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Investigating Sustainable Land Use

Possible Implications for Brownfield Regeneration Policy

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Abstract

Since the publication of the Brundtland Report, 'sustainable development' has become a popular yet contested concept among governments, international organisations and the private sector. To implement sustainable development, institutions attaining different objectives interpreted the definition in the Brundtland Report in various ways. These interpretations sometimes contradict each other.

Brownfield land is the legacy of industrialisation and urbanisation. Brownfield regeneration has been considered a tool to rebuild sustainable communities. Similar to the concept of sustainable development, countries define the term brownfield land or 'brownfields' in different ways. Therefore, utilising brownfield regeneration to pursue sustainable development became an intricate matter.

This study has developed a framework to define brownfield land to improve the quality of brownfield regeneration policymaking by analysing qualitative and quantitative evidence on the use of land and sustainability.

The analyses of sustainability indexes revealed that the types of strategies applied by countries to achieve sustainability depend on their progress in development and on population density. At the same time, data also showed that the population density of a country influences the ways the term 'brownfields' is deinfed in the regenerating policies. Therefore, population density, as an indicator of development density, is a useful differentiator of brownfield definitions in the policies that may or may not lead to the successful regeneration. Furthermore, the concept of development densities may change based on the geographic scales of concern as well as the development of technologies that allow higher development densities without compromising the quality of life.

Taiwan and England are both countries with high population densities. Preserving greenfield land and enhancing social capacities in the countries are important to maintain sustainability. However, the two countries perceive brownfield land at the opposite ends of the spectrum. England sees all previously developed land as brownfield land, while Taiwan considers 'brownfields' to be the result of industrial pollution. The textual analysis of parliamentary debate and news reports, in addition to the statistical analyses of land use, showed that neither definition has effectively tackled the issues of preserving greenfield land or improving social equality. In countries with higher development densities, to prevent further destruction of greenfields, and to increase the social capacities, the brownfield definition should help to focus regeneration efforts on the derelict urban land that requires interventions to bring back sustainable communities.

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The process of this PhD study has transformed many old perceptions of mine. Questions brought me to this study was answered in an unexpected way. I cannot pass my finishing line without support and advice from many teachers and friends.

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Glossary and Abbreviation

GLOSSARY	
Advanced Economy	*The term is frequently used by the IMF in place of conventional concept of 'developed country'. "The main criteria used by the World Economic Outlook (WEO) Report to classify the world into advanced and emerging economies are (1) per capita income level, (2) export diversification—so oil exporters that have high per capita GDP would not make the advanced classification because around 70% of its exports are oil, and (3) degree of integration into the global financial system." More detailed Explanation can be found in http://www.imf.org/external/pubs/ft/weo/faq.htm#q4b*
Brownfield Land	*Brownfield land is the land that is currently abandoned or underused as a result of deindustrialisation or suburbanisation. The agricultural land is excluded from the brownfield land. Some research and official documents directly refer brownfield land as 'brownfields'.* *Under the general concept, countries and institutions have had further interpretations of the term. The significance of the interpretation is part of the discussion of this thesis. For further review of the definition, please refer to section 2.3.* *One interpretation by CABERBET (2006):* *Brownfield land is the site 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; may have real or perceived contamination problems; and require intervention to bring them back to beneficial use.*
Brownfield Redevelopment	*The process or the action of converting a brownfield site for a new use.*
Brownfield Regeneration	*Urban regeneration that is delivered through brownfield redevelopment.*
Contaminated Land	*The term 'contaminated land' has legal content in England and Wales under Part 2A, s.78A, 1990. The statutory definition is "any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on, or under the land, that: (a) significant harm is being caused or there is a significant possibility of such harm being caused; or (b) significant pollution of controlled waters is being caused or there is a significant possibility of such pollution being caused".* *In this thesis, the term is capitalised when refers to the Contaminated Land defined in the UK regulations. It the term is not capitalised, it refers to the land that is contaminated in general.*
Control Site	*The term 'Control Site' has legal content in Taiwan under Soil and Groundwater Pollution Remediation Act. The 'Control Site' refers to the contaminated land that has one or more chemicals exceeding the soil or groundwater control standard.*
Derelict Land and Buildings	*"Land so damaged by previous industrial or other development that it is incapable of beneficial use without treatment. Treatment includes any of the following: demolition, clearing of fixed structures or foundations and levelling. Includes abandoned and unoccupied buildings (including former single residential dwellings) in an advanced state of disrepair i.e. with unsound roof(s).* ***Excludes*** *land damaged by development which has been or is being restored for agriculture, forestry, woodland or other open countryside use.* ***Excludes*** *land damaged by a previous development where the remains of any structure or activity have blended into the landscape in the process of time (to the extent that it can reasonably be considered as part of the natural surroundings), and where there is a clear reason that could outweigh the re-use of the site – such as its contribution to nature conservation – or it has subsequently been put to an amenity use and cannot be regarded as requiring redevelopment (Appendix C, DCLG, 2007)." "The definition of derelict land and buildings includes all derelict land buildings and not just those sites that are being actively considered for redevelopment (Appendix C,DCLG, 2007)."*

Developed Countries	*'High-income countries, in which most people have a high standard of living. Sometimes also defined as countries with a large stock of physical capital, in which most people undertake highly specialized activities. According to the World Bank classification, these include all high-income economies except Hong Kong (China), Israel, Kuwait, Singapore, and the United Arab Emirates. Depending on who defines them, developed countries may also include middle-income countries with transition economies, because these countries are highly industrialized. Developed countries contain about 15 percent of the world's population. They are also sometimes referred to as "the North."' This is the definition of the world bank from http://www.worldbank.org/depweb/beyond/global/glossary.html*
Developing Countries	*"…countries with low or middle levels of GNP per capita as well as five high-income developing economies -Hong Kong (China), Israel, Kuwait, Singapore, and the United Arab Emirates. These five economies are classified as developing despite their high per capita income because of their economic structure or the official opinion of their governments. Several countries with transition economies are sometimes grouped with developing countries based on their low or middle levels of per capita income, and sometimes with developed countries based on their high industrialization. More than 80 percent of the world's population lives in the more than 100 developing countries." They are also sometimes referred to as "the North."' This is the definition of the world bank from http://www.worldbank.org/depweb/beyond/global/glossary.html*
Emerging Economies	*The term is frequently used by the IMF in place of conventional concept of 'developing country'. "The main criteria used by the World Economic Outlook (WEO) Report to classify the world into advanced and emerging economies are (1) per capita income level, (2) export diversification—so oil exporters that have high per capita GDP would not make the advanced classification because around 70% of its exports are oil, and (3) degree of integration into the global financial system." More detailed Explanation can be found in http://www.imf.org/external/pubs/ft/weo/faq.htm#q4b*
Greenfield Land	*The greenfield land is the land that has not been developed or has been developed for agriculture or forestry purposes.*
Gross Domestic Product (GDP)	*Gross domestic product is the most commonly used single measure of a country's overall economic activity. It represents the total value of final goods and services produced within a country during a specified period, such as one year.*
GDP per capita	*Gross domestic product in a country divided by the population of the country.*
Previously Developed Land	*Previously developed land is the land that has been previously developed by humans. However, the agricultural land is excluded from these categories in this study. Additionally, the UK government has a specific definition of previously developed land to fit the regulatory requirements. In this study, when discuss the previously developed land under the definition of the UK government, the abbreviation of PDL was used.*
Vacant Building	*"Vacant buildings, unoccupied for one year or more, that are structurally sound and in a reasonable state of repair (i.e. capable of being occupied in their present state). Includes buildings that have been declared redundant or where re-letting for their former use is not expected. Includes single residential dwellings where they could reasonably be developed or converted into 10 or more dwellings (Appendix C, DCLG, 2007)." "Single residential dwellings are excluded (except where development or conversion for 10 or more dwellings) due to difficulties of identifying significant long-term vacancy within housing stock and the very large numbers involved (Appendix C, DCLG, 2007)."*
Remediation Site	*The "Remediation Site" refers to the soil and groundwater contamination on site deemed to potentially "endanger public health and the living environment" (Article 2 of SGPRA 2000). The site should be designated as "Remediation site", if the summation of the ratios of chemical concentrations to their corresponding control standard exceeds 20. This is the most often used criteria in the preliminary assessment.*

Vacant Land	*"Land that was previously-developed and is now vacant which could be developed without treatment. Treatment includes any of the following: demolition, clearing of fixed structures or foundations and levelling. Land previously used for mineral extraction or waste disposal which has been or is being restored for agriculture, forestry, woodland or other open countryside use is excluded (Appendix C, DCLG, 2007)." "The need for treatment is based on the presence of visible signs of dereliction likely to deter redevelopment. Sites may be defined as vacant where it is judged that only minor treatment is needed (e.g. light clearance) which is unlikely to hinder redevelopment (Appendix C, DCLG, 2007)."*

ABBREVIATION	
SGPRA	*Soil and Groundwater Pollution Remediation Act*
NGO	*Non-Governmental Organisation*
NLUD	*National Land Use Database*
NLUD-PDL	*National Land Use Database of Previously Developed Land*
CABERNET	*Concerted Action on Brownfield and Economic Regeneration NETwork*
CLARINET	*Contaminated Land Rehabilitation Network for Environmental Technologies in Europe*
DCLG	*Department for Communities and Local Government*
DEFRA	*Department for Environment, Food, and Rural Affairs*
DoE	*Department of the Environment*
DTLR	*Department for Transport Local Government and the Regions*
GDP	*Gross Domestic Product*
GNP	*Gross National Product*
HDI	*Human Development Index*
IMD	*Index of Multiple Deprivation*
LSOA	*Lower Super Output Area*
MDT	*Missing Data Techniques*
ODPM	*Office of the Deputy Prime Minister*
OECD	*Organisation for Economic Co-operation and Development*
ONS	*Office for National Statistics*
PCA	*Principal Component Analysis*
Part 2A	*Part 2A of the Environmental Protection Act 1990*
PDL	*Previously Developed Land (the abbreviation is used under the context of the UK regulations and policies in this thesis)*
PPG	*Planning Policy Guidance Note*
PPS	*Planning Policy Statement*
RESCUE	*Regeneration of European Sites in Cities and Urban Environments*
SGPRA	*Soil and Groundwater Pollution Remediation Act*
TEPA	*Taiwanese Environmental Protection Administration*
USEPA	*United States Environmental Protection Agency*
UN	*The United Nations*

Chapter 1 Introduction

1.1. Background and General Research Interests

Sustainable development has become a significant environmental discipline in recent decades. Sufficient land resources are crucial for human society to continue thriving. Therefore, maintaining the sustainability of land resources is a key focus for sustainable development.

The term 'brownfields' represents land and properties that have been artificially modified, but are not currently used to their optimised potential. Agricultural land is not generally considered as brownfields. In other words, brownfields can be conceptualised as 'unemployed' non-agricultural land resources (Myers & Wyatt, 2004).

The existence of 'brownfields' may contribute to pollution, unemployment, the decrease in the activities of local economy, and the deterioration of city centres (Grimski & Ferber, 2001; Ganser & Williams, 2007; The World Bank 2010). Redeveloping a brownfield site is likely to be unpopular because of the uncertainty of liabilities, the high cost of remediation, unattractive investment returns, and out-of-date public facilities in the surroundings (Spelman, 1993; Kolivas, 2007; and The World Bank 2010). However, regenerating brownfields has been considered a tool to improve sustainability of a country (for example, DETR, 1999).

In Taiwan, it is acknowledged that an effective strategy for managing land resources should be developed to recognise and resolve the contradiction between the needs for environmental protection and for better economic performance. Taiwanese officials mostly adopt established environmental policies from developed countries with modifications (Wu, 2001; Chen, 2003; Zhang, 2003; Wang, 2004; Luo, 2006), sometimes without proper evaluation of possible social and economic impacts (McManus, 2000). The lack of impact analyses increases the uncertainty surrounding policy implementation. One example is the adaptation of the USEPA Superfund regime to establish Soil and Groundwater Pollution Remediation Act (SGPRA) in 2000 (Wang, 2004; Luo, 2006). The Act has been considered the regulatory regime most relevant to brownfield problems. However, the Act was also believed to have slowed down the redevelopment of some contaminated sites without facilitating the clean-up process (Wu, 2008).

Meanwhile, the government in England has met redevelopment targets to build 60% of new houses on previously developed land (PDL) (DETR, 1999; ODPM, 2004a). Achieving the target has been considered one of the major successes towards sustainable brownfield regeneration in England.

One significant difference between England and Taiwan in brownfield policy lies in the definitions of the types of land qualifying as 'brownfields'. Therefore, in this study, I utilise both qualitative and quantitative data (both international and national) to investigate the effects of brownfield definition on the sustainability of land use. Based on the results, a policy framework for defining brownfield to improve land use sustainability is established. This may further inform policymakers regarding how to define brownfields in the regeneration policy to achieve truly sustainable societies.

1.2. Research Aim

This study aims to establish a framework for defining 'brownfields' that improves land use sustainability by analysing qualitative and quantitative evidence in land use and sustainability.

1.3. Research Objectives

1. To identify the issues concerning the conceptualisation of 'sustainable development' and 'brownfields' by reviewing existing definitions from the literature, organisations and countries (Chapter 2);
2. To investigate the relationships between sustainability and the existence of brownfield land by analysing PDL and socio-economic development in England (Chapter 4);
3. To demonstrate the influences of demographic differences on the successful strategies of sustainable development by comparing the performances in the indexes of sustainability among countries where the population density varies significantly (Chapter 5);
4. Also based on the demographic differences, to expand the framework of brownfield definitions established for European countries (Oliver et al., 2005) to the countries worldwide (Chapter 5);

5. To scrutinise the concept of land use sustainability by extracting major components from a collection of variables using the principal component analysis (PCA); each of the components may represent specific aspect of land use sustainability (Chapter 6);
6. To investigate the influences of demographic differences on strategies to achieve sustainability observed in Chapter 5 by comparing the scores of countries calculated based on the index of land use sustainability developed using PCA (Chapter 6);
7. To evaluate whether the target setting and the brownfield regeneration policy have delivered the declared policy objectives in England by reviewing relevant parliamentary debates, quantitative land use data, and the indicators of socio-economic conditions (Chapter 7); possible reasons for the un-satisfactory brownfield definition in the policy will be explained based on the two relevant voting results in conjunction with demographic differences within England;
8. To understand land use and demographic changes over time in Taiwan by comparing two surveys of land use finished in 1996 and 2008 (Chapter 8);
9. To evaluate the consistency between planning policy and the results of implementation by comparing the results of land use surveys and land use planning in Taiwan (Chapter 8);
10. To investigate the effects of perceptions of brownfields in Taiwan on land use efficiency by reviewing the cases of industrial pollution, reviewing the regulations, and conducting binary logistic regressions on the database of designated polluted sites maintained by Taiwan Environmental Protection Administration (TEPA) (Chapter 9);
11. To establish a framework for brownfield in regenerating policy based on the observed effects of brownfield recycling on land use sustainability (Chapter 10).

1.4. The Structure of the Thesis

The thesis begins with a literature review of brownfield regeneration and sustainable development (**Chapter 2**). The review particularly focuses on the diverse definitions and ambiguity in these two terminologies. **Chapter 3** briefly outlines the methodology of the thesis and the consideration of selecting data. Based on the literature review, in **Chapter 4**, I test the argument that reducing brownfield land improves sustainability utilising the Index of Multiple Deprivation (IMD) and the data of PDL in England collected by the UK Government.

The study then turns to the sustainability of land use in advanced economies and emerging economies. **Chapter 5** analyses the relationship between population densities and the strategies to achieve sustainability worldwide. This provides a general idea regarding the types of land use policy preferable in a country with high population density such as Taiwan. Additionally, **Chapter 6** utilises PCA on a collection of variables relevant to land use to extract environmental, social and economic aspects of sustainability. The result of the PCA is also utilised to evaluate the improvements to be made in the countries of interest in this study: the United Kingdom and Taiwan. Based on the conclusion, the issues of brownfield redevelopment of England and Taiwan are then analysed.

Chapter 7 investigates whether the target of recycling PDL (a.k.a. the definition of brownfield by the UK government) in England improves its brownfield regenerating effectiveness. Several parliamentary debates and voting results are analysed to show the controversy surrounding the garden land development resulting from defining brownfield land as PDL. Furthermore, the analyses of the annual statistics on developed land reveals effects of the 60% target set by the government on the land recycling as well as socio-economic sustainability. The analyses illustrate the possible pitfalls in the brownfield definition and quantitative target setting in England.

Chapter 8 evaluates the sprawl in Taiwan, one of the problems resulting from the brownfield land. The chapter also investigates the differences between current land use and planned land use to verify whether the observed sprawls or compacter settlements are the intended results of planning. In **Chapter 9**, I investigate the perceived barriers to brownfield reclamation in Taiwan. News archive documenting two polluted sites is reviewed to identify the problems of redeveloping contaminated sites portrayed by the media. The reports possibly shaped the perceptions of the stakeholders and policy makers in Taiwan on brownfield land and on the associated regulations. To verify the perceptions on the brownfield regulations, logistic regression is conducted to identify the probability of land vacancy after being designated as a polluted site in accordance with the Soil and Groundwater Pollution Remediation Act (SGPRA) in 2000 and related regulations.

Based on the results presented in the previous chapters, **Chapter 10** proposes a framework to define brownfield land in order to encourage sustainable brownfield regeneration. Possible applications of the framework are also elaborated. Finally, **Chapter 11** summarises and concludes this study. Suggestions for future research based on the conceptualised framework are made.

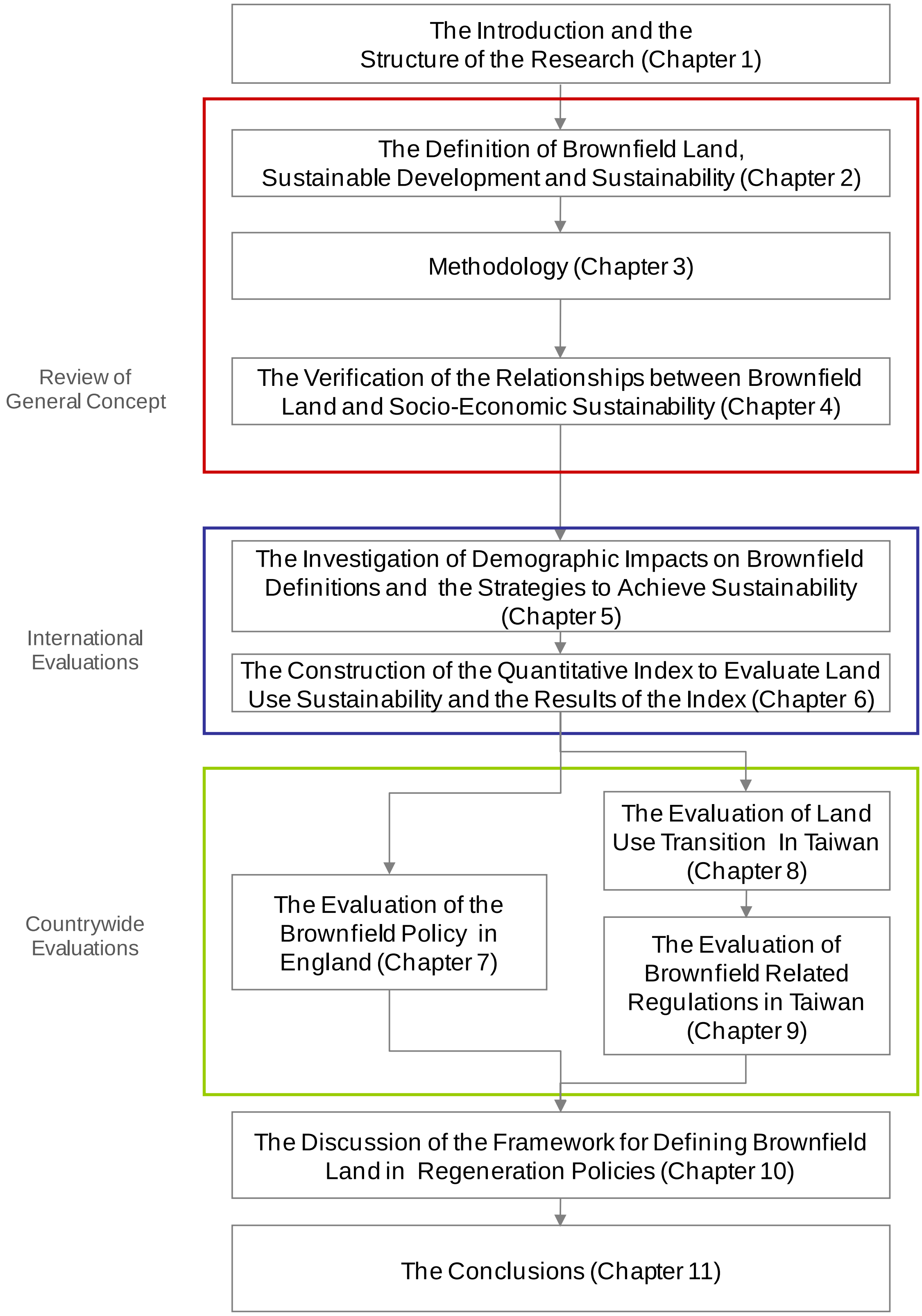


Figure 1.1 The Structure of This Thesis

Chapter 2 The Concept of 'Brownfields' and Sustainable Development

This chapter reviews the term 'brownfields' and the concept of sustainable development. Various definitions of 'brownfields' and sustainable development from institutions are summarised. Diverse definitions further researched in the following chapters are briefly reviewed.

2.1. The Importance of Definition

This study examines the effects of defining key terminologies in the policies. Before entering the discussion of specific terminologies, I present the contemplations by previous thinkers on the subject of defining a concept in the east as well as west.

In ancient China, two major schools of thoughts, Confucianism and Taoism, both commented on the action of defining concepts: Confucianism stresses the importance of defining rules clearly. It argued that a proper definition justifies actions. By contrast, *Tao Te Ching by Laozi*, the first and the most important philosophical statement of Taoism, suggested that the nature of a concept cannot be defined precisely by any form of language. When a concept is defined using the means of communications (such as texts and spoken words), part of the truth slips away. Therefore, Taoism encourages managers or government officials not to interfere in the affairs of general public. By contrast, the Confucianism encourages governments to educate citizens, (Emperor Chinese) royal members and aristocrats to discipline themselves based on the ethical criteria discussed in the teaching of Confucius.

Confucianism is more practical and easy to grasp, while Taoism is rather abstract. The implications of these different points of view in governing a country might be the reasons that Confucianism has much greater influences on many Asian political and Educational systems for thousands of years. The philosophy of Taoism, on the other hand was only applied in several short periods of Chinese history. It, however, flourished in society and grew into a religious belief.

Based on these observations, I established that defining things clearly in laws or policies, though risking losing part of the original essences of the concept, ensures everyone follows the same rule and make ruling and management easy.

Policymakers in Asian societies might have recognised the thoughts of Taoism but found Confucianism easier to implement. Confucian ideology is believed to be the foundation of the bureaucratic culture among countries of East Asia (Frederickson, 2002).

Approximately the same time as Confucius and Laozi, Father of Taoism, an ancient Greece philosopher, Parmenides, also pointed out there is 'the way of truth' and 'the way of opinion'. The truth cannot be described by 'the way of opinion' (or translated as 'the way of seeing'). This argument is quite similar to that of Taoism.

On the other hand, during the age of Enlightenment, John Locke argued that experiences are the key to construct concepts, or namely to form the perceptions. Thereby, the understanding of truth must be through experiences and observations. In this way, truth may be justified and knowledge may be defined. The view has great influence on modern science and (western) politics. The application of Empiricism can be observed in recent studies of sustainable development and brownfield regeneration, especially when the argument involves community involvement (for example, the discussion in Staley, 2006).

The examples of these philosophical thoughts show that both eastern and western philosophers have had two distinguishable views on defining a concept: one considered the truth or reality cannot be defined by senses or words, and another suggested that defining a concept is achievable and is important to allow further political or scientific development. This thesis, in discussing definition of brownfield land and sustainable development, took the latter view. This is because the definitions in policies and regulations influence the implementation of the policy significantly (Adams, De Sousa, & Tiesdell, 2010) and the study aimed for establishing a way to derive policies that deliver desired results.

Brownfield land (or simply named 'brownfields') and sustainable development are the terminologies invented after the industrialisation of western European countries and North America. The terms have been defined by institutions with different backgrounds and histories. They perceived sustainable development and brownfield land in various ways and aimed to utilise the terms to achieve different things as demonstrated in the following sections. The essence of the concepts, however, could be lost in these translations. With considerable diversity in the nature of these definitions, in this chapter (Section 2.2 to Section 2.4), the discussions and critique of the definitions of brownfield land, sustainable development and sustainability are reviewed.

2.2. The Causes of 'Brownfields'

Brownfield land appeared before it was formally defined. Previous literature indicates two causes of brownfield land: deindustrialisation and suburbanisation (for example Alker, Joy, Roberts, & Smith, 2000; Oliver et al., 2005; Ganser & Williams, 2007; Adams, De Sousa, & Tiesdell, 2010). The two causes have dictated how 'brownfields' is defined in regulations or policies. The origins of brownfield sites in countries affect the objectives of brownfield regeneration policy (Grimski & Ferber, 2001; Oliver et al., 2005; Adams, De Sousa, & Tiesdell, 2010).

Marked by the shrinkage of manufacturing sectors and the expansion of service sectors, deindustrialisation roughly started in the late 1960s or early 1970s in Western Europe and North America. Later on, Japan followed this trend (Rowthorn & Ramaswamy, 1997). In the recent decade, it has been observed in the 'Four Tiger' economies in East Asia (Hong Kong, South Korea, Singapore and Taiwan) (Rowthorn & Ramaswamy, 1997).

As deindustrialisation progresses, the adverse effects of industrial pollution became apparent. Initially, the concerns about pollution appeared to be relevant to the issues of public health and safety (Bell and McGillivray, 2006). Love Canal in United States (USEPA, 1979), and Lekkerkerk in Netherland (Cino, 2006) are two well-known cases. Governments imposed liabilities on the manufacturers that produced the pollution or on the landowners who own the contaminated land for usually expensive cleaning-up and compensation schemes. The famous legislation known as 'Superfund' in the U.S. is the product of such circumstances. As a result, fear of environmental liability played a part in increasing the number of derelict and vacant industrial, commercial and even residential settings (Dickinson, 2000).

At the same time, the ending of industrial activities resulted in loss of job opportunities and released large amount of land in the vicinity. Consequently, the economic condition of the surrounding communities started to fall. Deprivation then appeared. The deprivation affected the community welfare and further damaged the values of land. It reduced tax revenue and could bring unsatisfactory voting results for the parties in power. Therefore, these past industrial legacies are social and economic issues the government cannot ignore. The governmental intervention to revitalise these areas may be indispensable to make them more economically attractive (Grimski & Ferber, 2001).

At about the same time as deindustrialisation, more affluent people tended to move to the outskirt of cities in seeking better living conditions (Mieszkowski & Mills, 1993; Accordino & Johnson, 2000). This action of out-migration also involved the sense of being in a better social class or racial segregations (examples described in Gibson, 2007; Lees, Slater, & Wyly, 2008a; a documentary film: The New Metropolis by Andrea Torrice, released in 2009 in the U.S.). The landlords may give up actively maintaining the property in the inner city because demands fall (Keenan, Lowe, & Spencer, 1999). The empty properties therefore deteriorated to unmanageable degree (Keenan, Lowe, & Spencer, 1999). The vacant properties induced a vicious cycle of social and physical decline (Spelman 1993; Keenan, Lowe, & Spencer, 1999; Gibson, 2007). Abandoned residential properties increased as the suburbanisation progressed.

In the declined communities, public infrastructure such as railways or harbours could also be abandoned or underused (Grimski & Ferber, 2001), 'even though the general economic situation of the areas suggests that they could be used' (Grimski & Ferber, 2001, p144). Urban planning and large-scale facility construction are usually the means to reduce this type of urban blight (Grimski & Ferber, 2001). However, the recycling of land cannot always be accomplished by central planning. The history and the old infrastructure already in place all play roles in the transition of a city. The redevelopment of London dock land may be an example for this. BBC 2 narrated the redevelopment of the area in the second episode of the documentary Britain from Above, broadcasted on 10 August, 2008.

Although the deindustrialisation and suburbanisation could result in different types of abandoned properties, several consequences are shared by the abandonment. The communities adjacent to these properties usually suffer from unemployment, heightened criminal activities and falling economic output (Spelman, 1993; Webster, 2000; Brown, Perkins, & Brown, 2004; Gibson, 2007). Other aspects of deprivation such as poor education and underprivileged health care service may follow (Walkowiak & Frazier, 2000, Stewart, 2004; Gibson, 2007). The issue of pollution exist mostly on the sites previously used by industry. Therefore, the human health risks related to brownfield sites, though a very important aspect in regeneration, are not a universal problem for all types of brownfield sites discussed in this study.

2.3. Definition of Brownfields

'Brownfields' is defined differently in Europe and North America (Grimski & Ferber, 2001; Oliver et al., 2005; Ganser & Williams, 2007; Adams, De Sousa, & Tiesdell, 2010). This section summarised the definitions of brownfields and the possible implications of the differences. Alker et al. (2000) identified several major elements among the definitions of brownfields from governments and institutions: 'derelict', 'vacant', 'previously developed' and 'contaminated'. Table 2.1 summarises how these common elements have been considered in several institutions.

Table 2.1 The Common Elements in Brownfield Definitions

Elements / Institutions	*Derelict or Underused*	*Contaminated*	*Previously Developed*	*Urban*	*Require Interventions*
CABERNET[1] (Europe)	✓	∆	✓	✓	✓
England NLUD[2]	∆	–	✓	∆	∆
USEPA[3]	✓	✓	✓	–	✓
NRTEE (Canada)[4]	✓	✓	✓	–	✓
ALKER et al. (2000)	✓	∆	✓	∆	✓
This Study	✓	∆	✓	∆	∆

✓essential element in the definition
∆ optional element in the definition
- no mention of the element
1. Millar et al., 2005
2. DCLG 2007
3. the Small Business Liability Relief and Brownfields Revitalization Act (section 211(a)(39)(A))
4. NRTEE, 2003

The concepts of 'derelict', 'vacant' and 'previously used' can be derived either from the results of deindustrialisation or sub-urbanisation (Section 2.2). The concept of 'contamination', however, is closely tied to industrial activities and less relevant to suburbanisation (Section 2.2). Therefore, in the following discussion, I divided the definitions of brownfields into two groups: the definitions that consider 'contamination' an essential element of brownfield land, and the definitions that consider contamination non-essential.

2.3.1. Definition Associated with Contamination

The term 'brownfields' was first used in a U.S. congressional field hearing in 1992. The issues related to 'brownfields' were than analysed and acted upon (Greenberg & Justin, 2006). According to the definition in *the Small Business Liability Relief and Brownfields Revitalization Act (section 211(a)(39)(A)) promulgated in 2002*, the 'brownfield site' is '…real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.' The definition strongly connects the brownfields with contamination. It aims 'to promote the cleanup and reuse of brownfields, to provide financial assistance for brownfields revitalisation,… (USEPA, 2009a).' The Act provides legislative foundation to offer relief to small businesses affected by the Superfund Legislations (USEPA 2009b). This definition indicates the regime focuses mostly on dealing with the contamination and the consequences resulted from the contamination. The definition, however, does not include the designated 'Superfund Sites' where the presence of the contamination results in much higher risk on human health and environment (Lange and McNeil, 2004). Therefore, the sites fulfil the criterion of 'brownfields' are limited to those that have lower level of contamination.

In Canada, 'brownfields' is defined as 'an abandoned, vacant, derelict or underutilised commercial or industrial property where past actions have resulted in actual or perceived contamination and where there is an active potential for redevelopment (NRTEE 2003).'

Several European countries (e.g. Flanders Belgium, Bulgaria, Denmark, Italy, Poland, Romania and Spain) also define brownfield as land or properties affected by contamination (Olive et al., 2005). Flanders Belgium and Spain further narrow the brownfields to the polluted area previously used for industrial purpose (Oliver et al., 2005).

2.3.2. Definition Associated with Dereliction

Another type of definition associates brownfield land with dereliction or underused land. This seems to be popular among Western European countries (Oliver et al., 2005).

At European Union level, the Concerted Action on Brownfield and Economic Regeneration Network (CABERNET) has adapted the brownfield definition of the Contaminated Land Rehabilitation Network for Environmental Technologies (CLARINET): Brownfield sites are the 'sites that have been affected by the former uses of the site and surrounding land; are derelict and underused; may have real or perceived contamination problems; are mainly in developed urban areas, and require intervention to bring them back to beneficial use (Millar, Ferber, Grimski, & Nathanail, 2005).' This definition recognises that contamination on-site is possible but not necessary. It incorporates a new element of 'urban area' into the definition. This implies CABERNET believes that the regeneration can be more effective within the urban boundary. The definition has been cited by the World Bank as having 'wide acceptance in Europe and because it goes beyond just describing a type of site, acknowledging the need for assessment and remediation, and hinting to the benefits of redevelopment (The World Bank, 2010).'

Alker et al. (2000) attempted to provide a definition for 'universal usage': 'A brownfield site is any land or premises which has previously been used or developed and is not currently fully in use, although it may be partially occupied or utilised. It may also be vacant, derelict or contaminated. Therefore, a brownfield site is not available for immediate use without intervention.' Alker et al. (2000) also argued that the brownfields could exist both in urban and rural areas.

The UK separates the concepts of contamination and brownfield land. The country defines brownfield land as previously developed land (PDL) (Alker et al., 2000; Syms, 2001, DCLG 2006a; Adams, De Sousa, & Tiesdell, 2010). In England, before the new coalition government after May 2010, the Planning Policy Statement 3 (PPS3) defined the PDL as the land 'which is or was occupied by a permanent structure, including the cartilage of the developed land and any associated fixed surface (DCLG, 2006a).' Some revisions have been made in 2010 but overall, PDL is still considered brownfield land (Annex B in DCLG 2010a). Interventions are not necessary but 'could help' to improve the redevelopment of the brownfield land

(DCLG 2010a). This is similar to general understanding of infill and covered broader spectrum of land resources compared to the definition of CABERNET, or Alker et al. (2000). Chapter 7 continues discussing the effect of this definition.

Based on this definition, the National Land Use Database of Previously Developed Land (NLUD-PDL) has kept track of PDL in England since 2001 to evaluate the policy that is relevant to brownfield regeneration. The NLUD classified PDL into six types (Annex C in DCLG, 2007):

(A) Previously developed land which is now vacant;

(B) Vacant buildings;

(C) Derelict land and buildings;

(D) Land or buildings currently in use and allocated in the local plan and/or having planning permission;

(E) Land or buildings currently in use where it is known there is potential for redevelopment; and

(F) Previously developed land or buildings that have been developed or where construction has started.

These classifications exclude the agriculture, forestry, mining, landfill, recreation grounds or the land that has "blended into the landscape". Although the contamination may be associated with the PDL, it is not the necessity of brownfield defined by the United Kingdom.

2.3.3. Definition in Taiwan

In Taiwan, the definition of brownfields is ambiguous. When the brownfield issues discussed by the Taiwanese Environmental Protection Administration (TEPA) and in the environmental science literature, the brownfields often refers to the contaminated land resulted from the historical industrial development, sometimes including the agricultural field in the vicinity affected by the discharge of the factory (TEPA, 2007a). This concept is closer to the definition by the USEPA.

However, when 'brownfields' is discussed by the urban planning academy or the city-planning agency, the definition sometimes approximates the previously used land currently underused. They referred back to the discussion by British scholars, where brownfield land is defined to cover a broader spectrum of land. However, most literature in the planning still dwelled on the issues such as stigmatisation of brownfield sites because of the pollution, and regenerating a site that was polluted (for example Yung 2004 and Yung 2006).

One common consensus of the brownfield definition in Taiwan, though, is that 'brownfields' is always related to the industrial practice as observed in Spain and Flanders Belgium. This understanding emphasises on the effect of deindustrialisation but not suburbanisation.

