakeholders and alternative, limited stakeholders' criteria and allocation scenarios, and the usefulness of *what if?* PSS separately based on map comparison (with LE and LUP maps) and working experience.

The study has concluded with the findings around the proposed research questions. It has been found that the operational planning model (based on *what if?* PSS) and its capacity to provide planning support is promising in the real world.

Finally, the information provides by this study can be used as a guideline for the planning authorities and decision makers of developing country, which are willing to understanding PSS (especially for *what if?* PSS) and use it in real case to improve planning support for urban spatial development.

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ACRONYMS

AHP	Analytical Hierarchy Process
ALT	Alternative
CUF	California Urban Futures
DSS	Decision Support System
FAO	The Food and Agricultural Organization
GIS	Geographic Information System
GDP	Gross Domestic Product
LE	Land Evaluation
LUP	Land Use Planning
LUT	Land Use Type
LUCC	Land Use and Land Cover Change
MCE	Multi-Criteria Evaluation
MCA	Multi-Criteria Analysis
MCDM	Multi-Criteria Decision-Making
PSS	Planning Support System
SA	Stakeholder Analysis
SD	Sustainable Development
SP	Scenario Planning
SDSS	Spatial Decision Support System
UAZ	Uniform Analysis Zones
WLC	Weighted Linear Combination

1. Introduction

In this chapter, general information about the research will be given, including the background, research problem, research objective, and research conceptual framework. Background mainly introduces the land use change problem in China; research problem briefly describes the limits of current research approach to support planning for resolving land use problem in China, and this issue will be further explained in chapter 2; research conceptual framework gives a general workflow for this research and also will be further discussed in chapter 5. Lastly, this chapter gives the structure of the thesis.

1.1. Background

Rapid urbanization, expansion of urban area and loss of policy protected land

Urbanization is the process of transformation that affects geographic regions when they become more urban. During the urbanization process, a growing share of a region's land and people become included in cities, suburbs and towns (Pivo 1996). Urbanization in the present and prospected form is one of the most drastic global changes that mankind has ever faced. It will touch most humans in coming decades, particularly in developing countries, such as land use problems.

China is a big developing country, owning vast amount of land. However, the land, which can be used, is in serious shortage. About 15% of the total land area consists of cropland and horticultural land. Forests and grasslands together cover more than 55% of the country. Most grassland is of poor quality, due to climatic conditions, bad management or overgrazing (Wu and Guo 1994). The actual grassland area may have already declined further due to desertification. Another large part of the country (23%) consists of unused land—deserts, glaciers and bare lands. The built-up area is presently about 3% of the total land area (Bo 1997).

In China, cities are growing in importance, and urban areas are expanding rapidly, primarily because the population of the nation is increasing and proportionally more people are congregating in urban areas (Dai, Lee et al. 2000). With the process of urbanization, the value of urban land use area per capita in China keeps rising, and more land is required for urban construction. For its growing population China will need to provide housing. This alone will make a large claim on urban land-use.

Table 1-1 Urban land use area per capita in 1985—1994, China
Adapted from (Wei 1998)

	1985	*1990*	*1994*
Urban land use area per capita (sq m/person)	65.4	67.7	74.0

Table 1-1 shows urban land use area per capita from 1985 to 1994, the value keeps rising. Table 1-2 is a comparison of urban land use condition between china and other countries in 1994. From such a comparison, we can get that since our urban land use area per capita is becoming more and more, it is still lower than that of developed country. In the next few years, the value of urban land use is expected to reach 85 sq m/person in 2010 (Wei 1998), which is close to the standard in most developed countries where there is lower population.

Table 1-2 Comparison of urban land use condition
Between china and other countries (1994) Adapted from (Wei 1998)

	China	Developing country (Average)	Developed Country	World
Urban land-use per capita (sq m/person)	74	83.3	82.4	83.3

Meanwhile, the cultivated area decreased between 1985 and 1995 by 1.9% per annum, from 968,000 to 949,000 sq km (according to State Statistical Bureau, 1986, 1996). In recent years, the loss area of cultivated land still stands between 4,000 sq km and 8,000 sq km. From the twentieth century, the area of water-covered land has also been decreasing, losing 1,3000 sq km from 1950 to 1970. In Hubei province for example, the area of water-covered land has decreased since 1990 to by 75% of the area it covered in 1949, the number of lakes drops from 1066 to 326 (Ge, Zhao et al. 2000).

The relation between different land use changes is modified by the rate of urbanization. The reasons for the loss of cultivated land are various, such as sending cultivated land to woodland and gaze land. However, the main reason should be attributed to the increase of urban land use, which replaced mostly cultivated and water-covered land. From 1995 to 1998, 14,000 sq km of cultivated land has been changed to residential, industrial and mineral and infrastructural land uses, this accounts for most 74% of the total loss of cultivated land (Liang 2002). In the western part of China, where the regional economy quickly develops with the support of central policies and where housing construction can often take place only at the expense of the cultivated area or water-covered area, the spatial conflicts between urban development and environmental protection become more and more obvious.

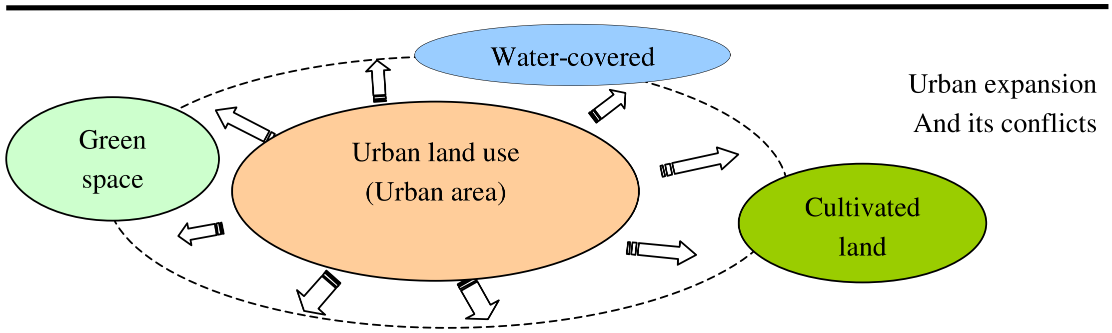


Figure 1-1 Urban spatial development and its conflicts

The figure 1-1 shows that urban sprawl is the result of the tendency to seek land, which is cheaper, and with better accessibility. From the figure, it can see that urban expansion usually goes without considering the effect of ecological, environmental problem. In most cases urban sprawl does not regard agricultural planning and green space planning, and such planning have been made as policy. The arrows in the graph indicate that urban expansion will take at diverse in directions, and mostly, it will occupy some ecological land. For water-covered land, because of its proximity to central city, it also can be replaced by housing or other urban land use.

The direct influence of the decrease of cultivated land is obvious; it can cause food supply problems and ecological deterioration, and then generate future social and environmental problems (FAO, 1976). This problem has also received wide attention from all kinds of international organizations, and it has become an important research content of LUCC (Land-Use and Land-Cover Change)(Liang 2002).

Changes in land use are considered the result of the interaction between policy variables that lead to the realization of a number of defined goals and possible side effects (Sharifi and Rodrignez 2002). In China, especially in the western region, urban expansion is a typical phenomenon in planning. To support the planning process and formulate policy, many planning support tools are developed and applied in the real world to resolve land use change problems and conflicts between different stakeholders.

1.2. Problem Statement

Land evaluation, as current planning support practice in China, is neither effective nor comprehensive for planning and sustainable development purposes

1.2.1. Land Evaluation in Planning Practice in China

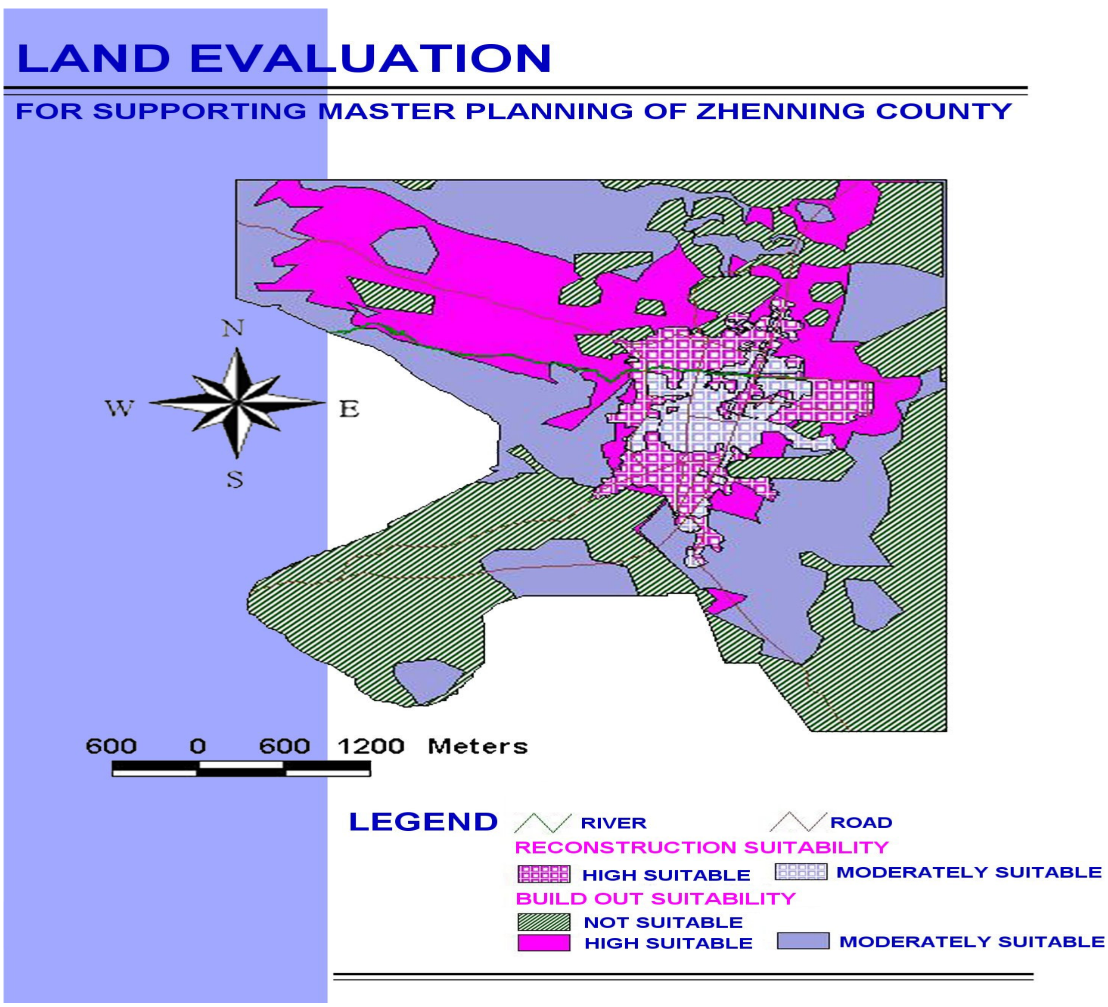
In China, land suitability evaluation is commonly used as planning support approach. Many researchers adopt suitability evaluation to analysis specific land uses, such as greenway suitability analysis (Miller, Collins et al. 1998), and urban land use evaluation (Chen 1997).

Table 1-3 is a typical index system of land suitability evaluation used in planning support for Wuhan city spatial planning. From the table 1-3, it is easy to see that, because the decision space/factors are limited to biophysical aspects, such as slope, evaluation, soil, hazard etc, the result of the evaluation can only reflect the land natural construction condition.

Map 1-1 is a typical land evaluation map used for supporting planning. In China, land evaluation is usually taken before land use planning, and the goal is to identify suitability classes in the study area. Generally, the suitability classes in China are divided into three groups, including not suitable, high suitable and moderately suitable. In some cases, the criteria and factors used for evaluation the suitability of reconstruction and built out area are different, but general idea is same, that is to identify which region can be developed firstly and which region cannot or need to develop later.

Table 1-3 Factor considered in land evaluation, Wuhan, China
Adapted from (Chen 1997)

Factors Considered	Geography	Land carrying capacity Water depth Water quality Land cover condition Soil characteristic Hazard
	Geomorphology	Landform pattern Slope Elevation Land surface characteristic
	Factors of water	Water distribution condition Water supplying condition
	Other factors	Mineral underground Excavated condition



Map 1-1 Land evaluation map used for supporting planning, China

1.2.2. Limits of Planning Support Practice in China

Land evaluation provides essential information on land resources. However this information is often not used in the planning and implementation of better land use system or land use practices. In this study, three main limits are identified to explain why land evaluation is not effective and comprehensive in planning practice in China. The first limit intends to reveal the ineffective aspect; the last two limits aims to describe the incomprehensive aspect of land evaluation in practice.

- Limit 1: Not considering stakeholders' interests (social, political)
- Limit 2: Not considering demand criteria (demographic)
- Limit 3: Not providing allocation scenarios of the different land use types

The above three limits will be given a detailed explanation in chapter 2 (section 2.6).

1.3. Research objectives

To investigate if the current planning support approach can be improved by creating allocation scenarios that considers stakeholders' interests and multiple criteria.

The main goal of the research aims to improve the suitability-based planning support approach for urban spatial development. In this study, the alternatives and criteria related to land use planning will be explored. MCE, GIS and *what if?* PSS will be used to create the needed allocation scenarios for the study area.

Sub-objectives

- To understand the concept of planning and sustainable development
- To understand the concept of stakeholder involvement in urban planning
- To analyze the limits of current planning support practice in China
- To show a picture of current planning support practice in the world
- To explain how *what if?* PSS can be used to improve planning support practice
- To generate criteria and weights sets and use *what if?* PSS to generate allocation scenarios
- To evaluate the strengths and weakness of *what if?* PSS

1.4. Research questions

To achieve the main objective and its related sub-objectives, several research questions are made to explore their answers. This thesis intends to focus on following questions and aims to give their answers in corresponding chapters.

To understand the concept of planning and urban sustainable development
- What are planning and urban sustainable development (SD)?

To understand the concept of stakeholder involvement in urban planning

- How to use stakeholder analysis (SA) and scenarios planning (SP) to achieve sustainable development (SD) in planning practice?

To analyse the limits of current planning support practice in China

- What are the limits of land evaluation (LE) for planning support in China based on the understanding of these concepts?

To show a picture of current planning support practice in the world

- What is a planning support system (PSS)?
- How can MCE and GIS be used in a planning support environment?
- How to use PSS bridge to link MCE, GIS with participatory planning support?

To explain how what if? PSS can be used to improve planning support practice

- What are the characteristics of *what if?* PSS?
- What data are needed for using *what if?* PSS?
- What are the limitations of what if? according to literature review?

To generate criteria and weights sets and use what if? PSS to generate allocation scenarios

- What is the condition of the study area?
- How can criteria sets be generated and values be added to the case study?

To evaluate the strengths and weakness of what if? PSS

- What is the actual benefit of using *what if?* PSS over land evaluation (LE) specifically for case study?
- What are the strengths and limitations of *what if?* PSS through the case study results and working experience?

1.5. Research approach

1.5.1. General Conceptual Framework

Figure 1-2 describes the general conceptual framework of development and evaluation of land allocation alternatives for the planning support, and the MCE, GIS, *what if* PSS are used in this thesis. It includes three main phases, goes as follows:

Phase 1: Intelligence

In this phase, the following issues are considered: the concepts of relevant problems; the reviews of relevant tools and methods used for resolving the problems.

In this period, a review of some literature related to urban spatial development, land use condition, planning, sustainability, stakeholder involvement and analysis, method on suitability analysis, planning support system, multiple criteria evaluation, GIS, system engineering, etc. was carried out. Next, ascertain research problem, objectives. Strengthen the rationale between factors and goals/criteria, the rationale between factor weights and stakeholders' view.

Phase 2: Design solutions

This phase provides the proposed model for generating alternatives. In this phase, GIS, MCE and *what if?* PSS will be used as planning support tools to integrate planning-related data and criteria to support decision-making using maps and reports.

In this period, the support of *what if?* PSS is especially important. The criteria behind alternatives will be discussed. The data set for using *what if*? PSS will be created.

Phase 3: Discussion

In this phase, around usefulness of planning support result, the evaluation of the proposed approach will be given. Alternatives and criteria selected will be discussed. The strengths and weakness of MCE, GIS and *what if?* PSS will be identified specifically for case study.

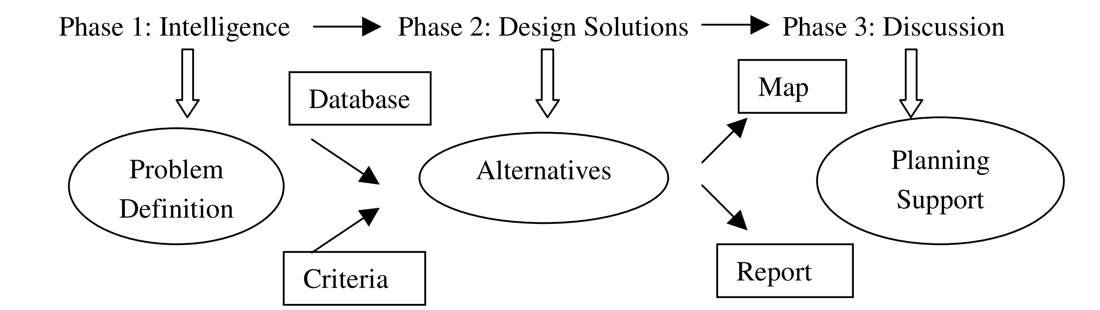


Figure 1-2 General conceptual framework
Modified from (Sharifi, Boerboom et al. 2002)

1.6. Structure of thesis

Chapter 1: Contains the background information, statement of research problem, research objectives, research questions, research approach, and thesis structure.

Chapter 2: Gives a literature review on the concept of planning and sustainable development, the concept of stakeholder involvement and scenario planning, the limits of current planning practice in China, and the picture of planning support practice in the world.

Chapter 3: Basically deals with the characteristics of *what if?* PSS, the data needed using *what if*? PSS, and the limitations of *what if*? PSS on the basis of literature review.

Chapter 4: Covers the description of the case study area, and the introduction of the thematic maps for the case study.

Chapter 5: States the approach to identify stakeholders in the study area and to generate alternatives and criteria for developing land allocation scenarios.

Chapter 6: Presents the results of analysis and discusses around stakeholders, alternative, criteria, scenarios, and the actual benefits and limitations of using *what if?* PSS over land evaluation (LE) and plan model (LUP) specifically for case study.

Chapter 7: Gives the conclusion and recommendations around the proposed research questions and key finding in the research.

2. Literature Review

In this chapter, three main aspects about planning support will be discussed. First of all, from the current planning support theory perspective, main elements included in land use planning and sustainable development will be identified. Following that, it is the introduction of stakeholder analysis and scenario planning, which helps for achieving sustainable development purpose. Secondly, based on the above reviews of planning theory, it is the analysis of the limits of the current planning support practice in China. Lastly, from the worldwide planning support practice perspective, PSS, MCE, GIS, and their inner linkage are introduced.

Part 1 Current Planning Support Theory

2.1. Planning and Land Use Planning (LUP)

2.1.1. Land, Land Use and Land Use Type (LUT)

- **Land**

Several definitions of land are referred to in various publications (Goudarzi 2000). The common aspect of these definitions is that they all consider the physical environment of land. FAO (1976) defines land, as an area that comprises the physical environment, including climate, relief, soils, hydrology and vegetation, to the extent that these influence potential for land use. FAO (1995) further supposes that land is a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near surface climate, the soil and terrain forms, the surface hydrology, the near surface sedimentary layers and associated ground water reserve, the plant and animal population, the human settlement pattern and physical results of past and present human activity. As Neameh (2003) suggested, in this definition, the implication of land has been broadened, including some socio-economic aspect.

Land is the ultimate source of wealth and the foundation on which civilization is constructed, efficient and thoughtful use of land is an important step in managing and developing any area. With growing populations and demands for welfare, land is becoming an increasingly scarce resource. As land can be used in different ways, it therefore becomes more and more important to put land to sustainable uses that best serve the interests of the land users and the community (Omakupt and Huizing 1995). Based on this understanding, the purpose of using land resource is to get sustainable development as well as to satisfy the concerns and interests of stakeholders.

- **Land use**

A series of operations on land, carried out by man, with the intention to obtain products and/or benefits through using land resources is called land use (Goudarzi 2000). According to FAO (1997), land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. Land use defined in this way establishes a direct link between land cover and the actions of people in their environment (FAO 1998). However, land use is easy to be confused with land cover. Land cover is the observed physical cover on the earth's surface (FAO 1997). It can be distinguished this two concepts with an example: recreation area is a land use term that may be applicable for different land cover types: for instance sandy surfaces like a beach, a built up area like a park, a forest, etc. In this study, the term "land use" is commonly used to reveal the functional aspect of land usage.

- **Land use type (LUT)**

FAO (1976) defines land use type as a use of land defined in terms of a product, or products, the inputs and operations required to produce these products, and the socio-economic setting in which production is carried out. Goudarzi (2000) briefly describe land use type as a kind of land use defined in a degree of detail greater than that of a major kind of land use. As Lin and Rentao (2001) suggested, according to the difference of land use types, it can be divided land uses into three broad classifications: urban land use, agricultural land and water-coved land & unused land (see table 2-1).

Table 2-1 Classifications and their descriptions of land use types
Adapted from (Lin and Rentao 2001)

Classes	Sub-classes	Description
Agricultural land	Cultivated	Cultivated lands, including paddy and dry land
	Horticulture	Horticultural lands, including orchards, tea and mulberry plantations
	Forest	Forestry lands, including timber, fuel wood, shelter
	Grassland	Grasslands, including natural and artificial grasslands
Urban land use	Urban area	Land for settlement, enterprises, mining and transportation
Water-covered land & unused land	Water	Water bodies and wetlands, including rivers, lakes, beaches, reservoirs and marshlands
	Unused	Other land, including glaciers, permanent snow, sandy land, deserts, saline land and bare land

In this study, considering that the research purpose is to find planning support for urban spatial development, and the research objective is about the urban areas, the land use types are classified into two broad classifications: urban area and non-urban area. According to the definition of FAO (1998), urban area is the area, which is used for or is covered by built-up area[1] elements of the residential, commercial, industrial or institutional sector.

Table 2-2 shows the classifications of land use types used in this study. For urban area, it includes residential, industrial, office/retail, green space and road. Non-urban area includes water-covered land, agricultural land and unused land. For future land allocation purpose, all existing land uses that are assigned to the "Developed", "Not Developable", and "Undeveloped". The "Developed" land use types will also be treated as "Allocation Land Uses" that may be used to satisfy future land use de-

[1] Built-up area is the area, which is characterized by an artificial cover, which replaces the original (semi-) natural cover FAO (1997). "Africover land cover classification."

mands. The “Not Developable” land uses will not be available for satisfying future land use demands. The “Undeveloped” land uses will be assumed to be available for accommodating future growth and will not be allocated (according to (Klosterman 1999)).

Table 2-2 Classifications of land use types used in this study

<table>
<tr><th>Classes</th><th>Sub-classes</th><th>For allocation purpose</th></tr>
<tr><td rowspan="5">Urban area</td><td>Residential</td><td rowspan="4">Developed</td></tr>
<tr><td>Industrial</td></tr>
<tr><td>Office/Retail</td></tr>
<tr><td>Green space</td></tr>
<tr><td>Road</td><td rowspan="2">Not developable</td></tr>
<tr><td rowspan="3">Non-urban area</td><td>Water</td></tr>
<tr><td>Agricultural land</td><td rowspan="2">Undeveloped</td></tr>
<tr><td>Unused land</td></tr>
</table>

2.1.2. Planning and Land Use Planning (LUP)

- **Definition of Planning**

Planning is an extremely complex subject; the definitions of planning can be seen in many documents and from different perspectives. This paper firstly goes into the planning concept from diverse definitions, and then tries to propose a comprehensive understanding about planning and land use planning, for the purpose of supporting this research.

The definition of planning adopted in this study is given by Conyers and Hills (1984) and Sharifi, Boerboom et al. (2002). They attempt to incorporate the main functions included in most other definitions. Conyers and Hills (1984) argues that planning is a continuous process, which involves decisions, or choices, about alternative ways of using available resources, with the aim of achieving particular goals at some time in future. They also emphasize that the term “resource” refers to anything, which is considered by those making decisions to be of potential use in achieving a particular objective. Sharifi, Boerboom et al. (2002) also defines planning as a means to make a choice, allocate resources, and achieve goals for the future.

- **Definition of Land use planning (LUP)**

Similarly, the definition for land use planning (LUP) is also covering many aspects of land use problems from diverse perspectives. FAO (1993) defines land use planning as a systematic assessment of land potential, alternatives for land use and other physical, economical and social conditions, for the purpose of selecting and adopting land use options which are most beneficial to land users without degrading the resources or the environment, together with the selection of measures most likely to encourage such land uses. This definition focuses on “land and land use” problems and defines land use planning as a land evaluation process, and it also considers that the allocation of land resources is the most important problem in the planning process.

Dent (1988) defines land use planning is a means of helping decision-makers to decide how to use land: by systematically evaluating land and alternative patterns of land use, choosing that use which meets specified goals, and drawing up policies and programmes for the use of land. This definition also emphasizes four aspects: a means to choose, to evaluate land, to achieve goals, relate to policy, which has a close relationship with the definition of planning proposed by Conyers and Hills (1984) and Sharifi, Boerboom et al. (2002).

