Recovering Urban Land: A Framework to Improve Brownfield Redevelopment Practices

Case of Shenzhen, China

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by

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Abstract

Old industrial sites, known as brownfield sites, remain idle or under-utilized within the urban core as a legacy of industrialization. Brownfield redevelopment is a rather new approach that started in the 1990s. It provides an opportunity for restraining urban sprawl by accommodating urban development activities and thus an opportunity to preserve greenfields. Furthermore, city governments have started to realize that these brownfield sites are also assets for achieving the goal of sustainable development.

This research aims at providing local governments, urban planners and other stakeholders with decision support in locating, evaluating and prioritizing the redevelopment potential of identified brownfield sites. Using the case study of Futian District in Shenzhen city, two frameworks are developed, one for identifying potential brownfield sites and one for evaluating them.

The first framework responds to the need in brownfield redevelopment process to prioritize the brownfield sites' development. Thus, the first framework identifies potential brownfields. The identification framework was performed in four steps: 1) locate target sites; 2) cross-check with industrial classification code; 3) verify environmental liability; and 4) confirm tax delinquency. Consequently, 38 sites were identified out of 89 for the further evaluation of redevelopment potential.

A second, major framework evaluates the redevelopment potential of identified brownfield sites. This research classified the relevant factors into three major categories for the development of a comprehensive criteria tree for the redevelopment potential evaluation of brownfield sites. These include 1) influencing factors for feasibility analysis, 2) potential benefits for community benefits analysis, and 3) specific local factors. Finally, three brownfield sites were selected among the identified sites which have been evaluated using the proposed framework. The result showed that two of three sites are found as sites with high priority for redevelopment.

These frameworks have the potential to be applied to other cases in different context given that three steps are undertaken for its development. These includes: the appropriateness of each criteria is examined; local data is identified and incorporated; and finally, data availability is verified in relation to the criteria tree. Thus, this framework provides decision-support for the brownfield redevelopment as a strategic process in achieving a sustainable development of cities.

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List of abbreviations

BF	Brownfield
BR	Brownfield redevelopment
CABERNET	Concerted Action on Brownfield and Economic Regeneration Network
CAUPD	China Academy of Urban Planning and Design
CBA	Cost-Benefit Analysis
CBD	Central Business District
CEPB	Central Environmental Protection Bureau
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CHAINET	Concerted Action
CLAB	Central Land Administration Bureau
DRB	Development and Reform Bureau
EIA	Environmental Impact Assessment
EPB	Environmental Protection Bureau
HKSAR	Hong Kong Special Administrative Region
LML	Land Management Law
LRC	Land Reserve Centre
LRRB	Land Resources and Real-estate Bureau
MCE	Multi-Criteria Evaluation
RAMC	Research Association in Ministry of Construction
RCRA	Resource Conservation and Recovery Act
SCB	Shenzhen Commercial Bureau
SEPB	Shenzhen Environmental Protection Bureau
SEPB	Shenzhen Environmental Protection Bureau
SGN	Smart Growth Network
SOE	State-Owned Enterprise
SSAT	Shenzhen State Administrations of Taxation
SSB	Shenzhen Statistics Bureau
SSEZ	Shenzhen Special Economic Zone
SUD	School of Urban Design
SUPLAB	Shenzhen Urban Planning and Land Administration Bureau
UPDIS	Urban Planning and Design Institute of Shenzhen
USEPA	U.S. Environmental Protection Agency
USMC	U.S. Mayor's Conference

1. Introduction

This chapter introduces the research background, problem, objectives, questions, and design. Taking sustainability as the fundamental means for urban development, this research attempts to develop two frameworks: one to identify potential brownfield sites and another to evaluate the redevelopment potential of the identified brownfield sites. This framework can be used by local governments, urban planners, and other stakeholders involved in establishing priorities and developing strategies to enable and to accelerate brownfield redevelopment (BR). The last part of the chapter outlines the structure of the thesis.

1.1. Research background

Cities are the consequence of the intrinsic nature of human beings ever since they settled along the river banks. Urban areas have expanded through population growth, and migration which brings along an increasing rate of urbanization. Despite that people boast the prosperity of a civilization, rapid growth of population and industrial activities are outpacing the city's capacity.

Cities provide industries with abundant resources such as infrastructure, skilled labour, access to capital, and market, and thus, industrial activities tend to concentrate in the city. However, as the city develops, many traditional industries (e.g. labour-intensive industries) cannot afford to stay in urban areas because of the increasing cost of rent, infrastructure, and labour. Therefore, they tend to move to the city outskirts to seek for cheaper resources; and in this way, affecting people's residential patterns. Thus, this shift heavily contributes to urban sprawl. This phenomenon can be characterized according to Ewing (1994) as the following,

- low density, scattered, and/or dispersed development;
- separation of where people live from where they work, and
- a lack of functional open space.

As a result, the previously developed industrial land in the urban area is left abandoned or underutilized for years. These areas are known as 'brownfield' sites and are generally considered problematic for cities. One reason is that these areas could be contaminated due to past industrial activities posing a risk to the surrounding neighbourhood. Moreover, given that urban sprawl has been identified as a major urban problem, the redevelopment of brownfield sites could provide an alternative for restraining the city's spatial expansion by accommodating urban development activities which otherwise would occur in greenfields.

Until very recently, it has been realized that brownfield redevelopment (BR) can be a strategy for achieving sustainable development (USCM, 1999; USCM, 2000; Thomas, 2002a). The concept of sustainable development was first defined by the Brundtland Commission's report as, "development

that meets the needs of the present without compromising the ability of the future generations to meet their own needs" (Hamm and Muttagi, 1988, pp.5). This concept is the first to explain the economic, social, and environmental relationship, and aims to provide the social and economic needs of society, while protecting environmental resources and values for the future (Randolph, 2004).

In this regard, brownfield redevelopment is seen as a sustainable land use strategy (USCM, 1999; USCM, 2000; Thomas, 2002b). This term is also frequently referred as 'land recycling' which is based on the same common principle as materials recycling, has gained support among land use planners (The California Centre for Land Recycling, 1998). Given that brownfields are considered a lucrative, but largely untapped land resource (Kirstenberg et al., 1997; Dennison, 1998), the redevelopment of brownfields is now realized as a potential 'win-win' situation for the majority of the stakeholders. Interestingly, economic development practitioners seek to turn brownfields into goldfields (Fleming et al., 2000) and the government has an interest in the near and long-term use of a currently overlooked asset.

1.1.1. Concept of brownfield

The term 'brownfield' was initially introduced to describe sites which had been previously in use, in contrast to 'greenfield' land which had not previously been used for development (CLARINET, 2002). The most widely used definition of brownfields refers to the U.S. Environmental Protection Agency's (USEPA) definition in which brownfields are defined as abandoned, idle, or underused industrial and commercial properties where expansion or redevelopment is complicated by real or perceived environmental contamination (USEPA, 1997).

1.1.2. The situation of brownfield redevelopment in North America and Europe

Since the beginning of the 1980s, brownfield redevelopment has received attention in the U.S. and Europe. Despite that brownfields possess great attractions for sustainable urban development; the redevelopment of brownfield lands involves both benefits and obstacles. Among the benefits are the control of urban expansion, creation of jobs and tax revenue, and environmental improvement; while the risks include a lack of financing, uncertain market potential, high costs of clean-up activities and time delays in comparison to greenfield development. In particular, contamination – the legacy of non-existence of environmental laws and our industrial past – turns out to be the origin of the obstacles listed above (Howland, 2004). For example, in the initial phase of environmental assessment in the U.S. (USEPA, 2001), liability has been a disincentive to even investigate whether there is actual or only perceived contamination because of the risks of being tagged with liability and associated financial penalties.

As a consequence of the risky and complicated redevelopment process, BR only tends to take place in big cities with high demand for land and for rapid development where land resource is limited. As for example, brownfield redevelopment takes place in cities like Toronto, Chicago, Detroit, Pittsburgh and Philadelphia where most of the available land is in the form of brownfields. Other similar examples of BR in Europe include London where there is a high population, and there is little available land for development projects in the inner city. In Europe, initiatives for BR have been particularly developed in the UK, France and Germany, which favour a regional derelict land policy and create specific derelict land recycling programmes. These initiatives were triggered on the one

hand by increasing awareness of the negative economic and ecological effects of the derelict sites and on the other hand by the recognition of the positive development potential for such sites (Grimski and Ferber, 2001).

In order to ease the redevelopment process, the government at all levels in the U.S. and Europe has implemented various policies and programs since the mid-1990s, conveying a general sense to the private sector that policies are changing in order to standardize at a national level the regulations for BR (Bartsch et al., 2001; USEPA, 2002; USCM, 2003). A prominent example of this trend is the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA), known as Superfund Law which was enacted by the USEPA in 1980s. In order to protect 'innocent' property owners or users, this law ensures that past contamination would be cleaned and that the contributor(s) of toxic waste should be held responsible for the cost of clean-up.

1.1.3. The situation of land recycling in China

Given China's rapid industrialization and urbanization, BR can provide a solution to the increasing urban sprawl and the limited land availability in urban areas. However, so far, the concept of brownfield has not been applied in Chinese urban planning or environmental practices. This does not mean that there are no potential brownfields in China (Niu, 2001). Despite that the development of brownfield theories and practices is far behind other developed countries, the concept and utility of 'land recycling' is gaining increasing attention from the central government and local authorities. Land recycling is a general concept referring to the redevelopment of a previously developed site; while brownfield redevelopment refers to a similar process but to a specific land redevelopment practice.

In China, the land redevelopment process works differently than in other countries as it is usually done by the developer in cooperation with the Municipality. In most of the land redevelopment cases, the government plays a more active role in the redevelopment process. Since 1970s, the government has been providing financial incentives and supportive policies to developers in accelerating urban redevelopment. Old industrial sites are frequently referred to as targets in the process due to the changing land reform policies since 1950s. Normally, the developer pays for clean-up costs and compensation to former user(s) if there is a land-use right transfer. After getting permission from the planning authority, developers can implement the construction plan (Zhang, 1997a). Particularly, residential land use is noticed to be the developers' favourite end use given that real estate investment provides a quick and ample return on profit (Li, 2003; Li and Chen, 2005).

The process of BR is relatively less complicated in China compared to other countries because there is an absence of specific regulatory framework to control the environmental aspect; and a lack of a concern regarding soil environmental quality. Moreover, planning decisions are generally made only by one group of powerful stakeholders based on their previous experiences. The complexity of land recycling, unfortunately, is not sufficiently understood by Chinese scholars and officials.

1.1.4. Defining 'brownfield' for this research

In recent years, brownfields have become a widely discussed research subject and a central topic in governments' agenda. However, the term brownfield can mean different things in various countries

and contexts. For example, in the U.S. legal discourse, contamination is emphasised as a key component of brownfields; while in the U.K. planning context, a brownfield site may be any site that has previously been developed for a non-rural purpose (Evans, 2004). In China, there is no such definition yet; however, in land use planning practices there are some land redevelopment activities and most of them refer to the re-use of previously industrial land. Nevertheless, not all those sites are derelict or contaminated land, which is one of the main characteristics for brownfields in the USEPA's definition.

As a starting point, the definition of brownfield in this research is as follows:

> *Brownfields are abandoned or under-utilized areas which are generally urban areas that have previously been built-on, yet have become derelict or have fallen into disrepair. Some of them may be contaminated.*

This definition integrates the characteristics of existing definitions, as well as common understanding and usage and can be applicable for the case of China. This will be further elaborated in chapter two.

1.2. Research problem

Despite that greenfield development still possesses a much greater attraction to both developers and consumers since the process is cheaper, quicker and simpler, BR is becoming an important component of the governments' strategies for achieving sustainable development. However, recent research on BR mainly concentrates on technical aspects, regulatory issues, or risk factors (Wood and Griffiths, 1994). This is a consequence of overemphasizing the influence of site contamination by American planning practices. Nevertheless, in many countries including China, there are very few theories on the location, condition and management of brownfield sites. This lack of understanding and knowledge makes BR a rather complex process; therefore, the urgent need for schemes with relevant information that can be used for providing decision support during the planning process.

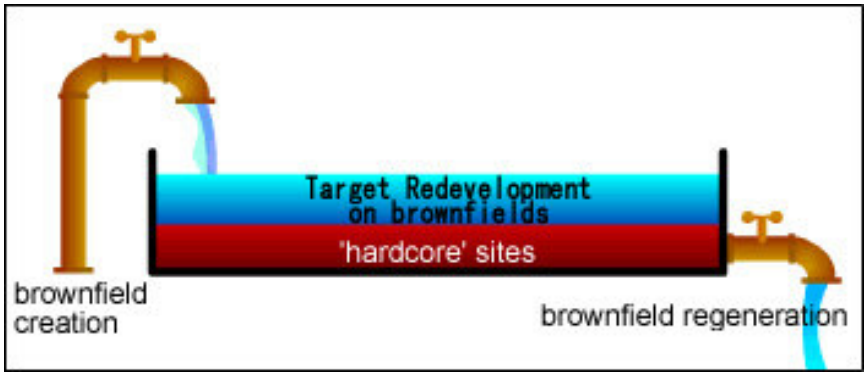


Figure 1-1: Bath Model
(Source: CABERNET, 2004)

One of the problems is that in land use planning practices, not all brownfield sites are equally worth to be redeveloped. According to the 'Bath Model' (**Figure 1-1**) developed by Concerted Action on Brownfield and Economic Regeneration Network (CABERNET, 2004), the persistent 'dregs' at the bottom of the bath, known as 'hardcore' sites because they present worst-off conditions for

redevelopment and thus are the sites that lay abandoned for many years. Conversely, there are other sites that present better-off conditions and thus are chosen for redevelopment. However, the information on the location, condition and regulatory aspects related to brownfields is not always available for the involved stakeholders, resulting in inappropriate decisions. This means that because a comprehensible method for assessing brownfields is lacking, decision-makers choose to redevelop 'hardcore' sites rather than the real 'target' sites. Moreover, there is a lack of integrated and comprehensive knowledge in the planning process to decide which sites can be relatively easier to be redeveloped in a short period and which ones would need more effort in redeveloping. This would require setting priorities for the alternative brownfield sites.

Consequently, the research problem lies on the following questions: How to identify potential brownfield sites? How to develop an integrated and comprehensive framework to evaluate the redevelopment potential of identified brownfield sites?

1.3. Research objectives and question

Given that BR is considered a strategy for achieving sustainable development, the main objective of this research is to develop a comprehensive framework to evaluate the redevelopment potential of identified brownfield sites in terms of their redevelopment feasibility and community benefits in the context of sustainable urban development.

This framework can be used by local governments, urban planners, and other stakeholders in establishing priorities and developing strategies to enable and accelerate brownfield redevelopment.

The specific objectives are outlined as follows:

Objective 1. To identify relevant factors influencing the redevelopment of brownfield sites:

- **a.** What are brownfields?
- **b.** What is the redevelopment process of brownfield?
- **c.** What are the benefits of brownfield redevelopment?
- **d.** What are the barriers for brownfield redevelopment?
- **e.** Which are the institutional regulations and specific factors influencing the redevelopment potential of brownfield sites in the case study area?

Previous BR research and theories may provide a better understanding of the research problem. National and local regulations could help to develop a feasible and regulated framework for the evaluation of identified brownfield sites.

Objective 2. To identify potential brownfield sites in case study:

- **a.** What are the characteristics that constitute a brownfield site?
- **b.** Which criteria can be used for identification of potential brownfield sites?
- **c.** Which is the available data to support the identification process?
- **d.** Which is the appropriate method for identification of potential brownfield sites?

Learn from previous research as well as analyze the local context to generate a set of relevant criteria for identifying potential brownfield sites.

Objective 3. To evaluate the redevelopment potential of identified brownfield sites in case study:

- **a.** Which influencing factors contribute to brownfield redevelopment?
- **b.** Which criteria can be used to measure redevelopment feasibility?
- **c.** Which criteria can be used for evaluating community benefits?
- **d.** Which method can be used to integrate these criteria and weights to evaluate the potential redevelopment of identified brownfield sites?

Because not all the potential brownfield sites are equally suitable for redevelopment, it is necessary to evaluate the redevelopment potential of these sites in order to prioritize their development.

1.4. Research process

The research process is demonstrated in the flow chart in **Figure 1-2**.

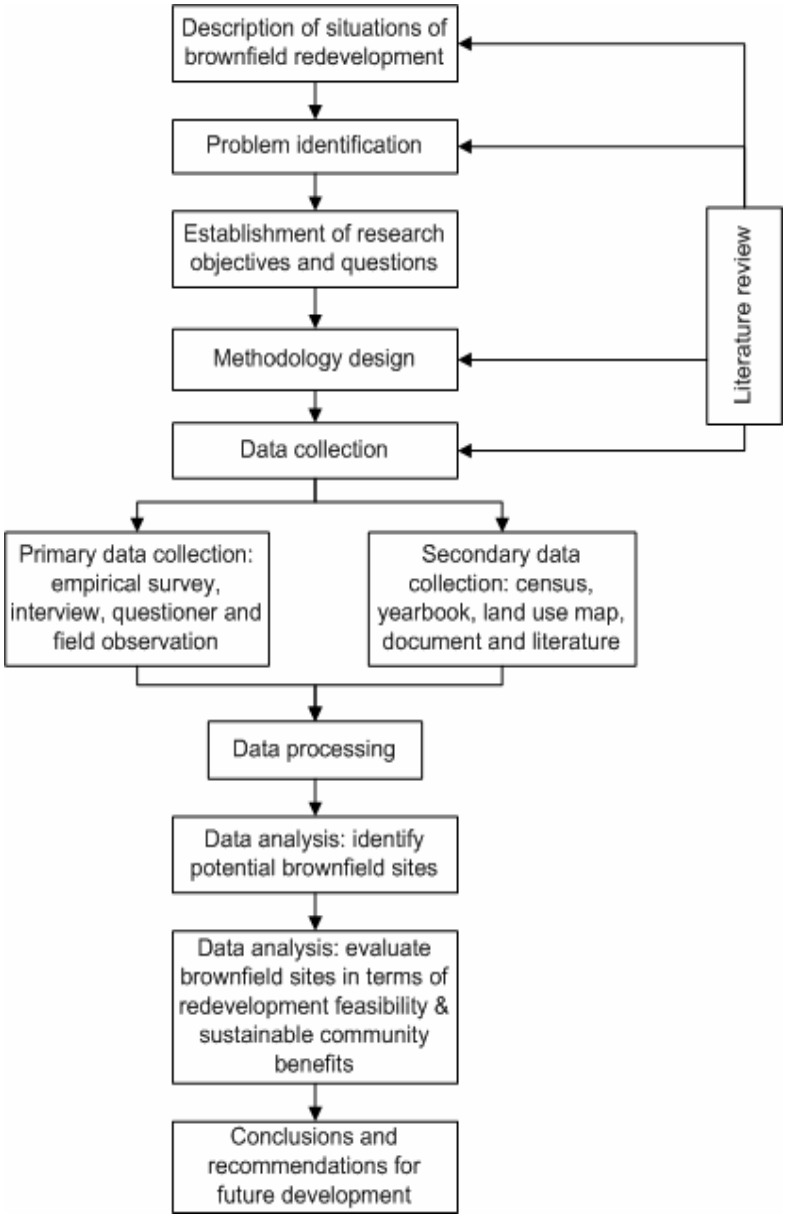


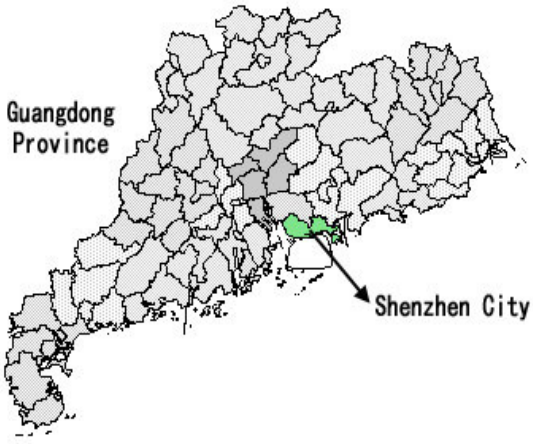
Figure 1-2: Conceptual research flow chart

1.5. Study area

The study area of this research is Shenzhen city, located in Guangdong Province, China **Map 1-1** and **Map 1-2**. Approximately 10% of the former industrial land use will be redeveloped according to the master plan of Shenzhen (1996 – 2010) (SUPLAB, 1996). The case study area of Futian District is identified in **Map 1-3** by the light yellow colour.

Futian District has functioned as an industrial base for Shenzhen Municipality for almost 10 years since the late 1980s. However, as the city develops, the strategic importance and regional function of Futian District needs to be reconsidered. According to the latest Master Plan of Shenzhen, Futian District is planned as the future central business district (CBD) and most of the former and current

industrial sites will be redeveloped according to the Revised Zoning Plan of Futian District (1998-2010) (SUPLAB, 2002).



Map 1-1: Guangdong Province in China

Map 1-2: Shenzhen City in Guangdong

Map 1-3: Case study area: Futian Distict in Shenzhen

1.6. Thesis structure

Chapter 1: Outlines the background information, research problem, objectives, questions, process, and thesis structure.