2.3.4. The Effects of the Brownfield Definitions

The definitions of brownfield land may be grouped into two types depending on whether the contaminants on the sites are required. The brownfield regeneration policies derived from these definitions target different land resources for regeneration. For example, it was observed during the brownfield 2009 conference in New Orleans, brownfield regeneration projects in the U.S. have to demonstrate the existence of pollutants on sites to obtain grants, although economic growth, social justice and planning issues may also be involved in the projects. Therefore, the derelict but uncontaminated urban land has not been included in the regeneration policies of the U.S or countries applied similar definitions. On the other hand, problems of deindustrialisation and suburbanisation may not be specifically targeted under England's broad-spectrum definition of brownfield land (Ganser & Williams, 2007). In Chapter 7, the policy implication of brownfield definition in England is further discussed. In Chapter 9, the effects of the definition or rather the perception of brownfields in Taiwan is analysed.

2.4. Sustainable Development

Regenerating brownfields is believed to improve environmental, economical and social conditions through effectively recycling the land (Ganser & Williams, 2007; Dixon and Adams, 2008; The World Bank, 2010). Thus, the land recycling is the means but not the end goal of brownfield regeneration.

'Sustainable development' as a concept emerged in 1970s. Significant amount of literature discussed sustainable development started with addressing the work of the World Commission on Environment and Development (WCED) and its consequent report, *Our Common Future*, in 1987 (a.k.a. *Brundtland Report*). The concept was proposed in response to the limitation of resources and uneven distribution of resources (Kates, Parris, & Leiserowitz, 2005). Sustainable development aims to seek economic development, social justice and environmental protection, ideally, all at the same time (Giddings, Hopwood, & O'Brien, 2002). In the *Brundtland Report*, land resources is one of the resources require attention to be developed in a more sustainable way.

Therefore, in terms of land resource management, brownfield regeneration and sustainable development share the end goal: to maintain the sustainability of land resources. The existence of brownfield land implies an unsustainable condition. Therefore, brownfield regeneration can be viewed as part of sustainable development. As a result, I considered the measurement of sustainability a benchmark to evaluate the performance of brownfield regeneration.

This section describes the origin of sustainable development (Section 2.4.1) and discusses the contemporary views on sustainable development (Section 2.4.2). Despite the ambiguity of the concept of sustainable development and sustainability, certain aspects are considered essential (Section 2.4.3). Moreover, the consideration of diversity and equality are often stressed in pursuit of sustainable development but less widely evaluated (Section 2.4.4). The essential aspects and the consideration of variations (diversity and equality) are the primary considerations in establishing the methods in this study to assess whether the brownfield regeneration policy improves sustainability.

2.4.1. The Beginning of the Concept

The academic discussion of sustainable development started around 1970. Searching ‘sustainable development’ in ISI web of knowledge finds a significant increase of journal articles and conference papers after 1970s (Figure 2.1). The search found 14 articles between 1970 and 1979, but 21,014 between 2000 and 2009. The initial discussion of sustainable development focused mostly on marine resources and fishery. During 1970s, only limited articles (2 out of 14 in ISI web of knowledge) expressed the concerns about the population growth and basic human needs (Holdren & Ehrlich, 1974; Streeten, 1979). These two factors were closely linked to the sustainability of land resources. They were not fully acknowledged in the content of sustainable development at the time.

Discussions on the sustainable use of land resources were initiated and focused on agricultural resources and distribution of farm ownerships (Beaver, 1950; Eckholm, 1979). The concern regarding sustainable use of urban land did not appear until the 1980s (for example Conway, 1984). Today, sustainable development has been broadly discussed within the disciplines of humanity, science and technology. Many of them were relevant to urban planning or the use of land resources.

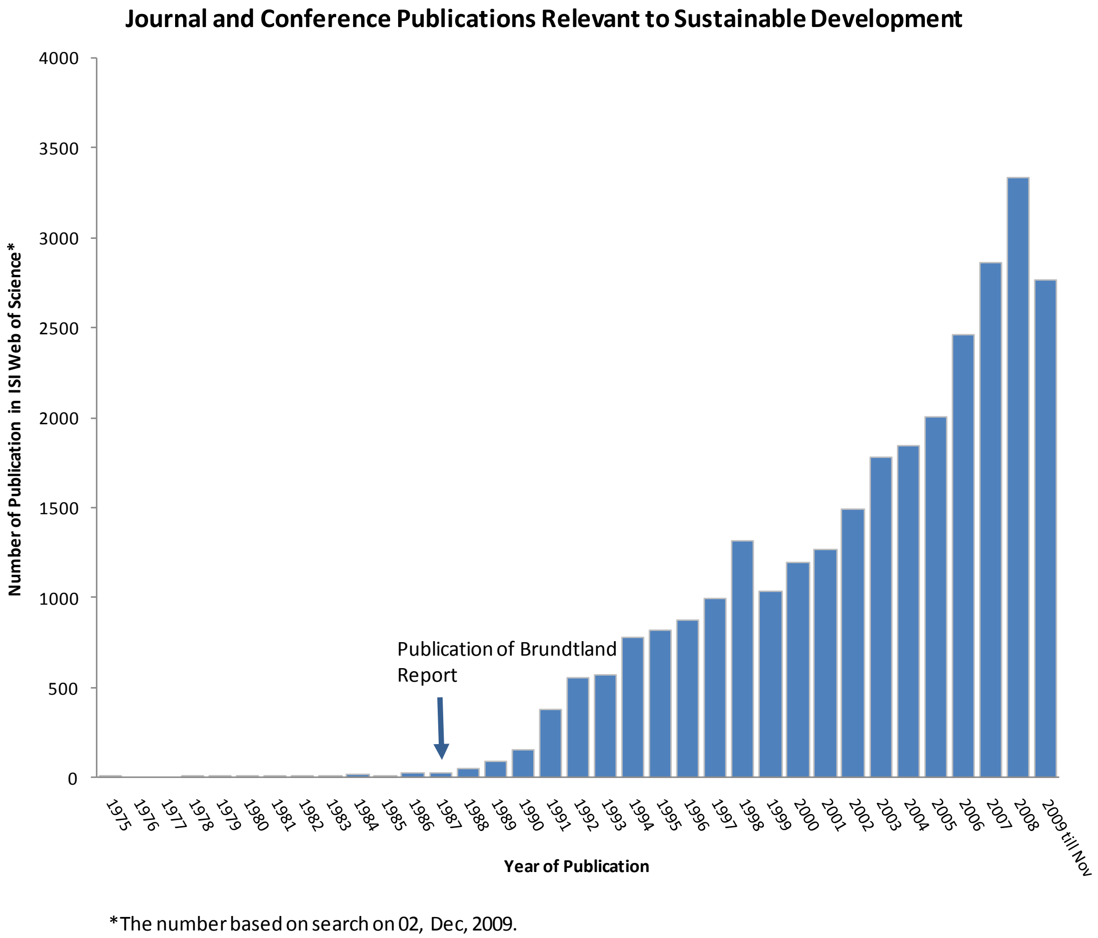


Figure 2.1 The Numbers of Publication Related to Sustainable Development since 1975 (Source: ISI Web of Knowledge)

The growing literature reflects increasing popularity of the research on the subject of sustainable development after the publication of *Brundtland Report* (Hueting, 1990; Kates, Parris, & Leiserowitz, 2005; McManus, 2000, p812-815) (Figure 2.1). The concept has become one of the important disciplines in the environmental studies (Bell & McGillivray, 2006).

2.4.2. Definitions of Sustainable Development: Creative Ambiguity or Oxymoron?

The interpretations of sustainable development have been inconsistent since the term gained popularity. More than one hundred definitions for sustainable development have been proposed (Lee & Chen, 2001). The interpretations are 'shaped by people's and organizations' different worldviews, which in turn influence how issues are formulated and actions proposed (Giddings, Hopwood, & O'Brien, 2002, p187)'.

The most often referenced definition of sustainable development is from the *Brundtland Report* (WCED, 1987, Chapter 2 Section I):

> *"The development 'meets the needs of the present without compromising the ability of future generation to meet their own needs."*

This definition is widely accepted because of its positive and optimistic implication (McManus, 2000). Moreover, certain degree of ambiguity in this definition seems to have provided a ground for consensus building. Kates, Parris, & Leiserowitz (2005) considered the ambiguity was creatively constructed. Since the definition is vague and open to interpretation (ICLEI, 2002. p16; Hopwood, Mellor, & O'Brien, 2005), translating the definition in *Brundtland Report* into practice has been diverse (Gibbs, Longhurst, & Braithwaite, 1998; Eisner, 2007; Smardon, 2008). Thus, exactly what sort of 'sustainability' to be achieved by practising the defined sustainable development can be unclear. Nevertheless, the trend of using this concept is growing. For example, Agenda 21 initiated by the UN aims for sustainable development has been increasingly translated into Local Agenda 21 (ICLEI, 1997 and ICLEI, 2002).

The following discussion categorised the discrepancies of the concept of sustainability pursued by sustainable development in several different characteristics: (1) values towards environment preservation, economic growth and social equality; (2) professional backgrounds; and (3) culture and economic conditions.

The **strong (or eco-centric)** sustainable development practitioners give nature (environmental sustainability) the highest and irreplaceable value, while the **weaker (or anthropocentric)** sustainable development supporters prefer to consider trade-off between development and loss of natural resources (Goodland & Ledec, 1987; Gladwin, Kennelly, & Krause, 1995; Gibbs, Longhurst, & Braithwaite, 1998; Hopwood, Mellor, & O'Brien, 2005; and Bell and McGillvray, 2006). The believers of neoliberalism support the development of free market but the social reformers argue for socio-economic equality (Hopwood, Mellor, & O'Brien, 2005; Kates, Parris, & Leiserowitz, 2005).

Institutions also have had different agenda in pursuing sustainable development. The scale of difference may range from maintaining the status quo to radically changing current political framework (Haughton, 1999; Hopwood, Mellor, & O'Brien, 2005). Curiously, the international and national governmental bodies usually take a more conservative view on changing the current political framework (Hopwood, Mellor, & O'Brien, 2005).

The critics have argued that the weak version is simply 'business as usual' (Bell and McGillvray 2006; Gunder, 2006). They hold the view that the definition can be conveniently used by politicians to pursue development. The 'deep ecologist' view argues that the anthropogenic view of sustainable development emphasises 'development' rather than the 'sustainability' of environment (Hopwood, Mellor, & O'Brien, 2005). Therefore, the term is an 'oxymoron' (Daly, 1990; Sachs, 2003; Kates, Parris, & Leiserowitz, 2005). For example, based on *Brundtland Report*, Clinton administration characterised sustainable development as 'economic growth that will benefit present and future generations without detrimentally affecting the resources or biological system of the planet (Eisner, 2007).' In this case, 'human needs' are interpreted as 'economic growth'. Some international organisations such as the World Bank and the UN have been promoting this kind of weaker sustainable development though recognising social issues in human development (Drakakis-Smith, 1995).

Additionally, in some weak versions of sustainable development, the environmental damage are internalised as the cost of the development. Some attempts have been made in economic evaluation (e.g. 'willingness to pay') to incorporate the 'intrinsic value' of environment (Goodland & Ledec, 1987). The 'intrinsic value', however, may vary considerably given different views or political framework (Pearce, Hamilton, & Atkinson, 1996; Ayres, van den Bergh, & Gowdy, 1998; Hopwood, Mellor, & O'Brien, 2005).

An alternative type of argument is that environment is the ultimate resources that human societies rely upon and not the other way around. Therefore, protecting environment should always come first as the 'need' to sustain (Ayres, van den Bergh and Gowdy, 1998). This is also considered the view of 'strong sustainability'. Since the incentive to protect environment in this argument is for the benefit of human society, I consider the ultimate purpose of sustainable development, in this version of sustainability, is still anthropogenic.

Moreover, adopting an extreme eco-centric view of sustainability may render sustainable development an insignificant concept. Environment as a whole always sustains. It is the quality of environment that fits the human survival may not sustain. The qualities of environment are the values imposed by human, and would only be of concerns with the existence of humanity. Therefore, the discussion of sustainable development is the issues always involved human survival. It may be less possible to hold a one hundred percent eco-centric view as far as policymaking and policy implementation are concerned. The sustainability to be achieved via sustainable development by governmental bodies is always relatively anthropogenic.

As Campbell (2003) stated, "we are all unavoidably anthropocentric; the question is which anthropomorphic values and priorities we will apply to the natural and the social world around us." Thornton et al. (2007) also expressed similar view upon defining the sustainability within the context of brownfield regeneration.

Different **disciplines** also have various interpretations of sustainability (Common, 1995, p55):

> *"Economists emphasise human management in human interests, narrowly conceived, and neglect considerations relating to the functioning of the biosphere and its constituent system. Ecologist emphasise system function considerations, but cannot relate those to human interests in any direct and simple way. The question which arises is whether there can exist a synthetic approach, which can operationally inform the analysis of human behaviour and debate over how human society should behave."*

Several sustainable indexes established to measure the degree of sustainability of different countries showed attempts to combine different aspects of sustainability. The indexes usually consist of a broad spectrum of social, economic and environmental indicators. The combinations of indicators could be considered an implicit definition of sustainable development (Kates, Parris, & Leiserowitz, 2005).

The indicators and the methods used to build indexes are briefly discussed in Section 2.4.5 and further described in Chapter 6.

Regions at various development stages may also view 'sustainable development' differently. For example, reducing unemployment or improving education quality has different significance to 'developing' and 'developed counties' (Streeten, 1979). The conditions of environment, society and economy also varies significantly in different parts of the world (Giddings, Hopwood, & O'Brien, 2002). The 'sustainability' to be achieved in different regions may be diverse. Because of these reasons, Eisner (2007) concluded an international agreement is less possible as a protocol to conducting sustainable development. A rather decentralised approach may be more feasible.

It might also be argued that the definitions of sustainable development is evolving so that the 'needs' of future generations may not be foreseeable. The relevant knowledge is also 'incomplete, imperfect and changing over time (Common, 1995, p55).' Drakakis-Smith (1995, p665) also bitterly pointed out 'all too often, "success" rests only in the eyes of the state which has brought about some short-term improvement in basic needs at minimal cost to its own limited resources. The literature on basic needs is littered with such schemes and their long-term failures.'

The countries at different development stages might benefit from the lessons already learnt by their 'more developed' counterparts. However, this does not mean the experiences may be completely transferable given the regional variations and the different paces of the development.

This argument is consistent with the critics of Giddings, Hopwood, and O'Brien (2002, p193) to the abstract sustainable development model: 'The abstraction … underplays the constant change and reinforces the idea of a static world, in which the present dominant structures and priorities have always existed and will remain'.

Because the difficulties and controversies of translating the concept of sustainable development into practice, in Europe, the use of the concept is more in the form of policy but not legally bound documents (Bell & McGillivray, 2006). For example, the United Kingdom adopted the concept at the administrative and institutional framework level without changing the environmental law substantially. In the case it has been translated into the international law, the debates about these policies are still on-going (Bell & McGillivray, 2006).

2.4.3. Aspects of Sustainable Development

Since the 1990s, the discussions of sustainability usually involved the issues of society, economy or environment (Munasinghe, 1993, Giddings, Hopwood, & O'Brien, 2002). The three aspects, collectively referred to as 'sustainable triangle' (Munasinghe, 2002), have been considered by international organisations such as the UN when developing sustainable development agenda. Balancing the three aspects of sustainability during the development is one of the criteria of sustainable development. However, in practice, it has been proved difficult. Most of the institutions prioritised one of the aspects (Giddings, Hopwood, & O'Brien, 2002). Usually, the priority has been allocated to the economy.

Giddings, Hopwood, and O'Brien (2002) argued that the triangle model is overly simplified. This might give decision makers a false impression that improving one of the aspects may compensate the damages made to other aspects. This impression ignores the connection and multi-layer characteristics of society, economy and environment. Moreover, the anthropogenic aspects such as society and economy cannot survive without the support of environment, while environment may keep on evolving without human societies. Thus, the three aspects may not necessarily be equal.

Likewise, in the land management point of view, it is argued that a planner should aim to accomplish the social equality, economic growth and environmental protection (Campbell, 2003, p.437). Unfortunately, planners usually face the dilemma to provide such a balanced development plan because these three aspects conflict with each other by nature (Campbell, 2003). Therefore, a city would not always develop according to the ideal sustainable development model.

Therefore, it may not be a surprise that Gunder (2006) observed the western industrialised countries seem to still to see economy growth as a priority; they heavily advertised environmental sustainability but did not practice enough; they often ignored social sustainability or social justice. This may lead to jeopardising natural resources and worsening social problems. Ultimately, this compromises the sustainability as a whole. This pessimistic view may be lightened by recent accumulating literature presenting numerical evidence that equality offers better quality of life to the human society. Possible ways are also proposed to improve the quality of living without economic growth (an extensive discussion can be found in Wilkinson & Pickett (2010)).

Additionally, recent studies suggested applying minimum standards to each of the three aspects to handle the conflict between aspects (Goodland & Ledec, 1987). Similar methods were also described under the names of 'triple bottom line objectives', or 'principle based criteria' (Pope, Annandale, & Morrison-Saunders, 2004).

Besides the three aspects discussed above, the institutional dimension has been proposed as the fourth aspects for sustainability (Thornton et al., 2007). An institution gives an interpretation to sustainable development (Gunder, 2006). It also functions as an agent to implement sustainable development (Volkery et al. 2006) and consequently, has to take responsibility of the performance (Wallington & Lawrence, 2008). The change of institutional behaviour reflects the shift of attitude toward the use of resources (Dobson, 2007; and Wallington & Lawrence, 2008). An institution capable of "mediating between the different sustainability dimensions" is essential to achieve the objectives of sustainable development (Thornton et al., 2007, p51). The descriptions in the literature suggested that institutions are important actors to pursue sustainable development. However, it has different characteristics than the three aspects. Institutions are proactive organisations capable of changing the three sustainability aspects. The conditions of the three aspects reflect the performance of institutions in conducting sustainable development.

2.4.4. Regional Variability and Sustainable Development

Sustainable development encourages regional diversity but tries to reduce the inequalities (Streeten, 1979, Giddings, Hopwood, & O'Brien, 2002; Wilkinson & Pickett, 2010). Several types of equalities may be of concern in the context of sustainable development: inter-generational equity, intra-generational equity, and inter-species equity (Haughton, 1999; Common & Stagl, 2005). Thus, one way to look at the degree of sustainability is to compare the relative deprivation, the distribution of income, resources and opportunities within a region. In pursuing sustainable development, the benefit and losses should be share fairly, now and in the future, the decision should be made in an equitable manner (Giddings, Hopwood, & O'Brien, 2002). However, the UN was only able to evaluate the major aspects of equality in the Human Development Index (HDI) started from 2010. Since the equality and diversity is often emphasised but less often measured, this study collected as much regional variations information as possible when composing an index to evaluate land use sustainability. The discussion is presented in Chapter 6.

During the process of land recycling, the equality issues may be presented under the phenomenon of 'gentrification' and the popular concepts of 'compact city' and 'smart growth' (Smith, 2002; Lees, Slater, & Wyly, 2008b). The design of compact cities usually resulted in replacing a relatively deprived working class with a new group of social elites (Smith, 2002; Lees, Slater, & Wyly, 2008c). The physical urban environment on sites might be improved and the greenfield development might be reduced, but the social justice may be overlooked (for example, the lack of affordable housing or ill quality of life described in Burton, 2000). These subjects are further discussed after the analysis in Chapter 4 and Chapter 7.

2.4.5. Models to Evaluate Sustainable Development

The ambiguity of the definition and the diversification of the interpretations of sustainable development may be reflected in the tools developed to evaluate the sustainability of development (Kates, Parris, & Leiserowitz, 2005). This section reviews several models applied to evaluate the sustainability.

Cost benefit analysis is a tool developed by the neoclassic economist (Goodland & Ledec, 1987). The analysis expressed the economic (or neoclassical economic) view on sustainable development. It requires assigning prices to natural resources or well-being to be evaluated. However, it is difficult to find shadow prices for many intangible assets such as the value of scenery. It is equally difficult to comprehensively evaluate the consequence of the exhaustion irreversible resources in the momentary term using cost benefit analysis. Furthermore, the analysis may overlook the issues of non-renewable resources depletion as well as irreversible environmental damages.

Kuznets curve is a reversed 'U' shape curve used to describe the relationships between environmental quality or social equality and economic development

(Common and Stagl 2005). In this model, the social equality or environmental quality declines when gross domestic product (GDP) increases. However, when the growth of GDP passes a 'turning point', the social equality and environmental quality gradually recover as GDP further increases. If this model is universal, sustainability may be improved by pursuing economic growth. In this way, economic growth is sustainable development and the performance of sustainable development may be measured by the accumulation of wealth. The relationship, however, is not always well established. It depends on the indicators of environmental qualities (Stern, Common, & Barbier, 1996; Heerink, Mulatu and Bulte, 2001). It also inherits the problem of measuring irreversible environmental consequences and therefore, discourages proactive policy to prevent depletion of non-renwable resources (Stern, Common, & Barbier, 1996).

Pressure-State-Response (PSR) model was developed by Organisation for Economic Co-operation and Development (OECD) (Annex II in OECD, 2003a). This model links the effect of human activities with the results of environmental alterations. The model portrays the human activities, especially economic activities, which add pressures to environment and natural resources (the 'pressure' in the model). The pressures change the state of environment (the 'state' in the model). In response to the change, society takes actions to mitigate negative effects, to reverse environmental damage, or to preserve existing resources (the 'response' in the model). Indicators associated with the three phases may be selected to represent the conditions in any particular environment issues (OECD, 2003a). Several environmental sustainability indexes have applied the model in indicator selections (Esty et al. 2005; Esty, et al. 2008).

Considering the impacts of human activities on land uses, PSR may have been realised in monoculture practice to push for higher production (in short period of time) supporting demands of a growing population. The biodiversity of this artificially simplified habitat decreased. The decrease of the biodiversity adds the pressure to the ecosystem. If human society does not take action to remedy the situation, the collapse of the agricultural ecosystem happens. One such example is the Irish potato famine in the last century (Holdren & Ehrlich, 1974).

The OECD (2003a) has suggested that the model itself does not apply any judgement but merely says which linkages exist. It emphasises the impact of human activities but 'misses the important dimension that economic growth does not merely cause pressures on the environment. It brings benefit… (Custance & Hillier, 1998, p284).' Additionally, the model does not cover the issues regarding how the three aspects in sustainable development may be balanced.

Based on different frameworks, models and theories, many studies have dedicated efforts to establish index to evaluate sustainability (for example, The HDI, Environmental Sustainability Index Quality of Life, Green GDP, Sustainable Net benefit, Environmentally Adjusted Domestic Product and Ecological Foot Print). These indexes are usually generated in three steps: (1) normalising or translating the collected variables into dimensionless ranking or ratio, monetarised unit, or a unit of land area; (2) assigning weight to each variable according to the expert opinion or statistic; and (3) aggregating the weighted variables into one sustainable index (Böhringer & Jochem, 2007).

Böhringer and Jochem (2007) indicated several difficulties in establishing a sustainable index based on this procedure. Two of the most controversial problems may be selecting the variables and weighting each variable (Böhringer & Jochem, 2007). The selections of indicators may not always reflect the explicit definitions of sustainable development. Rather, it implied the numbers and ranges of stakeholders participating in the negotiation process in establishing the indexes (Kates, Parris, & Leiserowitz, 2005). With these difficulties, the evaluation results using these indexes could be subjective and should be used with caution. Furthermore, these diverse results reflect part of the inconsistency of the interpretations of sustainability reflecting on the practice of sustainable development (Kates, Parris, & Leiserowitz, 2005).

To specifically evaluate sustainability on brownfield regeneration, several organisations attempted to establish indexes (Franz, Koj, & Nathanail, 2006; Williams & Dair, 2007). Variables in these indexes are represented in mixed quantitative or qualitative ways. The indexes usually focus on evaluating a single brownfield regeneration project but not the overall effect of national policy. Based on these results, it is difficult to argue whether the policymaking balanced the three aspects of sustainable development in a nation. However, the national policy of brownfield regeneration is the focus of this study.

2.4.6. Brief Summary of Defining Sustainable Development

The concept of sustainable development has been repeatedly interpreted based on the 'creatively ambiguous' definition in the *Bruntland Report (Section 2.4.2)*. The interpretations can be in forms of verbal declarations, setting policy objectives, and establishing indexes. Depending on different philosophical values, individuals or institutions may view economic growth or environmental protection as the most important aspects in sustainable development (Section 2.4.2 and Section 2.4.3).

The quantitative measurement of sustainability may not avoid the issues of subjectivities (Section 2.4.5). In addition to the professional judgement involved, the political negotiation also affects what is included in the measurement. It is inconclusive so far regarding what are the 'needs' for the present generations as well as the 'needs' for the future generations. The consensus of one unified definition of sustainable development has not yet emerged.

Sustainable development has become the political agenda to support the action of the brownfield regeneration (DETR, 1999; Grimski & Ferber, 2001; Syms, 2001; Klapperich, 2002; Syms 2010). The measurement of the sustainability of development may be a proper indicator to evaluate brownfield regeneration policy in a country. Chapter 6 demonstrates a process and result of developing an index to evaluate the land resource management under the consideration of sustainability triangle.

2.5. Conclusion

This chapter reviewed two important terminologies in this study: 'brownfield land' and 'sustainable development' (Section 2.3 and Section 2.4). The interpretation of the two concepts both show considerable diversities

Using brownfield regeneration to pursue sustainable development has been advocated by governments and scholars (DETR, 1999; Nijkamp, Rodenburg, & Wagtendonk, 2002; Dorsey 2003). The diversified definitions in both terms, however, raise the questions such as 'How do different types of brownfields affect "sustainable development"?'; 'How may brownfield regeneration operate under different interpretation of sustainable development?' On the other hand, the existence of brownfield land is only one of many factors that have negative impact on sustainability. Therefore, brownfield regeneration is only one of the tools the policymakers can use to improve sustainability. Chapter 4 presents some empirical data of the relationship between brownfield land and sustainability, particularly, socio-economic sustainability.

The ambiguity of sustainable development definition has not resolved the controversy between eco-centric practice and anthropogenic practice (Section 2.4.2). Interestingly, most governments or international organisations hold a relatively anthropogenic view on sustainable development (Section 2.4.2 and Hopwood, Mellor, & O' Brien, 2005). Additionally, the issues of socio-economic inequality are considered important but have not been fully evaluated until very recently (Section 2.4.4).

Brownfield land has its root in industrialisation and urbanisation (Section 2.2). These processes complicate socio-economic development (or deterioration) as well as environmental development (or deterioration). This study takes a more anthropogenic approach, viewing social, economic and environmental sustainability equally important (explained in Section 2.4.2). Based on this view, an index is generated to evaluate the effectiveness of land use sustainability (Chapter 6).

Institutions are considered the active agents to promote sustainable development (Section 2.4.3). Based on the result of sustainability in current land use (Chapter 6), the usefulness of current brownfield regeneration policies in pursuing sustainable development can be discussed (Chapter 7 for England and Chapter 9 for Taiwan). A recommend framework to improve sustainability via brownfield regeneration may then be established (Chapter 10).

Chapter 3 Methodology

Because of the ambiguity of the definitions of 'sustainable development' and 'brownfields' (Section 2.3 and Section 2.4), this study explores the factors that affect contemporary interpretations of sustainable development and brownfield regeneration. The exploration forms the basis for developing the framework of defining brownfield land in the context of policies or regulations to pursue sustainable development.

Various methods were applied at different stages of the investigation; the choice of methods depends on the objectives of the analyses, and on the nature of the available data to be analysed. This chapter provides the background information of the analysis. The chapter also explains the methods utilised to analyse the questions of interest. The explanations are followed by justifications for utilising the said procedures. Detailed steps of conducting the studies and the reviews of the data analysed are documented in each corresponding chapter.

3.1. The Relationship between Brownfields and Sustainable Development

There is a belief that brownfield regeneration is a tool for sustainable development (for example DETR, 1999). However, other arguments suggested that the brownfield redevelopment could become a means of gentrification and does not always contribute to sustainability (Smith, 2002; Lees, Slater, & Wyly, 2008b; and further explained in Section 4.1). Both sides have provided the case studies to support the arguments. Since brownfield redevelopment may lead to either sustainable or un-sustainable situations based on different case studies, this study utilised quantitative data of socio-economic sustainability and brownfield land in local authorities in England to clarify in general, whether reusing brownfields improved or reduced the sustainability.

In **Chapter 4**, I present the analyses of the relationship between the Index of Multiple Deprivation (IMD) from the Department for Communities and Local Government (DCLG) and the estimations of PDL areas in each local authority from NLUD-PDL. The IMD may represent the (English) view of socio-economic sustainability, and the PDL (defined as brownfield land by the UK government for

England) statistics may represent the scale of brownfields in England. Therefore, it was expected that the ways the deprivation scores behaved in relation to the amount of PDL areas depict the effects of the existence of brownfields on sustainability.

Before the relationship was established, the characteristics of the variables in the two databases were studied (Section 4.3.1.1 and Section 4.3.1.2). The characteristics of deprivation conditions (Figure 4.3 to 4.5) and PDL status (Table 4.1) in England were summarised. The distributions of IMD scores in nine regions (Figure 4.3 and Figure 4.13) as well as PDL scales in England (Figure 4.12) were depicted. Likewise, the distributions of IMD scores (Figure 4.9) as well as PDL scales depending on development densities in England were also described. The tools of data exploration such as box plots and the student t-test were applied to look at the effects of region and urbanisations among local authorities in England. Finally, the scatter plots between the IMD and PDL were generated to look at the relationships between the areas of the various types of brownfield and socio-economic sustainability. The relationships were examined based on regions, development densities and deprivation domains.

The use of data collected from local authorities in England was based on several considerations. In addition to the databases available on-line for free, the socio-economic conditions and the estimation of brownfields at local level in England have been regularly updated. No other country has provided free information systemically to the public. For example, since Oliver et al. (2005), detailed and updated statistics on brownfields in these European countries could not be located in the research discussing brownfield regeneration. Adams, De Sousa, & Tiesdell (2010) described the difficulties in aquiring brownfield data in North America counties. Therefore, although the definitions of brownfields and deprivation by the UK government may not be fully generalised to other countries as showed in Chapter 2, and neither can the relationship between the two, I decided to use these two databases as my point of departure.

In addition to data availability, the databases provide detailed coverage on the deprivation conditions and PDL to the level of local authorities, some to the smaller areas within a local authorities named lower super output area (LSOA). The large number of the data points (more than 300 points) decrease the uncertainty of statistic significance (or insignificance) observed in the analysis. Moreover, the IMD reported in 2004 and 2007 provided not only an overall deprivation ranking and scores for the local authorities but also different rankings and scores in various aspects of deprivation (Table 4.3 and Section 4.4.4). Therefore, the effects of brownfield land on various types of deprivations were discussed.

The use of scatter plots, box plots and t-tests was based on the consideration of unclear relationship between sustainability and brownfields. Since previous research pointed to both negative and positive effects of brownfield redevelopment on sustainability (Section 2.4.4.), no presumption of how the data points would behave was made prior to the analyses. Applying these methods to considerable amount of data points, the trends, if any, between the variables can be observed. A data exploration using scatter plots and box plots may reveal interesting patterns for further interpretations without the prerequisite of data distribution. To evaluate the significance of observed differences in the scatter plot illustrations, t-tests were sometimes conducted. However, the results of the tests alone should not be treated as the definite evidence since the distributions of data were not necessarily normal distributions or t-distributions.

3.2. The Effect of Development Densities

Chapter 4 shows that the densities of development (percentages of built-up areas in local authorities) affected the distributions of PDL and IMD conditions (socio-economic sustainability) in England (Figure 4.8). On the other hand, at global level, Oliver et al. (2005) demonstrated the population densities influenced the ways policymakers define the term 'brownfields' for the economic competitive (thus economic sustainability) European countries. In **Chapter 5**, therefore, I further verified the effects of population densities (an indicator of the development density) on the strategies used to achieve sustainability among countries worldwide. It was hoped that based on the knowledge of the effects of population densities on both sustainable development and brownfield policies in this analysis, I aimed to find a pattern of successful brownfield policymaking based on different development densities among countries.

I investigated the degree of sustainability of countries in relation to their population densities using three different sustainable indexes: Environmental Sustainable Index established in 2005 (ESI 2005), Environmental Performance Index in 2008 (EPI 2008), and the IMD World Competitiveness between 2005 and 2009 (Section

5.3). The choice of the indexes was based on several considerations. First, the sustainability in this study should refer to the three aspects sustainable development aims to improve: social, economic and environmental (Chapter 2). In the literature, no one index covered all three of them equally. Therefore, several indexes were review to collectively cover the three aspects. Second, this thesis is primarily concerned about the policymaking of brownfield regeneration at national level. The reviewed indexes evaluated the performance of sustainability at that level. Moreover, since the country of my primary interest is Taiwan, I chose those indexes that include Taiwan in their evaluations.

Additionally, ESI 2005 and EPI 2008 were developed by the same group of institutions and were aimed at evaluating 'environmental sustainability' (Section 5.3.4 and Section 5.3.5). Comparing the contents and results of these two indexes may further contribute to the discussion of defining sustainability (Section 5.4.2). The IMD World Competitiveness Scores in 2004 were used in analysing the brownfield definitions of the European countries (Oliver, et al., 2005). This chapter expanded the analysis to validate if the statement made in Oliver et al. (2005) also applied to countries outside Europe. Therefore, utilising the style of scatter plot in Olive et al. (2005) makes the verification easier and clearer (framework of the analysis further explained in Section 5.3.6).

3.3. Principal Components in Land Use Sustainability

Chapter 6 continued the quests on the interpretations of sustainability based on sustainable indexes in previous chapters. For example, the sustainability ESI 2005 measures the projection of the sustainability of each country while the EPI 2008 measures the current performance. They both looked at 'environmental sustainability' but at different timeframes (current or future). Other examples include the IMD World Competitiveness that measures economic and business sustainability in a country, and the HDI by the United Nation that is concerned about the sustainability of human society. These indexes, though claimed to measure 'sustainability', used different sets of variables and resulted in different rankings of the sustainability of countries worldwide (example in Table 6.1 and Table 6.4).

Rose (2005) indicated that benchmark standard stimulates policymakers to identify rooms for improvement in relation to their peer countries. However, given this variety of the measurements of sustainability, the policymaking based on different benchmarks may produce very different results. Therefore, before generating a principle to define brownfield in the regeneration policy, exactly which benchmark for 'sustainability' to use needs to be determined.

In a way, the collection of variables in an index represents the interpretation of sustainability (Mitchell, 1996; Kates, Parris, & Leiserowitz, 2005; Siche, et al., 2008). Brownfield regeneration always involves issues of land use and planning. Therefore, the benchmark for brownfield redevelopment should reflect this nature. Therefore, it should specifically collect the variables measuring land use sustainability. Chapter 6 collected the variables that are relevant to the issues of brownfield regeneration to establish an index to evaluate sustainability of land use (Table 6.2). The collection was particularly interested in the variables that described regional variations within a country. The collection of variables in this chapter is the interpretation of the sustainability of land use sustainability in this study.

I first chose quantitative variables from various databases collected and maintained by international organisations (summarised in Table 6.2). I then applied principal component analysis (PCA) to these variables. The results of the PCA determined what weights would apply to different variables in the index so that the environmental, social and economic aspects were quantitatively equally represented in the index. Based on the result, I discuss the significance of land use sustainability between advanced economies and emerging economies (Section 6.5.2). I also discuss what is important for the countries with high population densities to maintain, if not improve, the practices of sustainable development (Section 6.7).

Two important issues concerning establishing the index were the choice of variables at the national level, and applying weight to the variables to balance the social, economical and environmental aspects (Section 6.3.1.).

To fulfil the objectives of this study, three criteria were applied to the selection of variables. They are the relevance to sustainability, the relevance to land use, and the relevance to brownfields (Table 6.2). In addition, the selection of the variables may be constricted by data availability.

In determining the weight of variables in a composite index, four types of methods have been described in the literature (Bohringer and Jochem, 2007; Distaso, 2007;

Singh, Murty, & Gupta, 2007; Lawn, 2003; Sands and Podmore, 2000; Lawn and Sanders, 1999). They are equal weighing, converting the variable into standardised units (for example, currency, carbon foot print), weighting according to public or expert opinion, and weighting according to the results of statistical analyses such as regression analysis and principal component analysis (PCA). As Freudenberg (2003) indicated, each of them has limitations: Analysing each variable with equal weight ignores the possibility that different variables influence sustainability in various degrees; opinion-based weighing may introduce subjectivity that distorts the index; using the statistical methods (or so-called empirical methods) may risk misinterpreting the accidental correlations as real-world links.