Xiao (2002) defines land use planning in another way. She believes that urban land use planning is generally understood as an activity to prepare development plans regulate and control the use of land in the cities. She also believe the main objective of land use planning is to improve the living condition of the urban area and the welfare of urban dwellers. Dai, Lee et al. (2000) also think that a major objective of urban land use planning is to evaluate the advantages and disadvantages of one use of land parcels as compared to another, so as to yield the most beneficial use of land parcels and the conservation of fundamental natural resources.

2.1.3. Summary for Planning and Land Use Planning (LUP)

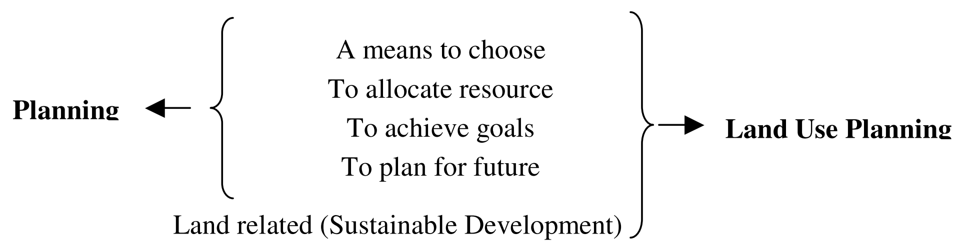


Figure 2-1 Main implications included in planning and land use planning

From these definitions, it can be seen that, the concept and content of planning and land use planning has some connection. Figure 2-1 gives the main implication included in planning and land use planning. The implication of planning includes four main aspects: a means to choose, to allocate resource, to achieve goals, to plan for future. However, as its name suggested, land use planning is one kind of planning, but more specifically on land and land use context. As discussed in section 2.1.1, land is the ultimate source of wealth and the foundation, on which civilization is constructed; therefore, it becomes more and more important to put land to sustainable uses that best serve the interests of the land users and the community. Based on this understanding, it can add the point of view about sustainable development into the implication of land use planning. As supported by Neameh (2003), land use planning aims at improved sustainable use of land and management of resources.

2.2. Sustainable Development (SD)

In the context of land use planning, sustainable development as a goal is often criticized as being vague and a paradox, and the reason may contribute to the uncertainty of the implication of suitable development in planning context.

2.2.1. Definition of Sustainable Development (SD)

FAO(1998) provides a definition of sustainable development: the management and conservation of the natural resource base, and the orientation of the technological and institutional change, in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Sustainable land use planning requires an in depth analysis of the existing resources (localization, features, sensitivity to development) and an understanding of development characteristics resource (needs and collateral effects) in order to identify an use for the natural resources that will not prejudice future development (Van Lier, Jaarsma et al. 1993).These definition more emphasizes the protection of natural resources and provides a sustainable condition for the next generation.
However, another kind of definition for sustainable development focuses more on economic and social benefits. Portnov and Pearlmutter (1999)believes that the definition of sustainable development is "a pattern of development which optimises the economic and other societal benefits in the present without jeopardizing the likely potential for similar benefits in the future".

Barbier (1987) defines sustainable development in more comprehensive perspective. He consider that sustainable development is not a separate system, but relates to different systems and tries to achieve a balance among them. Barbier (1987) further argues that sustainable development depends upon interaction among three systems: the biological system, the economic system, and the social system. Similarly, Brundtland (1987) also believes, to protect environmental and public health as well as to stimulate sounder environmental behaviour, balancing the economic, environmental and socio-cultural systems in particular when considering development possible for future generations, relates to the concept of "sustainable development".

2.2.2. Political Context (People) in Sustainable Development

As mentioned by Omakupt (1995), land use planning and sustainable development are meaningful only when: land users or the government feel that there is a need for land use changes; there is political will and ability to support and implement the plan; the planned changes are acceptable to the people (land users) involved. Sharifi, Boerboom et al. (2002) also believes that planning cannot be considered in isolation from the social, administrative and, in particular, political environment in which it has to operate. Planning can be influenced by political pressure from certain politicians or political groups. Policymaking involves making decisions about the general directions in which change or development should occur, while implementation is the actual execution of these courses of action. Population is a key factor to be considered in the implementation of sustainable development. As Sharifi, Boerboom et al. (2002) believes that, sustainable development can only be pursued if population size and growth are in harmony with the changing productive potential of the ecosystem.

2.2.3. Summary for Sustainable Development

From the above review, it can be seen that there is no general agreement on the concept of sustainable development. Some people may put high value on obtaining high quality of environment, while others may prefer to have improved living standards. Hubert and Lier (1998)describes the conflicting problem of economic development and ecological conservation as: ''we cannot save the environment without development, and that we cannot continue to develop anywhere unless we save the environment''. In practice, all present land use planning is caught up between two seemingly contradictory dimensions: ecological conservation and economic existence. Both dimensions are, in someway or another, related to urban sustainable development. However, all too often in debates about sustainable development, there is a tendency to forget that people are (or certainly should be) a key element in the development process, and that poverty alleviation and an improvement in human livelihoods are vital objectives.

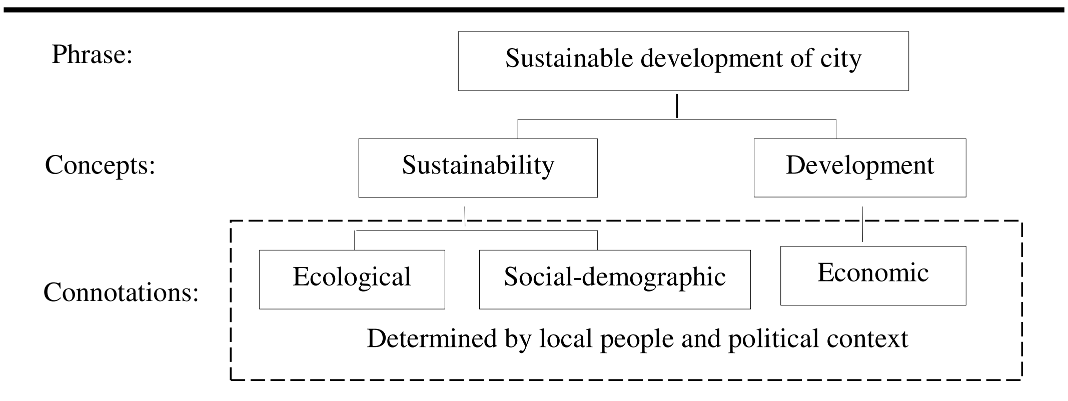


Figure 2-2 Semantics of sustainable development
Modified from (Lele 1991)

Figure 2-2 shows the semantics of sustainable development. We can regard urban sustainable development as both a sustainability process and an economic development process, which are equally important. The Ecological notion of sustainable development considers the phenomenon in terms of upward and downward pressure of the population on existing environmental resources, such as food, energy sources, water, etc. The Economic aspects of sustainable development consider the phenomenon in terms of economic development that can endure over time. The Socio-demographic aspects of sustainable development interpret the phenomenon in terms of the overall stability of population growth in particular geographic areas, and deal with specific aspects of the issue such as the `optimal size' of a settlement and the rural-urban balance of a region.

In planning practice, sustainable land use planning can be regarded as a complicated and multi-criteria thinking process. For each type of land use, it may consider its ecological, social-demographic, economic effect that it may bring. Those concerns can be embodied in planning process with the alternative factors about ecological, social-economic and demographic condition of the region. From the bottom of figure 2-2, it can be seen that it is not possible to design universal measurements and factors of sustainable development because of different weights that are given to different components by different communities.

2.3. Stakeholder Analysis (SA) and Scenario Planning (SP)

Stakeholder analysis is introduced to demonstrate the possible aspects of public participation and identify their interest for the planning support practice process. Scenario planning provides a useful process for pulling together all the major stakeholders in a strategic conversation that should ultimately lead to shared vision and action. In this research, what is considered is enabling communities to make their own decisions about sustainable development.

2.3.1. Definition of Stakeholder

FAO (1998) defines stakeholder as a large group of individuals and groups of individuals (including governmental and non-governmental institutions, traditional communities, universities, research institutions, development agencies and banks, donors, etc.). They have an interest or claim (whether stated or implied), which has the potential of having an impact on a given project and its objectives. Stakeholder groups that have a direct or indirect "stake" can be at the household, community, local, regional, national or international levels.

2.3.2. Stakeholder Analysis (SA)

For planning, the first problem is to identify the stakeholders involved in the planning process. Kammeier (1997) believes that stakeholder analysis (SA) is almost identical with the participation analysis in the participatory project planning procedures. Stakeholder identification is undertaken to determine who will be directly or indirectly affected, positively or negatively, by a project (commonly called project affected people or project-affected groups), and who can contribute to or hinder its success (commonly called other relevant stakeholders).

2.3.3. Introduction of Scenario

As reported by Kahn and Wiener (1967), scenarios were initially developed in response to the difficulty of creating accurate forecasts. Van der Heijden (1996) defined scenarios as the stories which are efficient for giving many different bits of information a mutual context, thereby making the cognitive aspects of any situation more manageable to deal with. Sharifi, Boerboom et al. (2002) believes that a scenario is a tool for ordering one's perceptions about alternative future environments in which today's decisions might be played out. Sharifi, Boerboom et al. (2002) also proposes that the key aim of using scenarios is to change people's habits of thinking, or their mental models of how things work so that they can deal better with the uncertainties of the future. In essence, just as Perterson (2003) mentioned, scenarios are alternative, dynamic stories that capture key ingredients of our uncertainty about the future of a study system.

Scenario analysis has been likened to a 'strategic conversation' because it involves bringing together groups of people to develop a set of plausible stories about how the future might turn out. Each story or scenario offers a different version of a possible future (Daymon 2001). Scenarios are constructed to provide insight into drivers of change, reveal the implications of current trajectories, and illuminate options for action. Scenarios can take the form of pictures, photos, written stories, dramas, poems, videos, dances, mathematical equations, piles of beans, geographic information systems (GIS), maps, sand drawings, graphs or any combination of these and other media (Sharifi, Boerboom et al. 2002).

2.3.4. Introduction of Scenario planning (SP)

As Scott (1998) reported, traditional planning is frequently based upon the belief that the application of professional expertise to achieve well-defined goals will ensure efficient and effective management. However, such plans often fail to consider the variety of local conditions or the propensity for novel situations to create extraordinary surprises. In this spirit, scenario planning is a creative process in which a group of people who share a common fate work together to create stories about the different ways that their future might unfold, and then use these stories to make decisions about what path they want to take.

Perterson, Cumming et al. (2003) defines scenario planning as a systematic method for thinking creatively about possible complex, uncertain futures. The central idea of scenario planning is to consider a variety of possible futures that include many of the important uncertainties in the system rather than to focus on the accurate prediction of a single outcome. As reported by Michigan (2001), scenario planning at its best is an ongoing strategic conversation amongst the decision makers in an organization.

2.3.5. Summary for Stakeholder analysis (SA) & scenario planning (SP)

From above view, it can see that there is a connection between stakeholder analysis and scenario planning. The purpose of stakeholder analysis is to understand which group of person will affect the planning project, and which group of person will be affected by the planning project. Further, stakeholder analysis provides the concerns and interests from the main stakeholders, which can represent the main push drivers of urban spatial development. Therefore, stakeholder analysis contributes to balance the benefits from stakeholders and reduce the conflicts in future urban spatial development. The purpose of scenario planning is not actually to predict the future—rather, it is a way to free us of fixed assumptions and mental models that may prevent us from seeing the future as it begins to take shape. Scenario planning contributes to offer different versions of uncertain future based on different possible choices and goals. In this way, scenario planning can also be understood that it reflects the outcome of stakeholder's concerns for urban future in maps, tables or other visible forms. At the same time, as reported by Pettit and Pullar (1999), scenario planning focuses upon map representations developed through the employment of analytical 'what-if' functions and spatial modelling usually undertaken in a GIS. It is closely connected to the view that planning should offer inspired visions of the future, based upon likely or preferred scenarios which are either founded upon existing planning policy or used to formulate planning policy. In general, stakeholder analysis (SA) and scenario planning (SP) improve public participation and strategic conversation, which further pushes to achieve urban sustainable development (SD) and to improve participatory planning support.

Part 2 Limits of current Planning Support Practice in China

2.4. Definition of Land Evaluation (LE)

According to FAO (1976) description, land evaluation is the assessment of land performance when used for a specified purpose, involving the execution and interpretation of surveys and studies of land-forms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison of promising kinds of land use in terms applicable to the objectives of the evaluation. This is a general definition for land evaluation and commonly used in agricultural and ecological land evaluation for choosing and assessing the physical condition of land.

2.5. Land Evaluation for Land Use Planning (LUP)

There are still some definitions, which build the connection with the land use planning. Dent (1988) proposes that land evaluation is the process of estimating the potential of land for alternative kinds of use. Once this potential is determined, land use planning can proceed on a rational basis, at least with respect to what the land resource can offer (FAO 1993). Thus, as Rossiter (1996)suggested, land evaluation is a tool for strategic land use planning. It predicts land performance, both in terms of the expected benefits from and constraints to land uses, as well as the expected environmental degradation due to these uses.

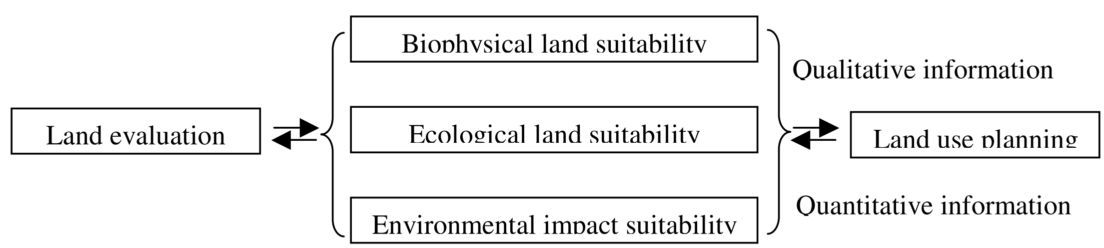


Figure 2-3 Connection between land evaluation and land use planning

The aim of land evaluation is to determine the suitability of land for alternative, actual or potential, land uses that are relevant to the area under construction. Omakupt and Huizing (1995)also believes that land evaluation produces information on the suitability of different tracts of land for specified, alternative land uses and provides qualitative or quantitative information on the expected productivity of theses uses, their sustainability, labour requirements, capital needs, gross margin, etc. Huizing, Farshad et al (1995) propose that land evaluation can support the land use planning from three aspects: biophysical land suitability, economical land suitability and environmental impact evaluation (see figure 2-3). For planning support, the aim is to allocate major land uses, including residential, industrial, office/retail, and green space etc., based on the local need for land; therefore, the information provided by land evaluation, which based on sustainable development purpose, should include qualitative and quantitative context.

2.6. Summary for Limits of Land Evaluation in China (Specific)

China has a rule to process land evaluation before land use planning and provide suitability maps for supporting planning practice. The typical index system and suitability maps of land evaluation have been introduced in chapter 1 (see section 1.2.1). As mentioned above (part 1 of chapter 2), planning has become much more complicated, integrated, more partnership-oriented and strategic, more future-oriented and scenario-oriented, and more interactive and participatory in nature (Stillwell, Geertman et al. 1999).

In such a condition, the limits of current land evaluation for planning support in China have come out. From methodological perspective, land evaluation in China is not based on the principle of sustainable development, therefore, the decision space, as can be seen in table 1-3, is focused on a limited area, such as geography and geomorphology (biophysical), which cannot reflect the main stakeholders' interests (social-economic, political) very well. Moreover, land evaluation in China has not a founded basis for the choice of area of each suitability category. From the typical suitability map (map 1-1), we can see that the quantitative (demographic) content of land evaluation is made by experience. However, based on the discussion in section 2.2, sustainable development has a close connection with population size and person's demand for land. Further, from the point of view of the final map, the information in suitability scenario map (see map 1-1) is limited. According to the scenario planning's concept, it needs to generate alternative feasible scenarios to address the existing problems, which can represent alternative stakeholders' interests and concerns.

Based on the above analysis, three limits of current land evaluation for planning support in China can be identified:

Limit 1: Not considering stakeholder' interests (socio-economic, political)

Generally, the factors considered in land evaluation are not enough for planning support practice. Land evaluation in China, focuses on evaluating land biophysical suitability for urban development, less considering social and political factors, which can better represent different major stakeholders' interests. As shown in table 1-3, the factors selected to assess the land suitability is limited to geography, geomorphology and other land physical elements. The information, which land evaluation produced, is frequently incompatible both with government' objectives and/or the preferences of the local people (Bronsveld, Huizing et al. 1994).

In China, government and investors are two big but opposing stakeholders. In planning practice, land evaluation has been done mostly based on the government's point of view. They would like to take current environmental and ecological policy and their proposed plan into consideration. Just as Bronsveld, Huizing et al. (1994) reported, land evaluation in this way is based on a top-down approach; such an approach does not take sufficiently into account the aspirations, capabilities are constraints of the local land users. For the investors, they also play an important role in land use and land use change. They more like to promote making new policy based on their real need, not from current policy to policy as government suggested. In real world of urban development in China, as a consequence shown by figure 1-1, there is always a conflict between land use planning and real land use development. Clearly understanding the stakeholders' interest and take the decision space/factors into consideration can reduce confliction between major stakeholders and improve planning support.

Limit 2: Not considering demand criteria (demographic)

Land evaluation provides the information about the supply of land based on specific criteria developed by stakeholders. However, planning needs to consider not just supply of land, but it should include the actual demand for land. From the sustainable development perspective, as Sharifi, Boerboom et al. (2002) believes, sustainable development can only be pursued if population size and growth are in harmony with the changing productive potential of the ecosystem. From the typical land evaluation map shown in map 1-1, it hardly finds the quantities relationship between the high or moderately suitable land and real demand for land. The land evaluation map gives a rough direction for future urban development (spatial), and the area of high suitable or moderately suitable land is determined by experience, because a dependable (quantitative) basis is lacking. In planning practice, population size and density can be predicted (demographic), and the result can be added into the consideration of land evaluation, which quantifies the demand for land.

Limit 3: Not providing allocation scenarios of the different land use types

Most of the time, land evaluation is used to assess certain kind of land use type for specific purposes, such as green space evaluation, agricultural land evaluation and commercial land use etc. In China, land evaluation is adopted to assess the land suitability for urban construction. It takes the same criteria/factors to evaluate the general suitability of all land use types. As shown in table 1-3 and map 1-1, the decision process of land evaluation has not considered the difference of criteria used in evaluating, and we still cannot get an idea about which place is high or moderately suitable for a specific land use type, such as residential, industrial, commercial or green space. To provide more comprehensive information and to improve planning support, it needs to be able to identify separately criteria to evaluate land suitability of different land use types.

Meanwhile, based on different points of view from stakeholders, the allocation choice of different land use types is diverse. In China, government and investors hold different opinions on allocating land uses. In general, the government pays more attention to city service functions and "intensive land use" problems. They prefer to allocate office/retail land uses firstly in the highly suitable areas and intend to control the urban development in a frame (Centralization of urban land use) and cut down on the expenses of infrastructure. However, investors think more about how to make most benefits from the land development. On the one hand, they disagree with the allocation order supposed by government. In current condition of China, developing industrial area is favoured and attracts most investment. Investors prefer to allocate employment zones first, and then consider the choice for allocating other land uses. They seldom consider the intensive use of land resource; therefore they would like to develop different land uses in a wide range of the region (Decentralization of urban land use). Overall, according to the different stakeholders' interests, different land allocation scenarios can be developed based on land suitability evaluation of different land use types, which will help to improve planning support and balance as much as benefits from diverse stakeholders point of views.

Part 3 Current Planning Support Practice in the World

2.7. Planning Support System (PSS)

More recently, the use of planning support system to facilitate planning support has been entering planning context. This section introduces the general concept of planning support system. In chapter 3, an operational planning support system, *what if?* PSS will be separately introduced.

2.7.1. Introduction of Planning Support System (PSS)

Some people believe that the way to improve panning support is to combine the planning model and GIS technique to formulate an integrated system for planning and decision support purposes. Based on this understanding, Harris and Batty (1993) proposed a general definition of planning support system. They associated the concept of PSS with combining a range of computer-based methods and models into an integrated system that is used to support a particular planning function. In a similar vein, Klosterman (1997) has described PSS as information technologies that are used specifically by planners to undertake their unique professional responsibilities.

However, the Planning Support System (PSS) is an architecture that, using computer science, supplies decision support information in the field of planning (Politecnico di Milano, 2003). As Geertman and Stillwell (2003)reported, it seems that PSS has much in common with the well-known system: SDSS. About the meanings of SDSS, Densham (1991)defines SDSS as systems designed specially to support a decision research process for complex spatial problems. He supposes that SDSS can provide frameworks for integrating database management systems with analytical models, graphical display and tabular reporting capabilities, and with the expert knowledge of decision-makers

Still some suggest that PSS and DSS can be defined together. Sharifi, Boerboom et al. (2002) believes that the general concepts of PSS and DSS are related and they defined planning/decision support system (PSS/DSS) as class of information systems that are supporting planning/decision process. PSS/DSS contributes to rationalizing planning process by providing necessary support to systematically structure and formulate problems, develop alternative plans or policy scenarios, assess and evaluate their impacts (considering objectives of the relevant stakeholders), and to choose the proper decision, policy, or plan.

2.7.2. Summary of Planning Support System

In this paper, PSS is not regarded as the same thing as DSS, SDSS and GIS. One difference between PSS and DSS is the emphasis of the two support systems. As Sharifi, Boerboom et al. (2002) further reported, PSS emphasizes on design stage while DSS pay more attention on making choice. Another difference lies in that the users of the PSS are technocrats but the users of the DSS are decision-makers. Geertman and Stillwell (2003)summarize the difference between PSS with GIS, SDSS by virtue of the fact that PSS is dedicated specifically to activities associated with planning in practice. PSS specifically support the whole of or some part of a unique professional planning task. SDSS, on the other hand, are generally designed to support shorter-term policy-making by isolated individuals or by business organizations(Clarke 1990). On many occasions, a proprietary GIS will form part of a PSS, given the standard sets of functional capabilities that the former very usefully provides.

According to (Klosterman 1999), PSS have matured, becoming integrated systems of information and software. They bring together the three components of traditional decision-support systems: information, models, and visualization in the public realm. In this concept, the information component includes not only GIS data but also statistical data and information stored in text and graphic images. The model component includes tools for spatial interaction, analysis, expert systems, and artificial neural networks, among other things. The visualization component includes charts, graphs, maps, 3D simulations, and multimedia presentations.

2.8. Multi-Criteria Evaluation (MCE)

2.8.1. Definition of Multi-criteria Evaluation (MCE)

The methodology which emerged in the 1970s and which seemed to be well suited to support the public decision-making process was MCE(Pettit and Pullar 1999). Jankowski (1995) gives a definition of multi-criteria evaluation (MCE), or sometimes also called multiple criteria analysis (MCA), is a procedure that assist decision makers in selecting the “best” alternative from a number of feasible choice alternatives under the presence of multiple choice criteria and diverse criterion priorities.

The basic principle of a MCE method is very simple. Rico (2001) describes the principle of MCE as using a matrix (effect matrix) to resolve a problem, and the matrix should be constructed whereby its elements reflect the characteristics of a given set of choice possibilities, which are determined by means of a given set of criteria.

2.8.2. MCE for Land Use Planning (LUP)

One of the significant initiatives for achieving sustainable urban development is the development of criteria and factors (Mendoza 2000). Prabhu, Colfer et al. (1998) give the definition of criteria. In their views, before developing criteria, it needs to set up a principle. They believe that principle is a fundamental truth or law as a basis for reasoning or action. In land use planning, they provide the justification for criteria. Criterion is a principle or standard that adds meaning and operationality to a principle without itself being a direct measure of performance.

The methods to measure criteria are diverse. The commonly used in practice are three ways, just as Mendoza (2000) reported: raking method, rating method and pair wise comparisons techniques. Ranking method involves analysis of each criteria and factors element by assigning a rank depending on its perceived importance. Rank can be assigned following a nine-point scale (1, weakly important; 3, less important; 5, moderately important; 7, more important; 9, extremely important). Ranks sometimes also can be assigned following a five-point scale or just three-point scale according to the use purposes. The relative importance or weight can be calculated based on the ranks assigned to each criteria and factors element. Rating method directly assigns weighs explicitly to each criteria and factors element by distributing values. The weights of all decision elements subjectively set by a participant.

The pair wise comparison technique is based on the AHP (analytical hierarchy process) method and more complicated than rating method.

As mentioned by Hofstee and Brussel (2000), Multi-criteria evaluation can provide a logical work-flow to organize data, the scoring and weighting system can be applied to the various aspects of suit-ability to assess the overall suitability for a specific land use. Many spatial decision making problems such as site selection or land use allocation require the decision maker to consider the impacts of choice-alternatives along multiple dimensions in order to choose the best alternative. The decision making process, involving policy priorities, tradeoffs, and uncertainties, can be aided by Multiple Cri-teria Decision-Making (MCDM) methods.