Chapter 2: Provides a literature review on brownfield and BR issues. These include various definitions of brownfields, current planning practices and regulations, standard redevelopment process, stakeholders and influencing factors of BR. Existing methods for identifying potential brownfield sites and for evaluating the redevelopment potential of brownfield sites are reviewed.

Chapter 3: Discusses the research approach, presents the background information of the case study area, explains the data collection process, develops one method for the identification of potential brownfield sites and develops one method for the evaluation of the redevelopment potential of the identified brownfield sites.

Chapter 4: Applies the method developed in chapter three for the identification of potential brownfield sites in the case study area.

Chapter 5: Applies the method developed in chapter three for the evaluation of the redevelopment potential of the identified brownfield sites.

Chapter 6: Concludes and discusses the results and findings from the previous chapters. Recommendations are provided.

2. Literature review of brownfields and their development

This chapter discusses the definitions of brownfields in various contexts and defines it for this research. Some international case studies and policies on BR are analyzed as well as the Chinese experiences and legal frame on land redevelopment. The chapter ends with a brief analysis on the process, involved stakeholders and influencing factors of BR.

2.1. Various definitions of the term "brownfield"

Generally, brownfields refer to previously developed or derelict land, which can vary in terms of size and location. The U.S. EPA's 1997 definition of brownfield puts emphasis on site contamination which already makes the redevelopment process complicated. This can be seen as the first official definition of brownfields and has become the most frequently used definition not only in North America but also across the world. Similarly, in Europe CABERNET [1] (Concerted Action on Brownfield and Economic Regeneration Network) has defined brownfields as sites which:

- have been affected by former uses of the site or surrounding land;
- are derelict or underused;
- are mainly in fully or partly developed urban areas;
- require intervention to bring them back to beneficial use; and
- may have real or perceived contamination problems.

Oliver (2005) discusses different definitions in Europe regarding the nature and scale of brownfields. Among the European examples he cites, two relevant definitions include Germany's and France's. In Germany, brownfields refer to both inner city buildings that are not under use and to inner city areas that require redevelopment and renovation. However, in France brownfield refers to previously developed space which is temporarily or definitely abandoned and needs to be reclaimed for future use. These can be partially occupied, derelict or contaminated.

From the discussion on the various definitions presented above, several common characteristics of brownfields can be drawn. These include:

- Previously developed land;
- Locating in urban area;
- Currently abandoned;
- Requiring redevelopment;
- May have real or perceived contamination problems.

[1] CABERNET is the European Expert Network addressing the complex multi-stakeholder issues that are raised by brownfield regeneration.

Incorporating these characteristics to the general understanding of brownfield, the working definition for this concept in this research can be summarized as:

> *Brownfields are abandoned or under-utilized areas which are generally urban areas that have previously been built-on, yet have become derelict or have fallen into despair. Some of them may be contaminated.*

2.2. Land redevelopment management

Since the 1980s, governments in many countries have been trying to ease the redevelopment process of brownfield sites. For example, in the U.S the reuse of urban land reform started since the late 1980s and then across North America and Europe. In the context of a transitional industrialization, the Chinese government is also dedicated to land redevelopment projects in order to achieve the goal of sustainable development.

2.2.1. Brownfield Redevelopment Management in North America and Europe

In the case of North America, the U.S. ratified several policies to standardize the redevelopment activities. In 1980, the government aimed to clean-up contaminant brownfield sites at a national level, so it enacted the CERCLA (discussed in chapter 1) and another major federal legislation *Resource Conservation and Recovery Act* (RCRA). CERCLA enables the U.S. Environmental Protection Agency (USEPA) to force the cleanup of contaminated sites by applying the 'polluter pays' principle. In some cases, CERCLA's liability scheme, strict cleanup standards and the law's tendency to produce long and expensive cleanups, discourage brownfield reuse. RCRA controls current generation, use, and disposal of hazardous materials. Later, in 1997 the U.S. government initiated and promoted a state cooperation agenda on brownfields and invested over 400 million dollars to the redevelopment of approximately 100 brownfield sites. In 1998, 16 brownfield sites were established as a successful illustration of 'land recycling', which attracted over 900 million investment dollars for further development (Deason et al., 2001).

In the U.K., research on contaminated land issues in terms of management and remediation started in the 90s. Contrastingly, this government intended to develop ideologies that hinged on the notion that, wherever possible, the private sector should be encouraged to remediate the contaminated land heritage. Therefore, in the 90s local authorities prepared registers of all areas subjected to 'contaminative uses' and in 1995, a risk-based model was produced for determining contaminated land. However, the need for statutory guidance describing how land should be determined and who was responsible for cleanup was not published until the year 2000. As a consequence, the process of brownfield redevelopment was little utilized (Boott, 1999).

2.2.2. Land recycling development and management in China

More and more Chinese researchers consider land recycling as a relevant trend to face the high-speed urbanization (Wu, 2006; Fan et al., 2005; Li et al. 2005; Zhang, 1997a). Though it is a sound strategy for sustainable development, the implementations are carried out only in few cities where the government's budget allows and land resource is limited. This bottle neck triggered most of the

redevelopment practices. Moreover, most of the land to be recycled is industrial land which was largely impacted by the policies of land reforms since late 1950s (Ding, 2003).

2.2.2.1. Changing land reform policies

The process of urban land reform in China can be regarded as a process moving from a highly centralized planned system to a market-oriented and decentralized one (Zhang, 1997). Previous to the land reform, urban land was state-owned whereas rural or farm land was collectively owned. During this period, the constitution banned all land transactions and land was allocated to state units free of charge for an infinite period (Ding, 2003). Many state-owned enterprises (SOEs), occupied too much land which usually caused low efficiency of land use. Under these circumstances, land market did not exist and industrialization was among the top priorities for development.

Land reform policy was brought forward in the late 1980s. In 1988, the Constitution was amended in order to separate the land-use right from land ownership. The land-use right could now be transacted while the land ownership remained the state's (Editorial Committee, 1992). This development paved the way to promote land markets.

The last two decades, land marketization has had profound impacts on the use and reuse of land in Chinese cities. First, land prices became key factors for the location and relocation strategies of the industrial sector. Second, the price for the land-use right can vary according to the nature and characteristics, like infrastructure, distance to city centre, distance to services, of the land parcel. As a consequence, many industrial SOEs moved to the urban fringe leaving industrial sites abandoned in the inner urban areas.

2.2.2.2. Land recycling practices

Since the late 1970s, the Chinese government has been providing financial support to redevelop underutilized industrial sites. In general, these projects are implemented within the limit of industrial zones, aiming at upgrading the basic infrastructure, improving the quality of public space and increasing the number of research centres (RAMC, 1982). In the late 1980s, land recycling became a frequently discussed topic. In order to raise more attention to the redevelopment of old industrial sites, two national conferences were held in 1984 and 1987 to discuss the experiences of different redevelopment policies and approaches in Chinese cities. However, unlike the practices in the 1970s, the activities in the 1980s are conducted with a widespread misunderstanding of 'successful' redevelopment. Plans were made to completely demolish existing buildings and start all over again.

Typically, the end uses of those redeveloped sites were residential and this practice still has an influence to present date (Li, 2003). However, planners in China have experimented with different ways to recycle urban land by transforming old industrial sites into different land uses. Three well-known examples include:

- Tangshan city, Hebei province. A previously derelict coal mine was successfully redeveloped into a lakeside park (Yang and Wu, 1999).
- Dashanzi Art District in Beijing. An old factory for weapon production was redeveloped into a thriving artist housing community (Huang, 2003).

- World Expo 2010, Shanghai. Several industrial sites are selected to be redeveloped into the future World Expo exhibition area. (Wang, 2006).

2.2.2.3. Regulatory framework

In China, there are several national laws that regulate the use and reuse of land resources. The most prominent one is the *Land Management Law* (LML) as it covers most of the aspects in land management. In order to enhance a balanced use, development, and preservation of land resources, LML provides the basic guidelines for developing local regulations for a) environmental and agricultural lands protection, b) market development promotion, c) public participation, d) planning and urban development coordination.

This precise balance is considered in LML as the backbone of sustainable development. However, LML regulations also have a negative impact on urban (re)development since land policy reforms have made land an expensive input for developers. Land cost consists of the price of land-use rights, tenant resettlements and destruction. Tenants can be very demanding and reluctant to move out unless they are satisfied with their financial compensation (Ding, 2003). For instance, in Beijing it is estimated that land cost can rise up to 60% of the total land development cost in existing urban areas; whereas if the development happens in greenfields the figure could possibly drop to 30-40%.

Furthermore, LML does not provide detailed regulations regarding the environmental aspect of urban land redevelopment; and there is no specific law or regulation in China related to the environmental liability regarding land recycling activities. Concerning land contamination, LML only states in a general way that *"Governments at different administrative levels should take proper actions to protect soil quality of land resources, in order to avoid soil salination, desertification, contamination or other soil degradations"* (CLAB, 1988, pp.57). Nevertheless, the Central Environmental Protection Bureau (CEPB) recently announced a budget of 1 billion Yuan for the investigation of national contaminated soil (Xinhua News Agency, 2007).

In sum, the government is committed to protect agricultural land and to enhance sustainable urban development; however, developers are still facing economic obstacles regarding brownfield redevelopment. Interestingly, the absence of specific environmental regulations in China makes the redevelopment process of brownfields less complex compared to other developed countries given that stakeholder have less limitations and regulations. However, if taking sustainable development as the underlining aim, there is still a need to improve environmental legislation for brownfield redevelopment.

2.2.2.4. Emerging relevance of sustainable development in China

'Sustainable development' is constantly on the lips of the researchers and officials engaged in making urban development strategies. Though it is an important milestone in environmental theory and is well known in China, there is a lack of sufficient understanding of the concept. In Taylor's words (1998, pp. 25): "the fundamental premise of the ideal-economic growth, if left unconstrained and unmanaged by the state, threatens unnecessary harm to the environment and may prove economically ephemeral." In this sense, most of the policy prescriptions are generally endorsed by those who are concerned about economic growth and are opposed to China's best environmental interests.

More and more research has been done by Chinese scholars regarding sustainable development and the concept is also being applied to management practices. Some 'pioneer cities', Shenzhen for instance, is seeking to be a model of sustainable development. In *Shenzhen 2030 Development Strategy – Towards a Pioneering Global City with Sustainable Development* (SUPLAB, 2006), outlines sustainability as the main goal for urban development. Moreover, land recycling is highlighted as a future trend and as an essential strategy to accommodate development.

2.3. Conceptualizing brownfield redevelopment

2.3.1. Brownfield redevelopment process

The ideal process for redevelopment of brownfield sites must consist of seven steps (**Figure2-1**):

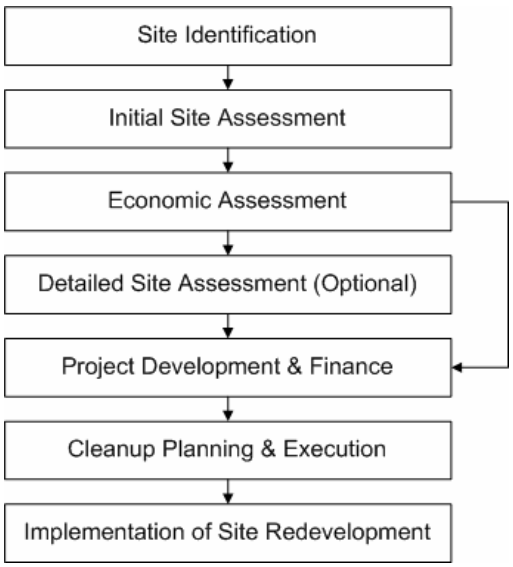


Figure 2-1: Brownfield redevelopment process
(Source: Based on USEPA, 2001)

1) Site Identification: It requires developing and maintaining a registry of sites, advertising and marketing abandoned properties, and helping developers to find suitable sites.

2) Initial Site Assessment: It involves reviewing public records, physical surroundings, and other readily available data related to the site.

3) Economic Assessment: It entails the evaluation of site characteristics to find out if the site is potentially viable or non-viable for redevelopment.

4) Detailed Site Assessment (if needed): It encompasses environmental engineering investigation, sampling, and chemical analysis of the site.

5) Project Development and Finance: It requires performing a financial feasibility analysis, developing financing plans for cleanup and redevelopment, and arranging financing which involves meetings with lenders, insurers, realtors, project partners, and nearby communities.

6) Cleanup Planning and Execution: It involves selecting and implementing a cleanup approach that can involve high capital costs of remediation, public notices, and reports for regulators.

7) Implementation of Site Redevelopment: It entails clearing and/or demolition, new construction, alteration and/or reuse to suit the new use for which the property is being redeveloped.

This seven-step model, which is widely used, can be summarized into a process with three distinct activities aimed at deciding which sites should be selected for redevelopment, investment and marketing (Thomas, 2002a). **Figure 2-2** demonstrates this process which not only identifies the three activities involved, but also the levels of decision making and collaboration among the participants. In the same way than the previous model, the initial activity in this model is the site identification and data collection process or site inventory. The second step, however, in this model is the screening and ranking process with the intention to narrow down the number of candidate sites. The third step is the analysis and evaluation process.

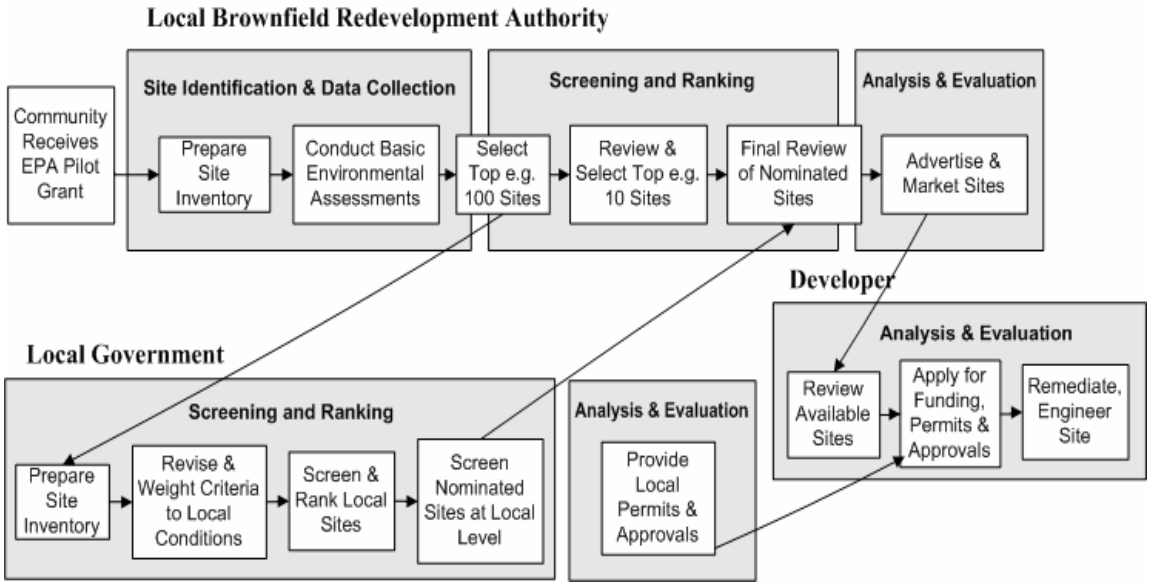


Figure 2-2: Brownfield redevelopment process in the context of the U.S.
(Source: Based on Thomas, 2002)

2.3.2. Benefits and barriers of brownfield redevelopment

Aiming at the overall goal of sustainable development, economic, environmental, social and technological aspects should be integrated for aiding the planning decision-making process as shown in **Figure 2-3**.

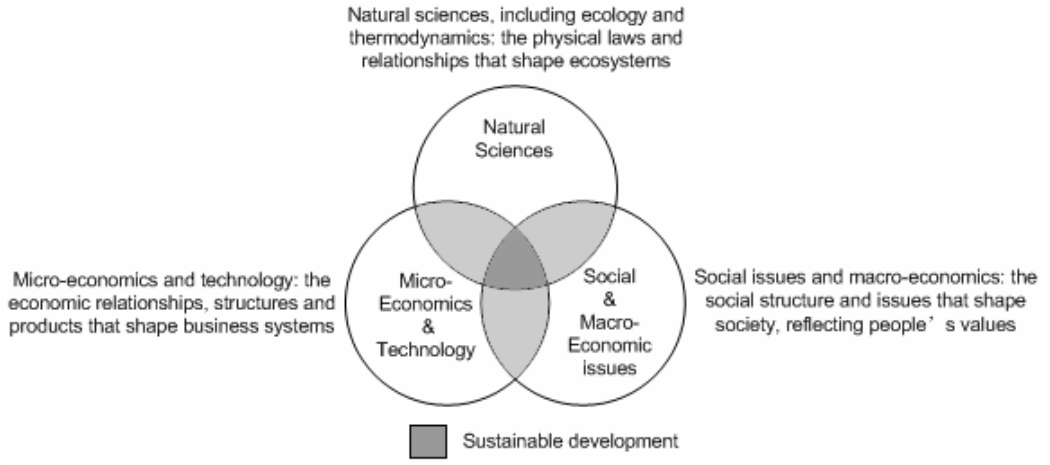


Figure 2-3: An interdisciplinary decision-making framework for sustainable development
(Source: Adopted after Cowell et al., 1997)

Supporters of brownfield redevelopment point out that this process can provide numerous benefits for cities in general and the community in particular (Gernstein, 2002; McCarthy, 2001; USCM, 1999; USCM, 2000; CUED, 1999). From a sustainable development viewpoint, the benefits of BR can be summarized as follows:

- Economic benefits
  - Increase investment
  - Create additional tax revenue
  - Create job opportunities
  - Make better use of existing, often underutilized, infrastructure and services
- Environmental benefits
  - Reduce metropolitan expansion/urban sprawl
  - Curtail traffic congestion and related air quality problems
  - Prevent other forms of environmental degradation
  - Improve the air and water quality of the region
- Social benefits
  - Better public health
  - Improve public safety
  - Encourage further neighbourhood revitalization

Prosperous development relies on maximizing inherent advantages and on minimizing barriers for BR. However, although the potential benefits are many, so are the barriers. The redevelopment process is made difficult by various obstacles which have been grouped by Brachman (2004) into three categories.

- **Legal**: a) liability; b) property transfer decisions; c) site control and title problems;
- **Institutional and political**: a) reluctant stakeholders and bureaucratic delays; b) lack of local political will and leadership;

- **Economic**: a) lengthy pre-development period due to thorough assessment; b) remediation expense and inadequate public funds.

2.3.3. Influencing factors on brownfield redevelopment

Additionally to the benefits and barriers of brownfield redevelopment, there are other factors that need to be taken in consideration for evaluating the redevelopment potential of brownfield sites.

Browner et al. (1998) found that there are five critical factors that most influence brownfield redevelopment decisions These include, (1) the 'market mismatch' between brownfields and greenfields as "every brownfield disincentive is a greenfield incentive," (2) actual or perceived urban crime rates which 'make brownfield sites look unattractive,' (3) intergovernmental competition, (4) the need to assemble parcels of land into tracts of sufficient size to permit economic redevelopment as well as clearing land titles, (5) the need for local governmental leadership.

Urban image is an important factor contributing to brownfield redevelopment. In some cases it has more weight than in others as for example, in Toronto, urban image was one of the most relevant driving forces for brownfield redevelopment (De Sousa, 2002). Similarly, urban image is one of the main incentives for redevelopment projects in China. According to the Ministry of Construction, approximately 20% of the projects approved last decade were projects aiming at improving the urban image. Moreover, economic development is considered as a significant indicator to measure the performance of municipal governance; therefore, local governments are competing for a thriving city image that can attract more investment and skilled labour force.

Finally, it is argued that the factor that most heavily influences the BR processes is the end land use (Davis and Margolis, 1997; Devine, 1996). This is because of the compatibility between the desired end use and the current conditions of the brownfield site will have a crucial effect on how successful the redevelopment process can be according to the different criteria. For example, an old industrial site that is moderately contaminated and that wants to be redeveloped into residential end use, would require higher number of resources than if it would be redeveloped into a commercial end use, given that the standards for clean up are more strict for residential purposes.

2.4. Methods to identify potential brownfield sites

Usually, the identification of brownfields is done by comparing potential sites with the predefined characteristics of brownfields. As mentioned in section 2.1, the predefined characteristics of brownfield sites are 1) previously developed; 2) locating in urban areas; 3) currently abandoned; 4) requiring redevelopment; and 5) may have real or perceived contamination problems.

However, information regarding potential sites is neither always available nor accurate (USMC, 2000). This is because registration of records is incomplete given that there is resistance on the side of the property owners to register their land as brownfield. According to Coffin and Meyer (2002), the central barriers to gathering information from property owners could be characterized as the following:

1. Fears about the potentially negative impacts on property values;
2. Fears about using the wrong data to characterize a site as a brownfield;

3. Concerns about limited institutional capacity for developing such an inventory;
4. The inability of communities to coherently identify the purpose behind such lists.

Little research has been done regarding the methods to improve the identification of suspected brownfields. An exception is the research done by Coffin and Meyer's (2002) where they proposed to make effective use of abundant databases for brownfield identification. They believe that the barriers in identifying potential brownfield sites can be overcome by linking currently available information sources.

