Land for the Dead

Locating Urban Cemeteries, Case Study Guilin, China

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September 2004

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by

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Abstract

Cemetery is the place for institutionalised burial practice. Although burial land is of special meaning and importance to people, both the dead and the living, yet cemetery planning has long been ignored. The cemeteries capacity may be not enough to meet the increasing demand due to the fast increase of population, and the indiscriminate placing of cemetery sites arise many conflicts between burial land and other kind of land use because of its particular characteristic. The lack of planned and affordable land, which is the basic component of cemeteries calls for the responsibility of urban planners to address the problem before the situation slips irretrievably out of control.

This problem frames this research. The north part of urban Guilin city in China has been chosen as a case study area. A comprehensive review of burial practice is carried out in order to determine the elements involved in cemetery planning. Existing situation in the case study area is assessed to define the burial needs and requirements. As cemetery planning concerns both practical and immaterial issues, problem is taken into account with a structured criteria system consist of institutional, environmental, social and cultural aspects.

To address a difficult urban planning work of this kind, a conceptual model is established, using a GIS-based decision support system to perform a multiple criteria analysis to support design and choice phase of locating urban cemeteries. The system supports the decision-making process in both designing the alternatives and making the choice. A particular form of sustainable development for cemetery location is analysed according to the special character of burial land. During the course, spatial-temporal analysis is carried out between three scenarios of different time based on the land use master plan of the study area in order to ensure a sustainable suitability of the alternatives for the sake of future development. Advice is given to the plan on the direction of urban expansion from a point of cemetery location. Alternatives are evaluated by both rational and emotional consideration in order to fulfil demands coming from various aspects. Sensitivity analysis is also carried out for the decision of which sites to develop and suggestions are given to future development and construction after analysing the result. Potential alternatives are ranked and suggestions have been given on how to deal with shortcomings after evaluated the choice. Recommendations have been presented for further works. Research shows special as burial land is, the planning procedure should be comprehensive as other kind of land use. Although based on current situation some limitations could not be totally avoid, this should not reduce the credibility and validity of the underlying planning theory and methodology recommended herein.

It can conclude that the GIS-based multi-criteria decision analysis is useful when locating suitable urban cemeteries. The attention paid to cemetery planning is valuable for development of both lands for the dead and for the living.

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1. Introduction

"THE earth is one vast burial ground. Even the chalk deposits favoured by the early cave dwellers are composed of countless millions of primitive forms of life deposited in the dark morning of creation."

Bertram S. Puckle, 1926

In this chapter, general information about the research will be given, including the background, problem statement, research objectives, research questions and research workflow, research scope and thesis structure. Background mainly introduces the burial and cemetery along with cemetery management and planning, and this will be further explained in chapter 2; research problem briefly describes the problems brought by the shortage of burial land and unreasonable location of urban cemeteries; research workflow gives a general framework of the research methodology and will be further discussed in chapter 4.

1.1. Background

1.1.1. Burial

Burial, the placement of human remains in grave, is of special meaning and importance to people, both the dead and the living. With ethic intention and following traditional custom, the system of burial is tied to the perpetuity of sepulchre and the conservation of the burial lands. Along with the step of anthropic history, the evolvement of superstitions, religions and customs, without exception, adorned these lands with a mysterious veil.

The research of the effect of burial is a concernful facet of sustainable development. Acknowledged or not, the living people pay a great deal on funeral and interment every year. Taking China for example, there are approximately 8 million people die each year, 5/8 of which are inhumed and 3/8 are cremated. The disposal of human remains consumes over 10 billion RMB, $4x10^6$ m^3 wood and $6.67x10^7$ land per annum (Zhou & Yang, 1998; CAOG, 2001). Some scientists have calculated that the area of Chinese burial lands needed in 10 years equals to the whole domain of a Singapore (Wen & Zhou, 1999).

1.1.2. Cemetery and its Management

Webster's *Third International Dictionary* defines a cemetery as:
An area for burial or entombment…any burial ground, typically a large one: a graveyard.

Civil Affairs Ministry of China defines cemeteries in *Temporary Measure of Cemetery Management* (Civil Affair Code 24 of 1992) as:
Communal facilities to inter cremated and/or uncremated human remains for urban and rural area residents.

Cemeteries have expanded with growing population. Whereas hundreds of years ago people were typically buried in a churchyard, graveyard, or lovely and suitable spot "in the ten-thousand-years'

felicitous ground" consulted by soothsayers, today the choices are a public cemetery owned and operated by a governmental entity, or a private cemetery owned and operated by either a profit or a non-profit corporation. Along with this development has been the formulation of the laws governing all types of cemeteries (BOE, 1983).

In many countries, management and construction of cemeteries is a matter for the local authorities, but central authority gives the main lines (Santarsiero et al, 2000). Since land is the most important component in cemetery construction, public authorities have to offer legal land alternatives for cemeteries. By this way they can guide urban growth and reduce the problem inherent in relying an illegal developments.

1.1.3. Cemetery Planning

For whatever reason, issues that are related to death become issues that are not discussed. Accordingly, the adequacy of cemetery planning is an issue which is irregularly reviewed and consequently, non-responsive to societal changes (Brackenreg, 2000). This attitude toward it is irresponsible and dangerous given the evidence that documents increasingly aged population in opposition to diminishing burial capacity. Governments and other planning authorities recognise the low profile that cemetery land has and observe that issues like cemetery planning which are irrevocably connected with death, are seen by the general public as taboo subjects. Such negative associations to cemeteries and their planning thereof are fed by irresponsible media reporting. From this, the general public overlooks the importance of body disposal and memorialization functions which cemeteries serve and instead, focus on the negative cemetery attributes. The challenge for the State Government and town planners is to overcome these negative restrictions and promote the need for adequate cemetery planning. For this to happen, we all need to be convinced that cemeteries are worthwhile places, and that they are extremely valuable in terms of their heritage, multicultural and multifunctional components.

In urban planning environment, cemetery is within the municipal utility of land-use classification, although seldom has it been included in the land-use plan. There are so many characteristics distinguish it from other facilities and infrastructures. There is no other ones carry cultural and historic significance like it, and its ethic and preservative function makes it a forbidden zone to be replaced or removed--so comes the saying "moving a graveyard" to describe a tough and thankless job. What's more, there is seldom any other has the similarity that its capacity of service has so direct causal nexus with its land tenure.

To build a cemetery is somewhat easier comparing with locating a reasonable cemetery since the cemeteries do not only figure out the burial place of the dead, but also react the dwelling space of the living from various aspects. Cemetery planning should concern social, institutional and technical perspectives and has close relation with many studies including history, sociology, psychology, legislation, economics, ecology and urban planning. All these bring many factors that need to be taken into account.

Hardly scholarly work can be found on cemetery location planning. In order to supply suitable land for cemetery development, spatial planning should be carried out. Spatial planning can be defined as the activity of making a compromise between terrain capacity and people's desire (Tanrikulu, 1999). To make better decision about future development, considerations on many issues like policies, economy, environment, social needs etc. should be evaluated.

These issues frame this research. The research will first review the cemetery planning from different perspectives and then a computer-based decision support system will be adduced to find suitable areas for the cemetery needs through a case study of Guilin City in China.

1.2. Problem Statement

The problem of shortage and unreasonable location of burial land arises in countries where there is a high density of built-up areas, customs of disposing of the dead by inhumation, a lack of available and suitable soils to designate as burial grounds. There is no comprehensive body of legislation dealing with this matter since some countries have no-space limitation for existing cemeteries or difficulty finding new suitable areas for the disposal of human remains. Many problems arise in countries that do have a shortage and unreasonable location of burial land, which is described as "scramble of land between the dead and the living" by some socialists (Zhou & Zhao, 1998).

1.2.1. Shortage of Burial Land

Widespread use of old individual burial (in vaults lined with burial niches) and family tombs (in private tombs having one or more spaces for bodies) has brought about the adoption of a burial system strongly dependent on the conservative burial in tombs and burial graves (Santarsiero et al, 2000). Even the management of modern cemetery is commonly based on a long rotation time of tenure system (for example, 20 years in China but actually the period is much longer) that brings a large scale of accumulation of burial land. Along with this, some traditional and religionary burial customs have priorities, or even doctrine disposal method of human remains, which generally appear to be inhumation--the most land-consuming one among all. There are also some particular traditional philosophy and technology on site selection, such as Feng Shui (geomantic omen). According to principles of them, people tend to have preference and taboo on landform and surroundings when locating cemeteries (Han, 2001). All these contribute to the difficulties in finding satisfying burial land. The rigidity and rigor of the system and poor alternative solutions have led to an insufficiency of burial areas and/or a supply of burial graves insufficient with respect to the demand for them.

The population growth and age structure change make the situation even urgent. Taking China for example, until 1995 the total population has increased to 1.2 billion, and is still increasing at a rate of 1.5 million annually. The aged people (above 60 years old) have increased to 117 million and will reach 370 million in 2040, counting to 24.8% of the total population. At the same time, the arable land per person in China amounts only 1/4 of the world average. The effect of high population growth and ageing problem that contributes to a potential demand of burial land, along with the current shortage of available land raises an urgent alarm (Zhou & Yang, 1998).

The shortage of burial land is not an exceptional problem occurs in China or developing countries but a popular one even in developed countries. The lack of available space for the disposal of human remains in cemeteries may worry city authorities and local health authorities, especially in medium-large cities, which are encountering difficulties in providing burial sites. The delay between the increasing demand for burial and the supply of available burial sites may lead to serious conditions also from a hygienic and sanitary point of view. Serious problems may derive, for example, from the temporary storage (ranging from 2 or 3 days to several weeks) of coffins awaiting final burial (Santarsiero et al, 2000).

So-called “pre-need” buying, which is buying one’s own gravesite during his lifetime--although is legal in some countries and viewed as a source of profit to the funeral industry--proved to be popular and form an odd scene of “burial ground of the living”. Sometimes even scare buying of gravesites occur because of rumour preaching the insufficiency of burial land, which bring on panic in society (Hu, 2004).

1.2.2. Unreasonable Location

Firstly, as the environmental problems that may be caused by burial, unreasonable location of cemeteries may bring much harm to living people. Environmental problems due to urbanization have changed things over the last decades in the field of cemeteries and burial grounds (Santarsiero et al, 1998). Today, cemeteries that in the past were located on the out skirts of the town happen to be in the middle of the town, because of the expansion of the towns and because of the lack of new suitable areas to designate to cemeteries and burial grounds (Santarsiero et al, 2000). Many inconsistencies occurred between the burial land and other kinds of land-uses.

In China, the location of urban cemeteries nowadays mostly follows the old burial areas in ancient time without further unification and planning. Some cemeteries locate in important tourist regions or central areas, demolishing the scene and image of cities (Wen et al, 1998). Some cemeteries become so close to the sprawling area of living people that the residents complain that they do not want to be the “permanent cemetery guards”(Zhang, 2001).

From a hygienic and sanitary viewpoint, Santarsiero (2000) concludes the inconveniences potentially tied to this type of burial, which must be prevented are: (1) pollution of the water-bearing stratum with products from the decomposition of the body due to chemical and microbiological processes; (2) air pollution caused by gases produced during decomposition; (3) spread of infectious diseases. Research shows that poorly sited cemeteries pose a threat of groundwater pollution, at least equal in magnitude to that posed by conventional waste-disposal sites (Fisher, 1992). In many cases, the microbiological organisms brought by cemetery leachates may contaminate the groundwater, posing serious health hazards to those who use or come into contact with this polluted water (Fisher, 1994).

Secondly, unreasonable location of burial land also acts on degradation of cemetery running. Take China for example, the management of the cemetery is based on a 20-year rotation interment system in the common cemeteries, after which buried cadavers are exhumed in order to recover the sites for new burials if the relation of the decedents do not pay for the rent of the next rotation, and the duration of the time of recovery is much shorter in some other countries (eg. only 10 years in Italy). Research shows that the hydrogeological characteristics of soil play a leading role in the establishment of the climatic characteristic of the environment surrounding the corpse in decomposition. Use of inappropriate spaces from a climatic point of view may in fact lead to the flowing back of gases as well as liquids generated during the process of decomposition of bodies and cause a high percentage of non-decomposed bodies at the expiry of their burial (Santarsiero et al, 2000).

Last but not least, ill-considered cemetery location may result in social problems. Some cemeteries are planned based on common intelligence and criteria like other kinds of utilities, taking it for granted that it’s a totally practical and technical job and ignoring the psychological and cultural aspect of people’s need. Dissatisfied on the location of burial sites, some people then tend to pay their own sooth-

sayers to select their private burial sites even at a very high cost. And this, once again, adds to the chaos of location of burial land, forming a vicious circle.

1.3. Research Objectives

1.3.1. Main Objective

The main objective of the research is to develop a GIS-based decision support model to find appropriate locations for urban cemeteries.

1.3.2. Sub-objectives

1. Analyse the common practice related to cemetery planning and the burial need of the study area (Intelligence Phase).
   - Explore cemetery-planning practice from difference perspectives.
   - Review the Decision Support System and Multiple Criteria Decision Analysis.
   - Assess the burial situation in the study area.
2. Develop a proposed plan of land allocation for urban cemeteries (Design Phase).
   - Develop conceptual model to identify suitable land for urban cemeteries.
   - Use a GIS-based Spatial Decision Support System to perform a Multiple Criteria Decision Analysis to locate urban cemeteries.
3. Apply the approach in the study area and choose the suitable sites (Choice Phase).

1.4. Research Questions

1. How to identify the elements of urban cemetery location planning?
   - What perspectives should be taken into account in common cemetery planning?
   - What is Decision Support System and Multiple Criteria Decision Analysis
   - What is the existing burial situation and need in the study area?
   - What are the local factors (criteria) to be considered?
2. How to design a plan to locate suitable land for urban cemeteries?
   - How can we develop the planning model according to its character?
   - What special characteristics should software have in order to run the model?
   - What are the weakness of this model and how it could be improved?
3. What could be done to improve decision on cemetery site selection?
   - How to select most attractive sites from alternatives?
   - What could be done to improve the reliability of the result obtained?
   - What recommendation can be given to the plan of the study area?

1.5. Research Conceptual Framework

The three major periods in this study are *pre-fieldwork* activities, *fieldwork* activities, and *post-fieldwork* activities. In pre-fieldwork activities the theoretical background of cemetery planning will be explored by literature review, and the proposal guidance for future study is developed during this period. Based on the considerations beforehand, the required data will be identified and collected during fieldwork activities. After that, detailed analysis is carried out according to the collected data by applying the model designed to support the decision-making process for locating urban cemeteries, and will receive desired outcomes within post-fieldwork activities. Figure 1.1 illustrates activities carried out in the research.

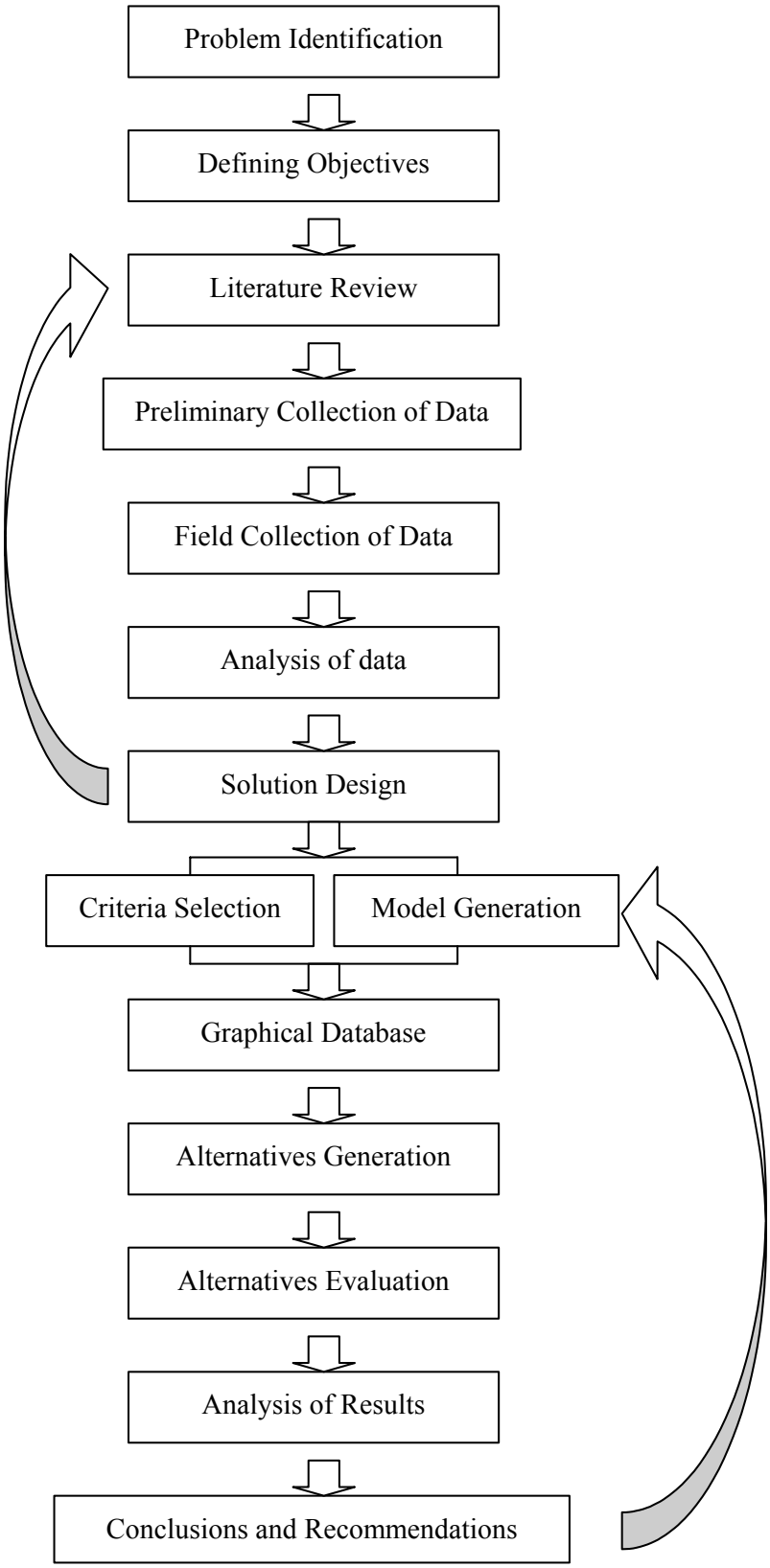


Figure 1.1: Research Conceptual Framework

1.6. Research Scope

There is no single solution that can settle the problems stated in this chapter, because they involve technical parameters as well as people's shifting value considering the burial practice. The purpose of the research is to determine right place for urban cemeteries through location planning approach. Although it will based on some local conditions such as policy, environment and culture in the planning and decision process, and the result of research may be reference and recommendation to policy maker, it is beyond the domain of this research to affect or change the these conditions which form the planning circumstance.

Since this research for this thesis will describe and consider some common information and practice on cemetery planning and investigation, it should be note that the regulations regarding funeral and cemeteries are notably different between countries, regions and nationalities. Even in China, the local political, environmental and social condition affecting cemeteries will vary from one community to the next. Nevertheless, the general nature of this research should have universality and be applicable for all jurisdictions across the field of urban planning.

1.7. Structure of the Thesis

Chapter One: Introduction
This chapter gives a brief introduction of the topic, including a general background, problem statement, research objectives and questions, research conceptual framework and research scope.

Chapter Two: Literature Review
This chapter gives an overview of the cemetery planning. Firstly it outlines the issues need to concern in cemetery planning from institutional, environmental, and social-cultural perspectives. Secondly, the definition and elements of decision support system and multi-criteria analysis are briefly explained.

Chapter Three: Existing Situation Analysis
This chapter describes and analyzes the existing situation of the study area. It includes a general overview, background of urban development and planning. Special emphasis is given to the burial situation of the city in order to define the burial needs of the study area.

Chapter Four: Methodology
This chapter includes the research methodology, which starts with the model generation with GIS analysis and multiple criteria evaluation methods for finding suitable areas for urban cemeteries. The data, materials needed in order to run the model as well as variables and techniques used in the approach are also presented. A step-by-step explanation is introduced which can strengthen the understanding of the concept of MCE analysis in this location problem.

Chapter Five: Results and Discussion
This chapter explains the results of the case study as an implementation of the model designed. A discussion is carried out during the course of generating the results.

Chapter Six: Conclusions and Recommendations
The research is finalized with the main findings in the previous chapters. An outline of opportunities in further research is given based on the result of the research.

2. Literatures Review

Two main parts are discussed in this chapter. In the former, it outlines the issues that need to be considered in cemetery planning from institutional, environmental and social perspectives. Firstly, from institutional perspective, policy interventions for the provision of land for urban cemeteries are reviewed, and cemetery business are briefly introduced in order to study the economic factors. Secondly, from environmental perspective, primary physical characters of cemetery and its ecological impact on human and nature are defined. Finally, the impact of cemetery location planning to urban development are explored from social perspective and the psychological implications of cemetery are analysed along with funeral customs, which make up the role to fulfil people's psychological and ethical needs from cultural perspective. Special attention is given to planning issues in China. The latter part of this chapter deals with the application of multiple criteria evaluation (MCE) concepts and methods to support decision-making process. Decision-making process and decision support system, MCE and spatial multiple criteria evaluation (SMCE) are introduced in this part.

2.1. Cemetery Planning Perspectives

Countries, which have space limitation for existing cemeteries or difficulty finding new suitable areas for cemetery planning have to re-examine all the systems of disposal of human remains and all the parameters involved in the process of the bodies decomposition (Santarsiero et al, 2000). It is a very difficult question to single out possible solutions because they involve technical parameters as well as a new way of considering the burial. In order to get a comprehensive idea of this ever ignored and almost undeveloped field in urban planning, cemetery planning is reviewed from different perspectives.

2.1.1. Institutional Perspective

Unlike in ancient days when burial land was largely or totally determined by customs or religions as will be mentioned in later words, today, many of the cultural traditions that were once part of our community and family have been institutionalised and commercialised. "Just as we have allowed the medical profession to institutionalise what is a natural experience at birth, we have allowed the funeral industry to commercialise a natural experience at death (Marika, 1996)."

2.1.1.1. Policies Aspect

Legislation Concerning Cemetery Planning

Most countries have their own policies on funeral and cemetery management, but seldom have any given special items for cemetery planning. Thus lack of norms in legislation, which brings lack of essential knowledge on them for urban planner, has aroused difficulties in developing the location planning for urban cemeteries. This makes it essential to extract those useful ones as the conditions in cemetery planning:

- The methods of human remain disposal: This is basic information resulted from institutionalised customs and related to the environmental and social impact of cemeteries as different type of burial will lead to its coordinate demand on physical/ chemical characteristics of land and the their contaminative effect will determine the minimum safety distance between the cemetery and the buildup areas;

- Number of cemeteries: Directions on how to size up the burial grounds in the construction of cemeteries to face the burial demand and on the other hand, avoid redundant land be lying idle for burial;

- Location of land use for burial purpose: On one hand, polices often give constraints on places where burial is not permitted in order to ensure the well-balanced land use pattern. On the other, as cemeteries may cause pollution, demolish urban scene and arise psychological impression, forbidden zone should be lined out for burial land and geological and hydro-geological characteristics of soil used as burial grounds may be pointed out;

- The principle and rules on cemetery management: Limits on size of graves, expiry of land utilization (the minimum time/rotation time of the disinterment system after which an operation of exhumation is permitted) related to cemetery capacity and business issues related to economic factors.

In many countries, central government gives guidance on national standards and oversees their implementation but is not directly involved in planning and policing burial grounds. In China, the Ministry of Civil Affairs in the State Department is in charge of the funeral and interment management of the country and local offices of civil affairs take the charge of local management. The planning of cemetery should first be examined by government and civil affair bureau of the city or county and then approved by the government and civil affair office of the province or autonomous region (see item 3 and 8 of Decree no.225, 1997). It should be pointed out that in China cemetery is a kind of essential funeral service and disposal method in current stage. But in a long term, disposal methods that occupy less or no land are more encouraged, helping to achieve the strategic objective of sustainable development. Thus cemetery construction is only a transitional operation and not the direction of funeral reform (Civil Affair Code 132, 1998).

Former policies have given some general conditions on the planning of new cemeteries and/or on the expanding of existing cemeteries, which concern: the hydrological, geological characteristics and weather, traffic and infrastructures of the area and convenience for residents (see *Temporary Measure of Funeral Industry Management,* Civil Affair Code 50, 1983). Location on or near barren hills or sloping fields is suggested and some forbidden zones are outlined (*Temporary Measure of Cemetery Management*, Civil Affair Code 24, 1992).

This study has been carried out based on review of the law in force in China in the field of funeral and interment management-- *Chinese Funeral and Interment Management Ordinance* (Decree no.225, 1997) and local policies in the study area established according to it. As regulation accumulates over the years as the need arises, some other statutes are cited in various parts when they are applied,

Chinese Funeral and Interment Management Ordinance (CFIMO)

Six parts constitute the Decree no.225 of 1997. Chapter 1 includes the general principles; chapter 2 gives conditions on management of funeral establishment; chapter 3 prescribes the management of human remains disposal and beravement activities; chapter 4 regulates the management of funeral equipment; chapter 5 orders the penalty rules and chapter 6 is the supplementary articles. As we searching for the correlative ones mentioned above, we may regard the following items:

Item 2 of the Decree gives guideline of Chinese funeral and interment management as "Spreading cremation actively and gradually as reform to inhumation; saving burial grounds, demolishing undesirable customs and advocating civilized and economical beravement." Item 4 gives guidance on zoning regulation in delimiting the cremation and inhumation districts to local authorities: "in regions with high population density, lack of arable land and convenient traffic, cremation should be carried out; while in regions without conditions for cremation practice, inhumation is permitted." In principle, human remains should be buried in the district where the death occurs; further procedure is needed when carriage would happen. Item 6 grants the right for some minority nationalities and clergies to retain their inhumation custom (further explained by another supplement which has defined 10 minority nationalities-- Hui, Wei'wu'er, Hasake, Ke'er kezi, Wuzibieke, Tajike, Tata'er, Sala, Dongxiang and Bao'an, as the objects).

Item 10 forbids burial activities in: (1) plantation, woodlands; (2) urban parks, beauty spots, relic protection areas; (3) reservoir areas, embankment areas, water protection area; (4) roadsides of highways and railways. The illegal graves in these areas should be moved to cemeteries or cleared. Item 15 forbids inhumation anywhere other than in cemeteries.

We may find it a general one as much legislation work is assigned into the charge of local authorities, and there is no comprehensive body of articles in it dealing with cemetery planning--Item 7 and 11 designate that local authorities shall plan their own municipal funeral facilities such as cemeteries, crematoria, columbaria or cineraria. Local authorities should define the number, size of graves and expiry of land utilization of cemeteries based on funeral management plan and burial needs. It is believed that such functions are best carried out at a local level, where the local authorities should have the knowledge to determine. More information will be given in a circumstantial way on the local policies of the study area made according to this decree in the next chapter.

2.1.1.2. Economic Aspect

While cemeteries may be motivated as are other business by the expectation of profit, they are unique in many ways. Properly located cemetery land can generate a very high net return, but the average urban planners know little about their organization, operation, background, or the laws under which they operate. Our discussion of these topics is intended to provide the planner with a better understanding of cemeteries and to aid urban planners in reaching a realistic conclusion.

Funeral Industry and Cemetery Business

1. Development

The money earned by funeral merchants would not be tolerated if it did not meet a profound need for society. At the beginning of the nineteenth century an undertaker was a tradesman who provided coffins and no other service. By the end of the nineteenth century an undertaker might furnish a coffin, embalm, lay out the corpse, coordinate the funeral, and place the body in the ground. The undertaker called himself a funeral director as evidence of his expanded services (Lafleur-Vetter, 2000).

Privatisation of cemeteries has become very common in western countries, ownership of the cemetery can be legally transferred, in such cases, people may even buy a cemetery for investment purposes (Remsberg, 1992). Many of the modern cemeteries are characterized, therefore, by large land holdings for cemetery use, with a variety of services available to the public.

2. Type of cemetery

Cemeteries may be categorized according to ownership as being either public or private (BOE, 1997). Public cemetery is one owned and operated by the federal, state, or local government. Cities and counties have the power to dedicate certain public lands for public cemetery use. The district may maintain a cemetery limited in use to burial in the ground of residents of the district, or members of the family of a resident who has purchased a burial plot. The money required for maintenance of the district's operation is raised by taxation. Cemeteries controlled and operated by any religious corporation, church, religious society or denomination, or fraternal or beneficial associations are likewise subject to public cemeteries.

Private corporation may establish, maintain, manage, or operate a cemetery and conduct any or all of the business of a cemetery, either for or without profit to its membership or stockholders. Private cemetery owners may have some authority to regulate and operate their cemeteries. Some of these powers include the rights to regulate the size and shape of markers and monuments, to prohibit markers and structures upon any portion of the cemetery, to remove structures or plants and shrubs from the cemetery, to regulate the conduct of persons and prescribe rules and regulations for the cemetery's operations (BOE, 1997).

Generally speaking, cemeteries can also be sorted into non-profit and profit-seeking ones according to their operational modes. "Profit " does not refer to the financial benefit that accrues to a cemetery association through the sale of burial space at a price in excess of its cost, but means net earnings which accrue directly or indirectly to the benefit of the stockholders or members of the association.

3. Funeral business

Cemeteries that are organized for profit, it should be recognized, are businesses having the characteristics of other businesses, a management intent on producing a profit for stockholders, and salesmen working for a commission by selling a variety of goods and services.

Buyers, on the other hand, are offered choices and often make selections from a group of alternatives. The idea of even selecting a cemetery to be buried in is probably a relatively recent concept for most people, but having become established as an acceptable alternative, it was only logical that cemetery businesses should have developed a line of products for the public to choose from, such as above-ground or below-ground burial, a variety of caskets and funeral services, and a choice of pleasant surroundings to serve as the final resting place.

4. Chinese funeral business

The operation of funeral business should be reviewed for conformity with the requirements of the constitution of the country. *Temporary Measure of Cemetery Management* (Civil Affair Code 24, 1992) classifies Chinese cemeteries into commonweal and commercial ones. The commonweal cemeteries are those provide non-profit service in interment of human remains for villagers in rural areas; the commercial cemeteries are those provide profit-seeking service in interment of human remains for residents in cities and towns, falling within the service industry.

In China, like in many other countries, although a cemetery undertaker/corporation has some authority to regulate and operate their cemeteries, he does not have absolute control over its property. Munici-

palities and counties may, pursuant to their police powers, impose zoning and other regulations affecting them. Local governments may even go to the length of forbidding cemeteries altogether in places in which it may be reasonably supposed that a cemetery would jeopardize or injure public health, safety, convenience, or welfare.

Land Utilization

1. Cemetery capacity

As mentioned above, a municipal cemetery shall have such a capacity of burial sites to face the demand from resident population, but only a few works has done on how to determine burial need as to plan the capacity of cemetery land. What's more, the term "capacity " herein only indicates the physical area needed for burial and not taking chemical characters of soil--such as biodegradability in regard to the decomposition process of human remains, which will be discussed in later texts—as its catabolism "capacity".

Planning work should supply enough land for burial purpose and on the other hand, avoid a large and valuable area of ground being locked up and rendered profitless by its use as cemeteries and burial grounds. Since land is a sizable expense for the cemetery, maximizing grave sites is an important consideration. We will find that it is not unusual for graves to be mapped at 1,500 graves to the acre, with individual graves varying in size from 24 to 32 square feet. Above ground burial or entombment, of course, may far exceed these numbers, as caskets can be stacked 8 or 10 high in the typical mausoleum (BOE, 1997).

2. Improvements

A description of the cemetery business would be incomplete without mention of mausoleums and columbarium peculiar to interment use. A mausoleum (or so- called "walled-grave" in some countries) is a building used for the interment of uncremated human remains. The building contains crypts into which the remains are placed. Crypts are typically located above ground and in rows. The crypts are usually stacked six to eight high, and two deep, on either side of a corridor. The size can vary, but crypts 32 inches wide, 25 inches high, and 90 inches long are not uncommon. Outdoor crypts are a variation of the entombment concept. There are rows of crypts usually located around a particularly well-landscaped area within the cemetery. A columbarium is a structure or room that contains spaces used for cremated human remains; it is may also located within a mausoleum. The space used for placement of the urn is called a niche, and the act of placing ashes in an urn is called inurnment. This is generally the least expensive method of burial; however, the price of a deluxe niche can exceed that of either a crypt or a ground plot.

Many cemeteries are improved with a variety of miscellaneous buildings. For example, a complete, efficient cemetery complex may contain a mortuary, autopsy, crematory, mausoleum, columbarium, business offices, chapel, flower shops, casket-making shop, caretakers' residences and equipment sheds (BOE, 1997; Santarsiero 2000).

3. Calculation of land utilization

Generally speaking, a municipal cemetery plan shall be laid down on the basis of the average mortality-rate and the types of burial normally carried out in the last decades. Santarsiero (2000) suggested the capacity of a cemetery-plan be evaluated approximately by the following formula under the circumstance of Italian cemetery planning:

$$C = \frac{P \times m \times t \times i}{1000} + st + b + se + sre$$

Where: [C]= capacity (area required); [P] = population of the town which the plan belongs to; [m] = mortality-rate calculated on a statistics base expressed as per thousandth ‰; [t] = expressed as a number of years, and represents the time limit after which a buried corpse may be exhumed, before such a time limit it is considered an offence to disturb human remains. [i] = inhumation ≈3.5 m^2/corpse, space required by the inhumation of a corpse; [st] = space designated to small temples; [b] = buildings; [se] = space designed for epidemic events; [sre] = space designated to roads among the various devices and buildings inside the cemetery.

The above formula shows implications that the capacity of a municipal cemetery should depend on some local conditions such as type of burial, size of grave, religions etc. and no absolute universality exists in it. The calculation approach should be modified if these parameters vary. For example, if cremation is also applied, the calculation of areas for inhumation and cremation should be separated as the graves size are different and if improvements such as mausoleum and columbarium are used, the number of human remains should be subtracted from the total while the area of land held by mausoleum and columbarium should be added. In addition, if the cemetery management is based on a rotation interment system, which means burial sites can be reused after a fixed number of years, the recovery of burial sites should also be considered if the cemetery goes beyond an absolute accumulation stage of early years (see Section 3.4.4 for the example in the case study).

In the circumstance of the Chinese policy and planning norms, no guideline is given on the approaches above. The land utilization of the grave district (not including improvements) in a Chinese cemetery experientially should be approximately 1.5 times as large as the gravesites in order to provide sufficient land for service space (Kang and Kang, 1999).

4. Economic Cemetery Size

The size of a cemetery is very often limited by the non-availability of suitable conditions, especially in areas characterised by dense drainage networks and where shallow bedrock or shallow water tables are prevalent. However, from an economic point of view, a minimum-sized unit should be defined to justify an engineering geological or geotechnical investigation of this nature. Moreover, whatever the whole size of the cemetery may be, the area of the improvement part would not fluctuate much from one to another because the fundamental demand and service of them are relatively invariant. So a too small cemetery size should be lack of economic feasibility (Kang and Kang, 1999). Considering factors such as the cost and time spent, as well as the period before implementation, a minimum continuous of at least two to three hectare (20,000 to 30,000 square meters) is recommended for burial purpose (Fisher 1992).

Economic Cemetery Location

Owners of profit-seeking cemeteries, like the owners of other commercial enterprises, are motivated by income incentives. The income stream is neither uniform nor stable throughout the economic life of the enterprise. This is due to competitive and economic conditions as well as the promotional policies employed. Location is an important factor in cemetery value, since it affects plot prices and absorption rates. Occasionally a site is selected because it is economically unsuitable for other purposes (BOE,

1997). The selection of a site, however, is at times influenced by circumstances that have no relation to physical, aesthetic, and geographic requirements.

"Economic" factors in cemetery planning should indicate not only the issues related to the economic conditions of cemeteries, but also characters that may affect preference to buyers because of "economical" superiority. Attractions brought by them will have impact on the competition of cemeteries and again react the profit of the cemetery owner as a feedback.

1. Land value

Cemeteries can generate a high net return imputable to the land. If the supply and demand for cemetery land is favorable, we can expect an established cemetery to generate a higher net return than surrounding land.

Cemeteries are located in most types of use zones. Since they fulfill a social need, local governments find various means of bringing them within their zoning structures. These means include the issuance of conditional-use permits, the granting of variances, and special cemetery zoning. For this reason the value of a cemetery site may differ substantially from that of surrounding parcels (BOE, 1997).

Assessing cemetery land is a complex work for it may include appraisal work of land value, improvement value and depreciation etc. The improvements are relatively scarce and represent only a segment of an operation business. The three causes of depreciation--physical deterioration, functional obsolescence, and economic obsolescence are all applicable to cemetery property, but cemeteries generally suffer less from obsolescence than most other types of properties. Nevertheless, not like the value for residential, commercial or industrial land, the land value for burial purpose is always ignored by government and appraiser. Generally speaking, discriminative work should be done to profit-seeking cemeteries and non-profit cemeteries, and all three of the traditionally accepted appraisal approaches—the cost approach, the sales comparison approach and the income approach may be applied (BOE, 1997).

2. Landform

Gently rolling land with favourable subsoil conditions and natural drainage is ideal for cemetery usage. Undulating land offers the best advantage for effective and economical landscaping. Flat areas can be developed in a manner to neutralize monotony, but require greater expense (BOE, 1997).

3. Accessibility

Firstly, the spatial proximity will affect the impression of cemeteries to the family of the deceased. Occasionally, bodies will be returned 'home' to the ancestral lands of the deceased but in most cases families psychologically want loved ones to be buried near to them (Salisbury, 2002). Secondly, the proximity will affect the carriage cost of human remains and the traffic cost when visiting the gravesites for the residents, although these pragmatic issues have much less importance than the emotional ones. This will lead to order of attraction if there comes more than on alternatives in a region, which will also affect the profit of undertakers. Thirdly, in China, there is custom of Gravesweeping festivals (see Appendix A; Teather, 2001), which are the routine times for families to visit and tidy their forebears' cemeteries. In this condition, the traffic should have enough capacity for mass troops.