2.8.3. Summary for MCE application

Pettit and Pullar (1999) describes the linkages between the land use planning and MCE in five phases. The first phase of the MCE process is deriving weights. These weights are based upon the relative importance of the initial goals and objectives (criteria) set within the planning process. The opportuni-ties and constraints are transformed into factors based upon user requirements. The derived weights are applied to these factors in order to formulate a matrix, which links the graphical, and attribute data through a user-defined rating value. The matrix, in turn, is the MCE representation of a planning ele-ment, where the set of values assigned by the planner to each of the spatial factors which comprise the planning element are assigned a combined row and column location within the MCE matrix. The final phase within the MCE process is based upon a technique known as weighted linear combination (WLC).

However, as reported by Rico (2001), like most planning methods, the MCE method has both positive and negative sides. Parts of MCE may be technically too complex to be understandable for non-experts in the field of evaluation. Meanwhile, MCE alone cannot assign the weighted value to spatial data layers. It needs spatial analysis functions such as attribute queries, buffering or data classification to incorporate the decision space into intuitive scenarios.

2.9. Geo-information System (GIS)

2.9.1. Definition of Geo-Information System (GIS)

There are many definitions for Geo-information system (GIS), but most of them focus on its func-tions. Nath.S.S., Bolte.J.P. et al. (2000)reports GIS as an integrated assembly of computer hardware, software, geographic data and personnel designed to efficiently acquire, store, manipulate, retrieve, analyse, display and report all forms of geographically referenced information geared towards a par-ticular set of purposes.

2.9.2. GIS for Land Use Planning (LUP)

Technologically, geographical information systems (GIS) provide a powerful tool for geo-environmental evaluation in support of urban land use planning (Dai, Lee et al. 2000). A planner can apply geographic information techniques in all aspects of the planning process, including data collection and storage, data analysis and presentation, planning and /or policy making, communication with the public and decision makers, and planning and/or policy implementation and administration (Neodoric 2000).

The application of GIS within planning practice has increased. One of the main reasons is the tremendous growth in accessible and affordable geodata. Data are represented as a finite set of objects. Meanwhile, since the real world is so complex, it would take an infinitely large database to capture the real world precisely. Data therefore must be generalized or abstracted to reduce it to some manageable quantity. Church (2002) describes the two principal data models in GIS: the raster and vector model. The choice of data model for using in planning support environment depends on data availability and operation environment. Another main reason is the nature of the developments in GIS, moving the field from being primarily technology-driven to being more user-driven (Geertman 1999). GIS became more accessible with the emergence of relatively cheap and easy-to-handle Windows-based (for example, Arc View) and Web-based (such as, Geomedia, MapObjects) tools.

In practice, GIS can be integrated with many methods and models to support decision-making for planning. Matthews, Sibbald et al. (1999)integrates geographic information system and environmental models to formulate spatial decision support system (LADSS) for rural land use planning. Zhu, Aspinall et al. (1996) promote the integration of GIS, expert systems and analytical models to support problem solving and decision making in strategic land-use planning (ILUDSS). Pettit and Pullar (1999)proposes an integrated planning tool based upon multiple criteria evaluation (MCE) of spatial information and GIS to support decision-making. Dai, Lee et al. (2000) demonstrates a GIS-based geo-environmental evaluation for urban land-use planning integrating multi-criteria analysis. Miller, Collins et al. (1998) presents an approach to greenway analysis that integrates suitability analysis with geographic information system (GIS) technology to identify suitable sites for greenway development in the town of Prescott Valley, AZ, USA.

2.9.3. Summary for GIS Application

The increasing usage of GIS data and its linkage to planning models are commonly used in planning support environment. However, there is still some inconvenience for using GIS specifically for planning support. Since GIS can combine with some models and analysis methods, the existing weakness is that the operation process is complicated and not easy to understand. What these applications do not provide is an intuitive software interface specifically designed for planners, and they do not fully utilize the spatial analytic capability of GIS in an integrated approach. Pettit and Pullar (1999) believes that GIS has mainly been used for data management and query of land records. More advanced site planning and analysis performed by planners has not taken advantage of GIS. Further, Hamidou (1998) argues that GIS generally can not solve problems, which require multi criteria analysis with conflicting objectives.

2.10. Linking MCE and GIS with Parcitipartory Planning Support

Compared to planning support practice in China, MCE and GIS have been commonly used in land evaluation. Generally, MCE provides logical workflow to organize data. The scoring and weighting system is applied to assess the overall suitability for a specific land use. Data management and scenarios development function of GIS is adopted in many planning filed, and the data query and spatial analysis function of GIS are also used for specific purpose, such as land use planning support. As discussed in previous section, the separately use of MCE and GIS cannot support planning well. One approach to improve support for land use planning is to integrate MCE with spatial analysis and presentation technique. MCE can provide a decision-making procedure specifically designed for planners, and the decision space is easy to visualize and get spatial analysis using geo-information technique, such as GIS.

However, as mentioned both in section 2.8.3 and 2.9.3, there is not an intuitive interface specifically designed for planners, which has made the operation process of MCE and GIS complicated and not easy to understand. PSS, as a bridge to link MCE, GIS with participatory planning support, is commonly adopted in the world of planning practice. The development of PSS is based on the assumption that a greater degree of access to relevant information will lead to the consideration of a greater number of alternative scenarios, which in turn will result in a better informed public debate (Shiffer 1995). PSS is the bridge not only to link techniques, but also to link stakeholders with the decision-making process in planning support practice. From the above analysis (see section 2.7.2), PSS can be GIS-based, model-based, and scenario-based, mainly designed for planning support purpose. PSS provides a user-friendly interface, which allows smooth and easy communication with the system, visualization and communication of the results of the analysis to the decision-makers in a manageable and understandable form (Sharifi and Rodrignez 2002). In this study, an operational planning supports system, *what if?* PSS is introduced and used to case study to develop scenarios, for the purpose of setting alternatives based on MCE, GIS techniques and stakeholders involvement.

3. *What if?* Planning Support System

The three typical characteristics mentioned in this chapter has a close relation with the methodology proposed in chapter 5. The introduction of data requirement also relates to the data used in the case study in chapter 4. According to the limitation based on literature review, a final assessment of *what if?* PSS based on case study result and working experience will be given in chapter 6.

3.1. Characteristics of *What if?* PSS

The w*hat if?* Planning support system is an interactive GIS-based system which supports all aspects of the planning process: conducting a land suitability analysis, projecting future land use demand, preparing a land use plan, and allocating this demand to suitable locations (Klosterman 1999).

3.1.1. Characteristic 1: Model-Based

The most important characteristic of *what if?* PSS is that it provides a planning support model for balancing the supply of, and demand for, land suitable for different uses at different locations using GIS data. Basically, w*hat if?* model is based on the first California Urban Futures (CUF I) model to which it is similar in many ways (Sharifi, Boerboom et al. 2002). The first California Urban Futures (CUF-1) model developed by John Landis and his colleagues in the early 1990s; CUF-1 was also the first metropolitan simulation model to use a geographic information system (GIS) to assemble, organize, manage, and display the millions of available pieces of information describing land development potential (Lee, Klosterman et al. 1999). *What if?* model divides urban growth into three separate processes with the purpose of better and easy achieving planning support. The general idea of the model is the same as the conceptual model of the decision-making process proposed by Cheng (2003). Cheng believes that the decision-making process for urban growth includes four stages: project planning, site selection, local growth and temporal control.

What if? considers the supply of land by incorporating widely used "weighting and rating " (MCE) land use suitability procedures. For different land use, the factors are chose to determine the suitability of different locations. Factor weights in *what if?* model is assigned on a three-point scale from 1 (low) to 3 (high). The factor weights are numerical scores, which indicates the relative importance of different factors for determining the suitability of different locations for a particular land use. Ratings are also numerical values, which indicate the relative suitability of locations with a particular factor type for locating a specified land use. The factor types are rated on a six-point scale from 5 (high) to 1 (low) and 0 (excluded).

What if? considers land use planning is a sustainable development process, which satisfies the future demand for land. The model uses the growth assumptions to project the demand in each projection year for all land uses. It provides two approaches for projecting the number of residential households and industrial or regional commercial employees that determine the future demand for different land uses. The first option automatically converts specified values for the past number of households and employees into the projected values. The second option allows entering previously defined projections for the future number of households and employees in the study area. This option may be useful when official forecasts for the area's growth are available and some one want to consider the implications these projected values may have on the area's future land use patterns (Klosterman 1999).

What if? projects future land use patterns by allocating the projected land use demands to different locations on the basis of their relative suitability. In this stage, the growth allocation can be controlled by specified land use control. That is to say, the land use control can be used to control growth by requiring that different types of development can occur only in areas that are planned or zoned to accommodate them (Klosterman 1999).

3.1.2. Characteristic 2: GIS-Based

The second important characteristic of *what if?* is that it uses increasingly available geographic information system (GIS) data to support community-based processes of collaborative planning and collective decision making. It uses the GIS data sets that communities have already developed to support community-based efforts to evaluate the likely implications of alternative public policy choice (Klosterman 1999). *What if?* can incorporate information stored in popular GIS systems such as ESRI's ArcView GIS, and all other systems that can generate ESRI shape files. Its outputs can also be viewed with ArcView GIS and any other program that can read shape files.

In the w*hat if?* operation environment, it uses a single SHAPE file (*.shp) containing Uniform Analysis Zones (UAZs). According to the definition given by Klosterman (1999), UAZs, are GIS-generated polygons, which are homogeneous in all respects considered in the w*hat if?* model. The UAZs are created by using GIS overly functions to combine all the relevant layers of information on suitability, demand and land use control policy. All points within a UAZ have the same value on land use requirement and demand. At same time, w*hat if?* directly incorporates currently available GIS and non-GIS data in order to support community-based dialogue and collaborative decision-making.

3.1.3. Characteristic 3: Scenario-Based

The third important characteristic of *what if?* is that it is a scenario-based planning support system. The system allows creating alternative development scenarios and determining the likely impacts of alternative public policy choices on future land use patterns and associated population and employment trends (Klosterman 1999). As discussed before, planning cannot determine the exact condition of future, and it can only give possible development scenario of future based on different policy choices and assumptions. *What if?* scenarios can provide information to support community-based planning and decision-making using different choices for diverse suitability, demand, and policy control alternatives by using the computer-based visualization techniques.

3.1.4. Summary

Urban growth and land use planning is a complicated process. The three main functions in *what if?* model allows to transfer planning ideas into operational processes in a computer-based environment. *What if? PSS* builds a bridge to link GIS and planning decision space with planning support practice. It makes full use of available GIS data sets and non-spatial social and demographic information for community-based planning. The outcome of what if? scenarios provides intuitive maps and table for community-based decision making and public debate. The whole system is based on a community-based planning support environment as well as a user-friendly interface. *What if?* PSS provides a familiar windows point-and-click interface that allows everyone to define or modify scenarios determining the relative suitability, demand and allocation of different locations. This quick and easy computer-based process allows controlling the complicated problem in planning process. Figure 3-1 summarizes the three characters of *What if?* PSS.

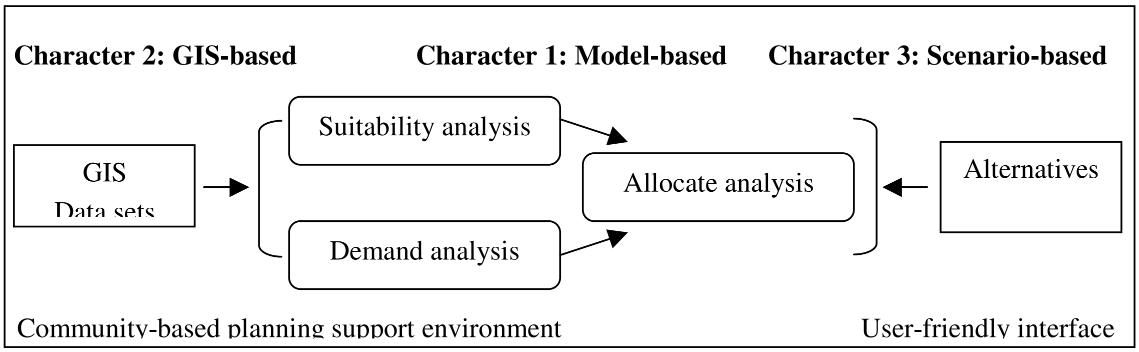


Figure 3-1 Characters of *What if?* PSS

3.2. Data needed for using *what if?* PSS

Basically, there are two types of data sets are required to use *What if?* PSS: spatial/thematic data and non-spatial/demographic data.

Specifically, for spatial data, three kinds of information are needed. The first piece of information is a digital map showing the area's current land uses. The second piece of required information is a series of digital maps showing the distribution of different suitability factors: slopes, soils, floodplains and so on. The last piece of information is digital map layers that describe alternative land use control police such as land plans, zoning ordinances, or infrastructure expansion plans.

For non-spatial data, two kinds of information are needed. The first piece of information is the projection for the future residential population and employment, which are required to project future land use demands. The second piece of information is the "scenario assumption", which is used to define the suitability, growth, and allocation scenarios.

3.2.1. Spatial Data

The only GIS map that is required to use *what if?* is the study area's existing land use. The current land use is the basis for allocating future land uses incorporating the suitability and demand analysis. Major land use types need to be selected for existing land use map. These land use types will be built connection with suitability and demand analysis according to local situation. The suitability maps are used in *what if*?'s Suitability option to determine the supply of land that is suitable for different uses from a natural features perspective. Depending on the available GIS data and real situation. The allocation maps are used to control the allocation of projected land use demands to the most suitable locations. The allocation should reflect the availability of GIS data and the most important control factors, which stakeholders developed. Typical "control factors" that can be used to allocate future land use demands include: existing zoning, existing or proposed master plans, existing or proposed sewer and water service plans, and major thoroughfare plans. The "boundary" maps define the boundaries for areas that can be used to report projected land uses and related information such as population and employment.

Additional "display" layers can be included to provide other layers that may be displayed over the *what if*? outputs. These layers could include parcels boundaries and the location of major and minor roads, streets, and streams. Any ESRI shape file can be used as a display layer in What if? (What if?,Inc., 2003)

3.2.2. Non-Spatial Data

For projecting future land use demands, the number of households, which will reside in the study area, the number of industrial and commercial employees, which serve for the study area, and the number of acres of the total land in the study area, which are devoted to each preservation for local use, are required to specify.

For providing "scenario assumption" information, the data should include: suitability weights and ratings for all factors considered in the suitability analysis and for all of the land uses being considered in the analysis; Residential information on the percentage breakdown of future residential construction, household density (dwelling units/acre), average household size, and the percentage of units that will be vacant or lost for all housing types; Industrial and commercial information on the number of square feet per employee, the floor area ratio, and vacancy rate for each category of industrial and commercial land use; The assumed acreage and/or percentage of the study area that will be devoted to each preservation land use in each projection year; The number of acres per thousand population for each local land use in each projection year for all sub areas in the study area (What if?,Inc., 2003).

3.2.3. Summary

In general, *what if?* PSS intends to use GIS-based data sets and non-spatial information to convert stakeholders' interests and concerns into alternative scenarios. Spatial data intends to provide the location of the future land uses; non-spatial data intends to qualify the future land uses. The data requirement covers land suitability, the demand for land, and land allocation aspects. Those data sets have close relationship with the three functions inside the *what if?* model (see section 3.1.1). Compared to the current planning practice in China, *what if?* PSS needs more social and demographic information. That information contributes to provide the rationale for demand for each land use type and builds a bridge with the spatial distribution provided by spatial data. Moreover, *what if?* provides an intuitive interface to facilitate the process of calculating the demand for land based on the number of units and its density (see figure 3-2). For better understanding the scenarios, *What if?* PSS also allows a variety of additional layers to be added, depending on the GIS data that are available and the analysis needs.

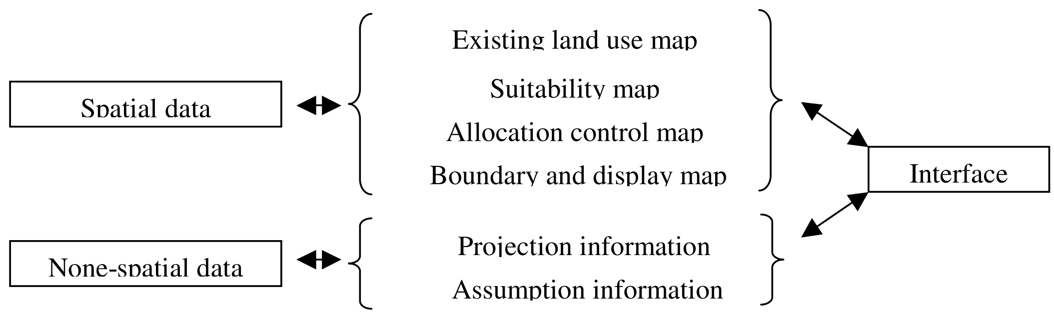


Figure 3-2 Data needed for using *what if?* PSS

3.3. Limitations of *what if?* PSS (Literature)

What if? PSS is an operational planning support system and has been developed by What if? Inc., a privately held corporation founded in 1996 (What if?,Inc., 2003). Its biggest advantage is that it is a fully operational model that can be adapted to the particular data sets and collaborative concerns in any area. A second obvious advantage is the model's simple and intuitive modelling structure. The general concepts of balancing the supply of, and demand for, land by determining the relative suitability of different locations, projecting the various demands for land, and allocating the projected demands to the most suitable locations, can readily be understood by elected officials and the public.

However, *What if?* PSS's simple structure and minimal data requirements are directly associated with the model's most glaring weakness, its lack of a rigorous theoretical basis. The model does not include measures of spatial interaction, which are widely recognized to be an important-if not the most important determinant of long-term urban growth patterns and the key component of most urban models (Klosterman 2001).

Analysing "What if" more specifically some operating problems can be found. The modelling process is iterative in the sense that the costumer begins both with an assumptions set about adaptability and one about the demand. When these two sets are combined together with conditions on the ground use control or with infrastructure plans, it can result that the space for that particular use isn’t sufficient. This needs to modify certain conditions made on the adaptability, on the growth or on the allocation parameters. At this point, the user must carry out again the model to verify if the new impositions set have a more appropriate result.

For this problem, it can be made up in three different ways: 1. Modifying the suitability scenario, in order to assure a greater land amount suitable for that particular use: increasing the available land amount in order to satisfy the future demand for that use. 2. Modifying the demand scenario, in order to reduce the land demand: “fixing” the growth rates for every activity. As consequence, the available soil demand estimation will low down. 3. Modifying the allocation scenario: it’s possible to modify the order of importance of the demand in the allocation process. If a use before has a higher allocation order, it results first, having in this way priority in the allocation (Politecnico di Milano, 2003).

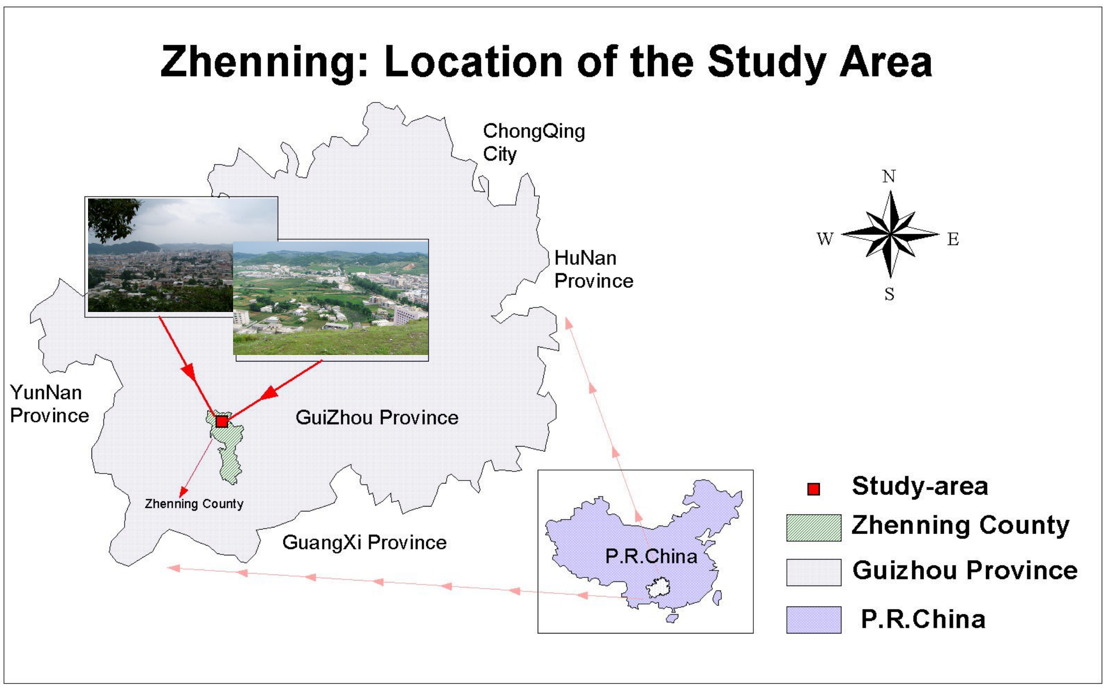
Generally, it is clear that *what if?* operates a simplification of the real decision process. As a matter of fact, it doesn’t want to take the place of the decision maker, but just to give him a valid aid. The real problem is certainly more complex than the one analysed in the software, and the factors in reality are more numerous than the ones considered in the PSS.

4. The Study Area

4.1. Introduction of the study area

4.1.1. Biophysical Profile

Zhenning County is located in south west of Guizhou province, which is situated in the south west of China. The urban area and vicinity of Zhenning County is selected as the study area in this thesis (Map 4-1). It is the political, economic and cultural center of Zhenning County, with an area of about 2200 hectares, varied in topography, relief, and relevant geological and geomorphologic processes.



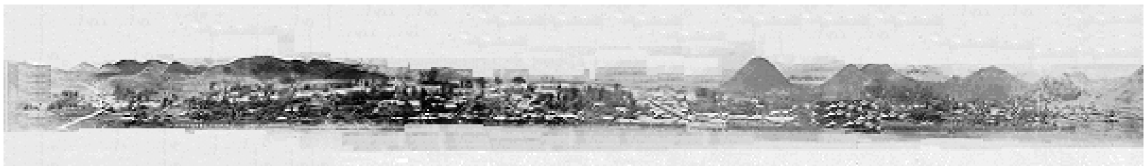
Map 4-1 Geographic location of the study area

In the whole county, the mountainous area and hill land area respectively account for 63.91% and 9.91% of the total land area (from statistics of Zhenning county, 2001). The county's landform is a typical Karst[2]; some of the land is slide land with a deep slope or changeable foundation. Historically, there are lots of hills distributed mainly at the southeast of the study area, and the topography in the north is higher than that in the south (see Map 4-2).

The agricultural soil in the study area is mainly located outside the build up area (more see section 4.2.2 and map 4-5); some of it belongs to the basic farmland, which have been severely controlled by local government especially for food production. The main wind direction of the study area is north-

[2] Karst is a term commonly used in the field of geography

east and southeast, and the general environmental condition of the study area is strongly affected by the wind direction change (more see section 4.2.2. and map 4-7). The average yearly temperature is 16.2 ºC, and the region has sufficient sunlight and precipitation.



Map 4-2 Landscape view of the study area in two hundred years ago

The future urban expansion needs to consider the land biophysical characteristics of the area. According to the requirement of the local land use planning, the maximum allowed slope for residential is 25% (more see section 4.2.2 and map 4-4), and the main wind direction should not locate industrial land. For other kinds of land use, different biophysical characters determine its suitability for future use.

4.1.2. Socio-Economic (Demographic) Profile

Zhenning County, traditionally and historically was considered as a good place to live, work, and visit, because of its location, the climate, attractive landscapes and long history. The buildings there has their own characteristics, such as stone wall, stone tile, which makes the county silvery white, and the county is famous and is referred to as the “silver town”. In the study area, there is a famous historic site, “rhinoceros cave”, which has a great potential for further development as a regional resort (more see section 4.2.2 and map 4-6). Meanwhile, the study area has a convenient proximity, just 15 km to the national resort, “Huang-Guoshu waterfall”, the second highest waterfall in the world. All these factors have made the county an important place for tourism.

Zhenning County has 16 towns, and the population in 1999 reached 330,000, of which 8% are non-farmer. In 2001, the GDP (gross domestic product) of the whole county reached 699,130,000 RMB, and the average GDP per capita is 2,062 RMB. The population of the study area in 2003 is about 30,000, and the population growth is mainly from natural growth (see Annex II Table 1). With the process of urbanization, the percent of non-farmer to total population has generally kept rising, which causes an increase of migration from the rural areas towards the county. With the support of the “western development” policy in China, the region gets good development opportunity. Meanwhile, Guizhou province will emphasize the development of 23 small cities till 2020; Zhenning is fortunately being included in its list. In such condition, the government of Zhenning County proposes to make a new master plan of land utilization from 2002 to 2020 to push the county’s development as a city as soon as possible.

According to the linear trend of the past years based on the observed demographic data from 1991 to 2000 (also see Annex II Table 1), the population in 2020 will not yet reach 50,000 (see figure 4-1). This future population assumption is made based on analysis of statistic data and population growth regulation of the study area. However, according to the calculation of the planning bureau, the population of the study area in 2008 will reach 60,000, and the value will reach 10,600 in 2020 (see Annex

II Table 2). This result bases on the assumption that the urbanization rate of the whole county is above 13.4% in 2008 and above 20% in 2020 using regional urbanization rate method.