None of the approaches is perfect. I selected PCA in this study for its potential to produce weights for the variables to make the index equally represent three aspects of sustainability as well as subjectively evaluate the performance of the sustainability.

3.4. Brownfield Policymaking and Target Setting – England Experience

In Chapter 6, the result of the index measuring sustainability of land use indicated that the countries with high population densities such as the UK and Taiwan need to limit their greenfield developments to maintain the land use sustainability. Therefore, in **Chapter 7**, I investigated the degree of protection greenfields received by implementing brownfield policy in England.

I reviewed the policy debates on defining house garden[1] as part of brownfields in the UK parliament (Section 7.3). I analysed the voting results of relevant bills to make sense of the effects of party politics on brownfield policymaking (Section 7.5). I then validated the reasoning in the debates on infill development with the actual

[1] A house garden, strictly speaking, is not considered greenfields that has little anthropogenic impact, but is considered urban green space. The analysis of the debates, therefore, was about the controversies regarding the effects of the definition of brownfields on urban planning. However, it was revealed latter on in the relevant statistics with this issue that the same definition has allowed the development of urban green space as well as further greenfield developments.

land use data in England to check whether the results of brownfield policy have functioned as claimed by the government (Section 7.6).

Within the UK, devolved administrations have defined brownfields differently (Section 7.1). The choice of England for this analysis was based on several considerations. First, England has been where most of population of the UK reside. There are about 50 million people living in England. That is 85% of the population in the UK. If the UK is considered as a nation with high population density, England has even higher density of population (about 1.5 times the national average). Additionally, comprehensive quantitative data on land use as well as the qualitative policy deliberations about England can be easily located. Particularly, England claimed to have reached the set target on brownfield recycling. Data of land use and policymaking may further prove (or disprove) that the brownfield policy have contributed to environment sustainability.

3.5. Differences between Plan and Reality – Taiwan's Current Land Use Condition

Similar to England, Taiwan has extremely high population density. Therefore, greenfield preservation is also a serious issue on land use sustainability in Taiwan (Chapter 6). Before investigating the impact of the brownfield definition on the land use, in **Chapter 8**, I reviewed the transition of the land development in Taiwan between 1990s and 2000s. This helped to determine whether the built-up areas in Taiwan have expanded faster than the population growth. The actual land use, compared to the planning designed by the government may assist to understand whether the development has been carried out according to the planning design. The results became the basis of the analysis in the next chapter.

I reviewed the classifications of the two land use surveys to determine the class of land that should be considered as a built-up area (Table 8.2). The changes of built-up areas between the two surveys were analysed quantitatively as well as qualitatively. The quantitative analysis depicted the changes of the development densities in built-up areas in counties and cities of Taiwan (Section 8.3.1). The comparison between (qualitative) classifications in the two surveys revealed the changes in the attitude of the policymakers (or government administrators) towards land resources (Section 8.2.1.3). Furthermore, I compared the urban planning statistics to the land use surveys. The comparison verified whether the changes of the attitudes of the government on land management have translated to the actual land use of local people (Section 8.3.2).

The choice of utilising land use surveys and planning statistics were based on the following considerations: The land use surveys were conducted by fieldwork of surveyors and the review of aerial photos (Section 8.2.1); the results of the surveys reflected the actual land use of the areas at the time of inspection. Therefore, the changes in built-up areas may be considered the direct evidence of the degree of greenfield development (this is further explained in section 8.3.1.1). The planning statistics quantitatively described government's plan on land use (Section 8.2.2 and Section 8.2.3). The surveyed results, combined with the planning statistics may reveal if the actual degree of development (change of built-up areas) has been done according to the planning. Finally, the two comprehensive land use surveys were conducted several years before and after the promulgation of brownfields related regulation in Taiwan (a.k.a. SGPRA) in 2000. The dynamic of built-up areas during this period could be affected by brownfield recycling.

3.6. Transitions of Unused Land and Contaminated Land in Taiwan

In **Chapter 9**, I investigated whether the brownfield policy in Taiwan have hindered the reuse of land resources and facilitated the sprawl observed in the result of Chapter 8. The designated polluted sites have been viewed as brownfields in Taiwan. Thus, the regeneration of brownfields was usually viewed as reclaiming contaminated land (Wu 2008). It is commonly believed that current contaminated land regulations have blocked the progress of regeneration. Therefore, I analysed whether these regulations are responsible for the sprawl of the settlement observed in the counties in Taiwan (Chapter 8).

Search and review of the news reports on two polluted sites using the China Times news archive provided one explanation regarding the impression of the negative effect of contaminated brownfields on redeveloping process (Section 9.1). The regulatory review showed the issues commonly believed to be the barrier of the regulation (Section 9.3). I then identified all the designated polluted sites from the database maintained by TEPA to quantitatively verify this impression (Section 9.4).

The descriptions of the sites in the database were utilised to identify the uses of the land right after being designated as ‘polluted’. The conditions of the sites became the basis to calculate the probabilities of the vacancy of the designated sites. The probabilities were the dependent variables in the logistic regression. It was assumed that the probabilities change according to the selected factors (independent variables). Particularly, if the probabilities of designated sites in the counties are higher than those in the cities are, the brownfield policy in Taiwan might have something to do with the sprawls. Other factors considered affecting the land use of brownfields such as the attitudes of local authorities, regional differences, and the previous land uses were also analysed in this regression.

I considered analysing the database suitable to answer the question in Chapter 9 because the designation has been conducted in accordance with SGPRA 2000, the regulations considered related to brownfields in Taiwan. The database provided a comprehensive list of designated polluted sites in Taiwan and its current usages. There could be sites that were polluted but have not been identified and thus designated (Section 9.2). The sites are not included in the analysis. However, since the vacancy or use of these sites does not result from designation in accordance with the SGPRA 2000, they are not the focus of this chapter.

For each designated polluted site, the dataset provided the attributes of the site in numerical or categorical manners (Table 9.3). The qualitative description of the land use of sites makes it difficult to precisely quantify the intensity of land use. Therefore, I converted the land use description into a binary variable, simply ‘vacant’ or ‘in use’. Consequently, the binary logistic regression was applied to evaluate the relationship between current land use and other characteristics of the polluted sites. This type of regression is often utilised when a dependant variable is binary or categorical (Chatterjee & Hadi, 2006). An additional advantage of using logistic regression is that it makes no assumption about the distribution of the independent variables. The independent variables could be categorical or numerical (Chatterjee & Hadi, 2006). Therefore, this method may be applied to the database without examining the distribution of each variable and is considered suitable for the nature of the dataset and the purpose of the analyses.

Additionally, both forward and backward stepwise (logistic) regressions were performed. The forward stepwise adds independent variables one by one to test the significance of the variables in the model; the backward stepwise starts with entire collection of independent variables and eliminates the insignificant variables one by one. If two procedures produce the same final result, it is more likely that the result is not sensitive to the analytical procedure and therefore, is more robust.

Chapter 4 Relationship between Brownfields and Sustainable Development

This chapter presents the test of the assumption that reduction of brownfield areas may improve socio-economic sustainability. The evaluation was based on the scatter plots depicting the relationship between deprivation data (Index of Multiple Deprivation) and previously developed land (PDL) percentages in the local authorities in England.

The scatter plots revealed although increasing amount of previously developed land (PDL) may increase the chance of deprivation, less amount of PDL did not necessarily lead to more sustainable communities. There are two possible explanations: First, the existence of a brownfield site is not the only factor that results in deprivation; second, it is possible that brownfields reduction has not been conducted in a way that deprivation level may be reduced. Therefore, to apply sustainable brownfield regeneration, the process of the regeneration needs to be carefully designed to prevent negative effects and enhance positive effects.

4.1. Land as a Renewable Resources

The land use in human societies may form a continuous cycle (Klapperich, 2002). Therefore, the land should be a renewable resource. However, the existing derelict and vacant properties implies obstacles preventing the reuse of land.

Klapperich's real properties life cycle considers stages between the changes of ownership for a property. Under the same owner, land use can be changed or properties renovated until the they are sold to the next owner. On the other hand, Smith (1979) suggested that during the period of an ownership, the land value kept on growing but the existing infrastructure depreciating and property price decreasing. The difference between potential land value at its optimised use and the current capitalised land value started to show. This is so called 'rent gap'. If the rent gap increases to a degree to make a potential buyer or developer considered the land profitable, the buyer or developer may purchase the properties to extract profit from better use of the land. The land is physically recycled as Klapperich (2002) proposed. However, this type of redevelopment could potentially displace the poor residents in the communities without solving the problems of deprivation. Thus, in the social perspective, the outcome of land recycle is not always sustainable. However, from the natural preservation point of view, land recycling is beneficial, 'On[c]e acre (~0.40 ha) of redeveloped brownfields has been estimated to conserve 4.5 acres of greenfields sprawl development (The World Bank, 2010, p 43).'

However, greenfield development is usually less costly and risky than brownfield redevelopment (De Sousa, 2000; McCarthy, 2002; Nijkamp, Rodenburg, & Wagtendonk, 2002; Stead & Hoppenbrouwer, 2004, the World Bank, 2010). Developers may favour the greenfield development over taking advantage of the rent gap mentioned above. In addition, the pollution left by previous land use, the existing nuisance in the communities, or the high level of crime and the atmosphere of threat created by deindustrialisation or dereliction may make the land unattractive (McCarthy, 2002; Nijkamp, Rodenburg, & Wagtendonk, 2002; Stead & Hoppenbrouwer, 2004, the World Bank, 2010). Furthermore, in many cases, the sense of class has played an important role in the urban development or gentrification (Lees, Slater, & Wyly, 2008a). All these factors influence the decision of new owners or developers to move in or to build on a site that has previously been developed. The redevelopment of the land may not be done without additional financial incentives or political interventions.

4.2. Factors that May Affect Land Recycling

This section briefly reviews the previous work on urbanisation and regional development in England relevant to brownfield redevelopment. Urbanisation and regional development are two possible factors affecting sustainable land reuse.

4.2.1. Degree of Urbanisation

The higher demand on land and space in urban areas is reflected by higher land prices in the area. Therefore, the derelict or vacant properties in a densely developed area could represent opportunities and financial benefit for redevelopment (Smith, 1979). CABERNET (2006) proposed a puzzle model further describing how this works. The model assumes within a fully developed urban system, an empty space is desirable for planners to renew some infrastructure without completely obstructing the functions of a city. Therefore, certain amounts of brownfield areas may become an opportunity for better planning. However, in a less urbanised area, this model may not apply since the greenfield development may be considered cheaper and easier (Section 4.1). Brownfield sites in settlements with different degrees of urbanisation are expected to be appreciated differently by the stakeholders involved in the redevelopment process.

Stead and Hoppenbrouwer (2004) presented evidence that 'city living' has advantages such as quick access to local facilities, convenient public transportation, better access to employment opportunities, and more occasions for social interactions. In the perspective of governments, more people living in the urban area could mean less greenfield development, more efficient delivery for power and water, and better accessibility of public facilities. These lead to more public saving and better environmental conservation, which can contribute to sustainable development. However, many people, if they can afford, still prefer to live in rural areas for better quality of life (for example, better air quality), and better access to green space. The factors that improve quality of life in urban and rural differ. This affects the potential of brownfield redevelopment. For this reason, the degree of urbanisation is considered possible factors affecting the relationship between brownfield recycling and sustainable development. It is not clear, however, how the degree of urbanisation would affect the relationship.

4.2.2. Regional Differences

For administrative purposes, England has been divided into 9 regions (the North West, North East, the Yorkshire and the Humber, the West Midlands, the East Midlands, the South West, London, the East of England, and the South East). Their regional developments are quite distinct from each other.

The concept of 'North-South divide' in England refers to political, economic and cultural differences between the northern regions (the North West, the North East, the Yorkshire and the Humber) and the southern regions (the South West, the London, the East of England, and the South East). The lines dividing the north and south run through the midlands in different fashions in the literature based on time of the studies and the subjects of discussions. For example, Martin (1988) pointed out during the second half of 1990s, the southern regions enjoyed prosperities while the northern regions experienced economic depressions. The service sector expanded and job vacancies increased in the south, while the industrial sector declined in the north (Martin, 1988). The overall unemployment increased rapidly in the north while more small businesses established in the southern regions (Martin, 1988, Keeble & Bryson, 1996). Particularly in the South East, house prices were the highest (Green, 1988). The political views of the two regions have been distinct as well (Martin, 1988). Social class division between north and south was still observed at the beginning of the millennium. The division even affected the epidemics of many health conditions (Doran, Drever, & Whitehead, 2004).

The variations between the north and south that affect land use demand could change over time: Different aspects of regional differences may exacerbate the issues of land use or antagonise the negative effects. For example, Blackaby and Murphy (1995, p.500) indicated that in the early 80s, 'little would be gained by individuals in employment in the north migrating south; their expected real wage is actually lower. It is not surprising, then, that many non-manual employees are only enticed to move south by very favourable mortgage schemes.' In this case, job opportunities had little effect on the demand of land in the south but the mortgage schemes had. Furthermore, it should be noted that the north and south divide is a generalised idea (Green, 1988). It overlooked the variation within the regions.

The other differences between the nine regions that may have a bearing on brownfield regeneration are the population and land resources. Figure 4.1 is a summary of current population distribution and land resources in each region. Both south and north have relatively densely populated regions (such as the North West and the South East) and less densely populated region (especially the South West). Therefore, both north and south could have similar rural and urban issues related to land use. The Greater London region is a special case in England considering its population density. Fifteen percent of the population of England resides in this 1% area. The population density is more than 10 times of other regions.

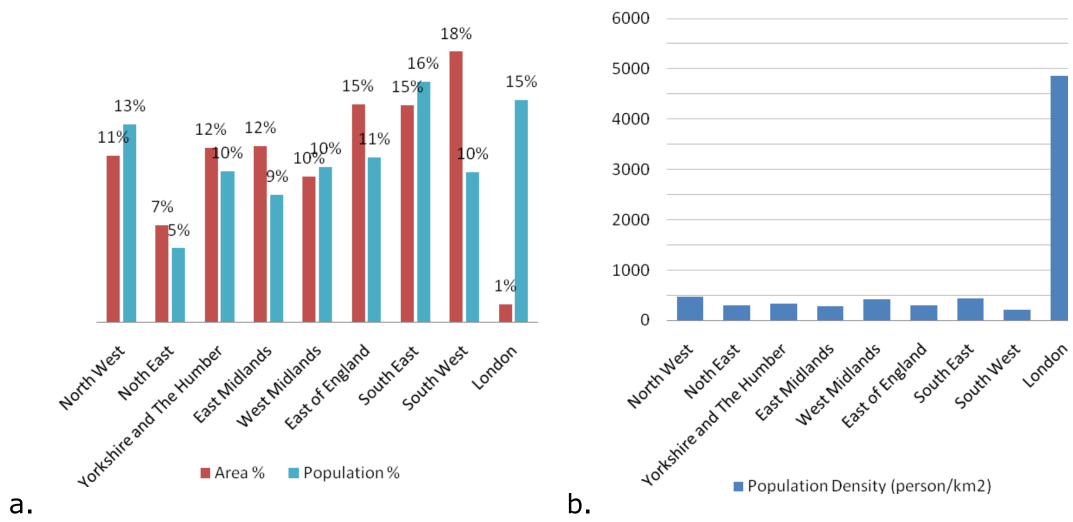


Figure 4.1 Summary of Land and Population of Regions in England (Area Estimation based on ONS (2011a), and Population Estimation Based on ONS (2010))

The socio-economic differences between northern and southern regions, between rural and urban regions are considered relevant to land use and thus brownfield regeneration strategies. Therefore, in the analyses presented in this chapter, regional differences were taken into consideration.

4.3. Examining the Relationship between Brownfields and Socio-Economic Conditions

The process and result of sustainable development concerns this study. One of the negative signals of sustainability is deprivation. The British government has established the Index of Multiple Deprivation (IMD) to monitor the degree of deprivation conditions in each local authority in England (DCLG, 2008b). This index measures people's living conditions such as the financial difficulties and social exclusion. Some parameters that measures physical environment such as air quality and distance to local facilities or services are also included because they affect the well-being of residents.

The government considered brownfield recycling as one of the means to reduce local deprivation (ODPM 2003); PDL was considered brownfields in the policy (DCLG, 2010a). Therefore, the quantities of PDL areas have been collected from local authorities by the NLUD-PDL to assess the performance of brownfield reduction

(Section 4.3.1). Furthermore, under this definition of brownfield, relatively larger numbers of brownfield sites in England are located in relatively deprived areas (DCLG, 2008a; Syms, 2010). This might reinforce the impressions that reduction of brownfields can alleviate the deprivation.

To establish how the existence of PDL affects deprivation conditions, I investigated the relationship between percentage of PDL and various deprivation scores in each local authority or lower super output area (LSOA) (Section 4.3.3 to Section 4.3.5). If the existence of PDL, as generally believed, results in deprivation, we should observe higher deprivation scores in the local authorities exhibiting higher percentages of PDL.

Additionally, the local authorities were further grouped based on degree of urbanisation or regions when analysing the PDL-deprivation relationship (Section 4.3.5). This is to account for the possible influences of urbanisation and regional variations on the relationship (Section 4.2.1 and 4.2.2). The relationships could also reveal whether in the local authorities with higher degrees of urbanisation, the existence of brownfields has become an opportunity to improve the quality of living.

Finally, the effects of PDL on different types of deprivations could vary. Therefore, the relationship between PDL and the seven deprivation domains were investigated (Section 4.3.4 and 4.3.5).

4.3.1. National Land Use Database of Previously Developed Land

The National Land Use Database of Previously Developed Land (NLUD-PDL) has kept track of PDL in England since 2001. Local authorities register the PDL and vacant buildings with the NLUD-PDL in one of six classes (Section 2.3.2).

4.3.1.1. General Description of the PDL Data

The NLUD-PDL was a database organised by English Partnerships (now part of the Homes and Communities Agency) and DCLG. Now it is managed by Home and Communities Agency. The PDL data have been voluntarily reported by local authorities since 2001. In the first year, two hundred and twenty three out of 354 local authorities (63%) reported the condition of their PDL. Since 2004, all local authorities except one (Gateshead) have provided updated land use data. The frequencies of updating data, however, vary among local authorities. Ninety-two percent of the local authorities updated the data in 2004 (ODPM, 2005). Some of the planning authorities have continuously reported their revised land use figures after 2004.

Only the data of categories A to D PDL were published in 2001. From 2002, the data of category E were also published. Although Category D and Category E constitute 'land in use', some temporarily unused structures may exist on the land. They are included in the PDL in the NLUD-PDL. The the types of PDL is explained in section 2.3.2.

This study obtained PDL data at local authority level from annual return by the local authorities to the NLUD-PDL (ODPM 2005). Detailed PDL data at lower super output areas (LSOA) were obtained from Office for National Statistics (ONS) (ONS, 2011b).

The local authorities have been asked to report land that is equal to or greater than 0.25 hectares since 2003 (ODPM, 2005). Otherwise, they may classify PDL within their administrative boundaries and determined the size of land that is significant to be recorded.

Between 2001 and 2004, the percentages of reported Category D PDL increased significantly (Table 4.1). However, the increase in Category D PDL became negligible when it is combined with other types of PDL.

In 2004, one local authority (Isles of Scilly) out of 353 reported 0 hectares of PDL within their administrative territories. Leeds, on the other hand, reported the largest sum of PDL, nine hundred and eighty two hectares. The highest percentage of PDL, 1.04%, was reported by Newham (377 hectares of PDL).

LSOA is a geographic unit that generally encompasses 1,000 to 3,000 people. England had 32,482 LSOAs in 2007 (DCLG, 2008b). The sizes of the areas range from 68,374.36 hectares (a LSOA in Tynedale; the code is E02005727) to 18.36 hectares (a LSOA in Kensington and Chelsea; the code is E01002842). Local authorities in England also vary in size and population. The biggest local authority is Bassetlaw (13,818,785 hectares) and the smallest is the City of London (3,345.52 hectares). As a result, each local authority has different number of LSOA.

Table 4.1 Comparison of PDL in Local Authorities in England between 2001 and 2004

Types of PDL	Average in Differences between 2001 and 2004 (hectare)	Distribution of PDL in Local Authorities of England (unpaired t-test value)	Change of PDL in Individual Local Authorities (paired t-test value)
Category C	*-4.06*	*0.662*	*0.216*
Category A	*-0.31*	*0.936*	*0.845*
Category B	*-1.08*	*0.547*	*0.179*
Category D	*12.83*	*0.028**	*0.004**
Total	*7.37*	*0.638*	*0.252*

**The difference considered statistically significant (p<0.05)*

At LSOA level, one hundred and twenty six out of 32,482 LSOA (0.39%) did not have record of PDL (all within the administrative area of Gateshead); twenty five thousand and seven hundred sixty-seven (about 80%) reported zero hectares of PDL. Among the LSOAs reported the existence of PDL, the largest total area of 730 hectares was reported by a LSOA in Peterborough (LSOA code 02003256). It is equivalent to 5.02% of the area in this LSOA. However, a LSOA in Wigan (LSOA code 02001319) reported the largest percentage of PDL, 39.43%. It was 268 hectares out of 679.7 hectares of the LSOA.

4.3.1.2. Issues in Data Manipulations

The downloaded dataset contains worksheets from the ONS with estimation of PDL at government office region (GOR), local authority (LA) and lower super output area (LSOA) level (ONS, 2011b). Some significant discrepancies among the three layers were observed. The differences might be the result of imputation. ODPM (2005) explained that the imputation was conducted under the assumption that the registered data was incomplete. The equations utilised for imputation have not been provided but it was stated that sixteen parameters such as the degree of urbanisation in local authorities, and the completeness of PDL survey are included in the procedure. Additionally, the area of each Category of PDL at local authority level is rounded to 10 hectares in the report. At LSOA level, data were neither imputed nor rounded. The published official evaluation of the PDL was based on the imputed data (ODPM, 2005).

Figure 4.2 shows a comparison of total PDL percentage between the 'imputed' PDL area from ONS and the sum of PDL area for each local authority from its LSOAs.

The line extends from the lower left corner to the upper right corner indicated the imputed value is equal to the reported value. The majority of the data is distributed above but close to the line. This implies that the imputed numbers are usually equal to or higher than the numbers added up based on the PDL in LSOAs. This is reasonable given the consideration of imputation is incompleteness of the registered PDL areas. In addition, the slightly smaller imputed numbers may be explained by the effect of rounding. However, some of the numbers are lower than rounding may explain (Table 4.2). Because of the unexplainable difference of these numbers, in the analyses of this study, the original (not-imputed) PDL data were used (Section 4.3.1.1). The effect of this difference was discussed in Section 4.5.5.

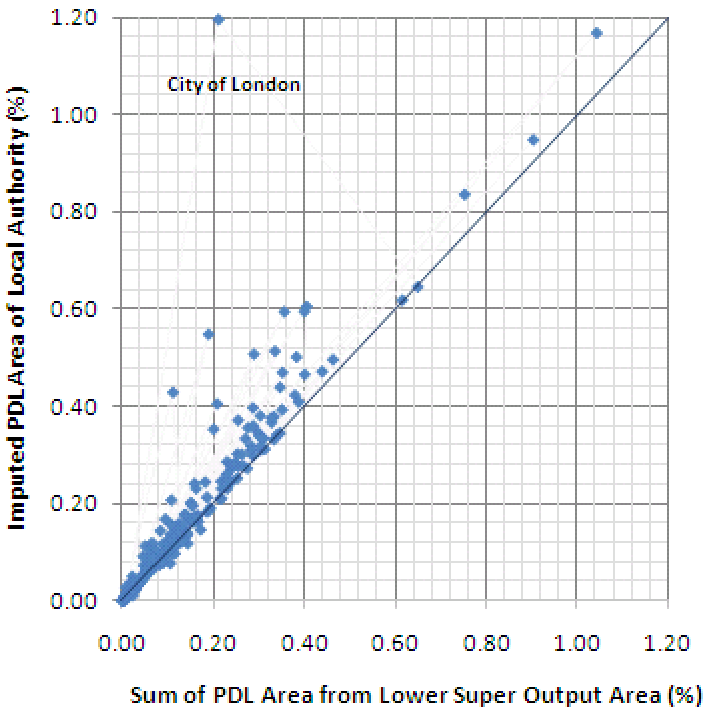


Figure 4.2 The Difference between the Imputed and Reported PDL in Each Local Authority

Table 4.2 The Discrepancies that Cannot be Explained by Incompleteness or Rounding

Local Authority Code	Local Authority Name	Imputed Total PDL*	Reported Total PDL**
34UC	*Daventry*	*0*	*11*
37UF	*Mansfield*	*60*	*80*
22UL	*Rochford*	*10*	*20*
26UJ	*Three Rivers*	*10*	*21*
33UD	*Great Yarmouth*	*30*	*40*
11UF	*Wycombe*	*40*	*50*
15UE	*North Cornwall*	*450*	*460*
15UF	*Penwith*	*10*	*20*
47UF	*Wychavon*	*10*	*21*

**ONS, 2011b*
***ODPM, 2005*

4.3.1.3. Limitation of National Land Use Database

Given the considerations of imputation (Section 4.3.1.2, ODPM, 2005), some inherited issues of using the original data may need to be taken into account. There is a possibility that the reporting of data from local authorities is not comprehensive and only reflects the areas they have conducted the survey recently. The incomplete records of PDL in the local authorities may affect the result of the analysis. However, using the original data set, I can be more certain that the potential errors may be the results of underestimation of PDL in some of the local authorities.

Another limitation of using the database in this analysis may be the frequency of the data update. Since the voluntary reporting of the local authorities may not be done annually, the database published in 2004 is essentially displaying the data reported in up until 2004. In the record of 2004, one data entry was carried over from 2001, four from 2002 and fourteen from 2003 (ODPM, 2005). This could be the source of errors.

Furthermore, using data in 2004, in conjunction with the Index of Multiple Deprivation Data published in 2007 might not be ideal to analyse the effects of brownfield land on the socio-economic deprivation (further discussed in Section 4.5.2 and 4.5.5). However, this is the best available and most complete dataset in England at the time the study was conducted.

Finally, the data in the NLUD-PDL cannot completely explain the flow of the previously developed land. Some trend may be revealed by comparing chronological data between different categories. For example, after one year, Category A or B PDL might move into Category C. if not redeveloped However, these comparisons are neither complete nor precise. The actual reasons for the fluctuation of PDL cannot be explained without detailed field investigation.

4.3.2. Index of Multiple Deprivation (IMD)

The degree of deprivation within each local authority was obtained from DCLG (DCLG, 2008b). The Index of Multiple Deprivation (IMD) incorporated seven components including income, employment, health, education, housing, crime and living environment (ODPM, 2004b; DCLG, 2008b). The parameters utilised in each of these domains are listed in Table 4.3. The index was not specifically established to assess brownfield regeneration. However, these parameters covered major consequences that could result from the existence of brownfield sites. Some deprivation conditions such as unemployment could be a direct and immediate result of derelict industrial land. Other deprivation conditions such as poor education performance could be the long term or indirect effect of a brownfield site.

The parameters estimated the degree of deprivation primarily based on the percentages of population exhibit one or more deprivation characteristics in a local authority or a LSOA (Table 4.3); additional parameters described deprivation conditions that may cause by poor infrastructure (such as the distance from household to the nearest post office).

The IMDs published in 2004 and 2007 were utilised in the analysis. These are the most updated IMDs at the time this study was conducted. The data used to calculate the IMD 2007 were collected between 2003 and 2005 (DCLG, 2008b); those used to calculate IMD 2004 were collected between 2000 and 2001 (DCLG, 2006b). Changes of scores between 2004 and 2007 are not statistically significant (paired t-test, $p=0.18$[2], un-paired t-test, $p=0.87$).

[2] The null hypothesis is the average values of differences within local authorities are not significantly different from zero.

Table 4.3 The Weights of Deprivation Domains

Deprivation Domain	Sub- domains	Weight in Deprivation Index	Components in the Deprivation Domains
Income deprivation	**-**	*22.50%*	*Income Support Household, Job Seekers Allowance Households, Pension Credit (Guarantee) Households, Working Tax Credit Households, Child Tax Credit Households, National Asylum Support Service (NASS) Supported Asylum Seekers*
Employment deprivation	**-**	*22.50%*	*Recipients of Jobseekers Allowance, Participants in the New Deal, Incapacity Benefit recipients, Severe Disablement Allowance Recipients*
Health deprivation and disability	**-**	*13.50%*	*Years of Potential Life Lost, Comparative Illness and Disability Ratio, Measures of acute Morbidity, The Proportion of Adults under 60 Suffering from Mood or Anxiety Disorders*
Education, skills and training deprivation	**Children / young people sub domain**	*6.75%*	*Average Test Score of Pupils at Key Stage 2 and Stage 3, Best of 8 Average Capped Points Score at Key Stage 4, Proportion of Young People not Staying on in School or non-Advanced Education, Secondary School Absence Rate, Proportion of those Aged under 21 not Entering Higher Education*
	Skills sub domain	*6.75%*	*Proportion of Working Age Adults with No or Low Qualifications*
Barriers to housing and services	**Wider barriers sub domain**	*4.65%*	*Household Overcrowding, District Level Rate of Acceptances under the Homelessness Provisions, Difficulty of Access to Owner-Occupation*
	Geographical barriers sub domain	*4.65%*	*Road Distance to a GP Surgery, Road Distance to a General Store or Supermarket, Road Distance to a Primary School, Road Distance to a Post Office or Sub Post office*
Crime	**-**	*9.30%*	*Burglary, Theft, Criminal Damage, Violence*
Living environment deprivation	**The 'indoors' living environment sub Domain**	*4.65%*	*Social and Private Housing in Poor Condition, Houses without Central Heating*
	The 'outdoors' living environment sub Domain	*4.65%*	*Air quality, Road traffic Accidents Involving Injury to Pedestrians and Cyclists*

The IMD 2007 was generated by sum of the weighted scores of all domains (DCLG, 2008b). The weights were determined using the factor analysis (DCLG, 2008b). Accordingly, income and employment were the most important components, while housing service, crime and living environment were considered the least important component (Table 4.3).

The index reports the deprivation conditions at LSOA level to identify small pockets of deprivation (DCLG, 2008b). The data of LSOAs were then combined to describe the deprivation conditions in a bigger geographic scale such as local authority.

In 2007, the most deprived LOSA has IMD of 85.46 (a LSOA in Liverpool) while the most deprived local authority has average IMD of 46.97 (Liverpool) (DCLG, 2008b). The difference implies considerable regional variations within a local authority. The deprivation hotspots may be masked in the local authority statistics.

To identify the potential deprivation hot spot, ODPM (2004b) and DCLG (2008b, 2008c) have provided a measurement named 'local concentration'. Local concentration is 'the population weighted average of the ranks of a district's most deprived SOAs that contain exactly 10% of the district's population (ODPM 2004b, p49, DCLG, 2008b p37).' ODPM (2004b) and DCLG (2008b) documented the results of local concentration in each local authority in 2004 and 2007. However, the local concentration of each deprivation was not reported and was calculated based on the definitions provided (Section 4.3.5).

4.3.3. PDL Data Handling

The statistics of PDL in 2004 was utilised in most of the analyses in this chapter. This is because the most updated deprivation index, IMD 2007, was calculated based on the data between 2003 and 2005. To examine the effect of PDL on deprivation, the data collected at least before 2005 are more suitable. Furthermore, 2004 is the year that most of the local authorities (354 out of 355) at least reported the PDL once. This is considered the most complete dataset of PDL before 2005.

For the purpose of this study, the five Categories of PDL were grouped into three types depending on the degree abandonment (Table 4.4): derelict PDL, vacant PDL, underused PDL. The derelict PDL refers to the Category C PDL in the NLUD-PDL. This type of PDL requires interventions to bring it back for beneficial uses. Category A and B are the land or building that has been vacant for longer than a year but an intervention might not be necessary to bring back beneficial use. The underused PDL is the PDL that is currently in use but has not reached its optimised potential according to Local Authorities (Category D and E). The total PDL encompasses all three types of PDL. These are summarised in Table 4.4. Additionally, the Category F PDL was not included in the analysis because the redevelopment has been commenced on sites; the estimation of the areas has not been published either.

Table 4.4 The PDL Classification

Cate gory	Definition	Derelict Land	Vacant Land	Underused Land	Total PDL
A	*Vacant PDL*	×	✓	×	✓
B	*Vacant Building*	×	✓	×	✓
C	*Derelict PDL*	✓	×	×	✓
D	*PDL in use with local plan or planning permission*	×	×	✓	✓
E	*PDL in use without local plan or planning permission*	×	×	✓	✓
F	*PDL that have been developed or where construction has started*	×	×	×	×

The reported number of PDL was converted to the percentage to the total area of local authorities. The area of local authorities were obtained from 2005 general land use database (GLUD) downloaded from Office for National Statistics (ONS, 2011a).

4.3.4. Index of Multiple Deprivation Data Handling

The scores of **Index of Multiple Deprivation (IMD)** and the scores of all seven deprivations domains are readily available on DCLG website (www.communities.gov.uk) at local authority level as well as LSOA in Excel spreadsheet format (the values were also documented in ODPM, 2004b and DCLG, 2008b). These data were utilised without additional transformation or manipulation.

The **local concentrations of IMD** 2007 and 2004 for each local authority are also available from the abovementioned sources (ODPM, 2004b and DCLG, 2008b). There is no available result on local concentrations for each deprivation domain. Therefore, the local concentration for each domain was calculated based on the definition by ODPM (2004b, p49) and DCLG (2008b, p37):

> *"The population weighted average of ranks of a district's most deprived SOAs that contain exactly 10% of the districts' population."*

During the calculation of local concentration, the rank of each LSOA was reversed so that the higher ranking number is assigned to the more deprived area (ODMP 2004b; DCLG, 2008c).

To calculate the local concentration, the definition was translated into the equation listed below:

$$Local\_Concentration = \frac{\sum(ranks\_of\_deprived\_LSOA_i) \times (population\_of\_LSOA_i)}{0.1 \times (Total\_Population\_of\_LA)} \quad \text{(EQ 4.1)}$$

Where the $LSOA_i$ represented the LSOAs that were at bottom 10% of deprivation in a local authority; i was the rank number of the most deprived LSOAs in a local authority that contain exactly 10% of the population. The 'rank-of-deprived-$LSOA_i$' was the rank of these LSOA in relation to all 32,482 LSOAs in England. The most deprived LSOAs in the local authority were determined by following steps:

1. Calculate the 10% of total population in a local authority based on the population documented in the census in 2005 (ONS 2008a).
2. Rank the deprivation scores of LSOAs within a local authority from the most deprived to the least deprived.
3. Calculate the cumulative population start from most deprived LSOA toward the less deprived LSOA until the number is equal or just over 10% of population in the local authority. (The numbers of population in the last LSOA included in the calculation usually made accumulated population exceed 10% of the population in a local authority. Therefore, the population of this LSOA was usually revised to match the exact number of 10% of the population in the local authority).
4. Repeat the three steps for each local authority in the seven deprivation domains.

Gini index of the IMD scores was also calculated for each local authority. The calculation applied the concept and calculation of Gini index of income equality (ONS, 2008b) to IMD 2007 scores in LSOAs within a local authority. The population data of LSOAs required in the calculation was obtained from 2005 census (ONS 2008a). The Gini index of the IMD represents the degree of the regional variation in each local authority.

The rank correlation coefficients between different deprivation domains were calculated based on the equation listed below:

$$Spearsman\_Rank\_Correlation = 1 - \frac{6 \times \sum_{i=1}^{n}(x_i - y_i)^2}{n \times (n^2 - 1)} \quad \text{(EQ 4.2)}$$

Where x_i is the rank of x deprivation domain of $LSOA_i$; y_i is the rank of y deprivation domain of $LSOA_i$; n is the number of LSOA in a local authority or in England depends on the correlation coefficients aimed to calculate.

4.3.5. Data Presentation and Analyses

The scatter plots were generated to depict the correlation between PDL percentages (derelict, unused, underused, or total PDL) in local authority and relevant deprivation parameters in England based on different purposes (Table 4.5).