On the other hand, some critics have claimed that the modern funeral industry charged with the tasks of caring for the dead has made decisions that "puts the needs of mowers before the needs of mourners (Sloane, 1991)." In keeping with this criticism, many people find the focus on automobile accessibility and expansive road systems detrimental to a tranquil setting.

2.1.2. Environmental Perspective

There are various issues of cemetery related to environment. Here they are classified to two categories: "physical aspect" mainly contains those concerns physical characters a cemetery should have for the sake of well-balanced running; "ecological aspect" mainly concerns those related to its contaminations to surrounding environment. However, to allow this to happen it is necessary to increase our understanding of the physical, chemical and microbiological processes occurring within a burial ground.

2.1.2.1. Physical Aspect

Demand from Cemetery Construction and "Perpetual care"

Traditionally, the demand to physical characters on land from cemetery construction is of much less causticity compared with those for the living. But as there comes the trend of modern cemetery business and variety of funeral service, many memorials along with improvements and buildings, which has been mentioned in early words, also becomes necessity of a complete, efficient cemetery complex. On the other hand, the aim of burial is to allow the family to remember their dead through the preservation of the remains, so system of cemetery is tied to the perpetuity of sepulchre and the conservation of the coffin and the burial site. As the cemetery maintenance scheme calls itself "perpetual care", to the lowest extent, it should ensure the stability, safety of the gravesites preservation. In this sense, some of considerations needed in housing the living should also be followed.

Demand from Recovery of Gravesites

In many countries, the management of cemeteries is based on a rotation interment. As a result of burial, the corpse is subjected to the decomposition process that transforms the organic matter until it skeletonizes. Upon final mineralization, bones lacking in ligaments remain. According to the law of some countries where this system is adopted, exhumation is possible only after the interment period of time foreseen by the law which represents the minimum time necessary to obtain complete skeletrization of the corpse (bones completely disconnected) in burial grounds of a soil of given characteristics. Otherwise an exhumation could incur legal penalties (Santarsiero et al, 2000). Even there may be no articles on this by legislation, like in China, exhumation of undecomposed bodies will also cause hygienic problems. So if there are a high percentage of undecomposed bodies after the expiry of the interment period, the normal running of cemetery will be largely suppressed.

This course leads to a solution strictly depending on the process of decomposition that occurs within a given reactor, which is the coffin and its surrounding environment constituted by soil in the case of inhumation or by the mausoleum in the case of entombment and, a combustion chamber in the case of cremation. Since the reactor is to affect the microenvironment around the body in decomposition in such a way to increase the rate of reactions involved, the character of land used for burial as well as materials used for coffins or used for mausoleum play a leading role in the establishment of the climatic characteristic of the environment surrounding the corpse in decomposition. Thus, putting right these modified parameters for inhumation, as expected, the natural rate of the process of decomposition should be restored.

Many techniques and technologies, used in other fields may propose to affect the process of decomposition by means of physically, chemically-physically and bio-chemical mechanisms. As the material of coffin, construction of mausoleum and combustion chamber, which related to many technical aspects and require an involvement of various disciplines (engineering, geology, natural science, architecture, physics, and chemistry), could be topics to other specialists, urban planners in the case of cemetery planning should hold the responsibility to investigate and gather data from the characters of land. They may include: topography; soil parameters such as permeability and water content; climatic conditions such as sunshine, air, wind, rainfall and evaporation; furthermore, the high thickness of built-up areas on-site and off-site cemeteries may largely modify the microenvironment and microclimate of burial grounds, leading to stagnation of wastewater around the coffin that may negatively condition the occurring decomposition process of buried corpses (Santarsiero et al, 2000).

2.1.2.2. Ecological Aspect

Pollution from Inhumation

The process of decomposition in fact involves the following phases: gas phase; colliquative phase; skeletrzation; that give rise to gaseous, liquid and solid outflows. The biodegradation of a buried corpse and the purification of its liquid, solid and gaseous products depend on several factors including the environment surrounding the buried coffin. Recent research and investigation (Fisher and Croukamp 1993) reveals several pertinent facts:

- The impact of cemeteries on the environment has been neglected worldwide.
- Cemeteries pose a pollution threat far exceeding original perceptions.
- A significant number of existing cemeteries (>40%) contaminate our already beleaguered water resources.
- Microbiological pollutants (including bacteria, viruses and parasites) remain active within the water table at much greater distances from their source than previously speculated.
- Town authorities do not perceive cemeteries to be a significant source of pollution.

The perceived lack of interest and knowledge prevailing in this field by laymen and professionals such as town and regional planners, engineers and people in related earth science fields, further adds to this pollution problem. In many countries there is no legislation exists either to govern the location of cemeteries from the consideration of pollution (Fisher 1992).

1. Pollution to the Water-Bearing Stratum

Recent research has shown that poorly sited cemeteries pose a potential ground water pollution threat of at least equal magnitude, as that posed by conventional waste disposal sites. The scale and severity exceeds existing perceptions. A point has been reached where this problem must be addressed before the situation slips irretrievable out of control (Fisher, 1994).

Burial grounds with a high number (>500) of burial sites, especially when constantly used for new graves at the expiry of the turn-over of the interment system may give rise to pollution. The problem of the past focussed mainly on point sources and their effects close to the discharge points. Now the non-point source pollution and their effects in remote areas demand increasing attention. Considering that the soil includes the deeper strata of the subsurface and groundwater forms part of it, it is possible to retain that soil at the affected location may be seriously affected by pollution point sources represented by buried coffins. In fact the layer of soil, due to the products coming in through it, may become saturated and may lose its power of purifying. However, groundwater may be affected by both

point sources and diffuse sources that represent an important threat to the environment because of their widespread occurrence, since water flow is the main transport mechanism, bringing pollution to deeper soil layers, to the draining surface water and ultimately to the groundwater. Taking into account also the fact that groundwater in soil is not omnipresent, nor is it even flowing at a significant rate (Santarsiero et al, 2000).

Researches on the exhumed corpses and soil samples shows that the factors playing a role in the mapping of the vulnerability of the topsoil layers and the groundwater, affect the decomposition process of buried corpses as follows:

- Texture of the topsoil;
- Land cover;
- Net precipitation of rain;
- Thickness of unsaturated zone (see Santarsiero et al, 2000).

Preliminary results of research shows that permeability is of critical hygienic importance in relation to the purification of wastewaters in the soil by means of filtration process through the deeper layers and to the groundwater pollution (Santarsiero et al, 2000; Fisher 1992; see Section 4.3.3.2).

2. Air Pollution

The main gases from the decomposition process which give rise to odors are: aromatic amines, CH_4, H_2S, mercaptans, NH_3, and PH_3. To detain such gases it is necessary to cover up the buried coffin with a layer of soil of suitable thickness. A layer of soil 2 m thick is sufficient to detain gases from decomposition (Santarsiero et al, 2000).

3. Infectious Diseases

Cemetery sites contribute only a fraction to the overall groundwater pollution problem, but the nature of that pollution differs substantially to pollution emanating from conventional waste disposal facilities. In many cases, cemetery leachates may be more hazardous to health. Decomposing corpses produce a variety of pathogenic organisms, including bacteria and viruses. In a poorly sited cemetery, these microbiological organisms contaminate the ground water in the vicinity, posing serious health hazards to those who use or come into contact with this polluted water. Epidemics breaking out as a result of this type of pollution is a realistic scenario.

As reported in the literature (Pearson, 1970; Smith and Williams, 1984), it is supposed that burial procedures may affect the development of the micro-flora necessary for the process of cadaver decomposition. With regard to infectious risk, pathogens may be present in the corpse if it was an incubatory carrier. Some saprophyte anaerobic microorganisms of soil that cause the putrefaction of organic substances, may become pathogenic for humans if they enter the tissues through injuries exposed to the soil. The survival of microorganisms, both pathogens and saprophytes, in soil is limited (from approx. 2-3 years for some resistant spores to less than 4 weeks for cholera vibrio). To guarantee hygienic and sanitary protection, the coffin should be buried in soil at a depth not less than 1.5-2 m (Santarsiero et al., 2000; Fisher, 1992 suggested a depth at least 1.8 m).

Pollution from Cremation

The use of cremation as a main burial system reduces considerably the quantity of area required by burial as well as the measures for the protection of environment from a hygienic and sanitary point of view. In fact, the quantity of ashes from a cremation is approximately 600 g for a corpse of an average

weight of approximately 80 kg and, they are exempt from hygienic and sanitary inconveniences since they are a product of combustion process carried out at a temperature above 800 C^o and for a period of approximately 2.5 hours (Santarsiero et al, 2000). It may be argued that cremation as an alternative would solve the cemetery problem, but this would probably never appeal culturally to a sizeable proportion of the general population. Burial will remain the preferred method of interment, which further justifies a study in the direction (Fisher, 1994).

However, environmental and sanitary aspects are also related to the presence on the territory of cremation apparatus. The cremation apparatus (crematorium plants) is the core equipment in crematorium and usually adjacent to or inside undertaker's and cemeteries that may affect surrounding environment by outflowings during the cremation process. These contaminations include soot (the disposal of residues from devices of escaping gas filtration and treatment), SO_2, peculiar smell and noise, but they are usually limited in a distance of 500 meters from the crematory. Data from investigation shows that the pollution caused by cremation is insignificant compared with those from chemical plants, print works, iron and steel industry etc. But because it comes from the cremation process of human remains, people are hard to accept it psychologically (CAOG, 2001).

2.1.3. Social-Cultural Perspective

2.1.3.1. Social Aspect

Urbanization and Urban Expansion

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. At the same time, the share of land and population in rural areas declines.

Urbanization affects the physical shape of a region as well as the social experience of those who live there. The ways in which urbanization transforms a region depends on the nature of what occurs. Physical urban growth alters the natural and built landscape while population growth reshapes politics and culture. Urbanization may produce new urban spaces and livable neighbourhoods or destroy critical environmental features and important cultural resources (Pivo, 1996). The rate and pattern of urbanization are producing deep public concern over growth related problems and negative environmental consequences.

Burial Lands: Static Location and Self-Increase

People pay their respect to the ancestors' remains by not disturbing the burial land, thus cemeteries are lands carrying cultural, historic and ethic significance. Its preservative function makes it the last zone to be replaced or removed.

On the other hand, cemeteries have expanded with growing population. Even when the gravesites could be recovered after a rotation interment period, the increase of population will also give rise to the demand of new gravesites. So in countries with high population radix number and growth rate, such as China, this phenomenon will appear itself much more obviously.

Sustainable Cemetery Plan

Today, cemeteries that in the past were located on the out skirts of the town happen to be in the middle of the town, because of the expansion of the towns and because of the lack of new suitable areas to designate to cemeteries and burial grounds (Santarsiero et al, 2000).

With the steps of urbanization and urban expansion, many inconsistencies occurred between the burial land and other kinds of land uses. From an urban planer's point of view, the criticism of "scramble of land between the dead and the living", which has mentioned in the first chapter, may be to some extent paraphrased as the conflict of land use between static state and dynamic state. City and regional plans should be prepared in response to these conditions with the common goal of promoting more sustainable urbanization.

In the same way, the newly developed cemeteries also bear the possibility to cause environmental and social problems in later years. By examining all uses of land in an integrated manner, it makes it possible to minimize conflicts, to make the most efficient trade-offs and to link social and economic development with environmental protection and enhancement, thus helping to achieve the objectives of sustainable development (also see Section 4.3.4.3).

2.1.3.2. Cultural Aspect

Death creates a combination of transformations and changes of the physical body, social relations, and community balances. Death is a phase of transition involving loss and adjustment. The cemetery must satisfy the needs of the bereaved during different stages of grief (Salisbury, 2002). The cemetery is an integral part of the larger community, both in a physical sense and in a psychological sense.

Psychological Needs

In his bookmaking The Image of City, Lynch (1961) has proposed five kinds of image elements from the perspective of landscape sense: path, edges, district, nodes and landmarks. He pointed out that image is resulted from the interaction between environment and observer. The process of grieving often far outlasts the funeral services, with the bereaved requiring many months, if not years, to fully recover. In many cases the memorial and cemetery becomes an important tool in the recovery process (Salisbury, 2002).

1. Role of the Cemetery in Healing

The concept of a therapeutic environment has traditionally been used in connection with the treatment of illness. In recent years the concept of what constitutes as "therapy" has been broadened from its original meaning 'that which heals medically' to include "that which takes care of" or "makes whole again" (Salisbury, 2002). Berry (1992) investigated the cemetery as a therapeutic environment recognised three key attributes: physical environments, administrative environments and behavioural environments. It provides a focal point or acts as a substitute for the deceased allowing the bereaved to maintain a role with that person, gradually letting go and becoming less preoccupied with the memorial as they recover. One central feature of cemeteries is their claim to permanence and stability over time. The capacities of a memorial to physically endure time, or its apparent resistance to the effects of time are equated with the persistence of living memory.

A cemetery like similar planned open space creates a refuge where mourners can find attractive and natural surrounds, a place of soothing influence and solace. Howard Weed (1912) wrote, "the landscape features of the modern park and the modern cemetery are essentially the same, with green grass,

flowers, shrubs and trees so arranged as to produce harmonious effect, pleasing to the eye." The cemetery, by definition, is too unlike the broader surrounding landscape to be considered normal. It should provide and environment where death is placed within he context of larger natural life cycles, as a natural and integrated landscape may help to normalize death and grieving. The natural landscape of the cemetery may indeed provide a normalized therapeutic environment for the grieving (Salisbury, 2002).

2. Ambience and Sacred Places

Death signals a passage, and often forces us into a kind of spiritual awareness. The deceased go from the known to the unknown and from the seen to the unseen. Burial sites could well be seen as portals in a metaphorical sense. Because of this, cemeteries often evoke a sense of spirituality. There are many complications in studying and discussing spiritual landscapes. Human aesthetic response within the context of spiritual landscapes can evoke a sense of harmony, a sense of well-being, connectedness and unity, the beautiful, and the inspirational (Mills, 1992). There are layers of symbol and meaning above and beyond universal responses to environments that may also induce spiritual feelings. These layers are dependent more on cultural, historical and personal contexts beyond the scope of this paper.

There are however general characteristics that researchers into spiritual landscapes have noted. "A sacred space is an organized space. As an organized space the viewer, or site visitor, responds to it in particular autonomic way. That effect is one of the recognition of power, sacred power, a particular power of place (Mills, 1992)."

According to research, there are four characteristics important to the creation of a sense of place, or spiritual landscape. These include "the axis mundi (the focus of our attention or the goal of our approach), the approach itself (the directionality of our attention or how we get there), the boundary of the site (that space in its defined particularity), and the site's domain (its effect)" (Korp, 1997). The "axis mundi" provides a central focus and takes place visually as well as abstractly on a large scale. The sense of centre is both personal and individual. It implies a sense of front and back, the front is emotionally charged being considered positive or sacred the back relates to the negative and profane. Romantic cemetery design of the 18th and 19th century interpreted axis mundi in terms of vistas and views into the distance; a perception of being at the centre looking outward. Reaching the axis mundi is often accomplished by passing through doorways, gates or some other form of threshold area. The boundary of a sacred place is often 'set aside' from the earthly or profane. "Some sacred places are sites that appear to be enclosed spaces rather than being open or elevated. Our attention is often directed down, not up or inward, not outward when we enter the site (Mills, 1992)." An enclosed space suggests an entryway and an approach to the entryway or path. Path involves the notion of time; the implication of embarking on a journey, and temporally sets the sacred apart from the earthly (Korp, 1997).

Tradition and Custom

Understanding of former practice is essential for any planning works. For this reason, a comprehensive review of former burial practice has been carried out on the funeral customs and cemetery evaluation. For more information, see Appendix A.

The modern cemetery has developed over the last several hundred years in part, as a result of changing values and cultural identities. But "many combination of the modern and the traditional are to be found

in concrete social settings" and "even in the most modernized of modern societies, tradition continues to play a role" (Giddens, 1990). The exploration of funeral customs presented revealed that the tradition and customs has considerable durative, and many of our current funeral practice have their basis in long held tradition and customs.

As customs is a regional concept, special attention is give to Chinese funeral customs that would have impact on nowadays cemetery planning. Chinese cemeteries are obviously different those of western countries. Not like western modern cemeteries that could even become parks or recreational open spaces, Chinese cemeteries are regarded as dangerous places because they represent liminal spaces (Teather, 2001). They are places of tribute, as a material part of social history and of contemporary social fabric, "memory places", and as expressions of the geomantic relationship between humans and their physical world (Teather, 2001). The most significant element of the social systems in which these traditions are embedded is the Confucian practice of ancestor veneration. Also relevant are the beliefs (about non-material worlds) derived from Buddhism and Taoism and from the earlier popular religions, and the cosmology of Feng Shui. They have last for thousands of years and still have strong influence even for modern cemeteries. These important compositions of out culture will likely continue to impact our decisions and behaviors surrounding death. Adaptations of burial traditions should continue to honor these ancient customs in order to ensure success.

2.2. Decision Support System and Multiple Criteria Decision Analysis

2.2.1. Decision Making Process and Decision Support System

Framework for Planning and Decision Making

Decision-making is a process of generating an evaluating alternatives and choosing a course of action in order to solve a decision-problem. The management science adopts the view that mangers can follow a systematic process to solve problems. Therefore it is possible to use scientific approach to manage decision-making. This approach includes identification of problem or opportunity, gathering important data, building a model, experimenting with the model, analysing results and making a sound decision.

As can be seen from Figure 2.1, the three phases do not necessarily follow a linear path from intelligence to design and choice. At each phase there may be a return to a previous phase. This means that decision-making process may also be a continuous process, going back or forward to another phase. This is certainly the case in many ill-structured problems such as research and development in which normally a prototype product is first designed, developed and improved through iterations (Sharifi, Herwijnen, et al. 2004).

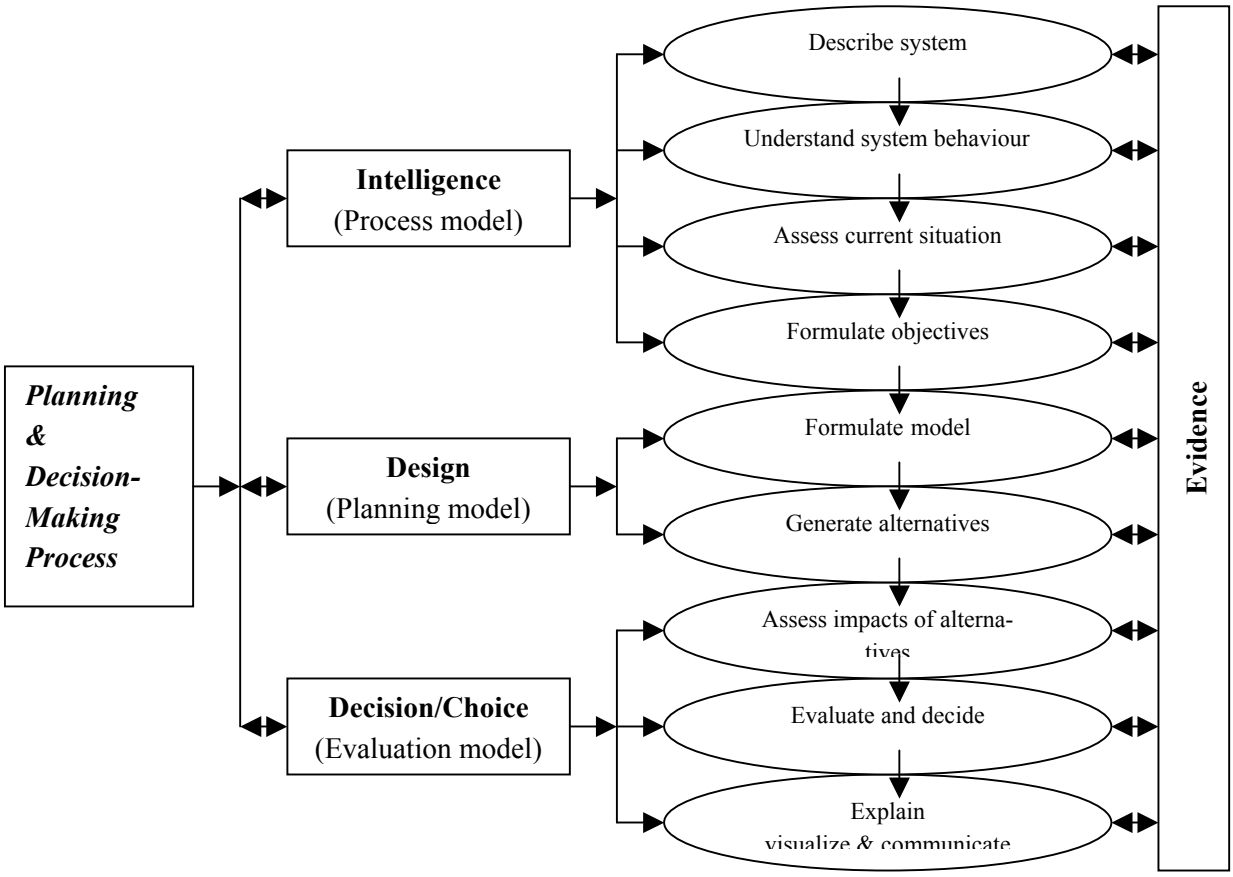


Figure 2.1: Framework for Planning and Decision Making Process

Decision Support System

Decision support systems (DSS) are a class of sub-systems of the management information system which support analysts, planners and managers in the decision making process. They can reflect different concept of decision-making and different decision situations. They are especially useful for semi-structured or unstructured problems where problem solving is enhanced by an interactive dialogue between the system and the user. Their primary feature is harnessing computer power to aid the decision-makers (DMs) to explore the problem, and increase the level of understanding about decision environment through access to data and models appropriate to the decision. They are aimed at generating and evaluating alternative solutions in order to gain insight into the problems, trade-offs between various objectives and support decision-making process (Sharifi, Herwijnen, et al. 2004).

To support solving spatial problems, GIS functionality and DSS have been merged to a powerful combination referred as Spatial Decision Support System (SDSS). It includes analytical techniques that are unique to both spatial and thematic analysis, and provides the user with a decision-making environment that enables the analysis of geographical information to be carried out in a flexible manner. SDSS should incorporate knowledge used by expert/analysts to guide the formulation of the problem, the articulation of desired characteristics of solution and the design and execution of the solution process.

2.2.2. Multiple Criteria Evaluation and SMCE

MCE and MCDM

In the opinion of Janssen (1994), "An evaluation method is any procedure that supports the ranking of alternatives using one or more decision rules. An evaluation method can generate:

-A complete raking: A>B>C>D;
-The best alternative: A>(B, C, D);
-A set of acceptable alternatives: (A, B, C)>D;
-An incomplete ranking of alternatives: A>(B, C, D) or (A, B)>(C, D);
-A presentation of alternatives."

He thinks an objective is a statement about the desired state of the system. Any attribute (factor) can be converted to a measurable quantity. The style is a kind of numeric value that reflects the degree to which a particular objective is achieved.

Multiple Criteria Evaluation (MCE) includes two methods (Prasad, 1999):
-Boolean overlays: in this, all criteria are reduced to a logical operator such as Intersection (AND) and Union (OR);
-Weighted linear Combination: in this, continuous criteria (factors) are standardised to a common numeric range, and then combined by means of a weighted average. The result is a continuous mapping of suitability.

The second method is used more often because it can reflect multiple aspects objectively ad completely. According to Prasad (1999), the general procedure of this method can be summarised as:

1. Selection of criteria;
2. Standardization of criterion scores;
3. Allocation of weights;
4. Applying the MCE algorithms.

All criteria need to be standardized and an appraisal score is calculated for each alternative by multiplying each standardized score by its corresponding weight, followed by summing of the weighted scores for all criteria. The final ranking of alternatives can be formulated as follow:

$$S = \sum_{i=1}^{i} \left(X_{ij} \times W_i \right), \text{ (i=1,…i; j=1,…j)}$$

Formula 2.1: MCE Algorithom

Where [S] represents the final score of alternatives. The higher the S, the better the ranking of the alternative. X_{ij} is the score of alternative j according to criterion i. W_i is the weight assigned to the evaluation criterion. Thus it can be showed that the final scores and ranking are affected by the standardization method (Section 4.4.4) and weights assigned and this method can provide a compete ranking and information on the relative differences between alternatives.

Colson and Bruyn (1989) define multiple criteria decision method (MCDM) as a world of concepts, approaches, models and methods to help DMs to describe, evaluate, sort, rank, select or reject objects (candidate, products, projects, options an so on) on the basis of evaluation (expressed by scores, values, preference intensities) according to several criteria. The main objective of MCDM is to assist the decision-makers in selection the best alternative from numbers of feasible choice alternatives under the presence of multiple criteria diverse criterion properties (Jankowiski and Richard, 1994).

Spatial Multiple Criteria Evaluation

Conventional MCDM techniques have largely been non-spatial. They use average or total impacts that are deemed appropriate for the entire area under consideration (Tkach and Simonnovic 1997). The assumption that the study area is spatially homogenous is rather unrealistic because in many cases evaluation criteria vary across space. The most significant difference between spatial multiple criteria decision analysis and the conventional multiple criteria decision analysis is the explicit presence of a spatial component. Spatial multiple criteria decision analysis therefore requires data on the geographical locations of alternatives and/or geographical data on criterion values. To obtain information for the decision making process the data are processed using MCDM as well as GIS techniques.

Spatial multiple criteria decision analysis is a process that combines and transforms geographical data (the input) into a decision (the output). This process consists of procedures that involve the utilization of geographical data, the decision maker's preferences and the manipulation of the data and preferences according to specified decision rules. In this process multidimensional geographical data and information can be aggregated into one-dimensional values for the alternatives. GIS and MCDM are tools that can support the decision makers in achieving greater effectiveness and efficiency in the spatial decision-making process. The combination of multi-criteria evaluation methods and spatial analysis is referred as Spatial Multiple Criteria Evaluation (SMCE) (Sharifi and Retsios 2003). SMCE is an important way to produce policy relevant information about spatial decision problems to decision makers.

An SMCE problem can be visualized as an evaluation table of maps or as a map of evaluation tables as shown in Figure 2.2.

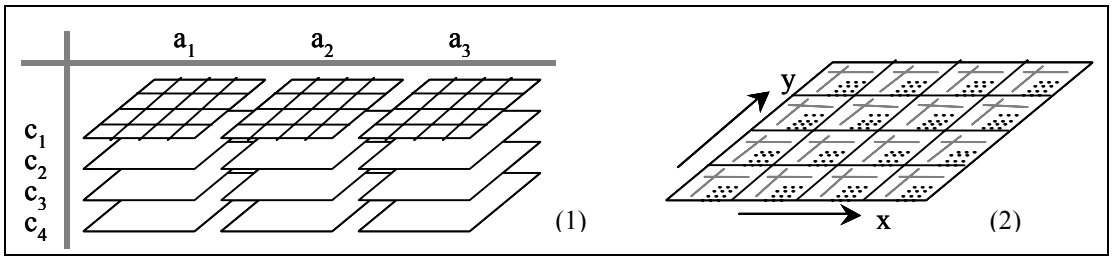


Figure 2.2: Two Interpretations of a 2-Dimensional Decision Problem (1: table of maps, 2: map of tables, after Sharifi, Herwijnen, et al. 2004)

If the objective of the evaluation is a ranking of the alternatives, the evaluation table of maps has to be transformed into one final ranking of alternatives. Actually, the function has to aggregate not only the effects but also the spatial component. To define such a function is rather complicated. Therefore, the function is simplified by dividing it into two operations: 1) aggregation of the spatial component and 2)

aggregation of the criteria. These two operations can be carried out in different orders, which are visualized in Figure 2.3 as Path 1 and Path 2. The distinguishing feature of these two paths is the order in which aggregation takes place. In the first path the first step is the aggregation across spatial units (here spatial analysis is the principal tool); the second step is the aggregation across criteria (multi-criteria analysis playing the main role). In the second path these steps are taken in reverse order. In the first case, the effect of one alternative for one criterion is a map. This case can be used when evaluating the spatial evaluation problem using so called "Path 1". In the second case, every location has its own 0-dimensional problem and can best be used when evaluating the spatial problem using so called "Path 2" (Figure 2.3). In this research, based on the characters of this two path, they will be applied in design phase and choice phase respectively. In design phase, a spatial evaluation (path 2) is carried out with ILWIS' SMCE module while the choice phase, a non-spatial evaluation (path 1) is done with DEFINIT.

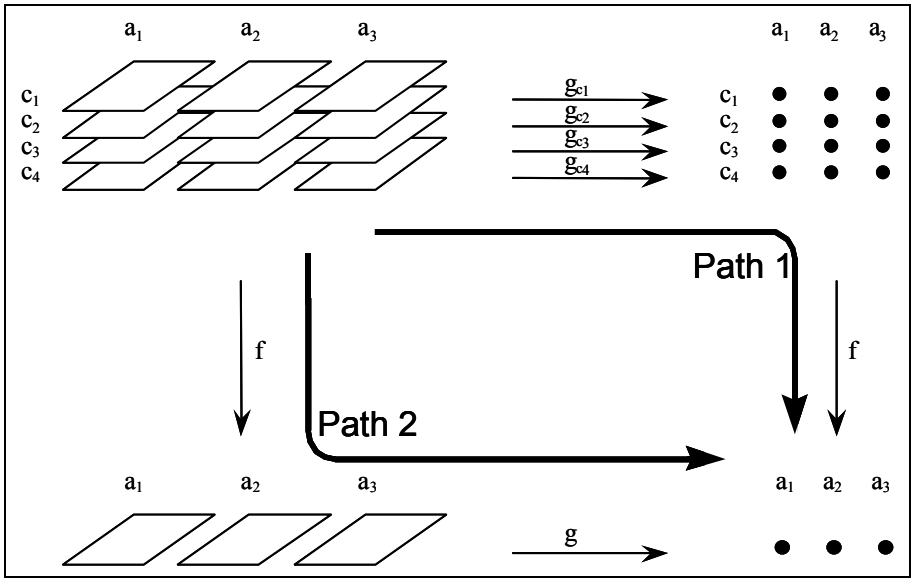


Figure 2.3: Two Paths of Spatial Multi-Criteria Evaluation (after Sharifi, Herwijnen, et al. 2004, for legend see Section 4.3.4.3)

3. Existing Situation Analysis

This chapter introduces the study area of this research, including the presentation of a general overview, background of urban development and planning, and current burial situation.

3.1. Justification of Case Selection

Guilin city is the political, economic and cultural centre of the north Guangxi province (Guangxi Autonomous Region of Zhuang Minority). It has a population of 4,876,190 until 2002, which mainly made up of 41 different Chinese nationalities such as Han, Zhuang, Yao, Miao, Dong and Hui (Source: Municipality of Guilin, 2003).

The scenery of Guilin has been called “the finest under heaven”. It is South China's shining pearl, with verdant mountains, elegant waters, magnificent crags and fantastic caverns. Its fantastic natural resource and long-history relic make it the most famous tourism city in China and has gained much world fame.

With the urban development, immense population pressure and custom of earth burial among some minorities have brought to Guilin shortage of land for urban cemeteries. Through investigation carried out by the Civil Affair Bureau of Guilin (CABG), there have been a large amount of random burial along with problems in existing urban cemeteries, which has greatly demolish the image of the city. This is the main reason for selecting Guilin as the case study area to apply the method developed in this research.

This situation also aroused governmental attention. In 2003, CABG accredited the Urban Planning and Design Institution of Guilin (UPDIG) to the project *Location Planning of Urban (Commercial) Cemeteries* in the study area. Although the project has not yet carried out by now because of lack of experience, method and technology, the forepart work such as data collection by the institution has settled foundation for the study. On the other hand, this research may also be a reference to the decision-maker of the planning project.

3.2. General Overview of Study Area

3.2.1. Location of Study Area

Guilin city is located in the northeast of Guangxi province, in the southwest of the Five Ridges and the west bank of Li River. It is bounded by 24°15′23″ to 26°23′30″ north latitude and 109°36′50″ to 111°29′30″ east longitude. Its administrative boundary includes five districts (urban area of Guilin)-Xiufeng, Diecai, Xiangshan, Qixing, Yanshan and twelve counties (suburban area of Guilin)-Lingui, Yangshuo, Lingchuan, Lipu, Yongfu, Quanzhou, Xing’an, Guanyang, Ziyuan, Pingle, Longsheng, Gongcheng. Guilin’s total administrative area is 27649 km^2, counting to 11.63% of the whole province (Guangxi Autonomous Region of Zhuang Minority). The total urban area of Guilin sum up to 565 km^2,

counting to 2.04% of the whole administrative area of Guilin city (Source: Municipality of Guilin, 2003).

The study is carried out as the same area as in the project *Locational Planning of Urban (Commercial) Cemeteries*, which is coordinated to the planned urban area of the city in the *Urban Master Plan of Guilin (2000-2010)*. The study area includes Xiufeng, Diecai, Xiangshan, Qixing districts and a part of Yanshan district. It sum up to 294 km^2, counting to 52.04% of the whole urban area. It is suggested by CABG that this area should planned for urban cemeteries to face the demand of the urban residents.

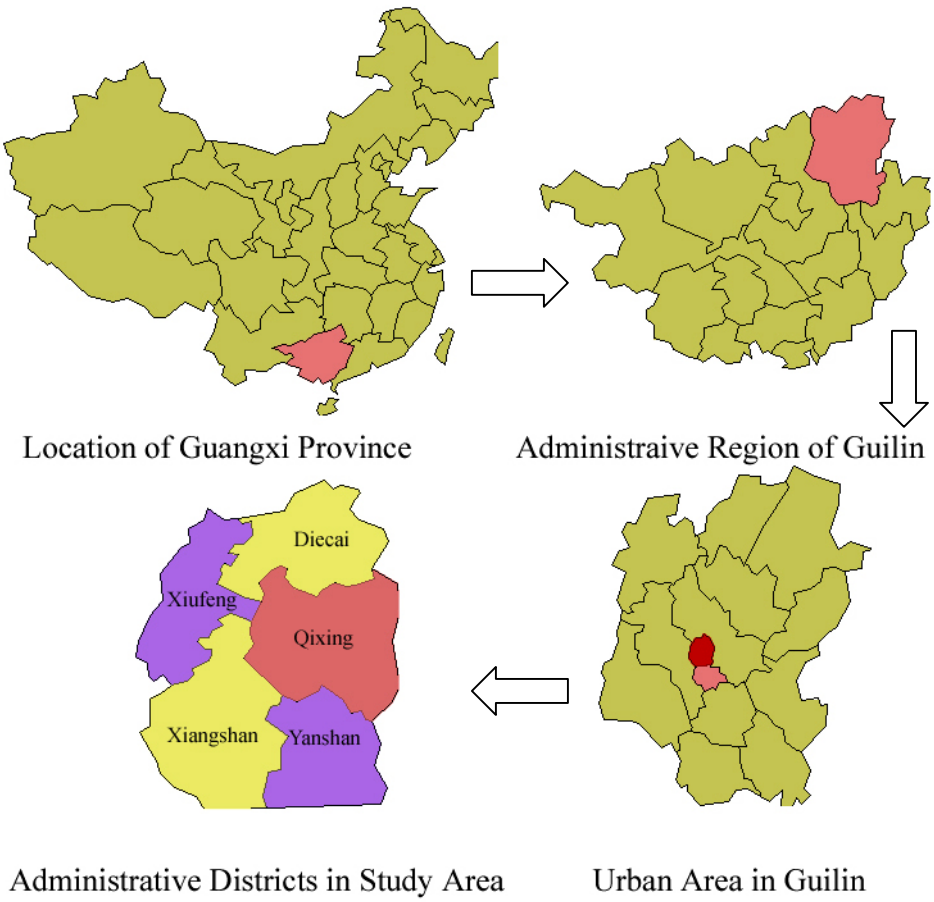


Figure 3.1: Location of Study Area

3.2.2. Historic Background

Guilin has a history of more than 2,000 years. In the 6th year of Yuanding During (111 B.C.) of the Han Dynasty, Guilin was a county called Shi An County in the reign of Emperor Wu. From the Song Dynasty (960-1279) to the Qing Dynasty (1644-1911), it became the political, economic and cultural centre of Guangxi and in the 5th year of Hongwu During (1372) of the Ming Dynasty, the city acquired its present name.

After the foundation of People' Republic of China in 1949, Guilin became a city directly under the jurisdiction of Guangxi Province. In August 1998 the State Department of China approved the foundation of new Guilin city of the consolidation of the five districts and twelve counties mentioned above.

Guilin abounds in historical sites. There are 6 national relic protection pots, such as the former residence of Li Zongren, office site of the Red Army, Mausoleums of Jingjiang Emperor, etc. Stone carving alone amounts to approximately 2,000 pieces (Source: Municipality of Guilin, 2003).

3.2.3. Physical and Environmental Characters

Climate

Belonging to the subtropical region, Guilin enjoys a mild climate of warm and rainy, plenty of sunshine, long frost-free period and clear division of four seasons. Its yearly average temperature is 16.5-20.0 C^{o}. The hottest month, August, has an average temperature of 28 C^{o}, while the coldest month, which is January and February is 8 C^{o} on the average. Du Fu, a very famous poet of Tang Dynasty so said of its climate: "When it is scorching hot everywhere around the Five Ridges, only Guilin has temperate weather."

Topography and Natural Resource

Guilin was originally a vast expanse of sea until about one hundred and ninety million years ago, when, owing to the movement of the earth crust, the whole area rose and became land. The Limestone, weathered and eroded by water, became today's fantastic stone forests, peaks, underground streams and caves, thus giving unique features to Guilin's scenery.

Guilin lies in the west part of Nanling Mountain, highland of Guangxi Basin. It is mainly made up of mountanious regions and plain. The mountains beyond altitude of 20000 m sum up to 50.41% of the whole area; hills with altitude between 250-500m equal to 8.97%; uplands lower than altitude 250m count to 5.39%, locating in mountain edges, river banks and around plains. Guilin has the purest and most typical karst formation in the world that makes up the fancy view of it. The mountains In Guilin, rising abruptly from the ground, stand in various stately shapes. Moreover, they have a great number of colourful caves in them. Lijiang River, a picturesque river well known both at home and abroad, is at its most beautiful starting from Guilin to Yangshuo, distancing 83 km. Winding her way amidst the mountains and through villages, the Lijiang River adds a great charm to the picture-like landscape of Guilin. At the same time, Guiin is on of the main forestry centre in Guangxi. It has abundant woods resource that counts to 66.46% of the whole area (Source: Municipality of Guilin, 2003).