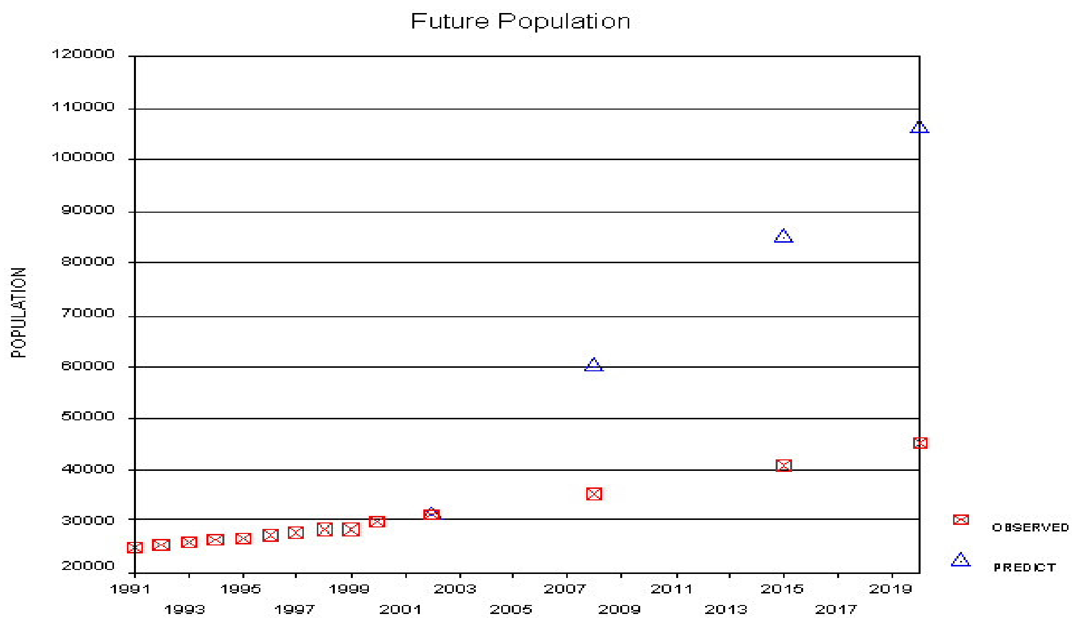


Figure 4-1 Two kinds of future population assumption and comparison

Seen from figure 4-1, there are two possible conditions (assumptions) about the future population. One is that if abiding by the population trend from 1991 to 2000, the future population in 2020 will reach below 50,000. Another possible condition is that if abiding by the calculation of the planning bureau and the assumption made by local government, the future population in 2020 will reach 106,000. The proposed population by planning bureau is higher than that of the population trend in past years. It is clear that the two different choices will affect the future land use demand differently; which one is most suitable is hard to say. For the study area, the local government intends to speed the local urbanization rate and push the residential and visitor population above 10,000. This result can contribute to promote Zhenning from county to a small city level but it will also occupy more undeveloped land for future use. In this study, these two population assumptions will be both considered into planning support environment to determine the demand aspect for land use.

4.1.3. Political (Stakeholders) Profile

As mentioned in chapter 1 (see section 1.2.2), in China, planning has been made usually based on a top-down method. Top-down planning describes the approach taken when senior management alone conducts planning activities with little or no input from the rest of the organization. This approach typically is lacking in internal environmental information and analysis, and therefore is an ineffective planning method.

For this research, the political profile means the concerns and interests from different stakeholders, which will bring impacts to urban future development. In China, the government as major stakeholder, usually decides on decision space/factors, which will be added into planning support process, according to their understandings and wills for managing urban development. With the development of democratic reforms in China and the improvement of global planning theory, people have recognized mocratic reforms in China and the improvement of global planning theory, people have recognized that participation is essential for ensuring more equitable development, both on environmental and socio-economic aspects. In real urban development process, the problems of conflicts (see figure 1-1) betweens alternative stakeholders' benefits, has gradually come out and needs to be resolved through improvement of the planning support method. For the study area, not just considering government as the only stakeholder, other major stakeholders, who will affect or be affected by the planning project, will also be identified and analysed to help achieve the balance of benefits. The detailed analysis of stakeholders and their results for the study area will be given in chapter 5.

Considerations the real development condition and data availability of the study area, two political options are identified to add into the planning support process: agricultural soil protection policy, land use control policy.

The soil suitability for agriculture has been mapped (refer to map 4-5) and classified by local agricultural bureau. The current policy about the use of agricultural soil is still effective but restrict to the urban further expansion because some of the basic farmland (high suitable for agriculture) suggested to specially use for agriculture has been located around the country growth direction. To protect the agricultural soil or to obtain full development without consideration of the restriction of farmland protection are two different policy choices, which will affect the land use direction of the study area.

Presently, the local government has supposed water service (infrastructure) plan (refer to map 4-9) to serve most of the study area gradually and periodically. This infrastructure plan contributes to use land resource intensively in a fix frame (Centralization of urban land use). For the study area, whether to consider the land use control policy or not (Decentralization of urban land use) are also two different policies to challenge the future land use condition.

4.2. Thematic maps about the study area (GIS operations)

In order to create a UAZ file and build a GIS data set to assist the design of alternatives, a set of thematic maps are generated through GIS's spatial operations using GIS/ARCVIEW. In this study, GIS is used for managing spatial data and overlaying related spatial thematic maps into one single SHP file.

For the study area, the total thematic maps include existing land use map, several suitability analysis maps, infrastructure control maps, boundary map and displaying maps. Except for the display maps, the thematic maps need to be overlaid to become the UAZ file for further analysis in *what if?* PSS.

Table 4-1 is the general information about the thematic maps of the study area. There are five thematic maps for suitability analysis; some of them reflect the soil and land structure condition, some of them show the cultural and environmental requirements, and some of them represent the benefit from different organization. There are also five thematic maps for displaying. These five maps can help to better understand the condition of the study area. Generally, these thematic maps were provided by the local department and generated by GIS/ARCVIEW. The categories in each thematic map are created according to the local conditions and requirement for analysis.

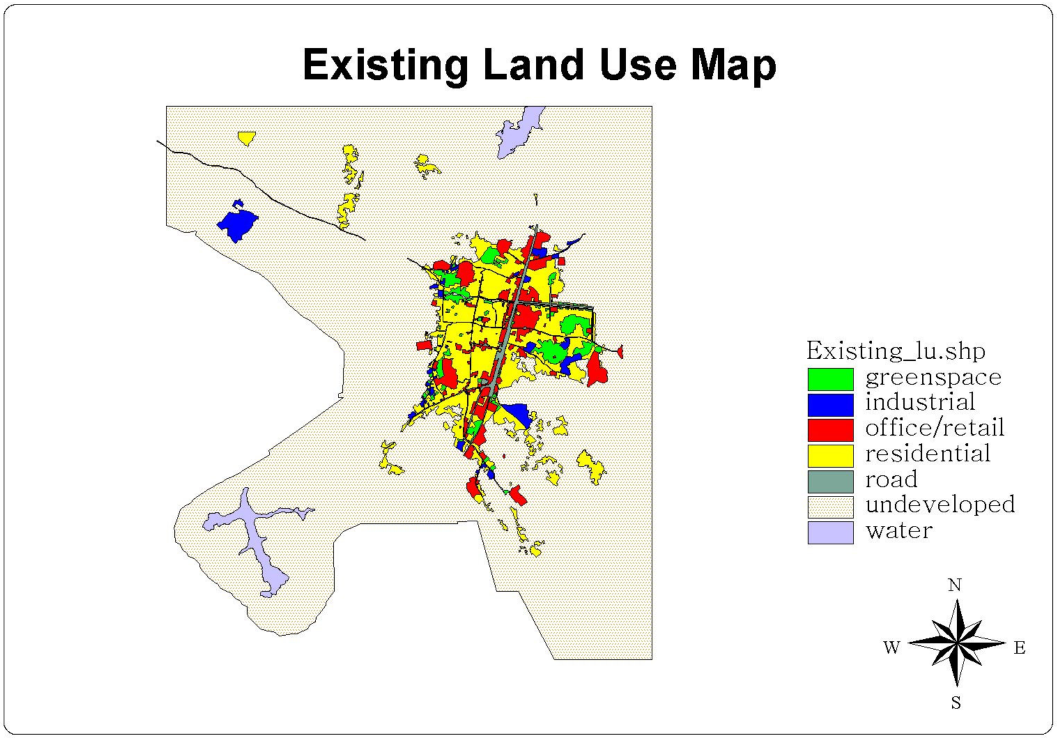
Table 4-1 General information about the thematic maps of the study area

Thematic maps		General information
Existing land use map		Provided by planning bureau in digitized form in July 2002 Including present land-use types, river, and road
Suitability analysis maps		
	Slopes angle	Generated using GIS/ARCVIEW 3D-ANALYSIS Including three categories of slopes
	The soil suitability for agriculture	Provided by agriculture bureau and digitized in July 2002 Including three categories of agricultural soil condition
	Structural suitability for construction	Field measurement in July 2002 Including three broad land use categories of land condition
	Wind suitability for location	Generated using the local wind direction literature Including five categories of wind strength
	Historic importance	Field measurement in July 2002 Including three categories of the distance to historic site
Infrastructure control map		Feedback from officials in July 2002. Including three periods water service location in future
Boundary map		Using the boundary of the study area
Display maps		
	Contour line map	Surveyed in March 2002, provided by planning bureau Including contour lines
	Existing road map	Extracted from existing land use map
	Future road map	Literature review and feedback from officials in July 2002.
	Water map	Extracted from existing land use map
	Wind direction map	Drawing according to the literature and field survey

4.2.1. Existing Land Use Map

Any projection for the future must be based on the present and the past. The existing land use information includes the current land use categories and land use condition.

Map 4-3 is the existing land use map of the study area. There are four main land use type: residential, industrial, green space and office/retail. Residential land includes all kinds of living space for local residents. Industrial land includes non-polluting industrial, light polluting and heavy polluting industry. Green space includes public green space and productive agriculture or protected land. Office/retail is a big land use type; it includes commercial and public facilities, warehouses, utilities and special uses (like military land). In the study area, road and water is considered as not developable land use and cannot be allocated for future further use. The other land use types, including undeveloped land, can be allocated for future use (see table 2-2).



Map 4-3 Existing land use map of the study area

Table 4-2 gives the land use area of each land use in the study area, and it also lists the current density for industrial, residential and office/retail according to the current household, employment and land use. For the study area, the average household size is 4 people and 50% of the population are employed.

Table 4-2 General information about the existing land use

Land use	Land use area (hectare)	Density (Units/hectares)
Residential	170.34	45.64
Industrial	23.28	667.91
Office/retail	57.92	268.46
Green space	28.99	
Road	18.89	
Water	32.79	
Total	332.22	
Undeveloped	1818.58	
Population: 31098	Household: 7775	Employment: 15549

4.2.2. Suitability Analysis Maps

The suitability analysis layers are used to determine the supply, location, and relative suitability of land that is available for development when viewed from comprehensive perspective. Depending on the available GIS data and the situation of the study area, five suitability factors are selected:

- **Slope angle**

The study area consists of two types of landscape: plateau and plain. The plateau in the study area has a deep slope and higher elevation that constricts the urban expansion and sprawl. The slope map is generated using contour lines provided by the local planning bureau. The slope below 10% in the study area can be regarded as the plains and have a good physical condition for urban construction. Meanwhile, according to the local and national standard for urban construction, the maximum allowed slope for residential areas is 25%, and suitable slope for industrial is below 10%. Considering the data requirement and local condition, the slopes of the study area are just divided into three categories.

Map 4-4 is the map of slope angle. The deep slope (above 25%) is mainly distributed towards the east part of the study area. The flat area (below 10%) includes the built up area, water area and some parts of undeveloped area. The slopes have different meanings for the different land use types in the study area. For example, steep slope is not good for industrial office/retail, and residential, but it is good for green space. The reason for that is because construction needs good foundation and steep slope will increase the cost comparing with flat areas. But for green space, it is suitable to develop in the steep area because it will add the environmental quality for the landscapes.

- **Soil suitability for agriculture**

The current map of soil suitability for agriculture is a plan map provided by the local agricultural bureau. The map is still in use and has effect on local land use changes. However, the current agricultural soil suitability map has a conflict with the county's further development. In this condition, the local government intends to adjust the agricultural soil suitability map to satisfy both economic and ecologic benefits. For analysing the suitability for different kinds of land use, there are two opinions about the suitability factors, one is considering the current agricultural soil suitability map, and another opinion is not considering the effect of the existing agricultural soil suitability map.

Map 4-5 is the map of soil suitability for agriculture used for suitability analysis. There are three categories, which represent different importance for agriculture. The basic agricultural soil has the best combination of physical and chemical characteristics for the production of crops. It has the soil quality, growing season, and moisture supply needed to produce sustained high yields of crops when treated and managed, including water management, according to current farming methods. The normal agricultural soil is similar to basic agricultural soil but has a poorer soil quality for the production of crops. The not agricultural soil is the area, which has no restriction on urban use. This suitability factor is selective according to the willingness of the local stakeholders. It is meaningful when considering the environmental effects and the balance of agriculture and industry of the study area.

- **Historical importance**

The study area has a long history. In the east part of the study area, there is a historic site, and it will be well developed in the coming years to build it as a regional resort. The frame of the historic site is drawn through fieldwork and feedback from local officials. The local government supposes that it is necessary to build a quiet and historic place to develop tourism. Inside and around the place, they suggest not developing noisy and polluting industrial uses and some types of residential uses. Office/retail are suitable to develop inside the region because they can provide more convenient service to the tourism.

Map 4-6 is the map of historic importance used for suitability analysis. There are three categories, which represent three levels for controlling certain land use development. The distance to the historic site is determined by local condition. In the study area, it commonly believes that 1000 meters to the frame of the historic site can be regarded as another controlling line, and within the controlling line it does not supposes to set polluting land uses.

- **Wind suitability for location**

It is necessary to consider the influence of wind to the land use distribution in the study area. Commonly, an industrial area is unsuitable in the main wind direction to the city centre because it can affect the environmental quality of the city, including air quality, water quality, and noise quality. The wind suitability map is drawn according to the surveyed wind direction and frequency map provided by the local planning bureau.

Map 4-7 is the map of wind suitability for location. On the left side of map 4-7, is a wind direction and frequency map, which has a close relationship with the wind direction and strength. Generally, the wind direction and frequency map reflects the wind direction and its frequency in the study area. The section of the lowest wind (strength) corresponds to the lowest wind frequency and the highest wind suitability for location because of the lowest effect by wind.

- **Structural suitability for construction**

The land character in the study area is various and changeable. In some part of the study area, there is some slide land, which cannot be used as construction land, such as residential or industrial because it may bring hazard. The built up area is one kind of land type in the study area, which has a good condition for reconstruction because in the region of the built up area it owns better infrastructure foundation. The water-covered area in the study area is specially used for irrigation and service for local residential and cannot be occupied.

Map 4-8 is the map of structural suitability for construction. This map is meaningful because it provides different land structural types for urban construction. In the map 4-8, there are four categories of land structural type: slide land, built up, water covered, and non-built up. Non-built up refers to the area that different to other three kinds of land type. Water covered land is non-developable area for future use, it will not be considered for future allocation to other land use. Slide land in the study area will be excluded from allocation to the residential, industrial and office/retail land uses.

4.2.3. Infrastructure Control Map

The infrastructure control layers identify areas that will be provided with a particular type of infrastructure in a given year. These layers may be used to control future growth patterns by specifying that future development can only occur in areas where a particular type of infrastructure is provided (Klosterman 1999).

For the study area, the water service map is used as infrastructure control map, which could specify that development of a certain kind of land use can only occur in areas that are served by water in a given projection period. This map is used as a policy choice for directing the development of the study area proposed by the local government. If this option is chosen to control the allocation of different land use, it is easy to manage the city (Centralization of urban land use) and make full use of infrastructure services.

Map 4-9 is the infrastructure control map used for allocation. There are three projection periods corresponding to the land use planning map periods. The control region of the three projection periods is drawn through field survey and feedback from local officials. Outside the region of the three projection periods, no development is supposed to take place. For the study area, all land uses need to be allocated in the water service region, because the local government would like to get total and better control for the balance of each land use. Choosing this water service map to allocate future land uses will bring different allocation scenarios and have an impact on the distribution of each land use in the study area. For this study, two alternatives are chosen for allocating the different land use based on choice of the infrastructure control map or not.

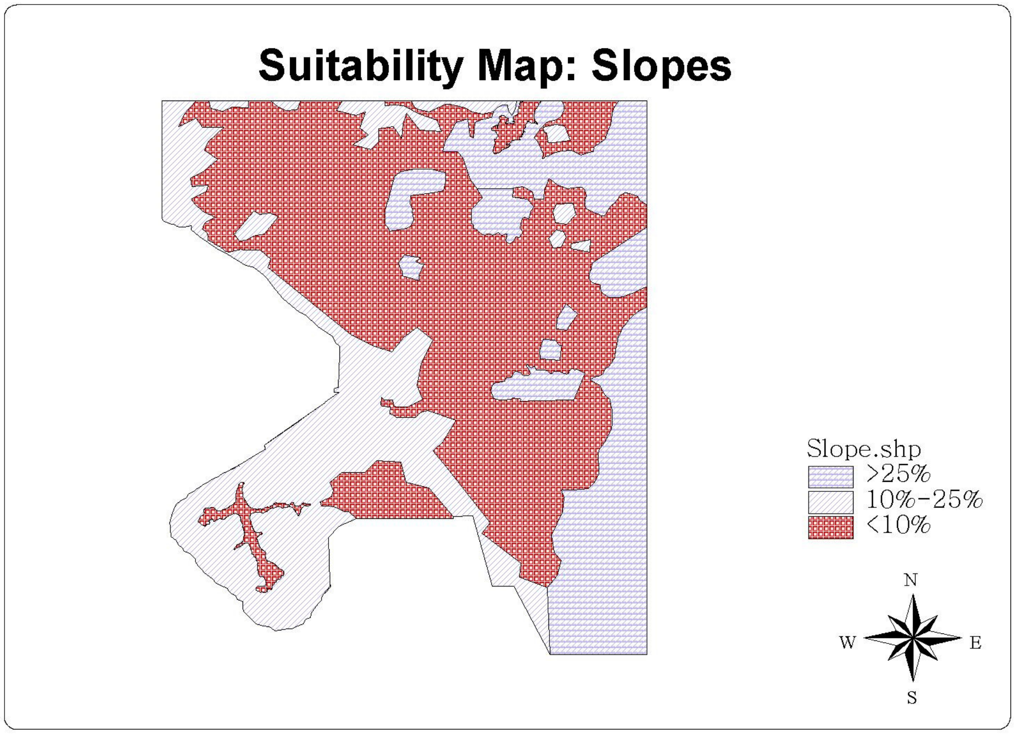
4.2.4. Boundary Map and Display Maps

One boundary layer showing political jurisdictions in the study area is required. The boundary layer defines the boundaries for areas that can be used to project land uses and related information, e.g., population and employment, for sub areas within the study area.

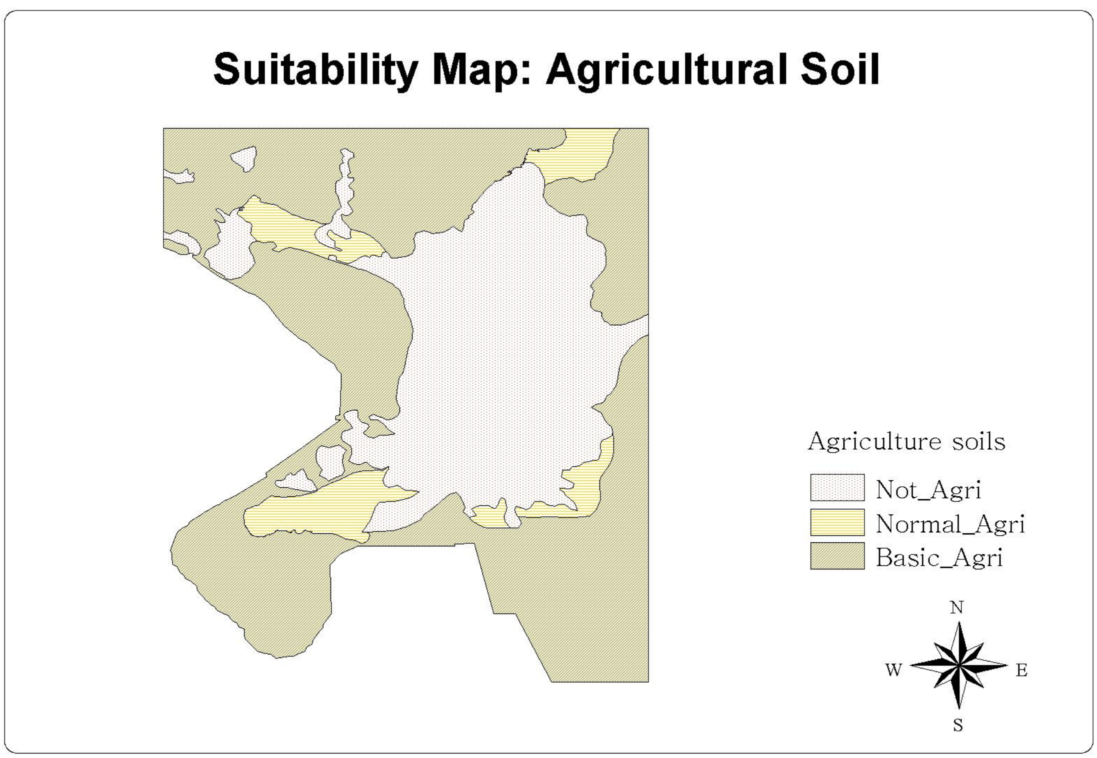
For the study area, only one sub area is used because the study area includes only one political jurisdiction. When using *what if?,* the boundary map is needed and absolutely necessary since only one political jurisdiction existed in the study area.

The display layers are ESRI shape files (*. SHAP) that can be displayed on top of the suitability and allocation maps. The function of display layers is to create more attractive and easy-understand map. For the study area, important infrastructure and important landmarks are chosen to provide a better understanding of the analysis results.

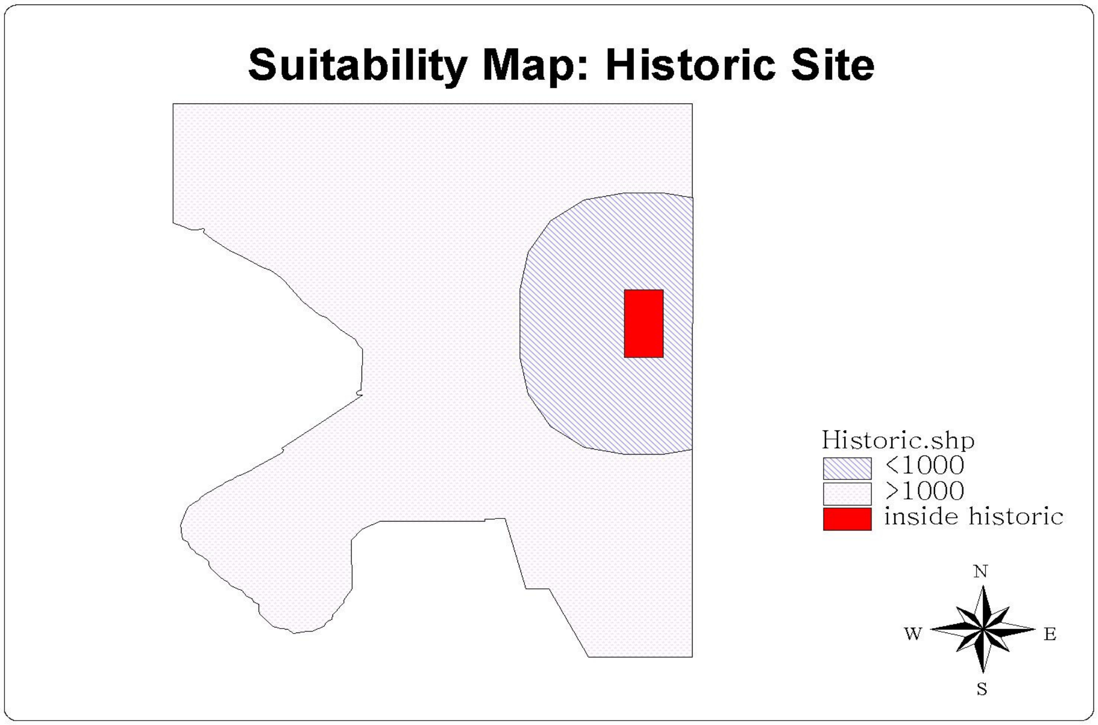
Map 4-10 is the map used for displaying scenarios. In the map, there are five kinds of display information, including wind direction and frequency, water-covered area, future road distribution, existing road distribution and contour line in the study area. The existing road is generated from the existing land use map and reflects the road condition in 2002. The future road is generated from the planning map designed by the local planning bureau and reflects the road condition in 2020. From the display maps, it is easy to understand the general current and possible future condition of the study area.