Coffin and Meyer separate brownfield data resources into three types: federal, state and local sources. Federal and state environmental agencies offer the most direct information about the confirmed locations of contaminated soil and groundwater. This sort of information provides a general overview of the environmental and safety requirements. Local information sources can provide more accurate and valuable information to identify the potential sites where the contamination is not sufficiently problematic to attract the attention of federal or state government. Such information can be found in local environmental records, zoning and individual parcels' property tax records - which can identify properties where delinquent taxes remain unpaid.

The framework shown in **Figure 2-4** shows an example of how Coffin and Meyer's innovative method is used for brownfield identification.

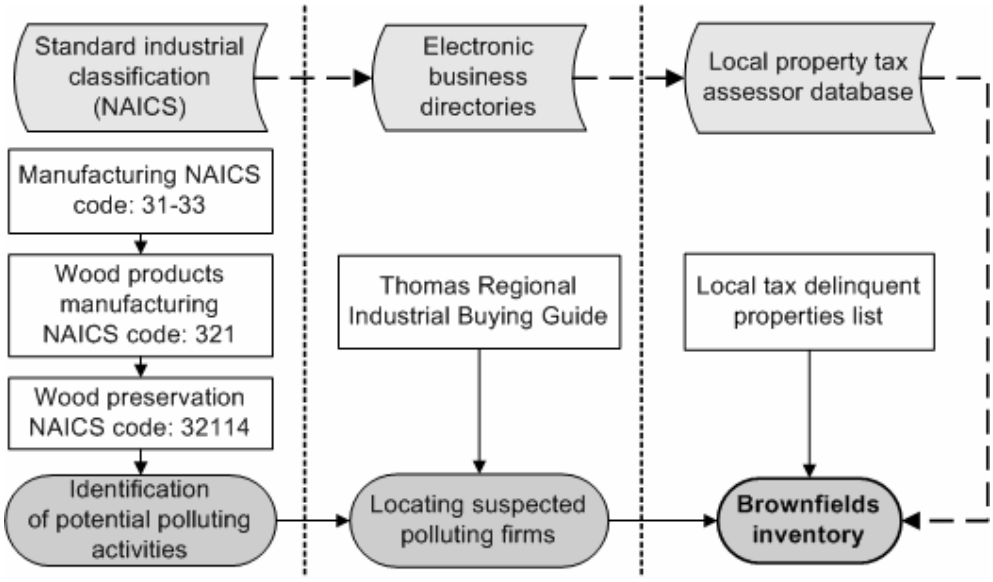


Figure 2-4: An example of brownfield identification in the context of U.S.
(Source: Based on Coffin and Meyer, 2005)

By linking industrial classification code, business directories and local property tax assessor databases, the identification of potential brownfield sites can be made without registration records. This method helps brownfield management organizations better understand the current situation. The requirement of various databases, however, is still a major obstacle to less developed countries and communities.

2.5. Methods to evaluate the redevelopment potential of brownfield sites

There is a lack of research on the methods for the evaluation of redevelopment potential of brownfield sties. Little has been published on the prioritization of sites and even less regarding the evaluation approaches. This section discusses two approaches for evaluating the redevelopment potential of brownfield sties. The first part deals with the frameworks developed by SGN and Thomas, which are able to assess different brownfield sites in order to prioritize them for redeveloped. The second part delves with three evaluation tools that evaluate the particular characteristics of a specific brownfield site.

2.5.1. Framework for evaluating redevelopment potential

With a limited government's budget and a large number of potential brownfield sites, the selection of sites for redevelopment is difficult. In order to make a sound decision, both relevant information and a method to integrate the information is clearly necessary. Based on the case study of three American cities, Smart Growth Network (1996) developed an integrated framework for site prioritization in terms of site-marketability and community benefits. A second evaluation approach proposed for site prioritization and selection is a Brownfield Site Ranking Model developed by Thomas (2002). The following section explains the methods.

2.5.1.1. SGN's integrated framework

Using a case study approach, Smart Growth Network (SGN) in the U.S. developed an integrated approach for the evaluation of redevelopment potential of brownfield sites. This tool aids in the selection of potential brownfield sites in terms of both their economical feasibility, and their environmental and social benefits.

With a goal to develop an integrated framework, considerations have been focused to economic and social perspectives, while environmental aspects are not emphasized explicitly. Essentially, the framework involves six steps to identify brownfield sites. It provides information to individuals and organizations involved in setting priorities and developing strategies for brownfield redevelopment. The following **Table 2-1** shows the basic six steps in the framework.

Table 2-1: General Framework for brownfield sites prioritization

1. Target Geographic Areas
2. Identify Brownfield Sites in Each Area
3. Characterize Brownfield Sites Based on Marketability
4. Screen Sites for High Potential Community Benefits
5. Evaluate Potential Impacts of Redevelopment Alternatives
6. Develop Strategy for Brownfield Redevelopment Activities

1. Target Geographic Areas: Focusing on certain target areas that comply with specific location characteristics, the objectives of the brownfield redevelopment can be better achieved. This means that the number of potential brownfield sites for redevelopment is narrowed down making the decision-making process more efficient. Identification is focused in three general geographic areas. a) Mixed use areas with highly exposed, low income, minority populations; b) Industrial areas with large land tracts and significant job creation potential; c) Waterfront/downtown areas that are attractive to businesses.

2. Identify Brownfield Sites in Each Area: Identification of brownfield sties reduces the complexities and uncertainties of the site location selection as well as the planning costs for developers. Information is gathered from a variety of sources. These include a) local knowledge and land use surveys; b) Contact local economic development offices; c) Coordinate with city urban planning activities; d) Use federal and state environmental databases; e) Use GIS to incorporate a variety of data sources.

3. Characterize Brownfield Sites Based on Marketability: Taking in consideration both site-specific and more general neighbourhood characteristics are important in this step. Moreover, characterizing the marketability of sites may need to be revisited as information, market and social conditions change. Sites can be characterized as a) Low marketability; public funding necessary (Public sector takes the lead); b) Marketable for specialized developers; could make use of alternative funding sources. (Public-private partnerships); c) Highly Marketable; traditional sources of funding (Private sector takes the lead).

4. Screen Sites for High Potential Community Benefits: This step assesses the potential community benefits associated with the redevelopment for the first two categories described above, so that governments can focus their efforts accordingly. Screening criteria include site and neighbourhood characteristics, as well as attributes of the redevelopment plan itself. Evaluating sites using these criteria will help to identify sites that are likely to provide substantial community benefits, and will identify obstacles that may hinder such benefits from being realized.

5. Evaluate Potential Impacts of Redevelopment Alternatives: After the previous assessing steps, it is important to evaluate impact of the high priority sites if the redevelopment is implemented. The purpose of this evaluation is twofold. First is to help governments prioritize potential sites in terms of the overall benefits, so that public funding efforts and redevelopment projects plan can be made accordingly. Secondly, this evaluation can also help identify site characteristics that qualify projects for alternative funding sources and to frame the rationale for tapping into those sources.

6. Develop Strategy for Brownfield Redevelopment Activities: Establishing priorities for development projects, identifying a diverse of funding sources, and an action plan.

This framework and criteria provide a tool that can be used by a variety of organizations and individuals involved in setting priorities and developing strategies for BR. Potential users and their applications include:

- **City managers;**
- **State and Federal governments;**
- **Stakeholders include:**
  -- Community development organizations,
  -- Environmental justice advocates,
  -- Lenders,
  -- Developers and other private businesses,
  -- Environmental regulatory agencies, and
  -- Local economic development agencies.

As the framework is developed in a general way, it still needs to be refined to accommodate each cities' 'unique constraints and priorities'. Criteria considered in step 3, 4, and 5 described above are reviewed in detail in the methodology chapter.

2.5.1.2. Thomas' GIS-based evaluation framework

As an effective tool to integrate multiple geo-spatial and socio-economic data, GIS is one of the essential information sources and analysis tools for both urban studies in general and brownfields in particular. Additionally, relevant information can be quickly and easily accessed in a web environment by stakeholders and the public which could help enhance public participation in the planning process (Thomas, 2002b).

Thomas (2002a) proposes the Brownfield Site Ranking Model for selecting sites for potential redevelopment. This model identifies 12 siting criteria derived from the review of general siting factors that can be evaluated in locating a business on a formerly used site. Such factors include commercial marketing guidelines, financial incentives, environmental regulatory compliance requirements, regional infrastructure and labour resources, and local community acceptance. These factors were integrated into a conventional, step-by-step site identification and selection process using a weighted multi-criteria procedure. **Table 2-2** and **Table 2-3** below shows the evaluation matrix of brownfield sites selection for redevelopment.

Table 2-2: Weighting and ranking criteria for brownfield site selection at the local level

LOCAL GOVERNMENT RANKING CRITERIA	Max. Point Value (Weight)
Site Conditions	30
Compatibility with Local Land Use Controls (Zoning Ordinance)	25
Current Use Compatibility with Local Land Use Plans (Master Plan)	20
Compatibility with Surrounding Land Uses	15
Utility Infrastructure Capacity	10
Telecommunications Infrastructure	10
Transportation Infrastructure	10
TOTAL AVAILABLE POINTS (LOCAL)	**120**

(Source: Based on Thomas, 2002a)

Table 2-3: Brownfield site selection, weighting and ranking criteria at the county level

COUNTY AUTHORITY RANKING CRITERIA	Max. Point Value (Weight)
Financial Incentives	40
Environmental Risk and Compliance	30
Land Re-Use Preferences	20
Labour Resources	10
Market Conditions	10
TOTAL AVAILABLE POINTS (REGIONAL)	**110**

(Source: Based on Thomas, 2002a.)

Thomas divides the criteria in two sets according to the perspective of the local government and of the county authority. The rationale for this division lies on the fact that the local government considers more important the physical conditions of the site as; whereas the county authority considers the marketability aspects as more relevant. Given that both sets of criteria contribute to identifying the aspects involved in the decision-making process, both levels are important to take into account when developing an evaluation framework for the potential redevelopment of brownfield sties.

Moreover, because the complete evaluation process can be computerized and adapted to a geographic information system (GIS), it provides a practical model for commercial developers, real estate brokers, siting consultants, and local communities in selecting target sites for redevelopment.

2.5.2. Evaluation tools

In order to achieve the overall goal of sustainable development, there are several different techniques that can be employed to assist decision-making process for the evaluation of redevelopment potential of brownfield sites (CLARINET 2002). For example, Pollard et al. (1990) identified several evaluation methods including: cost benefit analyses (CBA); environmental impact assessment (EIA); and multi-criteria evaluation (MCE). These three methods are discussed in order to identify their usefulness for the evaluation of the redevelopment potential of brownfield sites.

2.5.2.1. Cost-Benefit Analysis

Cost-Benefit Analysis (CBA) is an economic tool which can be used as a decision support tool on large investments such as highways and school projects (CHAINET, 2000). The basic principle of CBA is that all the considerations should be expressed in a common unit for measurement, namely, money. Economic and environmental costs and benefits are all interpreted as monetary values.

Typically, CBA has three steps. Firstly, a determination of which costs and benefits are involved. Then CBA tries to value these costs and benefits and weights them against each other to produce a final sum of value. However, it is argued that CBA, as an objective environmental decision making tool, suffers from several limitations (Martin et al., 1997):

- Monetary valuation of environmental benefits and impacts are hard to quantify on a reliable and consistent basis;

- Concerns exist about discounting future effects to net present value, when the potential for detrimental (or positive) environmental effect in the long term is important;
- The appropriateness, or lack of it, of a monetary value for less tangible environmental values such as biodiversity;
- The limitations of converting all decision factors to a single dimension

2.5.2.2. Environmental Impact Assessment

Environmental Impact Assessment (EIA) is the process of identifying the environmental and social impacts of a project before decision-making. Aiming at predicting environmental impacts at an early stage in project planning and design, EIA helps in finding ways and means to mitigate adverse impacts; shape projects to suit the local environment; and present the predictions and options to decision-makers (Loojien, 2006). Despite the diversity of different practices of EIA in different nations, CHAINET (2000) concludes that four important aspects of EIA are increasingly approaching consensus.

- Consideration of impacts on both the physical and the social environment.
- As a tool for decision-making, EIA is more likely to be realized in a timely communication of information between planners and individuals conducting the assessment.
- EIA should consider quantifiable as well as non-quantifiable attributes (e.g. sociological, political and psychological factors) which may also have significant influence on the process.
- Mitigation of significant impacts, which implies to minimize undesirable and enhance the desirable impacts, must be assessed for all possible impacts.

By using EIA both environmental and economic benefits can be achieved, such as reduced cost and time of project implementation and design, avoided treatment/clean-up costs and impacts of laws and regulations. In the particular case of brownfield redevelopment, EIA provides a tool for decision making that not only regards the economic factors, but offers stronger consideration for the social and environmental aspects.

2.5.2.3. Multi-Criteria Evaluation (MCE)

Traditional decision theory is firmly based on a single-criterion focusing on finding the best solution to any decision problem. However, most decision-makers would agree that a single criterion is not sufficient in most of the cases. With respect to brownfield redevelopment process, it is necessary to combine environmental, social and economic factors into one decision-making framework. In contrast to orthodox approach, "multi criteria methods are in principle an appropriate modelling tool for combined economic-environmental evaluation issues" (Munda et al., 1994, pp.6).

As a tool to deal with multidimensional decision problems, MCE is considered as a structured system for ranking alternatives and making selections and decisions. Important features of MCE are its relative simplicity and its ability to handle numerous criteria. MCE is particularly useful when three

factors combine: discrete decisions have to be made; possibilities for different choices are measurable; and the data have a quantitative and/or a qualitative character (Jankowski 1989). The considerations used in MCE are how great an effect is (score) and how important it is (weight). A general outline of the method is shown in **Figure 2-5**.

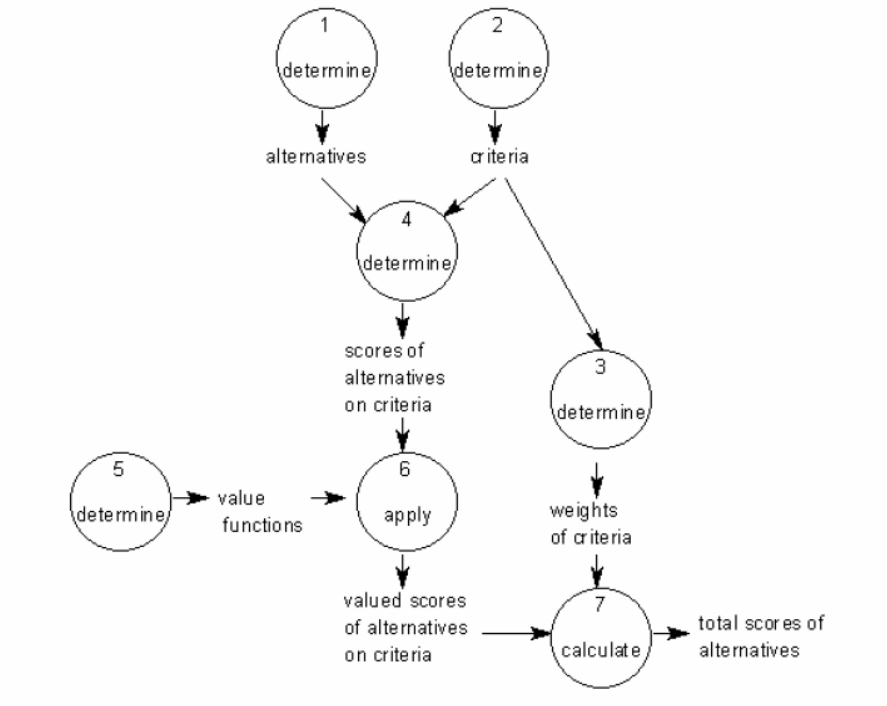


Figure 2-5: A general outline of MCE method
(Source: Adopted from Bardos et al., 2000)

This tool's relevance lies on the fact that it can handle a great amount of data. Given that the process of brownfield redevelopment is complex, MCE provides a tool to systematically analyze and weight the multiple factors involved.

CBA and EIA are relevant tools that can be used in assisting complex decision-making processes; however, both of them provide an already tinted analysis as the first one emphasizes the economic perspective and the latter the environmental view point. In addition, these tools are only appropriate for site-specific evaluations. Conversely, MCE provides a systematic approach to analyze a vast amount of criteria; moreover, it provides the possibility to rank and select between two or more sites.

2.6. Conclusion

This chapter builds on the theoretical background about brownfield and BR. Considering the variety of definitions that exists for brownfields, this research defines brownfield as sites that are 'abandoned or under-utilized areas which are generally urban areas that have previously been built-on, yet have become derelict or have fallen into disrepair. Some of them may be contaminated'.

Different characteristics of BR are found in the regulatory framework and development process in North American, Europe and China. Environmental liability stands a significant obstacle for BR.

Surprisingly, this cannot be applied to China because current legal framework is not able to regulate invisible environmental problems.

Brownfield redevelopment has been identified as a key strategy for achieving sustainable development. The process of brownfield redevelopment is achieved through seven steps which include three groups of stakeholders. Moreover, the benefits and barriers for brownfield redevelopment were identified together with other influencing factors like urban image and end land-use.

Literature for identification methods of brownfield sites is limited. Coffin and Meyer's developed an innovative method to tackle this problem and identify potential brownfield sites by integrating available data sources at different levels (federal, state, and local). However, this approach's major limitation is that in other countries than the U.S, relevant databases are not sufficiently reliable or accessible.

As for the evaluation methods, SGN and Thomas provide a comprehensive knowledge for site prioritization and selection and further integration with GIS. Contrastingly, the evaluation tools concentrate on site-specific evaluation. Both types of evaluation methods provide valuable insights for the evaluation of redevelopment potential of brownfield sites as the first one helps in prioritizing the redevelopment of a group of sites and the latter one allows a more detailed examination for the specific proposed redevelopment project. However, given the rationale of this research, MCE provides the best option for site prioritization and selection for redevelopment.

3. Methodology

This chapter discusses the research process of the study, the data collection process and the methodology development. It begins with the research approach undertaken for this study and introduces the study area – Shenzhen city, China. The data collection section includes the identification of data requirements, acquisition of primary and secondary data during fieldwork and field observation. Furthermore, two methods are developed: one for the identification of potential brownfield sites and another one for the evaluation of the redevelopment potential of the identified brownfield sites. The limitations of this research are discussed at the end of this chapter.

3.1. Research approach

The objective of this research is to develop a comprehensive framework to evaluate the redevelopment potential of identified brownfield sites. According to the research design, this research is implemented through three stages. The first stage is to understand diverse aspects related to brownfield redevelopment. In the second stage, potential brownfield sites are identified by using relevant data resources. In the third stage, the identified brownfield sites are evaluated (see **Figure 3-1**). The first stage is realized by the literature review in chapter 2. In order to undertake stage two and three, two frameworks are developed: one for the identification of brownfield sites and the other for the evaluation of redevelopment potential of brownfield sites. In the following sections, the detailed description of the method involved is developed.

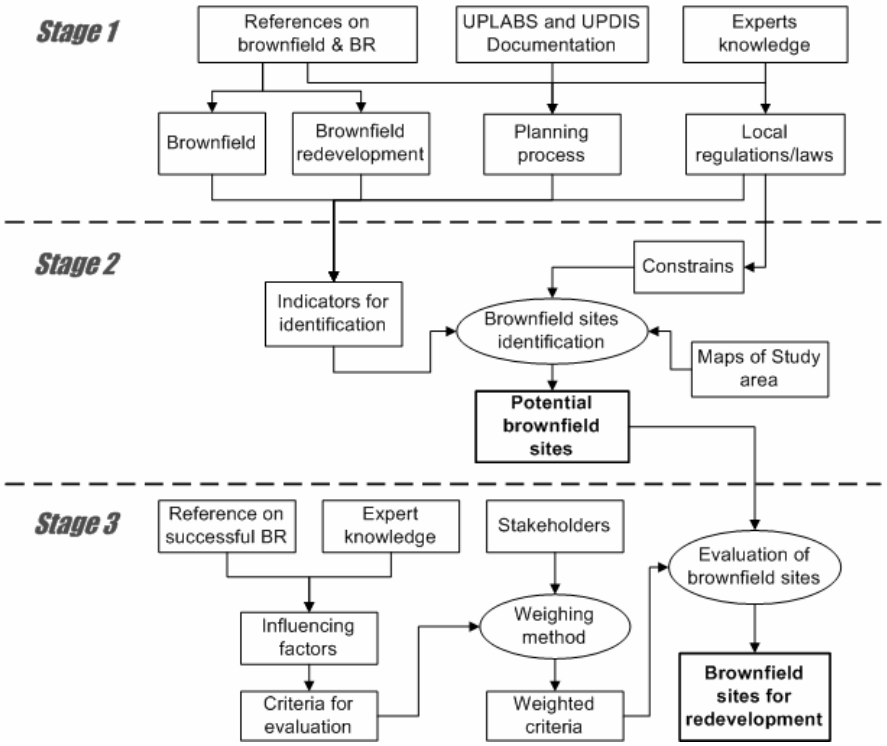


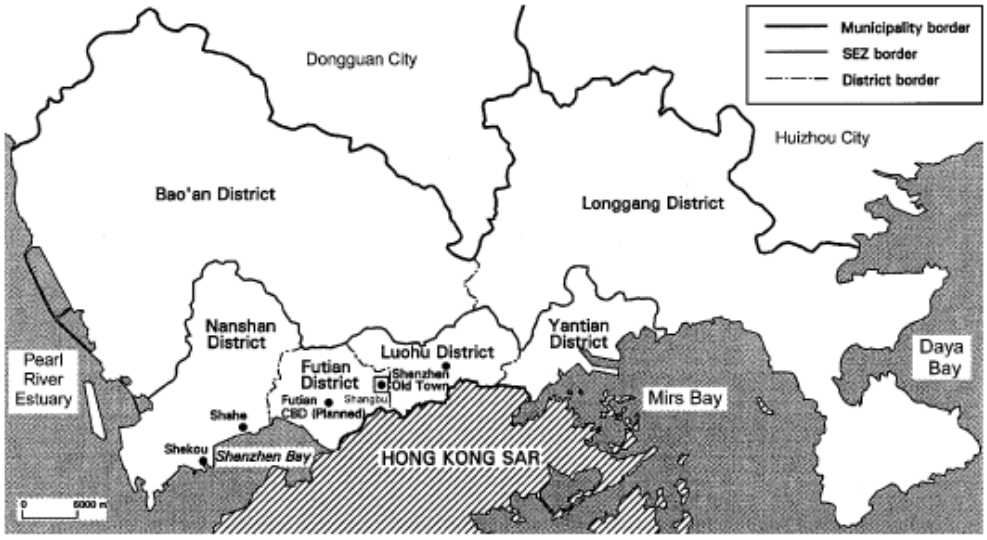
Figure 3-1: Research approach

3.2. Case study area

Given that this research involves a case study approach, this section provides the background information of the case study – Shenzhen, China. This section also gives a short description of the relevance of brownfield issues in this city. Finally, the rationale for selecting Futian District as the particular area of study is examined.