Photo 3.1: Karst Formation and Lijiang River inGuilin

Natural Hazard

Guilin has a damp monsoon climate. The yearly average rainfall in Guilin is above 1500 mm but the distribution of rainfall is unbalanced. Some area along the Li River and its branches face flood risk in early summer every year.

Karst collapse (sinkhole) is a main geohazard in karst regions. It is controlled by many factors, such as properties of overburden deposits, karstification of bedrock, hydraulic condition in karst and porous aquifer and human activities etc (Lei 1994). Guilin is one of the cities with most extensive distribution of karst collapses in China. According to incomplete statistics, there are more than 200 cases of karst collapses happened during last decades and distributed all over the city. It brings great trouble to people's life and urban construction and becoming one of the main environmental and engineering problems in Guilin (Lei, 1998).

3.2.4. Economic Developments

Guilin has a solid economic basis in tourism. Mountains with strange-shaped peaks, caves of unique formation, festoon-like fields, together with the crystal-clear rivers that surround the city characterize Guilin's scenery and have brought it world fame. With the construction of so-called "Cities of Park Landscape" from 1990's, more attention has paid to its value in tourism. Until 2002, it has seven 4A (highest level), seven 3A class tourist areas (sites) and several natural and cultural relic protection areas. In 2002 the tourism income has reached 4,933 billion RMB. As a tourist destination second to none in China, Guilin will surely continue to attract ever more visitors from home and abroad.

Along with these, Guilin has made great progress in agriculture, industry and even high tech domain in recent years. There are eleven standard farm produce areas covering 16800 hektares, 511 modern demonstration garden plots of agriculture science and technology and 50 agricultural reproduction plots in Guilin. As a focus of governmental investment, Guilin has a comprehensive industrial system covering electronics, telecommunication, photo electricity, biologic medicine and new materials.

3.3. Urban Developments, Population Trends and Master Plan

3.3.1. Urban Developments and Population Trends

According to *Manual of Amendatory Scheme for Urban Master Plan of Guilin (2001)*, There are mainly five stages during the planned urban development in Guilin:

1. Garden city and tentatively plan for the "Three Principles of the People"(before foundation of People's Republic of China);
2. Plan for Industrial city (1956-1967);
3. Plan for scenic modern industrial city (1960-1977);
4. Plan for scenic tourism city (1965-1970, 1973-2000);
5. Plan for scenic tourism and historic culture city (1980-2000).

In 1985, China State Department authorized *Urban Master Plan of Guilin (1980-2000)*, which legalized the actions of urban planning and present a blueprint of urban construction. It is the first urban planning of Guilin that authorized by the central government. The character of the city as a scenic tourism and historic culture city has been long retained. The confirmation of the State Department

pointed that Guilin is an "important national scenic tourism and historic culture city…every construction should correspond to its scene of landscape, and it is strictly forbidden for any architecture or construction that will degrade the image of city in any beauty spot or protection area…not only should we protect the landscape and historic sites, but also the scene of surrounding environment."

Generally speaking, the *Urban Master Plan of Guilin (1980-2000)* has performed its macroscopical control function and conducted the construction of the urban development. Guilin city becomes the political, economic and cultural centre of north Guangxi province. Until 2000, the urban land use is 55 km^2, very close to the planned 56.7 km^2, but the population growth has largely beyond expected number because of the change of economic state. By the end of 2002, the population of urban area has reached to 690,918, counting to 14.17% of the total population in Guilin. From the year 1985 to 2000, the total population of the urban area of Guilin has increased from 457,500 to 642,790. Through statistic carried out by the Statistics Bureau of Guilin and UPDIG, the average growth rate in this period is 2.44% and the average mortality rate is 4.17‰, resulting in an accumulated death in this period of 39992. According to these figures, there will be at least another 72 thousand accumulated death in the coming two decades (see Figue 3.1, Figure 3.2, Figue 3.4).

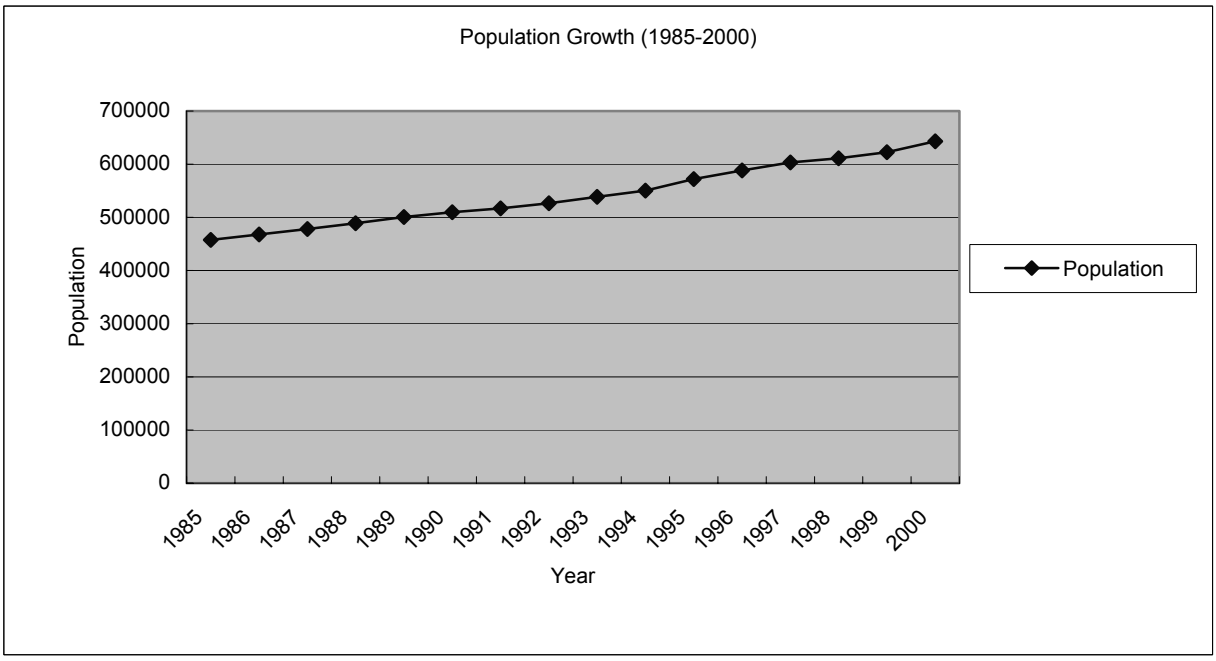


Figure 3.2: Population Growth (1983-2000)

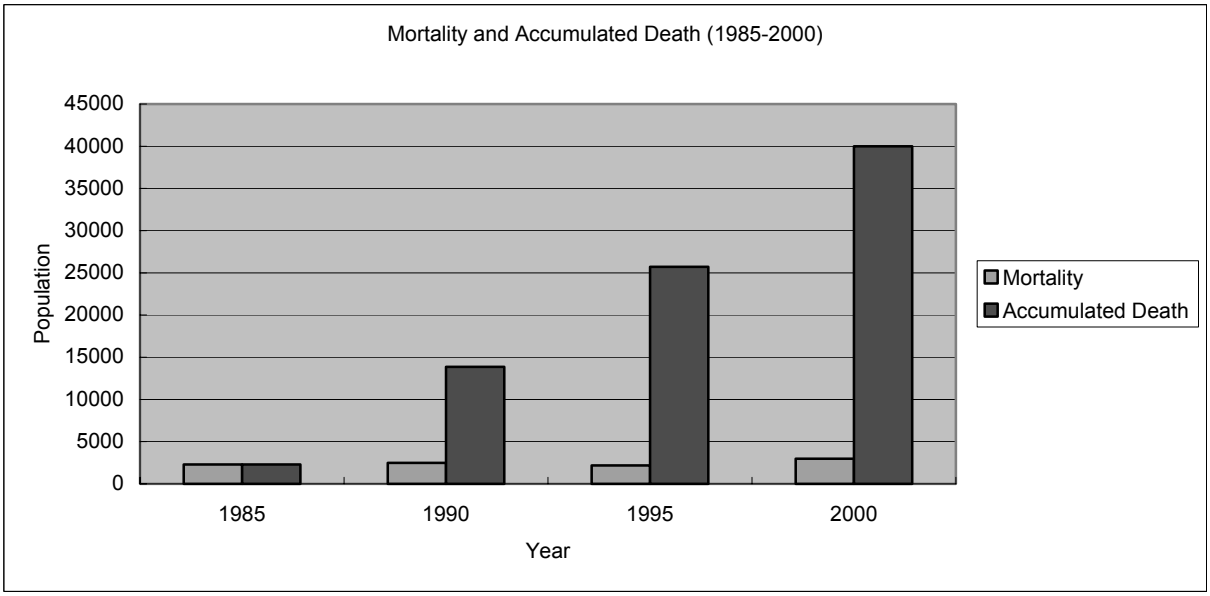


Figure 3.3: Mortality and Accumulated Death (1983-2000)

3.3.2. Master Plan

With the deepened implement of the open policy, the system reformation of market economy and the establishment of new administrative districts (the old Guilin city is combined with Guilin region in 1998), it shows a demand to amend the master plan for further development. The *Urban Master Plan (2000-2010)* is the blueprint of Guilin city confronted with the new 21st century. On the base of the old master plan (1985-2000), the development objectives and urban construction projects has been ascertained in the plan document.

According to this master plan, the term of the plan is 10 years (2000-2010); considering the relatively long impact of some important decisions and the period of amendatory scheme, it extended its strategic plan for the development condition and indicators as along-term plan to the year 2020, and a future expectation unto the middle of the 21st century.

It points out the character of Guilin is an international tourism city, a national historic city and the only one central city in north Guangxi province. The principle of urban land use development should be help to protect the natural scene and landscape; protect the tradition historical and cultural atmosphere; construct good land, traffic and environment for urban economic development; and form well-balanced planning structure and configuration.

This master plan brings forward the corresponding planning and regulatory objectives to the urban development. For example, it plans to improve the residential area in urban area from 15.7 m^2 per capita in 1995 to 25 m^2 per capita in 2010 and 28 m^2 per capita in 2020; increasing the municipal utilities to 2 m^2 per capita in 2010 and 3 m^2 per capita in 2020; increasing the green space to 10 m^2 per capita in 2010 and 20 m^2 per capita in 2020. So that, the total urban land use will increase from 43.78 km^2 in 1995 to 77.13 km^2 in 2010 and 89.17 km^2 in 2020.
It also gives a master arrangement on the urban land use in the future (see Map 3.3). The plan defines the main direction of urban development should be toward the west. The expansion to north to south,

especially north, has been to some extent limited, because the city has showed a trend to elongate its urban area along the Li River in the past decades, which has aggravated the burden of traffic of this direction. It adopts a “multi-centres and discrete- regiments” configuration to deal with the current situation (see Map 3.2). The plan makes it relative convergence and tries to use natural landscape features, such as hills and rivers to formulate the land use, hoping to create a “hill-river-city” module for ecological and sustainable urban development.

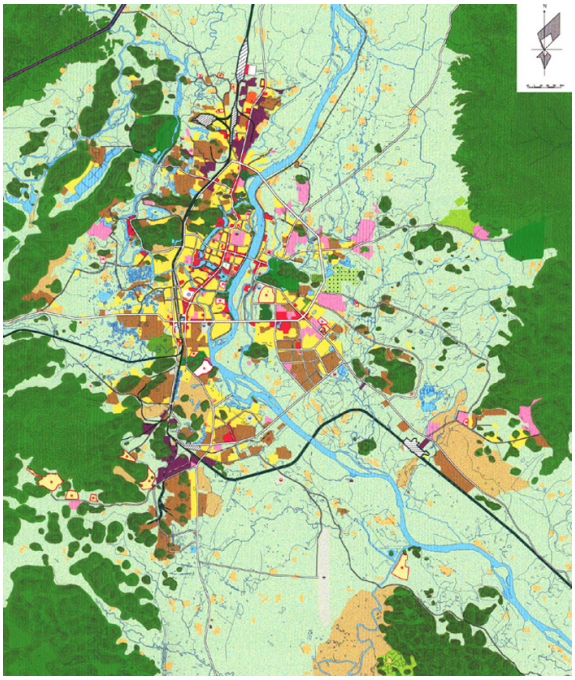


Figure 3.4: Urban Land Use 2000

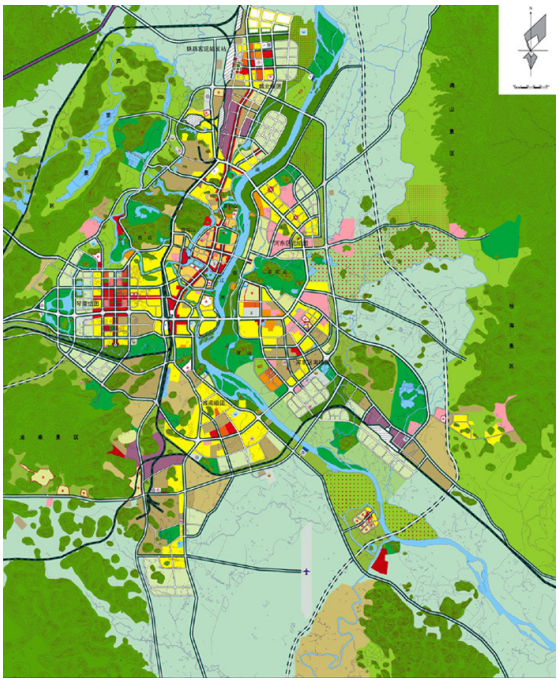


Figure 3.5: Urban Master Plan (2000-2010)

(Red: Commercial, Infrastructure; Yellow: Residential; Green: Green Space; Other: Other Land Use)

3.4. Current Burial Situation

3.4.1. Local Policies

There are various statutory provisions that pertain to the organization, administration and operation of cemeteries in Guangxi province based on CFIMO, 1997. No conflict is permitted in local policies to central decree. Local ones may only claim further restriction on funeral practice. The ones that may relate to cemetery planning are as follow and repetitions are avoid (see Section 2.1.1.1):

1. The *Funeral and Interment Management Ordinance of Guangxi (Guangxi Autonomous Region of Zhuang Minority)*(FIMOG, *Civil Affair Code 28, 2001*), which is enacted in 2001, is the first Chinese regional funeral management statute in minority autonomous region.

Item 13 define cremated remains should be buried in cemeteries or placed in columbarium if there are such services, and disposal method other than earth burial is encouraged.

Item 17 suggests cemeteries should be located on or near barren hills or sloping fields. It forbids cemetery construction on: roadsides of national highways, provincial highways and railways, banks of navigational rivers, reservoir areas, embankment areas, water protection area, relic protection area, plantation, beauty spots, development area. The illegal graves in these areas should be moved into cemeteries or cleared (see Section 4.3.3.1 for explanation).

Item 23 limits the grave size for cremated remain is 1 m^2 and for an inhumed corpse is 3 m^2. The time limit for a rotation interment is 20 years; it should be renewed if hopes to extend the reservation.

FIMOG claims to follow the zoning regulation in delimiting the cremation and inhumation districts (Item 8), thus the compartmentalization of cremation and inhumation area is assigned to government of cities, towns or counties. But there has no such practice up to now as to carry out the delimiting work, so in fact no legislation is in force to govern the zoning regulation (CAOG, 2001).

2. *Urban Development Plan of Guangxi Province (2000-2005)* publicized by CAOG in 1999 pointed out that until 2005, Guilin should plan at most 5 urban (commercial) cemeteries to fulfil its burial needs.

3. The *Charge Standard of Funeral Service (Civil Affair Code 36, 1999)* is established by the Price Bureau of Guangxi province and sent by CAOG. It points out that funeral service should improve the funeral industry but control the benefit, in order to ensure the normal operation and management. It limits price for every funeral service. The expense for every interment practice generally is the same. The only difference lies in the corpse carriage fee, which depends on the carriage distance, and the plot price, which depends on the land price (general 800-1500 RMB/m^2, investigation shows it is common that plot price may fluctuate among plots even in a same cemetery according to landscape and Feng Shui).

3.4.2. Customs related to Burial

Because inhumation is popular among minority nationalities in China and the traditional culture in Guilin is relatively well reserved. There is a prevalent custom of inhumation and Feng Shui in Guangxi province, according to the Civil Affair Bureau of Guilin (2001) and Zhou and Yang (1998).

The cremation rate there is only 12.5%, counting to 1/3 of the average cremation rate in China. Many random graves exist because lack of burial ground and because residents may have their own preference in locating burial sites according to the principle of Feng Shui (CAOG, 2001; see Appendix A). All those illegal graves should be moved to newly planned cemeteries according to law, but considering on economic and hygienic issues, the CABG suggested only those cremated ones be moved.

3.4.3. Existing Urban Cemeteries

There are two commercial cemeteries in the study area: Yaodi Park Cemetery and Guanmao Mountain Cemetery.

Yaodi Park Cemetery, which is totally 64,177 m^2, was founded in 1994. It lies in Shangyangjia Village, Diecai District, near the Guilin-Lingtian highway, 10 km from Guilin centre. It faces Li River with its back to Yao Mountain. There are already 2662 graves in this cemetery and the rest land is estimated to use up in the next three years.

Guanmao Mountain Cemetery, which is, was found in 1996. The 1700 graves in it have almost exhausted all the area of 26,680 m^2. It is anticipated to expand to 80,040 m^2, but this plan has not yet been authorized by now.

Both of them are only for earth burial of cremated remains. No mausoleum and columbarium is constructed. They have provided burial space to urban citizens in the city and to some extent helped to standardize burial management and avoid random burial. Because they all close to mausoleums of Jingjiang Emperor, whose location shows high value in Feng Shui, these cemeteries appears attractive, and profitable. But on the other hand, both of them lie right within the protection area of Mausoleums of Jingjiang Emperor, which claims to be illegal location because they will affects the development of tourism in this area (see Map 3.4; Section 2.1.1.1 and 3.4.1).

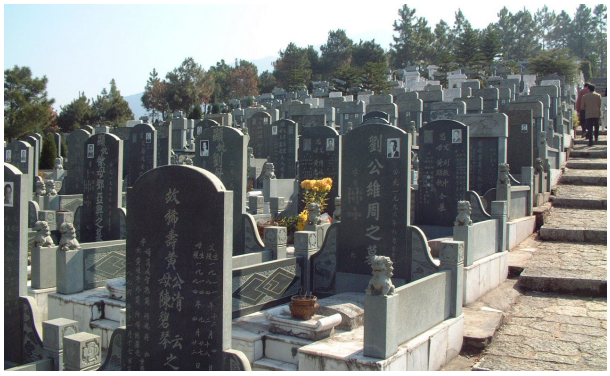
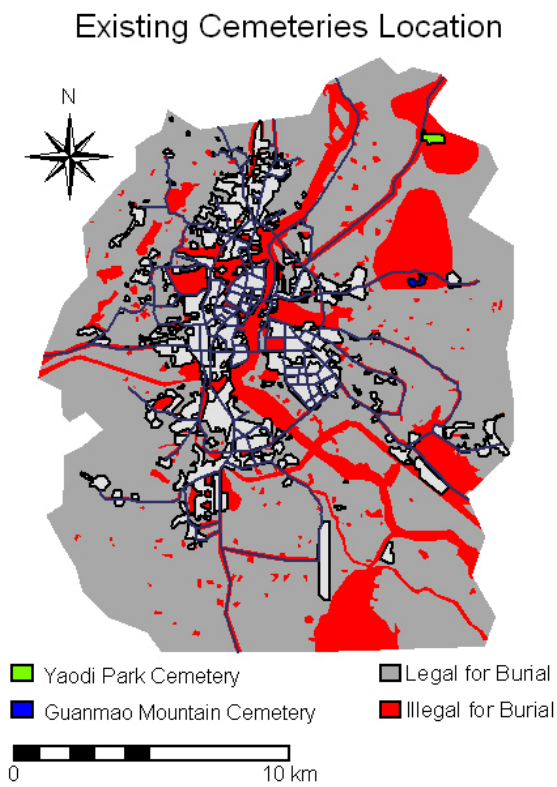


Photo 3.2: Existing Urban Cemeteries



Map 3.1: Location of Existing Urban Cemeteries

3.4.4. Burial Needs Related to Current Situation

As the master plan gives guidelines on land use development in the study area and the cemetery locational plan can be regarded as a supplement to the land use plan, the same term of 20 years is defined in estimating the cemetery capacity needed. This term is also corresponding to the expiry period of statutory rotation interment, so the span of time can be looked on as an entirely accumulation period of graves.

The data and indicators used in estimation are accorded to the work of Statistic Bureau, investigation of the Civil Administration Bureau and demands and rules of the funeral management office. Because according to policies and investigation, cremation is largely promoted and columbaria are ready to construction in the study area. But there is a doubt on how effective the policies will be enforced because cremation is promoted even from the beginning of the foundation of People's Republic of China but the proportion is still below half by now. For this reason, two scenarios are formed according to the performance of the cremation policy in order to carry out corresponding needs. We may found that even in case 1, the number of retained inhumation for minority nationalities is large enough to cause environmental issues (see Section 2.1.2.2). No assumption is given on the change of policies and custom of minorities to the scope of this research.

The cemetery capacity needed during the planned period (2000-2020) is made up by three parts: the graves needed by accumulated death, the current illegal graves to be moved in; and the complement

area (service area and improvements). The calculation should be carried out through the following steps:

1. $P_M = \sum_{i=1}^{21} \left[(1+R_g)^{i-1} \times P_{2000} \times R_M \right] \approx 72308;$

Where: [P_M]=total death during the period; [i]=1 to 21, length of the planned period, expressed as a number of years; [R_g]=2.44%, average population growth rate; [P_{2000}]=642970, population in year 2000; [R_M]=4.17‰, average mortality rate.

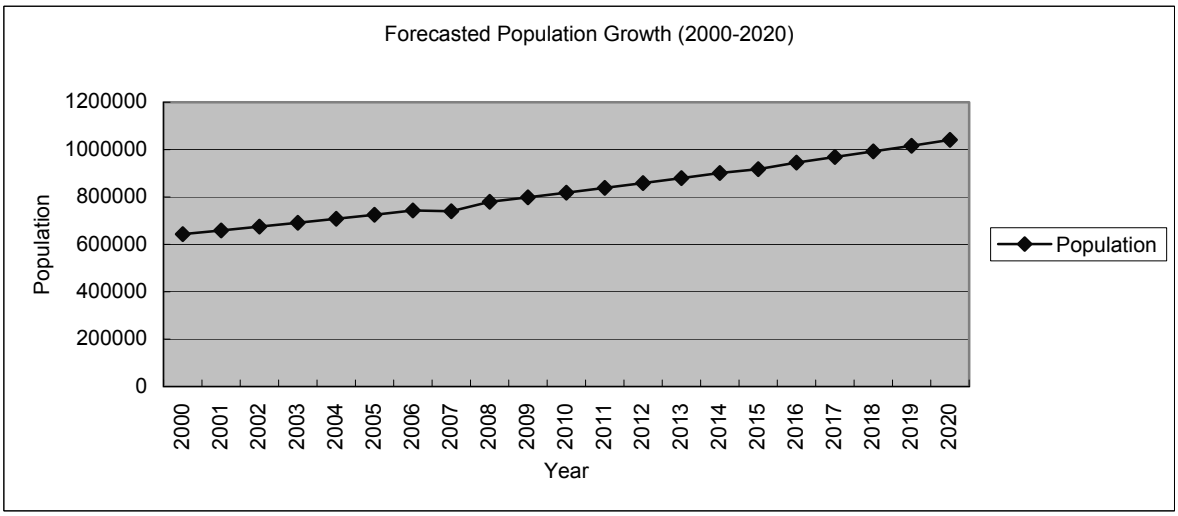


Figure 3.6: Forecasted Population Growth (2000-2020)

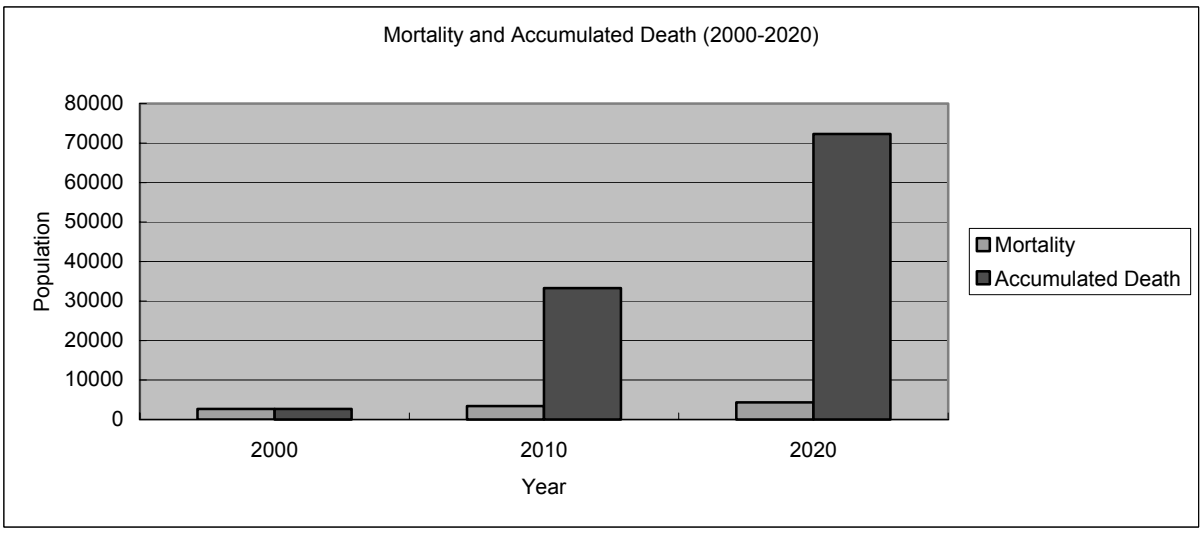


Figure 3.7: Forecasted Mortality and Accumulated Death (2000-2020)

2. $A_m = (G_r + G_{ex}) \times 1 = 32622 \text{ m}^2;$

Where: [A_m]=area for current graves to be moved in newly planned cemeteries; [G_r]=28260, number of random-buried graves that need to be moved; [G_{ex}]=4362, number of graves in existing urban cemeteries that need to be moved; [1]= grave size of a cremated corpse, expressed as m^2/corpse.

3. Case 1: the cremation policy is well performed; all residents apply cremation except those reserved minorities.

$P_m = 1.8\% \times P_M \approx 1302$;

$G_{\min} = 80\% \times (P_M - P_m) \times 1 + P_m \times 3 + A_m$=93332.8 m^2;

$C_{\min} = G_{\min} \times 1.5 \times (1 + 10\%) = 153999.12$ m^2;

Where: [P_m]=population of the minority nationalities whose burial custom of inhumation is reserved by law, mostly Hui nationality (Muslim); [1.8%]=proportion of these minority nationalities; [80%]=planned rate of cremated human remains by earth burial, the rest is expected to be inurned into columbarium or elsewhere; [$G_{\min}$]=minimum area for graves district; [$C_{\min}$]=minimum area needed for cemeteries. [1.5]= parameter for service area in grave district; [10%]= parameter for area reserved for improvements and unpredictable needs.

Case 2: the cremation policy is poorly performed; the cremation rate keeps current level.

$G_{\max} = P_M \times (R_i \times 3 + R_c \times 80\% \times 1) + A_m = 229661.3$ m^2;

$C_{\max} = G_{\max} \times 1.5 \times (1 + 10\%) = 378941.145$ m^2;

Where: [$G_{\max}$]=maximum area for graves district; [R_c]=12.5%, current cremation rate; [R_i]= 87.5%, current inhumation rate; [3]= grave size of an inhumed corpse, expressed as m^2/corpse; [$C_{\max}$]=maximum area needed for cemeteries;

4. Methodology

This chapter includes the research methodology, which starts with the model generation with GIS analysis and multiple criteria evaluation methods for finding suitable areas for urban cemeteries. The variables, such as data, criteria that fill up the framework of model as well as the material and techniques needed in order to run the model are also presented. A step-by-step explanation is introduced which can strengthen the understanding of the concept of multiple criteria analysis in this location problem.

4.1. GIS and Urban Planning

Geographical Information System (GIS) can be defined as a computerized system that facilitates the phases of data entry, data analysis and data presentation especially in case when we are dealing with georeferenced data (By, Knippers, et al. 2001). Urban planning is one of the main applications of GIS. Urban planners use GIS both as a spatial database and as analysis and modelling tool. The applications of GIS vary according to the different stages (analysis of existing situation, alternatives generation, selection of planning options, etc.), levels (regional, national, global, etc.), sectors (land use, infrastructure, transport, etc) and functions (general administration, development control, plan making, etc.) of urban planning.

Many functions in GIS meet their needs in urban planning. GIS is used for the storage of land use maps and plans, socio-economic data, environmental data and planning application; planner can extract useful information from the database through spatial query; spatial analysis and modelling are used for spatial statistical analysis, site selection, land suitability analysis, land use & transport modelling and impact assessment; mapping provides the most powerful visualisation tools in GIS thus it can be used to explore the distribution of socio-economic and environmental data and display the result of spatial analysis and modelling exercise. With the increase in user friendliness and functions of GIS software and the market decrease in the prices of GIS hardware, GIS is now an operational and affordable information tool. It is increasingly becoming an important component of decision support systems in urban planning.

There are many benefits of using GIS in urban planning include (RTPI, 1992):

- Improved mapping, better access to maps, improved map accuracy, more effective thematic mapping and reduce storage cost;
- Grater efficiency in retrieval of information;
- Faster and more extensive access to the types of geographical information important to planning and the ability to explore a wider range of “what if scenarios”;
- Improved analysis;
- Better communication to the public and staff;
- Improved quality of services.

One of the burning issues of the GIS application in urban planning is to establish the application and analysis models according to different requirements, such as land suitability evaluation, ecological sensitive areas analysis and so on. This has made use the core GIS functions in spatial analysis and modelling. Interpolation, map overlay, buffering, neighbourhood comparison, and connectivity measurement are the most frequently used in GIS function in spatial analysis and modelling. For the interaction between urban planning, GIS and spatial analysis see Figure 4.1 (Helmy, 2001).

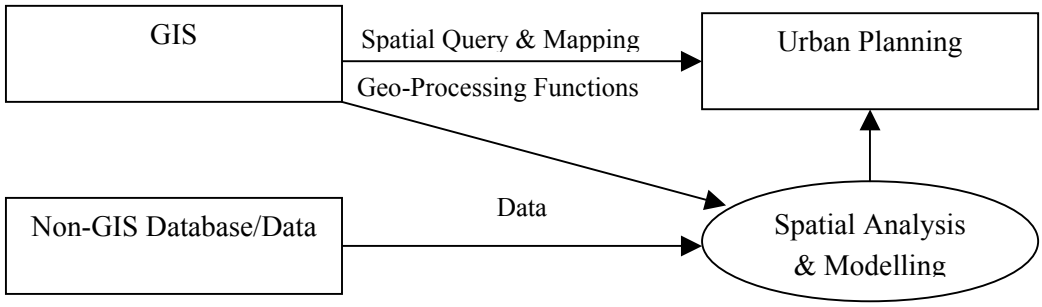


Figure 4.1: GIS and Urban Planning

4.2. Model Design

4.2.1. Modelling the Real World

Urban planning is concerned with making decision for the urban development. It implies the designing of a desired situation as well as identifying ways and means to achieve it. Spatial planning deals with space and society. It aims to serve the development of human life considering the natural and man-made environment with locating the human actives on the space. Spatial planning is also defined as the activity of searching for and bring about the best conceivable mutual adjustment between apace and society, for the benefit of the society (Al-Amer, 1996).

In order to make decisions, knowledge about our complex world is required. Through the selection of relevant information, a conceptual model of the real world is created. “A model is a simplified representation of reality which presents significant features or relationships in a generalised form, i.e., it is a selective approximation of reality. A model may be represented in words, in mathematical equations or a set of spatial relationships displayed as a map” (Valenzuela, 1992). Land suitability analysis is a process through which planners assign land to future use categories in such a way that the overall pattern has a logical relationship among the categories and is in harmony with the natural and built environment. Existing land-use patterns, availability of infrastructure and presence of certain environmental features will indicate the intrinsic suitability of land for various purposes (Timmermans, 1997).

4.2.2. The Conceptual Model

The characteristics of a model depend on the complexity of the problem, the number of the factors involved, the nature of the interactions between factors and the knowledge on the system. It is possible to build a conceptual model with the related data to test certain assumptions about spatial behaviour and development. They can be applied to theoretical situations to demonstrate certain concepts.

In this research, two kinds of analysis are carried out in the design and choice phase of decision-making process respectively. A spatial multiple criteria analysis is carried out in the design phase. The purpose of this phase is to allocate suitable land for urban cemeteries as generating alternatives for potential sites. Institutional and environmental criteria are used in this phase in order to find out relatively "rational" land for cemetery purpose. While in the choice phase, the result of the design phase is translated into its social impact as social criteria, which is the composite suitability of different time spans, after a spatial-temporal analysis. Along with cultural factors, the choice phase cares more about to what extent the rational alternatives generated could "emotionally" be accepted.

The conceptual model of this research is an integrated one of three parts: the existing urban situation, the urban planning work flow and the decision making processing of cemetery location planning.

- The database in a GIS is a model of the real world that can be used to simulate certain aspects of reality. It should be note that these data represents something about the real world at a particular point of time, this aroused the necessary of carrying out spatial-temporal analysis in the decision making process to compare situations in different time.

- A workflow model strings several steps, which also involves different stakeholders in series and brings about their own view and preference into the planning work. The concept model should reflect the relationship of the planning steps and the preference of stakeholders correspondingly.

-A spatial decision model, which can be structured according to the phases introduced in section 2.1.1. This study concerns on the design and choice phase. The design phase provides the alternatives, involving inventing, developing and analysing a set of possible solutions or alternative course of action. The evaluation is mainly part of choice phase. It includes selecting a particular/set of action/alternative from those available.

The following is the conceptual model developed for achieving the location objectives in this research:

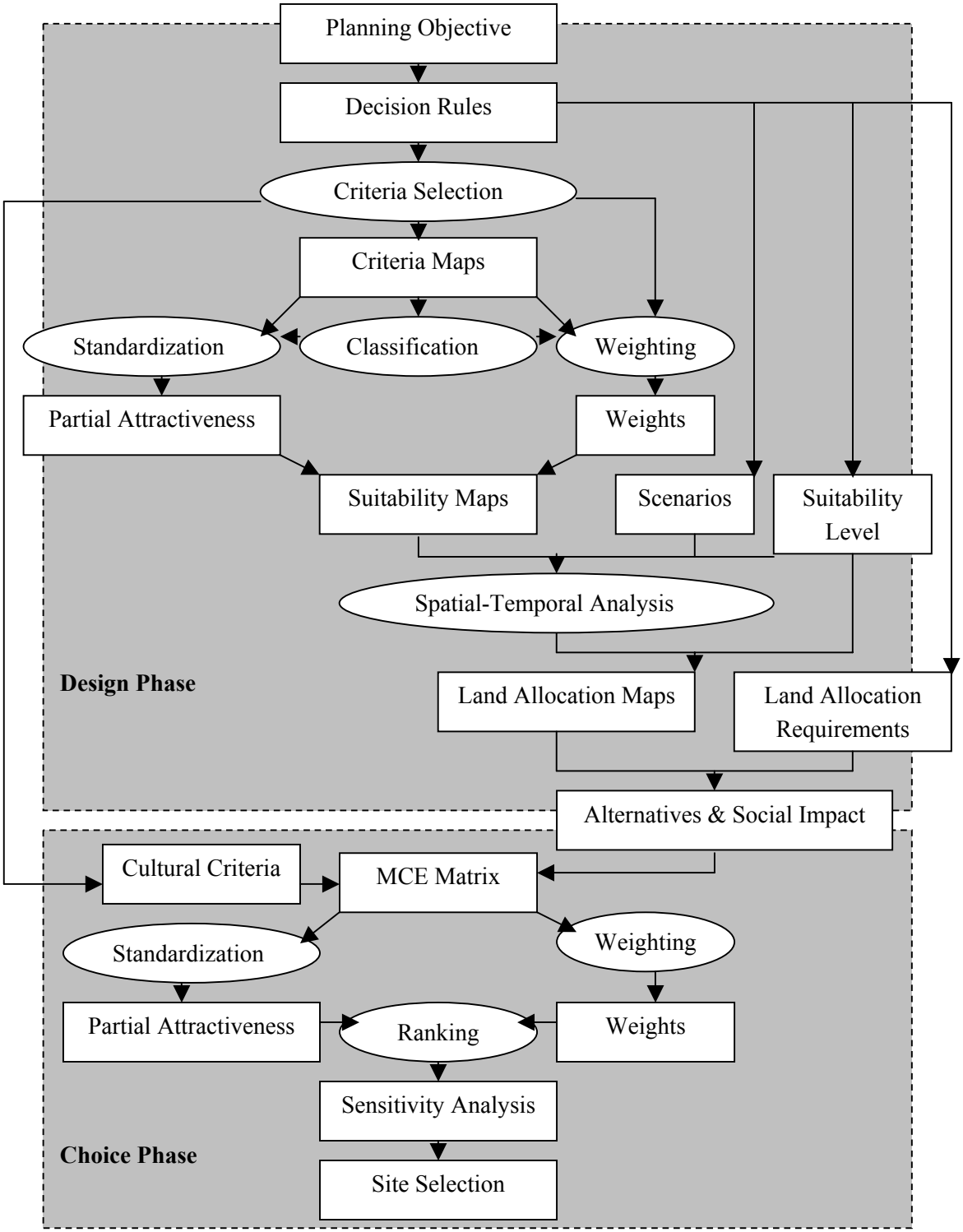


Figure 4.2: Conceptual Model

4.3. The Variables

4.3.1. Planning Process and Stakeholders Identification

Many groups are involved in the decision-making process of cemetery location planning, since it involves many institutional, environmental and social-cultural aspects. However, the involvement also varies from country to country and culture to culture.