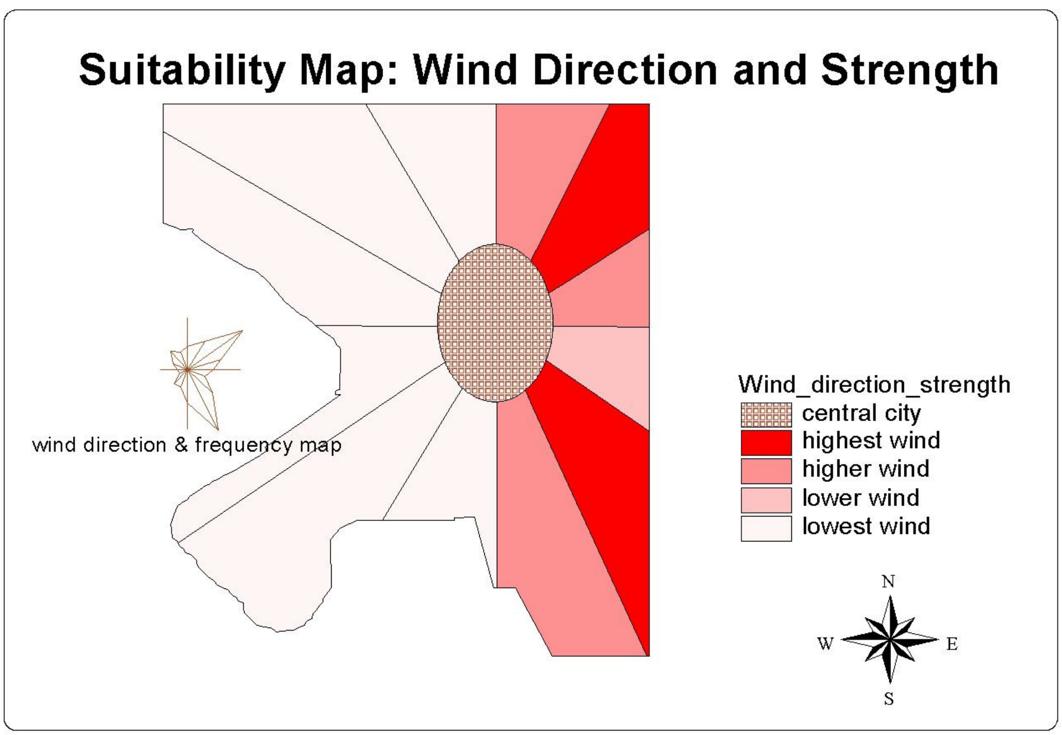
Map 4-4 Map of slope angle



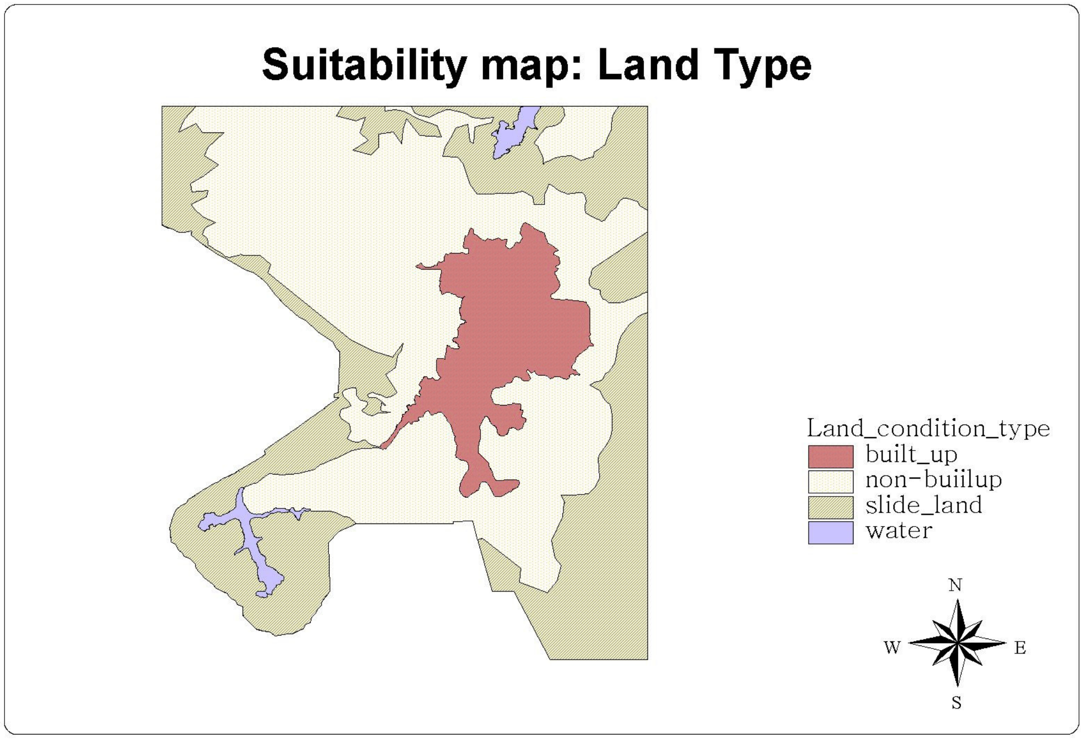
Map 4-5 Map of soil suitability for agriculture



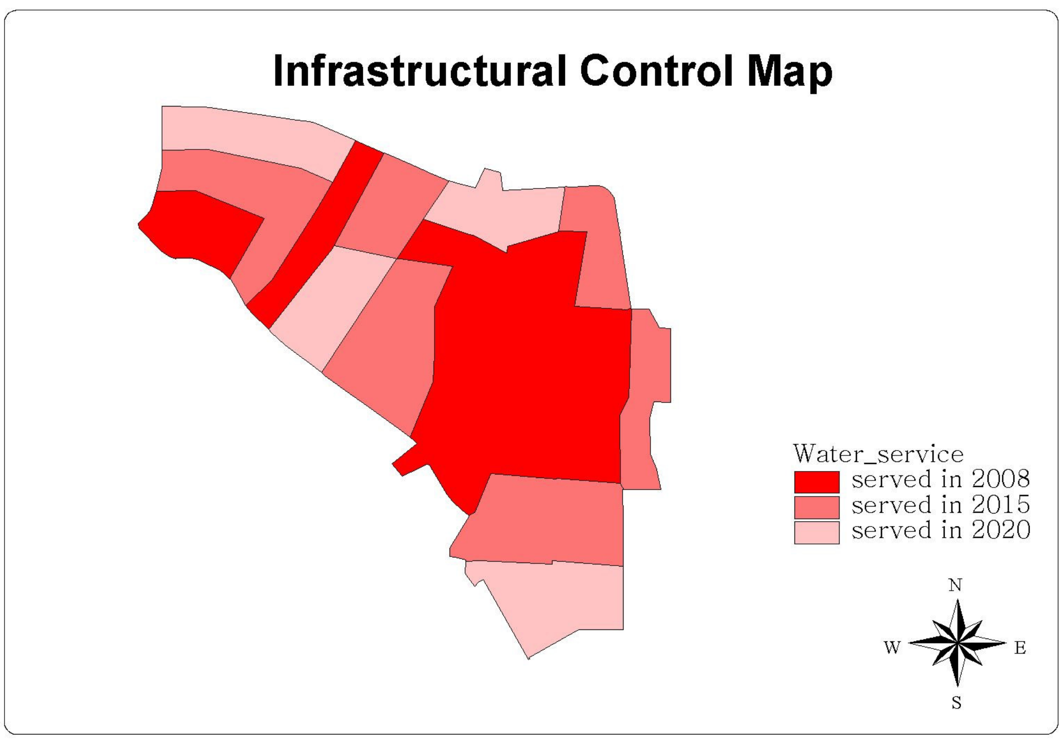
Map 4-6 Map of historic importance



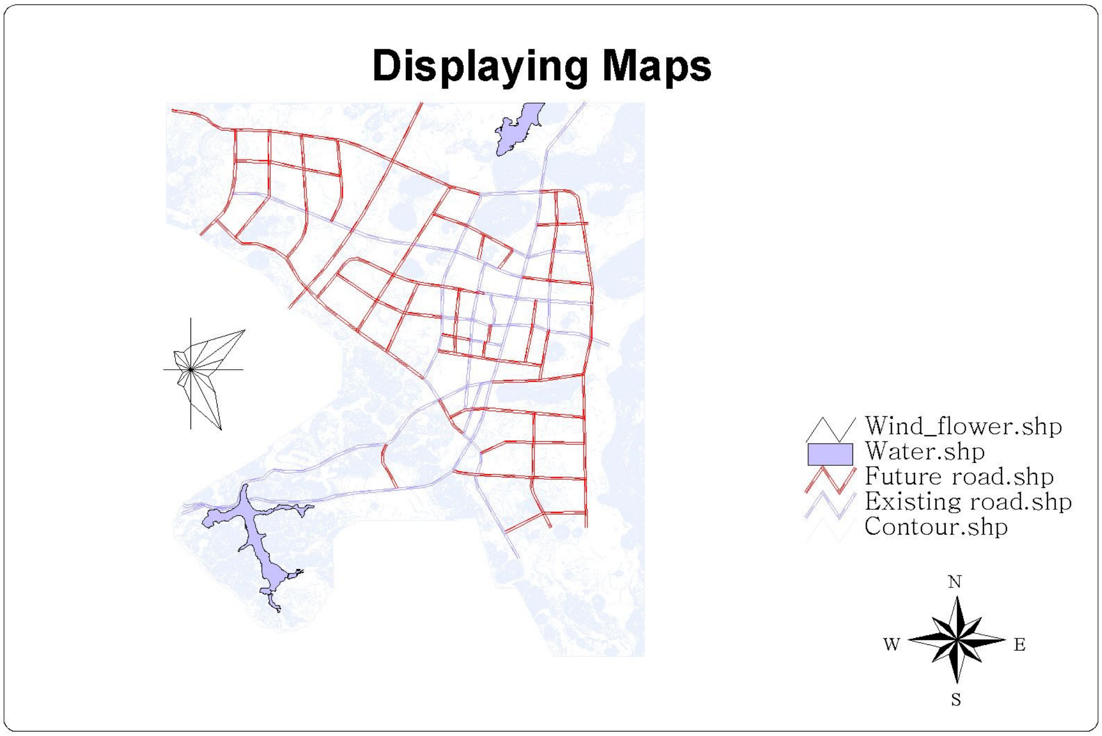
Map 4-7 Map of wind suitability for location



Map 4-8 Map of structural suitability for construction



Map 4-9 Infrastructure control map used for allocation



Map 4-10 Displaying maps used for displaying scenarios

5. Methodology

The problem for the study area is to set alternatives and provide land allocation scenarios of the future to support planning. This chapter gives the general method for resolving the problem, mainly including four sections: specific conceptual framework, stakeholder analysis (SA), designing of alternatives and identification of criteria. The whole process will be done in PSS, MCE and GIS environment. The result of criteria and scenarios will be given in chapter 6.

5.1. Specific Conceptual Framework

Figure 5-1 is the proposed specific conceptual framework. Comparing with the general conceptual framework in chapter 1, this conceptual framework is more specific. It focuses on using *what if?* PSS to link GIS, MCE and participatory planning support, and then assesses for the result.

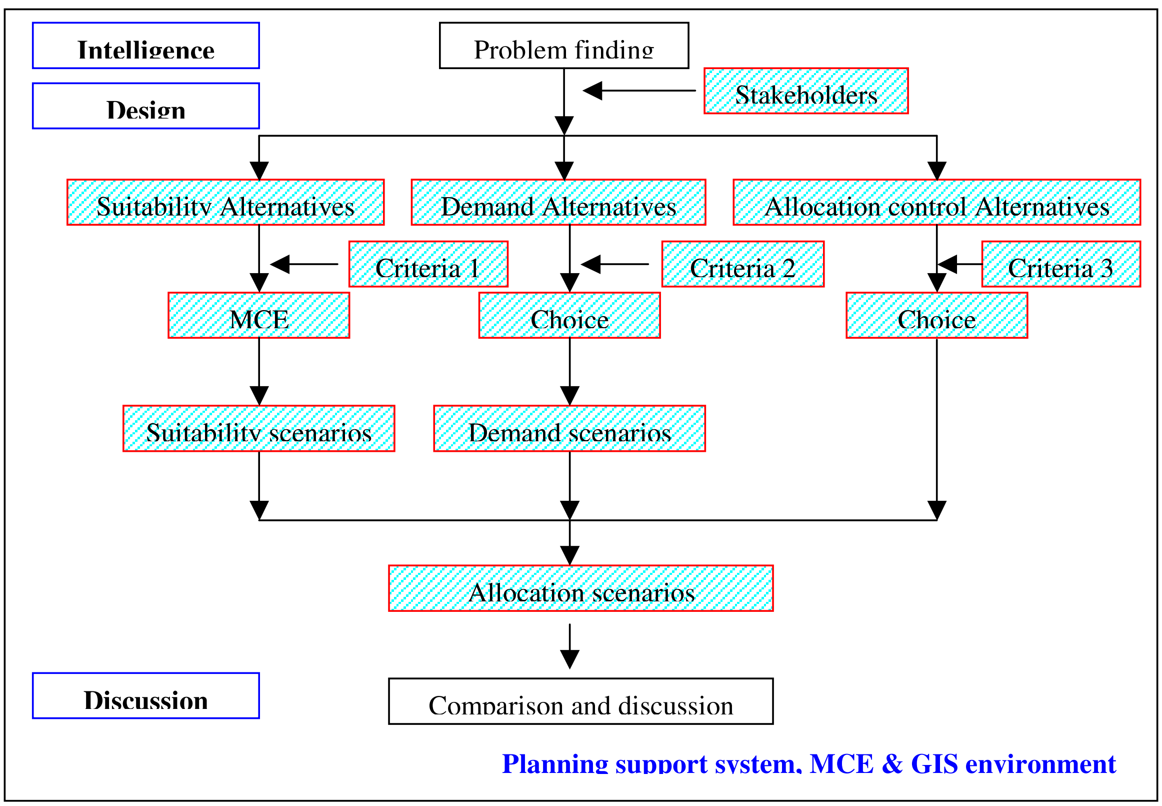


Figure 5-1 Proposed specific conceptual framework
Modified from (Sharifi and Rodrignez 2002), (Klosterman 1999)and (Rico 2001)

The proposed specific conceptual framework also includes three main phases, but more emphasize on the design stage. At the design stage, the *what if?* PSS generates suitability, demand and allocation scenarios. For the study area, stakeholders, related criteria and factors will be explored to formulate alternatives. In this stage, GIS/ARCVIEW, *what if?* software and MCE inside *what if?* PSS will be used.

At the discussion stage, the different allocation scenarios will be compared to analyse the impacts of different choices and assumptions to the land uses in the study area. Another comparison is done between the allocation scenarios with land evaluation map (LE) the land use plan map (LUP) to analyse the strengths and weaknesses of the *what if?* PSS used for the case study.

5.2. Stakeholder analysis (SA)

The first step to design possible resolution and alternatives is to identify the stakeholders in the study area. In this phase, firstly the list of potential stakeholders is made, involved in events related to the land use planning. Secondly, contact needs to be established with the selected stakeholders to understand their interests and motivation in land use planning. Lastly, final list of stakeholders participating in the study has to be identified.

5.2.1. Potential Stakeholders

The method to select potential stakeholders is to use brainstorming, literature review and feedback from local officials (seen figure 5-2). The potential stakeholders in the study area is firstly determined by the local planning department, because they play an important role in the planning process and better understand the total condition in the study area. The list of the potential stakeholders will be further discussed with professional planners for improving the quality of participation.

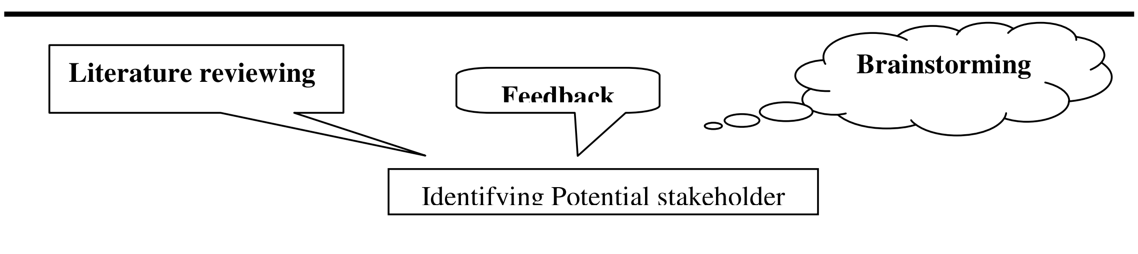


Figure 5-2: Three methods to identify potential stakeholders in the study

Annex II Table 3 has list of potential stakeholders in the study. Generally, the potential stakeholders have been divided into two broad classes: regional level stakeholders and local level stakeholders. This classification considers planning environment and requirement. The study area is part of the Zhenning County; the land use problem will not only relate to the local development, but also relate to the regional development of Zhenning County. For the study area, the regional urbanization rate and infrastructure construction has strongly affected the land use condition in the future as well as the regional management and control of the study area. The local economic and environmental construction also directs the land use condition as well as the local governmental management and control. Each level is further classified into two categories: governmental organization and non-government organization.

5.2.2. Contact with Relevant Stakeholders

After determining the potential stakeholders in the study area, the next thing is to establish contact with the relevant stakeholders. Identifying and consulting with stakeholder representatives, especially community leaders can be an efficient way for the project sponsor to disseminate information to large numbers of stakeholders, and receive information from them. The method is to organize a bilateral meeting, which provides a friendly environment for discussion about planning problems among officials, planners and stakeholders (see Annex I Photo 1).

The bilateral meeting is the first opportunity for the three main parties to be together and introduce their concerns. This meeting chance will be also utilised to introduce the research topic to the officials and stakeholders and let them understand that their opinions on the land use problem are important to the future allocation scenarios. At the beginning of the bilateral meeting, most important information about the study area needs to be introduced publicly to the stakeholders. This introduction contains the following information:

- The historical context of the study area
- The socio-demographic data in the past ten years
- The economic condition
- The current environmental problem
- The current road and other infrastructure condition
- The current development policies
- The planning goals supposed by planners

At the bilateral meeting, each stakeholder holds different opinions about the planning project (see Annex I Photo 2). Generally, the stakeholders, who attend the bilateral meeting, can be divided into three groups; one is likely to be involved in the planning project, one is likely to be kept informed because they are just interested in the project and do not want express any opinion on the planning project, and the last has no interest in the planning project. Based on discussions and negotiations with the stakeholders, considering their response to the planning project, relevant stakeholders were identified. The relevant stakeholders are presented in table 5-1.

Table 5-1 Relevant stakeholders identified in the study

Category	Participants in events related to planning project
Decision making group	Local government
	Regional government
	Economic development boards
	Environmental organisation
	Planning organization
	Academic institutions
	Professional expert
Interest group	Civic committee
	Individual investor
	Residence of the study area

5.2.3. Identification of Final Stakeholders

Once the process and agreements through bilateral meetings had been carried out, it is necessary to identify the final list of stakeholders based on their interest and influence on the study. The method to identify the final list of stakeholders is to analyse their interests around the topic of how to build a sustainable and characteristic future for the study area. The opinion from the relevant stakeholders can be summarized and jointly willingness is obtained if they hold the same objectives and position about the situation (see Annex I Photo 3). The final list of stakeholders participating in the study and their interest is presented as follows in table 5-2.

Table 5-2 Final lists of stakeholders participating in the study and their interests

Major Stakeholders	Underlying Stakeholders	Interests	
		Focus more on	**Care about**
Government's benefits	Local Government	Local service function Economic growth Living space expansion Build up area sprawling Employment zone's setting Local population reach to 10,000	County's image The balance of each land use
	Regional Government	Urbanization rate Regional infrastructure plan and proposal Local environmental condition	Local service ability County's development direction Local future population
	Environmental Organization	Agricultural soil protection policy Polluted land uses distribution Historical site's protection and development	Water service region in the future Future green space condition
Investor's benefits	Individual Investor	Employment zone's setting Economic benefits	Infrastructure condition
	Economic development boards	Employment zone's setting	The relation to agriculture land and environmental problem
Planner	Professional Experts	Best use of land resource Urban future Balance of conflicts and benefits	Safe problem on slide area Environmental problem

In China, the conflicts of urban development usually come from the imbalance of benefits of two major stakeholders: government and investors. In most condition, environmental organization, regional and local government stand together and hold the same position. Their union opinion can represent one kind of concerns for planning support. The interests of the investors mainly come from how to make best economic benefits from land allocation and land resource uses. As another union opinion, it includes both interests from individual and economic development boards. In this paper, the choice of a more "limited" stakeholder approach can contribute to simplify the analysing process and give a clear picture of what are real concerns for the study area. As shown in table 5-2, the planner, being a bridge to link and balance the interests from government and investor, hold an important role in the planning support process. Most of the time, planners propose alternatives according to the major stakeholder's concerns, and then negotiate with them to get a final agreement. In this way, stakeholder's willingness is taken into consideration in planning support process.

5.3. Design of alternatives

In order to generate a suitable solution to the problem, development of a number of alternatives was considered as an important aspect. Formulation and design of alternatives is done based on the following four steps. Figure 5-3 describes the steps to design the final set of alternatives.

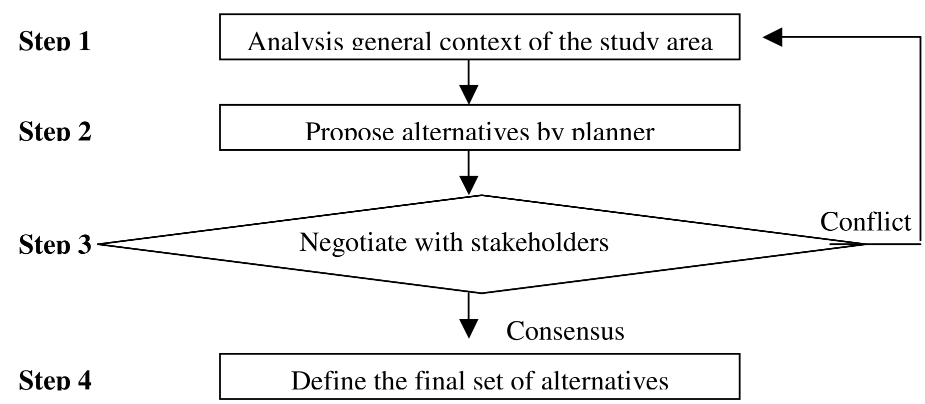


Figure 5-3 Four steps to design the final set of alternatives
Modified from (Rico 2001)

5.3.1. Step 1: Analyse General Context of the Study Area

As mentioned in chapter 2 (section 2.2.3), the basis of sustainable development is considering the local condition. For the study area, the first step for establishing alternatives is to analyse the general context of the study area. Two main aspects will be discussed:

- **Population size**

Population is a key factor to consider in the implementation of sustainable development. About the future population size, as introduced in chapter 4 (section 4.1.2), there are two scenarios. One is low growth of population, based on the linear analysis for demographic data of the past ten years from the 1991-2000. The linear analysis shows that population size in 2020 will be below 50,000. Another situation is high growth of population, adopting the projected valued predicted by the local planning bureau. According to their opinions, population size in 2020 will reach 106,000 because of positive policy support and great immigration. These two situations represent different assumptions for the future. The former one believes that future population size more depends on past population structure and growth trends. It is reasonable because every assumption should be made based on past situation and developing trends. On the other hand, the second situation is also possible because China is experiencing big development, especially in the western areas. With the support of national and regional development policy, the study area will, most possibly, upgrade from county level to city level. In this vein, the population size in the next several years will have a big change. The local planning bureau predicts future population size based on the choice of future possible urbanization rate. This method and the prediction result are also reasonable and accepted by regional and local government for the basis of the land use planning. As a conclusion, the above two situations about future population size have their own basis, and it is hard to say which assumption is correct.

o **Land use condition**

Land use planning is about land use problems and aims to allocate land uses for future. The current land use condition has been mapped and introduced in chapter 4 (section 4.2.1). With the population growing, the demand for different land use needs to be measured and satisfied accordingly. For the study area, four kinds of land use types (LUT) are considered: LUT1-residential, LUT2-industrial, LUT3-office/retail, and LUT4-greenspace. The demand for LUT1 is supposed to be calculated based on household size and household density; the demand for LUT2 and LUT3 are supposed to be calculated based on employment and employment density; the demand for LUT4 is assigned directly by local requirements. At the same time, the supply of land in the study area also needs to be measured and mapped. Similarly, for the four land use types, different criteria and factors are chosen to identify their suitability levels. Lastly, for allocating each LUT, the allocating order and area constraint need to be set. In the study area according to the importance and emergency of different LUT, the allocating order can choose differently. The area constraint/control for allocation is to consider the infrastructure plan designed by local government. The local government suggests developing the study area with consideration of water service plan in three periods of time. Their opinion has been mapped and introduced in chapter 4 (section 4.2.3).

5.3.2. Step 2: Proposed Alternatives and Their Impacts

The whole planning support process has been divided into three components: 1) land demand analysis, 2) land suitability evaluation, 3) land allocation assessment. Based on the above analysis for the general context of the study area, an alternative matrix has been designed by planners.