Similar scatter plots were also generated after the local authorities were grouped based on the degree of urbanisation, or the nine regions in England. The degree of urbanisation in this study was the percentage of urban area to the total administrative area in a local authority. To quantify this, two set of date were used: 1) Rural and Urban area classification (ONS 2009) and 2) General Land Use Database (ONS. 2011a).

The Rural and Urban Area Classification designated LSOA as 'urban', 'town and fringe and village', or 'hamlet and isolated dwellings'. The General Land Use Database kept the size of each LSOA in England. These two datasets were combined by matching the LSOA code of each entry. Within a local authority, areas under 'urban' designation were added up to represent the amount of urbanised area in a local authority. The percentage of urbanised area was than calculated.

Based on the degree of urbanisation, local authorities were sorted into 11 groups: 0%-<10%, 10%-<20%, 20%-<30%, 30%-<40%, 40%-<50%, 50%-<60%, 60%-<70%, 70%-<80%, 80%-<90%, 90%-<100%, and 100%. The authorities with 100% urban land were specifically singled out because they fit the description of the Land Use Puzzle Model proposed by CABERNET (2006). For these authorities, the opportunities of redeveloping PDL might become apparent.

The authorities were also grouped based on the 9 regions in England before generating another set of scatter plots. This is to investigate the possible influence of regional conditions on the relationship between IMD and PDL.

Table 4.5 The Purposes of Scatter Plots

Deprivation Parameters in the Scatter Plots	Objectives to Generate the Plots
Average Index of Multiple Deprivation (IMD) Scores of Local Authorities	*To investigate the possible relationship between percentages of PDL and the average deprivation conditions in a local authority.*
Local Concentration Scores of Local Authorities	*To investigate the possible relationship between percentages of PDL and the magnitude of deprivation hot spots in a local authority.*
Gini Indexes of Local Authorities	*To investigate the possible relationship between percentages of PDL and the uneven distributions of the deprivation conditions.*

Finally, the scatter plots were generated between PDL percentages and scores of local concentration of seven deprivation domains to investigate the possible effect of PDL on different types of deprivation.

4.4. Result

4.4.1. General Observation throughout England

Three deprivation parameters (IMD scores of local authorities, local concentrations of local authorities, and Gini index of local authorities) were utilised to investigate the effect of brownfield sites on deprivation conditions in England. The objectives of using these three parameters are listed in Table 4.5. The relationships between these three parameters were examined (Figure 4.3, Figure 4.4 and Figure 4.5). High IMD scores in local authorities (more deprived) correlated with wider variations of deprivation conditions (Gini index) (Figure 4.3). However, in several local authorities in the North East and London, despite relatively poor conditions, their Gini indexes were low in comparison to the majority of local authorities in similar deprivation conditions. The low Gini indexes indicated that the LSOAs within these local authorities were equally deprived.

Likewise, the most deprived local authorities (higher IMD scores) had more seriously deprived spots (higher local concentration scores) (Figure 4.4). However, the effect of IMD scores only extended to a certain degree. The seriousness of deprivation hot spots seemed to reach a maximum among local authorities whose IMD scores were higher than 30.

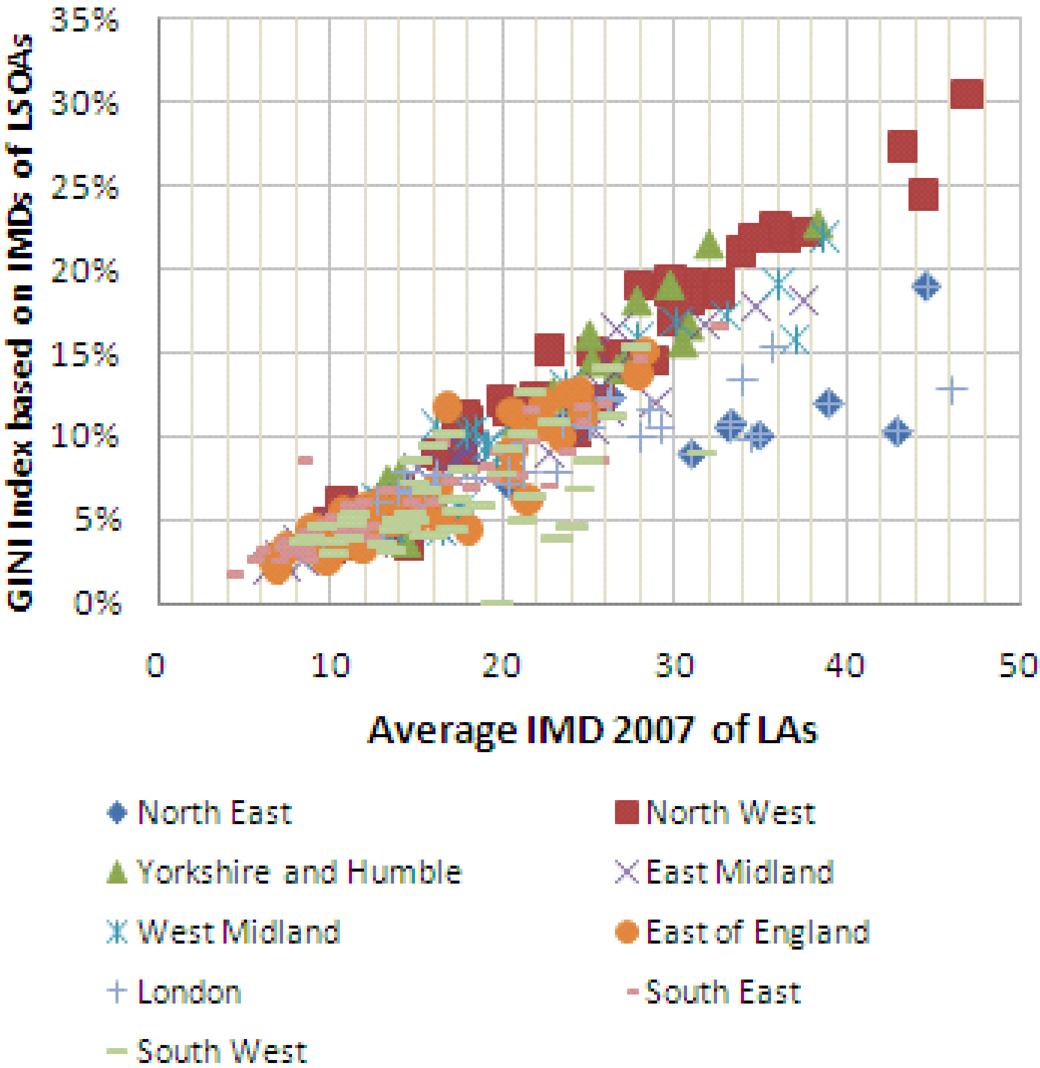


Figure 4.3 The Relationship between IMD and Gini Index (Original Data from DCLG, 2008b and ONS, 2011)

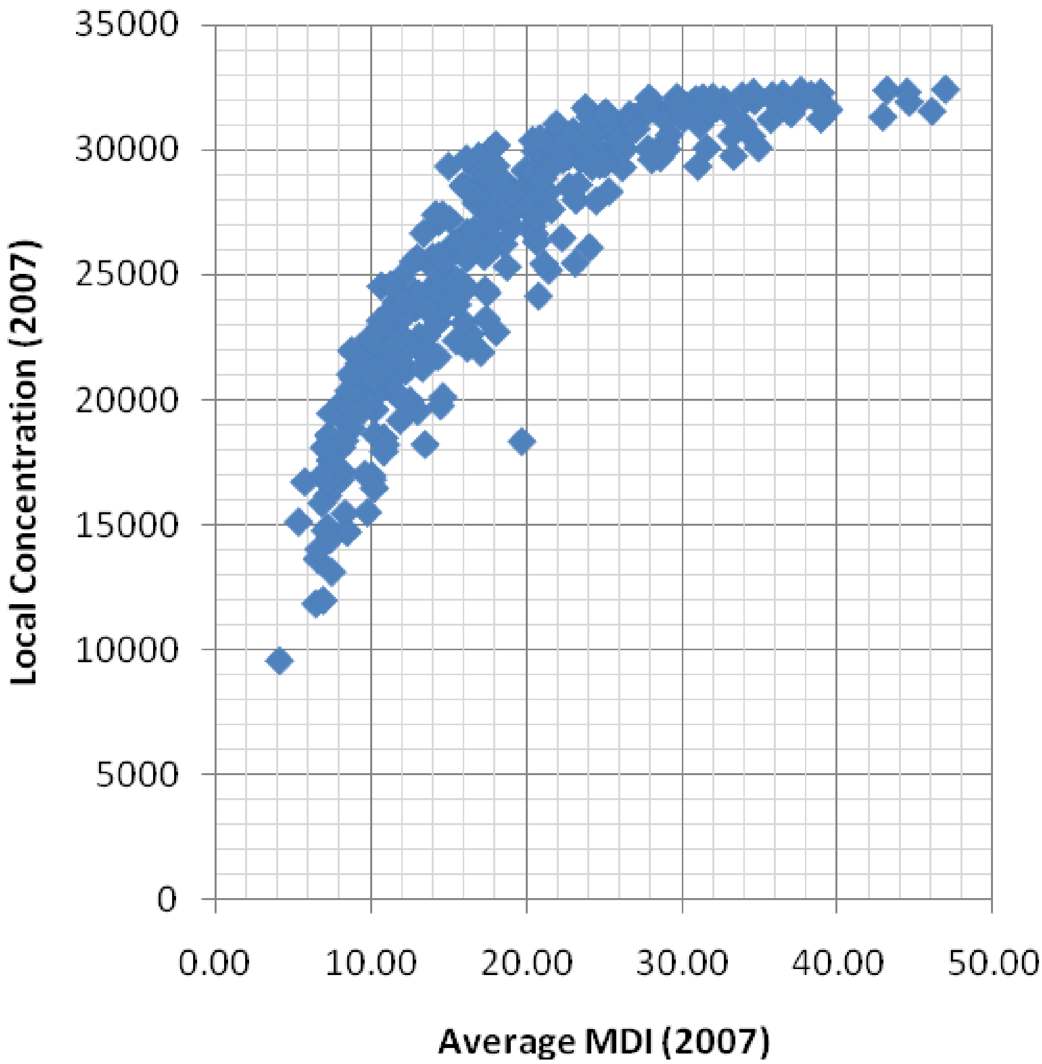


Figure 4.4 Relationship between MDI in Local Authority and Local Concentration (Deprivation Hot Spot) (Data Obtained from DCLG, 2008b)

Local concentration and Gini index did not form linear relationship (Figure 4.5) although they both represent the regional variations in deprivation conditions (Table 4.5).

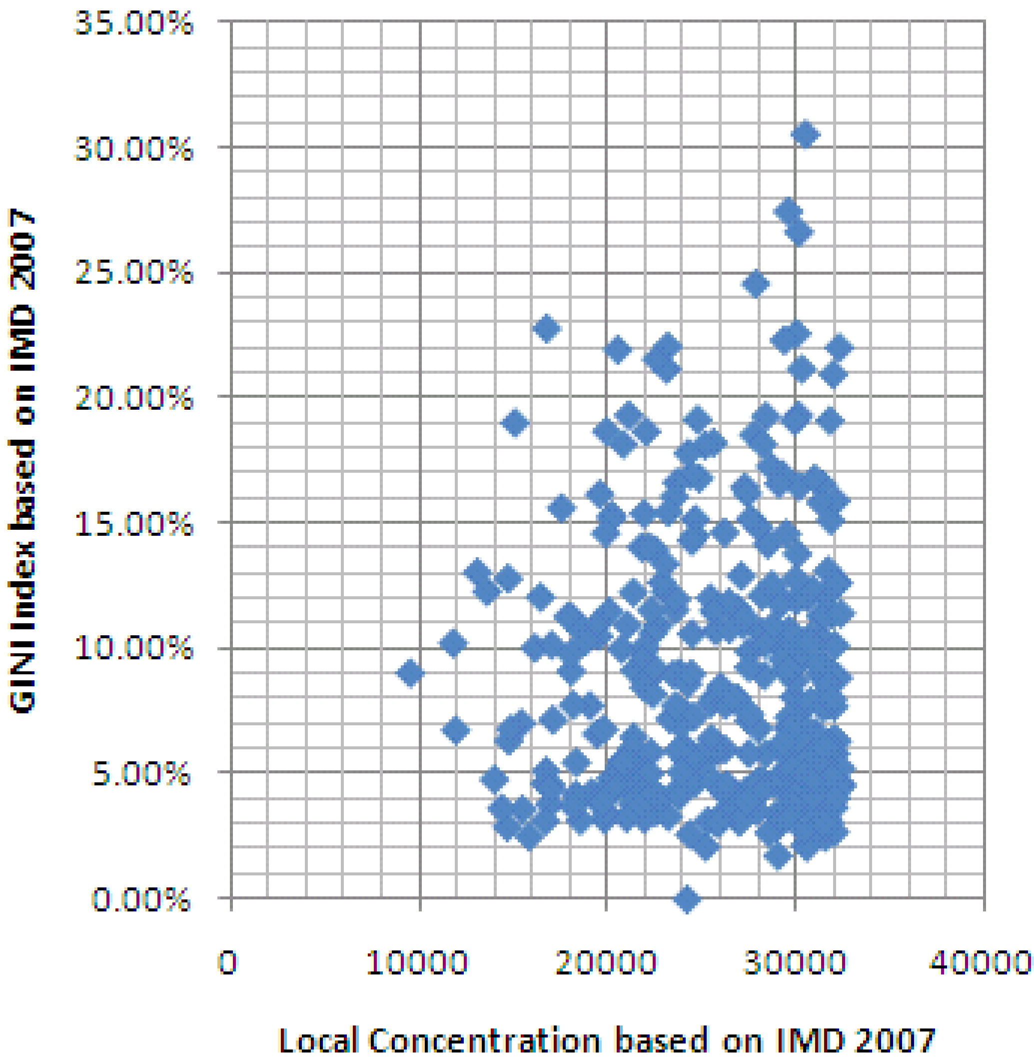


Figure 4.5 The Relationship between Local Concentration and Gini Index

Figure 4.6 shows that the relationship between IMD 2007 and PDL is quite similar to that of Gini index and PDL. The local authorities with higher percentages of PDL had higher chances to be in worse deprivation conditions, and had wider gaps between the least deprived populations and most deprived populations. The scatter plots of local concentration and PDL forms a somewhat different distribution pattern. Still, the local authorities with higher percentages of PDL tended to have severe deprivation hot spots.

Different types of PDL seemed not to alter the scatter patterns (Figure 4.6). However, the scales of different types of PDL are quite different. Derelict land and vacant properties usually occupied less than 0.2% of the total area in a local authority whereas underused land sometimes occupied twice as much.

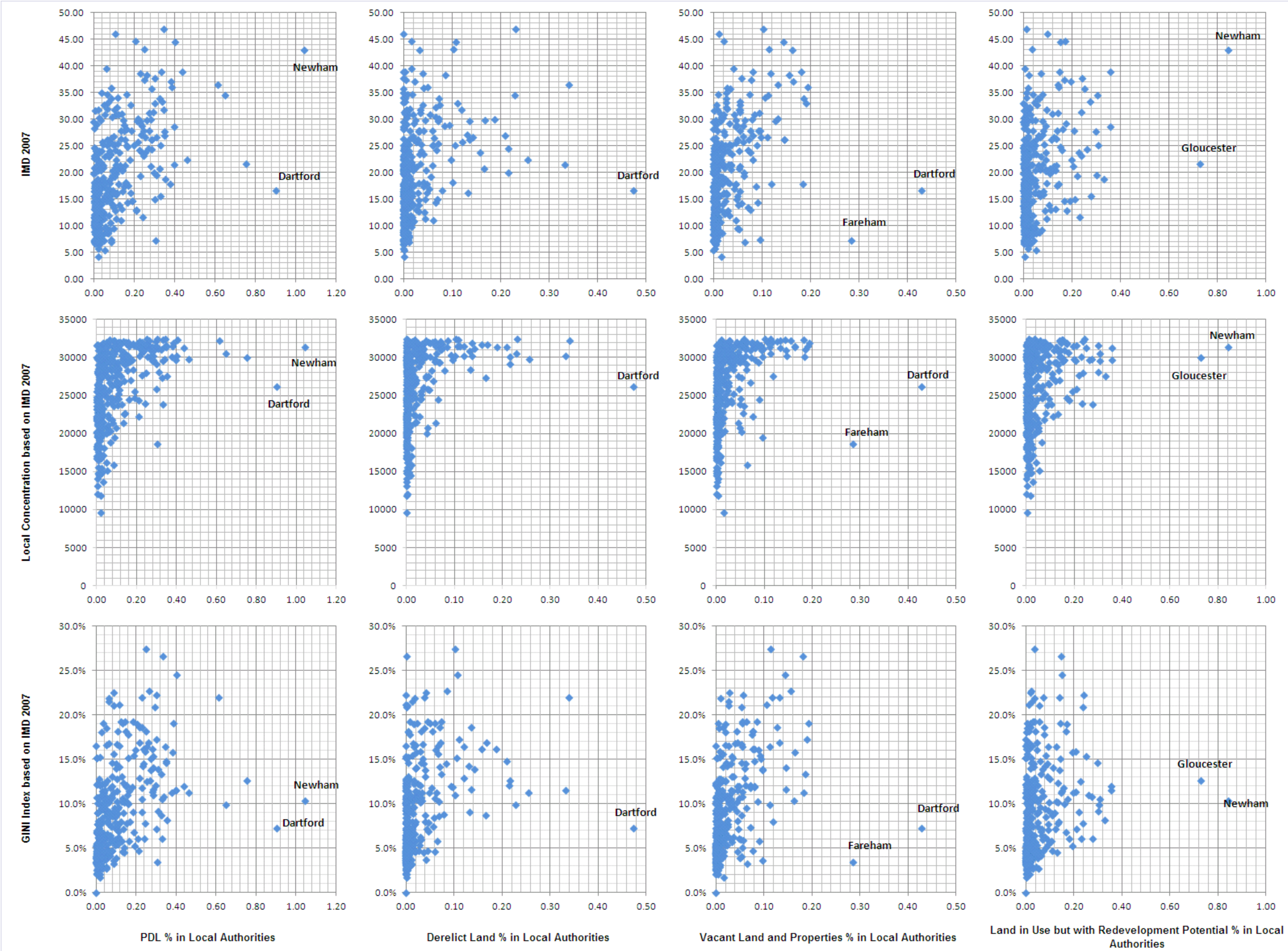


Figure 4.6 Deprivation Scores and Percentages of PDL

On the other hand, the lower percentage of PDL in a local authority did not decrease the chance of an authority being deprived. Therefore, there was no straightforward linear relationship between the measurements of deprivation (average IMD score, local concentration or Gini index) and PDL (derelict land, unused land or underused land).

The outliers in the plots are Dartford, Fareham, Gloucester and Newham. Dartford consistently behaved differently. It had more derelict and vacant land compared to the local authorities with similar degrees of deprivation measurements. Fareham had a higher percentage of vacant land but better social economic conditions than its counterparts had. Gloucester had a larger amount of underused land but better IMD score and Gini index. Newham had a higher percentage of underused PDL but less variation in IMD scores within its administrative territory. All four local authorities are relatively urbanised and located in the southern regions in England.

Table 4.6 The Summary of Outliers

Local Authority Name	Regions	Degree of Urbanisation	Relatively Large Amount of PDL											
			Derelict			Vacant			Underused			Total		
			IMD	LC	Gini	IMD	LC	Gini	IMD	LC	Gini	IMD	LC	Gini
Dartford	**South East**	**66.08%**	✓	✓	✓	✓	✓	✓				✓	✓	✓
Fareham	**South East**	**71.85%**				✓	✓	✓						
Gloucester	**South West**	**97.57%**							✓		✓			
Newham	**London**	**100%**			✓									✓

4.4.2. The Degree of Urbanisation

The 354 local authorities was categorised into 11 groups (Section 4.3.5). There are 30% of local authorities with least (0-<10%) and 20% of local authorities with the most (90-100% and 100%) (Figure 4.7). This is rather extreme distiburion.

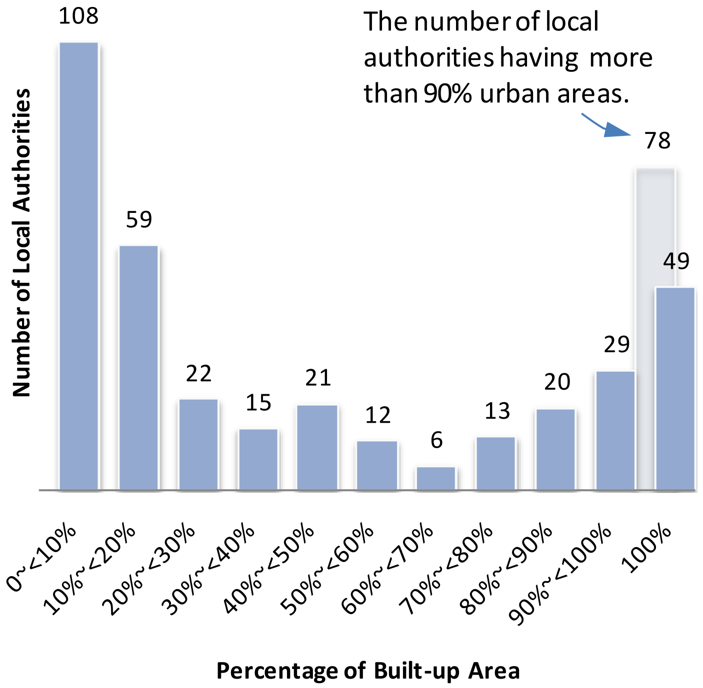


Figure 4.7 The Distribution of Urban Density of Local Authorities (calculation of urbanisation explained in Section 4.3.5)

Figure 4.8 depict the analysis of the possible influence of urbanisation on PDL. The local authorities urbanised less than 60% had significantly less average total PDL than 100% urbanised local authorities (Figure 4.8a). The local authorities urbanised less than 80% had significantly less average percentages of underused land than the 100% urbanised local authorities (Figure 4.8b). Moreover, local authorities urbanised less than 40% had less percentages of vacant land (Figure 4.8c). Only the least urbanised group had less percentages of derelict land than the 100% urbanised group (Figure 4.8d).

However, the trend of PDL distribution did not necessarily increase as the development densities increased. The average percentages of derelict and vacant land peaked at the local authorities that had 60%~70% urban areas (Figure 4.8c.and 4.8d). The percentages decrease at both higher and lower degrees of urbanisation. The underused land, however, gradually increased as the degree of urbanisation increased (Figure 4.8b).

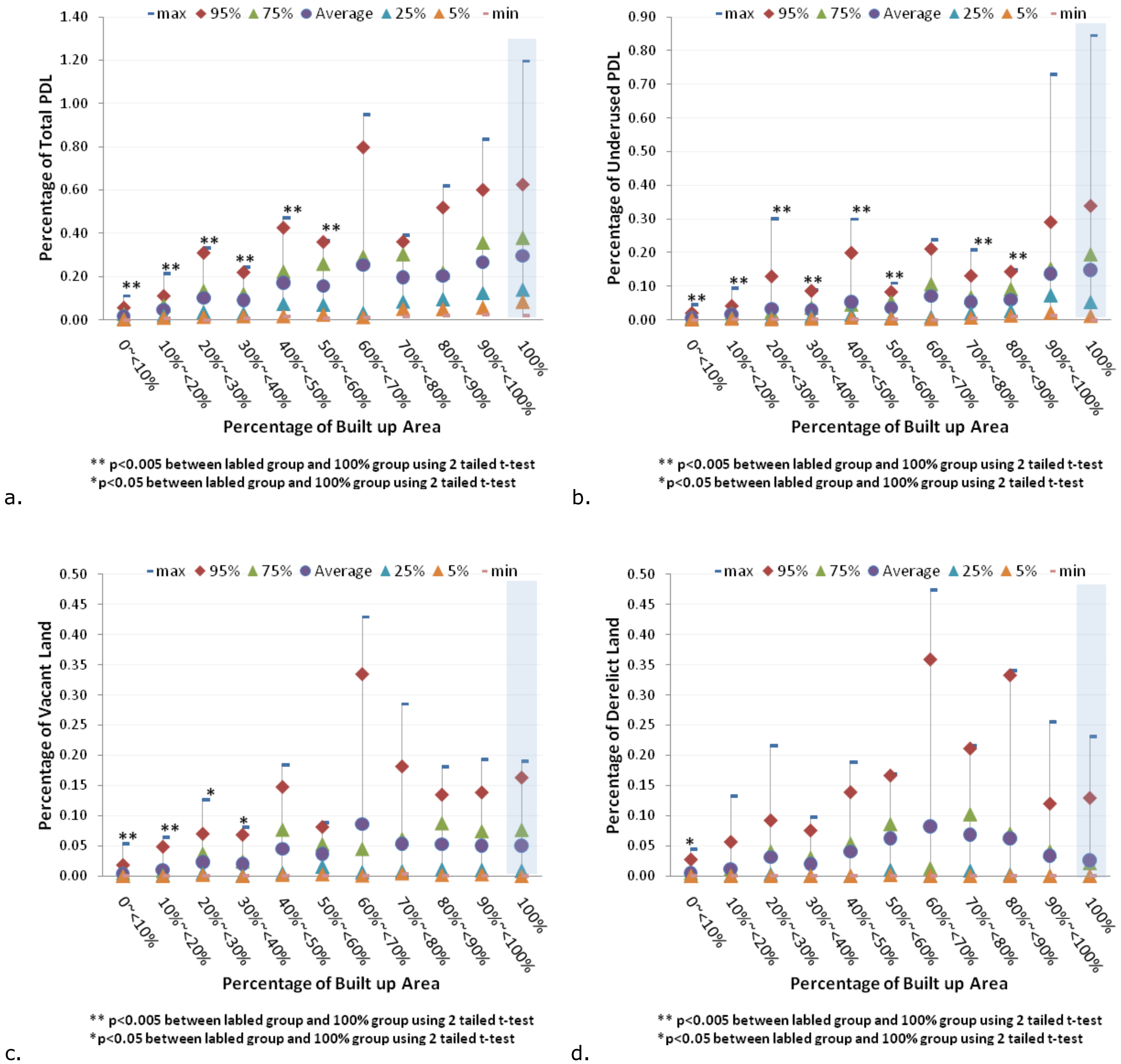


Figure 4.8 The Urbanisation and Percentage of PDL

Figure 4.9 shows the deprivation conditions among local authorities depending on the degrees of urbanisation. The average scores of deprivation increased when the degree of urbanisation intensified (Figure 4.9a). The average IMD scores of the groups urbanised less than 40% were significant lower average than the average IMD score of 100% urbanised group. The 100% urbanised group also had higher average local concentration score than the groups urbanised less than 30% had (Figure 4.9b). Furthermore, the distributions of deprivation hot spot narrowed when degree of urbanisation increased. The Gini indexes in the local authorities that urbanised less than 20% were also significantly lower than that in the 100% urbanised group. Generally, the deprivation conditions became worse when degree of urbanisation increased.

Therefore, on average, as urbanisation increased, the percentages of underused land as well as the degree of deprivations increased. However, the highest percentages of derelict land and vacant land were observed in the local authorities that were 50% to 90% urbanised.

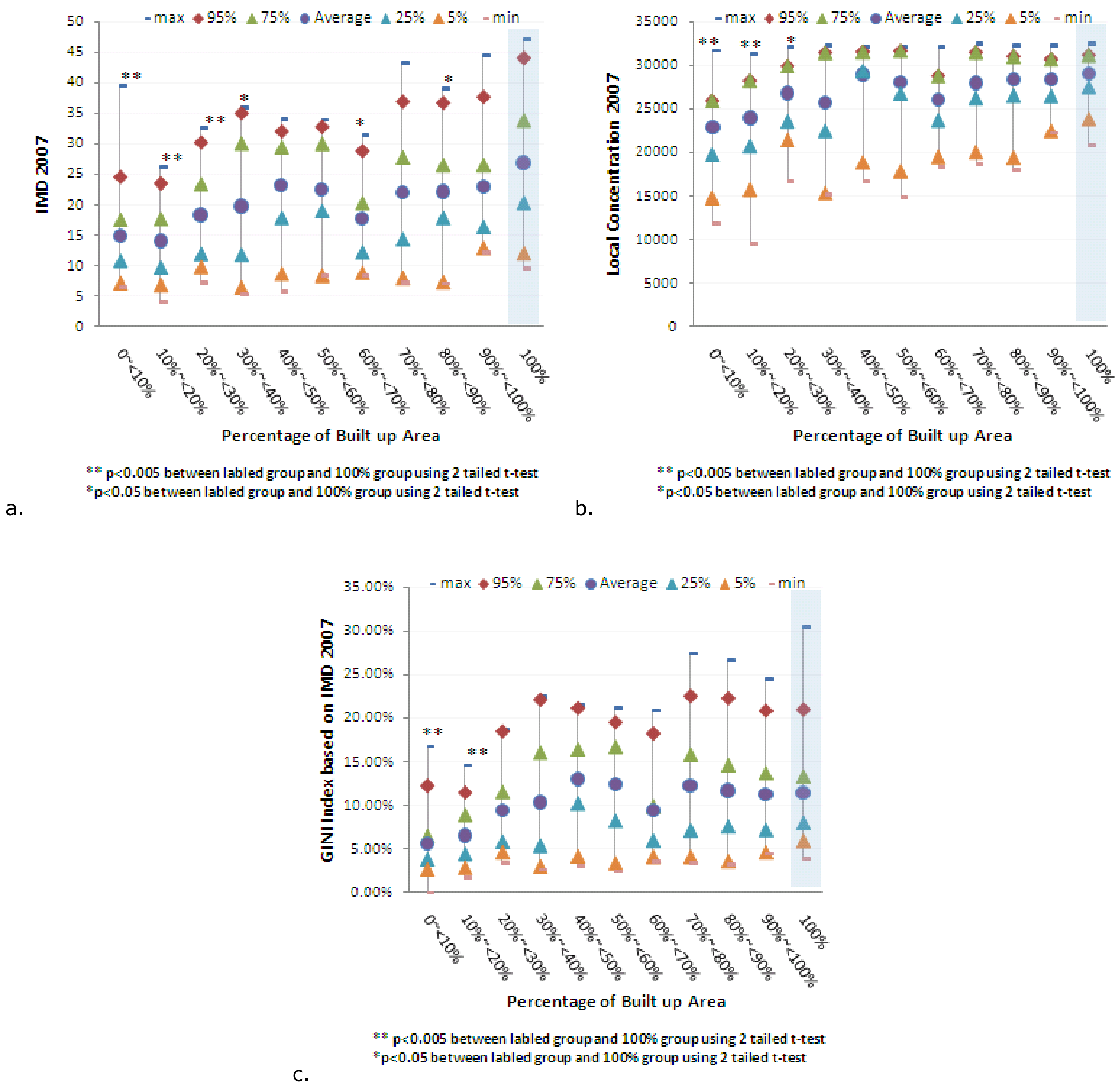


Figure 4.9 The Urbanisation and Deprivation Parameters

Figure 4.10 shows that lower degree of urbanisation (less than 20%) is associated with the wider spectrum of deprivation scores but fewer percentages of PDL. The PDL seemed irrelevant to the deprivation conditions in these local authorities.

By contrast, the highly urbanised local authorities (more than 70%) reported wide spectrum of PDL as well as deprivation scores. Authorities reported smaller amount of PDL could have very deprived conditions, or could do very well. However, the local authorities reported larger amount of PDL were almost always deprived. The PDL might be more relevant to the deprived conditions in highly urbanised local authorities compared to less urbanised local authorities.

The outliers were also observed in the plots. Warrington had higher percentage of vacant properties but low IMD among 40-50% urbanised local authorities. Dartford had considerable percentages of derelict land and vacant land but lower IMD among 60 to 70% urbanised local authorities. Fareham had large percentages of vacant land but low IMD among 80% to 90% urbanised local authorities. In the same group, Ellesmere Port and Neston had large percentages of derelict land but relatively low deprivation scores. Bury had more derelict PDL but low IMD compared to its counterparts among 80% to 90% urbanised area. Nuneaton and Bedworth also had higher percentages of derelict land but low deprivation scores. Gloucester was considered an outlier among the peer local authorities (90% to 100% urbanised). Among of these exceptions to the general trend, Warrington was the only outlier in the northern regions and had relatively lower degree of urbanisation.

Similar patterns were also observed in the scatter plots between PDL and local concentration with slight differences (Figure 4.11). In the less urbanised local authorities (less than 20%), the local concentration could be quite different but irrelevant to the PDL (because the amounts of PDL were low). Increasing severities of deprivation in hot spots as well as PDL percentages were observed in highly urbanised local authorities. The patterns in the local authorities with medium degree of urbanisation (especially 60%~<70%) were unclear due to smaller number of sample size. Fewer outliers was observed in the scatter plots between PDL and local concentration.