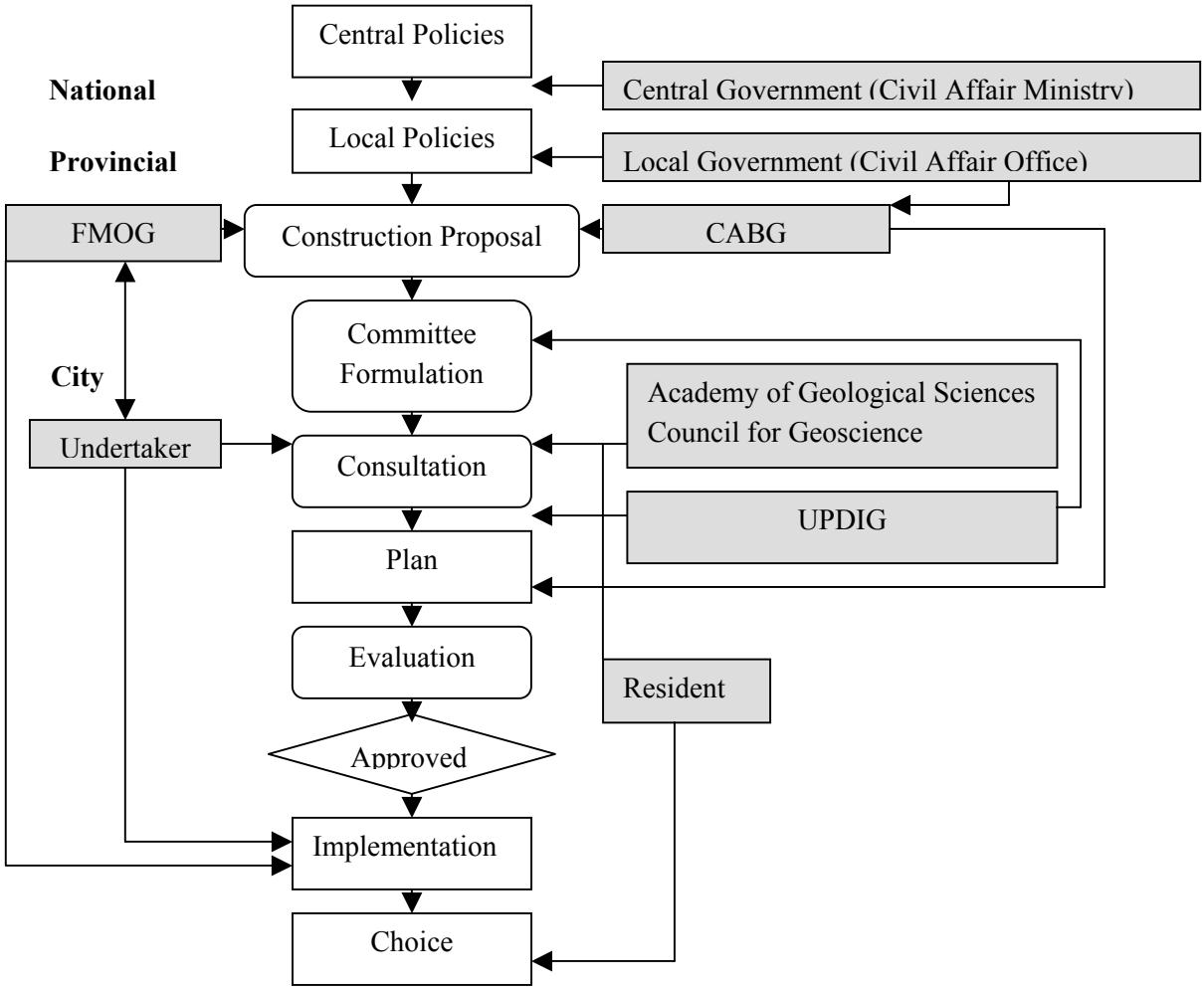


Figure 4.3: Planning Process of Urban Cemetery Location in Guilin

A schematic diagram on the process of the study area in this research is shown in Figure 4.3. Burial grounds are generally provided by local authorities in cemeteries (subject to planning consent and to compliance with any considerations for institutions). The construction proposal of a cemetery should be submitted to the Civil Affair Bureau of Guilin (CABG) by the Funeral Management Office of Guilin (FMOG), but also the CABG can do the same by itself. The planning work is assigned to the Urban Planning and Design Institution of Guilin (UPDIG) and it hosts a comprehensive study formed with representative from all concern departments to assess sustainability of the project and if needed form another committee to work out deficiencies if any. Their plan has been forwarded to studies of hydrological, geological characteristics of soil since it concerns environmental issues, and suggestions go to the planners to carry out the plan. Residents and undertakers' values and interests are also in-

cluded since it relates to people's choice of burial practice and profit of funeral service. The plan is submitted to local government for approval on its adoptability on urban development and economic feasibility. The implementation and maintenance of cemetery is by the undertaker under the supervision of the office of funeral management.

Stakeholders are those whose interests are affected by the issue or those whose activities strongly affect the issue. Stakeholder Analysis is a vital tool for identifying those people, groups and organizations that have significant and legitimate interests in specific urban issues. Clear understanding of the potential roles and contributions of the many different stakeholders is a fundamental prerequisite for a successful participatory urban governance process, and stakeholder analysis is a basic tool for achieving this understanding (Hemmati 2002). As such, four group stakeholders are identified in the analysis: government, expert, residents and undertaker. In the following section outlines of decision models from each of the stakeholders are discussed.

Government

This category comprises of institutes at the central and regional government. Their key personnel involved in cemetery planning are included. It consists of Civil Affair Department, Civil Affair Office of Guangxi province, Civil Affair Bureau of Guilin and Funeral Management Office of Guilin. Though their scope of work is different, but they share the common level of understanding about the cemetery location planning.

The common goal of these stakeholders is to implement development work satisfying regional plans and the political commitments. Both local and regional government gives guidelines on forbidden zone for burial practice, although their objects are non-spatial but more on economic and national policy oriented. The aim is to guarantee the future development will to the lowest extent affected by the stable location of cemeteries, considering both urban scene and residents' health care. One obvious evidence is that cremation is largely encouraged and said to be institutionalised in future years, because it minimize the land consumed and release the pollution to environment. Sustainable development is emphasized. On the other side, capital return from funeral industry is restricted in order to avoid disorder in funeral service and promote economical beravement. A low profit margin is kept by limit the charge during funeral practice, so cemeteries and funeral service are not necessarily considered as an approach of making money.

Experts

In this category people involved are the whole members forming the planning committee rather than the planning institute. The organizations in this category mainly include Academy of Geological Sciences and Council of Geoscience along with UPDIG.

A problem of former priority is that cemeteries are sited by planning authorities or township engineers who formally seem to regard cemeteries as an encumbrance to their planning, so that the prevailing attitude towards cemeteries is an underlying contributory factor to their improper location. The knowledge brought by consultants and experts from environmental, geological and hydrological field contributes to the rationality of the location planning process. Environmentalists would like to move cemeteries into the ambit of solid waste disposal. They argue that the first priority is to protect the living. The investigation on cemetery sites carried out by the Geoscience largely concerned on environmental and physical issues, such as studies of characteristics of soil with regard to its ability to purify

pollutants in groundwater, and its ability to skeletonize buried corpses within the given times foreseen by law. Greater environmental awareness has necessitated that new and existing burial grounds are assessed to determine the environmental load that they could release to soil or any downstream component. Urban planners has the scope to review the major proposals under their own structure plans, thus common components in land use plan such as topography and infrastructure will not be ignored. If it conflicts, there is scope for mutual bargain about the modification of the projects.

Undertakers

The construction and investment for most of the infrastructure for cemeteries are accomplished by the undertakers under the supervision of FMOG. Urban cemeteries are defined as a kind of service industry like any other profit-seeking ones. The purpose determines that they are certainly looking at their profit maximization schemes. Another aspect should be mentioned is the maintenance and modification of physical environment. As agreeable surrounding and natural features that fit in with psychological needs and traditional customs are always a significant selling point of cemetery, the layout and reconstruction on these aspects become regardful issues to this category, and this appears itself more obviously when there are several entities simultaneously competing with each other in a same region.

Residents

In a sense, the requirements of urban dwellers and environmentalists are the same. Both have the same aspirations for different reasons. A cemetery fulfilling the requirements of an anti-pollutionist will no doubt satisfy the needs of the urban dwellers (Fisher 1992). However, people have emotional as well as pragmatic considerations to the cemetery planning. As mentioned before, the cemeteries distinguish themselves from other facilities by its meaningful and ethic characters. The location and surrounding environmental features will have strong impact on people's attitude and choice on cemeteries. This case is much truer in a region like the study area where traditions are relatively unabridged reserved. The evidences are many random graves that show people's own preference according to customs, and that existing cemeteries proved to be attractive and profitable because of their agreeable customary location even when they are in the illegal regions.

4.3.2. Research Data

4.3.2.1. Relevant Data

Criteria that will be used to evaluate in a model must reflect the preferences of all stakeholders involved. In other words, the criteria use by decision-makers must be the same ones used by all the stakeholders who are to be satisfied. Availability and quality of data, however, can be serious constraints in this respect. Since data collection and input into GIS are very expensive and time consuming, "the optimal data quality is the minimum level of quality that will do the job " (Aronoff, 1991). In this case, there are basically four broad facets that should considered for the location planning of urban cemeteries: social-economic conditions, policy system, master plan and physical environment.

4.3.2.2. Data Provision

A portion of the data used in the research was collected during the forepart work of the project *Location Planning for Guilin's Urban (Commercial) Cemeteries* by the Landscape Department, Urban Planning and Design Institution of Guilin. The rest was collected during fieldwork. The following are the institutions approached from whic data of various formats was collected:

1. Urban Planning and Design Institution of Guilin (UPDIG)

2. Civil Affair Bureau of Guilin (CABG)
3. Civil Affair Office of Guangxi Zhuang Autonomous Region (CAOG)
4. Statistics Bureau of Guilin
5. Statistics Bureau of Guangxi Zhuang Autonomous Region
6. National Statistics and Census Institute
7. Mapping Office of Guangxi Zhuang Autonomous Region
8. Institute of Mineral Resources, Academy of Geological Sciences, China (AGS)
9. International Institute for Geo-information Science and Earth Observation, the Netherlands (ITC)
10. Engineering Geology Division, Council for Geoscience, South Africa (CGS)

4.3.2.3. Data Collected

The following table shows the types of data that are relevant for the purpose of the research, the data that was obtained and its format.

Required Data	**Obtained Data**			**Format**
	Yes	**Part**	**No**	
Social-Economic Conditions				
Population (growth rate, mortality rate)	x			Literature
Current burial situation (existing cemeteries, random graves, burial types etc.)	x			Analogue map Investigation
Policy System				
Central policies	x			Literature
Local policies	x			Literature
Land price		x		Literature
Master Plan				
Land use (residential, buildup areas etc.)	x			Analogue map
Infrastructures (road, water supplies)	x			Digital map Analogue map
Future plan (land use, infrastructures etc.)	x			Analogue map Digital map
Physical Environment				
Aerial survey base map (land cover, contour line)	x			Aerial survey photography Digital map
Hazards (flood area, karst collapse area)	x			Analogue map
Soil (soil type and profile)		x		Analogue map
Groundwater	x			Analogue map
Climate (rainfall distribution)			x	
Landscape and natural environment		x		Aerial photo Digital photo

Table 4.1: Data Collection

4.3.3. The Criteria

4.3.3.1. Criteria and Criteria Types

A structured hierarchical system of criteria is useful in problem with relatively large amount of criteria. After analysing the data obtained, the list of criteria system is produced in Table 4.2 (see Section 4.3.3.3 for descriptions). Constraints are limitations imposed by nature or by human beings that do not permit certain actions to be taken. Out of the list of selected criteria, three were handled as "constraint" criteria due to the need to exclude areas from the study:

1. "Land use" excluded all land that is illegal for burial purpose according to local policy.
2. "Flood-prone areas" excluded all areas likely to flood.
3. "Collapse areas" excluded all area likely to develop karst collapse/sinkholes.

Institutional and Environmental Criteria (Design Phase)	**Type of Criteria**
Policy Criteria	
Land use	Constraint
Distance to barren hills (meters)	Factor
Economic Criteria	
Land price (RMB/m^2)	Factor
Accessibility:	Factor group
- Proximity to main roads (meters)	Factor
- Proximity to residential areas (meters)	Factor
Physical Criteria	Factor
Hazards	Constraint group
- Flood areas	Constraint
- Karst collapse areas	Constraint
Soil excavatability	Factor
Grave stability	Factor
Slope (degree)	Factor
Ecological Criteria	Factor
Distance to water bodies (meters)	Factor
Soil permeability (centimetres per second)	Factor
Distance to water supplies (meters)	Factor
Distance to buildup areas (meters)	Factor
Basal buffer zone (meters)	Factor
Social and Cultural Criteria (Choice Phase)	**Type of Criteria**
Social Criteria	Factor
Sustainable Development Feasibility	Factor
Cultural Criteria	Factor
Landscape	Factor
Feng Shui	Factor

Table 4.2: Criteria and Criteria Types

4.3.3.2. Criteria Descriptions and Criteria Maps

The criteria are described here with information given in previous parts in order to structure the problem. Those criteria and their corresponding indicators, which concern hydrological and geological characters, have largely consulted the project *Cemetery Site Investigation* carried out by the Council of Geoscience, South Africa, Fisher (1994) and Santarsiero (2000).

Because SMCE will be carried out in the design phase, for each design criteria a criteria map is produced. In this case, tow types of maps are created: "value maps" and "classified maps". Value maps are those represent measured, calculated or interpolated values (e.g. distance, height). Classified maps are those contain classes, and elements in them are presented by the class name and corresponding codes (e.g. land use units, soil types). The class names and values of class maps are listed in Table 4.5. For the criteria used in choice phase, which is a non-spatial evaluation, their scores are presented as 0-dimentional values, so that they do not have map. For criteria maps, see Appendix B.

Here is the description of each criteria followed by its corresponding digital raster map, which contains relavent information for the criteria:

Policy Criteria:

1. Land use

The central and local government has defined forbidden zones for burial, and graves in these areas will be regarded as illegal burial. Not only newly cemeteries should not build there but also former illegal graves should be moved or cleared from these areas (see Section 2.1.1.1 and 3.4.1): build-up areas, roadsides of national highways, provincial highways and railways (200 meters), banks of navigational rivers, reservoir areas, embankment areas, water protection area, relic protection area, plantation, beauty spots, development area, woodland and urban parks. The purpose of the article is to retain the image and scene, ensure well-balanced development and protect residents from health hazard.

- Map "land use": a map whereby each pixel is classified in one of the two classes: "illegal for burial" and "legal for burial". The map is digitalized from the maps *Land Use (Plan)* in the master plan.

2. Distance to barren hills

Local policy prefers cemeteries be located on or near barren hills or sloping fields (see Section 3.4.1). Firstly, this will keep cemeteries on the edge of the urban area and decrease the possibility that burial land will cause conflict (dreadful feeling, pollution etc.) with other land use; Secondly, the article avoid use arable land on economic consideration for future development; Third, this may be regarded as an institutionalised burial custom because a place with a hill on its back is agreeable according to Feng Shui. It is assumed that, to some extent, to respect and make good use of the funeral custom could avoid random burials. The area defined in this case study are those claimed not suitable for cultivation in the map of *Land Use Evaluation* in the master plan.

- Map "distance to barren hills": a map whereby for each pixel its distance from the nearest barren hill is stored as a numerical value (in meters). The map is produced by distance calculation of digitalized map *Land Use Evaluation* in the master plan.

Economic Criteria:

3. Land price

The land price for burial is defined by the Price Bureau and publicized by the Civil Affair Bureau. It limits expense for every funeral service including the land price, in order to control the benefit of funeral industry and avoid ball-up. It does not make out spatial distribution of different land price but only a general range of 800-1500 RMB/m^2 (see Section 2.1.1.2 and 3.4.1). This case study is based on the assumption that the land price for burial decreases averagely from central city (CBD) to edge of the urban area.

- Map "land price": a map whereby each pixel is classified in eight classes of land price, ranging from "800 RMB" to "1,500 RMB". The map is produced by distance calculation, reclassification and an assumption that the land price for burial decreases averagely from central city (CBD) to edge of the urban area.

4. Accessibility

Although cemeteries are not places that people usually visit in China, the proximity of a cemetery affect its impression to the residents. This will lead to order of attraction if there comes more than on alternatives in a region, which will also affect the profit of undertakers. Also the accessibility of cemeteries related to economic cost during corpse carriage and visit of mourners (see Section 2.1.1.2). Two indicators --proximity to main roads and proximity to residential areas, are defined and taken in to account in the case based on the data obtained. Strictly speaking, too close to roads may cause adverse effect to a quiet atmosphere and too close to residential areas will cause health problem, but in this case, the former has been constrained by the land use policy and the latter is included by ecological factors. So there should be no argument that they may represent pretermission or duplication of criteria.

- Map "distance to main roads": a map whereby for each pixel its distance from the nearest main road is stored as a numerical value (in meters). The map is produced by distance calculation of digitalized maps *Land Use (Plan)* and *Road Network (Plan)* in the master plan.

- Map "distance to residential areas": a map whereby for each pixel its distance from the nearest residential area is stored as a numerical value (in meters). The map is produced by distance calculation of digitalized maps *Land Use (Plan)* in the master plan.

Physical Criteria:

5. Natural hazards

As introduced in the part of study area overview (Section 3.2.3), two kinds of natural hazards should be regarded with attention:

-Flood areas: Flooding refers to a rising and overflow of a body of water that covers land not usually under water. Some area along Li River and its branches are threatened by flooding.

-Karst collapse areas: Karst collapse is a main geohazard in karst regions. Since it is controlled by many factors, it is very difficult to assess potential sinkhole by using traditional method. To simplify the problem, flowing the way used in some geological research (Lei, 1994), it is supposed the area near historical sinkholes (200 meters) is favorable to potential sinkhole development.

- Map "Flood areas": a map whereby each pixel is classified in one of the two classes: "flood-prone area" and "flood free area".

- Map “Karst collapse areas”: a map whereby each pixel is classified in one of the two classes: “collapse area” and “non-collapse area”. The above two maps are digitalized from the map *Geologic Hazards and Underground Relics Distribution* in the master plan.

6. Soil excavatability

Soil excavatibiltiy refers to the ease of grave excavation without mechanical aids. A minimum excavatible depth of at least about 2 meters is essential for cemetery purposes (Section 2.1.2.2), but depths exceeding this would be preferential (see basal buffer zone). It is important to define excavatibility in terms of a single excavation method. Although a backator would be the simplest way of doing this, most communities do not have access to this machinery and excavation should therefore be defined in terms of manual labour, such as with a pick and shovel.

An excavatibility assessment based on the engineering geological soil profiling nomenclature as advocated by Jennings et al. (1973) for soil consistency and rock hardness, is presented in Table 1.

Soil Consistency	**Excavation Method**	**Cemetery Suitability**
Very loose and loose, very soft and soft	Spade	Suitable, but grave stability may be problematic.
Medium dense and firm	Pick and spade	Ideal
Dense and stiff, very soft rock	Backator	Suitable, although weathered rock should be avoided where possible.
Very dense and very stiff, soft and hard rock	Jackhammer	Not suitable, but allowable only if alternative site options do not exists.
Very hard rock and extremely hard rock	Blasting	Not recommended

Table 4.3: Excavatibility Assessment (after Fisher, 1994)

- Map “soil”: a geological maps of the area with three attributes: “soil excavatability”, “grave stability” and “soil permeability” by different soil types. The map is digitalized from the map *Land Use Evaluation* in the master plan.

7. Grave stability

Grave stability refers to the competence of the sides and verges of excavated graves. Soil with characteristics to support stable graves is desired for the following reasons (Fisher, 1994): Firstly, A few days usually elapse between excavation of a grave and the funeral. The soil should therefore have a consistency allowing for at least a few days of “stand up” time. Secondly, during the funeral and mourning, many people move around the grave and the disturbance could result in grave collapsing if the soil is unstable. What is more, the excessive crumbling of the excavation verge may hinder the smooth lower of a coffin into the grave.

A grave stability assessment based on the engineering geological soil profiling nomenclature as advocated by Jennings et al. (1973) for soil consistency and rock hardness, is presented in Table 1. Its criteria map is the map "soil" (see *Soil excavatability*).

Soil Consistency	**Cemetery Suitability**
Very loose and very soft	Not recommended
Loose and soft	Not suitable, but allowable if alternative site options do not exist.
Medium dense and dense, firm and stiff	Ideal
Very dense and very stiff	Suitable, although excavatability may be problematic.

Table 4.4: Grave Stability Assessment (after Fisher, 1994)

8. Site drainage/Slope

Site drainage is important in cemetery location. The ingress of surface water into graves must be minimized and storm water run-off controlled as far as possible. The following reasons are cited (Fisher, 1994):

-High velocity water run-off would lead to erosion of sites while Guilin is a pluvial region, especially when that a gravesite's surface soil horizon is in the process of being disturbed.

-The presence of surface water and excessive ponding would enhance the ingress of water into the soil, especially at recently closed graves, and the subsequent saturation of soil would increase the risk of ground water contamination.

-Poor site drainage could also lead to the flooding of recently excavated graves and subsequent destabilisation of grave verges.

-Poor drainage resulting in marshy conditions would have a detrimental effect on human and mechanical mobility around the graves.

-Poor drainage would also lead to the degradation of cemetery appearance. This is an important factor concerning the marketability of a cemetery site.

A gradient of between 2° and 6° is considered as ideal for cemetery purpose. This slope range would ensure adequate site drainage, minimum erosion and promote human and mechanical mobility on site. When the surface slopes at cemetery sites by necessity exceed 6°, a maximum gradient of 9° is recommended, but attention should give to grave arrangement to minimize surface erosion and impede rapid internal fluid movement. In flat areas where the gradient is less than 2°, surface drainage is commonly insufficient. And according to Chinese construction standard, a gradient more than 30° will cumber human activity, not to speak of mechanical mobility.

- Map "slope": a map whereby for each pixel the average slope of the corresponding area is stored as a numerical value (in degrees). The map is produced by building Digital Elevation Models (DEM's) on digitalized contour lines in the aerial survey base map.

Ecological Criteria:

9. Distance to water bodies

The water bodies should not be affected in any way by pollutants emanating from cemetery sites, and they must also not pose a flood hazard to any cemetery site. Investigation shows in area with high soil permeability ($\geq 1x10^{-4}$ cm/s), the safe distance may be as long as 415 meters, but to any condition (even very low soil permeability less than $1x10^{-7}$ cm/s), a minimum distance of 100 meters is needed- for humid regions like Guilin, and a further decrease of the distance for arid regions (rainfall <500 mm).

- "Distance to water bodies": a map whereby for each pixel its distance from the nearest water body is stored as a numerical value (in meters). The map is produced by distance calculation of digitalized aerial survey base map.

10. Soil permeability

Soil permeability is the major factor determining the rate of fluid movement through the soil (Fisher 1994). Soil permeability to water and air is a parameter of critical importance in relation to purification andror diffusion of leachates from inhumed corpses in the soil, and in relation to its influence on the time necessary to completely skeletonize a human corpse (Santarsiero 2000). For cemetery purposes, soil permeability must fall with in a predetermined permeability range. A measure of flexibility is again permitted to accommodate variable conditions.

Maximum Soil Permeability: Soil permeability should quite obviously not be too high, as it does not allow good purification of wastewater from coffins because of the speed of leaching through the deeper layers and the reduced time of contact soil with wastewater. Research indicates that an upper soil permeability limit of $5x10^{-5}$ cm/s should be recommended to safely contain microbiological pollutants.

Minimum Soil Permeability: Very low soil permeability would inhibit the dispersion of pathogenic organisms originating from decomposing corpses and also lead to anaerobic conditions within each individual grave. It gives rise to stagnation around the coffin that prevents both decomposition of corpses and filtration of wastewater through deeper strata. The decomposition process would then slow down to unacceptable levels. In many cases of undecomposed corpses from operations of exhumation carried out, it was observed that the burial site was characterized by a low permeability (Santarsiero 1998). Maintaining the normal rate of decomposition is necessary, but without polluting the environment in any way. The lowest recommended permeability is in the region of $1x10^{-7}$ cm/s (for soil permeability according to soil type, see Fisher, 1992). Its criteria map is "soil" (see *Soil excavatability*).

11. Distance to water supplies

The location of cemetery site in relation to water supplies utilised for human consumption is important, especially at many informal settlements around our cities, the only domestic water supplies are obtained from boreholes and small storage dams, usually without any form of purification. With waterborne diseases being prevalent worldwide (water-related diseases cause 33% of all deaths), it should be a high priority to preserve and protect potable water resources from contamination by potentially harmful organisms originating in cemeteries. A safe distance may base on the acceptable soil permeability range, in conjunction with the maximum survival times of bacteria and viruses. Investigation shows in area with high soil permeability ($\geq 1x10^{-4}$ cm/s), the safe distance may be as long as 465 meters, but to any condition, a minimum distance of 150 meters is needed.

- Map "distance to water supplies": a map whereby for each pixel its distance from the nearest water supply is stored as a numerical value (in meters). The map is produced by distance calculation of digitalized map *Water Supplies and Sewerage (Plan)* in the master plan.

12. Distance to buildup areas

The minimum safety distance between the cemetery and the built-up area shall depend on the type of system of burials estimated, on the technologies used for the construction of the crematorium and on the architecture of every device inside the planned cemetery, including the cemetery walls too (Santarsiero et al, 2000). As the safe distance to water bodies are defined by other criteria, a much longer distance of 500 meters recommended by CAOG through investigation on pollution from crematory carried by air is applied in the case (see Section 2.1.2.2.).

- Map "distance to buildup areas": a map whereby for each pixel its distance from the nearest buildup area is stored as a numerical value (in meters). The map is produced by distance calculation of digitalized maps *Land Use (Plan)* in the master plan.

13. Basal buffer zone

A basal buffer zone refers to the vertical soil succession that occurs between the base of the grave and the water table. This buffer zone essentially forms a barrier between the source of pollution and the water table. Through process of filtration and adsorption, microbiological pollutants are prevented by the soil from reaching the water table. The soil, however, tends to lose its filtration and adsorption capacity with time (Allen, 1978), and because a cemetery is a long-term source of pollution, a substantial buffer zone is proposed. A minimum buffer zone of 2.5 meters will adequately cater for most conditions. This case study is based on the assumption that all the graves for inhumation are buried at a depth of 2 meters, which is necessary to avoid some hygienic problems (see Section 2).

- Map "basal buffer zone": a map whereby for each pixel the average height of basal buffer zone of the corresponding area is stored as a numerical value (in meters). The map is produced by building Digital Elevation Models (DEM's) on digitalized contour lines in the aerial survey base map, and ground water contour lines from the map *Geologic Hazards and Underground Relics Distribution* in the master plan.

Social Criteria:

14. Sustainable Development Feasibility

The locations of cemeteries are relatively stable compared with rapid urbanization process. The urban development will change the suitability of cemetery location with the times to come. A composite value of land suitability from different time span is used to define how it can ensure sustainable development for both cemetery location and space for living people.

Cultural Criteria:

15. Landscape

Thinking and emotion, which are based on the local natural characteristics, can create a specific cultural landscape with those natural landscapes such as local terrain, soil, vegetation and water bodies. The landscape plays a role to satisfy the needs of the bereaved during grief. The agreeable natural landscape of the cemetery may indeed provide a therapeutic environment for the grieving. At the same

time, the landscape of cemetery evokes a sense of spirituality that build up the ambience and atmosphere of a sacred places for the psychological need of the mourners (see Section 2.1.3.2).

16. Feng Shui

Feng Shui is a traditional Chinese philosophy and technology of site selection, which finds ideal or suitable locations for dwellers, either the living or the dead (Han and Sinha, 1996). It shows the geomantic relationship between humans and their physical world. It is believed that harmonious and balanced lives will bring good luck. To achieve this, the formation of natural features should follow some certain rules in order to acquire and keep in balance sufficient Ch'i, which is generated from dynamic reaction of opposite kind of energy (see Appendix A).

Criteria (Constraints/ Factors) of Class Maps	**Values**
Land use	Illegal=0; Legal=1.
Flood areas	Flood-prone area=0; Flood-free area=1.
Karst collapse area	Collapse area=0; Non-collapse area=1.
Land price	800 RMB/m^2=8; 900 RMB/m^2=9; 1,000 RMB/m^2=10; 1,100 RMB/m^2=11; 1,200 RMB/m^2=12; 1,300 RMB/m^2=13 1,400 RMB/m^2=14; 1,500 RMB/m^2=15.
Slope	0-2 degrees=1; 2-6 degrees =5; 6-9 degrees =4; 9-30 degrees =2; greater than 30 degrees =0.
Soil excavatability Note: The soil profiles are after the assessment and classification in section 4.3.3.2, the soil type on the map *Land Use Evaluation* in the master plan, and interview with geologists from AGS, ITC and CGS.	Limestone: 0=very hard rock and extremely hard rock; Sandy shale: 0=very hard rock and extremely hard rock; Clayey gravel: 3=dense and stiff; very soft rock; Fat clay: 3=dense and stiff; very soft rock; Lean clay: 3=dense and stiff; very soft rock; Clayey sand: 4=medium dense and firm.
Grave stability	Clayey gravel: 2=loose and soft; Clayey sand: 2= loose and soft; Lean clay: 3=medium dense and dense, firm and stiff; Fat clay: 3= medium dense and dense, firm and stiff; Limestone: 4=very dense and very stiff; Sandy shale: 4=very dense and very stiff.
Soil permeability	Fat clay: 0=$1x10^{-8}$ to $1x10^{-10}$ cm/s; Limestone: 1=$5x10^{-2}$ to $5x10^{-4}$ cm/s; Lean clay: 2=$1x10^{-6}$ to $1x10^{-8}$ cm/s; Sandy shale: 2=$1x10^{-6}$ to $1x10^{-8}$ cm/s; Clayey gravel: 3=$1x10^{-5}$ to $1x10^{-8}$ cm/s; Clayey sand: 4=$5x10^{-5}$ to $1x10^{-8}$ cm/s.

Table 4.5: Classification of Criteria

4.3.3.3. Criteria Weights

Criteria weights show the relative importance of each indicator with respect to others. "Weighting should be applied when not all aspects have an equal importance. It should be realized that the choice of a weight is most important, as it has a great effect through multiplication of the scores "(Hofstee and Brussel 1999). Weighting factors are often based on a mixture of implicit knowledge, personal opinions and thoughts of different groups. In this case, the study includes a literature review on former researches, interviews, investigations and stakeholder analysis. For the purpose of this research and limitation on time, a unique set of weights is used in the forepart of design phase to carry out scenario maps, but uncertainty analysis on weights has been done in later spatial-temporal analysis and choice phase. Two techniques are used in this case: "pairwise comparison" method and "expected value" approach of "rank ordering" method (see Section 1.4.3).

4.3.3.4. Partial Evaluation

Given the variety of scales on which attributes can be measured, multiple criteria decision analysis requires that the values of the various criteria be transformed to comparable units. Only if the scales of the criteria are the same can the scores of these criteria be combined or compared. Making the scores of the criteria comparable is often called standardization or normalization. Various methods to standardize the scores are available. The method to use depends on the character of the problem and the character of the attributes. Table 4.6 gives an overview of the standardization methods to be used in what type of problem.

Type of Criteria	Standardization Method
Deterministic	Linear scale transformation Value function approach
Probabilistic	Utility function approach Probabilistic approach
Possibility	Utility function approach Possibility membership approach

Table 4.6: Overview of the Standardization Methods

As has introduced in section 4.3.3.3, each criterion is represented by a value map (e.g. distance, height) or a classified map (e.g. land use units, soil types). For decision analysis the values and classes of all the maps should be converted into a common scale, which is called "utility". Utility is a measure of appreciation of the decision maker with respect to a particular criterion, and relates to its value/worth (measured in a scale 0 to 1).

Different standardization is applied for different type of maps:
-For "value maps", standardization is done by choosing the proper transformation function from a set of linear and non-linear functions. The outcome of the function is always a value between 0 and 1. The function is chosen in such a way that pixels in a map that are highly suitable for achieving the objective result in high-standardized values, and unsuitable pixels receive low values. ILWIS' SMCE module provides a number of linear functions. Possible standardization methods for value maps in the developed SMCE module are e.g. "Maximum", "Interval" and "Goal". Together with the "cost/benefit"

property of the criterion, this information is sufficient for applying the selected standardization method in the correct way.

-For "classified maps", standardization is done by matching a value between 0 and 1 to each class in the map. This can be done directly, but also by pairwise comparison or rank ordering the classes (see Section 4.4.4).

It should be noted that, when carrying out spatial-temporal analysis, the same value function should be used to convert the pixels of all three scenarios (different time and different urban situation) to a value between 0 and 1. In this phase, an extra dimension is given to this process by making sure that the range is the same for all three scenarios per criterion. Only then it is meaningful to compare maps of the three scenarios with each other. This changes the way in which histogram values used in standardization functions are calculated. Where the maximum, goal and minimum may be simply the value of one map in static analysis, here it should be uniformed for all the scenario maps for one criterion.

4.3.4. The Decision Rules

A decision rule is a rule that tells how to decide. French (1988) defined a decision rule as "a specification of a procedure which may be used to identify the 'best' alternative in any problem". Mostly you will find several decision rules in a decision support system. They aim to combine the evaluation criteria, alternatives and priorities to provide ranking of the decision alternatives. Together they form an algorithm, which leads to a suggested decision. Generally speaking multiple criteria methods, cost-benefit analysis and also a criteria itself are all examples of decision rules (Sharifi, Herwijnen, et al. 2004).

It is important to know the rules because they form the basis of the decision support system. Rules could for instance be in the form of if then else statements, knowledge tables, quantitatively and qualitatively.

4.3.4.1. Suitability Levels

In the in the forepart of the design phase, by aggregating the criteria maps (constraint maps and the factor maps), scenario maps (composite score maps) are prepared. Then the distribution of the number of pixels for each set of scores is checked from the histogram of each map for determining visible clusters (natural break points). The values on the scenario maps can be grouped in classed according to these natural break points or a regular interval. In this research, for visualization purpose and in order to make the maps comparable to each other, the average values of the natural break points are used in slicing the composite score maps. In this way, the suitability levels in each of them are identified. Table 5.3 shows the used break points in this stage. It should be note that the suitability maps are produced using a 0 to 1 scale.

Scores	Suitability Levels
0-40%	Unsuitable
41-50%	Marginally suitable
51-60%	Moderately suitable
60-100%	Highly suitable

Table 4.7: Suitability Level for Scenarios

In the later step when generating alternatives, the breakpoint of the suitability level is revised according to different land allocation requirements. The method enables to identify a relatively highest suitability of the located land to fulfil the demand.

When evaluation is carried out in the choice phase, the analysis enables to identify, for each criteria, amount of land of a particular suitability level. The information is required for the purpose the multiple criteria evaluation but it can also be used to identify areas with weakness, such as supply of infrastructure and services, and planning of its future supply.

4.3.4.2. The Land Allocation Requirements

The land allocation target for urban cemeteries should fulfil the burial needs due to the population growth, a fraction of the accumulated deficit (such as the former random and illegal graves that need to move into newly planned cemeteries) as well as service space and improvements. Civil affair authorities restrict it through limitation on burial types, cemeteries numbers and grave size also. According to Section 3.4.4, the minimum area needed for cemeteries is 153999.12 m^2, while the maximum is 378941.145 m^2 according to the assumptions on effectiveness of the cremation policy in the study area. At the same time, at most 5 cemeteries should be constructed to fulfil the needs and small ones (< 2 hectares) that are lack of economic feasibility should be avoided (see Section 3.4.1. and 2.1.1.2.).

4.3.4.3. The Purpose and their Priority

As mentioned in Section 2.1.3.3, the characters of burial land give it a static location in a relatively long term which also arouse probability to unpredictable problem and conflict between other land use and newly planned cemeteries in later days with the rapid rate of urbanization. To this sense, the most commonly cited definition of sustainable development is introduced in this research as that which "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). Sustainable urbanization occurs when the urbanization process harmonizes with principles of sustainable development. It is sustainable development's urban embodiment and provides an urban manifestation of its fundamental ideas (Pivo 1996).

This gives an additional necessity for a temporal analysis on the location problem. In this way, we extend the dimension of the SMCE into a spatial-temporal MCDM. To this end, there are three types of aggregation functions that may be used for solving the spatial-temporal decision problem: function aggregates the criteria (f), function aggregates the spatial components (g) and function aggregates the times (h). Figure 4.4 illustrates the transformation of spatial-temporal data into single value. Note that the first two are the same as used in the 2-dimentional approach in Figure 2.3.

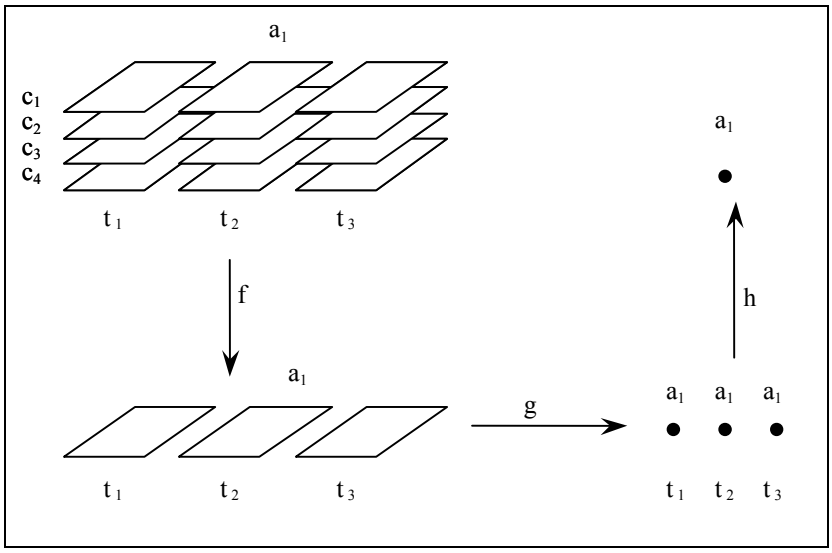


Figure 4.4: Transformation of Spatial-Temporal Data into Single Value (The starting point is a stack of dynamic maps for the three criteria c_1 to c_3 describing the alternative a_1. Function f represents the combination of criteria, g the spatial aggregation of a map to a non-spatial value and h the temporal aggregation of a time series of entities to one entity.)