Table 5-3: Proposed alternatives matrix

	Allocation control		No allocation control	
	High growth	Low growth	High growth	Low growth
Preservation				
Development				

Form the table 5-3; we can see a matrix composed of two suitability alternatives (i.e. preservation, development), two demand alternatives (i.e. high growth, low growth) and two land allocation alternatives are proposed (i.e. allocation control, no allocation control). Their descriptions go as follows:

- **Demand alternative 1: High growth**

This alternative assumes that the future population size will reach 106,000 according to the prediction by the local planning bureau (see 5.3.1).

The positive impact of this choice is that it has considered the regional and local policy's effect. As mentioned above, regional and local government aims to improve the study area's urbanization rate and employment opportunity for the purpose of upgrading the current county level to city level. The negative impact of this alternative is that it has based on uncertain assumption and it is more subjective.

- **Demand alternative 2: Low growth**

Compared with the high growth alternative, this alternative considers that the future population size cannot reach 50,000 based on the observed demographic data from 1991-2000 (see 5.3.1).

The positive impact of this alternative is that it considers the past population growth trend and the result is therefore thought objective. The negative impact is that it doesn't take the government will into consideration and policy effect.

- **Suitability alternative 1: Preservation**

As mentioned in chapter 2 (section 2.2.3), both ecological conservation and economic existence are related to sustainability. This alternative considers one main aspect different with the other suitability alternative: protecting farmland. This alternative suggests preserving this ecological space by considering the factor of soil suitability for agriculture in the suitability analysis.

The positive impact of this alternative is to guarantee more agricultural space for food production and for the ecological environment. The negative impact of this alternative is to restrict the county's fully development, especially in economic terms. As seen in map 4-5, most of the basic agricultural soil is located around the build-up area and there is limited space for the development of residential or other land uses in the future.

- **Suitability alternative 2: Development**

In contrasts to the preservation alternative, this alternative gives more emphasis on county expansion and sprawl without consideration of agricultural soil's restriction. This alternative regards the current soil suitability for agriculture as an unreasonable policy and assumes that the land use plan can promote its change.

The positive impact of this alternative is to break the restriction of the agricultural soil and allow the county free development. This alternative also aims to promote changing the existing agricultural soil policy. The negative impact of this alternative is that it regards economic development as the priority element and may occupy the planned basic or normal agricultural soil.

- **Allocation control alternative 1: Allocation control**

This alternative considers area constraint using the water service map, which was introduced in chapter 4 (section 4.2.3).

The positive impact of this alternative is that allows a cost-effective/rational management of the city by making full use of the proposed infrastructure service. The negative impact is that it restricts the county's development in a fix frame. Outside of the water service region, no development is supposed to take place.

- **Allocation control alternative 2: No allocation control**

As its name suggests, this alternative has not considered area constraint. Compared with the growth control alternative, the positive impact is that it allows the county's development in a free direction in which has the most suitability (Decentralization of urban land use).

The negative impact is that the direction of development is diverse and thus it is hard to control and manage.

5.3.3. Step 3: Negotiate with Stakeholders

According to the stakeholders analysis discussed in the above section (section 5.2), the final stakeholders and their interest are identified. Their interests will affect the final set of land allocation alternatives, which are based on the proposed alternatives.

For the study area, two major stakeholders: government and investor, hold different opinions on the choice composition of the suitability alternatives and allocation control alternatives. For government, they consider environment, urban service function and "intensive land uses" (Centralization of urban land use) as the most important aspects to take into account. As mentioned above, "preservation" suitability alternative considers preserving ecological space as much as possible in the suitability analysis. Therefore, government would like to choose "preservation" as the suitability alternative to achieve their concerns and wills on land supply aspects. At the same time, their concerns on "intensive land uses" can achieve by considering allocation control choice into land allocation process. Their concerns about urban service function can be achieved by choosing LUT3-office/retail as the first land allocation order. For investor, they consider development, economic benefits, and "extensive land uses" (Decentralization of urban land use) as the most important aspects to take into account. As to the suitability alternatives, they would like to choose "development" as the suitability requirement for land supply. They also would like to choose LUT2-Industrial as the first land allocation order when allocating.

5.3.4. Step 4: Final Set of Land Allocation Alternatives

This study aims to set land allocation alternatives for planning support. As mentioned in the specific conceptual model, the allocation alternatives are made on the basis of proposed suitability alternatives, demand alternatives and allocation control alternatives. After negotiating with stakeholders, the final set of allocation alternatives are identified based on the alternatives proposed by planner.

Table 5-4: Final set of land allocation alternatives

	Allocation control		No allocation control	
	High growth	Low growth	High growth	Low growth
Preservation	√	√		
Development			√	√

- ALT 1: Preservation-High growth-Allocation control
- ALT 2: Development-High growth-No allocation control
- ALT 3: Preservation- Low growth - Allocation control
- ALT 4: Development -Low growth- No allocation control

As shown in table 5-4, there are four land allocation alternatives to be considered by stakeholders. These four land allocation alternatives represent two points of view of major stakeholders and two assumptions for future population condition. Generally, two of them are based on high growth assumption, and the other two are based on low growth assumption. The composition of "Preservation" suitability alternative and "Allocation control" allocation control alternatives represents government's concerns and interests. The composition of "Development" and "No allocation control" represents investor's wills.

Basically, ALT 1 holds the same opinion with the rules and principle of land use planning for the study area. It is considered as the basic alternative, which has been developed as scenarios using land use planning model. ALT 1 and ALT3 represents government's concerns, the main difference between them is that they are based on different growth assumption. ALT 2 and ALT4 represents investor's concerns, the main difference between them is the same with ALT 1 and ALT3.

5.4. Identification of criteria and factors

As mentioned in chapter 2 (section 2.2.3), for sustainable development, the important step is to identify criteria and factors. Three steps to identify criteria and factors are adopted, as described in figure 5-4.

The first step is to propose criteria by planners. As mentioned before, planners determine which programmers or projects will best achieve stakeholders' objectives. They propose initial criteria based on their understanding of stakeholders' interests and current condition of study area, and then negotiate with major stakeholders for achieving consensus. In second step, planners associate the conflict between major concerns and try to achieve final criteria defined by stakeholders. Step 1 and step 2 will be given detail description as following.

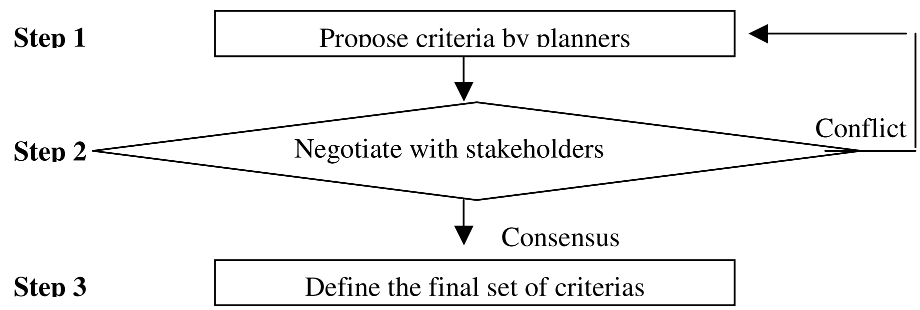


Figure 5-4 Three steps to design the final set of criteria
Modified from (Rico 2001)

5.4.1. Step 1: Proposed Criteria by Planners

According to the literature review and taking into account the history and context of the study area, the main principle and criteria are identified.

Principles for criteria development

- Use existing data as much as possible
- Gain sustainable development
- Easy to operate and understand
- Acceptance of stakeholders

Based on the above principle, initial criteria have been proposed by planners (see table 5-5).

Table 5-5 Initial criteria proposed by planners

Criteria	Descriptions
Ecological criterion	Slope angle, Soil suitability for agriculture Structural suitability for construction
Socio-demographic criterion	Future population, Wind suitability for location, Historic importance
Economic criterion	Infrastructure construction

The initial criteria are proposed based on sustainable development purpose and data availability (see section 2.2 and section 3.2) Planners intend to incorporate these criteria into operational planning support model (see section 5.1), based on stakeholders' participation.

5.4.2. Step 2: Negotiate with Stakeholders

Through bilateral meetings, the proposed list of principle and criteria formulated are introduced to the stakeholders in order to have a starting point to analyse and improve collaboratively the set of criteria proposed. During the process of negotiation, suggestions and observations are documented and considered into operational planning support environment. In this step, planners, being as the link between the stakeholders, also need to introduce the three functions of the proposed planning support model to the stakeholders, for the purpose of incorporating their criteria into operational model. As mentioned before (see section 5.1), suitability criteria, demand criteria and allocation control criteria inside the model are designed to cover the interests and concerns from stakeholders. The purpose of the negotiation is to let stakeholders define their criteria, which based on the criteria proposed by planners and can be related to suitability, demand and allocation function of the proposed model.

5.4.3. Step 3: Criteria and Factors as Defined by Stakeholders

Through the communication in the bilateral meeting, major stakeholder defines the criteria and factors. Generally speaking, there are three kinds of criteria, which will incorporate into the consideration of land allocation alternatives' development. Based on the different opinions and alternatives defined by major stakeholders (see section 5.3.4), several sub criteria have been developed and described.

- **Criteria 1: Demand criteria**

Description of criteria
The general idea of these criteria is to make a rule to measure the demand for land. Considering the general condition of the study area, some assumptions have been made to incorporate local data sets to the use of proposed model (figure 5-1).

General assumptions:

1. The average Household size[3] is 4 (person/per household)
   Household =1/4 * Population

2. The average burden of the employed[4] is 2 (person/ per employment)
   Employment =1/2 * Population

3. The future density growth of household, employment is set according to local standard
   Future density growth=ΔUnit/ΔArea=(Unit2-Unit1)/(Area2-Area1)

4. The future area of green space is assigned directly according to local requirement

The assumptions are described as followings:

For projecting future land use demands, the number of households, the number of industrial and commercial employees, and the number of acres of the total land in the study area, are required to specify (see section 3.2.2). However, these requirements for using the proposed model do not suit for the real condition in China. Basically, in planning support practice of China, future population, instead of household is commonly used to predict the future demand for land. At the same time, area per capita (see table 1-1), instead of density, is commonly used in planning context of China. For analysing the demand for different land uses, the basic formula is different with that in western country. In China, to predict the future land use area, the formula goes as:

---

[3] Household size: Numbers of persons/population of each household.
[4] Burden of the employed: Numbers of persons supported by each employed including employer himself or herself.

Area = Population * area per capita
However, in western country, they usually adopt another formula:
Area = Units / density
Although the basic concept of these two methods is different, they aim at the same goal, which is to predict the future land use area according to the real condition of study area.

In China, the concept of "household size" can link "population" and "household" well. For the study area, based on the survey of current condition, household size is assigned as 4. This value can reflect the general construction of population for the study area. The concept of "burden of employed" can be as a bridge to build connection with "employment unit" and "population". Based on the observation data and survey of local condition, it commonly believes that each employed person can support 2 people, including employer himself or herself. The implication of future density growth is shown in figure 5-5. To link the requirement of the proposed model with real condition of China, future density growth value is calculated based on certain assumption. It assumes that the future density growth is a fix value and future land use area will be grown following this value. As shown in figure 5-5, the slope of the line indicates the future density growth value. Time 1 and Time 2 means the start point and end point of research time, Unit1, Unit 2 and Area1, Area 2 means the employment units and land use area in the two periods.

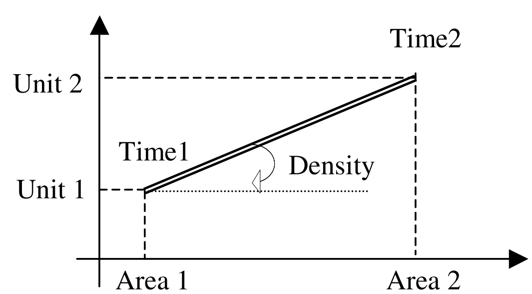


Figure 5-5 Implication of future density growth

Since the future population has been determined and transferred into household and employment units according to the general assumptions, it can divide the values into three periods of time. Table 5-6 gives the decision form for growth of different land use types.

Table 5-6 Decision form for growth of different land use types (LUT)

	Years		
	Basic Year - Project Year 1	Project Year 1 - Project Year 2	Project Year 2 -Project Year 3
Household (Employment) (Area)			
Future density ______ (units/hectare)			

Based on the above assumptions, two sub criteria are developed according to the major stakeholders concerns. As mentioned in section 5.3.1, the difference of the two sub criteria lies in the assumption value for future population.

Sub criterion 1-1: High growth
This criterion aims to use the predicted population value provided by local planning bureau.

Sub criterion 1-2: Low growth
This criterion aims to use the observed population value calculated by the linear method.

- **Criteria 2: suitability criteria**

Description of criteria
The general idea of these criteria is to make a rule to measure the land suitability of different land use types. In this study, suitability weight and rating for suitability factors will be assigned directly according to the general assumptions.

General assumptions:

1. Factors are chosen based on data availability and stakeholders' interests
2. Factor weights are assigned on a three-point scale from 1 (low) to 3 (high)
3. Factor types are rated on a six-point scale from 5 (high) to 1 (low) and 0 (excluded)
4. Factor weights and ratings are assigned directly by planner according to stakeholders' interests
5. It supposes that no conversion should take place on existing road and water area. Undeveloped area can be converting from to any other land uses.

The detail description of these assumptions goes as follows:

For suitability analysis, factors are chose based on two concerns: data availability and stakeholders' interests. In China, there is a common problem on the use of data. As discussed about land evaluation based on sustainable development in chapter 2 (see section 2.3), biophysical, ecological, and environmental aspects of suitability needs to be evaluated. However, the data, which to support these aspects are difficult to gather totally in China because of poor data management and technique tools. The available data has been shown and introduced in chapter 3. These thematic maps and demographic information are the basis for developing suitability scenarios according to stakeholders' interests and the rules of weighting and rating for suitability factors. In this study, the most simple but useful rating methods (see section 2.8.2) have been adopted. Factor weights and factor ratings are assigned directly according to their importance to stakeholders' interests. The general assumptions provides a model to link stakeholders' interests with numerical values of factor weights and ratings. Planners, being as a facilitator and promoter, direct stakeholders to achieve their concerns in practical planning support process (see table 5-7, table 5-8). Conversion choice indicates that different land use types can be converted from their current use to another use. Table 5-9 is the decision form for conservation choices. There lists seven kinds of land use types; the first four land use types have been introduced in this chapter (see section 5.3.1).

Table 5-7 Decision form for factor weight's identification

Factor weights	Importance/value		
	1--- Low	2---Middle	3---High
Factors			

Table 5-8 Decision form for factor rating's identification

Factor ratings	Importance/value					
	0--- Excluded	1--- Low	2	3--- Middle	4	5--- High
Types						

Table 5-9 Decision form for conversion choice

Current Land use type (LUT)	Convert from
Residential (LUT1)	YES or NO
Industrial (LUT2)	YES or NO
Office/retail (LUT3)	YES or NO
Green space (LUT4)	YES or NO
Road	NO
Water	NO
Undeveloped	YES

Based on the above assumptions, two sub criteria have been developed according to stakeholders' concerns. The difference between the two sub criteria is that the suitability factor: soil suitability for agriculture will not be considered in sub criterion 2. The reason for that can be seen in section 5.3.2 about suitability alternatives setting.

Sub criterion 2-1: Preservation

This criterion aims to preserve agriculture soil as much as possible and emphasize more on environment protection. The factors considered include all the suitability factors introduced in chapter 4 (see section 4.2).

Sub criterion 2-2: Development

This criterion aims to expand county area without consideration of agricultural soil's protection. The factors considered four kinds of suitability factors, including slope angle, historic importance, and wind suitability for location, structural suitability for construction.

- **Criteria 3: allocation control criteria**

Description of criteria

The general idea of allocation control criteria is to set a rule to allocate the projected land use demands to different locations on the basis of their relative suitability as well as considering stakeholders' interests.

General assumptions:

1. Local condition and stakeholder's interests determine allocation order of land use types.
2. Whether or not using proposed infrastructure plan map as allocation control depends on stakeholders' preference.
3. And it assumes that all land uses, except of water, road, and undeveloped, will be affected by infrastructure service if considering allocation control of infrastructure plan.

The detail description of above assumptions goes as followings:

Different allocation order will strongly affect future land use allocation condition. Based on the introduction of study area and stakeholders' interests, basic agreement on land allocation order can be achieved and used in planning support process. Table 5-10 provides a decision form for identifying land use allocation order. It builds a bridge to link stakeholders' interests with the use of the proposed model for computer operation. Table 5-11 is the decision form for identifying allocation control choice. As the mentioned in assumption, road, water and undeveloped land use will be considered as not being affected by infrastructure plan. Whether the other four kinds of land use types will be affected by the infrastructure plan depends on stakeholders' preference (see section 5.3).

Table 5-10 Decision form for allocation order's identification

Allocation order	**Importance/value**			
	1	2	3	4
Future land use types (LUT)				

Table 5-11 Decision form for allocation control choice's identification

Future land use type (LUT)	**Allocation control affect to**
Residential	YES or NO
Industrial	YES or NO
Office/retail	YES or NO
Green space	YES or NO
Road	NO
Water	NO
Undeveloped	NO

Based on above assumptions, two sub criteria have been developed according to stakeholders' interests (see section 5.3.2).

Sub criterion 3-1: Allocation control

This criterion aims to add infrastructure plan into consideration of allocating land uses in three periods of times.

Sub criterion 3-2: No allocation control

Different with sub criterion 3-1, this criterion does not regard the proposed infrastructure plan as a constraint for urban development. All kinds of land use types can be allocated in every location of the study area (see section 5.3).

6. Discussion of Results

This chapter presents the results and discussion obtained from this study. Since part of the results is already presented in chapter 5, their discussion will be included in the first sections of this chapter. The other results and their discussion of this study can be found in the second part of chapter 6.

6.1. About Stakeholders Analysis (SA)

The result of this section was already presented in chapter 5. Now, the main findings and their discussion is presented as follows:

Key findings:

1. Potential stakeholders are listed. They cover a range of the regional and local lever as well as government and non-government point of views.
2. Relevant stakeholders involved in the project are identified and contacted. They are divided into determine group and interest group. Their interests and concerns are documented and grouped.
3. Final major stakeholders and their underlying stakeholders are identified. Their jointly wills and interests are presented to public.

About the method to identify potential stakeholders, literature review, feedback from local officials and brainstorm practice well as much as possible information can be gained. Feedback from local officials is needed because they understand the current condition of the study area well and their opinions are operational and meaningful. Brainstorm and literature review area used by planners to explore reasonable and comprehensive stakeholders' composition.

The bilateral meetings provide a friendly environment for discussion about planning problems among officials, planners and other major stakeholders. Generally, the bilateral meeting is successful because it organized by local government and is paid more attention from broad range of stakeholders.

Unfortunately, an important limitation of this study is the absence of local residents as major stakeholders. Their participation could have contributed with other elements considerably, especially criteria referring to the social and cultural aspect.

Government and investors are identified as the final major stakeholders for the study area. This "limited" stakeholder approach can contributes to simplifying the analysing process and give a clear picture of what are the real concerns in the study area. Planners, as a special group of stakeholder, function a bridge to link and negotiate stakeholder's interests with planning support process.

6.2. About Alternatives

The results of this section are already presented in chapter 5. In this section, the main findings and their discussion is presented as follows:

Key findings:

1. Six alternatives are designed about the demand for, supply of, and allocation control of land.
2. The alternatives proposed are acceptable after negotiation with major stakeholders.
3. Four final land allocation alternatives are identified based on the alternatives matrix by the stake-holders.

It is needed to introduce the general context of the study area to stakeholders at the bilateral meeting before proposing the alternatives. At this stage, planners guide and direct stakeholders to understand the population and land use information of the study area.

Planners propose the alternatives matrix based on stakeholders' interests and planning support model proposed. Generally, the model provides three functions: about suitability, about demand, and about allocation. The interests of government and investors are not totally consistent, planners considers their interests into the three functions and give the six alternatives.

The decision matrix of final land allocation can be understood well by stakeholders. It can reflect the three functions of proposed planning model, six alternatives and their connection and composition intuitively.

6.3. About Criteira and Factors

The follows main findings are obtained in this section as results:

Key findings:

1. The initial set of criteria proposed by planners to the stakeholders is constituted.
2. Three kinds of criteria are identified collaboratively with the stakeholders to support alternatives development

The initial set of criteria is as a base to identify and complete the criteria needed to evaluate the alter-natives. Planners, according to the sustainable development purpose and data availability, propose three criteria: ecological criterion, socio-demographic criterion and economic criterion.

An important limitation of the proposed criteria is that there are a limited number of factors to support the criteria constituted because of limited data source. For measuring ecological aspects of land use, slope angle, soil suitability for agriculture, structural suitability for construction are used to take into consideration of land suitability. Wind suitability for location, historic importance factors are consid-ered as social criterion into suitability analysis. Infrastructure construction factor represents economic concerns of future land uses. More social and economic factors can contribute to simulating the complex future of land use on behaves of stakeholders interests.

The bilateral meetings and planners' guiding provide useful bridge to link planning support practice with stakeholders' interest and criteria. Based on the initial criteria proposed, planners aim to identity collaborative criteria, which can be used in the practical operation of planning support system.

Three criteria have a close relationship with proposed functions provided by the planning support model as well as the proposed initial criteria and factors by planners. The goal aims to incorporate sustainable development purpose into real consideration of computer-based planning support practice.

The results and discussion of the three criteria go as follows:

6.3.1. Criteria 1: Demand Criteria

Key findings:

1. General assumptions about the relationship between population with household and employment are made and acceptable by stakeholders.
2. The method to calculate/assign future density growth value and area of each future land use is identified and introduce to stakeholders.
3. The decision form for growth of different land use types is developed.
4. Two sub demand criteria are identified based on assumptions for future population.

The general assumptions are important to develop alternatives. The assumptions have built a connection between current condition and data set format with the proposed model and system requirement of what if? PSS. The assumptions are set based on the same goals of planning support, which aims to get quantitative values of future land use areas.

The method to calculate future density growth value is simple but operational. However, the obvious limitation of such a method is that it assumes a single density value for all future years. It seems more reasonable to assume that the densities will change over time and allow the to specify different values for different years.

The decision form for growth of different land use types propose in chapter 5 (see table 5-6) includes two main kinds of information: data about units and about future density. Table 6-1 is the information of population, householders and employment, which are used to determine units' value of future three periods of time. The three future points in time are year 2008, year 2015 and year 2020. These three points in time are same with the projection years predicted by government and they are making sense when comparing with plan map in 2020. For the low growth assumption, the *what if?* PSS automatically computers units' value of future three periods of time based on the consistent data of three observations.

Table 6-2 is the information of identifying future density growth. The basic principle has been explained in chapter 5 (see figure 5-5). Time 1 is the basic year (2002), Time 2 is the projection year (2020).

Table 6-1 Information of population, householders and employments

Year	Population	Households	Employment
Low growth---Observed data			
1991	24875	6219	12438
1996	27388	6847	13694
2000	29951	7488	14976
2002 (Current condition)	31098	7775	15549
2008	35200	8800	17600
2015	40668	10167	20334
2020	45088	11272	22544
High growth---Predicted data			
2008	60000	15000	30000
2015	85000	21250	42500
2020	106000	26500	53000

Table 6-2 Information of identifying future density growth

Land use	2002 Land use (Time 1)		2020 Land use (Time 2)		Future growth From 2002-2020		Future density growth
	Unit1	Area1 (Hectare)	Unit2	Area2 (Hectare)	ΔUnit	ΔArea (Hectare)	(Unit/hectare)
Residential	7775	170.34	26500	261.21	18725	90.87	206.06
Industrial	15549	23.28	53000	146.99	37451	122.62	305.42
Office/retail	15549	57.92	53000	192.77	37451	134.85	277.72
Green space		28.99		199.62		170.63	

6.3.2. Criteria 2: Suitability Criteria

Key findings:

1. General assumptions about factor weight and ratings are set to make a standard rule for measuring land suitability.
2. Decision forms about identification of factor weight, factor ratings and conservation choice are proposed and acceptable by stakeholders.
3. Two sub suitability criteria are developed based on major stakeholders' interest.

Four kinds of land uses types (LUT) are chose to make suitability analysis based on the requirement of land use allocation. For urban spatial development, residential, industrial, office/retail and green space hold different criteria for the supply for land. The assumptions about factor weight and ratings make sense to set a standard rule for measuring their suitability.

Decision forms about identification of factor weight, factor ratings and conservation choice provides intuitional tables about how to combine their interests and preference with standard evaluation rules (see table 5-7, table 5-8 and table 5-9).

It is meaningful to develop two sub suitability criteria for the basis of supporting two suitability alternatives proposed by major stakeholders. The difference of the two sub criteria is whether taking the agricultural soil factor into consideration. For the study area, government supposes to take agricultural soil as a constrain factor and take the standard rules to measuring it weight and factor types' rating when evaluating land suitability. Comparing with this choice, another possible scenario, which represents investor's preference and does not consider agricultural soil factor, is correspondingly developed.

The result of weighting and rating for suitability scenarios has been listed in Annex II Table 4. Table 6-3 is the result of conversion choice for suitability evaluation. From the tables, it clears that for each type of land use, factor weight and ratings are different. In the conversion choice table, it can be seen that residential suitability land use (LUT1) can convert from current industrial (LUT2), office/retail (LUT3) and undeveloped land uses. For other suitability land use, the conversation choices are diverse.