3.2.1. General information of Shenzhen city, China

Shenzhen City is located at the north of the Hong Kong Special Administrative Region (HKSAR), between longitude 113° 46′ to 114° 37′ and latitude 22° 27′ to 22° 52′ and administratively it belongs to Guangdong Province (**Map 3-1**). The municipality of Shenzhen consists of Bao'an District, Longgang Districts and the Shenzhen Special Economic Zone (SSEZ). It has an area of 2020 km2, housing a population of over 4.69 million. It is a linear city with a moderately hilly terrain. Its east–west span is over 49 km while its north–south span is only 7 km. In particular, the SSEZ occupies an area of about 392 km^2 with four administrative districts: Yantian, Luohu, Futian and Nanshan (Ng, 2003).



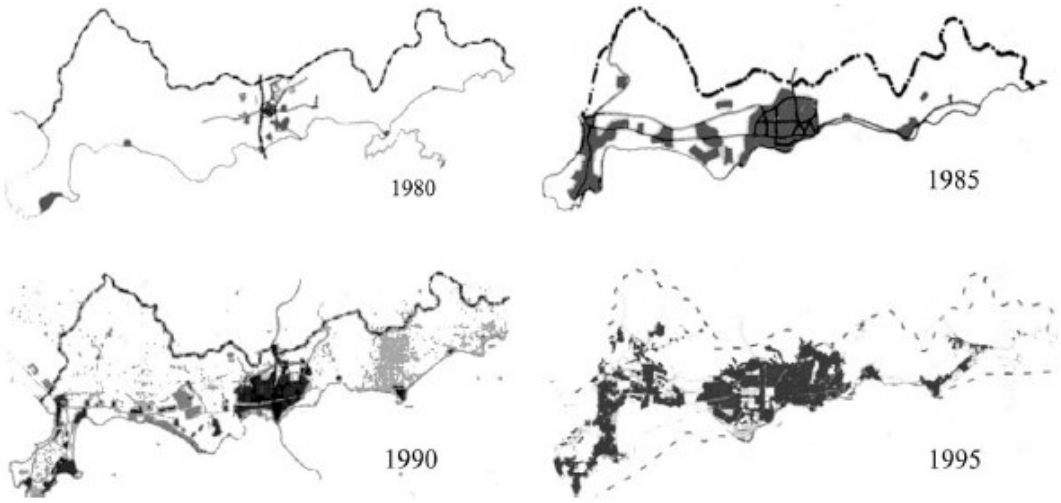
Map 3-1: Districts in Shenzhen

(Source: Ng, 2003)

3.2.2. Rapid industrialization and urban growth

Among Chinese cities, the city of Shenzhen, boasts an unusual history. This city is a direct product of the economic reforms introduced in China following the eleventh conference of the Chinese Communist Party in 1978. It has developed over a period of only 23 years from a small farming and fishing settlement of between 20,000 and 30,000 people to a mega city of more than 7 million in 2001 (Bruton et al., 2005). Following the introduction of the economic reforms in China, and with the establishment of the SSEZ in 1980 as an experiment to attract foreign capital, technology, and

management skills, the town was the first in China to experience the operation of a market economy. From then on, the city has possessed great attraction for industrial activities. Judged by economic indicators, the experiment of Special Economic Zone in the case of SSEZ is considered as a successful case. However, rapid industrialization and urbanization has caused serious urban problems such as urban sprawl which can be seen in **Map 3-2**.



Map 3-2: Growth of Shenzhen (1980–1995)

Source: SUPLAB, 1999, p 12.

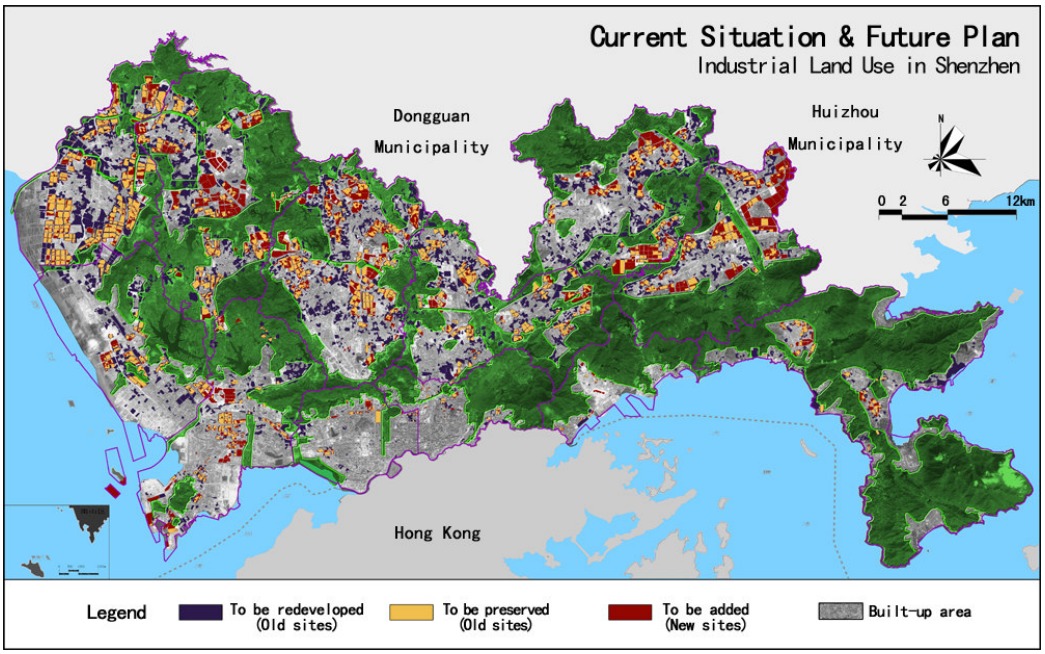
3.2.3. Limited land resources

With the high speed of industrialization and urbanization and a hilly geography, Shenzhen is now facing development challenges as availability of land resource is decreasing rapidly. At present, the area of the Municipality is 2020km^2 of which 1000km^2 are mountainous and not developable, leaving a total of 1020km^2 available for development. Of this amount, 700km^2 have already been developed further diminishing the available land for development to 320km^2. The uncertainty comes from conflicting concerns to (a) protect the high-quality environment of the remaining 320km^2 from development or (b) to take economic advantage of further growth (Bruton et al., 2005). Furthermore, in the latest *Recent Constriction Plan of Shenzhen (2006-2010)*, it is estimated that only 200km^2 are available for future development if the water bodies and forests are taken into consideration for environmental protection (UPDIS, 2006). Moreover, if is estimated that if the city maintains its present growth rate, those 200km^2 will be used for development in the next 10 years.

3.2.4. Urban land redevelopment and its management in Shenzhen

Shenzhen has been undergoing structural change of industry by moving from low-value added and labour intensive to high-value added and capital/technique intensive industries (Ng, 2003). As the transformation is going on, some traditional industries move out leaving a large amount of formerly industrial lands underused in the city. Meanwhile, the government is seeking a way to sustainable development. It is proposed in the *revised Master Plan of Shenzhen (1996-2010)*, as well as in the *Recent Construction Plan of Shenzhen (2006-2010)* that 35-45km^2 of former urban land should be redeveloped in order to meet the demand of urban development (SUPLAB, 2006a; UPDIS, 2006). The key components of the land to be redeveloped are previously industrial land and urban villages. **Map**

3-3 illustrates the previously industrial land waiting to be redeveloped according to the city's master plan.



Map 3-3: Current Situation and Future Plan of Industrial Land Use in Shenzhen

(Source: UPDIS, 2006).

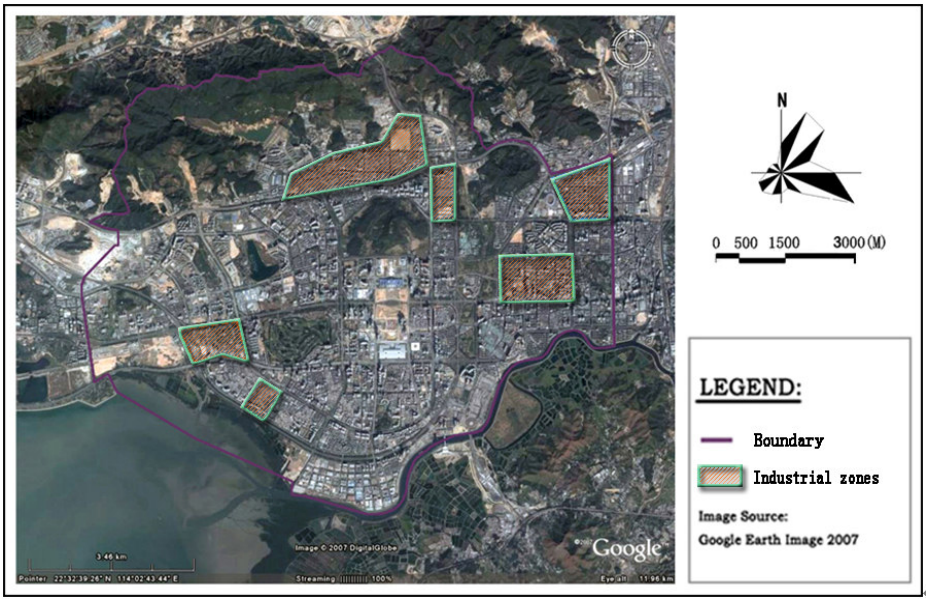
New policies are also made in collaboration with the master plan at both municipal and district level. Instead of the traditional way to waive land premium -- which has to a large extent caused the problem of real estate speculation -- the government intends to develop new mechanism such as tax relief, financial subsidies and special supporting fund among others to provide incentives for urban redevelopment (Shenzhen Municipality, 2006). With respect to urban image and fast financial return, the government puts emphasis on the sites which are located in the inner city and along the main roads/streets.

3.2.5. Futian District as case study area in Shenzhen

As shown in **Map 3-1**, Shenzhen city is administratively divided into 6 districts. Futian District is selected as case study area on the basis of the following criteria recommended by experts before fieldwork: 1) amount of old industrial sites; 2) population density; 3) existence of responsible organisations; 4) data availability.

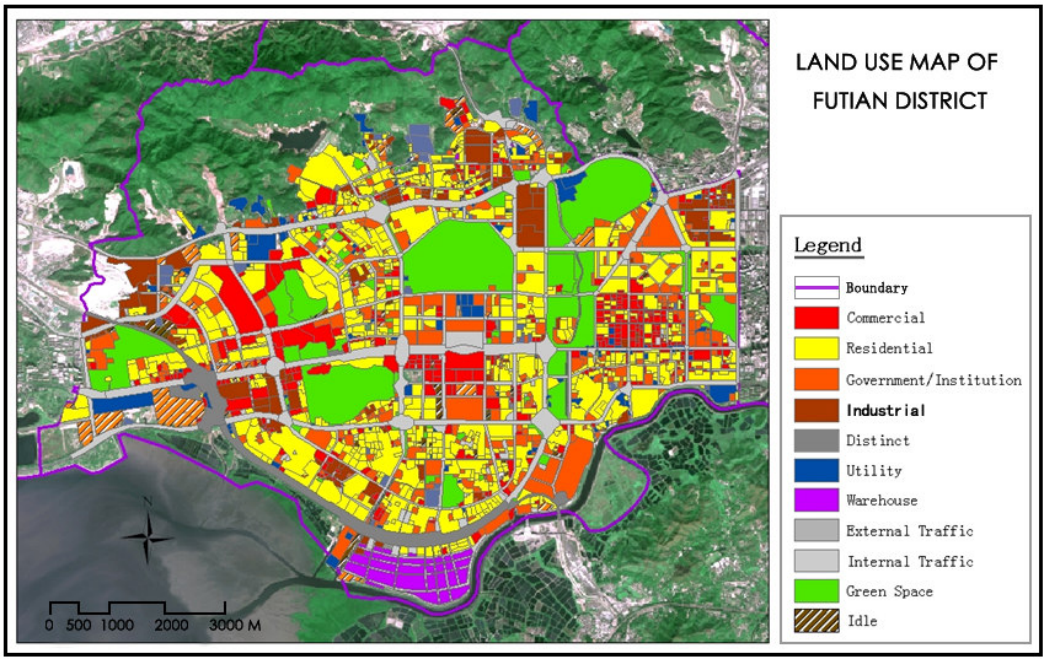
Located in the central part of SSEZ, Futian has an area of 78.8 km^2 and a population of 0.9 million (SSB, 2005). Futian has the highest population density in Shenzhen. In the primary stage of urban development, Futian was planned as an industrial district to accommodate 6 industrial zones (**Map 3-4**) out of 15 in the municipality. Contrarily, in less than 20 years, Futian has developed as the centre of business, politics, information, and international exhibitions of Shenzhen. The land use map shown in **Map 3-5**, demonstrates that the majority of the current land use is allocated for residential, commercial and governmental purpose. Since its establishment, Futian has achieved great success of economic growth by insisting on high standard construction, high speed development and human-

oriented strategy. With the accumulated experiences and education, Futian has realized the importance of sustainable development strategy. Increasingly, efforts are focused on improving the balance between economic development and sustainable community benefits.



Map 3-4: The 6 industrial zones planned in 1985 in Futian

(Image source: Google Earth Image 2007)



Map 3-5: Current land use map of Futian

(Source: SUPLAB, 2006)

3.3. Data collection

This section explains how the data collection process is planned and conducted. It includes the identification of required data, primary and secondary data collection, and field observations.

3.3.1. Identification of required data

Based on the literature review, relevant theories and practices were extrapolated in order to identify the required data for this research. The useful methods for this research are developed by Coffin and Meyer (2002), Smart Growth Network (1996) and Thomas (2002). Some data was available from previous research prepared by School of Urban Design (SUD) of Wuhan University (2006); however, not all necessary data was available, and thus fieldwork was needed. Data requirement and acquisition methods in relation to the research questions were developed before the fieldwork (see **Appendix I**).

3.3.2. Secondary data collection

Secondary data required, shown in **Appendix II**, was collected during the fieldwork period from Urban Planning and Design Institute of Shenzhen (UPDIS), China Academy of Urban Planning and Design (CAUPD) and the local planning authority Shenzhen Urban Planning and Land Administration Bureau (SUPLAB). But there is no law, regulation or research relevant to BR (following the definition in this research) issues in Shenzhen city due to the lack of awareness of brownfields concept. Instead, the redevelopment procedure of previously industrial sites was acquired from SUPLAB. Also softcopy of some planning practices and pre-planning research for the redevelopment projects of previously commercial and industrial sites were acquired from UPDIS.

3.3.3. Primary data collection

The primary data collection consists of interviews with city officials, planners and researchers; while the field observation was conducted to learn about the local context of brownfield redevelopment.

3.3.3.1. Interviews

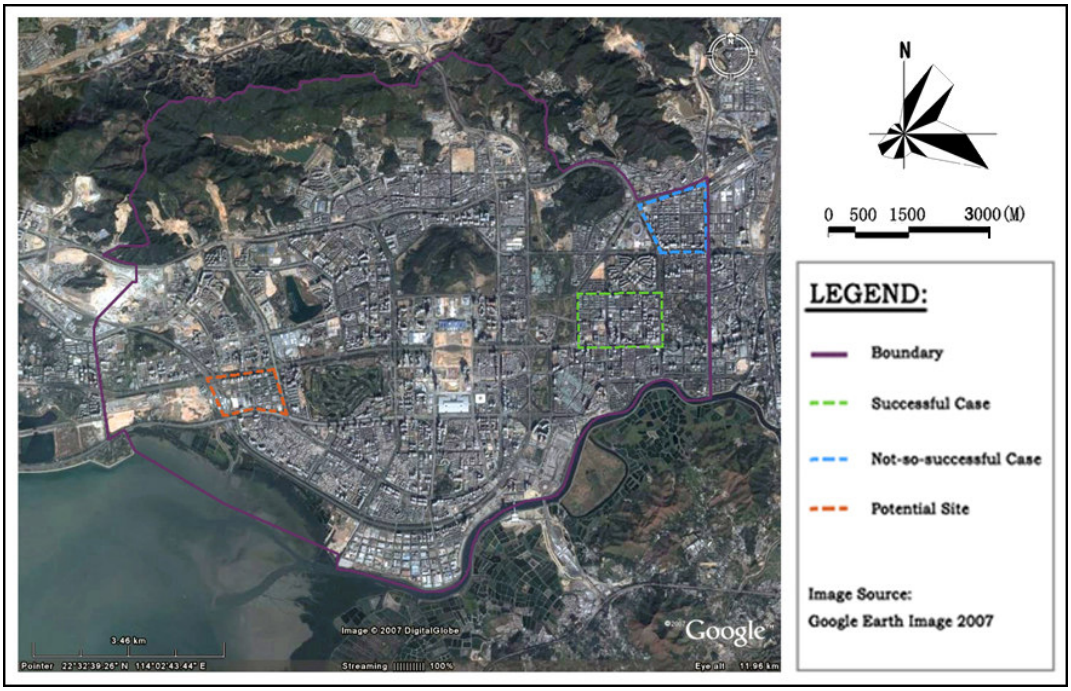
An interview is a conversation between interviewer and respondent for the purpose of eliciting certain information from the respondent (Groenendijk and Dopheide, 2003). During the fieldwork period, interviewing provided a wide range of information from domain definition, government concerns, to obstacles for a specific BR project. Interviewees were selected by a "snowballing" approach which allowed the addition of more and more interviewees as the interviews progressed. Furthermore, this flexibility allowed the acquirement of extremely rich information on the topic selected (Kumar, 1996). The first few interviewees are introduced by acquainted planners as expert planners in redevelopment projects. The checklist for interview topics and interviewees is provided in **Appendix III** and names of the interviewees are concealed due to privacy reasons.

3.3.3.2. Field observation

Field observation was undertaken with the purpose of exploring more about the local context of brownfield redevelopment and to identify the key influencing factors and mechanisms for

redevelopment; hence, to help for the development of a relevant framework for further evaluation. From the information acquired in the interviews, the target areas for field observation are set among old industrial zones in Futian District. In 1985, there were 15 areas planned as industrial zones for manufacturing in the SSEZ. Futian, as planned to be the industry base for Shenzhen, accommodates 6 of them (**Map 3-4**).

Among the six areas, three references cases were selected in order to understand in more detail the local context of brownfield redevelopment. These areas include: Shangbu, which was frequently referred to by many interviewees as a "successfully" redeveloped case; Bagualing, as several interviewees considered it to be a "not-so-successfully" redeveloped case; and Chegongmiao which is still an industrial site without formal redevelopment and thus, could be a "potential" brownfield site. Locations of these sites are displayed in **Map 3-6**. More detailed information and analysis of these three reference case are explained in chapter 5.



Map 3-6: Location of three reference cases

(Image source: Google Earth Image 2007)

3.4. Developing methods for this research

In this section two methods are developed. The first method consists of developing an approach for the identification of brownfield sites. The second method, and main objective of this research, is for the evaluation of redevelopment potential of the identified brownfield sites.

3.4.1. Method for identifying potential brownfield sites

To fulfil the second objective in this research, the first step is to identify brownfield sites in the case study area. Using two identification methods, one developed by Coffin and Meyer (2002) and the

other by SGN (1996), together with the available data acquired during the fieldwork in the case study area, a practical and functional approach is developed. This method is shown in **Figure 3-2**.