Based on this, three scenarios on time are defined with their different purposes. Scenario is a statement of assumptions about the operating environment of a particular system at a given time. It describes the decision, uncontrollable variables and parameters for a specific modelling situation and a new way of thinking about future. In a similar way to criteria, the purpose of scenarios can also show the relative importance of one another as weight sets (see Table and Section 5.2.1).

Scenario	Purposes	Weight 1	Weight 2	Weight 3
1	Current suitable land for urban cemeteries (2000)	0.584	0.333	0.135
2	Suitable land for urban cemeteries in 2010	0.281	0.333	0.281
3	Suitable land for urban cemeteries in 2020	0.135	0.33	0.584

Figure 4.5: The Purposes and their Priority

4.4. Technical Aspects of the Evaluation Process

4.4.1. Materials Used

The following is a description of materials used for the research:

1. Cartographic input:
   - Aerial photograph 1: 2500, 1997.
   - AutoCAD maps (dwg files): aerial survey base map and road network.
   - Analogue maps (jpg files): existing cemeteries, master plan (land use, infrastructures, future plan), natural hazards, soil type and profile, ground water level.

2. Software: see Table 4.8

Software	Version
AutoCAD	R14 and 2000
ArcGIS	
Arcview	3.2
ILWIS	3.2
Definite	2.0
SPSS	11
Excel	2000

Table 4.8: GIS and Assistant Software Used

4.4.2. Software and Data Processing

As mentioned above, the available data are mainly AutoCAD maps (dwg files) and analogue maps (jpg files). They should be converted into a format compatible for importing to the GIS. The basic procedure of data processing has been shown in Figure 4.1. At starting, a personal geodatabase in ArcGIS software is used for storage and management when digitalizing rude data into vector maps. Secondly, shapefiles are exported and imported to polygons in ILWIS software. This study hopes to take advantage of ILWIS' SMCE module to carry out the design phase, so the next step is to transfer polygons into raster maps and create criteria maps with distance calculation, DEMs and other GIS techniques. After producing the composite maps, they are again vectorized in order to generate alternatives with different attributes. The non-spatial attribute of each alternative are input into DEFINITE software to carry out MCE and sensitivity analysis to get a final ranking of each site.

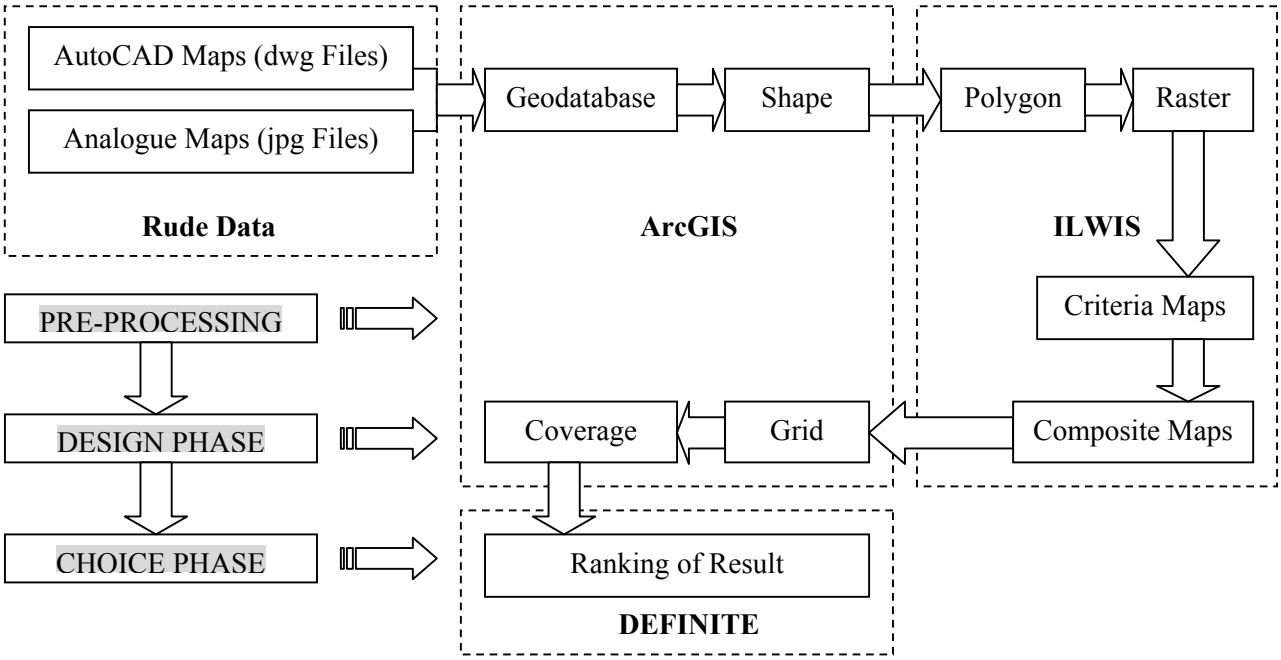


Figure 4.6: Software and Data Processing

Two kinds of decision support system (DSS) software are used in this study. ILIWIS' SMCE is a recently developed module. This module supports application of SMCE in planning and decision making processes through several compensatory and non-compensatory approaches, allowing inclusion of the spatial and thematic priority of decision makers. It enhanced the spatial data analysis capability of GIS to support planning and decision-making processes.

DEFINITE software will be used to make a ranking of the alternatives. DEFINITE is designed to support decision making on a finite set of alternatives. Actually it is a whole toolbox of methods that can be used on a wide variety of problems. DEFINITE includes multicriteria methods, cost-benefit analysis and graphical evaluation methods. Related procedures such as weight assessment, standardization, discounting and a large variety of methods for sensitivity analysis are also available. A unique feature of DEFINITE is a procedure that systematically leads an expert through a number of rounds of an interactive assessment session and uses an optimisation approach to integrate all information provided by the experts to a full set of value functions (Janssen, Herwijnen et al. 2001).

4.4.3. Developing Criteria Weights

Making a hierarchical structure of criteria is very common in large problems. Assigning weights to the criteria within a hierarchy can then be done in steps. One step is to assign weights within the groups and the other step is to assign weights between the groups. One advantage of assigning weights in this way is that the focus of a decision maker is only on the criteria in each group, and not on all criteria of the problem at the same time. The second advantage is that weighting within a category can also be done by an expert knowledgeable about this category. The third advantage of using hierarchies in assigning weights is to show results according to different viewpoints. Applying MCA with weights for the categories according to a certain viewpoint results in a ranking of alternatives for that viewpoint. In this way the preferences of different stakeholders can be made visible.

ILWIS' SMCE module and DEFINITE provides support for a number of techniques (direct, parewise comparison and rank order etc.) that allow elicitation of weight at any level and for every group in the criteria tree. After defining the relative importance of criteria (groups) by information gathered through approaches mentioned in Section 4.3.3.4, two other than direct assessment are used in this research. The methods and their corresponding result for each factor or factor group is shown in Figure

Pairwise Comparison Method

The pairwise comparison method is developed in the context of the Analytical Hierarchy Process (AHP). It is based on criteria that are measured on a ratio or ordinal scale. When comparing a pair of factors, a ratio of relative importance, preference or likelihood of the factors can be established. In the first step will use a method to rank the criteria, and then determine the relative and the degree of importance of each two consecutive criteria on scales of different importance. Once the matrix of pairwise comparison is generated, it can be converted to weights as output.

Structured pairwise comparison method, which is an extension (simplified version) of the original pairwise comparisons, has proved to be quite practical in practice. It has been verified that a number of these pairwise comparisons taken together form a sort of average, the results of which are very accurate. This "average" is calculated through a complex mathematical process using eigenvalues and eigenvectors. The results of this method have been tested experimentally and have been found to be ex-

tremely accurate. This method is used in AHP and many kinds of software such as ILWIS' SMCE and DEFINITE, allowing one to use both subjective and objective data in making pairwise comparisons.

1	Extremely less important than
2	Very strongly less important than
3	Strongly less important than
4	Moderately less important than
5	Equally important as
6	Moderately more important than
7	Strongly more important than
8	Very strongly more important than
9	Extremely more important than

Table 4.9: Scale for Pairwise Comparison

Expected value method

Due to the fast-growing number of pairwise comparisons it is not sensible to use the method for a large set of criteria. Expected value method assumes each set of weights that fits the ranking order of effects has equal probability. The weight vector is calculated as the expected value of the feasible set. Therefore, the expected value method simulates the average idea/opinion of a group (Sharifi, Herwijnen, et al. 2004). This method results in a unique weight vector. The expected value method gives rise to a convex relationship between ordinal and quantitative weights: the difference between two subsequent weights is larger for more important criteria. The expected value method, combined with a multiple criteria method, always leads to complete ranking of the alternatives.

The expected value method calculates the weight, w_k, for criterion k according to formula 2.5 where n is the number of criteria. The weights fit the rank order of effects, meaning that $w_1 \geq w_2 \geq \ldots \geq w_n \geq 0$. Table 6 shows the weight vectors for various numbers of criteria according to Formula 4.1.

$$w_k = \sum_{i=1}^{n+1-k} \frac{1}{n(n+1-i)}$$

Formula 4.1: Expected Value Method

Number of Criteria	Expected Value of Criteria Weights					
N	E (w_1)	E (w_1)	E (w_1)	E (w_1)	E (w_1)	E (w_1)
2	0.75	0.25				
3	0.61	0.28	0.11			
4	0.52	0.27	0.15	0.06		
5	0.46	0.26	0.16	0.09	0.04	
6	0.41	0.26	0.16	0.10	0.06	0.03

Table 4.10: Expected Value of Criteria Weights

4.4.4. Standardization of Criteria Scores

The value of standardization scores range from 0 to 1. The higher the value of the score, the more attractive is the criteria value. If a criterion has the attribute that the larger the raw score, the better the performance, this type of criterion is referred to as a "benefit" criterion. If the lower the score the better the performance, the criterion should be called a "cost" one. For a benefit effect the graph of the value function goes from low to high, in other words a low score gets a low standardized value. For a cost effect the opposite happens, i.e. a low score gets a high standardized value.

The suitable standardization method has been applied based on the characteristics of the data and the availability of software capacity. The ILWIS' SMCE had the capability to deal with linear scale transformation while DEFINITE support both linear and non-linear function. The linear scale transformation methods have a linear relation between the original values and the standardized values. In this research, three most often used linear procedures are applied: maximum, interval and goal standardization. The standardization method of each criterion can be seen in Figure 5.1 and Figure 5.8.

Maximum Standardization

The scores are standardized with a linear function between 0 and the highest absolute score. For a benefit effect the absolute highest score is indicated with 1, for a cost effect the lowest score becomes 1. The generic formulas of maximum standardization are:

$$\bar{x}_{ij} = \frac{x_{ij}}{\max_j x_{ij}} \text{ [Benefit Criteria]}$$

$$\bar{x}_{ij} = 1 - \frac{x_{ij}}{\max_j x_{ij}} \text{ [Cost Criteria]}$$

Where: $\bar{x}_{ij}$ is the standardized score, x_{ij} is the original score, $\max_j x_{ij}$ is the highest score.

Formula 4.2: Maximum Standardization

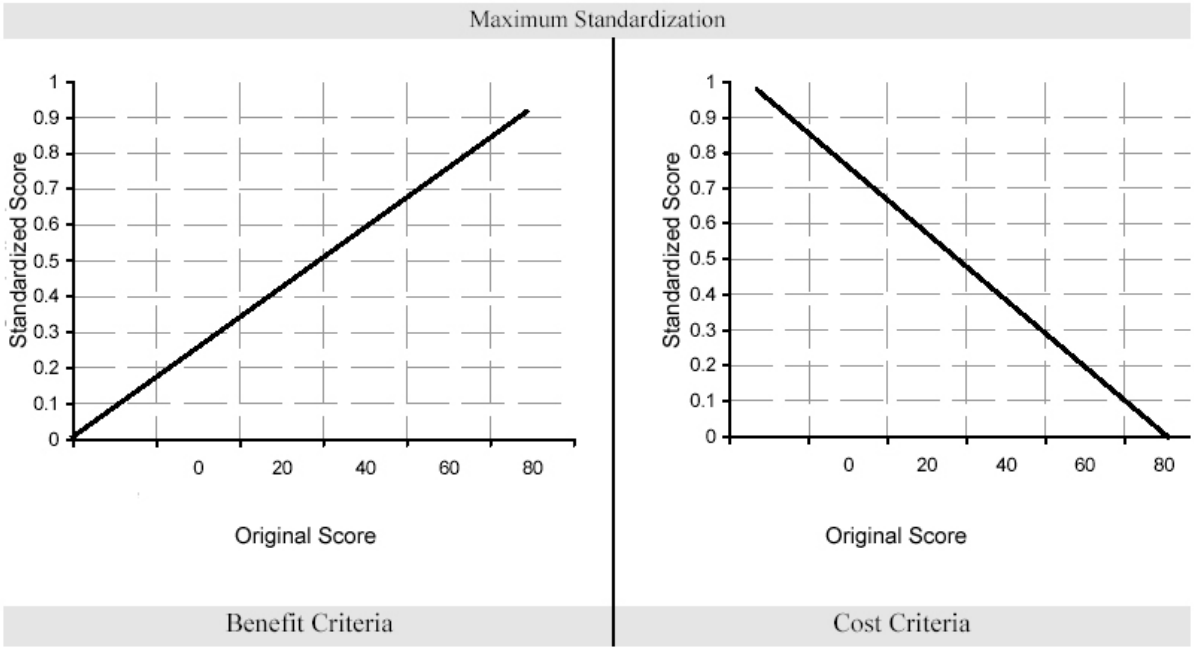


Figure 4.7: Maximum Standardization

Maximum standardization is recommended when the criterion is measured on a ratio scale. The advantage of maximum standardization is that the standardized values are proportional to the original values. A possible disadvantage or in some cases advantage of maximum standardization is that small differences between the alternatives do not become totally visible.

Interval Standardization

The scores are normalized with a linear function between absolute lowest score and the highest score. In a benefit effect the absolute highest score is indicated with a 1, and the absolute lowest with a 0. For a cost effect it is the other way round. The generic formulas of interval standardization are:

$$\bar{x}_{ij} = \frac{x_{ij} - \min_j x_{ij}}{\max_j x_{ij} - \min_j x_{ij}} \text{ [Benefit Criteria]}$$

$$\bar{x}_{ij} = 1 - \frac{x_{ij} - \min_j x_{ij}}{\max_j x_{ij} - \min_j x_{ij}} \text{ [Cost Criteria]}$$

Where: $\bar{x}_{ij}$ is the standardized score, x_{ij} is the original score, $\min_j x_{ij}$ is the lowest score, $\max_j x_{ij}$ is the highest score.

Formula 4.3: Interval Standardization

Interval standardization is evident when a relative scale is used. In these cases no true zero point is present. The standardized values are no longer proportional to the original values. The differences between the alternatives are accentuated because they are scaled between 0 and 1. Depending on the

situation, this can be an advantage when we want to exaggerate the differences, but it will be a disadvantage if the differences are only small and not significant.

Goal Standardization

Goal standardization is somewhat similar to interval and maximum standardization, but here instead of using the highest and lowest values in the matrix a specific reference point is specified. These reference points could be available, acceptable, ideal or goal value and a minimum value and define the range of the values to standardize. The scores are normalized with a linear function between the end points of the range. For a benefit effect the maximum of the range is indicated with a 1, and the minimum with a 0. For cost effect it is the other way round. The generic formulas of goal standardization are:

$$\bar{x}_{ij} = \frac{x_{ij} - \min_j x_{ij}}{V_{goal} - \min_j x_{ij}} \text{ [Benefit Criteria]}$$

$$\bar{x}_{ij} = 1 - \frac{x_{ij} - \min_j x_{ij}}{V_{goal} - \min_j x_{ij}} \text{ [Cost Criteria]}$$

Where: $\bar{x}_{ij}$ is the standardized score, x_{ij} is the original score, $\min_j x_{ij}$ is the lowest score, V_{goal} is the value of reference point, $\max_j x_{ij}$ is the highest score.

Formula 4.4: Goal Standardization

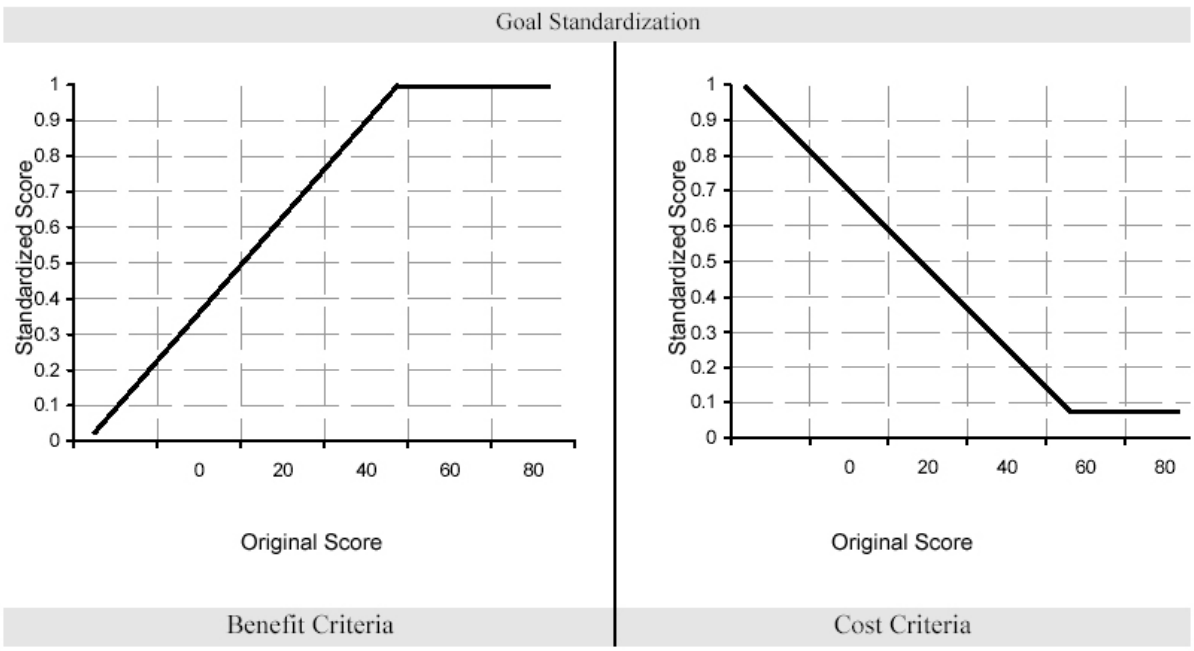


Figure 4.8: Goal Standardization

A meaningful minimum value is often the score in the no action alternative, or the score of the worst possible alternative. The result of this standardization is positive scores for both the benefits and the

cost effects. Goal standardization could, for example, be used with soil pollution data. The seriousness of the pollution can then be standardized between the background concentration (receiving a value of 1) and the concentration giving acute poisonous effects (receiving a value of 0). The advantage of this method is that the standardized values have a clear, real meaning independent of the alternatives evaluated.

4.4.5. Uncertainty Analysis

A ranking of alternatives is only certain if the criterion scores, priorities, value functions and/or threshold values can be measured with complete certainty and if all different evaluation methods yield the same ranking. However, most problems include different uncertainty factors and evaluation methods involve different assumptions. Uncertainty arises from lack of information or knowledge of some aspects of a decision problem. Sometimes uncertainty can be avoided by collecting more information, and sometimes it must be accepted because it is due to unforeseen occurrences (somehow related to the future). The main factors of uncertainty are the role of chance, the ambiguity and insufficient understanding of a problem and in making an abstraction of the actual problem (Colson and Bruyn 1989).

Multiple criteria evaluation (MCE) is composed of several components. Due to the existing ambiguity in one or all of these components the MCE result will always be associated with certain amount of uncertainty, which is built up from uncertainty in every component. Below, the uncertainty analysis, which has been carried in this research, is briefly discussed.

4.4.5.1. Uncertainty on Suitability Levels

In uncertainty analysis of non-spatial MCE, attention is often given to some of its main components such as criteria, criteria scores, weights and evaluation method. With the application of SMCE in suitability analysis, new demands may come up along with its spatial capacities.

While for visualization purpose and in order to make the maps comparable to each other, break points are used in slicing the alternative maps. In fact this method often can only define a relative suitability comparison between potential alternatives but not an absolute one according to the decision problem. Following the procedure of SMCE, mostly it is irrational to define a set of break points to classify the suitability level before generating alternatives and testing the result with regard to the demand. Thus changes in these break points should be carried out no mater on number, level or scale. Revises to suitability levels turn to be needed to test the ability of potential alternatives to fulfil their requirements.

4.4.5.2. Uncertainty on Scores

Sensitivity of the ranking to the scores can be examined by 1) looking at the overall uncertainty of the scores or by 2) looking at the influence on the ranking when changing one criterion score.

The first type of uncertainty can be examined using a Monte Carlo approach. The decision maker has to estimate the maximum percentage by which actual values may differ from the values included in the effects table. A random generator is used to translate this information into a large number of effects tables around the original effects table. The rankings, determined from these effects tables, are aggregated into a final ranking. This method can be applied for every evaluation method resulting in a complete ranking. The interdependencies between criteria have to be taken into account when applying the random generator. Otherwise, they may have a distorting effect on the results of sensitivity analysis on rankings of alternatives.

The second type of uncertainty concerns the influence of changing one criterion score on the ranking of two selected alternatives. The method results in a certainty interval in which the ranking of the two selected alternatives is not sensitive to changes in value of the selected criterion. If much debate exists on the value of a certain criterion-score and the certainty graph of this score shows that small changes in the score result in a different ranking of the alternatives, then more research will be needed to remove or decrease the uncertainty (Sharifi, Herwijnen, et al. 2004).

4.4.5.3. Uncertainty on Weights

Weights or Priorities, reflecting the relative importance of the criteria and criterionscores, have a major impact on the final results. This embodies a large amount of uncertainty, especially when weights are quantitatively assessed. Sensitivity of the ranking for the weights can be examined by 1) looking at the overall uncertainty of the weights; 2) looking at the influence on the ranking when changing one criterion weight; 3) looking at changes in all weights; and, 4) using different sets of weights. As the first two methods proceed analogously to the above methods concerning sensitivity of the ranking to the scores, here only emphasizes on the latter two methods.

Changes in All Weights

This method determines which combination, most similar to the original combination of weights, changes the ranking order of a selected alternative. The following three ways can carry out this operation (Sharifi and Herwijnen 2003). (1) rank reversal of two alternatives; (2) first position of an alternative; (3) loss of first position of an alternative.

Different sets of Weights

This method aims to test the sensitivity of the ranking of alternatives to the weights by using different sets of weights, which acknowledges the existence of more than one viewpoint and represents different strategic viewpoints. It is important to have a good inventory of the visions of all the interested parties. When there are too many visions, the goal may be lost making things unclear, and diminishing the value a vision approach can have. Therefore it is important to have a few clear viewpoints and pay more attention to the valuable ones.

5. Result and Discussion

5.1. Defining the Stakeholders' Preference

Spatial decisions are often made by groups (multiple decision makers rather than an individual decision maker). Especially in the public sector, group decision-making is frequent. Land use planning decisions are typically complex since it has unavoidable trade-offs inherent in protecting or developing specific lands and the differential impact on various stakeholder groups. So stakeholders' values and interests have to be analysed to determine the land use pattern that maximizes consensus or minimize conflict. The degree of consensus can be considered as a major determinant of the nature of decision process, and therefore of how a decision model should be organised. Consequently, the distinction between individual and group decision-making relies less on the number of people involved than on the consistency of the group's goals, preferences and arguments.

As analysed in section 4.3.1, different stakeholders expressed their own decision model about the location of cemeteries. It is attempted to have an idea about the decision model the stakeholders possess in their mind and practice because they may have special dimension away from urban planners. They have different operational objectives and different levels of preferences in satisfying the criteria involved with it. However, to consider their opinion into the decision support model of this research, their criteria and preferences are restructured and presented in Table 5.1. The lower the value, the higher the rank, and the more preferred by the corresponding stakeholder. In this table, it is shown that most stakeholders give emphasis on ecological issues, which indicates the potential pollution caused by cemeteries to the water-bearing stratum and safe distance between living space and them. On average the second important factor is the criteria concerning physical aspects. Firstly because cemeteries' location should insure the preservation of gravesites and normal decomposition process of human remains, and secondly some topographic characters of physical environment are preferable for mourning purpose according to funeral cultures. Relatively equal emphasis is given to policy and economic issues related to cemetery planning, concerned most by government and undertakers respectively, because each of these two group has their own emphasis on political management and profit seeking during burial practice. The criteria in the choice phase are averagely given equal attention, considering that cemetery planning involves both pragmatic and emotional particularities.

These different levels of preference on cemetery location have made the different importance of criteria groups in the decision-making process. Decision model has been re-structured as they can be fitted well within the ILWIS' SMCE framework. The decision model and the preference by stakeholders have been translated to the criteria tree to fit with the data and achieve the research objectives as SMCE operations can be performed efficiently.

Criteria Group	Rank Order of Preferences				
	Government	Expert	Undertaker	Resident	Overall
Design Phase					
Policy Aspect	1	3	4	4	3
Economic Aspect	4	4	1	3	3
Physical Aspect	3	2	2	2	2
Ecological Aspect	2	1	3	1	1
Choice Phase					
Social Aspect	1	1	2	2	1
Cultural Aspect	2	2	1	1	1

Table 5.1: Preference on Major Criteria by Different Stakeholders

5.2. Alternatives Generation through SMCE methods (Design Phase)

5.2.1. Structuring Decision Model and Scenarios Generation

Structuring Decision Model

The purpose of the design phase is to generate alternatives for suitable cemetery location in the study area. The decision model has been input into the criteria tree (Figure 5.1) that has been developed in ILWIS' SMCE module, which comprises of several components following design objectives. All criteria have been assigned in groups to structure the problem and linked to its corresponding map. The major four groups of the value tree is to set criteria from policy, economic, physical and ecological aspects. Their weighting and standardization methods are also presented along with their results.

Character of Cemetery Location and "Sustainable Suitability"

As mentioned before, the location of cemeteries will be relatively stable in a long term compared with the expansion of living space brought by the urbanization process. During the time, new areas for the living will be constructed and change the whole environment for cemeteries. Originally located outside the built-up areas, many cemeteries are now embedded in, or immediately adjacent to, the urban tracts (Teather, 2001). Thus cemeteries built before may not seem to be in the right place according to current urban situation. In the same way, newly planned cemeteries will also affected by the urban expansion. There should always be a doubt on whether the planned burial land will still be suitable some years later. Moreover, as nowadays cemetery planning is widely ignored when scheming out the land use master plan, they will also be a limiting factor to future urban development.

In this sense, the concept of "suitability" for lands with stable location, like cemeteries, should be added to another dimension of time. As our objective is to locate suitable land for urban cemeteries, spatial-temporal analysis is necessary to measure the "sustainable suitability" brought by the dynamic process.

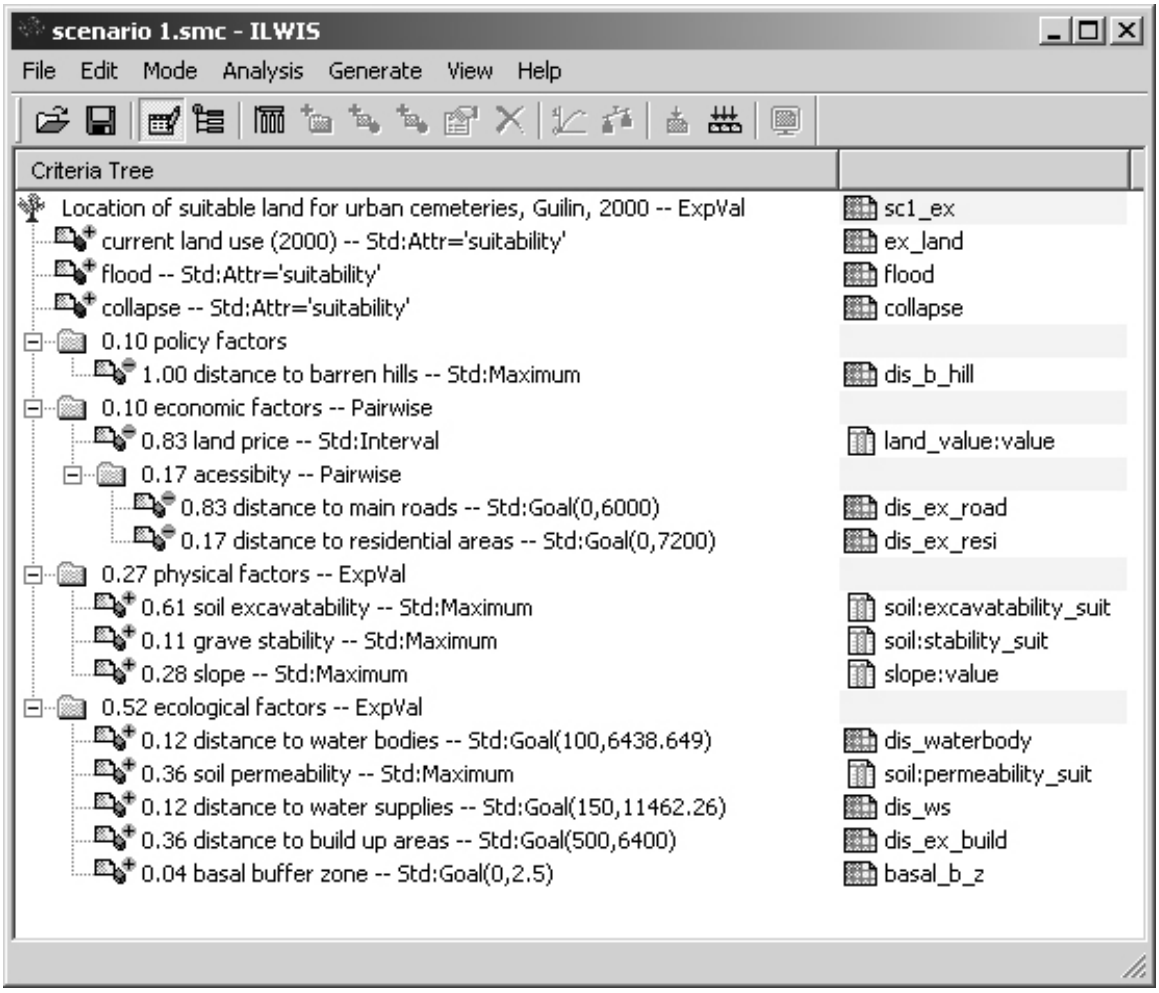


Figure 5.1: Criteria Tree in ILWIS' SMCE (Scenatio 1)

Three scenarios are generated to develop area for urban cemeteries based on the environment of urban development changes in current and future time. The data, which is used as the current and future urban situation (land use, road network, residential area and built-up area) of the study area, come from the *Urban Master Plan of Guilin (2000-2010)* carried out in 2000 (Section 3.3.2). There has also been an assumption that other parameters such as cemetery regulation and physical environment, which are showed in criteria maps other than the urban situation, will not change in this period. In this way, the same weight system and standardization value function are assign to the three scenarios in order to make the comparison of the results significative. For visualization purpose and in order to make the maps comparable to each other, the suitability level mentioned in section 4.3.4.1 is applied in this stage.

Scenario 1

In this scenario, the current situation of the study area (year 2000) is looked on as the environment of the planning thus the result is called "current suitable land for urban cemeteries".

In the suitability map (see Map 5.1), there shows at least four sites sum up to 592.83 hectares claim highly suitable and all of them located near the edge of the urban area. The one in Diecai district on the north part of the city is near to the existing Yaodi Park Cemetery and adjacent to the protection

area of Mausoleums of Jingjiang Emperor, enclosing most of its boundary. The one in Xiangshan district is along the high way from the urban Guilin to Lingui County, partly enclosed by the hills on the very south part of the area. On the east edge of Qixing and Yanshan districts, there are also two relatively small sites shows suitability score above 60%.

Scenario 2

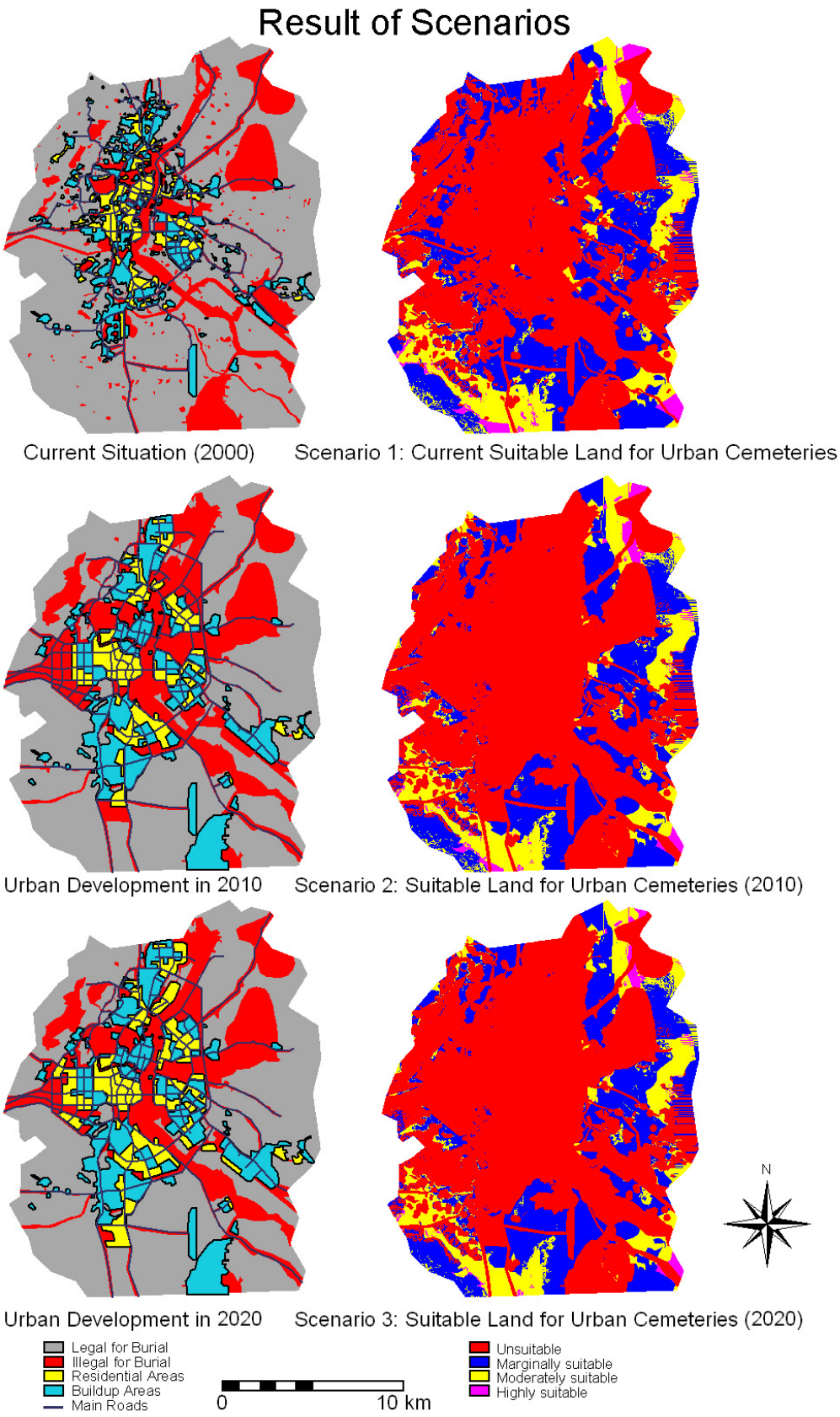
In this scenario, the situation of ten years later (year 2010) is looked on as the environment of the planning thus the result is called "suitable land for urban cemeteries in 2010". The data of *Urban Master Plan (2000-2010)* in the master plan is regarded as the situation.

In the suitability map, the highly suitable areas decreased to 401.08 hectares. Different changes happened among the sites described above. The sites in the Diecai and Xiangshan have largely decreased in area. The one in Qixing is not strongly affect by urban expansion, and the area of the site in Yanshan district, which will be closed to a newly planned highway, has even increase.

Scenario 3

In this scenario, the situation of twenty years later (year 2020) is looked on as the environment of the planning thus the result is called "suitable land for urban cemeteries in 2020". The data of *Urban Long-Term Plan (2000-2020)* in the master plan is regarded as the situation.

As the suitability map shows, the claimed highly suitable land decreased to 276.92 hectares, counting to half of the amount in the year 2000. Obvious change can be found from both the ones in Diecai and Xiangshan districts, which respectively locate on the north and south end of the study area.



Map 5.1: Result of Scenarios

5.2.2. Scenarios Results and Spatial-Temporal Analysis

According to the explanation in the last section, both the current and future should take into account in order to make a cemetery with advantage in sustainable development. First we should find out how and where the urban development will influence the suitability of cemeteries, and then in order to maintain the suitability of now-planned cemeteries and guarantee the well-balanced urban development, what advice and recommend should be given when determining the pattern of future development planning for living people.

Changed Criteria

The changed criteria in this model are regarded as the driving force for the change of suitability. As we refer to each of them among these scenarios, the changes and its effects on the total composite value can be explored (see Figure).