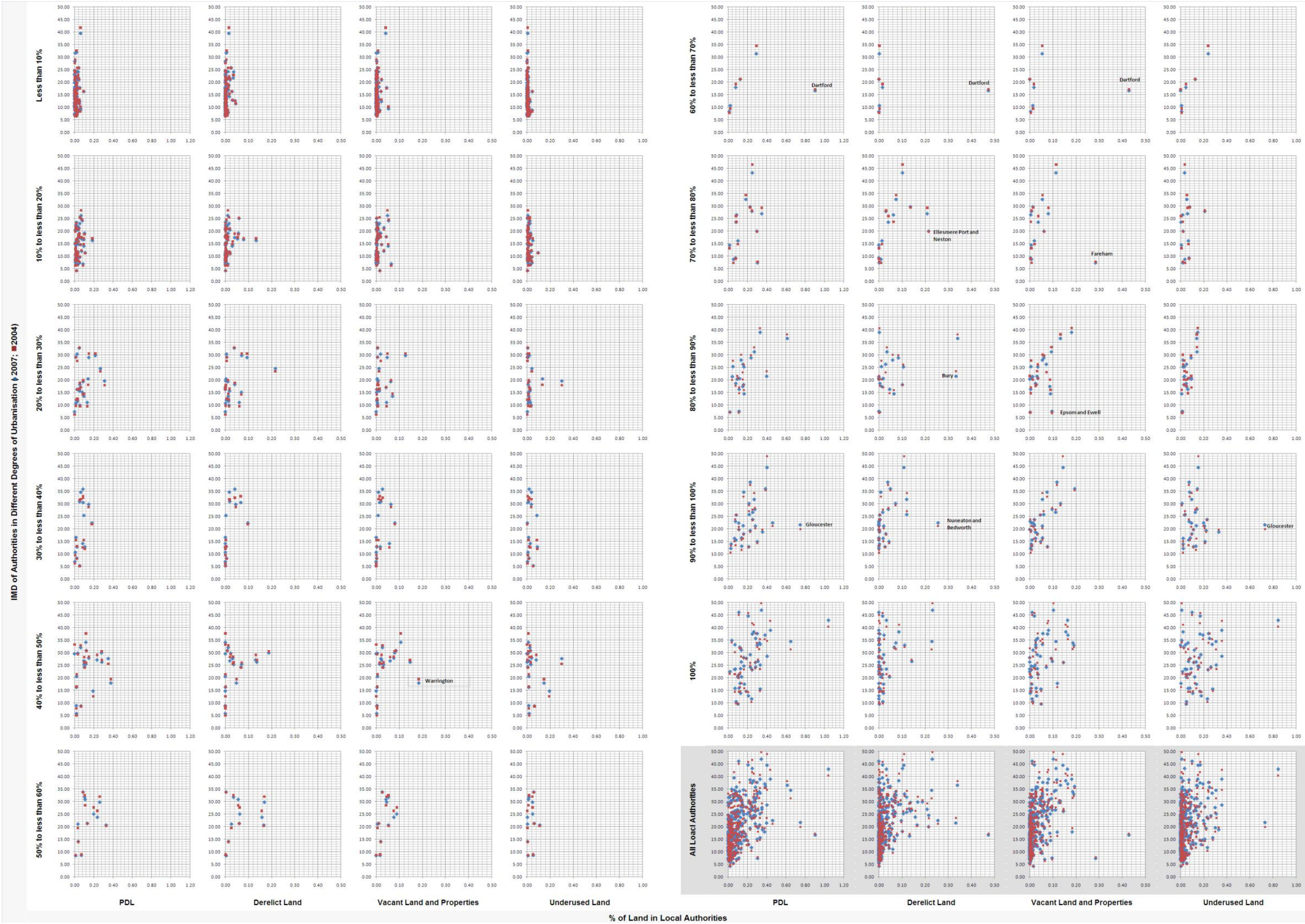


Figure 4.10 **Urbanisation and Deprivation**

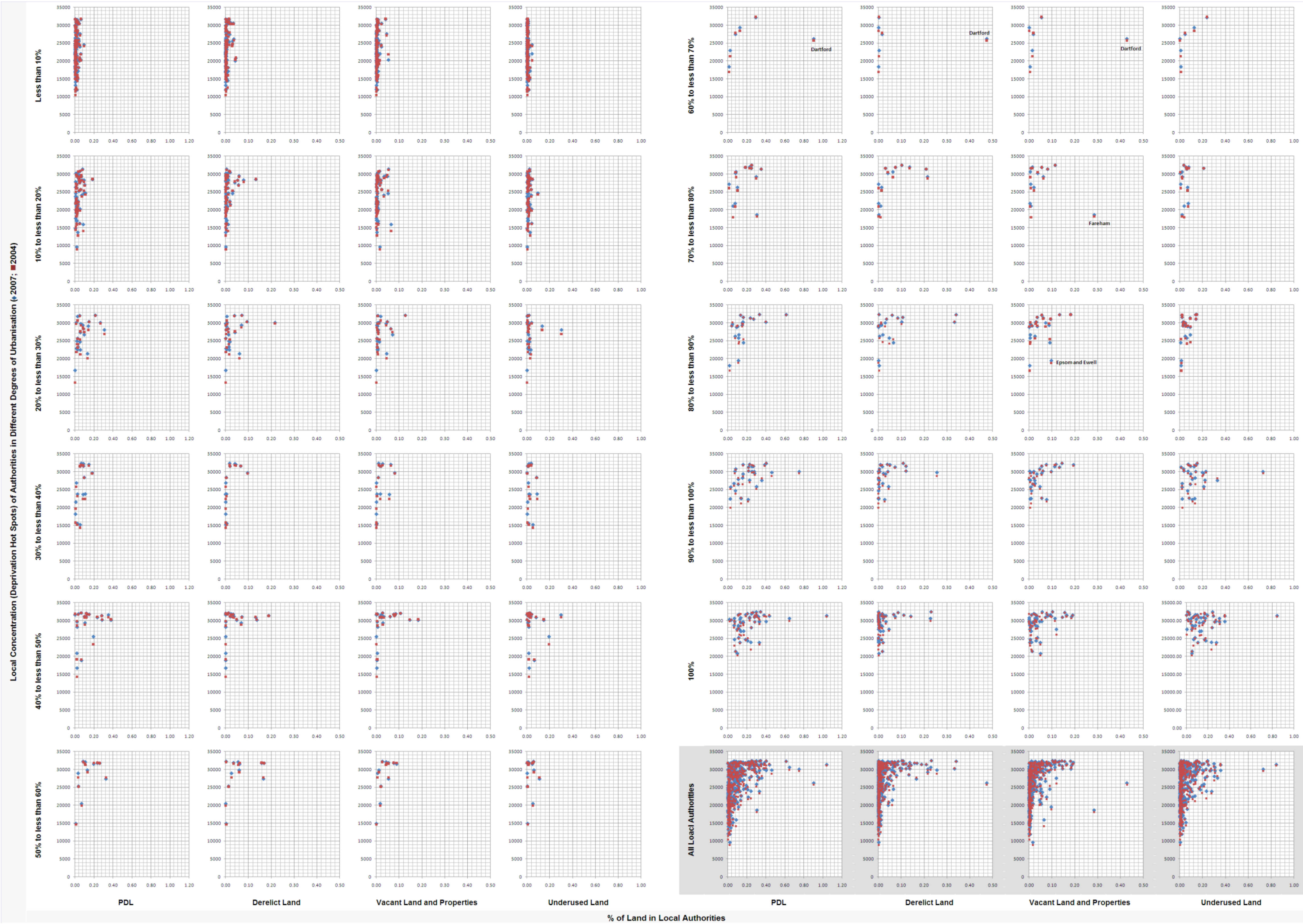


Figure 4.11 **Urbanisation and Deprivation Hot Spots**

4.4.3. Regional Differences

This section compared deprivation conditions, PDL distributions and the relationships among different regions in England.

Figure 4.12 shows that the average amounts of total PDL decreased from the north to the south, except the London region. However, considerable variations within the regions were observed, especially in London, the South West, and the South East (Figure 4.12a).

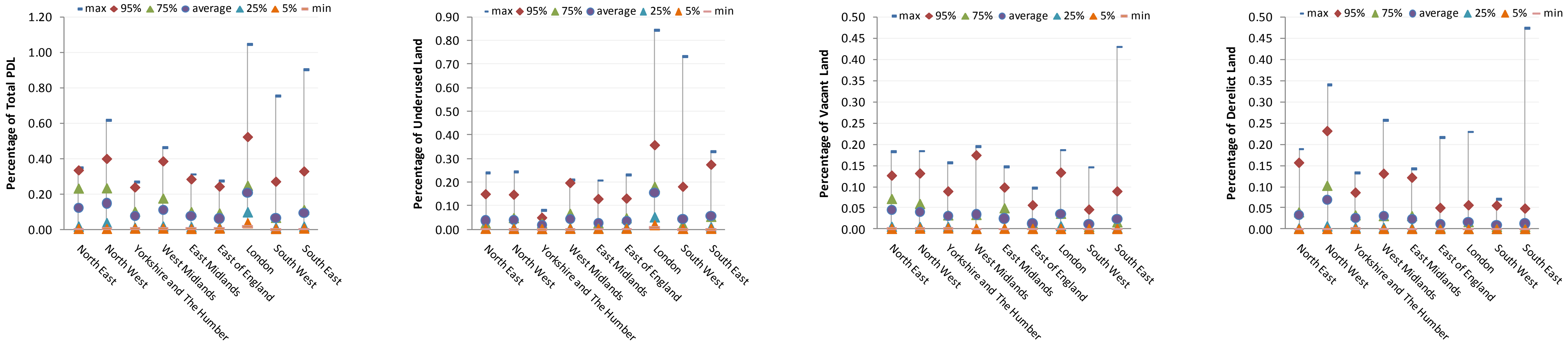
The large amount of total PDL in the London region was mostly contributed by underused PDL (Figure 4.12b), the land in use with further development potential. On the other hand, the total PDL in the north was mostly composed of vacant land, and derelict land (Figure 4.12c and 4.12d). Especially, the North West region had higher average percentage of derelict land.

The average IMD scores decreased from the northern regions to the southern regions except the London region (figure 4.13a). However, intra-regional variations were considerable. Moreover, the average scores of deprivation hot spots also decreased from the northern regions to the southern regions, except London (Figure 4.13b).

Figure 4.14 depicts the relationships between PDL and IMD of local authorities in nine administrative regions in England. The relationships between PDL and IMD in different regions were similar to the general trend: The local authorities with highest percentages of PDL in the regions had higher chances to be deprived. In the Northwest regions, the local authorities with higher percentages of derelict and vacant land had higher chance of being deprived. In the London region, the local authorities had higher percentages of vacant land and underused land also had higher chances of being deprived.

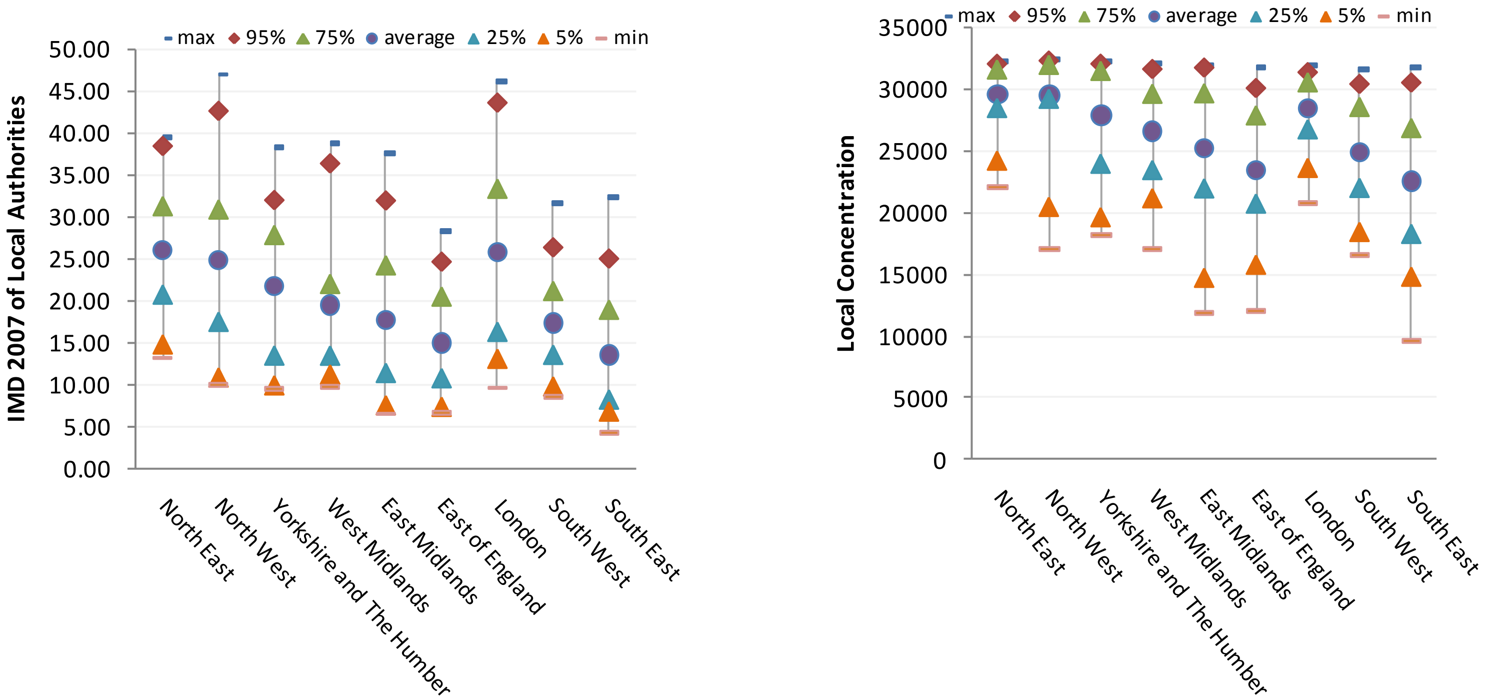
The outliers of this general trend were in the West Midlands (Nuneaton and Bedworth), the South East (Dartford and Fareham), the South West (Gloucester), and London (Barking and Dagenham).

Local concentrations in different regions also followed the general trend with fewer exceptions (Figure 4.15). The North West and London had larger amount of total PDL. Relative severe deprivation hot spots were observed in London region.



a. b. c. d.

Figure 4.12 Statistic Summary of PDL in Different Regions



a. b.

Figure 4.13 The Regional Difference in Deprivation (a. average deprivation scores in local authorities; b. concentrations of hot spots of deprivations in local authorities)

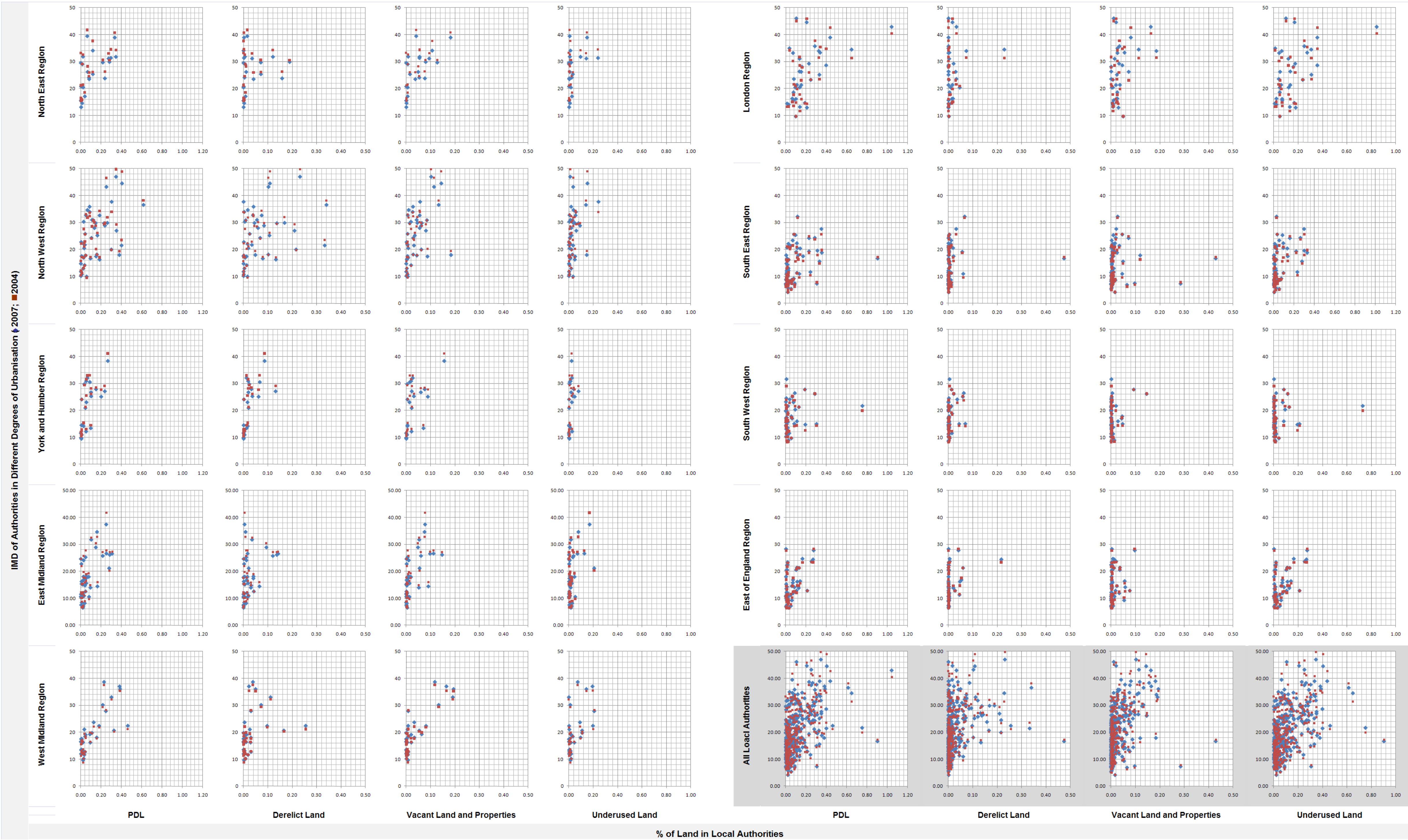


Figure 4.14 **Regional Difference in Deprivation**

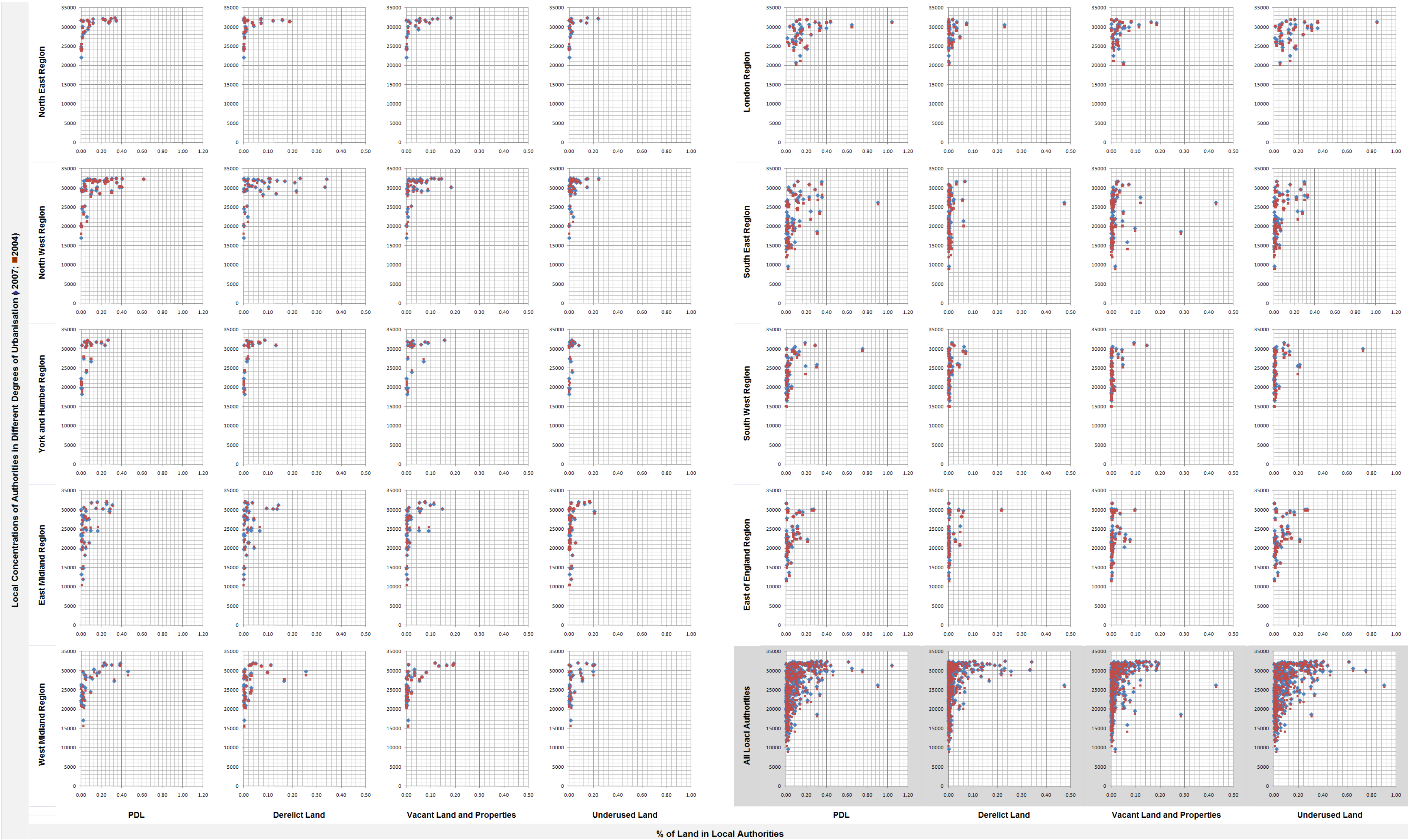


Figure 4.15 **Regional Difference in Deprivation Hot Spots**

4.4.4. Different Types of Deprivation

4.4.4.1. Interaction between Different Types of Deprivation

The interactions between the seven domains of deprivation were evaluated by comparing the Spearman's rank correlation coefficients between the ranks of the LSOAs in seven domains calculated in two ways (Table 4.7). One was the rank correlations of LSOAs within England (the numbers in upper right part of Table 4.7); another was the rank correlations of LSOAs within each local authority (the numbers in the lower left part of Table 4.7). In the latter case, the coefficients were calculated for 353 out of 354 local authorities. Isles of Scilly had only one LSOA and the calculation of correlation is impossible.

The results of rank correlations of all 32,356 LSOAs in England indicated **the income, employment and health deprivation domains** were strongly correlated. Their rank correlation coefficients were all higher than 0.8. The higher degree of income deprivation was accompanied with higher degrees of employment and health deprivations.

The education domain and **crime and order domain** had moderate correlations with the income, employment and health domains. The rank correlation coefficients of the education domain with these domains were between 0.78 and 0.74; the rank correlation coefficients of the crime and order domain and these domains were between 0.64 and 0.61. The correlation between the crime and order domain and education domain was 0.51.

The **living environment domain** had positive correlations with all other domains. However, the correlations were rather weak (between 0.54 and 0.19). Curiously, **the barriers to the housing service domain** had low or little correlation with other domains.

The Spearman's rank correlations calculated based on the rank of LSOAs within each local authority were consistent with the patterns of entire England. For example, at least 75% of the local authorities exhibited strong positive rank correlations between income, employment, and health (the 25 percentile of the coefficients between these domains are all greater than 0.80). All of the correlations were positive (minimum values of the coefficients between these domains are greater than 0.50). By contrast, the correlations between housing service and other domains were ambiguous (values of the coefficients could be positive or negative across wide range of values). The correlations between housing and other types of deprivations seemed to be particularly divided among local authorities.

Table 4.7 Rank Correlation between Different Deprivation Domains

	Spearman's Rank Correlation Coefficients of LSOAs of Each Local Authority in England	Income	Employment	Health	Education	Housing	Crime	Environment
		Spearman's Rank Correlations Coefficient of LSOAs in England						
Income	*median (75%,25%) (95%,5%) (max,min)*		*0.90*	*0.84*	*0.78*	*0.05*	*0.63*	*0.54*
Employment	*median (75%,25%) (95%,5%) (max,min)*	*0.89 (0.92,0.84) (0.96,0.72) (1.00,0.60)*		*0.92*	*0.78*	*-0.05*	*0.61*	*0.47*
Health	*median (75%,25%) (95%,5%) (max,min)*	*0.88 (0.92,0.82) (0.96,0.71) (1.00,0.60)*	*0.91 (0.94,0.88) (0.97,0.80) (1.00,0.55)*		*0.74*	*-0.07*	*0.64*	*0.49*
Education	*median (75%,25%) (95%,5%) (max,min)*	*0.80 (0.87,0.73) (0.93,0.58) (0.94,0.08)*	*0.76 (0.85,0.66) (0.91,0.50) (0.95,0.04)*	*0.77 (0.84,0.68) (0.91,0.54) (0.95,0.25)*		*-0.14*	*0.51*	*0.30*
Housing	*median (75%,25%) (95%,5%) (max,min)*	*-0.12 (0.08,-0.28) (0.42,-0.46) (0.67,-0.66)*	*-0.15 (0.09,-0.31) (0.41,-0.50) (0.66,-0.70)*	*-0.16 (0.08,-0.53) (0.39,-0.53) (0.66,-0.73)*	*-0.16 (0.05,-0.31) (0.36,-0.50) (0.55,-0.72)*		*-0.05*	*0.19*
Crime	*median (75%,25%) (95%,5%) (max,min)*	*0.56 (0.67,0.21) (0.67,0.43) (1.00,-0.21)*	*0.57 (0.67,0.44) (0.76,0.22) (1.00,0.02)*	*0.58 (0.68,0.43) (0.77,0.21) (1.00,-0.01)*	*0.49 (0.61,0.32) (0.71,0.05) (0.90,-0.26)*	*-0.18 (0.01,-0.37) (0.20,-0.56) (0.60,-0.74)*		*0.53*
Environment	*median (75%,25%) (95%,5%) (max,min)*	*0.41 (0.57,0.24) (0.74,-0.08) (0.85,-0.41)*	*0.37 (0.53,0.18) (0.71,-0.14) (0.78,-0.59)*	*0.38 (0.55,0.19) (0.72,-0.19) (0.83,-0.66)*	*0.24 (0.40,0.03) (0.65,-0.25) (0.81,-0.56)*	*0.02 (0.19,-0.17) (0.55,-0.40) (0.80,-0.71)*	*0.40 (0.55,0.24) (0.71,-0.15) (0.81,-0.56)*	

4.4.4.2. Different Deprivation Domains and Previously Developed Land

Figure 4.16 shows that the relationships between PDL and most domains followed the general trend observed in section 4.4.1 (Figure 4.6). The health deprivation domain and crime and order deprivation domain exhibited relatively clear pattern that the increased percentages of different types of PDL increase the chances of these deprivation conditions. However, the trends in other domains such as income, employment, education and living environment domains were smeared by data points with relatively high percentages of PDL but low degree of deprivations. The percentages of total previously developed land, derelict land, and vacant properties showed rather similar pattern within these deprivation domains.

The scatter distributions of housing service domain were unique. The distribution of scatters in the plot between underused land and housing service domain followed the general trend. However, it seemed the higher percentages of vacant or derelict land in local authorities, the lower chance the housing service was poor (lower scores means better conditions). On the other hand, at lower percentages of vacant or derelict land, the housing service could be good or bad. There were also several outliers in the scatter plots.

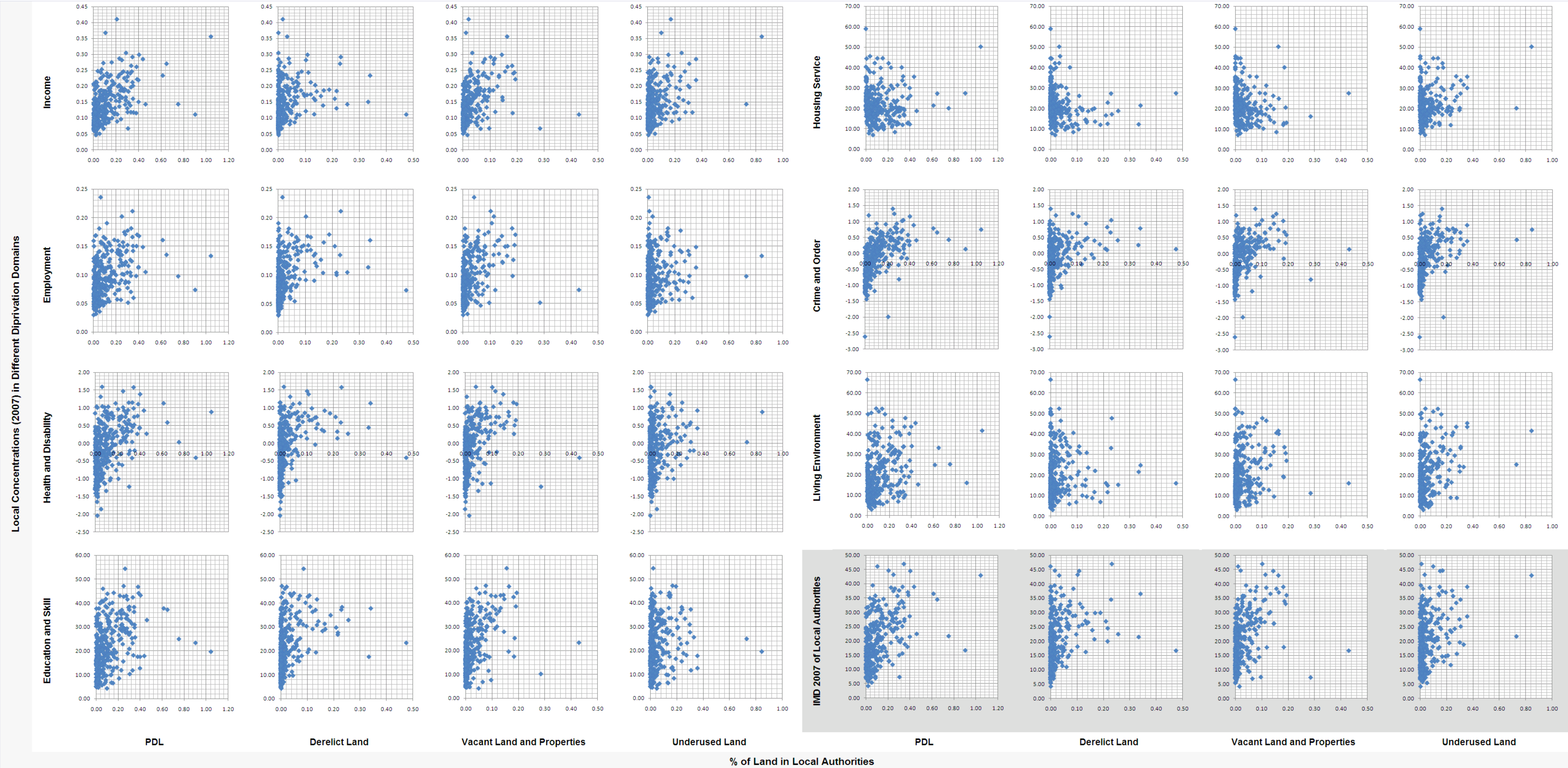


Figure 4.16 **Scatter Plots between PDL and Different Deprivation Domain**

4.4.4.3. Different Types of Deprivation Hot Spots and Previously Developed Land

Figure 4.17 shows that the relationships between PDL and the hot spots of different types of deprivation were similar to the general trend displayed in Figure 4.6. Generally, larger PDL percentages co-existed with more severe deprivation hot spots. The smaller percentages of PDL, however, did not necessarily generate less severe deprivation hot spots. The pattern between housing service and all types of PDL, though, was less clear.

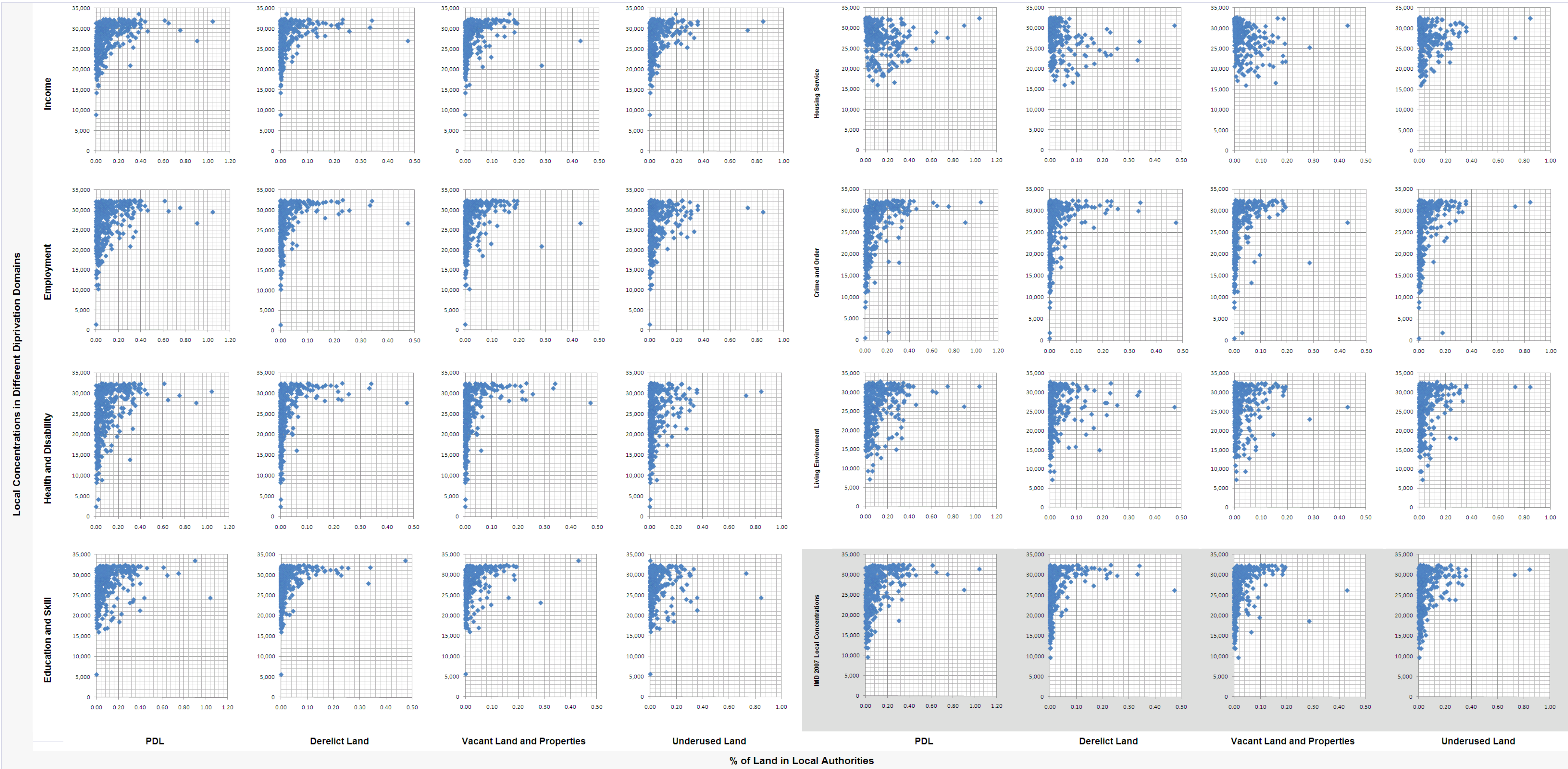


Figure 4.17 **Scatter Plots between PDL and Different Deprivation Domain Hot Spots**

4.5. Discussion

4.5.1. General Trend

This study showed that higher percentages of PDL coexist with deprivation conditions. Especially, the deprivation conditions in the hot spots were more severe. However, low percentages of PDL did not necessarily reduce the deprivation. The reduction of brownfields seems to be an important factor in the reduction of deprivation but the reduction alone cannot guarantee the alleviation of deprivation. This suggests brownfield regeneration is important to reduce deprivation only if it is conducted in a right way (Nathanail, 2011).

For the areas that have less PDL but worse deprivation hot spots, three probable explanations may be offered:

First, gentrification could be an issue (Lees, Slater, & Wyly, 2008b). Gentrification describes a process whereby middle class people move into a relatively poor area to take advantage of cheaper property values. The influx of wealthier residents frequently leads to the out-migration of previous, poorer residents. In this case, the PDL may be reduced during the gentrification process but the problems of poverty and deprivation just move elsewhere. The deprivation conditions in the entire local authority may not be alleviated.

If displacement is happening, the gentrified areas may appear to have much better deprivation score while the adjacent area may appear to be deprived, either because the adjacent areas have not been gentrified, or because the poorer people have been displaced to the adjacent areas. On several maps depicting deprivation scores in LSOAs in some metropolitans (such as Birmingham), it is quite common to spot the prosperous LSOAs surrounded by the most deprived LSOAs (DCLG, 2008b; Leeser, 2008; Talukder & Frost, 2008). This indicates the possibility of the phenomenon of gentrification. However, field work may be required to validate this assumption since gentrification generally only occurs within locations that are smaller than the LSOAs as the case described in Lees, Slater, & Wyly (2008c).

Second, the brownfield regeneration projects that aim to achieve sustainability do not always deliver (Williams & Dair, 2007). For example, the inner city housing estates built as a regeneration project sometimes need to be demolished because of low demand (Keenan, Lowe, & Spencer, 1999). The National Garden Festivals in the UK that aimed to facilitate brownfield regeneration also have mixed results (Chapter 5 of Leney, 2008). Moreover, the redevelopment might reduce unemployment rates at national level without resolving local unemployment issues (Howland, 2007). Therefore, the reduction of brownfields does not necessarily benefit the neighbourhoods. This could be one of the reasons that some high degree of deprivation observed in the local authorities where there is little PDL.

Finally, for the relatively rural local authorities, brownfield land may not exist at all (as showed in Figure 4.10 and 4.11). The condition of deprivation may be the results of other issues. There is no brownfield land to be regenerated. In these cases, brownfield regeneration is not the tool for improving sustainability.

The percentages of PDL within any of the local authorities are hardly higher than 1% (Section 4.3.1.1). The influence of the small percentage of brownfield area may not reflect in local authority's average deprivation score. The local concentration represents the degree of deprivation among smaller pockets of deprived people in a local authority in relation to England as a whole (DCLG, 2008b; ODPM, 2004b). This parameter shows clearer pattern in its relationship with PDL than average IMD and Gini Index do. The effect of brownfield land may be concentrated or surrounding the LSOAs with larger percentages of PDLs. Considering only about 20% of LSOAs in England reported PDL in 2004 (Section 4.3.1.1), local concentration should be a better indicator to evaluate the effect of brownfields on deprivation.

Syms (2010) also indicated that most of the PDL existed in the most deprived LSOAs. Therefore, to further investigate the relationship between PDL and deprivation, LSOAs may be the spatial unit to focus on. However, local authorities are the unit policies are implemented on a local level and policymaking is the focus of this study.

On the other hand, some interactions between local authorities may be overlooked in this analysis. For example, most of the residents who live in Dartford commute to London for work. This might reduce the deprivation levels (income and employment) without regenerating PDL within its administrative area. The effects of the interactions between different local authorities on brownfield sites may be worth further investigation.

4.5.2. The Effect of Urbanisation

Under the scenario of the CABERNET puzzle model, brownfield sites within on area become an important resource for allocating new development (Section 4.2.1; a detailed description can be found in CABERNET, 2006). The assumption may not be always sustainable because the development densities in local authorities may not always reach saturation point (Figure 4.7).