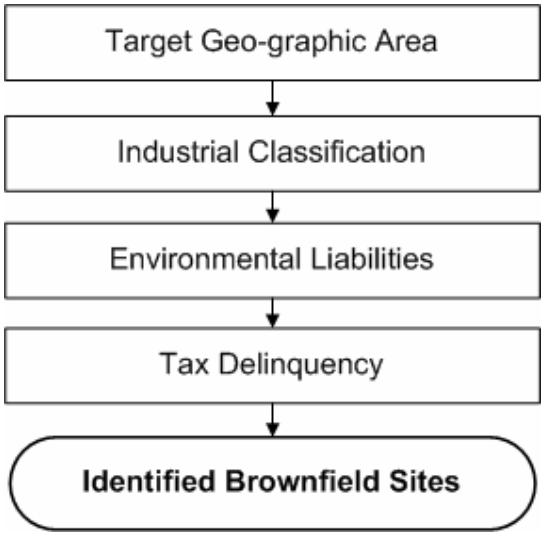


Figure 3-2: Method for identifying potential brownfield sites

- **Target geographic areas**

  Since brownfield sites may be scattered throughout the city, a limited number of candidate sites may help to increase the efficiency of decision-making for BR at a municipal level. In order to narrow down the number of brownfield sites for identification and the further evaluation, the first step in identifying brownfield sites is to define target geographic areas, i.e. to focus attention on certain geographic areas where successful brownfield redevelopment is most likely to happen.

- **Industrial classification:** Industrial classification supports in identifying potential polluting activities which contribute to be a brownfield sites.

- **Environmental liability:** Environmental data assists to identify perceived or real contamination.

- **Tax delinquency:** Property tax records not only identify the sites with tax delinquency but also further identify properties where the delinquent taxes remain unpaid.

Integrating all these elements helps to identify those properties located in environmentally suspicious areas that have had an industrially classified land use and now are tax delinquent, indicating a potentially abandoned property, which could be a brownfield.

3.4.2. Method for evaluating the redevelopment potential of brownfield sites

This research is aimed at evaluating the redevelopment potential of brownfield. The evaluation is divided into two parts. The first part consists of a feasibility analysis of the potential BR; and the second part is an analysis on the community benefits of the potential BR. By combining these two parts together, a comprehensive framework is developed.

3.4.2.1. Criteria for feasibility analysis

Through an extensive literature review, the first part of the evaluation framework consists on identifying a set of criteria that can be used for evaluating the potential of brownfield sites to achieve an economically successful redevelopment. The feasibility analysis is to ensure a profitable investment which requires that the market resale price be greater than the sum of costs (site purchase price, construction costs, cleanup costs), plus a minimum profit (SGN 1996). A *cost and benefit analysis* is normally used as the evaluation method in this process.

From the literature review in chapter two, the criteria for redevelopment feasibility is identified. The following **Table 3-1** presents the selected criteria and a short discussion.

Table 3-1: Criteria for feasibility analysis

Criteria		**Discussion**
Site condition	Physical condition	Physical conditions like size of land tract, geology hazards among others will impacts the cost and feasibility of redevelopment.
	Environmental condition	The type, extent and severity of the contamination must be evaluated to assess cost, time for remediation, and associated uncertainties. Availability and quality of environmental data for the site should also be evaluated.
Infrastructure	Utility infrastructure	The availability of infrastructure for water, gas and sewage has an impact on overall investment required for the project
	Transport infrastructure	Distance from transport network and transport nodes are both important factors for industrial and commercial land uses.
	Communication infrastructure	Communication infrastructure is important for modern industries, e.g. hi-tech industry. In general, fibre for internet is considered to be relatively more important than traditional communication infrastructure.
Market	Proximity to customer	Particularly, the accessibility to costumers will have a big impact for commercial land uses,
	Competitor	The existence of similar development activities in the surrounding areas allows a shared market and costumer base.
	Land price	This is the initial factor that will affect the total profit of the project.
	Owner's will	Owner's unwillingness to sell the land will increase the cost (money and/or time) for land purchase.
Financing	Policy incentives	Existence of financial and/or tax incentives attracts and encourages potential developers to locate their investment at brownfield sites.
	Financial support	Availability of financial resources and support from local lending institutions are important to remove economic barriers since most BR projects tend to be expensive.

3.4.2.2. Criteria for community benefits analysis

A set of criteria is identified in order to assess the potential of brownfield sites to achieve a sustainable redevelopment from a *community benefit* point of view. Taking in consideration that sustainability refers to the balance between the environmental, economic, social aspects, in this research, it focuses on the benefits that the potential redevelopment can bring to the community in these three aspects.

Based on the discussion in chapter 2 on the benefits of BR from these three aspects, criteria that can be used for assessing brownfield sites are identified and discussed as shown in **Table 3-2**.

Table 3-2: Criteria for community benefits analysis

Criteria		**Discussion**
Economic benefits	Development activities	Lack of development activity in an area and/or business closures suggest a need for economic development and revitalization; new economic development in the area can provide community economic benefits.
	Job opportunities	Redevelopment can create new jobs thus is important to areas with inadequate job opportunities.
Environmental benefits	Regional environmental quality	Regions with less satisfactory environmental quality can benefit from the remediation of brownfield sites and also from the reduction of pollution created by commuting traffic.
Social benefits	Public interests	Redevelopment close to sites and/or areas with special value is imperative to the community.
	Aesthetics	Redevelopment results in better appearance and overall neighbourhood quality. Improving aesthetics by the redevelopment can provide significant benefits to areas with pleasant surroundings.

3.4.2.3. Development of a comprehensive criteria tree

The feasibility and community benefits analysis above outlines the structure of a comprehensive criteria tree to be developed. Furthermore, local factors should also be considered given that each city has its specific BR context. To summarize above, a comprehensive criteria tree is developed as shown in **Figure 3-3**.

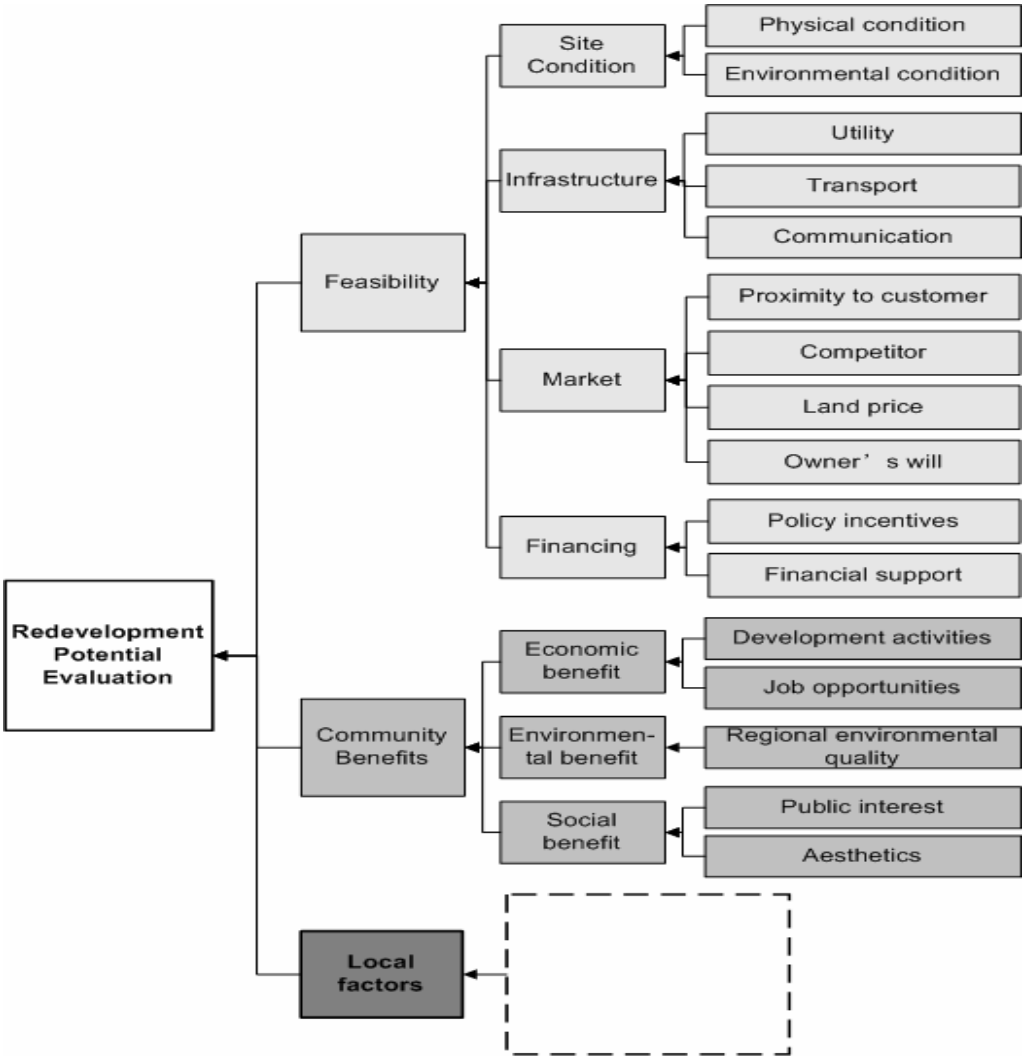


Figure 3-3: Comprehensive Criteria Tree

3.5. Limitation of this study

The identification and evaluation of potential brownfield sites relies largely on data availability and quality. The lack of a complete, representative and accurate data is a limitation for this identification and evaluation analysis. For an example, land value data collected from SUPLAB secondary sources in which data were gathered after previous alterations and modifications.. The limitations faced for during data collection are summarized as follows:

1. In Shenzhen, there are no comprehensive attribute data about all brownfield sites.

2. Environmental data such as soil, ground water quality cannot be acquired. Complementarily, the environmental reports of current years at municipal level are acquired, which cannot reflect the environmental situation in detail.

3. Taxation data are collected with the focus on firms in arrears because of the huge number of firms in taxation record and limited research time.

The spatial components of the identification and evaluation are generated from the digital maps of the study area by interpolation. The maps are collected from SUPLAB and some variations are found among different maps. Because these maps are not produced in the same year and Shenzhen is developing very fast, probabilities are high for encountering big changes. Some sites are not included in the map, and as a result, they are treated as missing values in the analysis process.

Time constraint is another factor which affected the research work. Learning, understanding, and familiarizing with the operational aspects of different soft wares, requires a quite considerable amount of time.

3.6. Conclusion

This chapter develops the research process, the data collection and the methodology for this research. A first framework is developed to identify potential brownfield sties; while a second, and main one, is developed for the evaluation of the redevelopment potential of identified brownfield sites. For the second framework, three steps were undertaken to identify relevant criteria in order to develop a criteria tree. The limitations of the research are also explained.

4. Case study: identifying potential brownfield sites in Futian

This chapter applies the method developed in the methodology chapter to identify potential brownfield sites. It begins with the analysis on the specific context of the case study area. Then, based on the applicable approach developed potential brownfield sites in Futian are identified. Some discussions on the identification process and result end this chapter.

4.1. Comparative analysis on context differences

As introduced in section 3.4, the identification approach in this research is developed based on two research methods developed in the U.S., one by Coffin and Meyer's (2002) and the other by SGN (1996). However, the context under which these two methods were developed is rather different to the case of China. This could result in considerably different outcome. Thus, it is necessary at this stage to compare and explore the context differences between the U.S and China in terms of their redevelopment process, information source, and government concerns.

4.1.1. Redevelopment process

In China, the procedure of land redevelopment is quite different than in the U.S. As some interviewees put it, "there is no existence of standard procedure for land redevelopment in China". They also mentioned that in different cities, the procedure and organisations in charge can be quite different depending upon particular governing mechanism carried out by the current local leaders. According to planners in CAUPD and UPDIS, the redevelopments activities are classified into two categories: 1) non-profit or 2) profit development activities. Two different approaches for these two types of development activities are also identified from the interviews. As for the non-profit development activities, the land to be redeveloped would not be put to the land market for sale. Moreover, the government would be the developer through the redevelopment process supporting marketing, clean-up and further development.

In reality, however, most of the redevelopment projects in Shenzhen are profit development activities, typically known as commercial, residential and industrial. In order to enhance the communication between different stakeholder groups, the government established a Land Reserve Centre to provide essential information that is considered to be 'transparent, accurate, and reliable' by some interviewees. The standard procedures for profit development involve three steps: land reservation, land selling and development.

Land reservation:

- Property owner registers to municipal Land Reserve Centre (LRC) with materials including the land-use right certificate, the contract between seller and municipality.

- LRC makes or entrusts related organization to make a field investigation, and conduct a valuation process to assess property value.
- After the assessment the property owner and LRC sign a contract for the purchase.
- LRC provides subsidy to property owner; cleans up the land and keeps the land in LRC.

Land selling:

- Public auction are conducted by the government to sell land-use right[2] to developers.
- Land Administration Departments evaluate different potential developers based on criteria such as future development plans and bids and sell the land-use right to the winner.

Development:

- After getting the land-use right, developers prepare project proposal together with other relevant materials and applies to municipal Development and Reform Bureau (DRB) for government procurement and funding.
- Developers prepare site submission together with other relevant materials to Urban Planning and Land Administration Bureau (UPLAB), Land Resources and Real-estate Bureau (LRRB) and Environmental Protection Bureau (EPB). Environmental assessment is done by EPB.
- Detailed planning is prepared by developers and applies for the project permission to UPLAB and DRB. UPLAB certificates land use permit and project permit to developer.
- After obtaining the certificate, the development plan can be implemented. 3

Figure 4-1 illustrates the procedure described above, together with an illustration of stakeholders involved and their tasks.

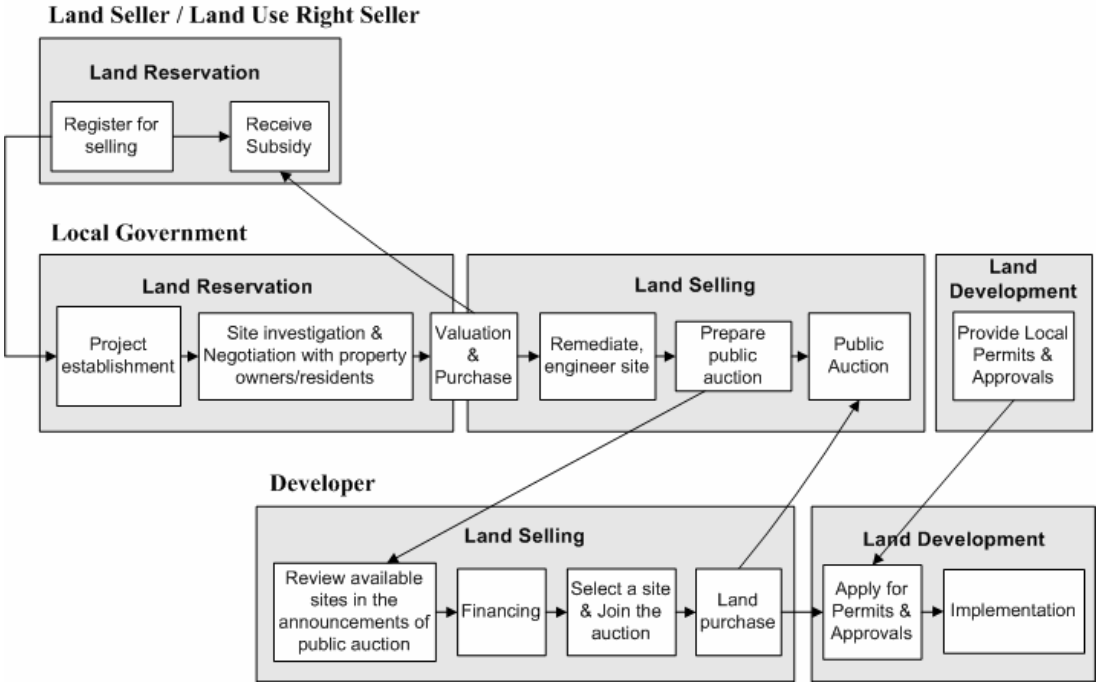


Figure 4-1: Procedure of land redevelopment in China

[2] According to LML in China, all the land resources are owned by the state or collective. Therefore, only the land-use right can be transferred in a trading process.

[3] Based on the documents collected from SUPLAB, LRC and other relevant orgnizations. Completed by the interview with Senior planners, Chief researcher in UPDIS; and planners in China Academy of Urban Planning and Design (CAUPD).

In conclusion, several observations can be drawn which are significant to take in consideration when identifying potential brownfields:

1. Contrarily to the top-down development in the U.S., China has a bottom-up process. This implies that from the government perspective, there is a lack of strategic consideration for redevelopment projects at a regional or municipal level.

2. Land reservation system makes the government play an intermediary role in the redevelopment process, which means that the government will take marketability into consideration in the purchase decision-making process.

4.1.2. Information source

Information source is another major difference between the two contexts. In Coffin and Meyer's research (2002), they identify a large variety of information sources supporting the identification of potential brownfields (chapter 2). However, with the ongoing strategy of further economic growth in China, governments at all levels are keen on developing and maintaining records for economic data while for the environmental and social information there is little concern.

Acquired environmental information can be classified into three groups: a) Shenzhen municipality's environmental report, which gives an overview of the environmental situation in the city; b) reports on environmental protection subjects, including agricultural land, forests, rivers, lakes, and reservoir among others; c) records on pending pollution fees which can lead to noticing areas with serious pollution problems. In the reports, most of the information is focused on visible pollution like surface water pollution, air pollution and noise pollutions; while the 'invisible pollution' such as underground water and soil pollution, which is considered essential elements for the identification of brownfield sites, is not available.

Location is another important attribute for site identification. However, it is found that some data sources, such as pending pollution fees or tax records, do not have a location attributed to them. Therefore, it can only be possible to locate the suspect sites and activities by manually linking a certain attribute among different datasets, anticipating that one database contains the location information. For example: two databases, one containing business location and another containing tax records, and both with the name of a firm in question, will allow to identify the location of the potential brownfield site.

4.1.3. Government concerns

Government's concerns on the redevelopment projects are revealed from interviews as well as documents acquired during the fieldwork period. Two relevant aspects for the identification of potential brownfield sites include:

- **Sustainable development**

Shenzhen has been successful in regards to rapid economic development (Zhao, 2004). But this unprecedented development speed was achieved with the expense of improvident consumption of natural resources. The limitation on land resource is set clear in the *Shenzhen 2030 Development*

Strategy – Towards a Pioneering Global City with Sustainable Development (SUPLAB, 2006). In this document, 'Efficient Shenzhen' is the new maxim to enhance sustainability for future development. The term was coined by the government to refer to the new model of development that emphasizes the role of sustainability. Therefore, Shenzhen is to be developed into a city with the "environment of Singapore and efficiency of Hong Kong" (Shenzhen Municipal Government, 2000, pp 1–2).

Future development should not be made by compromising natural resources to which the breakage is not irreversible. Since land is one of the most important resources, it has to be developed cautiously. Only when both planned and used land is carefully considered, the idea of sustainable development can be manifested. An example of this development goal is that in the *Environmental Plan* enacted by the Environmental Protection Bureau, Futian District's neighbourhoods are divided into several categories according to their expected environmental quality. This implies that BR in a neighbourhood with a high class distinction would receive more support from the government than in a neighbourhood with a low class distinction.

- **Optimize current land**

The *Shenzhen 2030 Development Strategy Plan* points out that the land demand for future development can be acquired in two ways: 1) earth filling to the sea and 2) optimization of current land use.

On the conditions of ecological protection and water conservancy safety, the idea of earth filling can be implemented for harbour industry and other important construction for infrastructure. However, this process still requires high prudence and awareness that these resources should be used in a sustainable way. Moreover, earth filling is an issue which has tremendous influence on the natural environment Given that this option might cause serious environmental problems and is of high risk, the government has preferential treatment for the second option on optimization of current land use. This refers to paying considerable attention to the development and redevelopment of current land use, in order to optimize the spatial distribution of different land-uses. This implies paying attention to:

- Redevelopment of old industrial sites
- Expansion of underground space
- Intensification of current land use
- Reconstruction of urban villages

In order to achieve the four objectives listed above, the government has already completed the identification of old industrial sites, which are considered to be high potential brownfields. Furthermore, as declared to be one of the strategic objectives, the redevelopment of old industrial sites receives more attention and support from the local government. Thus, old industrial sites are regarded as main target geographic areas where brownfield sites are to be identified.

4.1.4. Identification approach

After the development of an identification approach (chapter 3) and an assessment for its applicability to the Chinese context, an appropriate identification approach for the case study area of Futian District is developed (**Figure 4-2**).