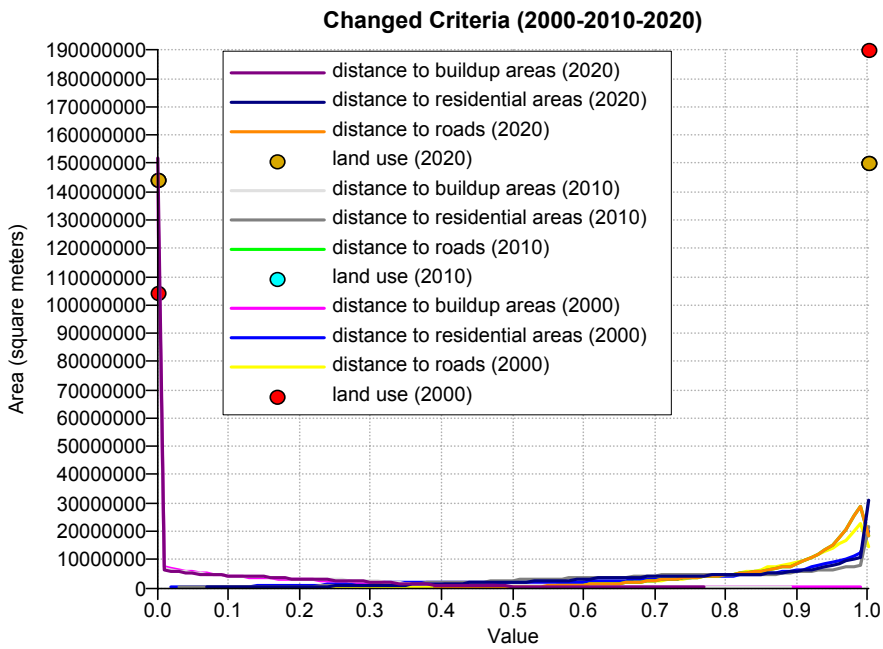


Figure 5.2: Changed Criteria

-Land use: from 2000 to 2020, the land available (legal) for burial is reduced from 19031.77 hectares to 15052.80 hectares because of the urban expansion. Since criteria that are defined as constraints are handled with a Boolean operator, a great portion of land has been discarded for future consideration.

-Accessibility: a relatively large land shows easy to access and the accessibility to cemeteries increased with the time because of the spatial expansion of living people and construction of newly planned roads. The road network plan makes it convenient for cemetery planning.

-Distance to buildup areas: compared with the criteria of accessibility, a relative low amount of land shows optimal distance. The land is even becoming less when the construction of new buildup occurs. It shows necessity to pay attention the safe distance from cemetery in order to avoid pollution with the time goes on.

Extent of Changes

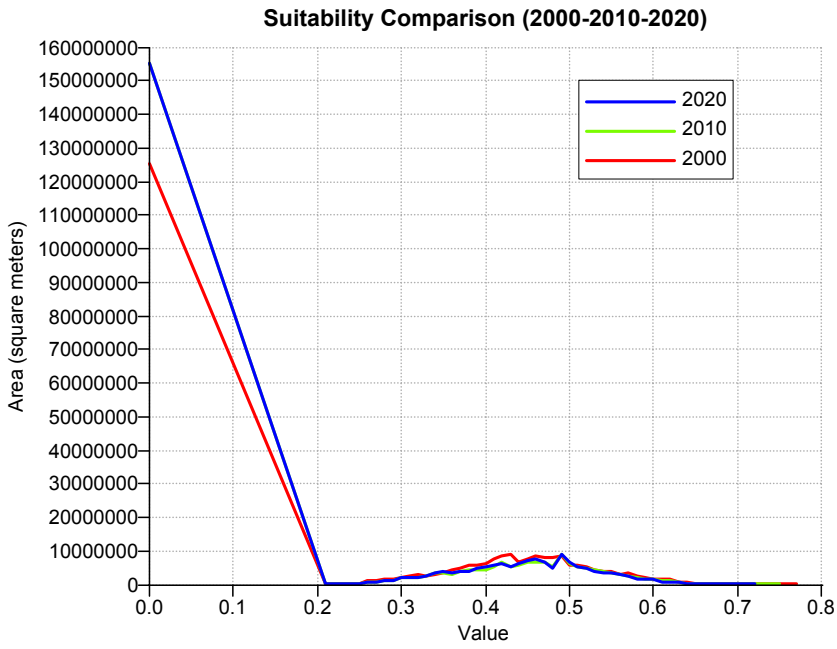
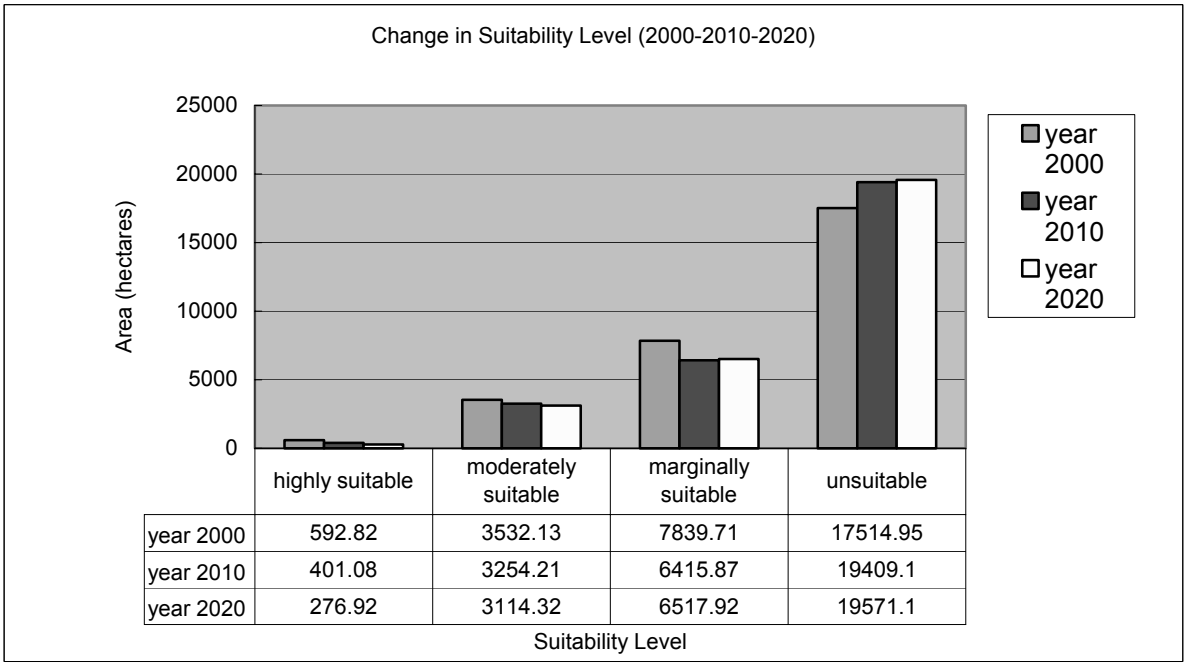


Figure 5.3: Suitability Comparison (2000-2010-2020)

The above figure shows the quantity of land according to their suitability values. In this case, the clearest changes happened to the land with very low values and marginally suitable (41-50%) lands. To the former, its increase is mainly due to the largely decline of legal land for burial. The change in the latter is a composite result of urban expansion.

From the study of the following figure shows the land of four suitability levels in each scenario (Figure 5.4), it is clear from the table that with the urban development, the quantity of highly and moderately suitable land for burial declines, but the unsuitable ones go up. It shows less and less land will be suitable for cemetery development and also suggests that the suitability of now planned cemeteries may descend in later days.



	highly suitable	moderately suitable	marginally suitable	unsuitable
year 2000	592.82	3532.13	7839.71	17514.95
year 2010	401.08	3254.21	6415.87	19409.1
year 2020	276.92	3114.32	6517.92	19571.1

Figure 5.4: Change in Suitability Level (2000-2010-2020)

Trend of Changes

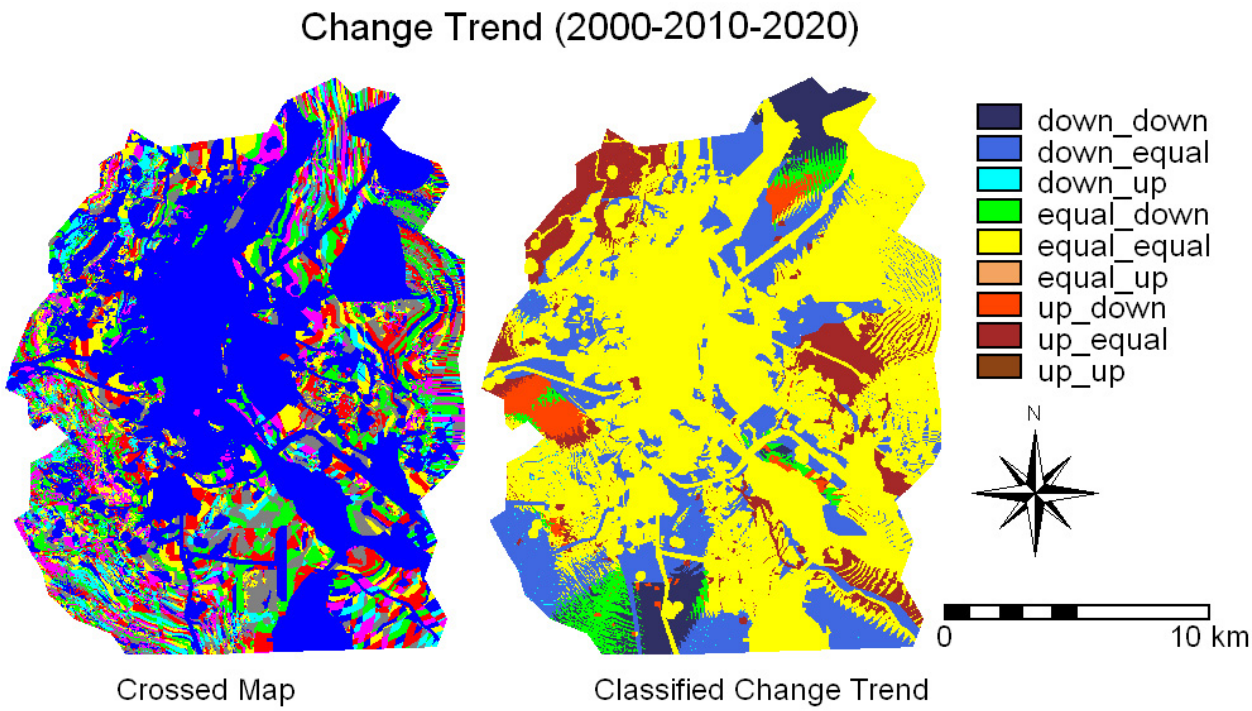
In order to know the spatial distribution of the changes brought by urban expansion, the scenario maps are crossed and classified according to the way each pixel has changed during the twenty years (see Map 5.2). The trend of change is described as "up", if it increase in suitability in a decade; it is called "down" if its suitability value becomes less.

From Figure 5.5 we can find that a large quantity of land keeps still in its suitability, by checking the map, a large portion of this is the illegal land for burial because their value stays zero. Followed by it is the land that decreases in suitability in the first ten years but keep still in the next. They are relatively near the land mentioned above which affected more by the expansion of new buidup area. This reflect that expansion rate of buidup descends in the second decade. But one thing should bear in mind is that these developments are defined by the plan rather than simulating the urban expansion of real future, the smaller changes may also caused by lack of knowledge, prediction ability and control method of the planner.

A surprising finding is that there are also lands show becoming better for cemeteries in the first decade whose area is not small. Referring to the spatial location of them on the map, they are mainly areas that new planned roads will be built, so the increasing suitability is largely due to the improvement of accessibility. By the way, the regulation of the informal land by the plan also has effect to this change. And because fewer roads are built in the second decade, these areas either remain or descend in suitability then. As shown in many cases, new roads may evoke buildup areas developing along them, so that we should not pay optimal opinion to this kind of temporary increase of suitability.

Another crucial finding is that a large section of the land on the northeast and southwest edges of the study area, which claims to be highly suitable in the scenario maps, keeps becoming worse during the twenty years. This indicates that the direction of the urban expansion is disadvantageous to these areas.

Although as mentioned in section 3.3.2, the master plan hopes to direct the urban development mainly toward west, for the expansion to north and south in the past decades aggravated the burden of traffic in this direction. But because the cemetery land is considered exclusively when scheming out the land use plan, the strength to limit the urban development seems not enough to grantee the future growth. If the cemeteries are chosen to be located there (as shown in the later choice phase, the ones on the northeast have the highest composite suitability), recommendation should goes to planning authorities to revise the urban expansion pattern.



Map 5.2: Trend of Changes (2000-2010-2020) (trend of change is described as "up", if it increase in suitability in a decade; it is called "down" if its suitability value becomes less in one decade; "equal" means no change happened to suitability value)

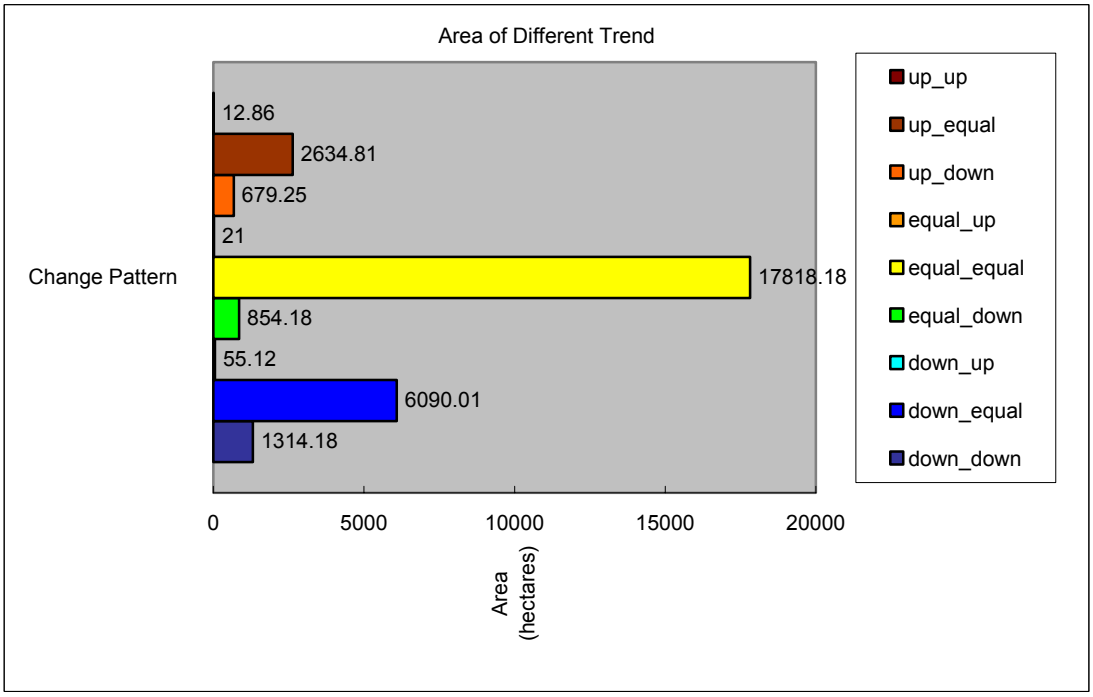


Figure 5.5: Area of Different Trend

5.2.3. Alternatives Generation

Because the future change of urban will affect the suitability of urban cemeteries, all the effort should be paid to our purpose as to find out location with sustainable development feasibility. In this sense, if every pixel on the scenario maps is treated as a potential site, the suitability of each scenario should be composed again as we did with criteria maps to check the sustainable suitability of it. So the problem is structured again in this stage into a criteria tree with higher level due to the added dimension of time (see Figure 5.6).

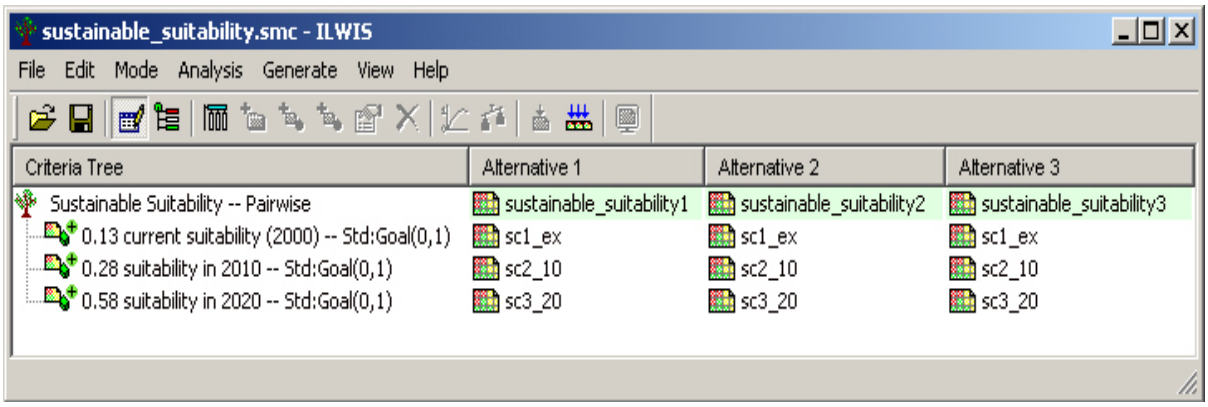
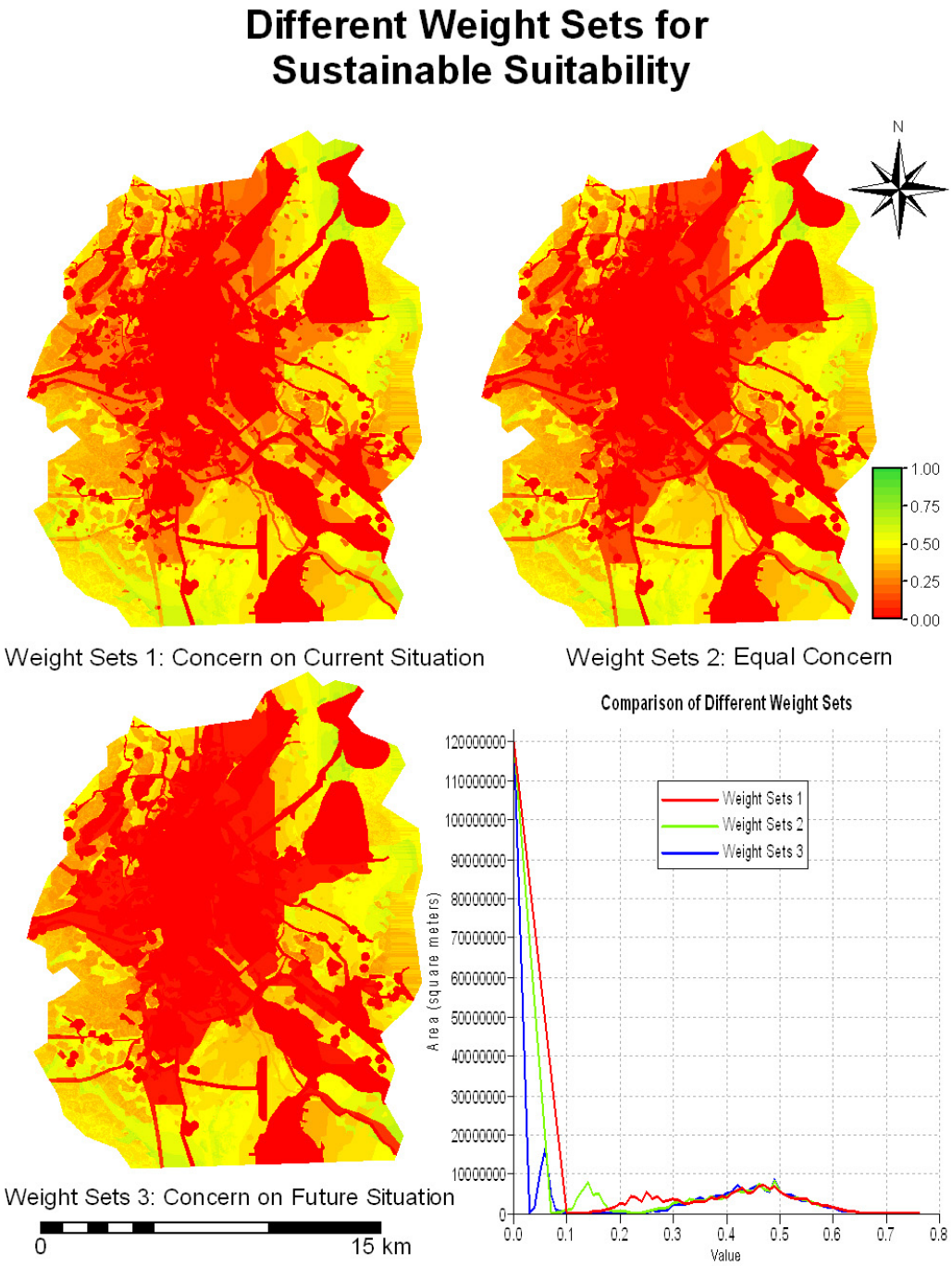


Figure 5.6: Criteria Tree for Sustainable Suitability

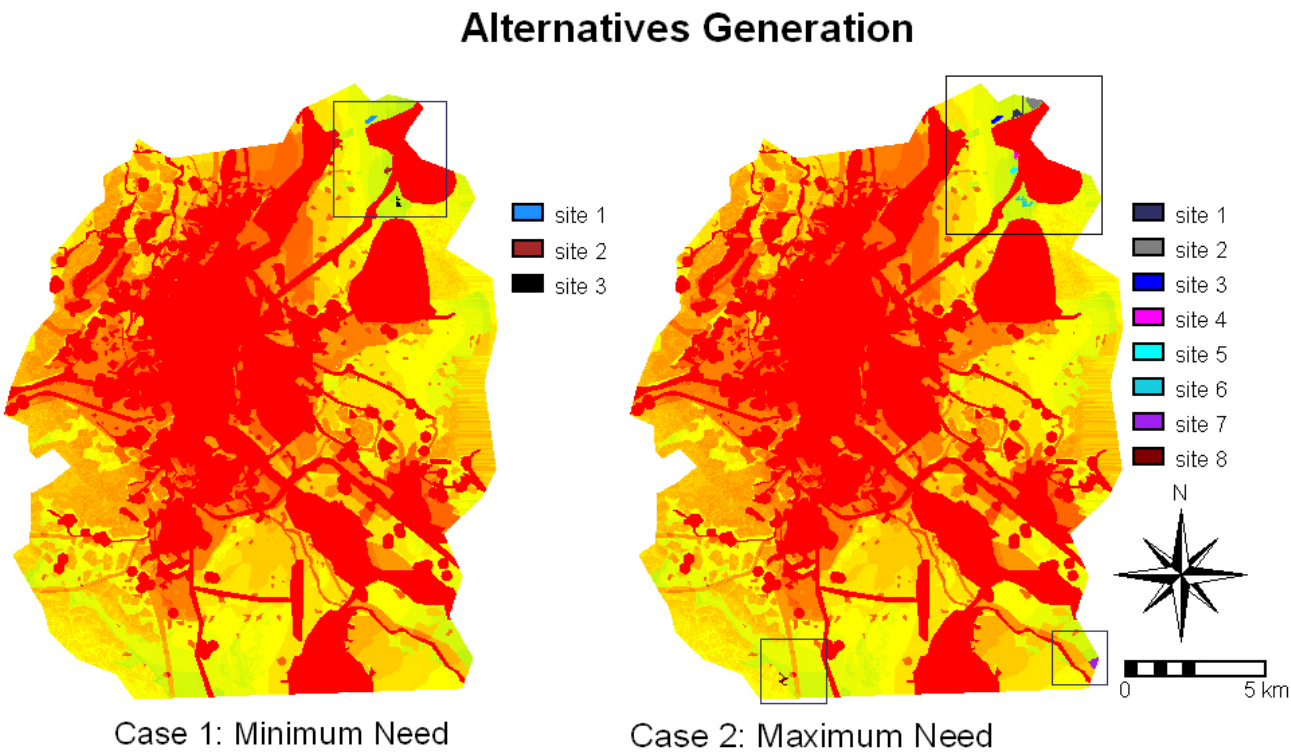


Map 5.3: Different Weight Sets for Sustainable Suitability

Different weight set (see Section 4.3.4.3) is given to each scenario map from three perspectives. The first concerns more about the current and the last give more priority to future. Another one gives equal emphasis on all the three times. The result shows that the different weight sets will cause unlikeness and fluctuation in the area with low suitability (≤30%), but will not strongly affect the most suitable ones where our aim goes. In this research, the first weight set is chosen not because we tent to ignore

the time to come, but because in this case our knowledge of current situation is much more reliable than that of future. The future development of the study area is based on the master plan, and there is an uncertainty on to what extent it could be relied on for forecasting the future situation.

The fact that land is claimed highly suitable does not necessarily mean that it is acceptable for the expected requirement. If there is not enough land with the highest possible suitability level to meet the allocation objective, land with a lower level will be selected. For this reason, it is important to review the suitability levels for the land allocation requirement (see Section 3.4.4). And then the small ones (≤ 2 hectares), which are not economically feasible (Section 2.1.1.2), are subtracted from the selection also. After having analysed the requirement and the map of sustainable suitability, land having a composite value above 67% could fulfil the requirement of the case when minimum burial land is needed, and when lower the value to 64%, the land is enough for the maximum need (for minimum and maximum land requirement see Section 3.4.4). As a result, three sites are identified in the first case and 8 alternatives in the second one, which have both enough suitability and sufficient capacity. The alternatives and are illustrated in Map 5.4



Case	Suitability Level (%)	Number of Alternatives	Total Area (m^2)
1: minimum amount	67	3	154900
2: maximum amount	64	8	650100

Map 5.4: Alternatives Generation

In this research, because only at most five cemeteries could be built defined by the local government, the three alternatives in the first case may already be the choice while in the latter a further step should be done as ranking and choosing the alternatives.

Another mention should be given is that the minimum need of cemetery capacity is calculated based on the assumed situation that cremation rate has largely improved by the cremation policy. In this context, theoretically the burial land may be to some extent released from environmental issues. But because the study area is an autonomous region of minorities, the population of the minority nationalities whose inhumation custom is reserved by policy has already enough to pose a threat to nature. According to the accumulated death of this group in section 3.4.4, the number has largely exceeded the threshold mentioned (see Section 2.1.2.2) for environmental concern. As we are now lack of knowledge on to what extent it can be released from some of the design criteria and weights, the result of this assumption is reserved. Therefore in the next procedure, which is the choice phase, attention is given to the case when maximum burial capacity is needed. Because it is based on the predicament in which cemeteries will cause the most problems to living people.

5.3. Site selection with MCE methods (Choice Phase)

Through former research and stakeholders analysis we know that to cemetery planning, the needs from psychology and spirit are no less than those pragmatic issues, and always lead to people's satisfaction and choice on cemeteries. As the result of the design phase was brought out by a relatively rational purpose, which concerns policy, economic, physical and ecological factors along with urban development, the cultural factors mind how it can fulfil people's psychological and ethic demands. In the choice phase, these two aspect are taken into account, thus we could identify how or to what extent a so-called "rational" or "reasonable" site could emotionally accepted by people.

5.3.1. Site Ranking

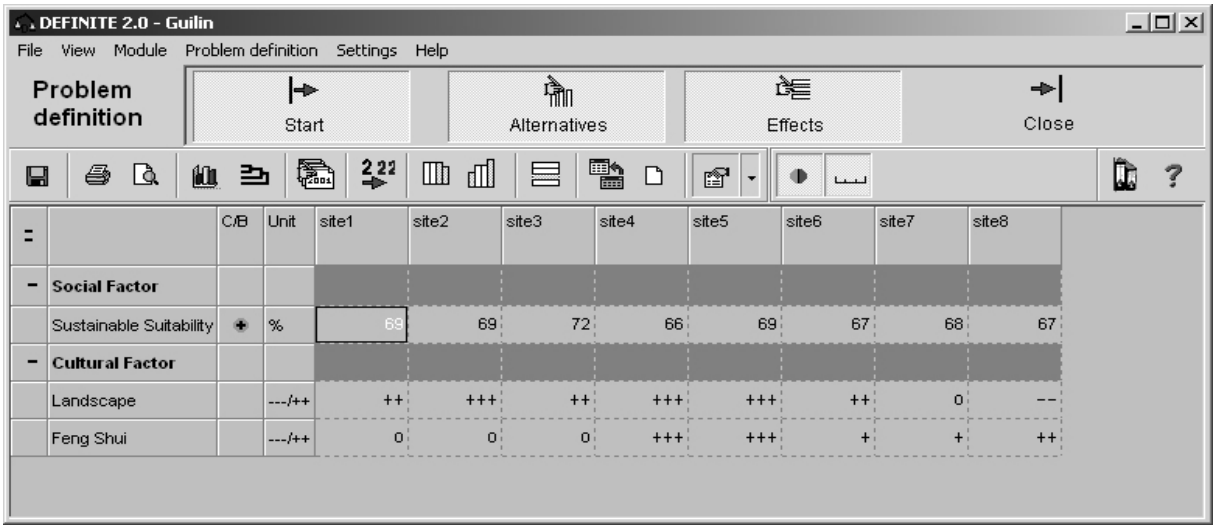
In the previous phase SMCE was used to identify potential sites. The purpose of the choice phase is to rank them and choose the site or a set of sites within all the alternatives that are relatively more attractive than the others. The result of the design phase is input into the evaluation matrix of the choice phase by regarding the sustainable suitability of each potential site as one of the criteria. As the choice phase is a non-spatial evaluation, only the 0-demantional value of each alternative is regarded, which is called social factor. The other two--landscape and Feng Shui, are grouped as cultural factors.

Site ID	Area (square meters)	Sustainable Suitability (%)
1	121100	0.69
2	149000	0.69
3	65800	0.72
4	28300	0.66
5	42900	0.69
6	97800	0.67
7	88200	0.68
8	57000	0.67

Table 5.2: Alternative Sites in Choice Phase (the sustainable suitability derived from the design phase has already given a ranking of these sites, the criteria use in the choice phase will further amend or conform the ranking)

Effects Table

In this case, this procedure is accomplished by structuring the choice procedure into a MCE matrix. The factors are regarded as "effects" in DEFINITE software to make a ranking among the eight alternative sites. The value of the social effect come from the sustainable suitability as a result of the design phase and the cultural ones are based on the local knowledge and investigation of the potential sites carried out the urban planners of UPDIG. The score of social effect is in a ratio scale as they are directly from the value of suitability. As a measurement of ordinal scale, pluses (+) and minuses (-) are used in evaluating the cultural effects. If it is good, at most three pluses (+++) could be given; if bad, at most three minus (---) are given. This provides a convenient and sound way for valuing some general and abstract effects other than those could be quantified. Thus an effects table is generated in DEFINITE (Figure 5.7).



	C/B	Unit	site1	site2	site3	site4	site5	site6	site7	site8
Social Factor										
Sustainable Suitability	+	%	69	69	72	66	69	67	68	67
Cultural Factor										
Landscape		---/++	++	+++	++	+++	+++	++	0	--
Feng Shui		---/++	0	0	0	+++	+++	+	+	++

Figure 5.7: Effects Table

Standardization and Weighting

As the processes in the design phase, through a standardization procedure the measurement units are made uniform and the scores lose their dimension along with their measurement units. The method to standardize should depend on the problem character and the attributes character. In this phase, because our purpose is to ranking the alternatives, the differences between the alternatives are accentuated by applying interval standardization (see Section 4.4.4). As the number of the effects of this phase is small, pairwise comparison is used to assign weights to each effect. The standardization method and final weights for those three effects are presented in Figure 5.8.

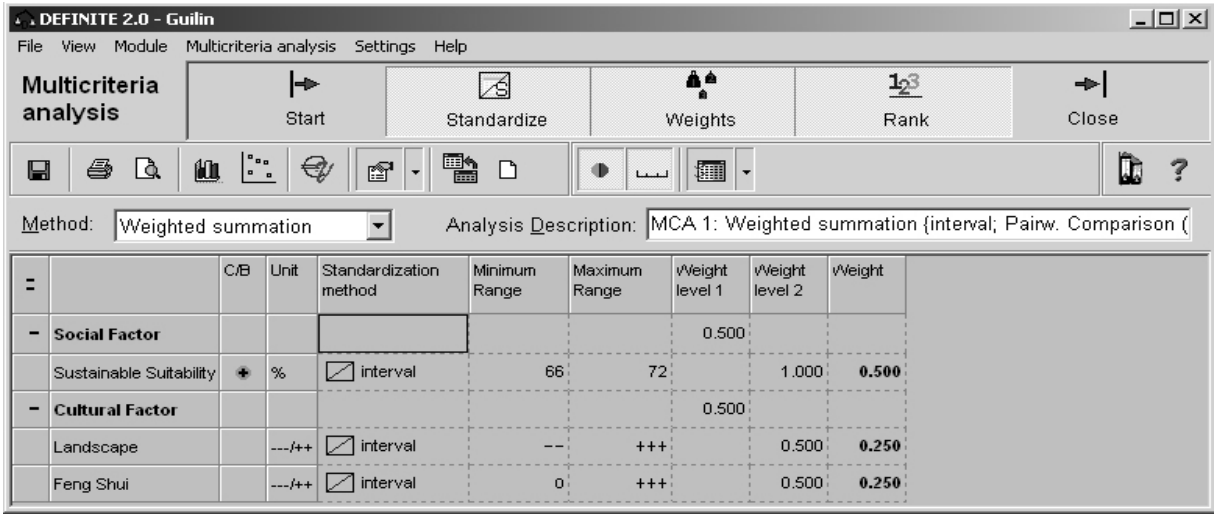


Figure 5.8: Standardizations and Weights

Site Ranking

After the standardized scores and weights have been determined, weighted summation is applied to make a ranking of the alternatives (from site 1 to site 8) according to Formula 2.1. In the figure below we can see the ranking results represented graphically. The weight is displayed as a pie graph next to the ranking window and stacked bar graph are used to view the contribution of the effects scores to the total scores. Note that according to current weights, site 5 is the best alternative, followed by site 3, 2, 4, 1, 6, 7 and 8. The effect of cultural factors is the main cause for site 8 to be the best alternative. By calculating the area of sites from Table 5.2, the first five sites can already fulfil the cemetery capacities need. If not, more information will be needed on whether the ranking is robust in order to determine if site 6, 7, 8 could replace the currently shown better ones or it is needed to lower the suitability level to find more land.

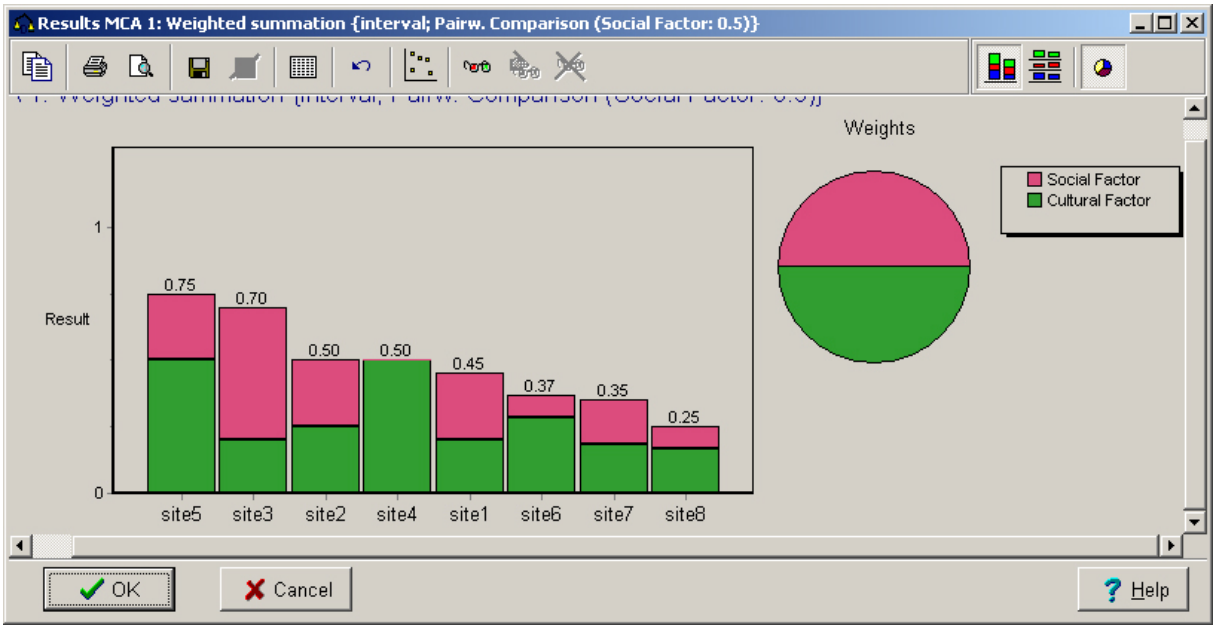


Figure 5.9: Ranking Result

5.3.2. Sensitivity Analysis

This step is aiming to identifying the effects of changes in the inputs on the outputs (ranking of alternatives). If the change does not significantly affect the output, the ranking is considered to be robust. If the current result is found to be unsatisfactory, we may use information about the output to return to the problem formulation step. The sensitivity analysis can be thought of as exploratory process by which the decision makers achieve a deeper understanding of the structure of the problem.

5.3.2.1. Uncertainty on Weights

We can see from the funeral policies that on one hand both central and local authorities hope to change the customs such as inhumation and grave location totally according to tradition, on the other hand they to some extent recognize and show respect to some of them and institutionalise them as policies. There are always competition and compromise between the rational suitability and traditional preference, so that we need to compare the importance of these two aspects and ask whether this would change our choice. This information is valuable for the government for determine the final choice on which alternatives should be developed.

Change of Effect between Two Weights

A scatter diagram is used to have a closer look at the two effects group that affect to the total scores. The best ideal alternative would have a score of 1 for both effects and would be found in the top right corner of the diagram. The alternative located closer to this ideal the better. By changing the weight of these two effects we may find that only if the cultural effects are weighted twice as important as social one could site 6 replace site 1 to become the choice.