Grouping local authorities based on the degrees of urbanisation reveals that urbanisation may affect both the scale of PDL and the degree of deprivation. Urbanisation itself seems to produce deprivation and larger amount of PDL (Figure 4.8 and Figure 4.9). However, the percentages of derelict PDL seem to increase in the local authorities that are not fully urbanised. This phenomenon implies that land resources become very precious in the highly urbanised local authorities, so no land within the area is left unused for long period of time. The temporary vacancy, however, is quite possible. This observation is consistent with the description of the puzzle model.

The extreme distribution on urbanised area in Figure 4.7 is consistent with the observation in the United States (Garmestani, et al., 2007). Population sizes of major American cities between 1860 and 1990 have moved towards two extremes: The bigger cities tended to get bigger and smaller cities gradually shrink. There were less and less middle size cities. The middle and small size settlements or cities may produce more brownfield land because of the decreased population. On the other hand, the growing cities need to be more effective utilising their brownfield sites to accommodate more people.

The positive correlation between PDL and deprivation emerges in the highly urbanised local authorities (Figure 4.10). The brownfield regeneration policy may be more important in the highly urbanised local authorities to improve socio-economic sustainability. Perhaps, it is beneficial to allow the PDL in the rural authorities to be 'blended into natural status' while effectively recycling the PDL in urban local authorities. In the highly urbanised areas, the demand of redevelopment may not be the issue. Finding a sustainable way to conduct the redevelopment is the issue (Section 4.5.1).

As the puzzle model indicated, certain amounts of the PDL in urbanised areas should be considered valuable resources rather than an obstacle to development.

However, the scatter plots in highly urbanised area did not show there is an optimised size or percentage of PDL coexists with lower degree of deprivation. The locations and conditions of PDL might not be suitable for the regeneration that is needed to resolve the issues of deprivation. It is also possible that the optimised percentage of PDL varies depending on the situation in each local authority. The scatter plots in this chapter are a snapshot of the PDL condition and deprivation conditions in the authorities within England. Detailed chronological analyses as well as statistics analyses may be needed to exclude possible confounding factors that might affect the amount of the brownfields needed for urban development.

4.5.3. Regional Differences

With the exception of the London region, the deprivation conditions are on average better in the southern regions and worsen towards north. The exception of the London region may not be a surprise considering 23 out of its 33 local authorities are 100% urbanised (Table 4.8), and urbanisation correlated with deprivation (Figure 4.9).

Table 4.8 The Distributions of Local Authorities that are Highly Urbanised and Highly Rural

Regions in England	Total Number of Local Authorities	Most Urbanised		Most Rural
		100%	90%–<100%	0–<10%
North West	*43*	*1*	*1*	*7*
North East	*23*	-	*1*	*8*
Yorkshire and Humber	*21*	-	-	*9*
West Midlands	*34*	*2*	*6*	*12*
East Midlands	*40*	-	*4*	*16*
South West	*45*	-	*3*	*27*
South East	*67*	-	*5*	*13*
East of England	*48*	-	*4*	*16*
London	*33*	*23*	*5*	-

The local authorities in the London region encompass more underused land. Equally deprived local authorities in the northern regions encompassed mostly vacant and derelict land (Figure 4.5 and Figure 4.14). This is consistent with the findings of Longo and Campbell (2007). Because of the different distributions of derelict and underused land and the different degree of urbanisation, the approach of regeneration in the London region should be quite different from that in the northern regions (as discussed in Section 4.5.2).

'The position of London in general is, of course, exceptional and the massive loss of blue collar employment in London in the last 20 years is balanced in the housing context by the large scale of net in-migration to this region, partly due to its attractions as a global centre and its appeal to young people escaping economic depression elsewhere (Keenan, Lowe, & Spencer, 1999, p709).' The density of dwelling in London has been increasing at the speed of more than one dwelling per hectare in 5 years (Bibby, 2009). Since the London region has attracted more population during deindustrialisation, it has to make the metropolitan more compact while maintain the public infrastructure to sustain the city life of residents and workers. Therefore, the most important issue on land use management may be to support accelerating recycling rate by improve the infrastructure to alleviate traffic congestion, ineffective health care service, and other problems that high population densities may bring.

Bibby (2009, p.54) pointed out that the dwelling density in the northern cities have fell and '…the regeneration of the cores of northern cities was offset to varying degrees by dis-intensification in their suburbs.' Inner city house abandonment 10 years ago was no longer the issue of concern (Keenan, Lowe, & Spencer, 1999); the focus of regeneration should shift to suburban areas in the northern regions. The low housing demand in the north may be the result of deindustrialisation but it is less possible to re-establish the previous industry (Keenan, Lowe, & Spencer, 1999). Because the demand may not be high, the way of regenerations may not necessarily involve more buildings for residential use. Recreational attraction or facilities to support new industrial sectors to attract people could be better alternatives.

4.5.4. Types of Deprivation

The larger percentages of PDL in a local authority usually coexist with deprivation hot spots in income, employment, health, education and crime domains (Figure 4.17). The large amounts of derelict, vacant or underused land may be one of the factors that worsen the hardship of the local communities. At the same time, these deprived conditions may also be the factors that push the developing opportunities away. For example, Cozens, Hillier and Prescott (1999) argued that the low-crime status of more rural areas offered opportunities for safer housing estates that may be more sustainable in the long-term. Longo and Campbell (2007) have presented regression results that the probability of PDL in use is negatively correlated with the deprivation index using the index published in 2004 (data collected at the beginning of this millennium) and PDL data in 2006. Therefore, a sustainable brownfield regeneration project should aim to reverse this vicious cycle.

The relationship of PDL and housing service (deprivation) domain is unique. The local authorities with larger PDL percentages seem to score no worse than those with less PDL do. The distinct pattern could be the result of the composition of the housing service domain (Table 4.3). One of the sub-domains measures the distance to the local public service such as post offices and hospitals out of the consideration that the availability of public service is the issue of deprived area. The distance, however, should not be the whole story. Long distance to the public service is less problematic in a wealthy rural local authority because the residents may have better means to travel to the facilities. Those areas should not be considered deprived in the housing domain. Furthermore, the rural local authorities usually have less PDL. The distance to the public service may not be the major issues that brownfield regeneration can help. The geographic distance to the public service facilities may not be an appropriate indicator to evaluate brownfield regeneration.

These points may also be validated by looking into the rank correlation between housing service domain and other domains (Table 4.7). The lack of correlation between this domain and other domains implies people living in remote areas may not necessarily be deprived. Taking the regional maps in London as an example, the LSOA scoring worse in geographic barrier sub-domain performed all above average in other deprivation domains (Greater London Authority, 2008).

At the same time, access to hospital may be near a deprived community but may not be available for service because the demand is higher than the service capacity. Furthermore, the recent centralisation of many service facilities has affected the residents who do not have car or convenient means to travel (Stead & Hoppenbrouwer, 2004). To cover all considerations, the time to receive the service may a better indicator to reflect the potential deprivation conditions.

4.5.5. Data Quality Issues

Using scatter plots to explore the relationships between PDL and IMD has limitations. Brownfield regeneration usually requires considerable amount of time to proceed. In the United States, a period of 5 to 10 years is usually estimated for the result of the regeneration starting to show. However, the data used in the analyses were taken at about the same time (Section 4.3). They present a snapshot of PDL and deprivation conditions one year before or after 2004.

Moreover, it is also noted that the distributions of PDL and deprivation conditions did not change significantly over time. The t-tests showed no significant change of PDL between 2001 and 2004 (Section 4.3.1.1), neither the IMD results between 2004 and 2007 (Section 4.3.2). This might imply those factors affecting the deprivation, including the percentages of PDL, are unlikely to alter the deprivation conditions within a short timeframe such as 3 years. It may be interesting to analyse the PDL data at first half of 2000's and the next published deprivation index to see whether a clearer pattern emerges.

Additionally, upon using the database, some quality issues were identified. The first issue is the uncertainty of data handling reported by DCLG (Section 4.3.1.2). The procedure of imputation is not clear and causes confusion. Different conclusions could be made based on imputed data and original numbers. The City of London, for example, might not be considered an outlier in 2004 in the scatter plot if the data were not imputed. Thus, the relationship between PDL and IMD could be interpreted differently. Secondly, the local authorities may not update the PDL estimations annually or regularly. Thus, the figure of PDL presented in 2004 was not completely updated. This may reduce the degree of confidence to make conclusion and recommendation based on the given dataset. However, if a longer timeframe is taken into the consideration, this effect could be reduced.

4.6. Conclusion

The result of this chapter indicates that brownfield regeneration has potential to improve socio-economic sustainability in highly urbanised area, if the regeneration aims not only to reduce brownfield land but also to improve social and economic conditions. The regeneration strategies should differ between urban local authorities and more rural local authorities; the types of brownfield land and the socio-economic issues faced by the regions in England are distinct from each other.

In Addition, the PDL regeneration strategies in the south are expected to differ from that in the north due to different population distributions and development pressure. In next chapter, I further explored the effects of the density of development on the national strategies towards sustainable land use.

Chapter 5 Population and Land Use Sustainability

This chapter extends the discussion of the significance of urbanisation (Chapter 4) on brownfield regeneration to the significance of population densities on sustainable land use. The differences in brownfield regeneration policy depending on population densities were observed among European countries (Oliver et al., 2005). This observation is expanded to countries worldwide in this study. The result was compatible with the result of cluster analysis based on Environmental Sustainability Index 2005 (ESI 2005) (Esty, et al., 2005). The compatibility reinforced the idea that appropriate strategies to use land resources sustainably can be developed depending on population densities.

5.1. Population and Sustainability

5.1.1. Urbanisation Defined by Population Density

In England, the scale of population clusters divides the urban and rural LSOAs into different categories (Table 5.1)(ONS, 2009). The criteria to differentiate urban and rural only sometimes make use of the idea of population density. For example, the 'major urban' designation at local authority level requires more than 750,000 people in the district and more than 100,000 people or 50 percent of the population live in urban areas. 'Fifty percent of the population live in urban areas' (ONS, 2009) may be considered a rough indicator of density while other criteria were all established based on size of population. Therefore, the variables describing degree of urbanisation in England measure the agglomeration of population.

Table 5.1 The Classification of Urban and Rural at Different Geographic Level in England

	Output Areas*	***Super Output Areas (SOAs) and wards****	***Local Authorities*****
			Major Urban *(districts with either 100,000 people or 50 percent of their population in urban areas with a population of more than 750,000.)*
Urban	*Urban (population over 10,000)*	*Urban (population over 10,000)*	***Large Urban*** *(districts with either 50,000 people or 50 percent of their population in one of 17 urban areas with a population between 250,000 and 750,000.)*
			Other Urban *(districts with fewer than 37,000 people or less than 26 percent of their population in rural settlements and larger market towns.)*
	Town and Fringe	*Town and Fringe*	***Significant Rural*** *(Local Authorities with more than 26 percent but less than 50 percent of their population in rural settlements and larger market towns.)*
Rural	*Village*	*Village, Hamlet and Isolated Dwellings*	***Rural-50*** *(districts with at least 50 percent but less than 80 percent of their population in rural settlements and larger market towns.)*
	Hamlet and Isolated Dwellings		***Rural-80*** *(districts with at least 80 percent of their population in rural settlements and larger market towns.)*

**Information obtained from the ONS (2009)*

*** Information obtained from DEFRA 2009*

However, in England, population densities are higher in more urbanised local authorities (Figure 5.1, for detailed description of the database, see Section 4.3.1 and 4.3.2) but after the urbanisation reach 100%, the population densities could increase to a disproportionally high level. Therefore, although population densities are not an official indicator for urbanization, it is positively correlated with urbanisation.

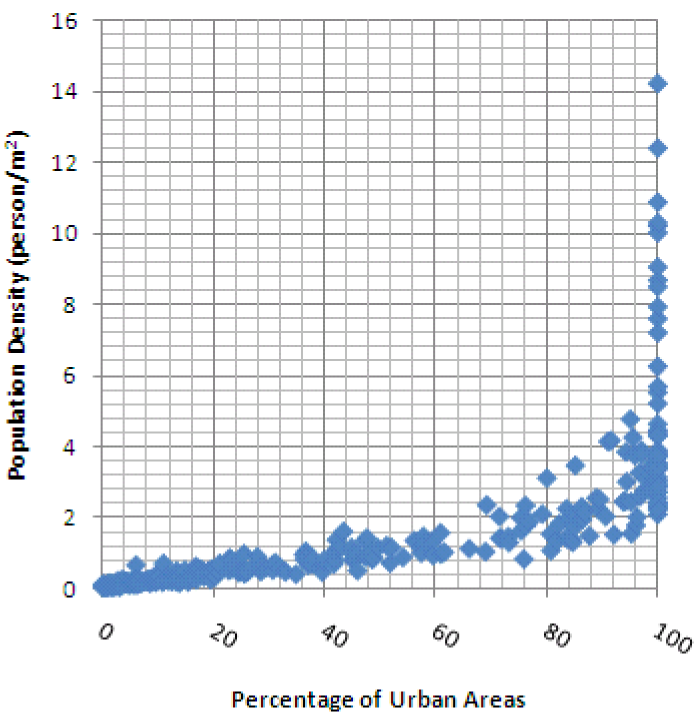


Figure 5.1 The Relationship between the Urbanisation and the Population Density in a Local Authority (percentages based on the calculation described in Section 4.3.5, population data obtained from 2005 census (2008a))

At the international level, the *CIA World Factbook* (CIA 2008) provided two parameters to measure urbanization: 'Urban population', the percentage of the total population living in urban area (CIA 2008), provides a snapshot of the condition of population aggregation in a country at time the data were taken. This parameter was also used in other urban studies (for example Antrop, 2004; Garmestani, et al., 2007). 'Rate of urbanization' describes the 'projected average rate of change of the size of the urban population over the given period of time (CIA 2008).' The two parameters are also based on the degree of population aggregation.

Other parameters utilised to measure urbanisation include 'the scale of built-up areas', 'residential land use', 'land taken by urban expansion', 'population density', and 'urban density' (Kasanko, et al., 2006). Overall, the measurement of urbanisation consists of the parameters describing population agglomeration and sometimes built-up areas and land uses. Describing urbanisation as a combination of population agglomeration and the extent of built-up area is representing urbanisation as the development density in an defined area.

The use of these parameters sometimes may be limited in international comparison, because the availability of the statistics is limited and the definition in each country for the same parameter is not always been consistent. For example, the *CIA World Factbook* documented 'urban population' and 'urbanization rate' in only a few countries. In addition, the quantitative measurement may be biased based on different countries definition of 'urban area' (Antrop, 2004).

Among these parameters, population densities may be the best available indicator for development density. The statistics in England also showed that population densities are positively correlated with urbanisation (Figure 5.1) and urban areas should be the focus of the brownfield regeneration (Section 4.6). Furthermore, urbanisation is related to and supported by the available resources from rural areas in the vicinity (Antrop, 2004). Given population densities as ratios between people and land resources, it should be a meaningful indicator for managing land resources. However, I also recognise that population densities may fail to reflect the uneven distribution within a defined area (in this case, a country) (Antrop, 2004).

Country size can be an important determinant in the distribution of urban population (Bertinelli and Strobl, 2003). Smaller countries could have higher percentage of urban population and urban primacy, but rather even distribution of population; bigger countries with higher percentage of urban population may show quite uneven population distribution. Therefore, the effect of concentrated urban areas could be masked in a bigger country if population densities are used as an indicator.

5.1.2. Population Density and Sustainability

The concern about the sustainability of human society, partly, was initiated because of the projection of population growth (Malthus, 1798; Holdren & Ehrlich, 1974; Streeten, 1979; Meadows et al., 1972). Population sizes, however, may mean different things for countries (Drakakis-Smith, 1996). The productivity of a country is related to both human capital and material resources (Henderson, 2003). Optimising the productivity may be equally important to managing the consumption to accommodate current and future demands for sustaining a society. Thus, depending on the ratios between population sizes and land resources, countries may develop various strategies to improve sustainability.

The economically successful European countries have two types of distinct strategies to manage damaged or contaminated land resources. The countries with lower population densities tend to remediate the land back to their 'nature' status, while the countries with higher population densities tend to remediate the land based on the 'suitable for use' principle. The land does not have to be returned to its nature status but have to be proven safe for planned land use (Oliver et al. 2005). This is to save time and money for land recycling.

The Environmental Sustainability Index published in 2005 (ESI 2005) also demonstrated the different behaviours of countries depending on population densities to produce better environmental sustainability results (Esty, et al., 2005). In the cluster analysis of ESI 2005, countries were grouped into seven clusters (Table 5.2). Cluster 1 and cluster 3 are countries with better economic performances (average GDP/capita of $27,480 for cluster 1, $29,860 for cluster 3, and no higher than $5000 for the rest of the clusters) as well as high average ESI 2005 scores. However, the average population density in cluster 1 (238 person/km^2) was 15 times more than that in cluster 3 (13.5 person/km^2). Therefore, the high population densities or limited land resources did not stop a country to achieve both economic prosperity and environmental sustainability. One of the exceptions in cluster 1 is Taiwan (another South Korea). It has alarmingly low ESI 2005 score. This is further discussed in Section 5.2.

Table 5.2 Some Statistic Summary from Cluster Analysis in ESI 2005*

	Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**	**Cluster 5**	**Cluster 6**	**Cluster 7**
Number of countries	*17*	*41*	*8*	*18*	*19*	*19*	*24*
Average ESI Score	*52.9*	*47.1*	*66.3*	*49.6*	*57.1*	*44*	*46.2*
GDP/capita	*$27,480*	*$420*	*$29,860*	*$4,390*	*$2,980*	*$3,810*	*$1,730*
Population Density (person/km^2)	*238*	*70.3*	*13.5*	*122*	*32.1*	*56*	*174*

**data after Esty, et al. (2005)*

Although both clusters had higher ESI 2005 scores, they showed different patterns in the scores in the sub-domains of ESI 2005 (Esty, et al., 2005). Cluster 1 had low average score in the sub-domain that evaluates environmental resources but high in the sub-domain that evaluates 'global stewardship'. The high scores of ESI

2005 of Cluster 3 contributed significantly from the sub-domain that evaluates environmental resources. Both clusters were good at 'reducing human vulnerability' and 'socio-institutional capacity'. Therefore, the governments of the countries in the two clusters have exercised their powers to protect basic human needs but via different strategies. The countries with high population densities did not have sufficient natural resources but managed to utilise their human and social capital to promote international cooperation in achieving environmental sustainability.

In summary, countries with high population densities usually achieve higher sustainable status via increasing the efficiency of using available resources and quality of human capital, while countries with low population densities depend on their abundant land resources and try to maintain the quality of those resources. This argument is further developed in the analysis of this chapter.

5.2. The Population Density and Brownfield Regulation in Taiwan

Taiwan had high economic competitiveness but very low ESI score (Esty et al., 2005). The low ESI score might be the result of poor data quality (Table 5.3) (Yeh, et al., 2006). However, even with the updated data to recalculate the score, Taiwan's ranking was still low (124 out of 147 countries estimated by Yeh, et al., 2006). Furthermore, Taiwan had very high scores in the component representing social and institutional capacity but very low scores in other components (Esty et al., 2008). Taiwan is also the country with the highest population density among cluster 1 countries. These collectively imply that Taiwan might not have effectively utilised the human capital in achieving sustainability.

Table 5.3 Some Statistical Summary and the Suggestions of Revision for Taiwan in ESI 2005

Problematic Use of Variables for Taiwan in ESI 2005	The Values Used in ESI 2005	The Values Suggested by Yeh, Liou, & Yu, 2006	Effect on ESI Using Revised Data
Percentage of Undernourished in Total Population	*13.27%*	*Much lower than 11% (the number of mainland China)*	*Improve Ranking*
Average Number of Deaths per Million Inhabitants from Floods, Tropical Cyclones, and Droughts	*no data*	*Better than world average of 39.11 according to data from National Fire Agency*	*Improve Ranking*
Number of Researchers per Million Inhabitants	*1258.4*	*4270 according to data from National Science Council*	*Improve Ranking*
Number of ISO 14001 Certified Companies per Billion Dollars GDP	*no data*	*1414 according to Industrial Development Bureau*	*Improve Ranking*
Child Death Rate from Respiratory Disease	*7.54 (per 100,000 persons) from WHO*	*Much lower than 2 (the number of mainland China)*	*Improve Ranking*
Death Rate from Intestinal Infectious Disease	*3.85 (per 100,000 persons) from WHO*	*Much lower than 0.19 (the number of mainland China)*	*Improve Ranking*
Hydropower and Renewable Energy Production as a Percentage of Total Energy Consumption	*1.55% obtained from the United States Government*	*3.9% according to TaiPower (Nation Own Electronic Company)*	*Improve Ranking*
Percentage of Total Land Area under Protected Status	*8.30% (from UNEP)*	*20.30% according to Directorate General of Budget, Accounting and Statistics*	*Improve Ranking*
Percentage of Country under Severe Water Stress	*6.8% (University of Kassel)*	*The actual condition should be worse*	*Lower the Ranking*
Salinised Area due to Irrigation as Percentage of Total Arable Land	*no data*	*0*	*Improve Ranking*

In Environmental Performance Index published in 2008 by the same research institutes, Taiwan was ranked 40 out of 149 countries. The different results may be explained by what the two indexes measured. The ESI 2005 'gauges the long term environmental trajectory of countries by focusing on environmental sustainability

(Esty et al., 2005).' The ESI 2005 included the statistics of contemporary environment, the evaluation of relevant socio-economic conditions, institutional capacities, and projections of future condition (for example, population growth rate to year 2050). On the other hand, the aim of EPI 2008 was to 'assess current environmental conditions (Esty et al., 2008).' It focused on parameters that are relevant to contemporary environmental performance. Therefore, the scores of Taiwan in these two indexes indicated that the current environmental, social and economic conditions of Taiwan are acceptable (higher than average EPI 2008 score). However, if Taiwan maintains current practice, it may lead to a very un-sustainable future (very low EIS score).

In the cluster analysis of EPI 2008, Taiwan belonged to the same cluster with the U.S. They both had high 'environmental health' and low 'carbon reduction efficiency'. Most of the countries with high population densities with good ESI 2005 scores were not in the same group as Taiwan. They belonged to another cluster that excels in both 'environmental health' and 'carbon reduction'.

The cluster analysis from ESI 2005 indicated that Taiwan demographically resembles the countries in Cluster 1. These countries had much stronger social and economic performances but poor environmental resources. The U.S., however, belongs to Cluster 3 in ESI 2005. The cluster has more environmental resources (the lowest average population density among all seven clusters). Since Taiwan is particularly limited in land resources, to improve current practice of sustainable development, it should look for successful model from the Cluster 1 countries.

However, the brownfield policy of Taiwan has been heavily influenced by the U.S. (Wang, 2004; Luo, 2006). This is partially due to the technocrats and scholars in Taiwan who are dedicated to brownfield regeneration usually received their postgraduate education in the U.S. It is also partly due to some geopolitical reasons (the detailed history can be read in Zhang, 2003). Despite these backgrounds, the difference in population densities may have made learning regeneration policy from the U.S. unsuitable.

Population densities seemed to be one of the important factors for a country to take different approaches in pursuit of sustainable development (Section 5.1). Taiwan has a considerably high population density and low ESI 2005 score (Table 5.2). This implies that Taiwan might have taken unsuitable approaches to pursue sustainable development. The approaches could include the brownfield regeneration policy.

To identify suitable approach of sustainable development in Taiwan, in this chapter, analyses were conducted to investigate following questions:

1. Can the competitiveness (economic sustainability) and population density framework established by Oliver et al. (2005) based on European data be further generalised to the rest of the world? Is this framework consistent with the observations in ESI 2005 and EPI 2008 (environmental sustainability)?
2. What are the major differences between Taiwan and its ESI 2005 peers in terms of brownfield regulatory style?

5.3. Database and Analytical Method

5.3.1. Selected Countries in the Analysis

Countries evaluated by world competitiveness, ESI 2005 and EPI 2008 were included in this analysis. Usually, the countries with competitiveness scores also had ESI 2005 and EPI 2008 scores. Therefore, the selection of countries was primarily based on whether the countries were included in competitiveness evaluation by International Institute for Management Development (IMD).

The exceptions are Hong Kong and Singapore. These two countries have very high competitiveness ranking but no ESI 2005 scores. This is because they have no 'any sizable hinterland and have evolved to rely almost entirely on outsiders for provision of critical natural resources (Esty et al., 2005).' Esty et al. (2005) also considered that the two territories are too small to support a complete ecosystem. Therefore, the two countries were excluded from the analysis.

5.3.2. Population Density

Population densities (person/km^2) are calculated based on the estimation of population in 2005 of the UN in 2004 (UN, 2004) and the area reported in the CIA World Factbook in 2005.

5.3.3. Competitiveness, a Measurement of Socio-Economic Sustainability

The evaluation of competitiveness was obtained from the International Institute for Management Development (http://www.imd.org/). The institute has published the world competitiveness once a year since 1989 (Rosselet-Mccauley, 2007). The organisation defines competitiveness as 'the ability of nations to create and maintain an environment that sustains the competitiveness of enterprises (Rosselet-Mccauley, 2007, p19).' The index encompasses four domains: 'Economic Performance', 'Government Efficiency', 'Business Efficiency' and 'Infrastructure'. Each of them had several sub-domains (Rosselet-Mccauley, 2007).

The resulting estimate of competitiveness has been based on quantitative criteria in countries and survey data collected from executives in top and middle management in the countries. The selection of executives depends on the distribution of the industrial sectors in a country, the GDP of a country in relation to others, and proportion of local and foreign investments. The objective of the survey is to understand some important issues that are not easily quantified such as labour relations, corruption, environmental concerns and some types of quality of life. Upon composting the competitiveness evaluation, International Institute for Management Development gave two-third weight was to the results generated from quantitative data and one-third from the survey. Based on the content in the index, I considered competitiveness not only measures the economic sustainability but also reflects the development progress from the business or commerce point of view.

In this study, the competitiveness scores in 2005, 2007 and 2009 were used to account for some variations in economic condition in recent years.

5.3.4. ESI 2005, a Measurement of Social Capacity and the Outlook of Environmental Sustainability

The data of ESI 2005 were obtained from the Environmental Performance Measurement Project website (http://www.yale.edu/esi/). The index was developed through the collaboration between Yale University, Columbia University and the World Economic Forum. The evaluation focused on 'overall progress towards environmental sustainability' of a nation.

The five domains of the index are 'Environmental Systems', 'Reducing Environmental Stress', 'Reducing Human Vulnerability', 'Social and Institutional Capacity' and 'Global Stewardship'. Each of them encompasses several indicators to represent different aspects within the domains. The indicators measure not only the current environmental quality (such as air quality and biodiversity) and speed of environmental degradation (such as annual average forest cover change rate and population change) in a country, but also the abilities of governments to improve the quality of environment and human life (such as rule of law, corruptions and Natural Disaster Exposure Index). The total 21 indicators were weighed equally. The use of indicators shows that the ESI 2005 measured environmental sustainability outlook as well as the social capacity.

5.3.5. EPI 2008, a Measurement of Current Environmental Performance

Environmental Performance Index (EPI 2008) measured 'the ability of countries to actively manage and protect their environmental systems and shield their citizen from harmful environmental pollution (Esty et al., 2008).' The indicators utilised in EPI 2008 focused on assessing environmental pollution, natural resources productivity and performance in dealing with climate changes. The two domains in the index were 'Environmental Health' and 'Ecosystem Vitality'. The former aimed to measure the environmental impact on human life quality (such as sanitation and indoor air pollution) whereas the latter aimed to measure the conditions of ecosystems and the impact of human activities on ecosystems in the countries (such as effective conservation and irrigation stress). The two domains were given equal weights. Their sub-domains were weighted based on policy judgement. The EPI 2008 was considered the index measuring current environmental conditions of a country.

5.3.6. Analysing Sustainable Indexes and Population Density

The framework of analysis were replicated (Figure 5.2) after Oliver et al. (2005). However, the x-axis of the plot was transformed into logarithmic scale to accommodate wider range of population densities among countries to be analysed. The three groups defined by Oliver et al. (2005) (summarised in Table 5.4) were utilised to verify whether the conclusion made for the European countries may be apply to other industrialised countries (Section 5.4.3). The definitions of brownfield in the governmental websites or government documents were considered official and were collected for the analysis. The competitiveness scores between 2005 and 2009 were used in the analysis to account for the variation of score between these five years (Section 5.4.1).

The distribution of countries in the framework was then overlaid with clusters grouped by ESI 2005 and EPI 2008 to evaluate the relationship between environmental sustainability and population densities (Section 5.4.2). The results of the patterns of brownfield definition and environmental sustainability in relation to population density were then compared and discussed (Section 5.4.3. and Section 5.5.1).

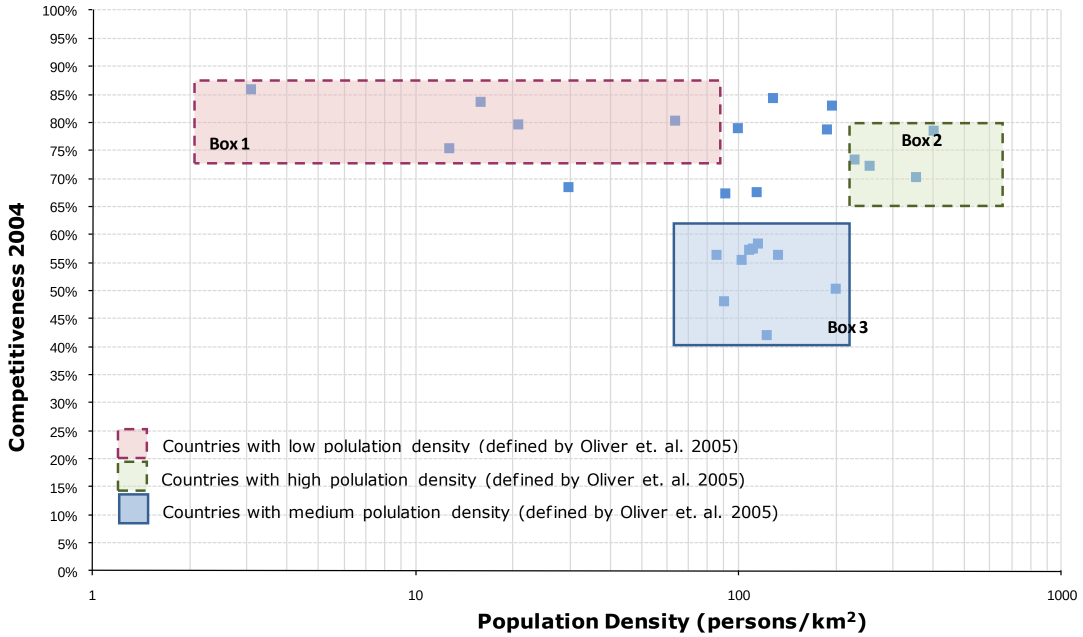


Figure 5.2 The Framework to be Validated (the data points include European Countries Listed in IMD Competitiveness 2004 scoreboard.)

Table 5.4 The Characteristics of the European Countries Defined in Oliver et al. (2005)

Boundary	Population Density (Persons/km^2)	Economic Competitiveness	Characteristics
Box 1	*10~80*	*72.5~87.5%*	*High level of competitiveness and relatively low population density - brownfield regeneration focuses on dealing with contamination*
Box 2	*225~480*	*65%~85%*	*High population density and consequent lack of available greenfields - brownfield (previously developed land) regeneration is priority.*
Box 3	*50~210*	*41%~61%*	*Medium population density and lower competitiveness*

5.4. Results

5.4.1. Population Density and Economic Competitiveness

Figure 5.3 shows scatter plots of economic competitiveness scores and population densities of countries worldwide. The figure also shows that the relative positions in competiveness of most countries between 2005 and 2009 generally remained the same. The values of correlation coefficients between competitiveness scores among these three years confirmed the observation (0.8367, 0.7961 and 0.8942 between 2005 and 2007, 2005 and 2009, and 2007 and 2009, respectively). However, Iceland was dropped from the competitiveness evaluation in 2009 probably because of its economic crisis in 2008.

The countries on the continent of America were either close to Box 1 or to Box 3 depending on their stages of development. The highly economically developed countries such as the U.S. and Canada were close to or inside the box 1. Other America countries in the figure were mostly emerging economies. They had relatively lower population densities than countries in Box 3 but had similar economic competitiveness scores to the countries in Box 3.

The countries on the continent of Asia were mostly closer to Box 2 and Box 3. Asian countries close to Box 2 were Japan, Taiwan and South Korean. There were several countries with lower population densities than the range of Box 2 but high economic competitiveness (for example China, Thailand and Malaysia). Rest of the Asia countries included in the analysis were located in the positions near Box 3. The two Asian-European countries are Russia and Turkey. Turkey is located inside Box 3 while Russia had similar level of competitiveness score with the South America countries but lower population density.

Australia and New Zealand are located in Box 1. They belong to the Oceania countries. Culturally and demographically, however, they may be considered Western countries, or belong to the 'Global North'. Most Asian countries or Oceania countries are considered the 'Global South'.

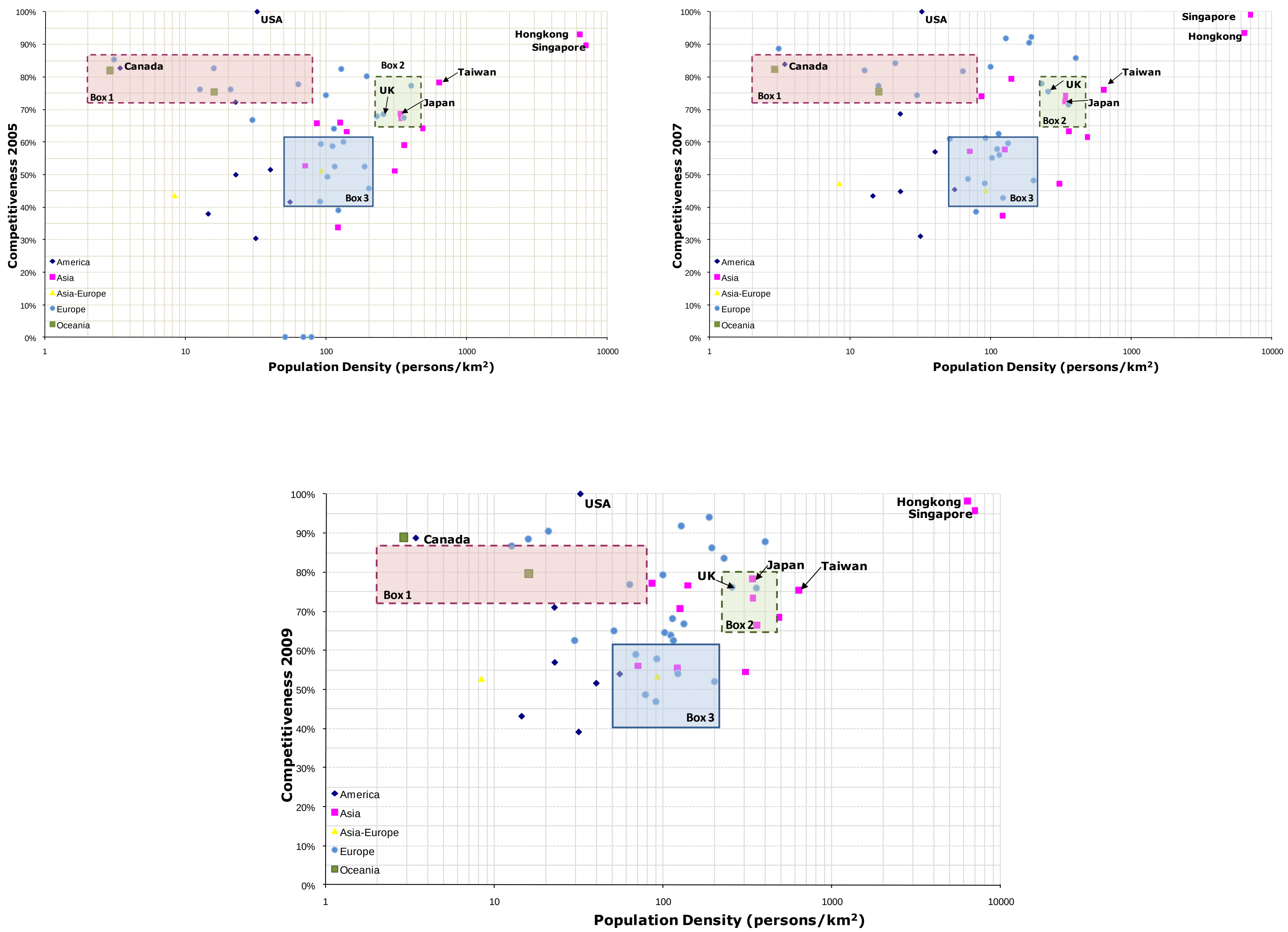


Figure 5.3 The Distribution of Population Density and Economic Competitiveness

Singapore and Hong Kong exhibited very high economic competitiveness scores and population densities. Their population densities are much higher than the countries near Box 2. They might have achieved the high economic performance utilising natural resources outside their territories (Esty et al, 2005).