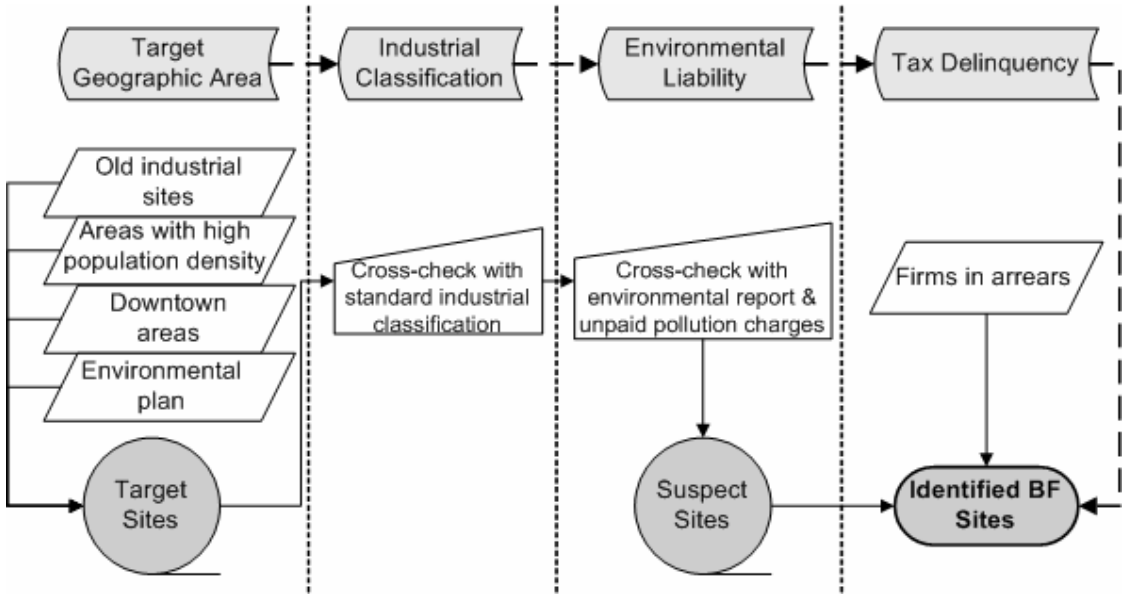


Figure 4-2: Identification approach

With the overall goal of achieving sustainable development, the target geographic areas in this case study are identified by the following factors: a) old industrial sites; b) areas with high population density, where is most likely to create social benefits; c) downtown areas that are attractive for business and hence have a great potential to bring economic benefits; and d) areas with expected good environmental quality, which are considered to have important environmental value.

4.2. Identification of potential brownfield sites

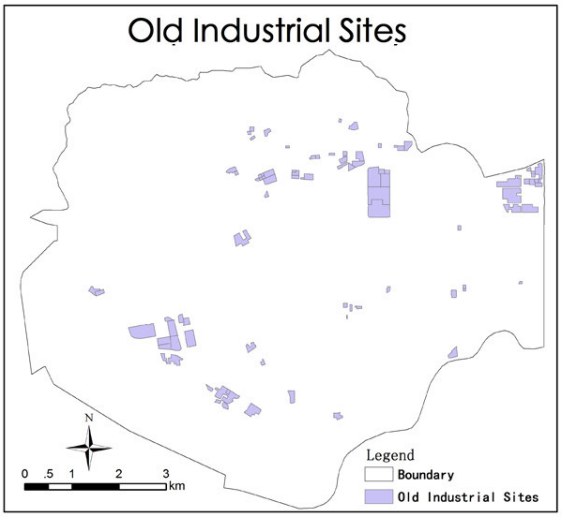
As shown in **Figure 4-2**, there are four steps in the identification process which are demonstrated in the following sections by applying them to the case study area of Futian District.

4.2.1. Target geographic areas

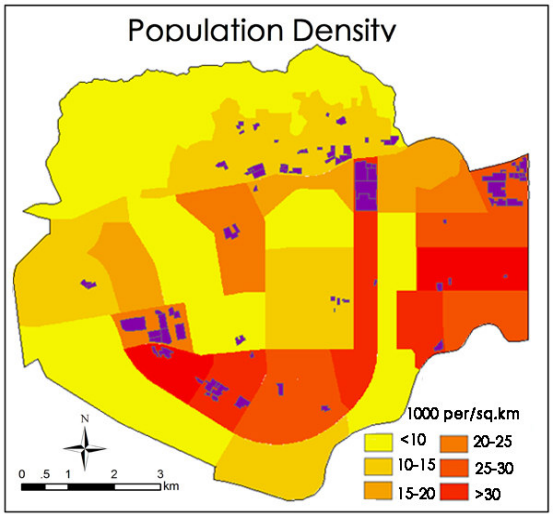
For step one, a map of old industrial sites is shown in **Map 4-1** in order to provide a base map for the identification step. Old industrial sites are identified as potential brownfield sites when they are among areas with a) high population density or b) downtown areas or c) expected good environmental quality

4.2.1.1. Based on population density

Based on the census report of 2005, the population density is measured at the neighbourhood administrative level. The classification of this criterion cannot be derived from norms, regulations or references, but can only be defined according to the specific condition in the case study area. As shown in **Map 4-2**, the population density in Futian is classified into 5 categories using an equal method and the old industrial sites located in areas with a population higher than 20,000 person/km^2 are selected.



Map 4-1: Old Industrial Sites



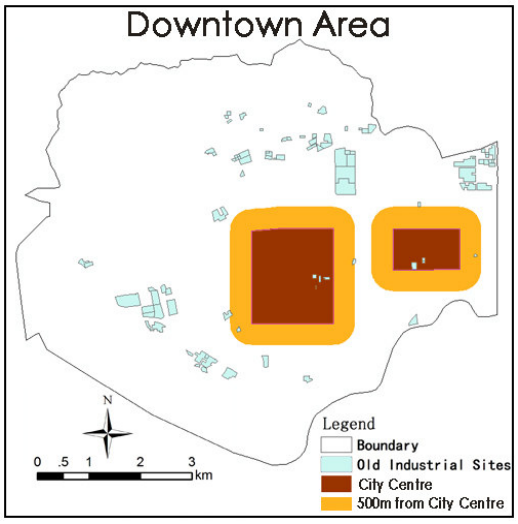
Map 4-2: Population density

4.2.1.2. Based on downtown areas

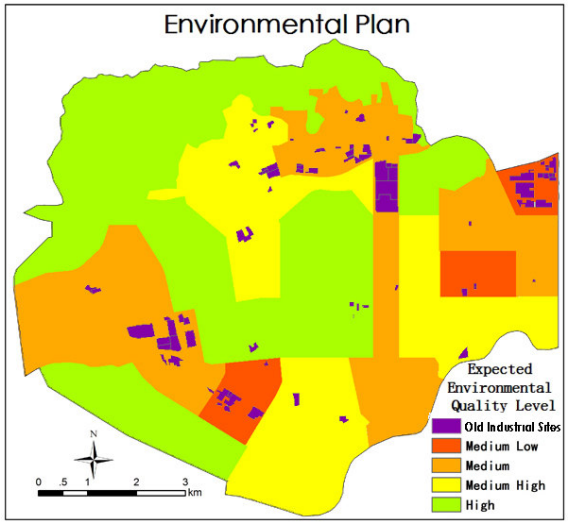
Currently, there are two city centres in Shenzhen. One is Shangbu wich was redeveloped from an old industrial zone to a commercial zone; and the other is the future CBD according to the *Master Plan of Shenzhen (1996-2010)*. Taking in consideration that the city centres have influence on the surrounding areas, sites located in or within 500 metre distance from the city centres are selected as target sites (**Map 4-3**).

4.2.1.3. Based on environmental plan

The *Environmental Plan (2000-2010)* acquired from SEPB, shows the different classifications according to the expected environmental quality of the different neighbourhoods (**Map 4-4**). According to officials in SEPB, old industrial sites located in the 1st and 2nd classes should be considered for redevelopment and therefore they are selected as target sites.



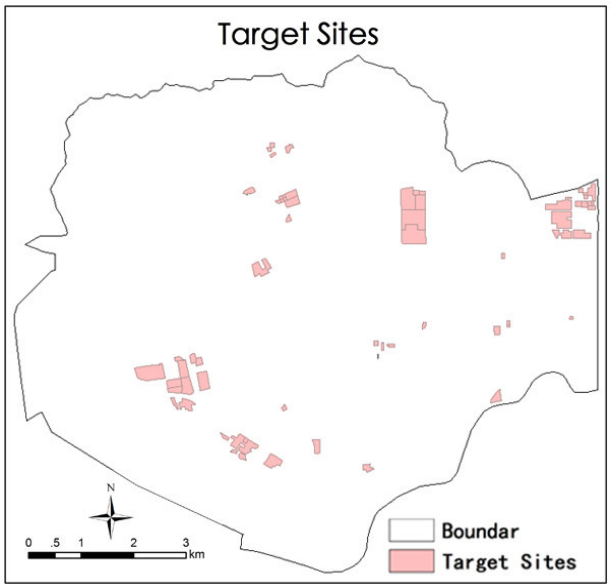
Map 4-3: Downtown areas



Map 4-4: Environmental Plan

4.2.1.4. Target sites

Incorporating the results of the analysis above, the final inventory of target sites is shown in **Map 4-5**.



Map 4-5: Target sites for identification

Compared to the Industrial Zones Plan in 1985 (see **Map 3-4**), it can be found that identified target sites mainly concentrate in four old industrial zones that were established in 1985. From the maps above, we can see that the second step population density has contributed most to this result. There are two reasons for this, 1) these industrial areas have attracted people to settle down due to former industrial activities, 2) the city centre step has little influence on the result given that the current city centre, Shangbu area has been redeveloped from an old industrial zone (see section 3.3.3.2).

4.2.2. Industrial classification

According to the interviews with experts in SEPB, innocent industrial activities such as clothing industries and toy assembling should be eliminated from the target sites; and industries such as pulp and paper industries, plastic and synthetic resin industry should be considered as potential polluting industries. For step two, cross-checking the industrial classification information provided by Shenzhen On-line Business Directories, potential brownfield sites are identified among the target sites.

Moreover, with the business directories, information such as firm address and firms name are added in the attribute table of target sites. These data may be useful to provide aid for the following analysis given that information like firm address is not available in datasets such as pending pollution fees and tax records.

4.2.3. Environmental liability

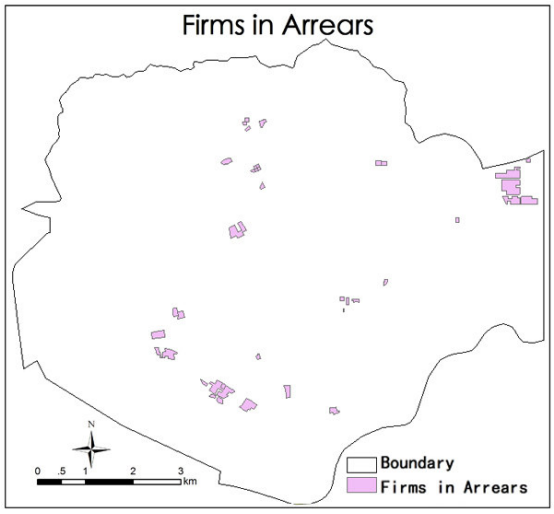
The third step in the identification process is to identify suspect sites based on the environmental data. According to the environmental report of 2005-2006, areas with severe pollution problems are identified in terms of air quality and surface water quality. Moreover, records of unpaid pollution fees can provide information to identify if firms are producing a considerable amount of pollution, while

unable to pay for it, due to the declining business. This combination of factors indicates a high potential for becoming a brownfield.

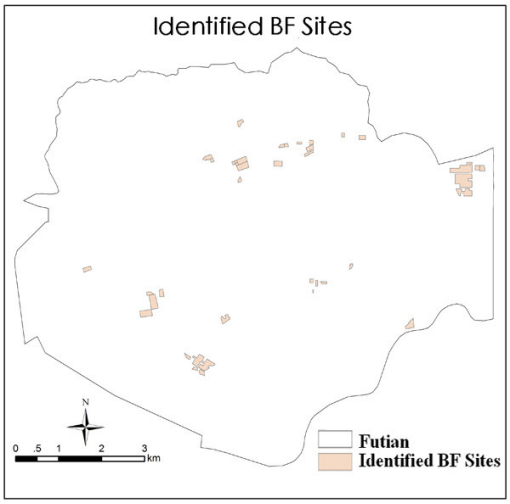
Both industrial classification and environmental liability information are assigned to each target site by creating two new columns in the attribute table. The identified sites are given a value of 1, and sites that are eliminated are given a value of zero, which is treated as a missing value for the final identification of potential brownfield sites.

4.2.4. Tax delinquency

The fourth step of this approach requires the identification of firms in arrears. Based on tax records acquired from SSAT, together with the firm address and name information acquired from business directories, the firms in arrears are identified among suspect sites as shown in **Map 4-6**.



Map 4-7: Identified brownfield sites



Map 4-7: Identified brownfield sites

4.2.5. Identified potential brownfield sites

The four-step approach which combines and overlaps the four criteria of identifying target geographic areas, industrial classification, environmental liability and tax delinquency, has led to the identification of the potential brownfield sites in Futian District. These areas are shown in **Map 4-7**.

4.3. Conclusion

The potential brownfield sites in the study area have been identified in this chapter. Based on the framework developed in methodology chapter, there are four steps for the identification. The first step is to identify sites located within target geographic areas. Taking available data into consideration, these areas identified for this research comply to at least one of the following characteristics in addition to being old industrial sites: 1) high populated areas, 2) downtown areas, and 3) expected high environmental quality. The second and third steps are to identify suspect sites using industrial classification and environmental liability. Instead of detailed information for each site, the data acquired for supporting this analysis is at administrative neighbourhood level. The fourth step is to correlate identified sites with tax records of the firms in arrears. Finally, 38 sites are identified out of 89 industrial sites to be potential brownfield sites.

5. Evaluating the redevelopment potential of identified brownfield sites in Futian District

This chapter evaluates the redevelopment potential of identified brownfield sites by taking Futian as a Case Study. It uses the theoretical framework developed in chapter 3 which consists of three aspects: feasibility analysis, community benefits and local factors. Given that this chapter takes a case study, it identifies local factors that have a significant influence on the redevelopment process and thus, adds them into the framework.

In order to evaluate the comprehensive criteria tree, three steps are undertaken. The first one is testing the appropriateness of each criterion; the second step consists of incorporating the local criteria; and the third step is to verify the data availability for each criterion.

5.1. Testing the appropriateness of the criteria

At this point, the appropriateness of the criteria for the evaluation has to be questioned as the decision of taking a set of criteria is unconvincing. Particularly, in the case of brownfield redevelopment, some solutions may be over-engineered (Wood and Griffiths, 1994) and an adequate understanding of the brownfields and their redevelopment proves to be essential. Therefore, the comprehensive criteria tree is applied to the first two reference cases mentioned in section 3.3.3.2 which were examined during the fieldwork period. In the following paragraphs, the case of Shangbu area is referred as a successful case (SC); the case of Bagualing area is referred to as a not-so successful case (NSC); and the case of Chegongmiao area is referred as a potential case (PC). Despite that the last case of Chegongmiao is a potential case and thus, it does not provide a direct opportunity for testing the appropriateness of the criteria, it still provides insights of how unplanned redevelopment occurs.

5.1.1. Reference case 1: Shangbu area (SC)

Redevelopment type: Industrial → Commercial

Process description: With an area of 171 hectare, SC was planned firstly for electronic and communication devices manufacturing. Cluster of similar specialized firms led to an extensive demand of common electronic components. This demand brought along a supporting market and this market has expanded radically. Thanks to the superior transportation network and economic connections, SC converted gradually from "urban fringe area" into a "transitional city centre". As a consequence, the land value of this area has increased dramatically. Land use has transferred from industrial to commercial land use simultaneously. The centralization of commercial services has therefore attracted a large variety of businesses to locate in this area. So far, SC accommodated more

than 10,000 firms and it has become one of the most flourishing commercial centres in Shenzhen (**Figure 5-1**).

Observation findings: The redevelopment of SC is a market-driven process. From the document analysis it could be conclude that geographic location, mature market and compatibility with master plan are the key factors for the successful story. However, not all the sites in this area are well redeveloped. Difference can be drawn from the distance to main road, distance to transport node and building quality among others. From the observation and comparison, it could be concluded that the key factors contribute to the successful process are: A) high accessibility; B) buildings with flexibility to adapt uncertain functions; C) proximity to green space; D) fine-quality infrastructure.

Figure 5-1: Development of SC from 1980s to 2000s
(Source: UPDIS, 2004)

5.1.2. Reference case 2: Bagualing area (NSC)

Redevelopment type: Industrial → Residential

Process description: NSC is located on the east side of Futian and has an area of 116 hectare. Similarly to SC, NSC is also one of the 15 industrial zones planned for manufacturing in 1985. In the beginning of 1990s, about 500 enterprises were located in this area and the highest employment rate reached more than 90 thousands people. NSC has functioned many years as one of the industrial bases for the economic growth of SSEZ. With the recent urbanization, this area which was regarded as urban fringe has now become the fringe of city centre. Many enterprises followed the experience of SC to transfer industrial land use into commercial. However, this transfer was not as successful as in the case of SC due to the innate deficiencies such as location and market potential among others. In 1996, SUPLAB started establishing a land use plan for NSC to redevelop industrial land to residential. Given the complexity of the redevelopment process, preparation of the plan encountered enormous difficulties and the planning process took over 3 years to complete. However, in 1999 the

unwillingness of various stakeholders repeatedly challenged the implementation of the redevelopment plan. Meanwhile, scattered redevelopment projects have formed a muddled landscape and created a mixture of incompatible land uses. Currently, planners are still calling for redevelopment for NSC, while the research prepared by UPDIS suggests that it is not worthwhile to redevelop NSC in the next 10 years (**Figure 5-2**).

Figure 5-2: Current situation in NSC

Observation findings: The redevelopment of NSC area is conducted by the government. However, it turned out to be a not-so-successful redevelopment case. From the field observation and comparison among different locations in this area, it can be concluded that the key factors influencing residential redevelopment are: A) distance to transport node; B) neighbourhood environment and image; C) employment opportunities in the neighbourhood; D) proximity to shopping centres; E) availability of daily services (**Figure 5-3**).

Figure 5-3: Bird's eye view of NSC
(Source: UPDIS, 2002)

5.1.3. Reference case 3: Chegongmiao area (PC)

PC has an area of 95 hectare and was also designated for manufacturing in 1985. In recent years, it had become one of the most popular places for business offices. However, industrial land use is still holding a dominant position in this area which occupies approximately 50% of the built-up area. There is an increasing demand for office buildings while many manufacturing buildings remain underutilized or vacant (**Figure 5-4**).

Observation findings: Although this area has not yet been officially planned to be redeveloped, there is not only an increasing demand for office space, but the area is already being redeveloped to accommodate this demand. Therefore, the market alone is changing the character of the area.

Interestingly, the prosperity in this area can also be noticed by the thriving environment of restaurants along the streets.

However, most of the development activities only concentrate in high accessible areas, e.g. areas around subway stations, main bus stops, and liner development along the main roads, secondary roads and local streets. While there are still many underutilized properties especially industrial buildings looking for potential development activities.

Figure 5-4: Chegongmiao Industrial Zone (PC)

5.1.4. Examining the appropriateness of each criterion

Based on the field observation, together with relevant document analysis and interviews with planners, researchers and local residents, the performance of each criterion in the criteria tree is evaluated as shown in **Table 5-1**.

Table 5-1: Examining the appropriateness of each criterion in the criteria tree

Category	Sub-category	Criteria	Evaluation score in SC	Evaluation score in NSC
Feasibility analysis	Site condition	Physical condition	Good	Good
		Environmental condition	Good	Medium
	Infrastructure	Utility infrastructure	Medium	Medium
		Transport infrastructure	Good	Medium
		Communication infrastructure	Good	Medium
	Market	Proximity to customer	Good	Poor
		Competitor	Poor	Medium
		Land price	Poor	Medium
		Willing seller	Good	Poor
	Financing	Policy incentives	Good	Medium
		Financial support	Good	Medium
Community benefits analysis	Economic benefits	Development activities	Good	Medium
		Job opportunities	Good	Poor
	Environmental benefits	Regional environmental quality	Poor	Medium

	Social benefits	Public interests	Good	No available information
		Aesthetics	Good	Poor

Findings:

After comparing and analysing the above **Table 5-1**, complemented by relevant document analysis and post-fieldwork telephone interviews, conclusion of this criteria tree testing can be drawn as following:

1. According to the literature, a high concentration of 'Competitors in the same area' leads to a negative impact for redevelopment; however, in the SC this criterion should be considered as a positive factor that contributes to the successful development.

2. Land price is an important factor to be considered. However, the reference cases reveal that this criterion does not have significant importance in this specific context.

3. Poor performance of 'regional environmental quality' is identified to be the consequence of high concentration of attracted population and the absence of sewage for people's daily activities. This proves the importance of utility infrastructure; however, the criterion of 'regional environmental quality' should still remain in the tree because the poor performance found is not a consequence of redevelopment.

Additionally, it can be concluded that redevelopment indeed helps to provide community benefits from economic and social aspects.

5.2. Incorporating local criteria

After evaluating the appropriateness of the initial criteria tree, it is realized that a 'local factors analysis' should also be considered. Given that each city has its own land use preferences for redevelopment projects, it is pivotal to include the city's particular context for the analysis of BR. This section provides the background of the case study area by analyzing the local factors.

5.2.1.1. Land re-use preferences

Based on the analysis of acquired documents during the fieldwork period, together with interviews with researchers and government officials, an analysis on the municipal government's concerns on BR shows that it consists on attaining sustainable development, optimization of current land use, employment in inner urban areas and urban image.

- **Employment in inner urban areas**

Several years back, Shenzhen used to boast its well planned city structure which had avoided commonly identified urban problems. However, the situation has changed.

Given that in the SSEZ, daily services including school, public library, cinema and high-standard shopping centres have been developing fast and now are highly accessible, the land value has increased tremendously since the last 20 years. As a consequence, manufacturing enterprises can not

afford the increasing costs of land and are forced to move out of SSEZ where land value is relatively cheaper. However, people still prefer to either remain in the city centre or move into the inner urban areas due to the high concentration of services. This situation implies that there are more and more commuters increasing the number and extent of traffic jams, which is considered a serious problem for Shenzhen.[4] Therefore, the policy prepared by UPDIS states that the government intends to create more job opportunities in inner urban areas in order to decrease the overload on the transport network.