The process to identify suitability criteria has some difficulties. The reason for that is the stakeholders experienced some difficulties to achieve consensus about the measurable criteria. They have the tendency to hold uncertain position in choosing the measurable values for factor weight and ratings. In such condition, planners need to negotiate with the representatives several times and direct them on the weighting and rating.

Table 6-3 Information of conversion choice for suitability scenarios

Convert from current LUT	Suitability LUT			
	LUT1	LUT2	LUT3	LUT4
Residential (LUT1)			√	√
Industrial (LUT2)	√			√
Office/retail (LUT3)	√			√
Green space (LUT4)				
Road				
Undeveloped	√	√	√	√
Water				

6.3.3. Criteria 3: Allocation Control Criteria

Key findings:

1. General assumptions about land allocation are set to make a rule for incorporating land demand and land suitability.
2. Decision forms about identification of land allocation order and allocation control choice are developed.
3. Two sub allocation criteria are developed based on major stakeholders' interest.

The objective of this study is to develop land allocation alternatives for planning support. The general assumption provides the criteria to link stakeholders' concerns with computer-based planning support model.

Table 6-4 is the result of allocation order for land allocation proposed by the major two stakeholders in the study area. From 1 to 4, the priority of allocation for each land use types is given. The difference between the two orders is the concerns for importance of each land uses. Government proposes office/retail need to allocate firstly to reflect their concerns for service function of study area. Investors insist to allocate industrial firstly to use the best suitable land for economic function. Still more, as shown in chapter 5 (see table 5-11), allocation control choice makes different sense for the two allocation alternatives. Government considers using allocation control and insists it can effect allocation of each land use proposed. This thoughts base on the principle of "intensive land uses" proposed in China.

The allocation order is the simplest way to arrange different land uses in the given frame. It can provide general concerns for future land use condition. However, it never considers the interaction of each land use since it is a very complex process to achieve this idea.

Table 6-4 Information of allocation order for land allocation

Future land use type (LUT)	**Allocation order/priority**	
	Investor's interest	Government's interest
Residential (LUT1)	3	3
Industrial (LUT2)	1	2
Office/retail (LUT3)	2	1
Green space (LUT4)	4	4

6.4. About Scenarios

This section provides the results of three main scenarios obtained in this study, including maps and tables. Main findings and their discussion go as follows:

Key findings:

1. Two groups of demand scenarios (tables) on each land use type are developed based on two assumptions about future.
2. Two groups of suitability scenarios (maps) on each land use type are developed based on stakeholders interests.
3. Four final land allocation scenarios (maps) are developed based on stakeholders analysis.

The maps and tables provides intuitional material for planning support. *What if?* PSS is a scenario-based planning support system; it automatically generates three kinds of scenarios based on inputting criteria and GIS data sets. The operation process is simple and clearly understandable.

6.4.1. Demand Senarios

Table 6-5 is the information of future area demand of each land use type. The general idea of computing future area demand is based on the assumption proposed in chapter 5 (see section 5.4.3). It follows the formula: ΔArea = ΔUnits / future density. Table 6-6 lists the land demand of each projection year as well as total land use demand in whole projection year based on the different growth assumption. From the table 6-5, it is clear to see that the total land use demand based on high growth assumption (519 hectare) is much higher than that of low growth (156 hectare). This result is reasonable because the growth of household and employment units based on high growth assumption is nearly 4 times of that of low growth (see table 6-6).

Table 6-5 Information of future area demand of each land use type (LUT)

	Future land use	**Additional hectares requires** (Hectare)			
		2002-2008	2008-2015	2015-2020	2002-2020
High growth	LUT1	35.1	30.3	25.5	90
	LUT2	47.4	41.0	34.4	122
	LUT3	52.0	45.0	37.8	134
	LUT4	51.0	70.0	50.0	171
	TOTAL	185.4	186.3	147.7	519
Low growth	LUT1	5.0	6.6	5.4	17
	LUT2	6.7	9.0	7.2	22
	LUT3	7.4	9.8	7.9	25
	LUT4	31	30	30	91
	TOTAL	50.1	55.4	50.6	156

Table 6-6 is the future units number and density growth behind demand scenarios. The value of population, households and employment based on low growth assumption is calculated by *what if?* PSS based on linear method according to the observed data in the past years (see table 6-1). The value of future density growth is determined according to method proposed in table 6-2 and figure 5-5.

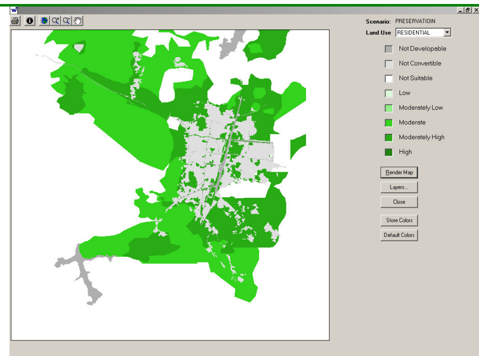
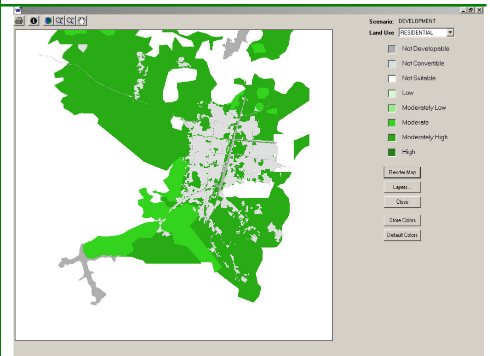
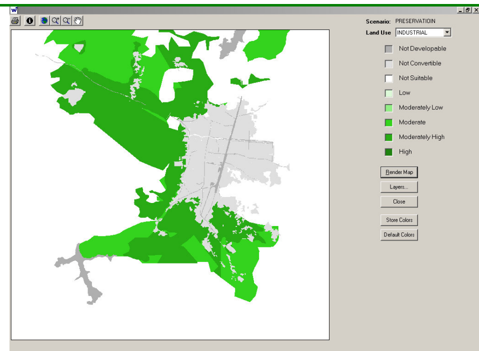
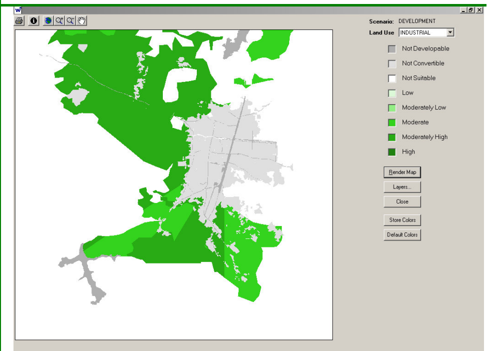
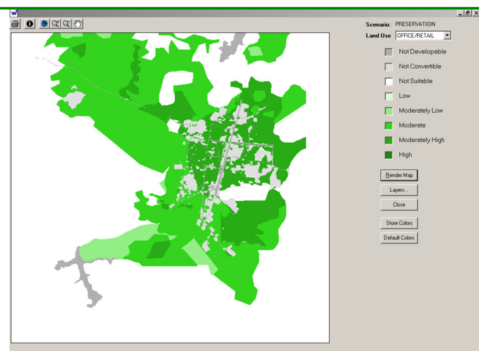
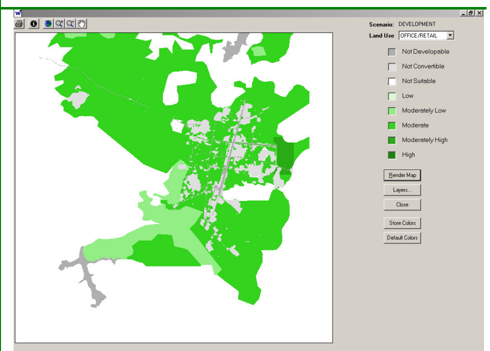
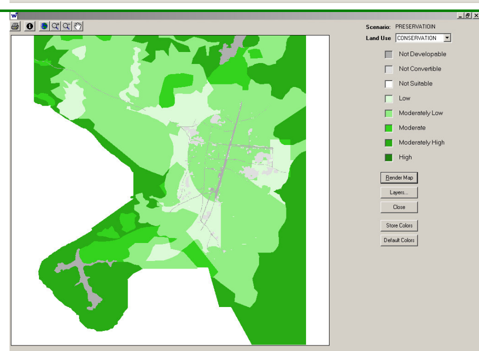
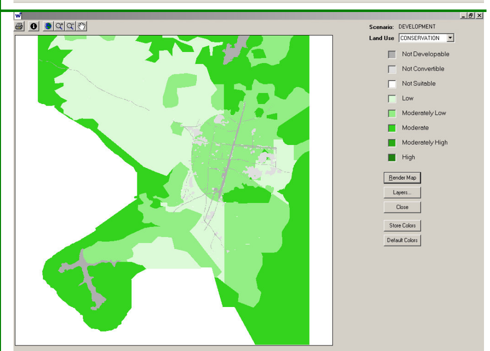
Table 6-6 Information of future units' number and density growth

Year	**Population**	**Households**	**Employment**
Low growth			
2008	35200	8800	17598
2015	40668	10167	20332
2020	45088	11272	22542
Current condition			
2002	31098	7775	15549
High growth			
2008	60000	15000	30000
2015	85000	21250	42500
2020	106000	26500	53000
Future density growth (Unit/hectare)			
LUT1=206.06, LUT2= 305.42, LUT3=277.72			

6.4.2. Suitability Scenarios

Map 6-1 is the suitability scenarios. *What if?* automatically generates two groups of suitability scenarios based on underlying suitability criteria proposed in section 6.3.2. Generally, there are two main aspects, which will affect the result of suitability scenarios: one concerns thematic maps and another relates to factor weighting and rating set by stakeholders. This set of thematic maps is already presented in chapter 4. The different sources and different scales are a limit to generate these maps. From Map 6-1, it can be seen that some of the UAZ (united analyse zone) are so big, which makes the same attribute is assigned in a quite large region. Smaller and standard UAZ will contribute to improve evaluation result. Stakeholders' criteria make the scenarios of different land use types various based on different suitability scores in each UAZ (see Annex II Table 5).

The suitability categories (see Annex II Table 5) have been divided into eight classes, including not developable, not convertible, not suitable, low, moderately low, moderate, moderately high, and high. Generally, for evaluating suitability of each land use types, the first step is to define whether the land use types can be developable from their current uses. For the study area, current water and road are regarded as not developable area for suitability analysis and their total area is 51.5 hectare. Except of them, the other kinds of current land uses are regarded as convertible to future uses. As seen in Annex II Table 5, the not convertible area of each land use types is 0 hectare. Not suitable area is defined at the rating process when the factor types are considered as not suitable for development.

Suitability LUT	Suitability scenarios	
	PRESERVATION Scenarios	DEVELOPMENT Scenarios
Residential (LUT1)		
Industrial (LUT2)		
Office/retail (LUT3)		
Conservation (LUT4)		

Map 6-1 Suitability scenarios

For measuring each UAZ's suitability categories, a rule has been developed seen in Annex II Table 5: for example, when suitability score is between 1.0 and 15.0 in preservation scenarios, its suitability category is regarded as low. Still more, the measuring rule is changeable according to the considered factor numbers. For example, in preservation scenarios, six factors are considered (see section 6.3.2). According to the assumption made in suitability criteria (also see section 6.3.2), the maximum factor weigh is 3, and the maximum factor rating is 5, therefore the maximum total suitability score is 3*5*5=75, according to WLC (weighted linear calculation) method. At same time, five fix suitability categories (from low to high) are set. According to the above two analysis, the measuring rule is developed based on total maximum suitability score and the fix five suitability categories. For preservation scenario, the measuring rule is 75/5=15. And for development scenarios, the measuring rule is 3*5*4/5=12 (because the considered factors are 5).

This measuring rule is simple and operational. However, the obvious limit concerns the abnormal area distribution of each suitability category. As shown in Annex II Table 5, the area of some kinds of suitability categories is so small or even 0 but some are too large. Area frequency analysis can contribute to improve measuring rules' set. In this study, changing factor weight and ratings by negotiating with stakeholders for several times can makes the result reasonable.

6.4.3. Allocation Scenarios

The final achievement is the development of alternative land allocation scenarios, which can represent major stakeholders' interests clearly. Basically, two kinds of population growth assumption and two kinds of suitability and allocation concerns combine the four alternatives for land allocation (see map 6-2).

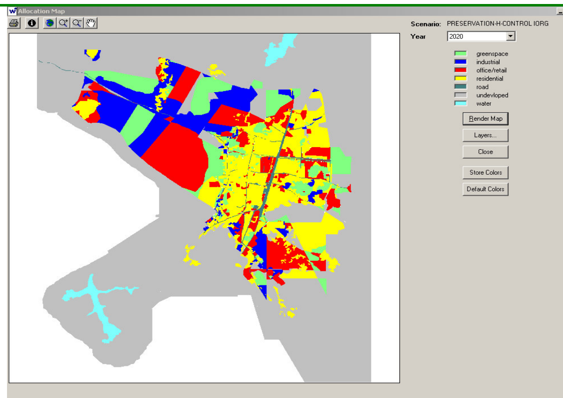
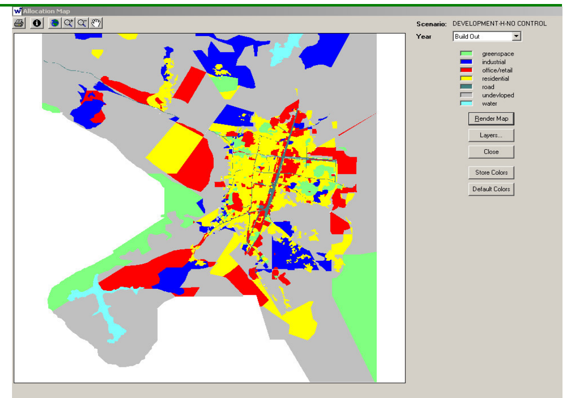
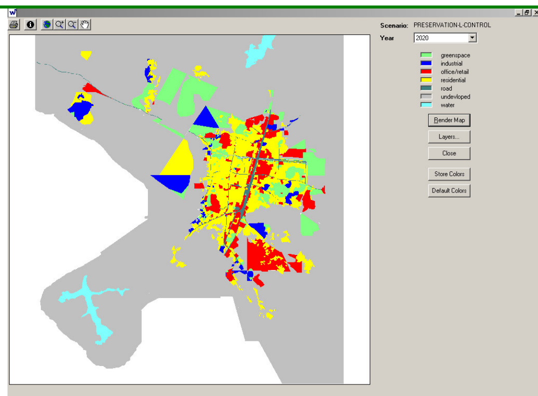
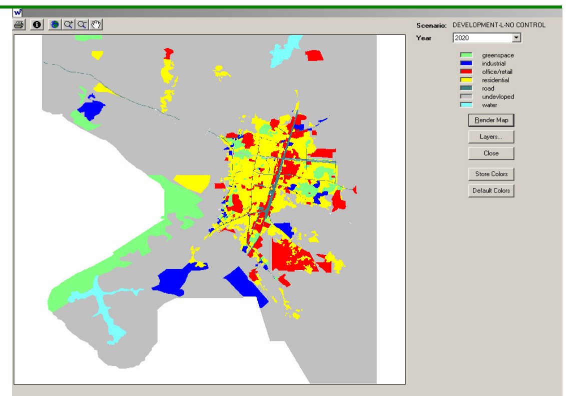
Map 6-2 shows the land allocation condition in projection year 2020. From the maps, the location and its related area of four major land use types (LUT): residential, industrial, office/retail and green space are easy to understand. As the name suggested, ALT 1 and ALT 2 are based on high growth assumption as well as ALT 3 and ALT 4 on low growth assumption. ALT 1 and ALT 3 can represent government's interests as well as ALT 2 ALT 4 represent investors' interests. The criteria behind these alternatives can be seen in section 5.3.4 (method) and section 6.3.3 (result).

From the maps, it is clear that different criteria make totally different scenarios. The goal of developing these scenarios is to present stakeholders' concerns and preference in visualized maps. Generally, these four alternatives can achieve such a goal and have special meaning when being comprised each other.

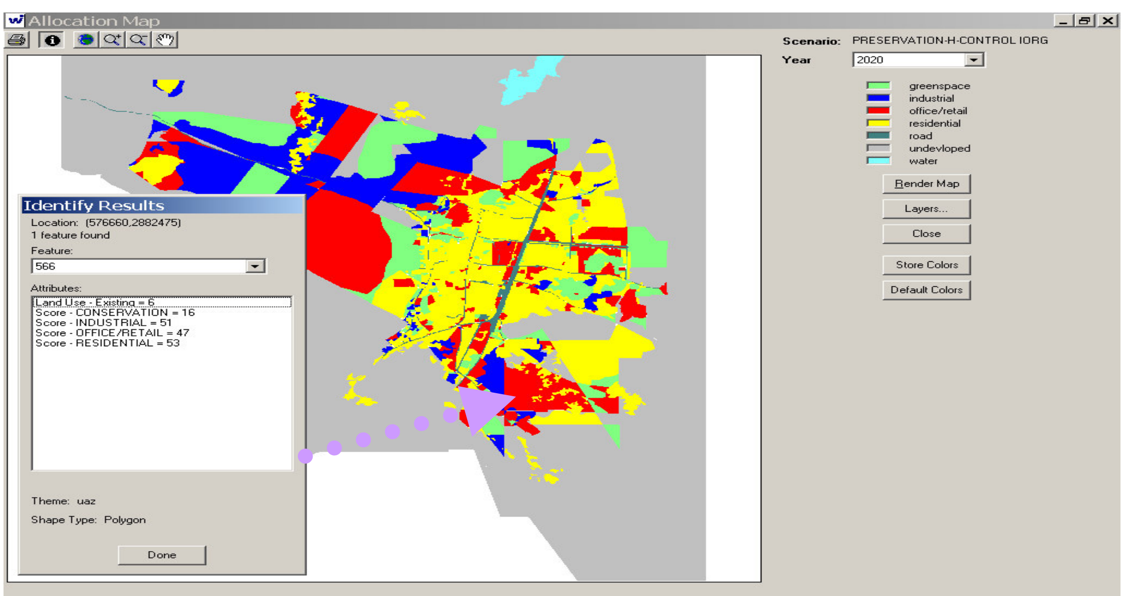
As mentioned in chapter 2, the emphasis of planning support system is around design, not about choice. These four land allocation alternatives will be presented in public and be chosen by decision-maker based on the clearly defined criteria behind them. Most of the time, part of the criteria and related scenarios will be used in real planning practice based on final negotiation and compromise of stakeholders and decision-maker.

When going inside the scenarios, it can discover the underlying rationale of allocation. Take ALT 1 as example, shown in map 6-3. The arrow builds a link between spatial locations of one UAZ (red region) with its suitability score when used for different purposes. In the identifying figure, it lists four suitability score: conservation=16, industrial= 51, office/retail= 47 and residential= 53. If just seen from the comparison of suitability score, it can conclude that the selected UAZ is best used for residential purpose, then for industrial, and for office/retail, last for conversation based on the score order. However, in real condition, as mentioned before, when allocating different land uses, it needs to consider the allocation order. In this sample, the considered allocation order goes as: office/retail>industrial>residential>conservation. Based on this assumption, it is easy to understand the reason of why the selected UAZ is finally allocated for office/retail land use purpose in this alternative. Similarly, when changing the allocation order as industrial > office/retail >residential>conservation, as shown in ALT 2, the same UAZ will be allocated as industrial land use purposes.

It is pity that there is not possible to generate maps to evaluate the strengths and limits of ALT3 and ALT4 in *what if?*. However, the development of ALT3 and ALT4 is still useful and necessary to let stakeholders understand the possible urban future when population growth goes as a lower trend.

	Allocation scenarios	
	Government's interests	Investors' interests
H	 ALT 1	 ALT 2
L	 ALT 3	 ALT 4

Map 6-2 Land allocation scenarios



Map 6-3 Underlying rationale behind allocation scenario

6.5. Discussing *what if?* PSS Based on Map Comparison

This section dwells on comparison among the results of *what if?* PSS with land evaluation (LE) map and land use planning (LUP) maps in 2020, for the purpose of identifying strengths and weaknesses of this computer-based planning support system, *what if?* PSS.

6.5.1. With Land Evaluation (LE) Map

From map 6-4, it can see that suitability map can provide suitability region for supporting land use planning. However, when compared with *what if?* maps, it can see that the information provided by land suitability map is limited for planning support purpose. Generally, *what if?* maps can supply three additional information. At one hand, *what if?* maps can represent major different stakeholders' interests. Since the limitation concerning the stakeholders' criteria is still existed (see section 6.3), the maps have provided clear resolution for satisfying stakeholders' main needs. At another hand, *what if?* maps are generated on the basis of rational assumption about future population, which link spatial location with local need for land resource. Still more, each of the *what if?* maps provides the information about location of each land use type. This kind of bountiful information cannot be seen in suitability map in planning support practice of China.

6.5.2. With Land Use Planning (LUP) Map

The land use planning map in 2020 is generated in 2003 by professional planning institute. Its basic criteria concern three aspects: future population assumption, land use suitability, and political concerns. Because the same suitability and demand criteria are adopted in ALT1, ALT2 and planning map in 2020, it can make a comparison to find out the efficiency of *what if?* PSS. ALT1 can represent government's preference, and ALT2 can more represent investors' preference. Their difference behind the maps mainly concerns the considered suitability factors, allocation order and allocation control.

Five comparison regions are chosen as samples in both planning map and *what if?* maps: A, B, C , D and E. For the specific sample region proposed, the final land use types are not same in ALT1, ALT2 and land planning map.

In sample region A, "Industrial" is the main land use type in ALT1 same as in land use planning map. This condition means that *what if?* PSS succeed to transfer government's ideal scenario into a computer-based future urban development scenario. For ALT2, there is not a clear evidence to say which major land uses are locating in the sample region A. At same time, there is not so much land uses occupied in the region A of ALT2's map because of its poor suitability for urban spatial development based on investors' criteria.

In sample region "B", it is interesting to see that "Office/retail" is the main land use type in each of the three maps. In ALT 1, most of the area in region B is assigned into office/retail use based on government's criteria. This computer- based result is closely similar to that in planning map in 2020.

In sample region “C”, the same major land use type locates in planning map and ALT2 proposed by investors. In ALT1, since “Industrial” is also seen in sample region C, it is not the same as the main part of land uses in the region.

In sample region “D”, “office/retail” is the major land use in both planning map and ALT 2’ map. However, it is strange that “office/retail” is not the major land use in region D of ALT 1, which represent government’s concern for urban service function’s improvement. When looking at sample region B and C in ALT1’s map, it can find that most demand for office/retail land use has been satisfied in these regions, which makes region D locate other kind of land uses.

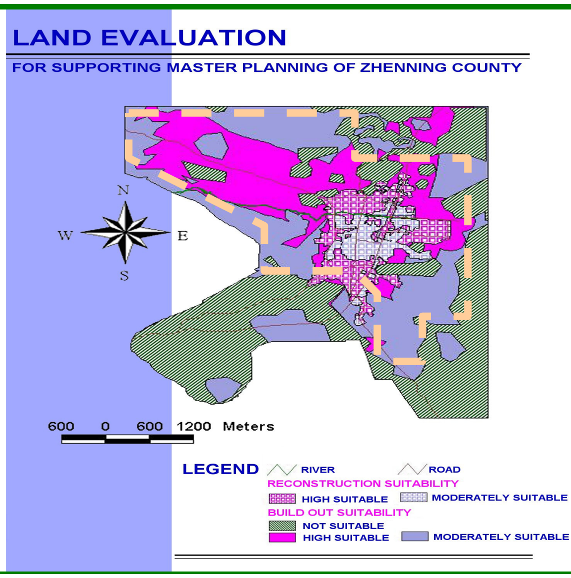
In sample region “E”, it can find that the same problem has been occurred in sample region “D” of ALT2’s map. Because of most of the demand for green space has been satisfied in other region in ALT 2, sample region “E” provides opportunity for other kind of land uses.

When going deeper into of the criteria used in ALT1, ALT2 and land use planning, it is clear to identify the successful and failing aspects of using what if? PSS to provide computer-based planning support based on stakeholders’ involvement through the case study results.

Take sample region “A” as example. Region “A” in land use planning map in 2020 is planned to be used as employment zone for developing intensive industrial. The main reasons for such a consideration comes from following criteria: intensive land use policy (land allocation control), wind suitability for location and other land suitability factors. Comparing with ALT2, ALT1, which are set to represent government’s interest, can be successful to achieve this planning goal proposed by professional expert. The main successful reason of ALT1 over ALT2 is that it considers the land allocation control’s effect.

Take sample region “C” as another example. Region “C” in land use planning map in 2020 is also be planned to be used as industrial. The main decision space is that in this region it owns a better land natural suitability for urban expansion and professional expert want to provide more working opportunity in south area. Comparing with ALT1, ALT2, however, which are set to represent investors’ preference, can be successful to get this objective proposed by professional expert. The main successful reason of ALT2 over ALT1 is that it considers industrial as the most important land use in allocation order.