The competitiveness scores of South Africa were 51.95%, 44.48% and 52.85% for 2005, 2007 and 2009, respectively. The population density (40/km^2) was just outside of lower end of Box 3. It was the only country in Africa with a measurement of competitiveness.

5.4.2. The Relationship between ESI 2005 and EPI 2008 Clusters and Population Density

ESI 2005 and EPI 2008 clustered countries using different criteria. The characters of clusters are summarised in Table 5.5 and Table 5.6 for ESI 2005 and EPI 2008, respectively. Both indexes differentiated countries earning low GDP and high GDP. The GDP was reportedly positively correlated with scores of EPI 2008 (Esty et al., 2008).

Cluster 1 and 3 in ESI 2005 had better scores in human vulnerability domain and Cluster 5, 6, and 7 in EPI 2008 had better scores in environmental health domain. These clusters all have relative high average GDP values. Thus, GDP per capita are a good indicator of human living condition in both indexes.

However, the GDP per capita was not a good indicator for natural environmental condition and stress. The population density corresponded with the environmental conditions much better in ESI 2005. Higher population density corresponded with worse environmental conditions. In EPI 2008, GDP is not a good indicator for the performance of responding to climate change issues, nor the population density.

Among countries evaluated in ESI 2005 and EPI 2008, only the economically progressive countries were included in the economic competitiveness survey. For example, countries in the clusters with the highest averages of GDP in ESI 2005 (Cluster 1 and 3) were all covered in the economic competitiveness evaluation. More countries were included in the competitiveness survey in Cluster 5 and 7 of

EPI 2008. These two clusters also had highest average GDP per capita. The economic data of wealthier countries seem more readily available.

The population densities and competitiveness scores in Cluster 3 countries in ESI 2005 overlapped with Box 1 defined by Oliver et al. (2005), while the values of these two variables in most of the Cluster 1 countries and some of the Cluster 4 countries overlapped with Box 2 (Figure 5.4). Most of the Cluster 7 countries and some of Cluster 4 countries appeared within the boundaries of Box 3 defined in Oliver et al. (2005). The EPI 2008 clusters, however, did not differentiate boxes in Oliver et al. (2005) (Figure 5.5).

Table 5.5 Characteristics of Countries in ESI 2005 Cluster Analysis (after Esty et al., 2005)

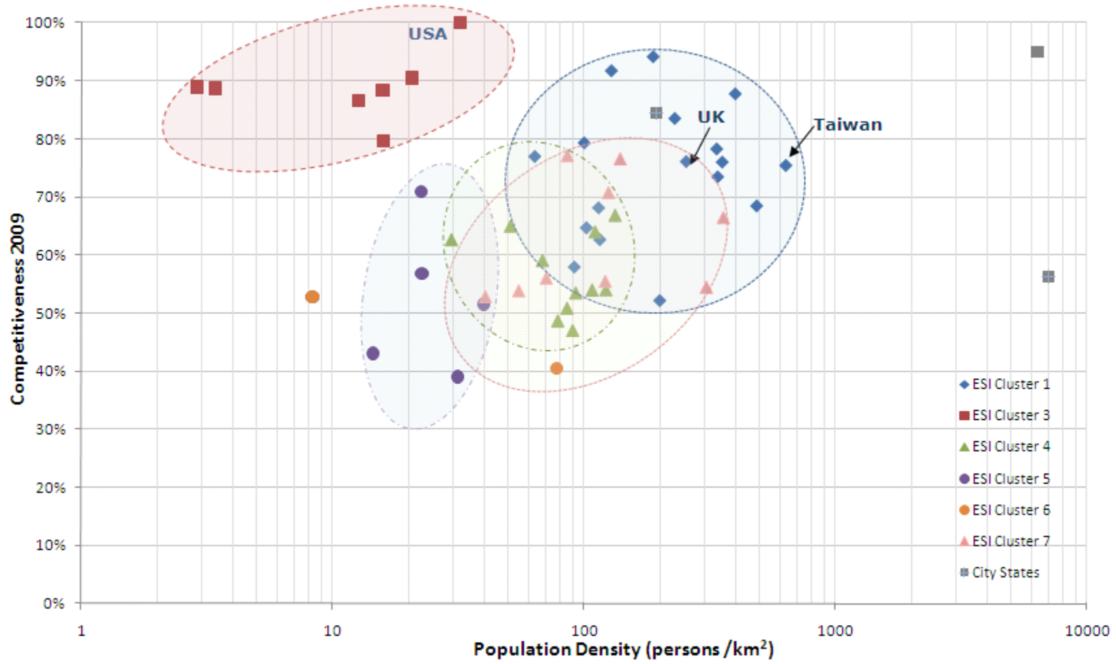
ESI 2005 Cluster	Ecological Condition and Environmental Resources		Human Living Condition	Institutional Capacity	Global Stewardship	GDP($)	Population Density (person/km^2)	Number of Countries Included in the Competitiveness Evaluation
	System	Stress						
1	*Low*	*Low*	*Good*	*High*	*Moderate*	*27,480*	*238*	*17 out of 17 countries*
2	*Moderate*	*Moderate*	*Bad*	*Low*	*Good*	*420*	*70.3*	*0 out of 41 countries*
3	*Good*	*Moderate*	*Good*	*High*	*Moderate*	*29,860*	*13.5*	*8 out of 8 countries*
4	*Moderate*	*Moderate*	*Good*	*Moderate*	*Low*	*4,390*	*122*	*11 out of 18 countries*
5	*Good*	*Moderate*	*Moderate*	*Moderate*	*Moderate*	*2,980*	*32.1*	*5 out of 19 countries*
6	*Moderate*	*Moderate*	*Moderate*	*Low*	*Low*	*3,810*	*56*	*2 out of 19 countries*
7	*Low*	*Moderate*	*Moderate*	*Moderate*	*Moderate*	*1,730*	*174*	*9 out of 24 countries*

Table 5.6 Characteristics of Countries in EPI 2008 Cluster Analysis (after Esty et al., 2008)

EPI 2008 Cluster	Characters					GDP($)		Population Density (person/km^2)	Number of Countries Included in the Competitiveness Evaluation
	Environmental Health	Biodiversity	Climate Change	Development Stage	Geographic Feature	Average	(5%; 95%)		
1	*low*	*low*	*-*	*-*	*geographically disparate countries*	*4039.6*	*(1287.5;8300.8)*	*99.812*	*4 out of 26 countries*
2	*-*	*low*	*low*	*-*	*geographically diverse group*	*4078.8*	*(1888.8;6227.3)*	*30.924*	*0 out of 6 countries*
3	*low*	*-*	*high*	*developing to transition*	*-*	*1555.2*	*(735.3;2696.7)*	*134.376*	*1 out of 19 countries*
4	*low*	*high*	*-*	*developing to transition*	*-*	*1205.5*	*(682.9;2138.2)*	*71.104*	*0 out of 16 countries*
5	*high*	*-*	*low*	*several levels of development*	*several geographic regions*	*13574.5*	*(3538.6;34847.9)*	*131.884*	*13 out of 26 countries*
6	*high*	*-*	*-*	*-*	*-*	*9998.5*	*(1923.3;23021.4)*	*102.540*	*1 out of 12 countries*
7	*high*	*-*	*high*	*economically diverse*	*geographically diverse*	*19631.9*	*(4958.1;33568.1)*	*109.397*	*33 out of 42 countries*

a.

b.



c.

Figure 5.4 ESI 2005 Country Clusters in Relation to Demographic and Economic Conditions

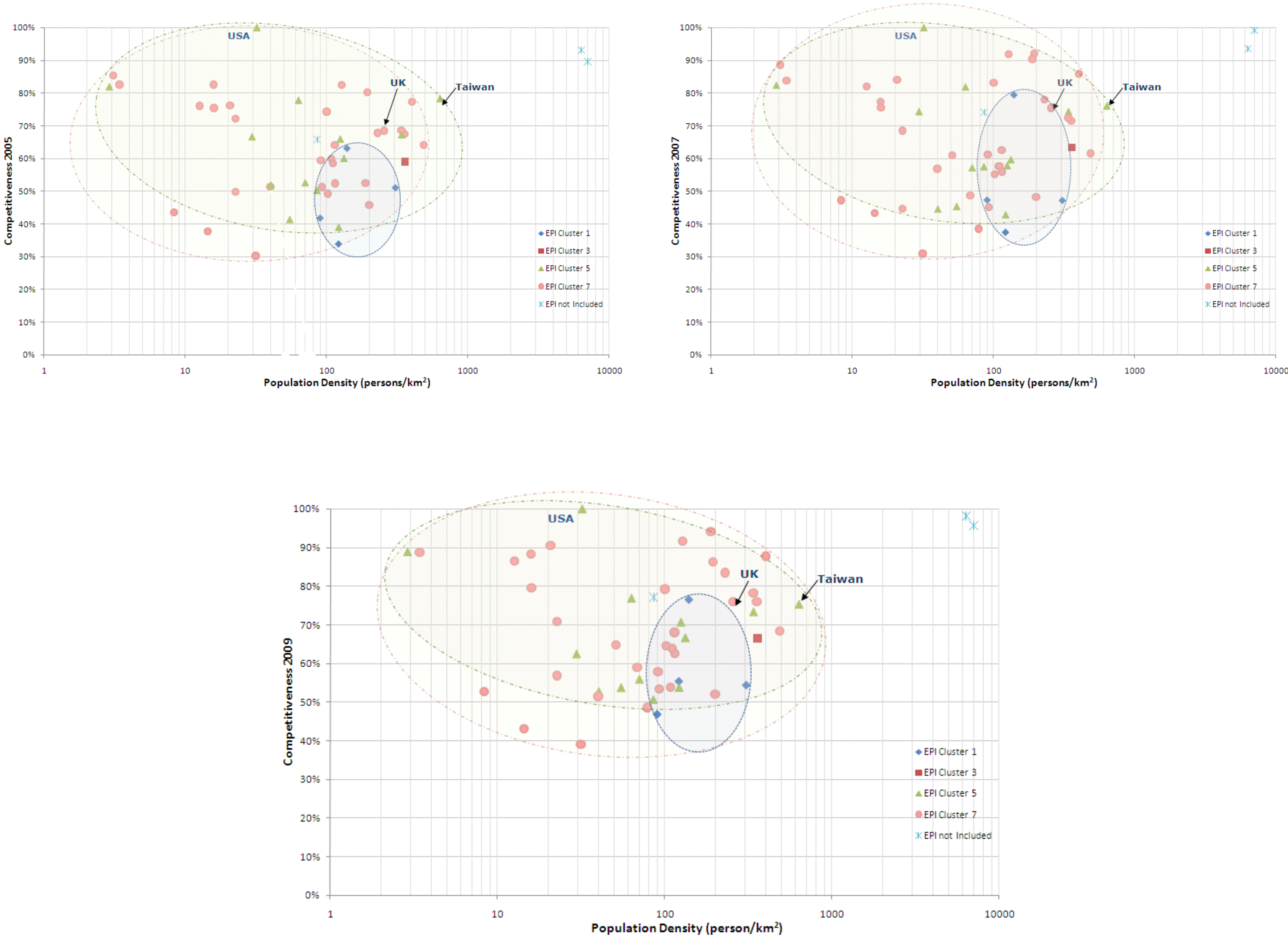


Figure 5.5 EPI 2008 Country Clusters in Relation to Demographic and Economic Conditions

5.4.3. Brownfield Definitions Corresponding to Different Clusters

Outside the European countries, Canada, the U.S., Australia and New Zealand fitted the profile of Box 1 countries defined by Oliver et al. (2005) (Section 5.4.1). They had high economic competitiveness scores and low population densities. Canada and the U.S. have considered the presence of contamination as an essential criterion for a site to be considered 'brownfields' (Section 2.3.1). Additionally, both countries established legally bound soil and groundwater standards for wide range of chemicals. Site-specific risk-based clean-up standards have been considered optional only when the responsible parties plead for alternative remediation standards (usually a less strict criterion). For the seriously contaminated sites such as 'superfund sites' in the U.S., the risk assessment could also be used as a tool in the court for compensations. The brownfield regeneration policies of the two countries focus on contamination clean up.

The definition of brownfields in New Zealand seemed to be closely related to contamination. One official report relevant to Auckland City defined 'brownfields' as the 'industrial site that has demonstrated evidence of what Auckland City Council considers to be a high soil contamination health risk for the purposed land use (Auckland City Council, 2010, p8).'

By contrast, Australia, though a low population density country, has adopted the approaches of the UK. The definition of brownfields in Australia is 'land within an urban area on which development has previously taken place' (The Department of the Environment, Water, Heritage and the Arts, 2009, p84).

Overall, the countries with low population densities and high economic competitiveness scores tend to define brownfields based on the contaminations.

Japan fitted the profile of the countries in Box 2 defined by Oliver et al. (2005). In an Interim Report '*Current Status of the Brownfields Issue in Japan*' in Japan's Ministry of Environmental website, 'brownfields' was defined as 'lands which are unused or with extremely limited use compared to their intrinsic values because of existence or potential existence of soil contamination (Expert Studying Group for Countermeasures against Brownfields, 2007, p1).' The study surveyed and discussed the land that may require higher cost than its current value to remediate.

The report cited the guidance established by the U.S. Therefore, it is understood that like the U.S., Japan associates brownfield land with contaminants on site. At the same time, the report pointed out the potential economic and social consequences resulted from brownfield sites. The social issues of brownfield sites also became the background for a crime thriller *Namonaki doku* (*Poisons with no Names*) written by a famous Japanese writer Miyuki Miyabe (Miyabe, 2006). Therefore, Japan is quite aware that returning the site back to previous environmental conditions is not the only problem. The country recognises the importance of regenerating brownfield to solve the socio-economic issues.

Taiwan has relatively high economic competitiveness and population density. Its position in Figure 5.3 was closer to Box 2 defined in Oliver et al (2005). However, the perceptions of brownfield land in Taiwan resembled the definition of 'brownfields' in the U.S (TEPA, 2007a; TEPA 2009c). The impacts of adopting the brownfield definition from the U.S. are discussed in Chapter 8 and Chapter 9.

5.5. Discussion: Various Strategies to Achieve Sustainability

5.5.1. Variations among Countries

The analysis in this chapter revealed that countries have the potential to achieve higher economic and environmental sustainability regardless of the density of the populations. However, population density determines suitable strategies to pursue sustainable development.

Superimposing the analytical framework of Oliver et al. (2005) with clusters in ESI 2005, a pattern emerges (Figure 5.6). The Cluster 3 countries in ESI 2005 overlapped with Box 1 countries in Oliver et al. (2005). They have good environmental and economic performance. Likewise, Cluster 1 overlapped with Box 2 countries in Oliver et al. (2005). They generally have good economic performance. Although the scores of ESI 2005 are high in these countries, the environmental stress is high partly due to high development densities. The similar pattern of the Oliver et al. (2005) and ESI 2005 also indicates that to establish a brownfield regeneration strategy to successfully improve sustainability, development density is an important factor to consider.

Taiwan belongs to Cluster 1 countries. However, it behaved as an outlier in ESI 2005 score, and in the framework of analysing the definition of brownfield. The possible effect of the brownfield definition on the environmental sustainability in Taiwan is discussed in Chapter 8 and Chapter 9.

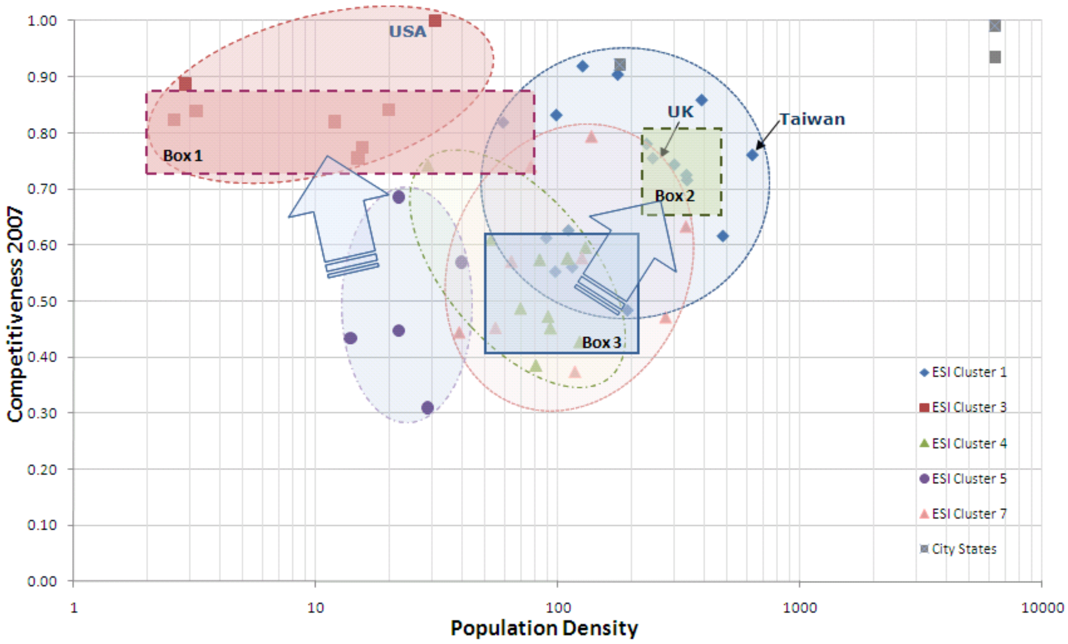


Figure 5.6 The Oliver et al. (2005) boxes and ESI 2005 Clusters and Possible Progressing Path of Countries

Cluster 4 and Cluster 7 occupy similar position as Box 3 described in the framework of Oliver et al. (2005). These countries include former Eastern European countries and some emerging economies such as Mexico and China. Their economic performances are moderate (based on GDP per capita) and so are their environmental performances and social institutional capacities. Several southern America countries (Argentina, Brazil, Chile, Colombia and Venezuela) in Cluster 5 do not overlap with any boxes in the framework of Oliver et al. (2005). They have relatively abundant natural resources and low population densities. Their economic performances are moderate.

The population in the emerging economies are usually expected to grow. The population densities of Cluster 4 and Cluster 7 countries would move closer to the group of countries in Cluster 1 or Box 2 (Figure 5.6). Therefore, like Cluster 1 countries, these countries may have better chances to improve their economic and environmental sustainability through improving the institution capacity. On the other hand, Cluster 5 countries may utilise either social or environmental resources (or both) to improve sustainability because their population densities are relatively low. If their strategies are successful, the may develop towards the positions of Box 1 or Cluster 3 in the framework of Oliver et al. (2005). The countries in Clusters 4, 5 and 7 are experiencing industrialisation. The problems of brownfield land are gradually becoming apparent. Therefore, they may also need to look for lessons to regenerate brownfiels from their industrialised counterparts with similar level of population densities.

The information of Cluster 2 and 6 countries is not available for evaluating the economic competitiveness. The two clusters have moderate environmental sustainability and low social capacities. Their population densities (Cluster 2, 70.3/km^2 and Cluster 6, 56/km^2 in Table 5.2) were at lower end of Box 3 (50/km^2 in Table 5.4). To catch up with their peers, these countries need to improve the social capacities and make better use of the environmental resources. Further investigation of the stages of development and the scales of brownfield land of these countries may be needed to see whether brownfield regeneration is a suitable tool to improve sustainability.

The cluster analysis in EPI 2008 was not very selective in terms of population density and economic performance (Figure 5.5). Since the index measures the 'current environmental status', this result demonstrates the good economic performance and abundant environmental resources of a country could be helpful but cannot guarantee good environmental sustainability.

Cluster 1 countries have high population densities, high economic competiveness and high environmental performances. In this group, western European countries have defined brownfield land as previously used and currently underused (or vacant), but not necessarily contaminated. They apply 'suitable for use' principles to manage the brownfield land. However, also in this group, Japan and Taiwan associate brownfields with industrial contamination. The case of Taiwan is further discussed in this thesis.

Although the density of population may help to group better approaches in brownfield regeneration, the effects of the pace of development, and the effects of political contexts of countries on brownfield regeneration require further considerations. For example, styles of urbanisation and the trend of demographic changes in Pacific Asia countries are quite different from their industrialised predecedors (Drakais-Smith, 1996; AECOM, 2010). These may affect the land use demands and brownfield regeneration policies.

Moreover, the discussion in this chapter is mostly based on overall environmental and economic sustainability. It does not specifically evaluate the sustainability relevant to land resources. The evaluation of land use sustainability, specifically for sustainable brownfield regeneration, is dealt with Chapter 6.

5.5.2. Variations within Countries

Although uneven socio-economic resources distributions lead to un-sustainable situations (Section 2.4.4), demographic variations do not necessarily limit sustainable development. The ESI 2005 Cluster 3 countries are the economically advanced countries with relatively low population densities. Their population distributions are highly uneven (Figure 5.7).

The ESI 2005 Cluster 1 countries had relatively even population distributions. Given the high population densities in these countries, people may have occupied most liveable areas (Section 5.1.1) and greenfield land becomes scarce.

On the other hand, Cluster 4 countries (mostly emerging economies) have just moved into the process of urbanisation. Therefore, the distributions of population are relatively even. As their land is relatively limited and the populations are expected to grow, they might move towards the distribution patterns like Cluster 1 countries.

There is not enough information to evaluate the Cluster 5 countries, which encompass mostly South American countries. They still have relatively abundant land resources. The analysis in this chapter suggested that they may be successful in sustainable development if they follow the strategies of Cluster 3 countries. As results, their demographic distributions may resemble that of Cluster 3 countries and remain uneven.

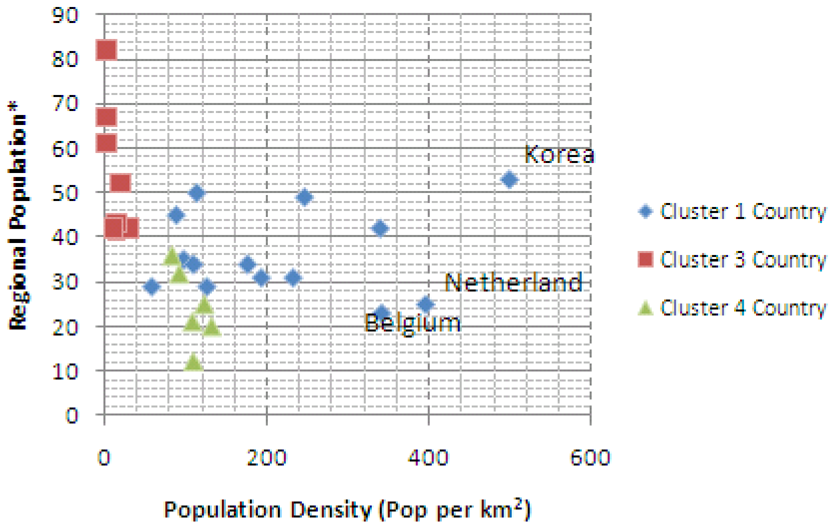


Figure 5.7 Population Density and Index of Geographic Concentration of Population (*the 'Regional Population' refers to highest percentage of population concentrated on 10% of countries area, the data were obtained from OECD 2008)

5.6. Conclusion

The analysis in this chapter indicated that the framework established by Oliver et al. (2005) can be generalised to the rest of the advanced and emerging economies. The demographic factor strongly influences the approaches of brownfield regeneration and contaminated land clean up. The economically competitive countries with limited land resources may be more successful in pursuit of sustainable development (as measured by ESI 2005 and EPI 2008) if they apply 'suitable for use' principles on brownfield regeneration to improve social capacities. Taiwan is an exception of this principle. The result of this is discussed in Chapter 9.

Chapter 6 The Principal Components of Land Use Sustainability

The excessive amounts of brownfield areas coexist with un-sustainable socio-economic conditions, but reduced amounts of brownfield areas do not always decrease the level of deprivation (Chapter 4). Furthermore, countries with different demographic conditions may require different styles of brownfield policies to improve sustainability (Chapter 5). However, measurements of sustainability in previous chapters have not specifically evaluated the issues of sustainability relevant to brownfield regeneration. High level of sustainability may have been achieved by implementing other policies but not brownfield regeneration. Problems resulting from brownfield sites could be masked.

To further test the applicability of the conclusion from previous Chapters, an index was established to evaluate sustainability of land resources and brownfield redevelopment. Brownfield regeneration should aim to revitalise the community, boost the economy and reduce further damage to greenfield sites (Dixon and Adams, 2008; the World Bank 2010). Therefore, the selection of variables was based on these considerations. Additionally, this index sought for a balanced view between environmental, social and economic aspects (Section 2.4.3). Because brownfield regeneration is not solely an eco-centric issue (Section 2.4.2), the performance was evaluated by considering both natural and artificial environments.

The Principal Component Analysis (PCA) was conducted on the selected variables to extract environmental, social and economic aspects of land use sustainability. The result of the analysis determined the weight of each variable in the index to balance the measurements of the three aspects. The resultant index showed the three aspects sometimes compliment but sometimes contradict one another.

The scores of countries were calculated based on the composed index. The result indicated that the ideal style of brownfield policy in Taiwan should be closer to western European countries. It is important for Taiwan to at least retain, if not reduce, the anthropogenic impact within current limits. Reusing limited land resources to maintain social and economic sustainability is crucial for a sustainable Taiwan.

6.1. Analytical Tools for Evaluating Land Use Sustainability

6.1.1. Evaluating Land Use Efficiency

The goal of brownfield regeneration is to optimise economic, environmental and social conditions (Dixon and Adams, 2008; the World Bank 2010). The improvement of each of the three aspects in sustainability, however, could be dependent on or contradict each other (Section 2.4.2 and Section 2.4.3). This chapter establishes a benchmark to equally represent the three aspects. In this way, the positive and negative effects may be valued in a relatively neutral perspective.

On the other hand, the existence of a brownfield site is only one of many factors that can damage sustainability. For example, the rural local authorities in England can be deprived without having much PDL (Section 4.4.2 and Section 4.5.2). An unsatisfactory condition may imply either the bad brownfield regeneration policy, or the existence of other development issues. Thus, the result of the index should be established and utilised under the consideration of 'whether the unsatisfactory score could be improved by changes in brownfield policy'.

6.1.2. Issues with Current Sustainable Indexes

The indexes of sustainability were usually generated in three steps (reviewed in Section 2.4.5 and detailed in Böhringer and Jochen, 2007). The variables and the weight of variable define the 'sustainability' in these indexes (for example, ESI 2005 and EPI 2008 discussed in Section 5.3.4 and Section 5.3.5). Therefore, selecting the variables and determining how to weigh them were the sources of controversies (explained in Section 2.4.5 and Section 3.3). With these difficulties, judging the sustainability of a country based on any of these sustainable indexes without understanding how they were composed may be misleading.

For evaluating the sustainability of brownfield regeneration, several organisations have attempted to establish indexes (for example, Williams & Dair, 2007; Thornton et al., 2007). However, for various reasons discussed in Section 2.4.5, they are considered unsuitable to evaluate the performance of brownfield regeneration policy at the national level. Therefore, an index specifically fulfils the objectives of this study needs to be established.

6.1.3. Statistical Issues when Evaluating Land Use Sustainability

The initial step of building an index (Section 2.4.5.) is to collect representative variables related to brownfield regeneration. Then, the weights are assigned to the selected variables. In this study, the weights should be determined in order to represent social, economic and environmental sustainability equally.

Four types of methods have been employed in determining the weights of variables in the final composite index (Lawn and Sanders, 1999; Sands and Podmore, 2000; Lawn, 2003; Böhringer and Jochem, 2007; Distaso, 2007; Singh, Murty, & Gupta, 2007). However, each of them has limitations (Freudenberg, 2003; also briefly discussed in Section 3.3). The choice of the statistical method PCA was based on the consideration of the characteristics this index intended to possess (Section 3.3).

Sustainability is an ambiguous concept (Section 2.4.2). An ideal method for generating index of sustainable brownfield development should convert the ambiguous concept into a quantifiable index. Furthermore, the index should equally represent three aspects of sustainability as well as subjectively evaluate the sustainability relevant to brownfield regeneration.

PCA is a statistical method that helps quantitatively describe ambiguous concepts (Bryman and Cramer, 2005; Child 2006). The method evaluates the linear correlations between variables to extract common components among the collected variables. The normal distribution of the collected variables may not be necessary (Child, 2006). Since the distributions of the variables were unknown before being collected, this would be advantageous to this study. Additionally, PCA may help identify the relative percentage contributed to the index from the extracted components by calculating the percentage of the variance explained by each component. This may be advantageous to the analysis since representing the three components of sustainability equally is important. Therefore, this study utilised the PCA as a method to establish a sustainable index.

6.2. Regional Variations and Sustainability

Regional variations and sustainability could relate to each other in different ways (Section 2.4.4, Section 4.5.3 and Section 5.5). Understanding the effects of regional variations on sustainability could provide insight that the average statistical values of a country cannot provide. However, except income equality, measurements of regional variations were not often included in the established index to evaluate sustainability. For this reason, the variables measuring variation within a country are included in the index of this study when possible. In this section, I discuss some issues of regional variations to justify the use of the variables measuring regional variations.

6.2.1. Variations Affecting Sustainability

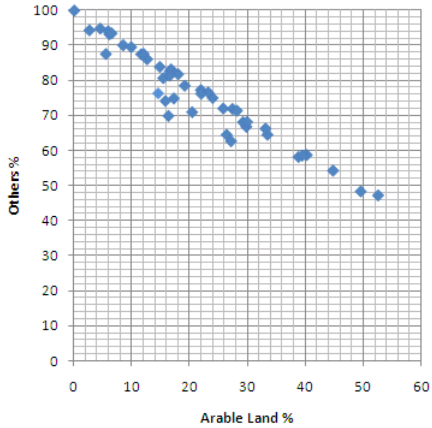
Significant geographic and demographic variations do not necessarily make development un-sustainable (Section 5.1.2 and Section 5.5.1). Some studies further argued that proximity and agglomeration are sometimes constructive to economic and industrial development (Malmberg & Maskell, 1997; Brulhart & Sbergami, 2009), which is required to maintain a sustainable human society. In the case of agriculture, in recent years, a homogenous cropland has been considered not good for biodiversity and the safety of food production (Holdren & Ehrlich, 1974). Therefore, the variation of the environmental landscape can be positive to sustainable development (Section 2.4.5).

The distribution of sectors may represent the stage of development in a country (Section 2.2). This can be represented by the distributions of sectors in land uses, labour resources as well as GDP. Available agricultural land and other types of land use (presumably built-up areas for industrial, residential and service purposes, or undeveloped areas) appear to be negatively correlated (Figure 6.1a). Service sectors seemed to take up both capital and human recourses from the industrial sector as well as for agriculture (Figure 6.1b to Figure 6.1e). These negative correlations demonstrated the shift of dominant sector during the process of development or industrialisation/deindustrialisation.

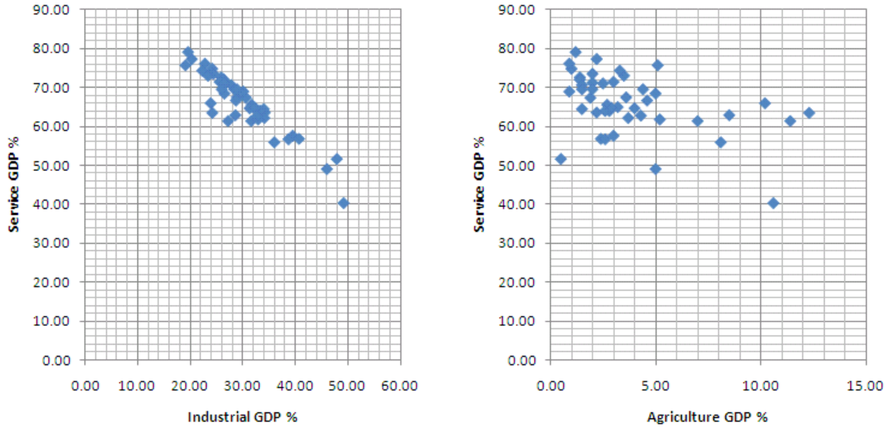
Countries with various degrees of industrialisation, however, may have their own ways to achieve or maintain sustainability as the results of ESI 2005 and EPI 2008 suggested. Some less economic developed countries can perform well in the two indexes (Table 6.1). For example, according to the *CIA World Factbook* in 2010, Albania had GDP per capital lower than world average in 2010, relatively high percentages of agricultural labour and GDP. However, the country scored high in both ESI 2005 and EPI 2008. In this case, the variations of GDP and labour forces may be relevant but not necessarily good or bad to sustainability.

However, the proportions of different types of land use affect environmental sustainability. As human development progresses, the anthropogenic land use increased and the natural environment degraded (Figure 1 in Foley, et al., 2005). Innovative ways are needed to utilise environmental services so that environmental resources can be reasonably preserved. This is vital to satisfy the need for the current generation, while preserving a fair amount of natural resources for future generations.

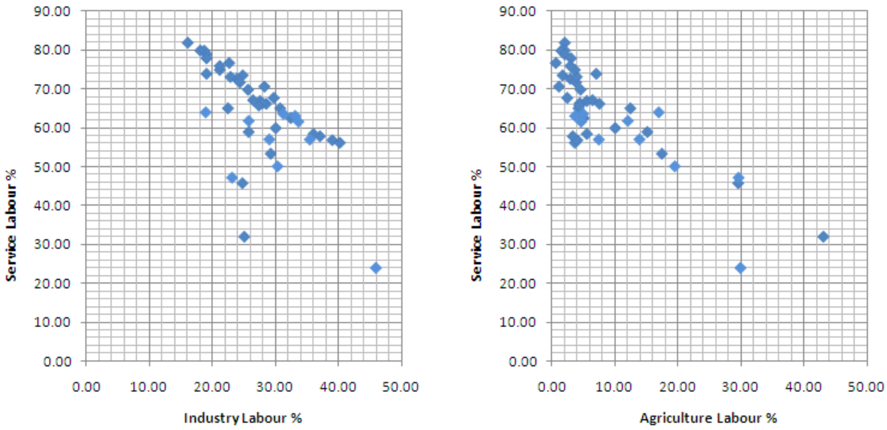
Furthermore, the proportion of different types of land use may reflect the level of social and economic development in a country. The switch from an industrial sector dominant to a service sector dominant economy is responsible for the emerging of brownfields (Section 2.2). Therefore, the different distributions of land use based on sectors may reflect the need of different strategies for brownfield regeneration.



a.



b.



c.