- **Encouraged end uses**

According to key interviewees together with the analysis above, it can be concluded that the priority ranking of land re-use preferences of the BR in Shenzhen is: 1) Industrial; 2) commercial; 3) residential.

Furthermore, the government encourages clean industries like gift processing and packing or jewellery processing as the end use of potential brownfield sites in neighbourhood areas. The reasons for choosing this type of redevelopment include:

1) No pollution to the neighbourhood;

2) Less land-consumption - the sites requiring redevelopment may be irregular in shape and small in size;

3) Service provision to the neighbourhood;

4) Relatively a small investment requirement - easy to start and maintain;

5) Less skill requirement - providing people the utmost potential of job opportunities.

5.2.1.2. Urban image

A review of the Recent Construction Plan together with other policy and planning documents, and key interviews, reveals that 'urban image' is a key factor contributing to the driving force for supporting BR in Shenzhen city. The government has invested considerable amount of economic and human resource to create a pioneer, creative and sustainable urban image of the city. This image aims at attracting not only highly educated people who would want to work and live in the city but also companies who would do business and invest in the city.

The area targeted by this type of projects is mainly the city centre and adjacent areas to the main roads, both highly visible for the dweller and the tourist. For example, the government invested a big sum of money in the construction of Shennan Road which crosses the city in an East-West direction. Given that the area is highly visible, there are continuous projects to maintain the sides of the road and illegal construction is strictly prohibited. Furthermore, landmarks like the Exhibition Centre, the Central Park and several Theme Parks are located on the road impacting the view of the city and its image.

[4] This statement is concluded from the interview with urban researchers in Research Centre of UPDIS.

5.2.1.3. Local policy incentives

According to interviewees, the government intends to redevelop abandoned sites in inner urban areas to meet the increasing land use demand and to avoid the consumption of greenfield. Moreover, the redevelopment of these previously developed sites would create more job opportunities.

Recently, Shenzhen municipality endorsed the "1+7" documents where policy is aimed at reinforcing the optimization of current land use. Through these policies the administration aims at increasing the land use efficiency supporting industrial investment projects that have a high plot ratio, by a land price reduction of up to 50%. However, this does not apply to the entire city. A *Construction Saturation Plan* acquired from SUPLAB controls the build bulk ratio of each neighbourhood in the case study area.

5.3. Verification of data availability and relevance

Making use of the comprehensive tree would provide a more complete analysis; however, this is only the ideal framework as in reality there are limitation in terms of data availability. Thus, a cross-reference between the data collected during fieldwork and the comprehensive criteria tree is carried out in order to select the evaluation criteria whose supporting data is available.

Data relevance is an important factor to take in consideration. For example, data on unemployment rates in Shenzhen only includes people who have Shenzhen registration and disregards the huge amount of floating population living in the city. Therefore, this data does not provide a real picture of the unemployment dynamics in Shenzhen and thus it is not used for this research.

From the interviews with official in SCB and manager in consultancy, it is implied that the availability of financial support from the local lending system is largely depend on the relationship between the loan applicants and the lending units like banks. Therefore, it is difficult to get reliable information for measuring this criterion within the limit of research period.

5.4. Final Criteria Tree

The comprehensive criteria tree developed in chapter 3, which consists of a feasibility analysis, community benefits and local factors, has been examined by a first step of testing the appropriateness of each criterion by using the reference cases. In addition, step two and three contribute to the creation of a final criteria tree shown in **Figure 5-5**. This criteria tree is developed with the use of available supporting data in order to evaluate the redevelopment potential of identified brownfield sites in the case of Futian.

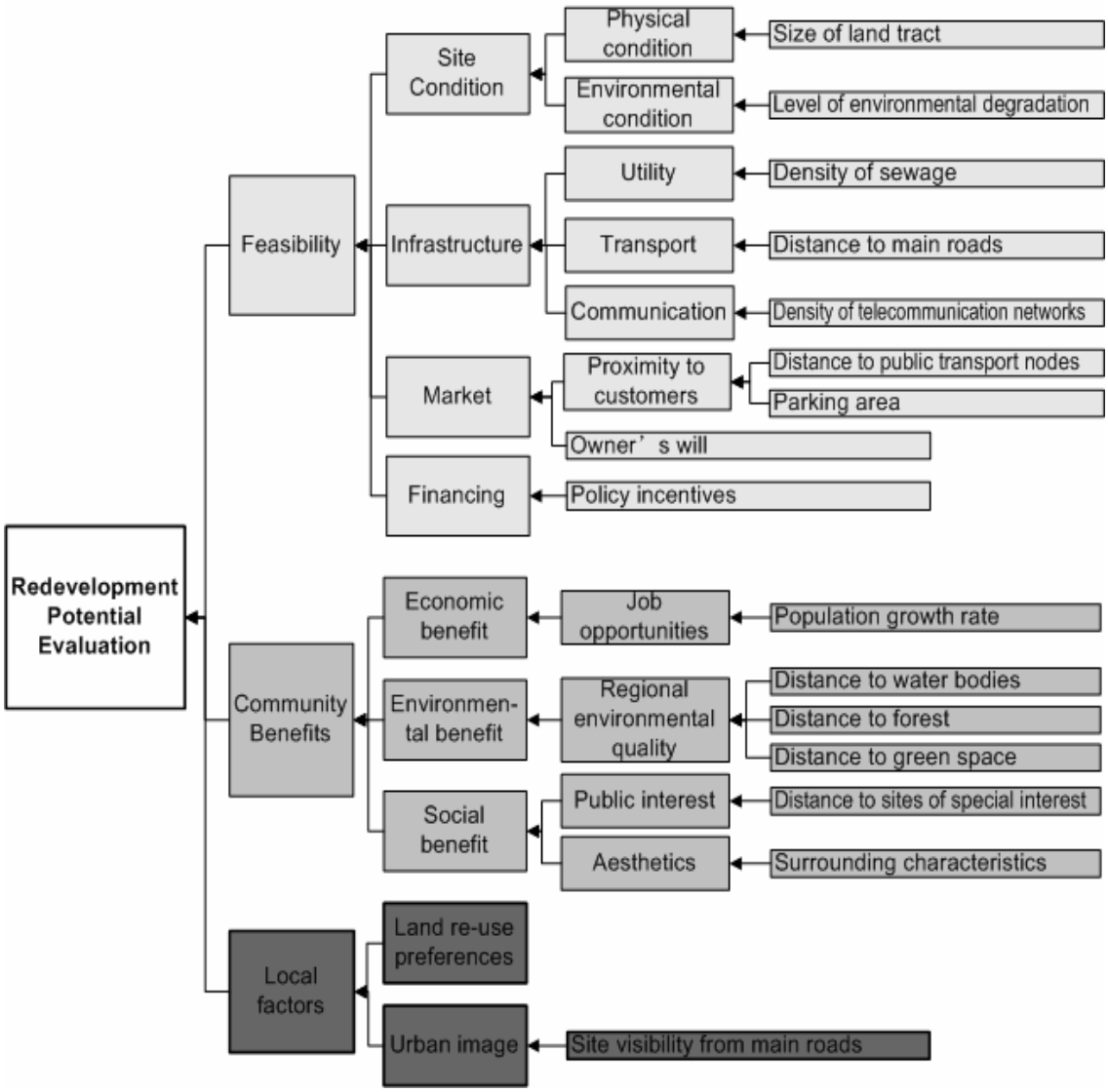


Figure 5-5: Final criteria tree for this case study

5.5. Evaluating the identified brownfield sites for redevelopment

By using the selected criteria and indicators in the final criteria tree, the redevelopment potential of identified brownfield sites are evaluated from three aspects including feasibility, community benefits, and local factors.

This evaluation uses an MCE approach (chapter 2) and the criteria include both spatial and non-spatial variables. Maps are used to illustrate the criteria with spatial attributes and non-spatial criteria are measured in an effect table. However, the non-spatial criteria require site-specific data. Due to the time limit of the research and large amount of data to be dealt with, three of the identified brownfield sites in chapter 4 are taken as three alternative sites for this evaluation. The spatial evaluation is conducted with criteria maps in ArcGIS and the non-spatial evaluation is done in the effect table.

5.5.1. Feasibility

The feasibility analysis consists of four sub-categories being site condition, infrastructure, market and financing. These sub-categories are considered as key elements influencing the feasibility of the project from the developer perspective. Therefore, the criteria examined in this section are based on principles for achieving the highest economic profit.

5.5.1.1. Site condition

This sub-category includes the criteria of physical condition, environmental condition and surrounding in order to perform the analysis.

- Physical Conditions
  - Size of land tract: Normally, the size of area for commercial and industrial land use should not be less than two acres, which is equivalent to 0.8 hectares. Therefore, the classifications of land size for each alternative site are presented in **Table 5-3**.
- Environmental Conditions
  - Level of environmental degradation: Based on the environmental report acquired from EPB, it can be drawn that certain areas are worse-off than others in terms of environmental degradation. However, the information available for each area has a qualitative nature and, only descriptions are provided. This makes it difficult for direct and quantifiable comparison. Nevertheless, a qualitative classification is shown in **Table 5-3**.

5.5.1.2. Infrastructure

This sub-category includes the criteria of utility, transport and communication in order to perform the analysis.

- Utility:
  - Density of sewage: The **Map 5-1** shows the density of sewage infrastructure.
- Transport:
  - Distance to main roads: The **Map 5-2** shows distance to main roads and the classifications.
- Communication:
  - Density of telecommunication networks: **Map 5-3** shows the density of fibber cables (telephone, TV and/or internet lines).

5.5.1.3. Market

This sub-category includes the criteria of proximity to costumers, land price and owner's will in order to perform the analysis.

- Proximity to costumers:
  - Distance to public transport nodes: **Map 5-4** and **Map 5-5** shows the analysis of the distance measured from public transport nodes such as subways stations and bus stops.
  - Parking area: **Map 5-6** shows the distance calculation result and classifications of existing parking lots.

- Owner's will: Based on previous research undertaken by UPDIS, it can be drawn that: a) if the land is owned by the government, acquiring land use rights is relatively easier, b) if the land is owned by the government, but the land use right belongs to a group (of companies or individuals), then transferring the land use right is more complex. The reason being that for example, there might be a boundary dispute within the group. Furthermore, owners' will can also influence the cost including both monetary and non-monetary. The unwilling seller either refuses to sell the land or increase the price. In addition, he or she can request to be one of the future shareholders of the project. The qualitative classification of this criterion is shown in **Table 5-3**.

5.5.1.4. Financing

- Policy incentives: In the context of Futian, there is a policy providing land price reduction for industrial land redevelopment projects based on plot ratio of the future development (**Table 5-2**). However, the construction saturation plan as shown in **Map 5-7** regulates the plot ratio at a neighbourhood level. Combining these two factors together for analysis, the policy incentive criterion can be classified into three categories for the alternative sites as shown in **Table 5-3**.

Table 5-2: Land price policy for industrial land use

Future Plot ratio	Land price (% of the total land price)
<1	150
1-3	30
>3	0

5.5.2. Community benefits

The community benefits analysis consists of three sub-categories being economic benefit, environmental benefit and social benefit.

5.5.2.1. Economic benefit

This sub-category includes the criteria of job opportunities.

- Job opportunities:
  - Population growth rate: The classification of this criterion has been defined and the spatial distribution is illustrated **Map 5-8**.

5.5.2.2. Environmental benefit

The criterion of this sub-category is regional environmental quality including distance to environmental protection objects. **Map 5-9**, **Map 5-10**, **Map 5-11**, and **Map 5-12** show the distance calculation of lakes and sea, river, forest and green space using concentric rings.

5.5.2.3. Social benefit

This sub-category is evaluated using two criteria including public interest and aesthetics. The maps of public interest distance calculation are shown in **Map 5-13**, and the descriptive classifications of the aesthetics criterion for each alternative site are shown in **Table 5-3**.

5.5.3. Local factors

The feasibility analysis consists of two sub-categories being urban image and land re-use preferences.

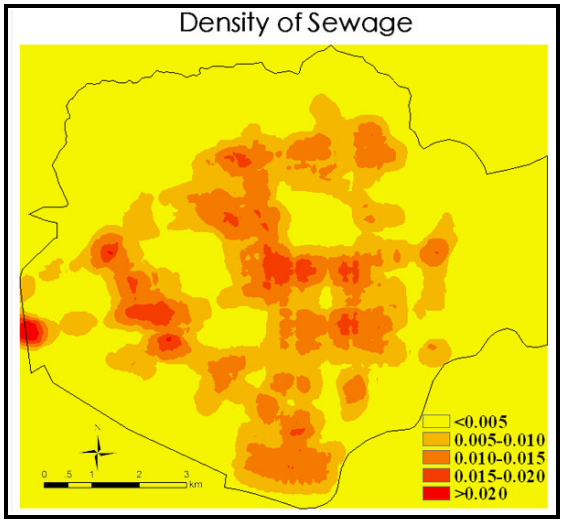
5.5.3.1. Land re-use preferences

With the analysis of local governments concerns, the priority order of land re-use preferences are summarized as 1) industrial, 2) commercial, and 3) residential. Assume that the end use is compatible with the land use control according to the *Regulatory Plan of Futian*; the classification for this criterion can be concluded as shown in **Table 5-3**.

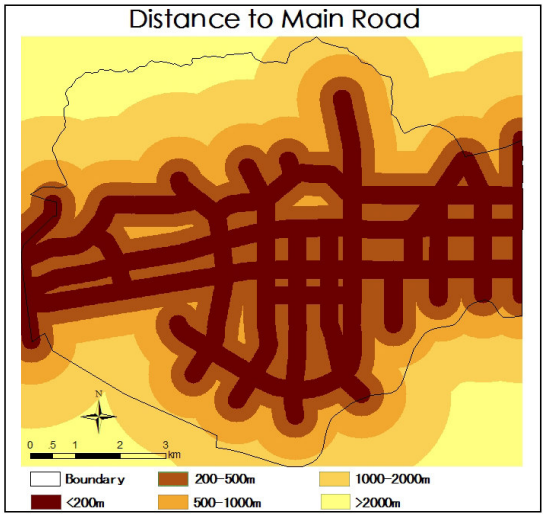
5.5.3.2. Urban image

This sub-category includes the criterion of visibility from main roads.

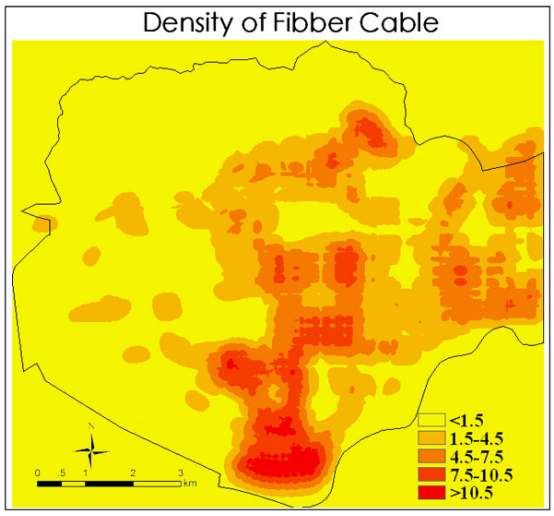
- Site visibility from main roads: This classification as shown in **Table 5-3** is drawn by field observation.