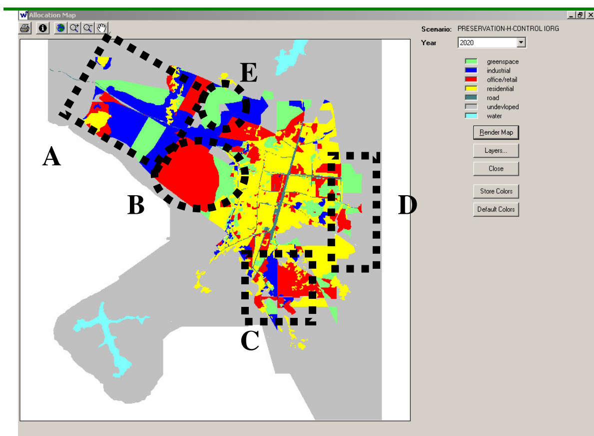
Generally, when making a map comparison among ALT1, ALT2 and land use planning map in 2020, it can be found that the result of both ALT1 and ALT2 are reasonable and can support planning successfully. These two land allocation alternatives provide two possible future scenarios based on two different stakeholders’ interests. There is not a measuring rule to evaluate which alternatives is “best” or “right”. In real planning making process, the decision maker can use the provided scenarios and their underlying criteria to make a final decision. Computer-based planning support method can never replace the making of the final decision.



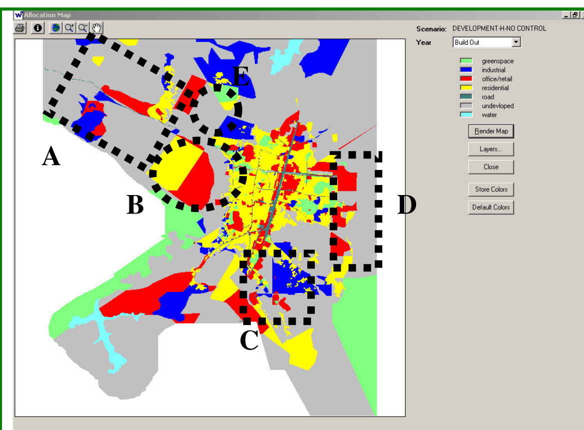
Land evaluation (LE) MAP

Suitable region

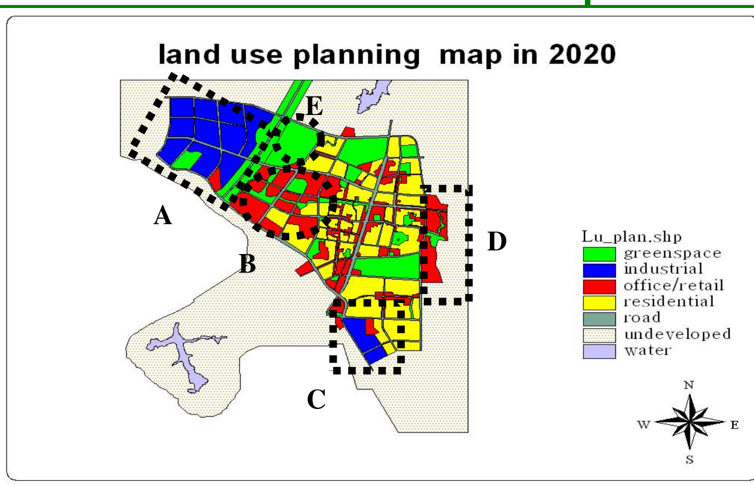
What if? PSS MAP



ALT 1: government's interests



ALT 2: investors' interests



Land use planning (LUP) MAP

Comparison region

Map 6-4 Comparison maps among the scenarios of what if?, LE and LUP in 2020

6.6. Discussing *what if?* PSS Based on Working Experience

6.6.1. About the UAZ

Creating UAZ is the basis of using *what if?* PSS. The shape file includes all information needed to take into consideration of spatial analysis, such as suitability analysis and allocation analysis. This requirement makes UAZ as the only resource of GIS data set. In the process of using *what if?* PSS, most of the time and energy is spent on recreating UAZ. Creating UAZ is not only a matter of overlaying process in GIS/ARCVIEW, but also an understanding process for *what if?* PSS. Better understanding the concept and requirement of UAZ can improve efficiency of using *what if?* PSS. On one hand, one needs to understand that the GIS information provided by UAZ can support what if? planning support model. Some missing or unsuitable considering space/factors may attribute to recreate UAZ. One another hand, one needs to understand that the final allocation scenarios have a close relationship with UAZ. Regular shapes and normal distribution of units in UAZ will improve quality of allocation scenarios. This requirement can be achieved through modifying the thematic maps in GIS/ARCVIEW and overlaying them all again.

6.6.2. About Future Density

The concept of future land use density is not easy to understand in *what if?* PSS. This problem is made partly because of difference planning background between China and Western Counties. In Western Counties, future land use density is a measuring rule to assess the units' number in a given area. In China, corresponding to the concept of "density", "area per capita" is commonly used as measuring rule to assess the land use area for one person. So, the problem of using *what if?* PSS in the case study is how to change the measuring rules of planning support from the Chinese context to the western context. As a matter of fact, "density" is closely related to "area per capita" if we notice their underlying meaning. In this study, the growth assumption (see chapter 5) builds a bridge to link these two concepts and find an operational way to use western model into China's planning context. Another problem concerns a trade off between "simplicity" and "accuracy" as mentioned by Klosterman (2003)[5]. With the process of urban spatial development, the units' number in the given area may change over time. *What if?* PSS assume only a single future land use density for all future years. However, there are several ways to assume density will change over time and there is no way to know which one will be "right". This assumption is only one of many assumptions that the planning support model makes, which is a trade off between "simplicity" and "accuracy".

6.6.3. About Weighting and Rating

What if? PSS incorporates MCE's weighting and rating method with stakeholders' interests by providing a friendly interface for specifying numerical values at the process of using *what if?* PSS. Generally, it is an easy-understandable but effective way to transfer one's idea into scenario using computer-based method. However, it needs to understand that the suitability weights and rates are one kind of standardization value, unlike the commonly used MCE method. In commonly used MCE method, the value is from 0 to 1. But in *what if?* PSS, the weights are assigned directly from 1 to 3. It

[5] Email connection and communication

also needs to be understood that there is another trade off between "simplicity" and "accuracy" concerning weighting and rating in *What if?* PSS. *What if?* PSS provides a simple way to assign weights and rates directly, but the "accuracy" of its results is hard to be measured. For the suitability weights and rates, there is no "right" answer, the *what if?* PSS just shows the result of the choice. Still more, at the process of using *what if?* PSS, it needs to understand that planners are as a bridge to link stakeholders' interests with the use of the program. Letting the stakeholders understanding the general ideal of weighting and rating function in *what if?* PSS is an important step to achieve smoothly operation of *what if?* PSS. Planners' involvement can better balance the "simplicity" of the operation and the "accuracy" of its result when using *what if?* PSS.

6.6.4. About Allocation

The final and most important step when using *what if?* PSS is to allocate land based on suitability and demand analysis. As mentioned before (see section 3.1), several limitations about operation of *what if?* PSS can be reviewed from lots of literatures: *What if?* PSS fails to consider the spatial interaction of different land uses; the allocation process is not easy to be success because of in incompatibility of supply of and demand for land. At the process of using *what if?* PSS in case study, it is pity that spatial interaction also fails to be totally considered into the computer-based planning support system because of its complexity. In China, spatial interaction is mostly reflected as the negative interrelationship of different land uses, such as industrial and residential. Because of the different environment requirement (quiet for residential) and effect (noisy from industrial), the spatial interaction should be in some way in planning support process. Basically, *what if?* PSS has never provided a model to deal with spatial interaction problem. However, at the process of using *what if?* PSS, employing spatial intervention to constraint the location of different land uses can be partly resolve the problem. Another solution for the considered limitation is to be achieved by decision makers in the final decision process instead of through this computer-based method. About the insufficiency of particular land use allocation problem, literature review provides three solutions: modifying the suitability scenarios in order to increase the available land amount for satisfying future demand; modify the demand scenarios in order to decrease future demand; modifying the allocation scenarios in order to change the allocation order. In this case study, future demand and allocation order is regarded as a constant factors based on different assumptions and stakeholders' concerns. The changeable point to deal with the insufficiency problem is to modify the suitability scenarios. This way is reasonable because it generally believes that every kind of "suitability" is made based on person's criteria.

7. Conclusions and Recommendations

This chapter is the final chapter of this study, which is divided into three sections. The first section gives a glimpse of the study. The second section summaries the major findings of case study. The final section recommends some issues for further studies and understanding.

7.1. Introdution

This research aims to investigate if the current planning support approach can be improved by creating allocation scenarios that considers stakeholders' interests and multiple criteria.

To contribute to a solution of this objective, several research questions (see section 1.4) are answered. The first two questions lead to understand the concept of planning and urban sustainable development, and the concept of stakeholder involvement in urban planning. The next question is to analyse the limits of current planning support practice in China. Investigations the planning support practice of PSS, MCE & GIS, and their inner linkage are the answers to the next three questions. Another three questions lead to analysis the characteristics, data requirement and limitation of using *what if?* PSS. The introduction of study area and investigation of ways to generate criteria sets and add values into case study are the answers to the next two questions. The last two questions are to evaluate actual benefit of using *what if?* PSS over land evaluation (LE) and to assess the strengths and limitations of *what if?* PSS through the case study results and working experience. These questions are answered by reviewing literatures on current planning support theory and worldwide planning support practice as well as analysing the proposed approach and result of the case study.

7.2. Conclusions

Through the literature review, it has found that land use planning is one kind of planning, but more specifically on land and land use context. Sustainable development is the goal of urban spatial development, and its implication covers not only ecological aspect, but also economic and socio-demographic aspects as well as considering local policy and people's will. Stakeholder involvement and scenarios planning improves public participation and strategic conversation, which further pushes to achieve urban sustainable development and improve participatory planning support.

After the introduction of the general planning support condition in China (chapter 1), and the analysis of current planning support theory (chapter 2, mentioned above), three main limits of LE has been identified to explain why land evaluation is not effective and comprehensive in planning practice in China:

- Limit 1: Not better considering stakeholders' interests (social, political)
- Limit 2: Not considering demand criteria (demographic)
- Limit 3: Not providing allocation scenarios of the different land use types

Through the review of worldwide current planning support practice (chapter 2), it has found that MCE can provide logical workflow to organize data; the scoring and weighting system can be applied to the various aspects of suitability. However, parts of MCE may be technically too complex to be understandable for non-experts in the field of evaluation. It needs spatial analysis functions to incorporate the decision space into intuitive scenarios. GIS can provide strong function for data management and spatial analysis as well as combining with some models and analysis methods to generate alternatives. However, what these applications do not provide is an intuitive software interface specifically designed for planners. PSS is regarded in this paper as being not the same concept as DSS. In this study, it has been believed that PSS emphasizes on design stage while DSS pay more attention on making choice, as well as the users of the PSS are technocrats while the users of the DSS are decision-makers. An important finding is that, PSS, as a bridge to link MCE, GIS with participatory planning support, provides a user-friendly interface, which allows smooth and easy communication with the system, visualization and communication of the results of the analysis to the decision-makers in a manageable and understandable form.

The introduction of chapter 3 concerns three aspects about *what if?* PSS: characteristic, data requirement and its limitations based on literature review. The proposed characteristics (GIS-based, model-based, and scenario-based) has been the basis of the proposed research approach in chapter 5 (methodology); the data requirement proposed (spatial and non-spatial) has been closely related the contents of chapter 4 (study area); its limitations (literature) has a linkage with the final discussion on the strengths and weaknesses of *what if?* PSS in chapter 6 (based on result and working experience).

The proposed approach, which is based on the *what if?* model, has been used for the case study of Zhenning County in China. For the study area, the stakeholders (potential, relevant and final ones) have been identified. Alternative and criteria have been made based on the negotiation between stakeholders via planners' participation. As a result, land demand criteria (criteria 1) and its two sub criteria (from the assumptions of two future population: high growth and low growth) have been made for land growth analysis, land suitability criteria (criteria 2), land allocation criteria (criteria 3) and theirs sub criteria (from the views of two major stakeholder groups: government and investors) have been documented and taken into consideration of land suitability and land allocation analysis. Eventually, four final land allocation scenarios (ALT1 to ALT 4) have been generated based on the integration of the three kinds of stakeholders' interests (criteria 1 to criteria 3).

From the discussion of the result of the case study, it has found that general assumption about the criteria is useful to smoothly transfer stakeholders' interest into computer-based approach (chapter 6). The bilateral meeting is successful because it organized by local government and is paid more attention from broad range of stakeholders. Planners' guiding provides useful bridge to link planning support practice with stakeholders' interest and criteria.

In this study, the use of *what if?* PSS is to develop land allocation alternatives, and it emphasis on "design" stage, not on final "choice". Therefore, about the final four land allocation alternatives (ALT1 to ALT 4), *what if?* PSS just shows the results of a number of criteria by various stakeholders, who are able to express their preference, not provides the final choice about which alternative is the "best" or "right" choice.

The assessment of *what if?* PSS based on case study has been done in chapter 6. From the map comparison of *what if?* results, the strengths and weaknesses of *what if?* PSS has been identified. From the discussion of the working experience at the process of operating *what if?* PSS, some findings has been generated.

Based on maps comparison, the actual benefits of using *what if?* PSS over LE specifically for the case study are clear: *what if?* results can provide more bountiful information than LE does because of stakeholders' involvement, future population's consideration and different land use's allocation. The comparison among ALT1, ALT2 and land use planning maps has been shown that the results of *what if?* PSS are reasonable and can support planning successfully.

Based on working experience, four aspects about using *what if?* PSS has been discussed: about UAZ, about future density, about weighting and rating, and about allocation. It has been found that better understanding the concept and requirement of UAZ can improve efficiency of using what if? PSS. UAZ is the bridge to link GIS data set and *what if?* PSS usage. The concept of future land use density is not easy to understand at the process of using *what if?* PSS. The demand assumption proposed in this paper (chapter 5) builds a bridge to link the concept of "density" and "area per capita", and then find an operational way to use a western model to resolve China's planning problem. *What if?* PSS incorporates MCE's weighting and rating method with stakeholders' interests. However, it needs planners' involvement (a bridge) to link stakeholders' interests with the use of the program. It has been found that there is a trade off between the "simplicity" of the weighting and rating's operation and the "accuracy" of its result. This study has been adopted a simply way to deal with complex problem. In this case study, it also has been found that *what if?* PSS does not provide an integrated model for dealing with spatial interaction problems. However, a possible approach to partly resolve the spatial interaction problem in *what if?* PSS's application is to employ spatial intervention (like land use control policy in this study) to constraint the locating of different land use.

7.3. Recommendations

The central idea of scenario planning is to consider a variety of possible futures that include many of the important uncertainties in the system rather than to focus on the accurate prediction of a single outcome. For the result of *what if?* PSS (scenarios), there is not a measuring rule to evaluate which alternatives is "best" or "right". In real planning making process, it is recommended that the decision maker can use the provided scenarios and their underlying criteria to help for making the final decision.

It is unfortunate that spatial interaction in land allocation also fails to be totally considered into the computer-based planning support system because of its complexity. Basically, what if? PSS does not provide an integrated model for dealing with spatial interaction problems. A possible approach to partly resolve the spatial interaction problem in what if? PSS's application is to employ spatial intervention to constraint the locating of different land use. For example, allowing industry to be located in part of the city but constraining residential land uses there. In real world, it is recommended that the final resolution for this limitation should be achieved by the decision makers in the final decision process. Computer-based planning support can never replace the making of the final decision.

Another important limitation of this study is the absence of local residents as major stakeholders. Their participation could have contributed with other elements considerably, especially criteria referring to the social and cultural aspect.

Although there are some limits to using *what if?* PSS, this study has shown that the operational planning model and its capacity to provide planning support can also be useful in the real world.

Finally, the information provides by this study is recommended to be used as a guideline for the planning authorities and decision makers of developing country, which are willing to understanding PSS (especially for *what if?* PSS) and use it in real case to improve planning support for urban spatial development.

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Annex

Annex I - Photographys

Photo 1 Contact with relevant stakeholders

Photo 2 Discuss between relevant stakeholders

Photo 3 Document the interests of final stakeholders

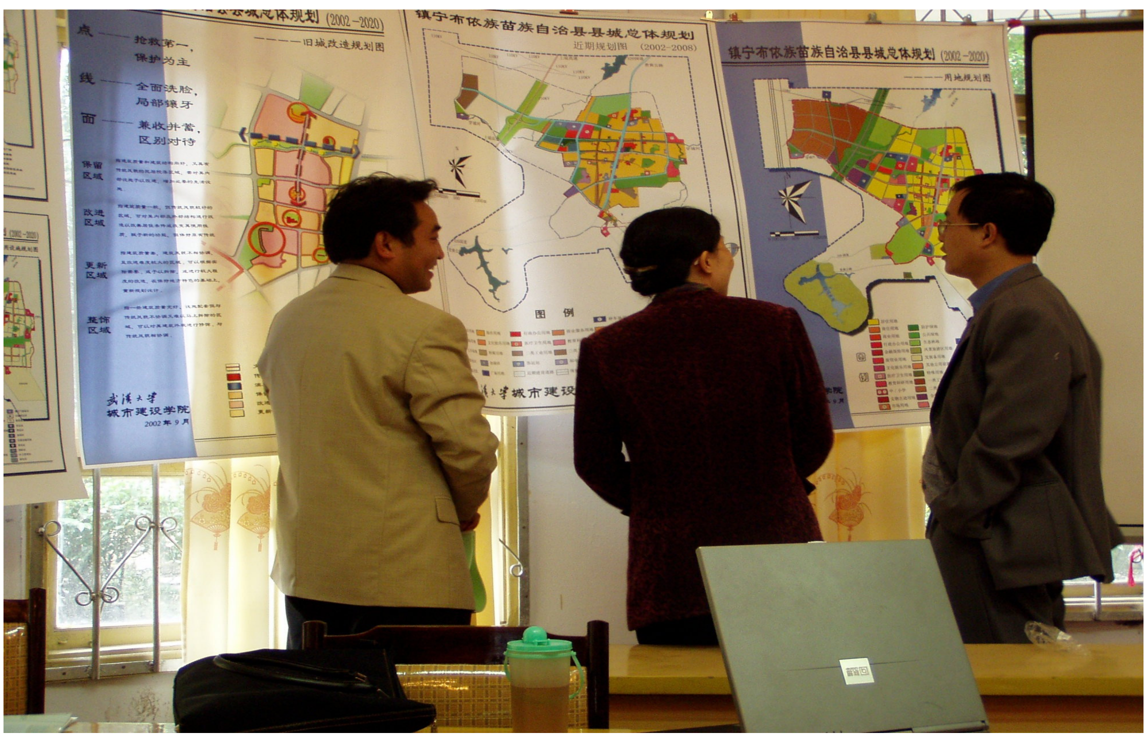

Photo 4 Negotiate with the representatives of major stakeholders

Annex II - Tables

Table Annex 1 Demographic data, 1991-2000, Zhenning County
(Provided by statistic bureau)

Year	Total Population	Male	Non-farmer	The percent of non-farmer to total population	Population growth (‰)	
					Natural growth	Mechanical growth
1991	24875	12863	7162	28.79	4.28	-48.80
1992	25562	13277	7386	28.89	12.48	4.74
1993	26075	13458	7466	28.63	16.05	4.46
1994	26405	13659	7713	29.21	5.62	4.88
1995	26874	13914	8218	30.58	11.64	5.80
1996	27388	14142	8472	30.93	13.54	5.22
1997	27917	14479	8749	31.34	12.77	6.16
1998	28403	14702	9081	31.97	14.07	3.04
1999	28194	14508	9057	32.12	8.49	-14.46
2000	29951	15630	9067	30.27		

Table Annex 2 Projected population using regional urbanization rate method
(Provided by planning bureau)

Year 2008	Year 2008 regional urbanization rate 13.4% Year 2008 regional total population 371000
	Year 2008 Zhenning county total population 60000
Year 2020	Year 2020 regional urbanization rate 20% Year 2020 regional total population 425000
	Year 2020 Zhenning county total population 106000

Table Annex 3 Potential stakeholders in the study

Stakeholders		**Participants in events Related to master planning**
Regional level	Governmental organization	Department of state
		Department of transportation
		Department of planning
	Non-governmental Organization	Planning organization
		Academic institutions
		Environmental protection organization
Local level	Governmental organization	Department of state
		Department of planning
		Department of health and human services
		Department of treasury
		Department of labour
		Department of defence
		Department of energy
		Department of justice
		Department of transportation
		Department of science and technology
		Advisory council on historic preservation
		Environmental protection agency
		Department of housing and urban development
	Non-governmental Organization	Academic institutions
		Economic development boards
		Civic committee
		Environmental, agricultural and public interesting group
		Academic institutions
		Residents of the study area

Table Annex 4 Weighting and rating for suitability scenarios

Factor considered	Factor weight	Factor rating	
		Factor type	**Rating**
LUP 1: residential			
Wind direction	1	Central city	5
		Lowest wind	1
		Lower wind	2
		Higher wind	3
		Highest wind	4
Historic site	2	Inside historic site	0
		<1000	4
		>1000	5
Land type	3	Build up	4
		Non build up	5
		Slide land	0
Slopes	3	<10%	5
		10%-25%	2
		>25%	0
Agricultural soil	2	Not agricultural soil	5
		Normal farmland	2
		Prime farmland	1
LUP 2: industrial			
Wind direction	3	Central city	0
		Lowest wind	5
		Lower wind	4
		Higher wind	2
		Highest wind	1
Historic site	3	Inside historic site	0
		<1000	0
		>1000	5
Land type	1	Build up	1
		Non build up	5
		Slide land	0
Slopes	2	<10%	5
		10%-25%	1
		>25%	0
Agricultural soil	3	Not agricultural soil	5
		Normal farmland	2
		Prime farmland	1
LUP 3: office/retail			
		Central city	5

Wind direction	1	Lowest wind	1
		Lower wind	2
		Higher wind	3
		Highest wind	4
Historic site	3	Inside historic site	5
		<1000	4
		>1000	3
Land type	2	Build up	4
		Non build up	5
		Slide land	0
Slopes	2	<10%	5
		10%-25%	1
		>25%	0
Agricultural soil	3	Not agricultural soil	5
		Normal farmland	2
		Prime farmland	1
LUP 4: green space			
Wind direction	1	Central city	5
		Lowest wind	1
		Lower wind	2
		Higher wind	3
		Highest wind	4
Historic site	2	Inside historic site	1
		<1000	3
		>1000	3
Land type	2	Build up	1
		Non build up	1
		Slide land	5
Slopes	3	<10%	1
		10%-25%	5
		>25%	5
Agricultural soil	3	Not agricultural soil	1
		Normal farmland	4
		Prime farmland	5

Table Annex 5 Suitability scores behind suitability scenarios

Suitability LUT	Suitability Categories	Suitability scenarios			
		PRESERVATION Scenarios		DEVELOPMENT Scenarios	
		Suitability scores	Hectares	Suitability scores	Hectares
Residential (LUT1)	Not developable	NA	51.5	NA	51.5
	Not convertible	NA	0	NA	0
	Not suitable	NA	852.8	NA	852.8
	Low	1.0 TO 15.0	0.0	1.0 TO 12.0	0.0
	Moderately low	16.0 TO 30.0	0.0	13.0 TO 24.0	0.0
	Moderate	31.0 TO 45.0	612.3	25.0 TO 36.0	166.4
	Moderately high	46.0 TO 60.0	438.2	37.0 TO 48	884.2
	High	61.0 TO 75.0	0.0	49.0 TO 60.0	0.0
Industrial (LUT2)	Not developable	NA	51.5	NA	51.5
	Not convertible	NA	0	NA	0
	Not suitable	NA	988.9	NA	988.9
	Low	1.0 TO 15.0	0.0	1.0 TO 12.0	0.0
	Moderately low	16.0 TO 30.0	0.0	13.0 TO 24.0	0.0
	Moderate	31.0 TO 45.0	32.07	25.0 TO 36.0	220.3
	Moderately high	46.0 TO 60.0	512.7	37.0 TO 48	613.0
	High	61.0 TO 75.0	0.0	49.0 TO 60.0	0.0
Office/retail (LUT3)	Not developable	NA	51.5	NA	51.5
	Not convertible	NA	0	NA	0
	Not suitable	NA	832.6	NA	834.9
	Low	1.0 TO 15.0	0.0	1.0 TO 12.0	0.0
	Moderately low	16.0 TO 30.0	78.9	13.0 TO 24.0	156.4
	Moderate	31.0 TO 45.0	706.4	25.0 TO 36.0	981.7
	Moderately high	46.0 TO 60.0	204.3	37.0 TO 48	19.1
	High	61.0 TO 75.0	0.0	49.0 TO 60.0	0.0
Conservation (LUT4)	Not developable	NA	51.5	NA	51.5
	Not convertible	NA	0	NA	0
	Not suitable	NA	0.0	NA	0.0
	Low	1.0 TO 15.0	156.4	1.0 TO 12.0	658.6
	Moderately low	16.0 TO 30.0	802.2	13.0 TO 24.0	601.6
	Moderate	31.0 TO 45.0	157.3	25.0 TO 36.0	813.1
	Moderately high	46.0 TO 60.0	706.3	37.0 TO 48	0.0
	High	61.0 TO 75.0	0.0	49.0 TO 60.0	0.0