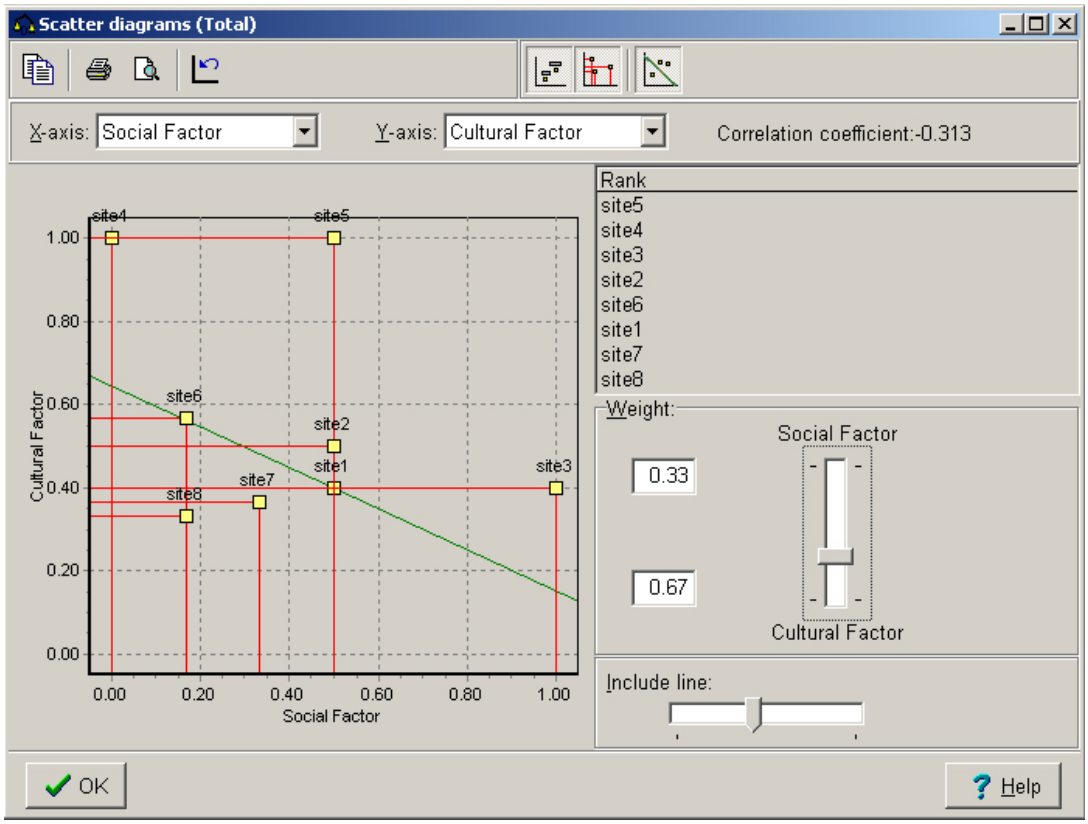


Figure 5.10: Scatter Diagram

Overall Uncertainty of Weights

As mentioned in section 4.4.5.2, the sensitivities of ranking to overall in scores and weights are analysed by using a Monte Carlo approach. The decision maker is asked to estimate the maximum percentage that actual value may differ from those included in the elements of the effects table or set of weights. Figure 5.11 shows a result of sensitivity analysis on the ranking of alternatives by looking at the overall uncertainty of the weight. Here it is assumes that the weights can fluctuate 50% from the assigned weights and that this deviation is normally distributed. The large-sized circles on the main diagonal indicate that the ranking of the alternatives under this uncertainty is relatively stable. The figure shows that site 6 have little chance to rank as choice but site 7 and 8 absolutely could not be.

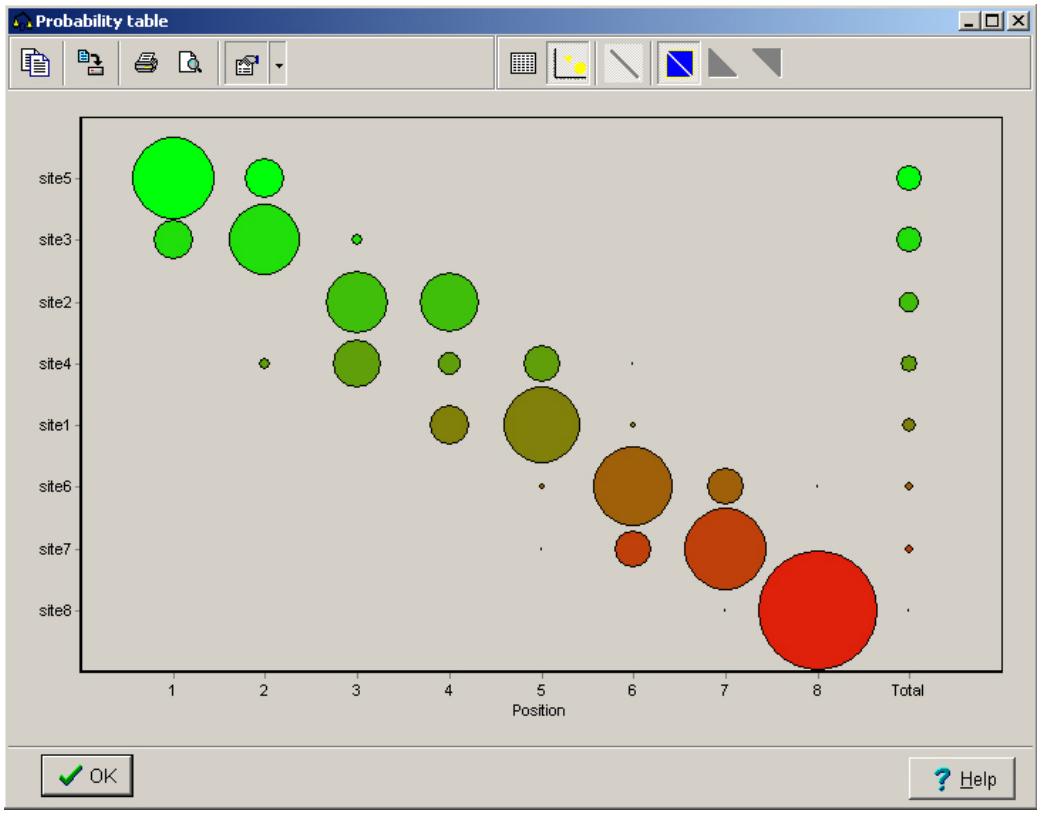


Figure 5.11: Uncertainty analysis on Weights (50%)

5.3.2.2. Sensitivity on Score

In this section a procedure is described to estimate certainty intervals for criterion scores. Within a certainty interval the ranking of two alternatives is not sensitive to changes in criterion scores. Analysis shows the difference between site 6 and site 1 is somewhat large because only a large increase in scores of effects of site 6 could make it a better alternative than site 1.

Another thinking is that among these effects, landscape is the one that usually will be modified after cemetery construction. A sensitivity on the score of landscape will reveal how much should the effort be given on improving landscape in order to make it better than others. This information is useful for exploring the marketability of a cemetery sites when more than one cemetery will be developed and

compete with each other. Figure 5.12 shows that if the landscape of site 3 is improved to a higher level (+++), it would has the same rank as site 5 to be the first choice.

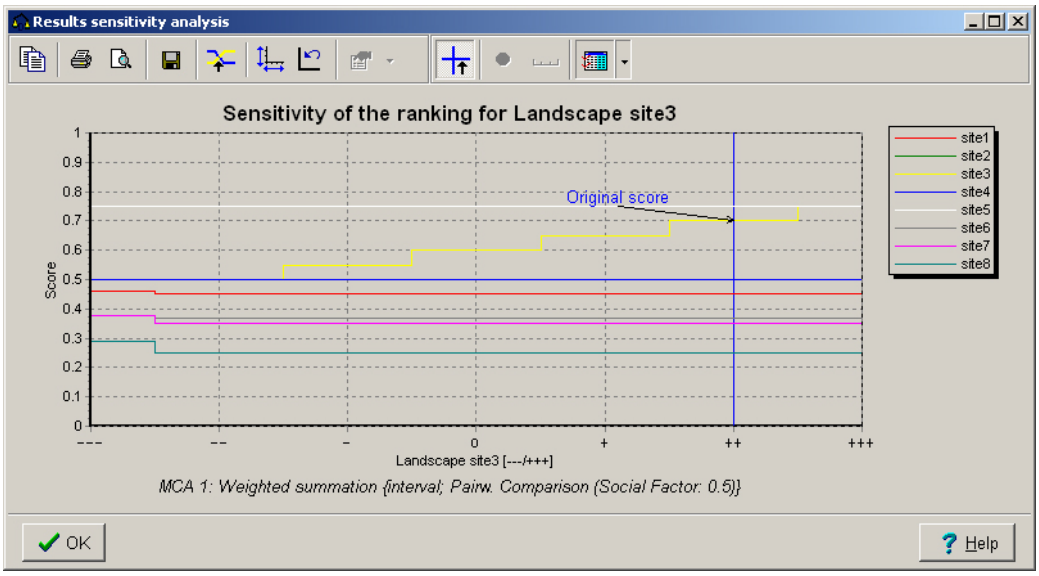
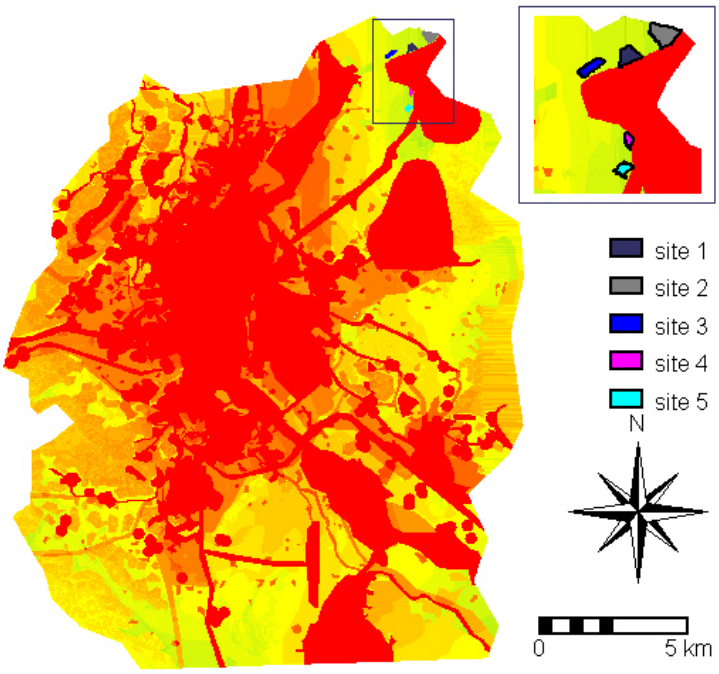


Figure 5.12: Sensitivity of the Ranking for Changes in Single Score

5.4. Result Evaluation and Summary

From all above ranking and sensitivity analyses, it can be concluded that the ranking of sites is robust and site 1 to 5 should be the choice for urban cemeteries development in the study area.



Map 5.5: Site Selected

Selecting sties from the result of the multiple criteria analysis does not necessarily mean that it will be successful soon, because in order to fulfil the requirement on the area of the land, we pose an uncertainty on the quality of the land. With out providing support development it may not perform well. Thus evaluation of these chosen sites should be carried out to define the insufficient and weakness of the sites chosen.

By looking into the criteria of each site, most of the demand from the criteria can satisfied but there are also some shortcomings as follows:

- While site 1, 2, 4 are all within walking distance (≤500 m, see Montoya, 1998) from main road (Guilin-Lingtian highway), the nearest distance of site 3 is 967 m. There shows a demand on road construction for this site.

A large amount of land (28.63 hectares, counting to 70.33% of the total area) has a gradient lower than 2°. It shows a potential problem would be brought by poor drainage. When a cemetery is located in these low-gradient areas, the best possible drainage must be ensured, even if a drainage system has to be installed. The introduction of vegetation, especially hydrophilic species, would also be beneficial (Fisher, 1994).

These five chosen sites as development projects add up to 40.71 hectares, which can fulfil the maximun needs of 37.89 hectares until 2020. All of them are located on the northeast corner in Diecai district, near to the Yao Mountain and adjacent to the protection area of Mausoleums of Jingjiang Emperor. Because the site of Mausoleums of Jingjiang Emperor was located in ancient times totally by Chinese Feng Shui masters, the result of this research confirms that there are rational components in the philosophy and technology of Feng Shui.

From Figure 5.8, 5.9 and Table 5.2, all of these sites show both high suitability in rational criteria, which were used in design phase, and emotional criteria in the choice. Only site 4 has largely benefited from its nice landscape and Feng Shui. Without these features it will be ranked below site 6, 7 and 8.

It shows that although from design phase a ranking could already derive from the rational suitability of the sites, cultural effects also play important role to modify the ranking and educe the choice. According to the result, the local authorities would be able to give guidance on contract with undertakers and encourage well-balanced development through institutional and economic means, such as establish spatial distribution of land price for burial purpose.

In this way, this model has concerned both current suitability and future development, both rational feasibility and emotional value, which tries to ensure the suitable location planning, which is our objective to the most extent. As mentioned in previous words, the direction of the urban expansion should be further controlled in order to ensure the sustainable suitability of the sites, if not they would loose their priority in the future according to the trend of the changes shown in Section 5.2.2. At the same time, the performance of cremation policy, the reuse and renew rate of the graves, along with the new proposal method of human remains developing in this study area (such as newly planned columbaria mentioned in Section 3.4.4) will largely affect the duration when the sites could still fulfil the burial demand in a long turn.

6. Conclusion and Recommendation

6.1. Conclusion

In this research, effort was focused on applying GIS and MCE to locate urban cemeteries. The research questions include the following main aspects:

1. How to identify the elements of urban cemetery location planning?
2. How to design an approach to locate suitable land for urban cemeteries?
3. What could be done to improve decision on cemetery site selection?

In the following section in this chapter, some findings and problems encountered in this research will be discussed and then the conclusion of this research will be given based on the result of this research.

6.1.1. Elements of Urban Cemetery Location Planning

Cemetery planning has been neglected worldwide. This is true for urban planners who regard cemeteries as an encumbrance to urban planning, so that the prevailing attitude towards them is an underlying contributory factor to their improper location. In many countries the awareness and knowledge about cemetery is weak or imprecise. Comprehensive location planning for urban cemeteries relates to many aspects and both spatial and non-spatial data and information are needed in the planning process. Thus selecting the effective factors, which can reflect the suitability on land for urban cemeteries with available data, is very important to carry out the plan.

Generally, the institutional, environmental, social and cultural perspectives should be considered. From them, policy, economic, physical and ecological environment, social impact and cultural heritage are reviewed for defining the element. The different stakeholders may have their own preference and priority on these elements. At the same time, the local burial needs should be assessed as they could have great regional characters.

It is realized that the element of cemetery planning should correspond to its specific character other than ordinary land use plan. It has relative stable location compared with urbanization process. It could pose pollution and hygienic threaten to living people. It should concern many practical planning issues as well as peoples' shifting values on death. Cemetery planning is complex and difficult to model or evaluate.

In this research, the planning criteria are selected is as follows based on knowledge of literature, local investigation and stakeholder preference: land use, proximity to barren hills, proximity to main roads, proximity to residential areas, land price, hazards, soil excavatability, grave stability, drainage/slope, distance to water bodies, soil permeability, basal buffer zone, distance to water supplies and distance to buildup areas. For fulfilling the cultural and emotional needs, landscape and Feng Shui is also considered as evaluation criteria that consist the elements of urban cemetery location planning.

6.1.2. Approach to Locate Suitable Land for Urban Cemeteries

With the development of GIS, it is reasonable to expect a better informed, more explicitly reasoned decision-making in urban planning. Enough analytical capacity should be integrated to GIS in order to provide decision support function in a user friendly and easy to use environment. One of the very important analytical capabilities is Spatial Multiple Criteria Evaluation which together with the analytical functionality of GIS, supports producing decision and policy relevant information about spatial decision problems to decision makers. GIS and MCDM can support decision makers in achieving greater effectiveness and efficiency in the spatial decision-making process, therewith enhancing the use of geo-information.

In this research, a spatial decision support system has been developed after analysing existing situation and defining the need of the study area. Spatial data were converted to ILWIS raster format as criteria maps prior to joining to the "criteria tree" in the SMCE module as a structural mode of the design problem. To compare the maps in evaluating the importance of the location, standardization has been done using appropriate methods. Weight has been allocated to factors based on stakeholders' analysis and knowledge from literature review, investigation, expert interview and AHP methods. Three scenarios were developed based on urban development situation of different time span, and the results of scenarios were composed to find out the location with sustainable development feasibility. The case shows how effectively and efficiently SMCE can be applied in designing alternative sites for urban cemeteries for it integrates information from a variety of sources (spatial, non-spatial) to support decision-making processes.

A particular form of sustainable suitability analysis for cemetery location is analysed according to the special character of burial land. During the course, spatial-temporal analysis is carried out among three different times based on the land use master plan of the study area in order to ensure a sustainable suitability of the alternatives for the sake of future development. It gives us a chance to review the plan from the perspective of cemetery plan. As cemetery is always excluded from land use plan, the deficiency of the plan is identified for sustainable development for both the cemeteries and the urban space for the living. Recommendation is given on strengthening the control of the direction of urban development based on the result. It shows the concept of "suitability" for lands with stable location, like cemeteries, should be added to another dimension of time in order to achieve the planning objective. As a result, eight sites are generated which show high value according to design criteria as alternatives for development choice.

6.1.3. Improve Decision on Cemetery Site Selection

The information from the design phase as the sustainable suitability of the land for burial purpose is input into an evaluation matrix in DEFINIE software along with cultural factors to select the most attractive sites for cemetery development. Its purpose is to find out how the alternatives generated from practical and rational criteria could emotionally accept by people and affect their choice. Local authorities may use the information to get a ranking of the alternatives and decide which one or set of alternatives to choose as future development.

As a result five sites are selected which can together fulfil the burial needs of the study area. Sensitivity analysis is carried out on both weight and score. It confirms the ranking is robust and recommendation is given on sites from a marketable perspective. The DSS supports the whole choice phase to rank

the alternatives. Its various scale of alternative scores provides input of both quantitative and qualitative data, which shows useful when valuating abstract effects such as cultural ones. Its sensitivity function gives the decision maker a deep understanding into the problem, which may be useful for further decisions on cemetery development. Selecting sites from the model result does not necessarily mean that it will be successful soon. Without providing support development it may not perform well. Thus evaluation of these chosen sites are carried out and insufficiency and weakness of the sites are defined.

It can be concluded that to ensure decision of suitable site for cemetery development, both pragmatic and emotional issues should be considered. A comprehensive evaluation process is valuable through all phase of cemetery location and development, and benefit both cemeteries and the space for living people. Optimum utilization of land is of vital importance. By using a scientifically based evaluation system, which is easy to apply, cemeteries, which should be classified as a special land use type, can be located with confidence.

6.1.4. Limitations

Knowledge and Data

The lack of previous work is one of the major limitations foreseen at the beginning, as to exploit backwoods is always a tough job. Because not many literatures could be found on cemetery planning, the comparative review is difficult to carry out so that there should be unsureness on how unbiased and reliable these studies are. In this way, the author have to devote himself to a lot of basic information from fields other than urban planning, such as history, sociology, economics, ecology and geology which also bring the author's intelligence into a challenge for the result of the research. Notwithstanding this, there are always gaps from those studies to the intention of this research, for the basic interest of them is not toward planning issues. Along with this, the legislation on cemetery disregard cemetery planning largely and the performance for the funeral policy is poor thus bringing much uncertainty in the research. What's more, as cemetery planning is a work that has great regionality, such as physical environment and funeral customs, the value of the conclusions from ecdemic studies will be weakened during the "transition phase".

Because death is such a taboo topic in China, to collect data about the dead is no more difficult than from the dead. There is no former project or investigation on cemetery planning in the study area before either. Fortunately, the Urban Planning and Design Institution of Guilin also started working on the location planning for urban cemeteries during the period of the research and applied official approaches to gather information. In this way, the data collection work largely depends on the intelligence of the practitioners. Their attitude and cooperation were considered important factor to affect the research.

Model

The requirement for running the model is sometimes limited by knowledge, data and method. Firstly, the weighted summation method of MCE requires that each factor should be independent, but actually many factors has correlation or dependence with each other. For example, the permeability of soil is affected easily by the pressure of constructions, roads built on and around it. Again, the safe distance from cemetery to water bodies or water supplies will affected by the different soil permeability. Secondly, people's preference on cemetery location proved to be difficult to get. Traditional interview for the masses proved to be not efficient in the case of cemetery plan. The one asking serious questions on burial is looked on either a gerund-grinder or a crackpot. In addition, the scenarios on time require

more predictable method about the future on both spatial and non-spatial data, such as the urban development pattern and socio-economic characters. Efficient simulating and predicting models will strongly contribute to the accuracy of the result of the model. In this case, the land use master plan was used as the situation of future for the spatial-temporal analysis. Thus the accuracy of the result is directly affected by the ability of prediction and control of the plan.

Software

The analysis is done in applying GIS tool in network environment. The overall performance of the software package was very positive and no serious problems were encountered. However some minor drawbacks may also be potential limitation for research result: It was found that non-linear value function for standardization is not integrated into ILWIS' SMCE module; The uncertainty management is still under development; ILWIS does not have enough compatibility with data from AutoCAD, which may cause error when importing contour line (dwg files) into DEM in ILWIS; sometimes raster file need to be reclassified when transforming between Arcview/ArcGIS and ILWIS.

6.2. Recommendations

Based on the result of this research, the recommendations for further are:

- Cemeteries should be taken into account when carrying out land use master plan to ensure well-balanced urban development, because its characters of static location and pollution generation may cause conflict with other land use with urbanization process. Planning for other constructions have the similar character should also claim higher concern.

- More detailed and pragmatic legislation is needed for cemetery planning. The cemetery planning has great regional characters, so that comprehensive local policy measure should be carried out based on local knowledge and conditions to regulate and facilitate the planning process.

- Government should involve in the whole planning process. As we can see from the stakeholder analysis, spatial-temporal analysis and sensitivity analysis, many information generated during the course are useful for better decisions on cemetery and future urban development.

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Appendix A.

Cultural Heritage of Former Burial Practice

Review of Funeral Customs and Cemetery Evolution

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1. Introduction

"Show me the manner in which a nation cares for its dead and I will measure with mathematical exactness the tender mercies of its people, their respect for the laws of the land, and their loyalty to high ideals."

William Gladstone (1809-1888)

Every culture and civilization has faced the task of caring for its dead. The manner in which people deal with their dead reflects cultural shifts in perception and indeed a shift in cultural values.

Funeral is the method and rite of human to dispose their remains, an external social phenomenon, dominated by ideology and notion of people and under the category of custom and convention (Shi & Xu, 2001). The history of funeral customs and burial rites is a history of mankind. There are various customs during the entire course of funeral activities--wakes, mutes, mourning, burial, sometimes embalming, etc., forming a splendid anthropologic encyclopaedia. What's more, fantastic funeral constructions for governors such as the Pyramids of Egypt, the Mausoleums of India, and ones for religions such as Brahmanic wats, Buddhist pagodas, Mohammedan minarets have been built up. Yet no sketch, however slight, on the subject of funeral practices would be complete without a glance at these stupendous monuments of the dead. Very many such findings could be mentioned which are interesting as intimately connected with the study of funeral customs, but fascinating as they are, they lead too far from our subject, forming a separate study for archaeologists, historians and architects.

This part of the article will focus on the principle factors, which has direct or indirect relation with the location or planning of the burial place, lies in former common practice for the majority, affecting modern burial traditions and show the relative influences these customs are likely to have on present urban planning.

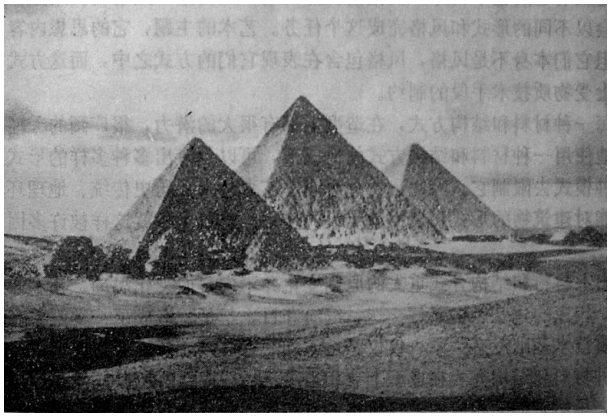


Figure 1: Pyramids of Egypt

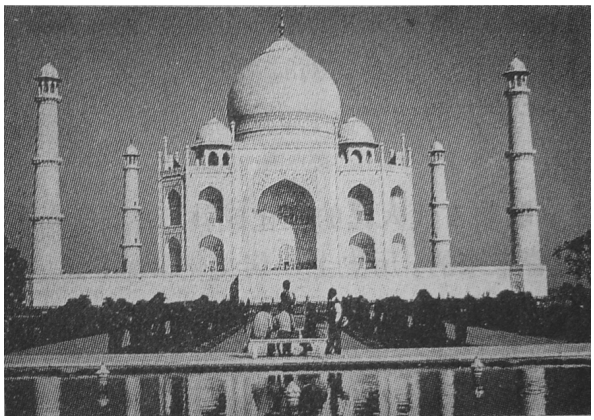


Figure 2: Mausoleums of India

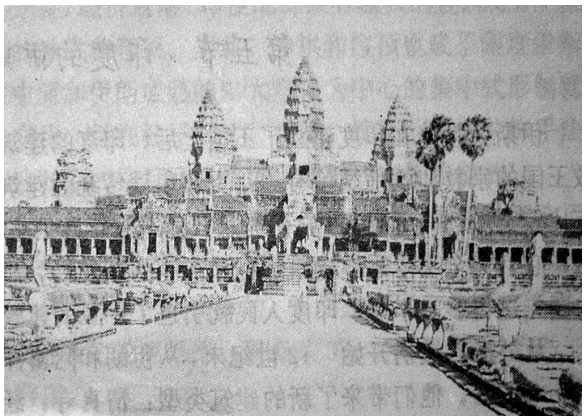


Figure 3: Brahmanic wats

2. Origins of Funeral Customs

"A world survey of mortuary customs, given the central importance that such rites often have, would amount almost to an encyclopedia of world cultures."

Metcalf and Huntington, 1992

2.1 Ancient Beliefs

The funeral custom, as the tangible form of belief, makes us feel the decisive and dogged denial about death. We may hear again and again the inexorable faith--the dead is still living (Cassirer, 1944). Almost every culture and civilization ever studied has three things in common relating to death and the disposition of the dead (www.wyfda.org):

1. Some type of funeral rites, rituals, or ceremonies
2. A Sacred Place for the dead
3. Memorialization of the dead

Religion is believed to have originated from the awe or fear that people felt when confronted with natural or supernatural phenomena of change. It is an attempt to overcome such feelings by joining together and performing rites of reconciliation with the supernatural powers regarded as the cause of the changes (Matsunami, 1998).

Fear of the dead is a common theme in many funerary practices around the world. Early Christians were instructed to "send away from camp anyone who is ceremonially unclean because of a dead body. Send them outside the camp so they will not defile their camp, where I dwell among them. (New International Version Bible, 1984)" In Old Persian scriptures, anyone who touched the dead body was "powerless in mind, tongue, and hand". These paralyses were inflicted by the evil sprits, which were associated with the dead body. Often fire was employed to free the living from the spirits of the dead, in many cases bodies were cremated, or fires were maintained during the burial ceremony to fend off spirits. Buddhists in China ignite a series of firecrackers during a funeral to scare away demons.

Even today, many funeral customs can be traced back to rituals based in fear. The modern mourning attire came from the custom of wearing special clothing as a disguise to hide the identity of the mourners from returning spirits. Wakes held today come from the ancient customs of keeping watch over the deceased in hope that life would return; the lighting of candles stems from the use of fire to protect the living from evil spirits. Similarly, the twenty-one-gun salute mirrors certain tribal practices of throwing spears to ward off spirits and the ringing of bells is based in the medieval belief that spirits would be kept at bay by the sound of a consecrated bell (www.wyfda.org).

Fear continues to be a significant motivation behind the customs, traditions and behavior of the bereaved, and in turn, will continue to influence funeral practices and cemetery design.

2.2 Early Burial

In early times caves provided both shelter for the living and a sepulchre for the dead. Little wonder that we find in the caves and catacombs an endless field for the investigation of burial customs, for not only do they contain remnants of the period at which they were first occupied, but of successive periods and peoples. When one of these primitive homes ceased to be used for the living, it was at once appropriated for the dead.

The alternative was to find a new home for the dead, so as to reserve the cave for a more useful purpose. This led to the construction of Dolmen (Dol=a table, men=a stone, Celtic), a crude imitation of the cave that had been deserted, built up of cairns or heaps of stones. Later, earth burial became general, and the barrows or cumuli were commonly used. These were placed conveniently near to the villages or settlements, but sufficiently remote to avoid a dreaded proximity to the dead. Thus we trace both the origin of the tomb and the cemetery (Puckle, 1926).

From the earliest times the barrow was regarded as sacred ground, and near it the Pagan temple was erected. Many country churches in England, often built on the actual foundations of Pagan temples standing guardian over the dead, are surrounded by rows of grass-covered mounds. The present custom of piling turf over the grave may in fact owe its origin to the barrow formation.

During the later burial practices, no mater in burial ground, catacombs, churchyards or modern cemeteries, earth burial remains one of the most important funeral traditions. It is reasonable to assume that earth burial will continue to play an important role in cemetery design, landscape planning and urban planning for many years to come.

2.3 Cremation

The well-nigh common practice of burning the dead in the Bronze Age was probably resorted to, as a yet more effective way of getting rid of the ghost than by the burial of the body. This altar-like erection of earliest pyre must have been very nearly related to the pagan sacrifice of human and animal offerings to the gods, and may have had something to do with the Christian attitude.

The Greeks and Romans originally buried their dead, but later cremation became customary. Incineration was the general practice of the ancient world, with the exception of Egypt, which embalmed. Judea, which learnt embalming and other practices from the Egyptians, buried in the sepulcher, and China in the earth (in accordance with the doctrine of Feng-Shui) (Puckle, 1926).

Superficially, the reason why the Early Church objected to the funeral pyre is that the body of its Founder was buried, but this in itself can hardly be called a logical reason. Traditionally, the body was not buried in the earth, as we bury, but walled up in a sepulcher, according to the manner of the Jews. The Jews, believing that the stages, of decay in the grave were experienced as physical pain by the deceased as an atonement for sins, might very well hesitate to commit their remains to the flames (Puckle, 1926).

Stimulated by changing social perception of urban cemeteries and by the potential link between decaying corpses and urban epidemics, cremationists used the fear of disease to promote the cremation of bodies as an alternative to burial (Salisbury, 2002). They further claimed that by doing away with the burial grounds, not only would the public health be safeguarded but also that a vast acreage of land, instead of lying idle, could be put under cultivation and a considerable revenue gained thereby. Cremation was described as being the same basic process of decomposition, only scientifically accelerated. During the late 1800's there was a marked increase in cremations as a result of significant public debate surrounding the health implications of cemeteries. The cremationists criticized the cemetery as " wasteful expenditures resulting in unproductive land, ostentatious memorials and overpriced extravagant funerals that only served to enrich the promoters rather than console the survivors"(Lafleur-Vetter, Hazel, 2000).

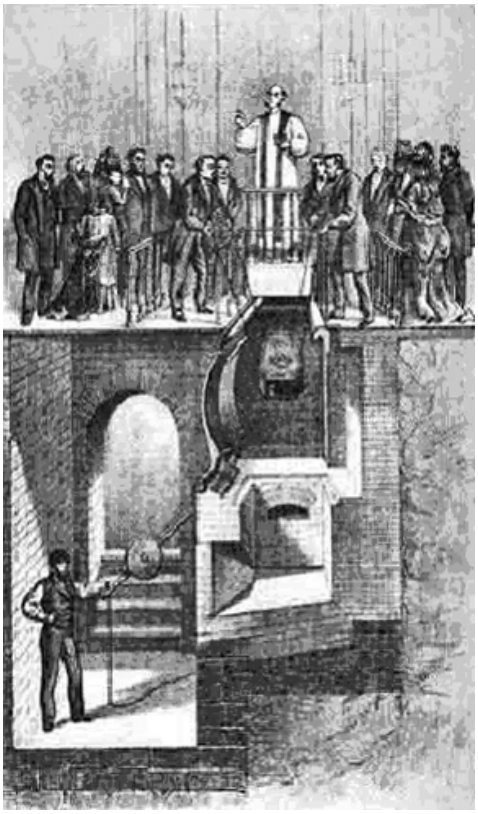


Figure 4: Siemens' Cremation Apparatus

The first serious experiments in modern cremation were carried out by Brunetti in Italy, 1869. The apparatus bearing his name was exhibited in Vienna in 1873, the process being conducted in the open. A later contrivance invented by Siemens was of the closed type. Between the years 1887 and 1906 nearly every country in Europe had erected a crematorium (Puckle, 1926).

Society's re-evaluation of the death process in the late nineteenth century gave rise to many changes in public opinion and cultural traditions surrounding death. While cremation presented a more abstract spiritual relationship with death, mourners still desired a place of memories and celebration that cremation could not provide. In many cases cemeteries remain the final resting place for cremated remains. This may take place for the purpose of memorialization, but possibly to give the remains a final resting place that is removed from the realm of the living. In some cases the entire urn is buried or placed within a columbarium (Lafleur-Vetter, 2000). In other cases the ashes are scattered within an area set-aside at the cemetery. Either way, the cemetery fulfils an important role for those who choose burial, as well as those who choose cremation.

2.4 Other Funeral Customs

Celestial Burial

Various means have been adopted to dispose of the dead other than those of burial or incineration in the generally accepted form; of such, perhaps, the best known is practised by the Parsees, who place the corpse on a tower or on the tree-tops, there to be devoured by the vultures. At first sight this might seem a callous and inhuman practice, but the motive underlying it is not without beauty. It arises from the belief that the elements are sacred, therefore to bury the body is to defile the earth; to burn it would defile the fire, and to cast it adrift on the river, as some people have done in order that it might float out to sea, is held as defiling the water. There is a side in the thought that whatever the social position of the deceased, no difference is made in the final disposal of the body. Whatever barriers of wealth or birth may have separated individuals during life, naked and side by side they face the last ordeal in the spirit of common brotherhood.

The Parsees are not alone in leaving the dead to be devoured by birds or beasts. The Persians and Tibetan also hold similar customs in disposal of human remains. Corpses are placed at high altitude, and let the birds of prey settle to consume the dried flesh, a sign to the mourners who are watching, that the debt due to the sun has been satisfied, and that the birds have come to bear away the soul to the place of spiritual bliss which awaits it on the summit of the sacred mountains.

Water Burial

It is from the pages of the ancient Sagas that we learn how the dead Norseman was sent out to sea in his Viking ship, wrapped in a pall of flames, as befits a chief--with all his personal belongings about him. The natives of Borneo have a similar custom, whilst the placing of the dead in the sacred river Ganges has been held to account in a large measure for the spread of cholera in India. This practice of sending the body to sea (a symbol of the source of life), or the scattering of the ashes at sea is to be met with in many parts of the world (Puckle, 1926).

Disposal of human remains other than in the earthen burial have been common in all ages, but the psychological implications and social history of these practices are well beyond the scope of this paper.

3. Evolution of Cemeteries

Cemeteries are an ancient concept, and while the basic function of the cemetery has not changed, the physical layout as well as the intellectual and emotional role of the cemetery within our society has undergone profound changes over time.

3.1 Burial Grounds

A burial ground is a repository for the dead and not associated with a church. They were usually located on private land as family or clan burial grounds. These types of burial grounds are generally not permanently marked or developed as cities grew during the early settlement. With the establishment of permanent towns, parish churches were built and church graveyards were developed to service the growing community.

3.2 Catacombs

In the early days of Christianity when persecution was the lot of those who embraced the new faith, the Roman catacombs were used by the Christian community for the purposes of sanctuary and burial, for they well knew that the superstitious dread which the Romans had in common with the Jews for places of burial, rendered the labyrinths comparatively secure, where they might even meet to worship with a minimum risk of disaster. Here in these underground vaults they buried their dead during the first four centuries of the Christian era.

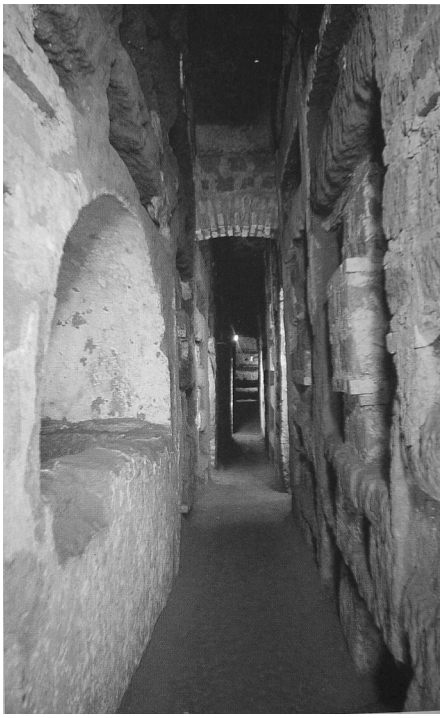


Figure 5: Catacombe Di S. Callisto

It is not generally realized that a great number of catacombs exist other than those of Rome. Burials in catacombs took place generally where the soil was of a nature to render mining easy, or where disused quarries or excavations presented the opportunity--such as those in Paris. The Jews, who shared the oriental custom of interment in subterranean chambers instead of earth burial, also used the catacombs. Their tombs are easily discovered by the symbols of the old dispensation, the Ark and the branched candlestick with which they are marked.

These burial grounds were much like present form, they were surrounded by hedges or stone walls, cypress trees were planted and memorial chapels or sarcophagi were built on the spot. The dead were from quite early periods interred in graves dug from the surface of the ground, and as many as ten bodies laid one above the other, each separated only from the next by a slab of stone. Such a method would not be tolerated by the Jews who are forbidden to place one body above another, either on shelves, in the sepulchre, or in the ground. From this period the catacombs were guarded and preserved (Puckle, 1926).

3.3 Churchyards

The tombs of the Martyrs were the first altars upon which the Christians solemnized the rites of their faith. So it was that when the bodies of those who had been put to death were removed from the impending plundering of the Saracens and Lombards in the eighth and ninth centuries, their relics were

placed within the walls of the city (a privilege previously forbidden by Roman law), and churches were built over them. In this manner the tomb became the temple.

In ancient times, burial always took place in the fields outside the walls of the cities and towns, for before the advent of Christianity it was not lawful to bury the dead within the city. In the year 752, Saint Cuthbert obtained leave of the Pope to have churchyards added to the church, as places suitable for the burial of the dead (Puckle, 1926). A churchyard is associated with a religious denomination and was adjacent to a church building at the time the graveyard started. The primary purpose of the land when purchased was for religious services rather than burials (McVicker, 1989). Churchyards were under the immediate control of the Church, and the clergy were largely dependent upon the fees charged for interment, in return for which they conducted the remains to the grave prepared for its reception and safekeeping. Early churches were as much community centres as religious establishments and soon replaced individual burial grounds as cities began to develop. It was not till the ninth century that the consecration of cemeteries became customary.