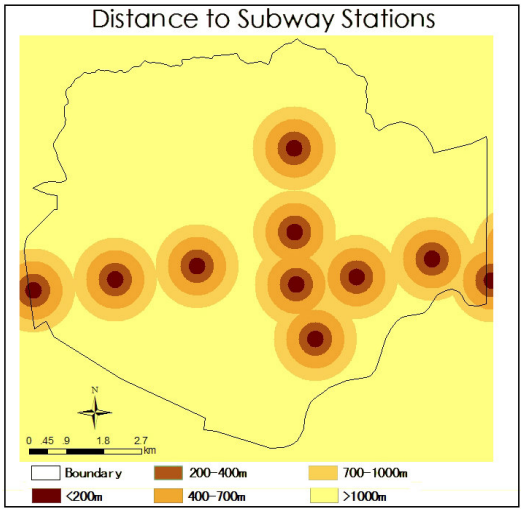
Map 5-1: Density of sewage



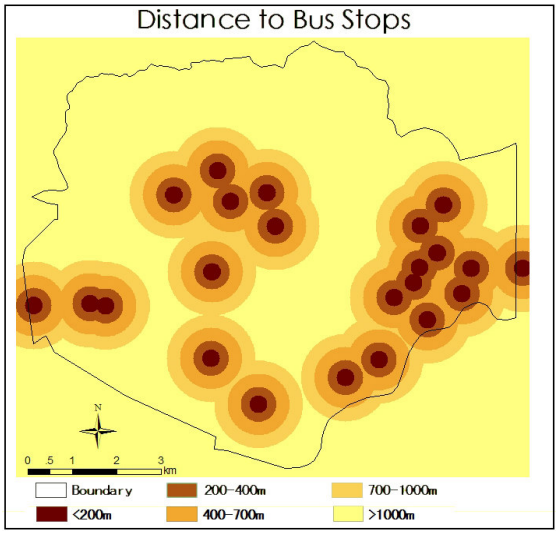
Map 5-2: Distance to main roads



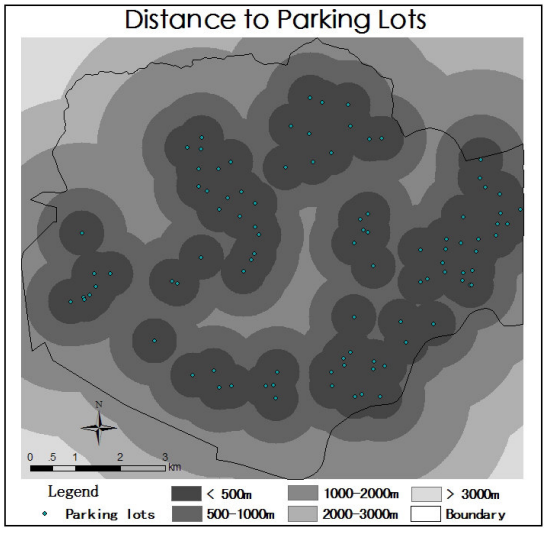
Map 5-3: Density of fibber cables



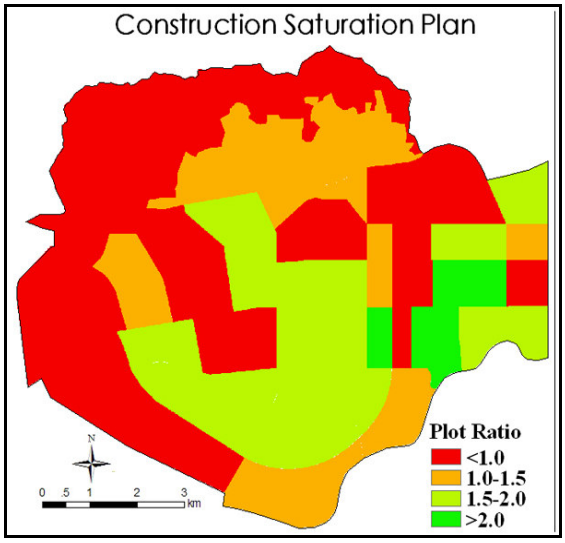
Map 5-4: Distance to subway stations



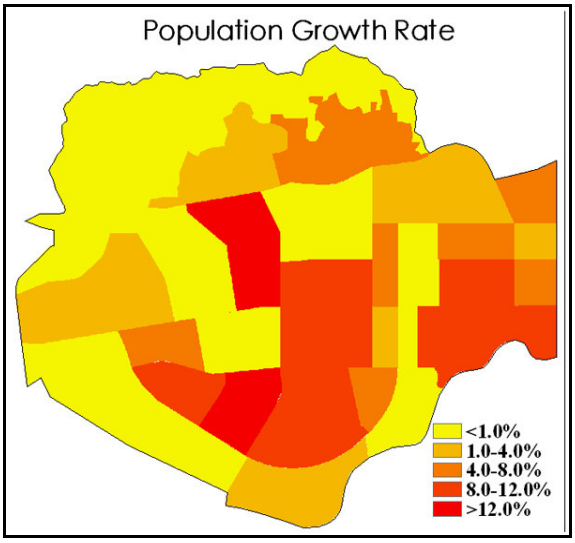
Map 5-5: Distance to bus stops



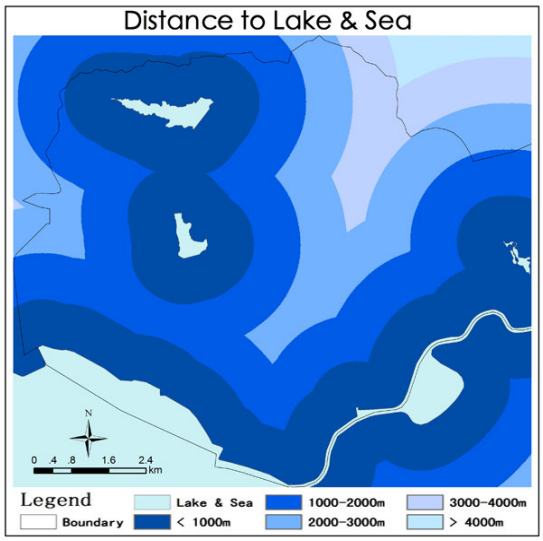
Map 5-6: Distance to parking lots



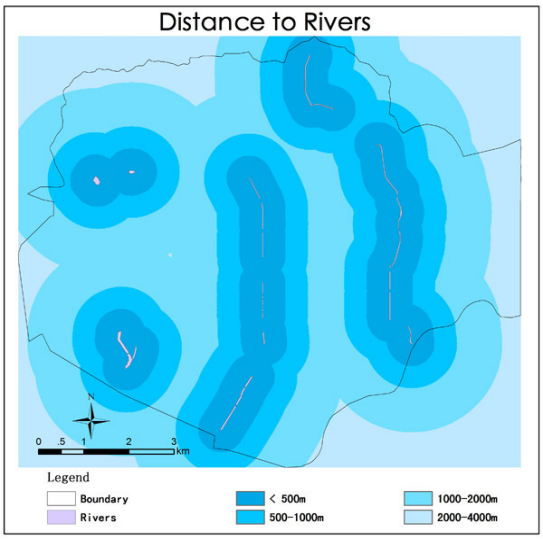
Map 5-7: Construction saturation plan



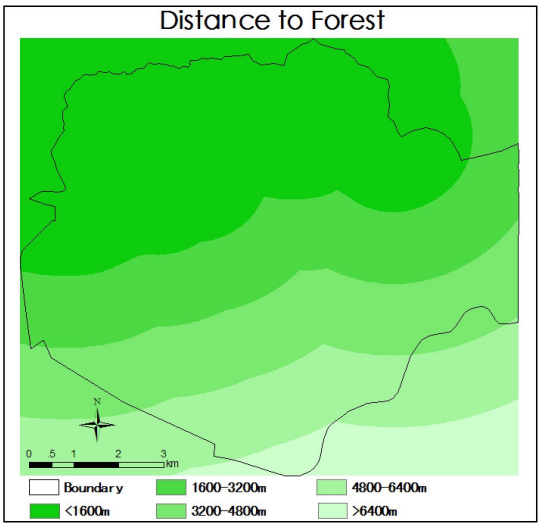
Map 5-8: Population growth rate



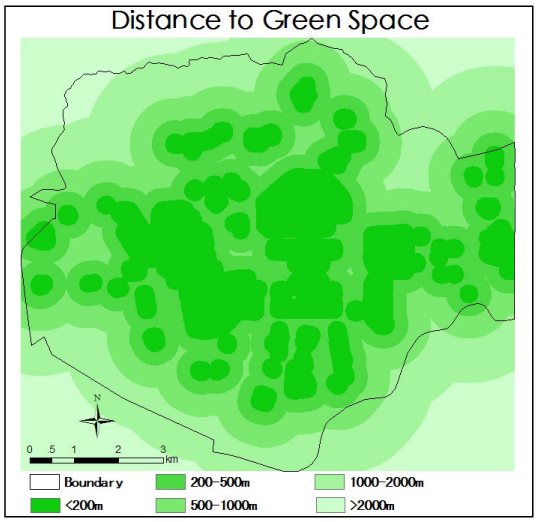
Map 5-9: Distance to lakes and sea



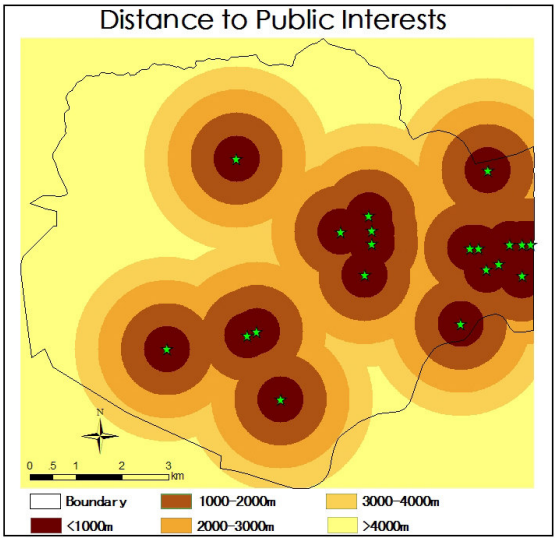
Map 5-10: Distance to rivers



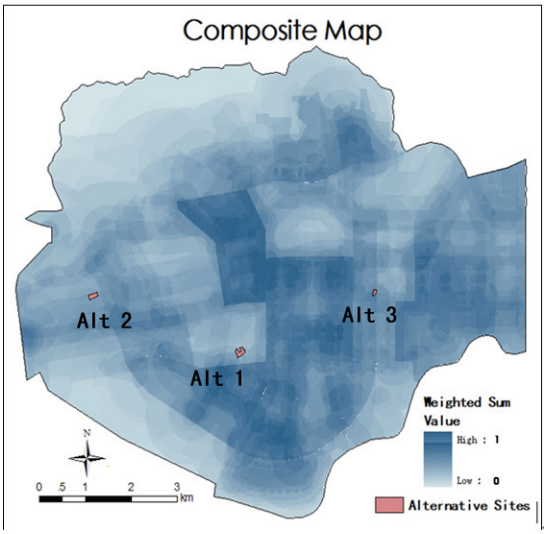
Map 5-11: Distance to forest



Map 5-12: Distance to green space



Map 5-11: Distance to public interests



Map 5-12: Result map of spatial analysis

Table 5-3: Effect table of non-spatial criteria

Criteria (equal weights)	Alt 1		Alt 2		Alt 3	
	Score	Std. Score	Score	Std. Score	Score	Std. Score
Size of land tract (ha)	2.32	1.00	1.62	0.70	0.72	0.31
Environmental degradation	2	1.00	1	0.50	1	0.50
Owner's will	3	1.00	2	0.67	2	0.67
Policy incentive	1	0.33	1	0.33	3	1.00
Aesthetics	3	1.00	2	0.67	3	0.67
Land re-use preferences	3	1.00	1	0.33	1	0.33
Site visibility	1	0.33	3	1.00	3	1.00

(The Std. Score is standardized using a maximum method)

5.5.4. Composite evaluation in ArcGIS

Using a multi-criteria analysis approach, the evaluation or this research consists of four steps. These include: 1) establish effect table, 2) standardization, 3) criteria ranking and weighting, and 4) ranking. **Table 5-3** is the effect table for non-spatial criteria and all the criteria are standardized by maximum method with a range from 0 to 1. Then weights are given by using the direct way, with the assumption that all criteria have the same importance. Using weighted sum function in ArcGIS, the result map based on the weighted spatial criteria is generated as shown in **Map 5-12**. Finally, each sum value of each alternative site is calculated using the Zonal function. In order to achieve the overall analysis, the final sum value results from the sum of the spatial criteria analysis and the sum of the non-spatial criteria using a weighted sum method. The final result is shown in **Table 5-4**.

Table 5-4: The evaluation value based on weights and score

Weighted sum value	Alt 1	Alt 2	Alt 3
Spatial analysis	0.47	0.54	0.65
Non-spatial analysis	0.81	0.60	0.64
Total	**1.28**	**1.14**	**1.29**

5.6. Discussion

This chapter demonstrated a case study approach for evaluating the redevelopment potential of brownfield sites in Futian. Before the evaluation, the set of criteria developed in the methodology chapter are examined and modified through three steps: 1) testing the appropriateness of criteria by reference cases observed during fieldwork; 2) analysing and then incorporating relevant local criteria; 3) cross-referencing data availability.

After the three steps analysis, a final criteria tree with supporting data is developed for the evaluation of 3 identified brownfield sites. Using a multi-criteria evaluation approach, the final evaluation result suggests that both alternative 1 and alternative 3 have high redevelopment potential. Alternative 1 reflects the local government's preferences and policies' influence. The option of alternative 3 performed well in spatial aspects because it is located in the city centre with the concentration of all kinds of infrastructure services as well as population. Alternative 2 scores low in both spatial and non-

spatial aspects given that this area is neither close to city centre nor to the main roads, and the infrastructure condition in this area is not good. Additionally, the end use is residential which is not encouraged by the government.

However, from the analysis process, it can be concluded that this evaluation process is rather data-demanding. It requires a large amount of data and the data should be timely, accurate and reliable. Again, a criterion may have different importance for different stakeholders. However, the criteria are treated equally in this research given that only a limited number of stakeholders are interviewed and analysed during the fieldwork and therefore it cannot be applicable.

6. Conclusion and recommendations

In this chapter, the main findings and limitations of this research are discussed and recommendations for future research are presented.

6.1. Conclusions

Given that there is still a lack of information and decision support tools which drags on the process of brownfield redevelopment (Thomas, 2002b; Erzi, 2000; Zhang et al., 1999), the objective of this research was to develop practical frameworks to evaluate the redevelopment potential of identified sites in order to provide local government, urban planners and other stakeholders with decision support in establishing priorities and developing strategies in BR.

The above research aims have been reformulated as three sub-objectives as the following.

1. To identify relevant factors influencing the redevelopment of brownfield sites;
2. To identify potential brownfield sites;
3. To evaluate the redevelopment potential of brownfield sites.

To fulfil these three sub-objectives, research has been undertaken in order to identify potential brownfield sites and evaluate the redevelopment potential of three of the identified brownfield sites. With the help of two main research methods, literature review and case study, two frameworks are developed and applied to the local context. One is used to identify potential brownfield sites and the other is for evaluating the redevelopment potential of identified sites. Finally, the identification and evaluation methods were demonstrated in case study area of Futian District in Shenzhen City.

The first sub-objective is **to identify relevant factors influencing the redevelopment of brownfield sites**. To respond to this sub-objective, theoretical and empirical studies related to BR are examined. From the literature review, different characteristics of BR are identified in North American, Europe and China. Environmental liability in North America and Europe is regarded as the main barrier for impeding the redevelopment of brownfields. However, the lack of a comprehensive legal framework in China leads to fewer obstacles for brownfield redevelopment but also to further environmental problems.

The process of brownfield redevelopment is achieved through seven steps, and this model is widely used. It can be summarized into a process with three distinct activities aimed at deciding which sites should be selected for redevelopment, investment and marketing. These three activities are 1) site identification and data collection, 2) screening and ranking, and 3) analysis and evaluation of brownfield sites. The second step for site ranking often difficult due to the lack of information and decision support.

With the overall goal of sustainable development, potential benefits of BR are grouped into three aspects including economic, environmental and social benefits, among which 'reduce urban sprawl', 'create additional tax revenue and job opportunities' and 'reduce human health risk' are highlighted as the most significant ones. Barriers include both environmental and non-environmental issues. Environmental contamination raised obstacles such as stakeholders' reluctance, clean-up cost and lack of financial support; while non-environmental barriers are frequently referred to small land tract size, and outdated facilities. Moreover, in some cases, other influencing factors like urban image and end land-use also have considerable influence on the BR decision-making process.

The second sub-objective is **to identify potential brownfield sites**. Based on the review of various definitions of brownfields, essential characteristics of a brownfield can be summarized as: 1) previously developed, 2) locating in urban area, 3) currently abandoned, 4) requiring redevelopment, and 5) may have real or perceived contamination problems. However, the identification process is difficult as it relies upon the registration of records; while the property owners are reluctant to register due to fear of liability issues.

Although the literature for identification methods of brownfield sites is limited, Coffin and Meyer (2002) developed an innovative approach that integrates various data sources to identify potential brownfield sites. This method allows the identification of brownfield sites that have not registry record. However, this approach's major limitation is that in other countries than the U.S, relevant databases are not sufficiently reliable or accessible. Given that this research uses a case study approach, this method needs to be modified with the specific local context. Three relevant aspects which are significantly different are analysed, including redevelopment process, information source and government concerns.

In China, a bottom-up process is adopted for redevelopment projects, which indicates the government's lack of strategic plans for redevelopment projects. Moreover, the land reservation system designates the government to be an intermediator between former owner and future developer, which implies that marketability in the redevelopment process is important.

Environmental and social databases in China are not well established. Environmental data which is relevant to this research is focused on visible pollution such as surface water pollution; while required data including underground water and soil pollution data are not available. Location data acquired is not complete in the relevant data sets such as unpaid pollution fees and tax records.

Subsequently, the identification framework based on Coffin and Meyer's approach together with the local context allows the identification of potential brownfield sites though four steps: 1) locate target sites; 2) cross-check with industrial classification code; 3) verify environmental liability; and 4) confirm tax delinquency. Consequently, 38 sites were identified out of 89 for the further evaluation of redevelopment potential.

The third sub-objective is **to evaluate the redevelopment potential of identified sites**. To fulfil this objective, it is required first to identify the potential benefits of BR, as well as the barriers and other factors influencing the brownfield redevelopment process. From a sustainable development viewpoint, potential benefits of BR are identified and classified into economic, environmental and social benefits; and 'reduce urban sprawl', 'better public health' and 'create additional tax revenue' are identified as

the most prominent ones. Barriers like 'environmental liability', 'small land size', 'outdated infrastructure' and 'lack of financing' are identified as the main obstacles. Other factors like 'end use' and 'urban image' are also considered to be significant influence on BR.

Moreover, two comprehensive frameworks developed by SGN and Thomas provide an approach for site prioritization and selection among a vast amount of potential sites. Conversely, the evaluation tools concentrate on site-specific evaluation. Given that the first approach helps in prioritizing the redevelopment of a group of sites and the latter one allows a more detailed examination for the specific proposed redevelopment project, both types of methods provide valuable insights for the evaluation of redevelopment potential of brownfield sites.

However, given the rationale of this research, a comprehensive framework is required to be developed by integrating the principle of MCE and the insights from SGN's and Thomas' frameworks. Subsequently, this research classifies the relevant factors into three major categories for the development of a comprehensive criteria tree for the redevelopment potential evaluation of brownfield sites. These include 1) influencing factors for feasibility analysis, 2) potential benefits for community benefits analysis, and 3) specific local factors.

Given the complexities of the redevelopment process of brownfields, more detailed classifications of the relevant criteria for the evaluation is generated. In conclusion, the influencing factors for **feasibility analysis** are classified into four sub-categories including: 1) site condition, 2) infrastructure, 3) market, and 4) financing. The criteria for **community benefits** analysis are grouped into three sub-categories including: 1) Economic benefit, 2) Environmental benefit, and 3) social benefit. Specific **local factors** provide a possibility for the application of this framework in different local context. In order to evaluate the set of criteria developed based on the literature review, three steps are undertaken including 1) testing the appropriateness of each criterion; 2) incorporating the local criteria; and 3) verifying the data availability. Consequently, through these three steps, it is found that 'competitors in the same area' and 'land price' are not relevant in the local planning practice; while areas with industrial end use as well as visible areas from main roads or city centres pose high priorities to local government. Moreover, the environmental data in China focus on the visible pollution while the invisible pollution is still pending due to lack of knowledge and technology support. It is also found that the unemployment data is not applicable for this research given that Shenzhen is a city where the floating population accounts for approximately 80% of the total population.

With this framework, and three brownfield sites selected among the identified sites are evaluated in terms of their redevelopment potential. The result shows that alternative 3 and alternative 1 are found as sites with high priority for redevelopment. The reasons for this are from both spatial and non-spatial aspects such as 'distance to main roads' and 'land re-use preferences'. The results reflect the government's preference and can be considered as a useful approach for the evaluation of redevelopment potential of brownfield sites; while the evaluation process is also acknowledged to be data demanding.

6.2. Recommendations

This research provides contributions as follows:

- The frameworks employed in this research can provide useful information to identify and evaluate brownfield sites for BR and other similar areas in Shenzhen City or other cities.
- The approach to generate and evaluate the framework for identification and evaluation can be used for generalizing this framework in other areas or cities.
- The results of this research can be taken into account in policy making such as establishing priorities and developing strategies for BR in urban planning practices.

Further research is recommended in order to:

- Apply the framework in other Chinese cities so that the model can be improved and thus, generate a national standardize approach.
- Test the framework in order to examine its ability to be generalized in different contexts.
- Given that each criterion may have different importance to altered stakeholders; it is good to carry out a comprehensive stakeholder analysis for better understanding the situation and enhance the decision-making quality.

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Appendix I

Data collection in relation with research questions (RQ)

Fieldwork Objective	Data Requirement	Data Source	Methods or Tools
1. To justify the significance of brownfield and the necessity of BR; (RQ: 1a, 1b, 1c, 2a;)	・Reference on brownfield and its (re)development ・Reference on existing countries experience in dealing with BR	・Scientific journal ・Working paper ・Minutes ・Proceedings ・Personnel	・Literature review ・Experts interview
2. To define brownfield and understand BR in China and its similarities and differences with international BR; (RQ: 1f, 1g;)	・Reference related to land recycling in China ・Laws, regulations and standard procedure for land recycling in China ・Local institutions in study area	・Scientific journal ・Archive ・Personnel ・Planning authorities and institutes	・Literature review ・Document analysis ・Experts interview
3. To identify the influencing factors to BR as well as government actions for removing barriers; (RQ: 1d, 1e, 3a;)	・Reference on successful and not-so-successful BR cases ・Successful projects in study area – Shenzhen city	・Scientific journal ・Working paper ・Personnel ・Field observation	・Literature review ・Document analysis ・Experts interview ・Field observation
4. To identify potential brownfield sites in study area; (RQ: 2b, 2c, 2d;)	・Characteristics of brownfields and potential brownfield sites ・Criteria for identification of brownfield sites ・SPOT image ・Tax records of the firms in my study area ・Environmental report of study area	・Field observation ・Scientific journal ・Working paper ・Personnel ・SUD of Wuhan University ・State and Local Administrations of Taxation ・Environmental Protection Bureau	・Field observation and survey ・Literature review ・Experts interview ・Secondary
5. To prepare for the evaluation of redevelopment potential. (RQ: 3b, 3c, 3d.)	・Maps of identified brownfield sites ・Criteria for evaluation of redevelopment potential ・Supporting data sets (selection is derived from criteria selection) ・Site-specific characteristic	・Scientific journal ・Working paper ・Minutes ・Proceedings ・Personnel ・Planning authorities and institutes ・Field observation	・Literature review ・Experts interview ・Secondary ・Field observation and survey

Appendix II

Secondary data checklist

Data Description			Year	Data Source
Spatial	Land use survey of Shenzhen		2005	SUD of Wuhan University
	Spot image of Shenzhen		2005	SUD of Wuhan University
	Master plan of Shenzhen (1996-2010)		1996	SUPLAB
	Zoning plan of Futian District (1998-2010)		2002	SUPLAB
	Benchmark land value map (2006)		2006	SUPLAB
	Urban data	1.City centres and town centres 2.Urban landmarks	2005	Shenzhen Commercial Bureau (SCB)
	Green Data	1.Main green areas/parks 2.Nature conservation areas	2005	Shenzhen Environmental Protection Bureau (SEPB)
	Transport	1.Main roads 2.Secondary roads 3.Highway 4.Bus stations 5.Railway Stations 6.Subway Stations	2005	Shenzhen Transport Bureau (Acquired from SUPLAB)
	Water Courses	1.Important rivers 2.Reservoir 3.Floodplains of rivers	2005	SEPB
	Study Area	Administrative boundaries	2005	SUPLAB
	Public Interest	1.Ecology Priority Zones 2. Sites of special interest	2005	SUPLAB; SEPB
Non-spatial Data	Socio-economic data	Population (2003)	2004	Census report
		Land price data (2005)	2006	Shenzhen Real Estate Yearbook (2003)
		Rent price data (2005)	2006	Shenzhen Real Estate Yearbook (2003)
	Report on historical development and present situation of industry zones in Futian District		2002	Research Centre of UPDIS
	Tax records of the firms in arrears		2005	Shenzhen State Administrations of Taxation
	Environmental report		2005	SEPB

Appendix III

Interview topics and interviewee checklist

No.	Position	Organization	Topic	Utility for this research
1.	Official	SUPLAB	BR related regulations and institutions	・Standard procedure to redevelop a formerly developed land ・Local regulatory framework in BR
2.	Researcher	Research Centre of UPDIS	BR related to theories and local context	・Driving forces and obstacles of BR ・Stakeholders involved ・Concerns of different stakeholders ・Success factors for BR ・Not-so-success factors ・Sustainable indicator for BR
3.	Planner	UPDIS	BR related projects	・Criteria to identify a brownfield site for redevelopment ・Criteria to evaluate a brownfield site based on the redevelopment potential ・Methods for identification and evaluation ・Difficulties in the planning phase
4.	Planner and Engineer	Urban Planning Institute of Futian	Historical development of and current situation of existing potential brownfield sites	・General understanding of potential brownfield sites in study area ・Location of potential brownfield sites for field observation

Interview topics and interviewee checklist (continued)

No.	Position	Organization	Topic	Utility for this research
5.	Planner	CAUPD	BR related planning practices and policies	・Criteria to identify a brownfield site for redevelopment ・Criteria to evaluate a brownfield site based on the redevelopment potential ・Methods for identification and evaluation ・Difficulties in the planning phase
7.	Official	Land Reservation Centre of Shenzhen	Transition process of land use right in BR	・Land use right transition in BR process
8.	Official	SEPB	Environmental liability in BR	・Environmental criteria for identification ・Environmental criteria for evaluation ・Useful data for supporting the identification and evaluation ・Environmental data reliability
9.	Manager	World Union	Barriers to redevelopment projects from developers' perspective	・