Figure 6: Churchyard Cemeteries

Once started, it very quickly spread. The most honoured of the flock received the special privilege of sepulture in the immediate proximity of the church, but this, like most concessions, presently became a general rule. It was a nice question as to where to draw the line between those who were worthy, and the lesser kind. This wider tolerance had its sequel, for the saints were in course of time so elbowed by the sinners, that they sought seclusion in the sacred edifice itself. The pressure must have been great, for it was entirely against the spirit of the Early Church to enshrine a body under its roof unless that of a saint or martyr, for the corpse was considered as an unclean thing. Even as late as the late 16th century, the practice gave offence to the orthodox mind. Those devout are much offended by the novel custom of burying everyone within the body of the church and chancel, that being a favour heretofore granted to the martyrs and great persons, this excess of making churches charnel-houses being of ill and irreverent example and prejudicial to the health of the living, besides the continual disturbance of the pavement and seats, and several other indecencies. Dr. Compton, Bishop of London, had also said, “The churchyard for the dead--the church for the living. (Puckle, 1926)”

By the mid-18th century in Europe, urban space was at such a premium that burial plots were stacked in crowded church graveyards. They were typically sold for use for a period of only fifty years during which time the people who actually remembered the deceased would have also died. At the end of the lease period the bones were disinterred and moved to a charnel house or cremated, so that the plot could then be reused (McVicker, 1989). By the end of the eighteenth century the conditions of grave-

yards in England were so desperately overcrowded that cemeteries were becoming a health and sanitation issue (Salisbury, 2002).

3.4 Modern Cemeteries

Thomas Millar, a British cemetery designer during the mid-18th century, proposed the concept of a cemetery where people could walk through a landscape surrounded by tokens of affection for the deceased. This has the effect of placing equal importance on both the mourners and the mourned. Millar combined the three basic concepts of the Romantic movement of that time period: the beautiful, the picturesque and the sublime, with a park like atmosphere of the English garden in a new type of burial ground. In order to separate this new design from the older antiquated graveyards he used the term "cemetery" from the Greek word for sleeping chamber (koimeterion) (McVicker, 1989), which mirrored the contemporary religious view of the grave as a holding chamber for sleepers awaiting the glory of resurrection.

Figure 7: The Evolution of Cemeteries Advertisement of Memorial Parks

A cemetery is established solely for burials, but is often designed with consideration for other cultural uses. Cemeteries are usually not adjacent to a church but are sometimes associated with a religious denomination. Private cemeteries are established as commercial businesses. Although some cemeteries are non-profit organizations, many modern cemeteries today are profit-generating corporations while municipal cemeteries are maintained and supported through taxes (Salisbury, 2002).

The writings of Thoreau and Emerson and the development of Romanticism in Europe spawned a new trend in community design. Cemeteries were no longer viewed as something to be shunned and feared but as a place of eternal security and peace. The great romantic park-like cemeteries of the nineteenth century were recreational areas as much as repositories for the dead (McVicker, 1989).

In order to distinguish from former ones, we may call them "modern cemeteries". Many types of modern cemeteries present themselves throughout the world, such as rural cemeteries, lawn-parks, memorial cemeteries, woodland cemeteries:

Rural cemeteries were large, non-sectarian burial grounds located 5-10 kilometres from the center of their communities (Salisbury, 2002). These planned public landscapes included serpentine roads and pathways amid a naturalized setting. Rural cemeteries were designed to project an image of permanence and connection with nature. While the urban church cemetery emphasised vault burial, rural cemeteries stressed ground burial with large ostentatious family monuments in the Romantic style. Vistas and secluded retreats replaced high walls and narrow passageways of the city churchyards.

Lawn-park cemetery design departed from the Romantic design of the rural cemetery with the minimization and eventual removal of aboveground monuments from the cemetery landscape. The design appealed to urban families and individuals without ethnic, religious, or specific community membership. Memorial parks developed during the 1920's and 30's featured large central monuments amid wide-open natural spaces with either no individual markers or small markers set flush with the ground to provide a cultural and heritage focus for the open lawn-park landscape.

Woodland cemetery, also known as an eco-cemetery, or green graveyard, is a burial ground where the body is returned to nature, in a biodegradable coffin, with a tree planted over or near the grave. The resulting forest establishes a living memorial and forms a protected wildlife preserve.

Figure 8: Woodland Cemetery (National AIDS Memorial Grove in San Francisco)

With the development of computer and Internet, the creation and maintenance of a "virtual cemetery" provide a place where mourners could express a wide range of feelings. Virtual cemetery such as http://www.virtual-memorials.com assists mourners with the placement of photographs, biographical information, stories, poems and tributes on their Internet site.

Changes in Old World cemetery attempted to alleviate the social problems and cultural developments of that period. Eventually, the evolving culture of the New World created a new language that reflected the unique physical and social conditions of post-industrial world (Salisbury, 2002). Cemetery planning should correspond to not only the practical aspects like those in the planning of other facilities but also the social customs and cultural values of the shifting world.

4. Chinese Funeral Customs and Cemeteries

4.1 Chinese Funeral Customs

Chinese people are credited with very special knowledge of occult matters, and they performed many most elaborate rites for the dead. It is customary in China to have coffins prepared for the occupancy of particular tenants, from their youth upwards. The Emperor provides his coffin on the day he ascends the throne. Contributions are given to the friends of the poor, to provide handsome coffins; and the humblest classes desire nothing more than that their remains shall be laid in "the eternal mansion," in a coffin of cedar, or other odoriferous wood (Allom and Wright, 1847).

Funeral customs have close relations with regional environment, life mode and enlightened level. At the same time different religions and beliefs also have great influence on it (Shi & Xu, 2001). Chinese funeral custom was mainly affected by Confucianism, Buddhism and Feng Shui:

Influence of Confucianism

The doctrine of Confucianism, which began in the Spring and Autumn Period (770-476 B.C.), is characterized as one with ethic colour and milk of human kindness. A fundamental persuasion of it is "treat the dead as the living", that is to look on the spirit of the dead kiths in the same way as living people (Shi & Xu, 2001). The faith of courtesy and filial piety was imposed and falsified by governors so that luxurious funeral customs are canonized, although actually the inward belief of Confucianism is to advocate prudence and incorruptness.

Influence of Buddhism

Wei, Jing and the South and North Dynasty (220-589), when Buddhism was preached into China, were the time that austerity in funeral was upholded. The main origin of the transformation was based on the new notion about death brought by doctrines of Buddhism. It was the athanasy of spirits make up the beliefs of earlier funeral practice, but people have no idea about either the image of "living world of the dead" nor the end-result of the human spirits. "Samsara"(The eternal cycle of birth, suffering, death, and rebirth, Sanskrit) portrayed people the picture of what we called "reincarnation", "metempsychosis" or "transmigrate", thus people tended to care much more about the afterlives, which are determined by their alms deeds and otherworldly monachism and pay less attention to burial practice (Li, 2001).

Another new funeral custom brought by Buddhism was cremation. Disciple of Buddhism followed this method in disposal of bonzes' remains and in Song Dynasty (960-1279) cremation was once broadly prevailed throughout China. But because cremation offended the notion of the feudal government and is not accordant with the belief of "safe earth, peaceful death", latter governments forbade it forcibly through statutes.

Influence of Feng Shui

Feng Shui is a traditional Chinese philosophy and technology of site selection, which finds ideal or suitable locations for dwellers, either the living or the dead (Han and Sinha, 1996). Feng Shui originated at least three thousand years ago in the Western Chou Dynasty (1100-771 B.C.), while written records about Feng Shui can be traced back as early as the late Ch'in Dynasty (879-221 B.C.) (Hu, 1994).

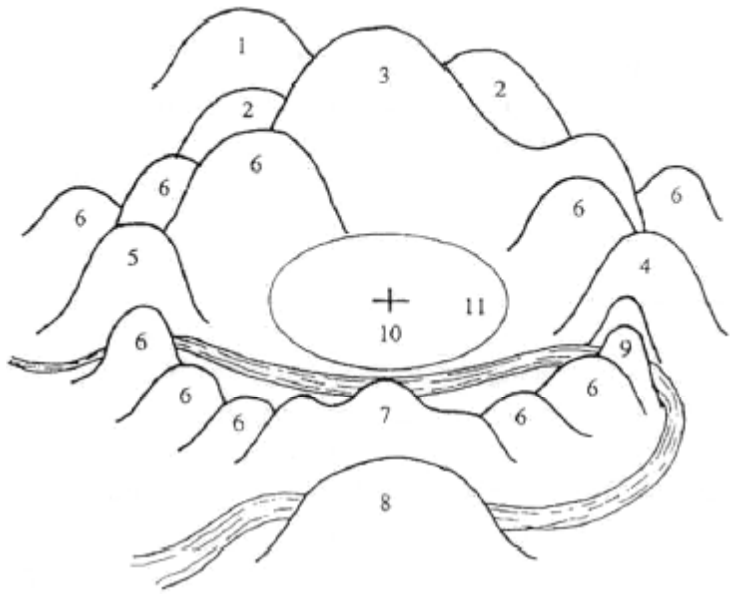
The ultimate goal of Feng Shui is to achieve a harmonious and balanced interaction with the environment, other people, and the cosmos (Han, 1994; Yu, 1994; Xu, 1998). The Chinese continue to believe that harmonious and balanced lives will bring good luck. Therefore, as a vehicle of pursuring harmony, Feng Shui continues to be widely practiced in Chinese societies, Eastern Asia and even in Western countries (Rossbach, 1983). According to Feng Shui, the only one strategy can achieve this ideal situation is to acquire and keep in balance sufficient Ch'i, which could be explained as an energy that pervades every element in the cosmos and is the beginning of all life. Ch'i is blown away by wind and is accumulated by water, thus an ideal site would attract little wind and stand near the water. This is, in fact, where Feng Shui's name came from literally; Feng Shui means "wind and water". Since Ch'i is inisible, using wind and water to locate Ch'i is important.

It was from the Han Dynasty that Feng Shui was applied into the location of burial places when the governors firstly realized the importance of it in finding the "dwelling place for their spirits". Site selection for burial land is a significant part in Feng Shui, and it has great influence to the funeral notion Many present Chinese cemeteries, no matter domestic or overseas, paid great attention to the principle in their planning.

Figure 9: The Manoa Chinese Cemetery in Hawaii

The practice of Feng Shui is complex and is generally applied by Feng Shui masters rather than layman. Its judgements are intuitive and somewhat subjective, but two schools of Feng Shui theory can guide them: Luan Tou (mountain peak) and Li Ch'i (arranging Ch'i) (Han, 2001). This article focuses on the Luan Tou School because it is the original model of Feng Shui and its components are manifested primarily in natural phenomena (Han, 1994; Yu, 1994).

An ideal Feng Shui site has the following features. A high mountain forming a backdrop site called Hsuan Wu (black turtle). A lower mountain to the right called Pai Hu (white tiger), and one on the left named Ch'ing Lung (blue dragon). The relatively flat grassland just in front of Hsuan Wu is termed Ming Tang. Its centre, Hsueh, is the specific spot accumulating the most Ch'i of the entire site. A winding inward river flows in front of Ming Tang and separates it from hills of An Shan and Chao Shan. An Shan refers to the near front hill because it lies near the river and Ming Tang, while Chao Shan refers to the far front hill (Figure , for more detailed Feng Shui criteria see Han, 2001).



1. Background mountains
2. Background mountains
3. *Hsuan Wu* (black turtle)
4. *Ch'ing Lung* (green dragon)
5. *Pai Hu* (white tiger)
6. Protecting hills
7. *An Shan* (near front hill)
8. *Chao Shan* (far front hill)
9. *Shui Kou Shan* (water entering/exiting hill)
10. *Hsueh* (central spot)
11. *Ming Tang* (central grassland)

Figure 10:The Basic Pattern of Ideal Feng Shui Location

Recent research shows that, although its origin as a fortune-telling art to avoid ominousness and pursue auspice, Feng Shui has close interrelation with ecology, economics, agrology and geography, as well as aesthetics components. There are considerable scientific rationality existed in the site selection and planning of cities, landscape and architecture design and planning of many famous mausoleums based on Feng Shui in every past dynasties of China. Many western scholars acclaim the wonderful philosophy and technology the peak of perfection as “oriental cultural ecology”, “environmental landscaping”, etc (Shi and Xu, 2001).

4.2 Ancient Chinese Cemeteries

It was the custom of the East, and in its earliest ages, to detach every profane object, or relic, or even sentiment, with the utmost scrupulousness from the sacred shrines of their gods. Whatever may have been the root, origin, or source of the practice, in all Eastern countries cemeteries are detached from places of worship. The Chinese extend the regulation still further, for they strictly prohibit interment within the walls, or suburbs, of any town or city; properly concluding, that the resting-places of the dead should be at a suitable distance from the dwellings of the living (Allom and Wright, 1843).

Away from the civilization, presented helplessly to grave robbers, beasts and erosion of time, as no one will care about the dreadful and occult land other than graves of his own family or relations, the

ancient cemeteries are the first places to become "the lost world". The research of ancient Chinese cemeteries can only rely on the archaeological discoveries and fragmentary data of the relative firmer mausoleums of the monarch and noble stems. Although some fragments of human history may not show directly the common burial practice of the majority, the information draws an outline of the mainstream of funeral desire and customs in ancient China.

Early Burial

The consciousness of burial human remains started in the middle of Early Stone Age (about 40 to 100 thousand years ago). The Shandingdong Hominid, living in Beijing 18 thousand years ago, had already performed some rite as scattering some wine ironstone powder around the deceased and bury them with wares and adornment as funerary objects (Wu and Zhao, 1996). As early as the aboriginal society (about 6 to 7 thousand years ago) when there is no conception of clan or kin, there has already been custom to bury the dead of a tribe together. With the development of human society, after the emergence of families and privately owned properties, clanship and family graveyards came into being and lasted a long time. This formation existed in both monarchs and common people.

Primary regional planning layout can be found even in early clanship. Aboriginal village always located on mesas of riverbanks, where natural environment is suitable for cultivation and traffic. The ancient site of Banpo Viliage in Xi'an shows that the district of inhabitation lies in the south, separated from burial ground in the north by an artificial ditch (Pan et al., 1993). As "burial" has the same pronunciation and meaning with the word "hide" in Chinese, early Chinese burial ground did not erect any signs around burial grounds.

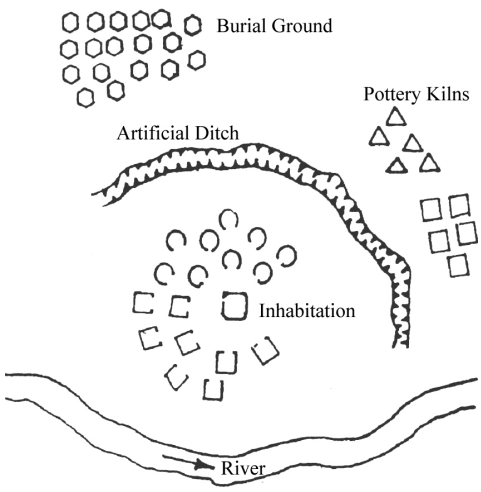


Figure 11: The Ancient Site of Banpo Viliage in Xi'an

In the Spring and Autumn Period (770-476 B.C.), Yong City, the capital of Qin had its royal cemetery 5km to the south of the city. The 5km wide, 2.5km long cemetery was enclosed by empty entrenchment and not by fence or bounding wall, forming one character of Qin cemetery.

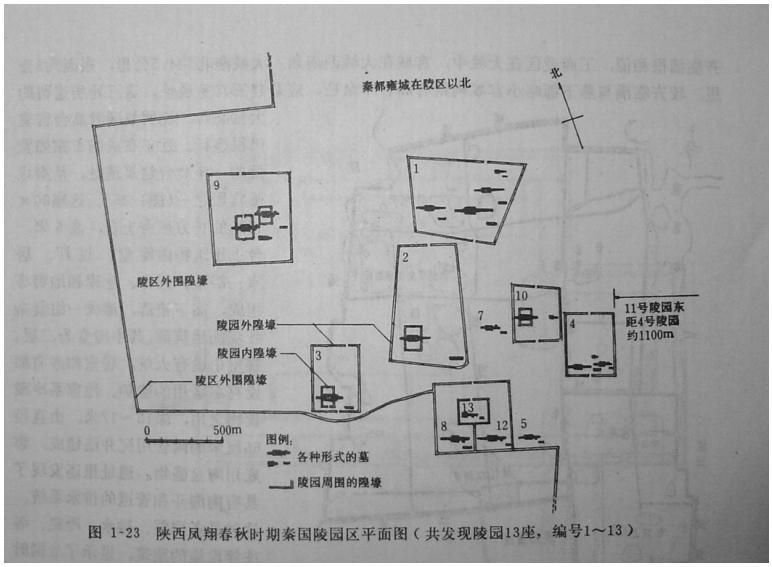


Figure 12: Royal Cemetery of Qin

Tomb and its Development

According to archaic literature *The Book of Courtesy*, ancient Chinese burial ground did not erect any signs until the Spring and Autumn Period when Confucius (551-479 B.C.) founded the custom to build mounds and plant trees on his parents' graves as showing filial piety. In this way the "burial ground" became the aggregation of "tombs".

With the appearance of hierarchical social class, the social hierarchy of the living also materialized itself in burial as the different forms and standards of tombs. Until the Warring States Period (475-221 B.C.), almost all the graves have mounds on and trees around them. This was also brought into the feudal governors' ideological intention--the higher the rank, the bigger the mound and the more the trees were planted around (Wu and Zhao, 1996). More and more extravagant practice developed in the construction of tombs for monarch and noble stems. The mound began to be piled so huge that the tomb became "mausoleum", which means "hill" in Chinese. Chinese mausoleums are Alhambresque tombs looked on as the living palace of the dead. The mausoleum constructions came to their climax in Qin Dynasty presenting as the Mausoleum of Qin Shi-huang (259-210 B.C., the first Emperor of China). Tombs lost their meaning as signs and turned into symbol of feudal hierarchy.

Figure 13: Mausoleum of Qin Shi-huang

Stonework

With the masonry development during this period, stone catacomb came into being, while the governors still prefer wood as the constructional material. In Han Dynasty (206 B.C. - A.D.220), stone catacomb and mausoleums became commonly used and there has been a popular use of "cliff graves" which are catacombs or chambers excavated into cliffs or hillsides (Pan et al., 1993). There had also been a mysterious custom of so-called "hanging coffins" of Bo nationality in central China, which is overhanging coffins in high caves or on stakes tacked on overhanging cliffs.

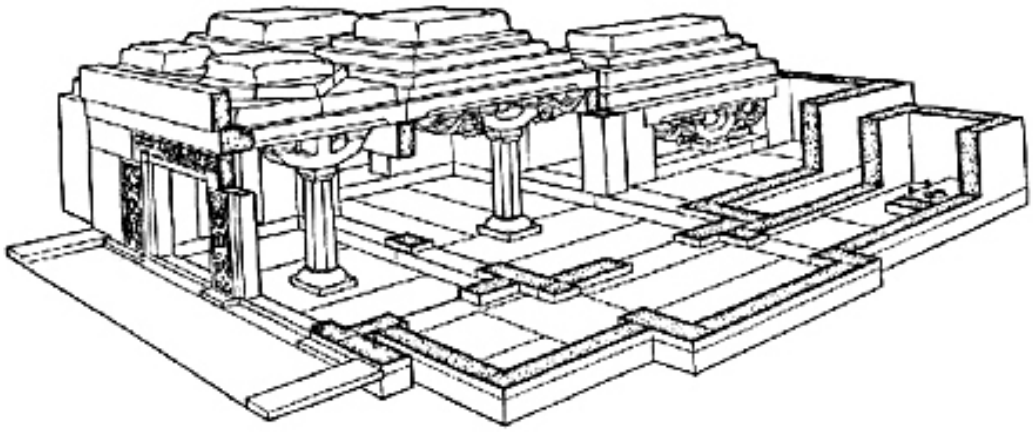


Figure 14: Chinese Catacomb

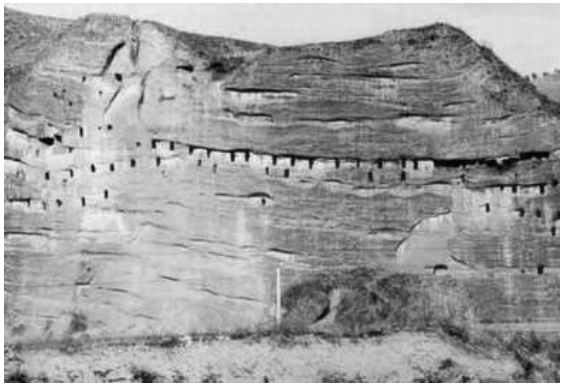


Figure 15: Cliff Graves

Figure 16: Hanging Coffins

Mausoleums

A Chinese Mausoleum is the combination of huge palace-like underground catacomb and constructions above ground such as entrance, tomb corridor, altar, etc. Until Tang Dynasty (618-907), the arrangement of construction groups tended to comprehensively developed and well balanced in variety of aspects, so did the cemetery planning. The method of piling earth as mound to build mausoleums was replaced by making use of existing landforms and landscapes. Subsistent hills were employed as the bodies of mausoleums and slops between the forward hills as corridors. The Qian Mausoleum of this time typically reflected these changes. The technique of using existing topography and introductory space is looked on as the source of cemetery planning and layout of those in Ming (1368-1644) and Qing Dynasty (1644-1911). These later mausoleums are good at applying landforms and environment to create sacred and grand atmosphere. The mountainous regions with enclosed circumstance were preference locations of these royal cemeteries (Pan et al., 1993).

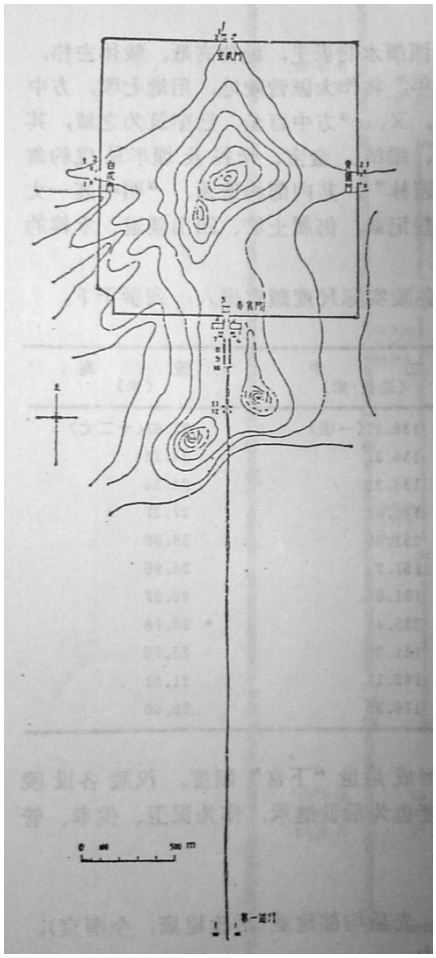


Figure 17: Qian Mausoleum

Cemeteries

In the past, a village lineage had its own graveyard, with gravesites being, in the main, located according to the relationship of the occupant to the most senior member of the lineage buried there (Hsu, 1967). Many city dwellers in Imperial China retained links with their ancestral place and returned there to be buried (Goodman, 1995). This practice persisted until well into this century (Davis-Friedmann, 1983; Teather, 2000). Some overseas Chinese still choose repatriation after death (Teather, 2001).

These graveyards are outcome of familial burial and different from the cemeteries as public burial ground. In this sense, there are mainly two kinds of cemeteries in ancient China. One is Yidi (righteous land), the burial land provided to the pauper and poor people by the government or some bureaucrats as public charity. The other is Yiyuan (righteous park), the burial land for the people who died in a place other than their hometowns and not able to return their ancestral places to be buried. Some regional associations afforded these as a righteous act undertaken for the public good (Wu & Wang, 1999).

Scarcely any literature illustrated in detail the cemetery for common people (both family graveyards and Yiyuan, Yidi) with its bureaucratic management, geometrical layout and commodified grave space in Imperial China. Allom and Wright's (1843) work gives us a peep into ancient Chinese cemeteries: "Cities of the dead, therefore, are in China separated from those of the living, but furnished with buildings and structures, and designs if possible more various and fantastic. A barren district, especially if the site be open and agreeable, is chosen for the demesne of the dead; and here the graves of the poor are seen in countless assemblages, resembling the barrows so frequently observed in Asia Minor, as

well as in many parts of Europe. The rich, however, assert their prerogative of distinction even in the grave, by the eccentricity and pomp of their vast mausoleums. Buildings of stone, or brick, often two or more stories in height, distinguish the mandarin's last earthly tenement."

Figure 18: Ancient Chinese Cemetery

4.3 Present Chinese Cemeteries and Funeral Customs

The present cemeteries refer to those modern ones have large-scale facilities and formal management, and not based on clannish or family burial. The appearance of modern cemeteries was greatly influenced by western culture. In the late nineteenth centuries, Europeans firstly established Wanguo cemetery in Shanghai and the later Chinese cemeteries have learned a lot from the western countries in organization and management (Wu and Wang, 1999).

After the establishment of People's Republic of China, the government try hard to throw the irrational funeral customs into discard. Excessive waste, superstitions, stern hierarchy in funeral are forbidden by policy and cremation is largely pushed. With the process of funeral reformation, cemeteries replaced random burial grounds and luxurious mausoleums, setting an important role in burial system (Shi & Xu, 2001). Cemetery business and funeral industry are also developing, along with systems of funeral management.

On the other hand, many of the location of present Chinese cemeteries mostly follow the old burial areas in ancient time without further unification and planning. The planning of urban cemeteries in China is almost a blank in urban planning works. A few funeral customs that show regional cultural characteristic are institutionalised such as preference of burial on hillsides, and inhumation custom of some minority nationalities are reserved by law. Feng Shui retains its influence in contemporary Chinese society, whether on the mainland (Bruun, 1996) or overseas (see Knapp, 1982, for Taiwan; Yeoh, 1999, for Singapore; and Lai, 1974; 1987, has demonstrated how Feng Shui was used to select an early Chinese cemetery site in British Columbia). Even the increasing use of cremation has not eliminated the influence of Feng Shui.

Another prevailing funeral customs in present China is Gravesweeping festivals (Qingming festival in spring and Chongyang festival in autumn) which are days specially for families visiting and tidy their forebears' graves. Setting aside specified days to pay respects to deceased forebears in a ritualised manner has been pare of the Chinese calendar since the Tang Dynasty. For most of the year, Chinese cemeteries are deserted, except for occasional funeral groups, an isolated visitor of workmen busy in the sections designated for exhumation that year. But at Qingming and Chongyang, the brooding power of cemeteries and columbaria is confronted en masse, any lingering fears of the spirit world dispelled by the presence of huge numbers of family groups carrying plastic bags of offerings: flowers, joss sticks, candles, whole suckling pigs in pink polythene wrapping, fruit and other foods, "Hell Bank Notes" (paper money), and small paper and bamboo models of consumer items. Researches revealed that the Gravesweeping Festivals are, as they have been foe centuries, firmly embedded in Chinese social system, where routines of ancestor veneration continue to renew and strengthen the family bonds that are at the heart of Confucian values (Teather, 2001).

5. Conclusion

In this paper there is a general survey of cultural heritage related to burial practice, which includes descriptions about funeral customs and evolution of cemeteries. Special attention is given to Chinese cemeteries. It examines the principle factors affecting modern burial traditions and determines the relative influences these factors are likely to have on the development and planning of cemeteries.

The exploration of funeral customs presented revealed that the tradition and customs has considerable durative, and many of our current funeral practice have their basis in long held tradition and customs. It reflects that no matter in ancient time or present time, the funeral customs strongly affect people's burial practice and cemetery form quality. Funeral customs, as they have been for centuries, are firmly embedded in social system where routines of ancestor veneration continue. Their continued observation may well represent practices that are of deep ontological significance to communities to which they belong. These important compositions of out culture will likely continue to impact our decisions and behaviours surrounding death. The commonsense factors and options are essential and valuable for later cemetery planning work.

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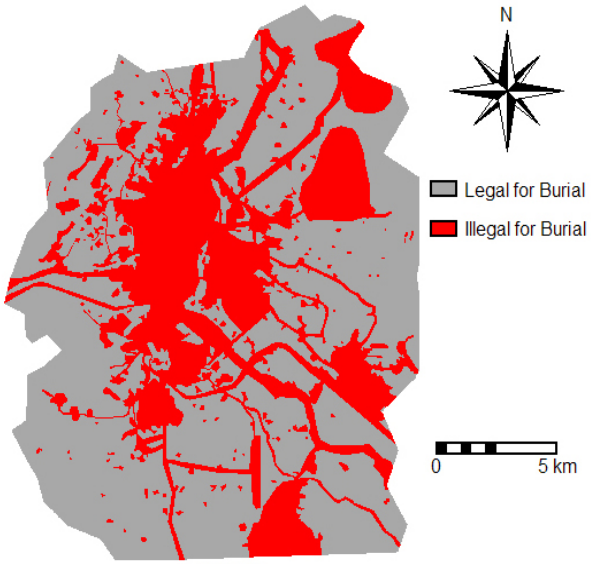
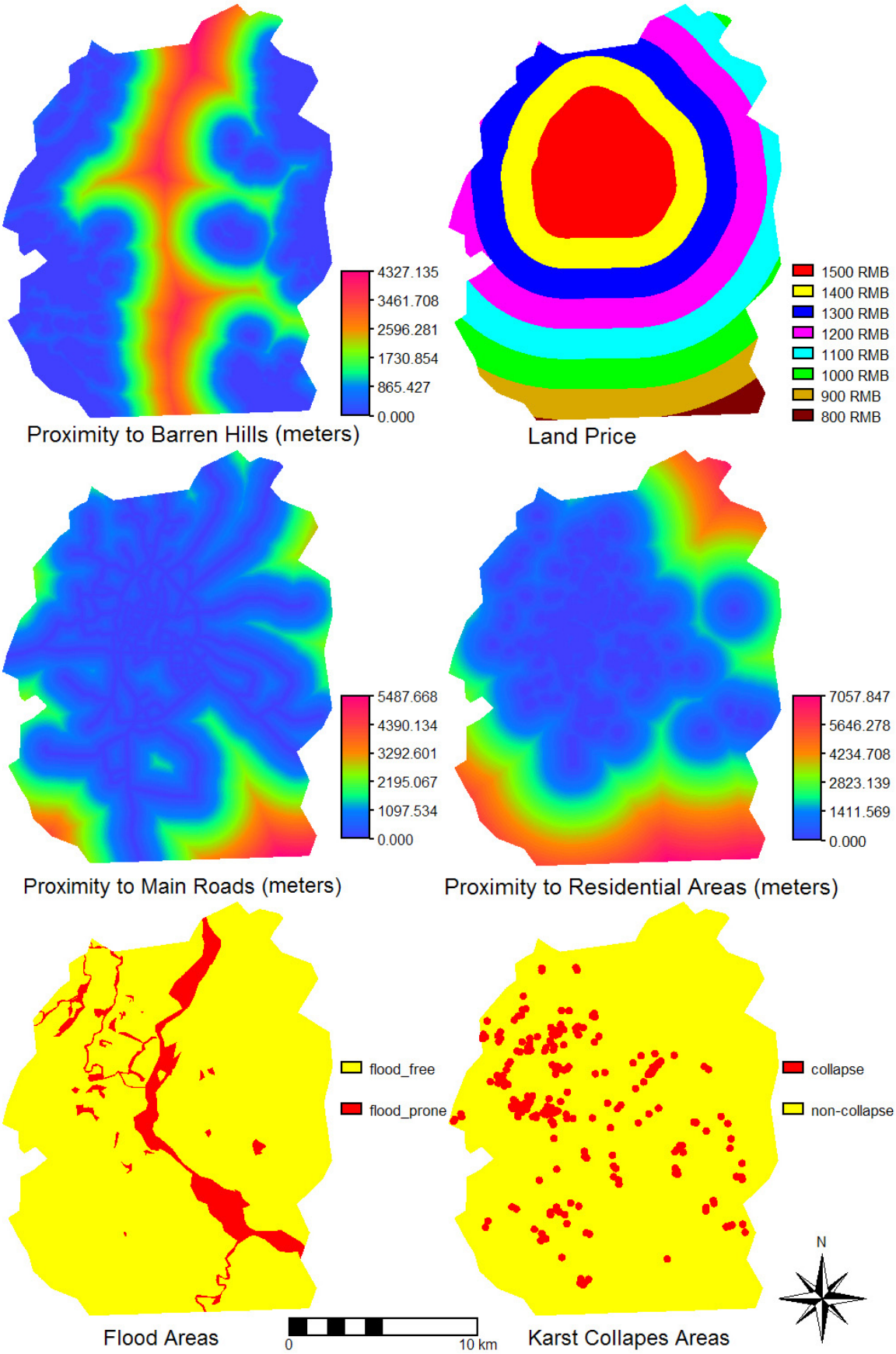
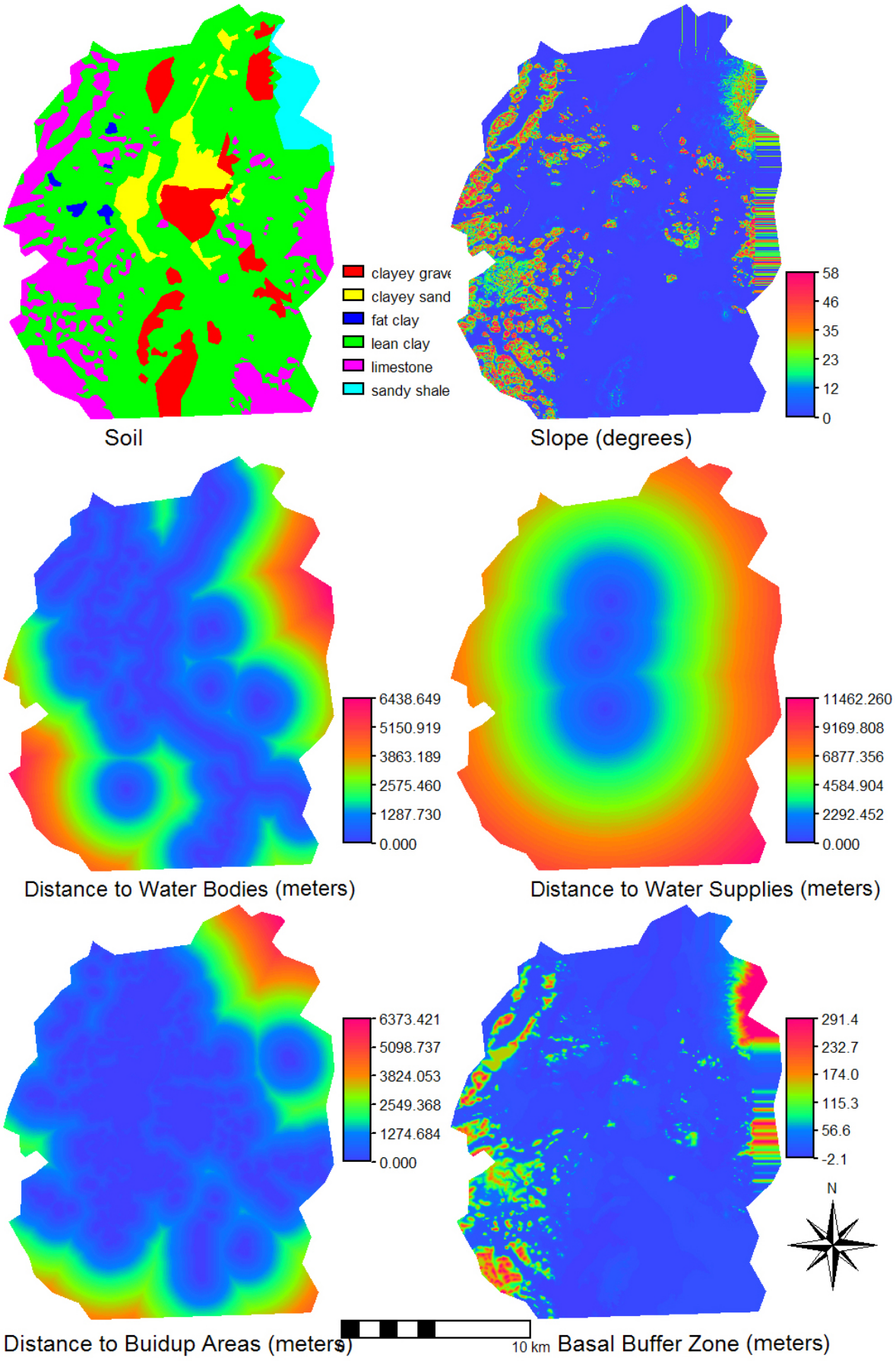
Appendix B. Criteria Maps



Land Use (2000)


4327.135
3461.708
2596.281
1730.854
865.427
0.000
Proximity to Barren Hills (meters)
1500 RMB
1400 RMB
1300 RMB
1200 RMB
1100 RMB
1000 RMB
900 RMB
800 RMB
Land Price
5487.668
4390.134
3292.601
2195.067
1097.534
0.000
Proximity to Main Roads (meters)
7057.847
5646.278
4234.708
2823.139
1411.569
0.000
Proximity to Residential Areas (meters)
flood_free
flood_prone
Flood Areas
0
10 km
collapse
non-collapse
Karst Collapes Areas
N


clayey grave
clayey sand
fat clay
lean clay
limestone
sandy shale
Soil
58
46
35
23
12
0
Slope (degrees)
6438.649
5150.919
3863.189
2575.460
1287.730
0.000
Distance to Water Bodies (meters)
11462.260
9169.808
6877.356
4584.904
2292.452
0.000
Distance to Water Supplies (meters)
6373.421
5098.737
3824.053
2549.368
1274.684
0.000
Distance to Buidup Areas (meters)
291.4
232.7
174.0
115.3
56.6
-2.1
N
10 km
Basal Buffer Zone (meters)