Figure 6.1 The Relationship between the Land Use, GDP and Labour Force of Different Sectors (data recorded in year 2005 obtained from CIA the World Factbook between 2005 and 2008)

Table 6.1 The Rankings of Countries in ESI 2005 and EPI 2008

		ESI 2005		
		H	M	L
EPI 2008	H	Albania, Argentina, Australia, Austria, Belarus, Brazil, Canada, Chile, Colombia, Costa Rica, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Japan, Latvia, Lithuania, Malaysia, New Zealand, Norway, Portugal, Russia, Slovakia, Slovenia, Sweden, Switzerland, United States, Uruguay	Bosnia and Herze., Cuba, Ecuador, Georgia, Greece, Hungary, Israel, Italy, Macedonia, Mexico, Nicaragua, Spain, Sri Lanka, United Kingdom, Venezuela	Dominican Rep., Pakistan, Poland, Taiwan
	M	Armenia, Bolivia, Botswana, Congo, Croatia, Gabon, Ghana, Namibia, Netherlands, Paraguay, Peru	Algeria, Azerbaijan, Bulgaria, Czech Rep., Honduras, Jordan, Kyrgyzstan, Madagascar, Malawi, Moldova, Mongolia, Nepal, Oman, Romania, South Africa, Thailand, Tunisia, Turkey	Belgium, Guatemala, Iran, Jamaica, Kenya, Lebanon, Morocco, Philippines, Saudi Arabia, South Korea, Syria, Tajikistan, Trinidad & Tobago, Turkmenistan, Viet Nam, Zimbabwe
	L	Central Afr. Rep., Guyana, Mali, Myanmar, P. N. Guinea, Panama	Benin, Burkina Faso, Cambodia, Cameroon, Côte d'Ivoire, Egypt, El Salvador, Guinea, Guinea-Bissau, Indonesia, Kazakhstan, Laos, Senegal, Tanzania, Uganda, Zambia	Angola, Bangladesh, Burundi, Chad, China, Dem. Rep. Congo, Ethiopia, Haiti, India, Iraq, Kuwait, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Sierra Leone, Sudan, Togo, United Arab Em., Uzbekistan, Yemen

H: countries ranked the first third in the index

M: countries ranked the middle third in the index

L: countries ranked the last third in the index

6.2.2. Variations Leading to Un-sustainable Conditions

Some regional variations, however, are definitely the sign of un-stainable situations. For example, in Figure 4.3, high variation of regional socio-economic conditions (Gini index of IMD) is positively correlated with worsening average deprivation conditions (IMD Scores). Regional variations in socio-economic status have negative impacts on sustainability.

Anand and Sen (2000) indicated that the 'distribution' of income among a group of people matters the most in terms of improving human development. 'In particular, the biggest impact may be expected to occur if the rise in average GNP per head goes with a sharp reduction in the poverty of the worst-off people, rather than going in other directions (Anand & Sen, 2000, p2032).' They further indicated that sustainable conditions may be optimised if the increase of total economic power is primarily invested in improving public infrastructure; countries with different GDP levels may achieve similar levels of quality of life. It depends also on the cultural background and policy implementation in these countries. Examples and detailed explanation may be found in Wilkinson & Pickett (2010).

6.3. Data Selection and Analytical Method

6.3.1. Selecting Factors Affecting Brownfield Regeneration

Three basic criteria were used in selecting the variables included in the PCA: in addition to the relevance to sustainability, the variables should be related to land resource management or problems that brownfields may bring. The selected variables based on the criteria are summarised in Table 6.2.

Among 30 variables identified, the majority of variables have data at least up to the year 2005. Thus, most of the data used in the analysis, if not otherwise specified, were addressing the situation in year 2005. The source of data depicted in Table 6.2 is where the majority of data came from. Sometimes, the numbers were still missing after additional efforts to find numbers unavailable in the specified database. This is because the definition of the variables in alternative source was not consistent with the majority, or because no similar survey was published outside the databases used here.

The selected variables were considered being linked to at least one aspect of sustainability. Some links between the variables and the three aspects were identified before the PCA was conducted (Table 6.3). Among all the variables, I identified 12 that are relevant to environmental sustainability, 10 to the social sustainability and 17 to the economic sustainability. More than likely, some links were overlooked; the importance of each variable to the sustainability may not be equal. Therefore, the identification of the links is not equal to the quantitative evaluation of the variables. Nevertheless, this preliminary evaluation later helped to identify the characteristics of the major components in the PCA (Section 6.3.5).

Table 6.2 The Relevance of Variables with Selection Criteria

Perspectives Related to Brownfield Regeneration and Land Use	Nature of Measurement	Abbreviation	Definition	Relevant Perspectives			Source of Data
				Sustainability	Land Resources Management	Brownfield Relevant Issue	
Ecological	Direct Measurement	ECORISK	*Percentage of country's territory in threatened ecoregions*	•	•	•	*ESI 2005*
	Variation	NBI	*National Biodiversity Index*	•	•	•	*ESI 2005*
Land	Direct Measurement	ANTH40	*Percentage of total land area having high anthropogenic impact*	•	•		*ESI 2005*
		ANTH10	*Percentage of total land area having low anthropogenic impact*	•	•		*ESI 2005*
	Variation	Permanent Crops %	*The percentage shares of total land area for permanent crops land, land cultivated for crops not replanted after each harvest.*	•	•		*CIA factbook, 2008*
		Others %	*The percentage shares of total land area for other land, any land not arable or under permanent crops.*	•	•		*CIA factbook, 2008*
		Arable Land %	*The percentage shares of total land area for arable land, land cultivated for crops replanted after each harvest.*	•	•		*CIA factbook, 2008*
Population	Direct Measurement	GR2050	*Percentage change in projected population 2004 - 2050.*	•	•		*ESI 2005*
		Population Density	*Number of people per square meter.*	•	•		*Population-UN 2005,or CIA factbook 2005 Area-CIA factbook,*
	Variation	Regional Population-Index of Geographic	*Spatial distribution of the population taking into account the area of each region*	•	•	•	*OECD 2008*
		Elderly Population - Index of Geography	*Spatial distribution of elderly population taking into account the area of each region and reveals large international differences in the degree of geographic concentration of elderly people*	•		•	*OECD 2008*
Urbanisation	Direct Measurement	Urban Population	*The percentage of the total population living in urban areas, as defined by the country*	•	•		*CIA factbook, 2008*
		Urbanisation Rate	*The projected average rate of change of the size of the urban population over the given period of time*	•	•		*CIA factbook, 2008*
Economy	Direct Measurement	Real GDP growth	*GDP growth on an annual basis adjusted for inflation and expressed as a percent.*	•		•	*OECD 2008*
	Variation	Agr GDP %	*Percentage of agricultural sector contributed to GDP*	•			*CIA factbook, 2008*
		Ind GDP %	*Percentage of industry sector contributed to GDP*	•		•	*CIA factbook, 2008*
		Service GDP %	*Percentage of service sector contributed to GDP*	•		•	*CIA factbook, 2008*
		Regional GDP-Gini Index	*The Gini index offers an accurate picture of regional disparities. The index ranges between 0 and 1: the higher its value, the larger the regional disparities.*	•		•	*OECD 2008*
		Income Inequality	*This index measures the degree of inequality in the distribution of family income in a country.*	•		•	*CIA factbook, 2008*
Employment	Direct Measurement	Long-Term Unemployment	*People's unemployment for 12 months or more as a percentage of total unemployed.*	•		•	*OECD 2008*
	Variation	Agr Labour %	*percentage of labour sector in agricultural sector*	•			*CIA factbook, 2008*
		Ind Labour %	*percentage of labour sector in industrial sector*	•		•	*CIA factbook, 2008*
		Labour service %	*percentage of labour sector in labour sector*	•		•	*CIA factbook, 2008*
		Regional Unemployment-Gini	*The Gini index offers an accurate picture of regional disparities. The index ranges between 0 and 1: the higher its value, the larger the regional disparities.*	•		•	*OECD 2009*
Education	Direct Measurement	PECR	*Female primary education completion rate*	•		•	*ESI 2005*
		ENROL	*Gross tertiary enrolment rate*	•		•	*ESI 2005*
Crime	Direct Measurement	Victimisation Prevalence	*Victimisation percentage, one-year prevalence among the entire population*	•		•	*OECD 2009*
		Fear of Crime	*Feeling unsafe or very unsafe on the street after dark, percentage of entire population*	•		•	*OECD 2009*
		Rule of Law	*The extent to which agents have confidence in and abide by the rules of society: They are perceptions of the incidence of crime, the effectiveness and predictability of the judiciary, and the enforceability of contracts.*	•	•	•	*ESI 2005*
Satisfactory	Direct Measurement	Subjective Satisfaction of Life	*The measurement combining the self-reporting and physiological satisfaction of life.*	•		•	*White, 2007*

Table 6.3 The Relevance of Selected Factors with Sustainability

Perspectives Related to Brownfield Regeneration and Land Use	Nature of Measurement	Abbreviation	Definition	Relevant Perspectives			Source of Data
				Environment	Social	Economy	
Ecological	Direct Measurement	**ECORISK**	*Percentage of country's territory in threatened ecoregions*	●			*ESI 2005*
	Variation	**NBI**	*National Biodiversity Index*	●			*ESI 2005*
Land	Direct Measurement	**ANTH40**	*Percentage of total land area having high anthropogenic impact*	●			*ESI 2005*
		ANTH10	*Percentage of total land area having low anthropogenic impact*	●			*ESI 2005*
	Variation	**Permanent Crops % (2005)**	*The percentage shares of total land area for permanent crops land, land cultivated for crops not replanted after each harvest.*	●		●	*CIA factbook, 2008*
		Others % (2005)	*The percentage shares of total land area for other land, any land not arable or under permanent crops.*	●		●	*CIA factbook, 2008*
		Arable Land % (2005)	*The percentage shares of total land area for arable land, land cultivated for crops replanted after each harvest.*	●		●	*CIA factbook, 2008*
Population	Direct Measurement	**GR2050**	*Percentage change in projected population 2004 - 2050.*	●	●	●	*ESI 2005*
		Population Density	*Number of People per square meter*	●	●	●	*Population-UN 2005, or CIA factbook 2005* *Area-CIA factbook, 2005*
	Variation	**Regional Population-Index of Geographic**	*Spatial distribution of the population taking into account the area of each region*	●	●	●	*OECD 2008*
		Elderly Population - Index of Geography	*Spatial distribution of elderly population taking into account the area of each region and reveals large international differences in the degree of geographic concentration of elderly people*		●	●	*OECD 2008*
Urbanisation	Direct Measurement	**Urban Population**	*The percentage of the total population living in urban areas, as defined by the country*	●	●		*CIA factbook, 2008*
		Urbanization Rate	*The projected average rate of change of the size of the urban population over the given period of time*	●	●		*CIA factbook, 2008*
Economy	Direct Measurement	**Real GDP growth**	*GDP growth on an annual basis adjusted for inflation and expressed as a percent.*			●	*OECD 2008*
	Variation	**Agr GDP %**	*Percentage of agricultural sector contributed to GDP*			●	*CIA factbook, 2008*
		Ind GDP %	*Percentage of industry sector contributed to GDP*			●	*CIA factbook, 2008*
		Service GDP %	*Percentage of service sector contributed to GDP*			●	*CIA factbook, 2008*
		Regional GDP-Gini Index	*The Gini index offers an accurate picture of regional disparities. The index ranges between 0 and 1: the higher its value, the larger the regional disparities.*		●	●	*OECD 2008*
		Income Inequality	*This index measures the degree of inequality in the distribution of family income in a country.*		●	●	*CIA factbook, 2008*
Employment	Direct Measurement	**Long-Term Unemployment**	*People's unemployment for 12 months or more as a percentage of total unemployed.*		●	●	*OECD 2008*
	Variation	**Agr Labour %**	*Percentage of labour sector in agricultural sector*		●	●	*CIA factbook, 2008*
		Ind Labour %	*Percentage of labour sector in industrial sector*		●	●	*CIA factbook, 2008*
		Labour service %	*Percentage of labour sector in labour sector*		●	●	*CIA factbook, 2008*
		Regional Unemployment-Gini	*The Gini index offers an accurate picture of regional disparities. The index ranges between 0 and 1: the higher its value, the larger the regional disparities.*		●	●	*OECD 2009*
Education	Direct Measurement	**PECR**	*Female primary education completion rate*		●		*ESI 2005*
		ENROL	*Gross tertiary enrolment rate*		●		*ESI 2005*
Crime	Direct Measurement	**Victimisation Prevalence**	*Victimisation percentage, one-year prevalence among the entire population*		●		*OECD 2009*
		Fear of Crime	*Feeling unsafe or very unsafe on the street after dark, percentage of entire population*		●		*OECD 2009*
		Rule of Law	*The extent to which agents have confidence in and been abided by the rules of society: They are perceptions of the incidence of crime, the effectiveness and predictability of the judiciary, and the enforceability of contracts.*		●		*ESI 2005*
Satisfactory	Direct Measurement	**Subjective Satisfactory of Life**	*The measurement combining the self-reporting and physiological satisfactory of life:*		●		*White, 2007*

6.3.2. The Database Searched

The databases searched were selected depending upon the availability, credibility and the transparency of the methodologies. Most of these international organisations have offered quality guidance or at minimal, provided the source of references (for example, CIA on-line references of Definition and Notes, OECD 2003c, Appendix A and Esty et al., 2005, Appendix C).

The majority of the variables were obtained from Environmental Sustainability Index 2005 (ESI 2005), Organisation for Economic Co-operation and Development (OECD), United Nation Economic Commission for Europe (UNECE), and *CIA World Factbook*. These databases have published the economic, environmental and social statistics annually or updated the statistics regularly for countries worldwide. Information about the OECD, UNECE and *CIA World Factbook* has been summarised in this section. ESI 2005 was introduced in Section 5.3.4.

6.3.2.1. Organisation for Economic Co-operation and Development (OECD)

The OECD is an international organisation established in 1961. Currently, there are 31 countries officially in the organisation. The organisation aims to achieve 'the highest sustainable economic growth and employment and a rising standard of living in Member countries', 'to contribute to sound economic expansion in Member as well as non-member countries', and 'to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations' (Article 1 of the OECD Agreement). The mission is to enhance economic sustainability and to raise living standards (social sustainability).

The organisation has been producing comparable statistics to analyse trends and to publish the forecasts on social and economic development of the world. It has been considered a major source of statistics for economic and social analyses for its consistency and reliability.

6.3.2.2. United Nations Economic Commissions for Europe(UNECE)

The UNECE was established by the United Nations Economic and Social Council. The aim of the organisation is 'to promote pan-European economic integration' (www.unece.org/about/about.htm). It provides analyses, policy advice and assistance to governments 'in the economic field'. The expertise of UNECE covers economic, energy, environment, housing and land management, gender, population, statistics, timber trade, and transport. The database of UNECE (w3.unece.org/pxweb/Dialog) was utilised to allocate some of the data points that could not be located in the OECD database .

6.3.2.3. Central Intelligence Agency the World Factbook (*CIA World Factbook*)

The *CIA World Factbook* recorded intelligence information collected by the CIA of United States. The first unclassified Factbook was published in 1971. It updates the statistics information for more than 165 countries annually. The database is commonly used by governments and other researchers.

The *CIA World Factbook* has been documenting several variables relevant to the variations of sectors and the variables measuring urbanisation in countries (Table 6.2). These data were not found in the OECD and UNECE. Since the transition of sectors (especially from industry to service sectors) plays an important role in sustainability (Section 6.2) and brownfields (Section 2.2), these variables were utilised in the PCA in this study.

6.3.3. The Countries Included in the Analysis

Thirty-three countries were selected in this analysis. The number of countries fulfilled the minimum requirement of the PCA. Generally speaking, the sample size should be bigger than variables in PCA (Child, 2006). In this analysis, thirty variables were picked to compose the index. However, a stricter rule of the number of required is five samples per variable (Bryman & Cramer, 2005; Child, 2006). In this case, data of 150 countries would be needed or only 6 to 7 variables could be used in the analysis. This was difficult to achieve, given some of the variables have not been commonly published in many countries.

Furthermore, the 33 countries selected for this analysis were mostly members of the OECD. This is because ESI 2005 and the CIA Factbook covered more countries than the OECD database. Even with this restriction of countries recruited, there were still some data points missing. The treatment of missing data was described later in Section 6.4.1.

The 33 countries covered four out of seven different clusters defined in ESI 2005 (Table 6.4) (see Section 4.1.2 for the discussion of these clusters). Briefly, Cluster 1 included the countries with higher social capacity but also high environmental stress (usually high in GDP and population density), while Cluster 3 encompassed the countries with higher social capacity and lower environmental stress (usually high in GDP and low in population density). Cluster 4 and 7 were countries with moderate to low social capacity and high to moderate environmental stress. The number of countries in Cluster 1 (17) in this analysis was much larger than that in other clusters. Therefore, it was expected the result of the PCA to reflect the view of economically developed countries especially those with higher population densities.

Table 6.4 Countries Included in the PCA Analysis

		ESI 2005		
		H	**M**	**L**
EPI 2008	**H**	Austria (14, VH), Denmark (13, VH), France (24, VH), Germany (16, VH), Ireland (21, VH), Japan (27, VH), Portugal (37, VH), Slovenia (52, VH), Switzerland (4, VH), Australia (5, VH), Canada (7, VH), Finland (19, VH), Iceland (30, VH), New Zealand (20, VH), Norway (9, VH), Sweden (6, VH), United States (3, VH), and Slovakia (49, VH).	Israel (17, VH), Italy (40, VH), Spain (36, VH), United Kingdom (22, VH), Greece (46, VH), Hungary (42, VH), and Mexico (47, H).	Taiwan (8, -), and Poland (32, VH).
	M	Netherlands (12, VH)	Czech Rep. (28, VH), and Turkey (48, H).	Belgium (25, VH), and South Korea (23, VH).
	L			China (18, M)

The number behind each country are the rank of business competitiveness calculated by IMD in 2010

The characters behind the countries are the group labeled by HDI (2010): VH, very high development; H, high development; M, medium development; -, not included

H: countries ranked the first-third in the index

M: countries ranked the middle-third in the index

L: countries ranked the last-third in the index

Dark red: Cluster 1 counrties in ESI 2005

Dark blue: Cluster 3 counrties in ESI 2005

Green: Cluster 4 counrties in ESI 2005

Organe: Cluster 7 counrties in ESI 2005

6.3.4. The Process of the Sustainable Index Establishment

The general procedure of establishing the index was reviewed and discussed (Section 2.4.5, Section 3.3, Section 6.1.2 and Section 6.1.3). The detailed steps are described below:

1. Establish criteria to recruit variables in the analysis: representativeness of sustainability, relevance to land resources management, relevance to the potential problems caused by brownfield sites (Table 6.2). The variables should be numerical and available at national level (explained in Section 6.1).
2. Identify databases that may have variables fulfilling the criteria described in step 1 (summarised in Section 6.3.2).
3. Estimate missing values (detail described in Section 6.4.1).
4. Produce and scan the correlation matrix of all the variables to examine the effects of imputation and the general relationships among variables (Appendix A).
5. Conduct the PCA on all the variables using SPSS (Section 6.4.2).
6. Carry out an initial interpretation of the PCA result. The result of PCA should provide a general understanding of the major components embedded in this collection of the variables (Section 6.4.2).
7. Evaluate the characteristics of each component based on the determined characteristics listed in Table 6.3 (Section 6.4.2).
8. Obtain the weight of each component based on the percentage of variation the component may explain (Section 6.4.2).
9. If the variances explained by each of the major components identified in the result correspond to social, economical, and environmental aspects are relatively equal, the index of land use sustainability can be established based on the result. If the result is not satisfactory, conduct a rotation (orthogonal or oblique) to refine the structure of the components (Section 6.4.2) to see whether the results may represent the three aspects more equally. In this study, the rotation was conducted.

10. After conducting step 6 to 9, by looking into the percentages of variance explained by each component, if the percentages in the major components in the (rotated or un-rotated) PCA results correspond with social, economical and environmental aspects equally, the index is to be established based on that result. If not, consider altering the compositions of the variables based on the communalities or component loadings of variables. The two parameters may determine the number of variables to be kept in the analysis (Section 6.4.2; Section 6.4.3). After altering the variables, repeat step 6 to 9 until the collection of the variables equally balanced the aspects of sustainability (Section 6.4.2).

11. Establish the Index of Land Use Sustainability: Determining the relationship (positive or negative correlations) of each component to sustainability, and assigning weights to the variables in each component based on their component scores coefficients (Section 6.5.1 and 6.5.2).

12. Calculate factor score for each country according to the final result of PCA. The scores were used in cluster analysis to identify countries with similar characteristics (Section 6.5.2).

13. Evaluate and compare the performances of Taiwan and the UK (Section 6.7).

6.4. Data Treatment and Principal Component Analysis

6.4.1. Missing Data Handling

Table 6.5 presents the descriptive statistics for the variables collected. The missing data were left blank if still unavailable after searching other databases, journal articles, or country profiles. The data describing regional variations were the most difficult to obtain (The effect of this is discussed in Section 6.6.4).

Several missing data techniques (MDTs) have been established to handle missing data in statistical analysis. SPSS provides three simple MDTs: listwise deletion, pairwise deletion and mean substitution. However, they all have advantages and disadvantages (Roth, 1994). I summarise these below:

Listwise data deletion deletes any individuals (in this case, individual countries) from the analysis so long as they miss any variables of interests. There is a risk of eliminating too many individuals thus reducing the power of statistics dramatically. In this study, the data was not randomly missing but concentrated on certain countries and variables. In this aspect, the negative effect of listwise deletion may not be as serious as Roth (1994) has suggested. However, listwise data deletion may make the numbers of individuals less than the variables analysed. This is the major problem.

To remedy the impact of listwise data deletion, **pairwise data deletion** only omits individuals when the specific variables to be analysed were missing. For example, when the correlation between unemployment Gini and income Gini was examined, Israel, Slovenia, Taiwan, China and Slovak were eliminated. However, only China was eliminated when the correlation between long-term unemployment and income Gini was analysed. In this way, a country would not be eliminated from the entire analysis. Therefore, significant amounts of information can be preserved. Pairwise data deletion is controversial, though, because it may result in 'not positive definite'. This means the deletion of data makes the collections of individuals analysed in each pair of variables so different that the results cannot be integrated mathematically. This renders PCA unfeasible. This was the case in this study.

Finally, the **mean data substitution** procedure means filling the missing blank with the mean estimated from rest of the individuals. It does not delete any individuals (countries) and preserves the sample points without creating the situation of 'not positive definite'. However, since some 'real' data points are replaced by the mean, it 'tends to attenuate variance estimates'. The more data are substituted by the mean, the greater the risk of attenuating variance and correlation estimation. Roth (1994) has suggested that mean substitution to be applied when the correlation among variable is not strong and less than 10% of the data are missing. In the case of this study, some variables missed more than 10% of the sample points while the correlations among data were mostly moderate to low (discussed in Section 6.4.2, the correlation matrix printed out of SPSS were inserted in Appendix A).

In this study, the mean substitution was chosen to handle the missing data because using the other two MDTs may violate assumptions of the analysis. A comparison of the results of correlation based on the three MDTs is inserted in Appendix A.

Table 6.5 The Data of Different Countries in Principal Component Analysis

Variables\Descriptive Statistics		Number of individual	Average	Standard Deviation	Minimum	25 Percentile	Medium	75 Percentile	Maximum
Ecological	ECORISK	33	58.00	38.80	0.00	23.10	67.34	99.02	100.00
	NBI	32	0.48	0.18	0.11	0.37	0.48	0.56	0.93
Land	ANTH40	33	11.01	8.54	0.24	3.77	10.12	14.60	29.18
	ANTH10	33	16.93	27.89	0.00	0.10	0.71	35.55	88.23
	arable land %	33	20.22	13.20	0.07	9.91	17.29	27.42	52.59
	permanent crops %	33	2.21	2.89	0.00	0.21	1.00	2.67	9.85
	others %	33	77.44	13.74	47.22	66.80	80.67	87.54	99.93
Population	GR2050	33	6.09	20.16	-25.00	-10.00	1.00	18.00	56.00
	Population Density	33	152.08	151.26	2.84	53.00	110.00	193.00	636.00
	Regional Population-Index of Geographic	29	39.31	15.26	12.00	29.00	36.00	49.00	82.00
	Elderly Population - Index of Geography	29	37.76	16.19	14.00	28.00	35.00	42.00	82.00
Education	PECR	33	97.85	3.47	85.33	97.00	99.00	100.00	104.09
	ENROL	33	51.27	15.65	12.61	45.50	53.58	60.55	77.62
Employment	Long-Term Unemployment*	32	32.23	17.93	0.80	17.23	32.95	48.75	68.10
	agr Labour %	33	6.85	8.66	0.60	2.90	4.00	6.40	43.00
	ind Labour %	33	26.17	6.06	16.00	22.40	25.60	29.20	40.20
	ser labour %	33	66.84	10.68	32.00	60.00	67.20	74.00	82.00
	Regional Unemployment-Gini Index	29	0.18	0.07	0.10	0.13	0.16	0.22	0.34
Economy	Real GDP growth	33	3.64	2.21	0.60	2.40	2.90	4.00	10.40
	agr GDP %	33	2.93	2.05	0.90	1.50	2.50	3.50	10.60
	ind GDP %	33	30.28	6.75	19.60	26.00	28.90	33.40	49.20
	service GDP %	33	66.72	8.03	40.20	64.00	68.50	71.50	79.20
	Regional GDP-Gini Index	26	0.15	0.05	0.06	0.12	0.14	0.17	0.27
	Income Inequality	33	32.40	6.66	23.00	27.00	32.00	34.90	47.90
Urbanization	Urban Population	33	0.74	0.13	0.43	0.66	0.77	0.82	0.97
	Urbanization Rate	33	0.01	0.01	-0.01	0.00	0.01	0.01	0.03
Crime	Conventional Crime	26	15.44	4.02	9.10	12.08	15.95	18.55	21.90
	Fear of Crime	24	25.29	8.79	6.00	18.75	26.50	33.00	42.00
	Rule of Law	33	1.29	0.66	-0.22	0.88	1.41	1.85	2.03
Satisfactory	satisfaction with life index	33	230.20	26.16	176.67	210.00	233.33	250.00	273.40

**The data of Taiwan was obtained from Wang, Y.T (2007) Social Quality in Taiwan. Presented at the Second Asian Conference on Social Quality and sustainable Welfare Societies, March 28-29, National Taiwan University, Taipei, Taiwan*

6.4.2. The Results of Principal Component Analysis

The PCA was applied on the selected data to establish the index measuring land use sustainability. This section summarised the results of the initial PCA and two different approaches of the PCA to simplify the structures of the components. Based on the results, the composition of the index was determined.

6.4.2.1. Initial PCA with all Variables

The first PCA using all 30 selected variables (listed in Table 6.2) resulted in seven significant components based on **Kaiser's criterion**[3]: the meaningful component should have an eigenvalue greater than one[4]. The seven components together explained 81.095% of total variance (Table 6.6).

Another criterion to determine significant components commonly used is **scree test**. The eigenvalue of each component was plotted against the number of component based on the capability to explain the variance. The components before the slope changes dramatically should be included in the analysis. Based on this rule, the first three components were considered significant in the PCA (Figure 6.2).

These two criteria indicated it would be reasonable to include the first 3 to 7 components in building index. Further evaluation to determine the number of the components (between 3 and 7) to be included was based on consideration of equally representing the three aspects of sustainability.

Matrix 6.1 illustrates the significance of the component loadings (the correlations between the variables and the component) of each variable in the seven major components in the PCA. The loadings range from 1 to -1. The value closer to zero indicates weaker correlation between the variable and the component. The significance of correlation was divided into five levels based on the absolute values

[3] According to Bryman and Cramer (2005, p330), the Kaiser's Criterion can be applied to the dataset with less than 30 variables and average communality greater than 0.70. The datasets utilised in this analysis fit this description. The variables were 30 or less and the average communalities are always greater than 0.70.

[4] The components exhibit eigenvalues less than one explains less variance than a single variable and therefore consider less useful

of the component loadings in this study. In the matrix, the darker colour indicates the heavier loadings (closer to 1 or -1). The loadings higher than 0.6 or lower than -0.6 were considered influential variables in the corresponding components.

Table 6.6 The Extraction of Components with All Selected Factors

Total Variance Explained including All the Indicators Selected

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.023	26.745	26.745	8.023	26.745	26.745	5.928	19.758	19.758
2	6.542	21.806	48.551	6.542	21.806	48.551	5.674	18.915	38.673
3	2.842	9.473	58.024	2.842	9.473	58.024	3.355	11.184	49.857
4	2.362	7.873	65.897	2.362	7.873	65.897	3.296	10.987	60.844
5	2.042	6.806	72.703	2.042	6.806	72.703	2.135	7.116	67.960
6	1.289	4.297	77.000	1.289	4.297	77.000	2.075	6.917	74.878
7	1.229	4.095	81.095	1.229	4.095	81.095	1.865	6.218	81.095

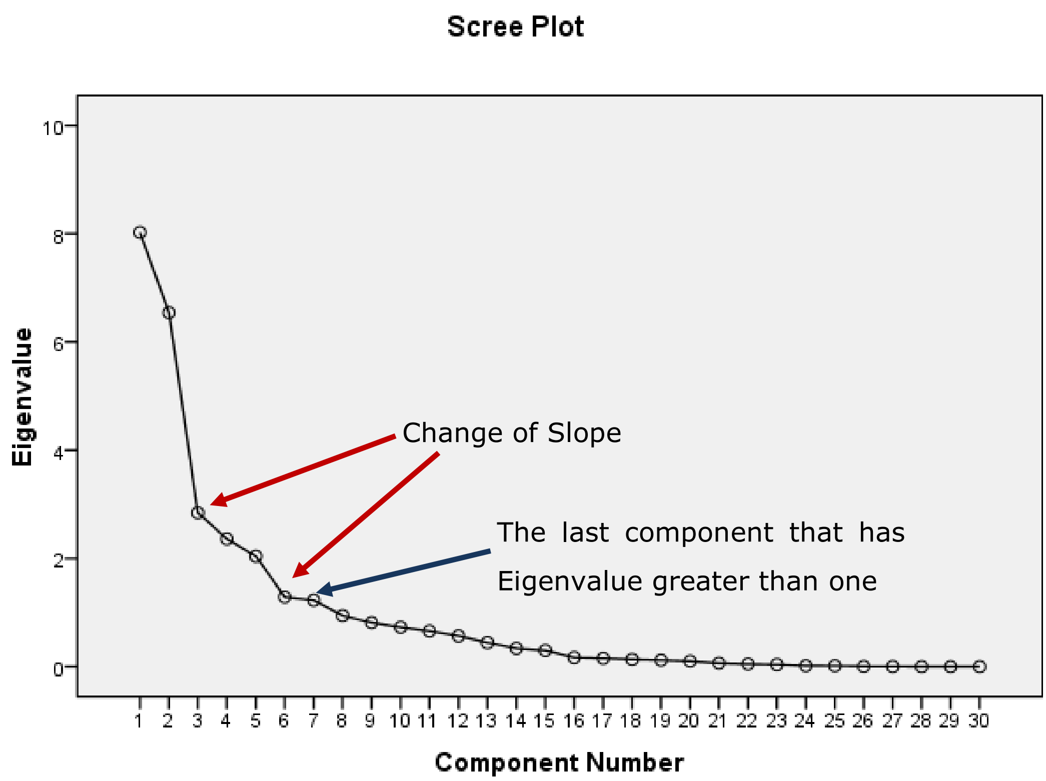
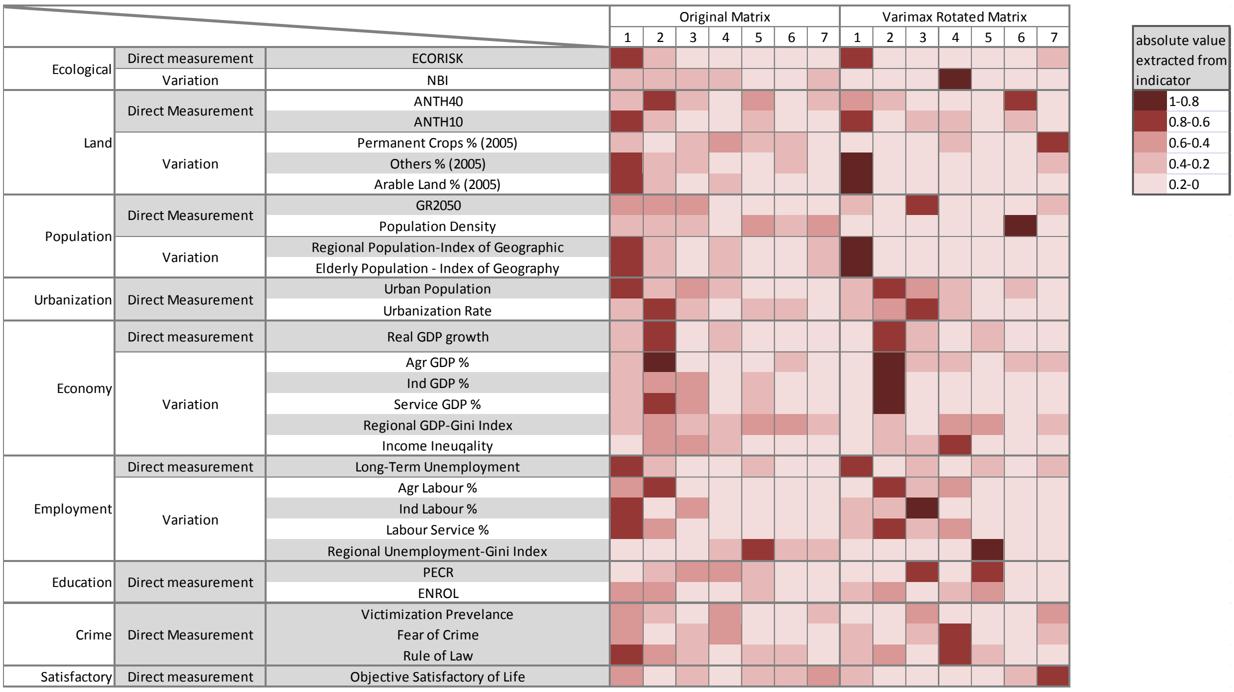


Figure 6.2 The Scree Plot between the Extracted Components and Eigenvalues

Matrix 6.1 The Composition of Components (First Iteration)



In the result of the initial PCA, the clustering of the influential variables in the first two components made the evaluation of the characteristics of the component tricky. It is less possible to tell whether the three aspects can be equally presented.

To overcome the problem, procedure of rotation was conducted to optimise the data extraction. SPSS offers five types of rotation including orthogonal style (Varimax, Equimax, and Quartimax) and oblique style (Oblimin and Promax). All five of them were performed.

Table 6.7 summarises the influential variables in each components after using different rotation technique. After the rotations, each component had at least one influential variable. Besides, applying different rotating methods did not alter the composition of components drastically. Since different rotation methods did not significantly affect the rotated outcomes, the result of the most often utilised Varimax rotation was selected for the further evaluation.

The relation of these components to each aspect of sustainability was evaluated based on the influential variables in each component (Matrix 6.1) and the perceptive judgements (Table 6.3) on the characteristics of the variables. The results of original PCA and Varimax rotation (Matrix 6.1) were displayed in Matrix

6.2. Three colours in the matrix represent the perceived relevance of the influential variables to any of the three aspects in sustainability: green for environment, orange for social and blue for economic aspects.

The un-rotated PCA loaded most of the influential variables in the first component. Only several highly economically relevant variables were not included. They were in the second component (which had 4 blue cells compared to 2 green cells and 2 orange cells). Besides components 1 and 2, only component 5 had relatively high loading on one variable, unemployment Gini index. This variable was considered both relevant to economic and social aspects of sustainability.

After the rotation, the environmental relevance in first component became apparent (5 green cells). The second component was highly relevant to economic aspect (6 blue cells). The variables mostly relevant to social aspect moved to the third component (4 orange cells), and fourth component (3 orange cells). The natures of fifth, sixth and seventh components could not be identified since no more than two influential variables were in the component.

Table 6.6 shows after the rotation, the first component explained 19.758% of the variance, the second 18.915%, and the combination of third and fourth 22.17%; each of them explained roughly 20% of the variance of the entire datasets. Given the first component represented environmental aspects, the second component represented economic aspects, and the third and fourth components represented social aspects, the three aspects were roughly equally represent in the result.

The next two sessions present the process to consolidate the result of this first iteration by reducing the number of variables to simplify the composition of the index. One method is to eliminate the variables that were least ‘extracted’ from the original analysis using communalities (Section 6.4.2.2); another is to eliminate the variables that do not show any significant loadings in any of the components in the original analysis using component loadings (Section 6.4.2.3).

Table 6.7 The Major Variables in Components Using Different Rotating Methods

Component	Variable	Rotating Methods					
		No Rotation	Varimax	Equimax	Quartimax	Oblimin	Promax
1	ECORISK	✓	✓	✓	✓	✓	✓
	Regional Population-Index of Geographic	✓	✓	✓	✓	✓	✓
	Elderly Population - Index of Geography	✓	✓	✓	✓	✓	✓
	Arable Land %	✓	✓	✓	✓	✓	✓
	Long-Term Unemployment	✓	✓	✓	✓	✓	✓
	Others %	✓	✓	✓	✓	✓	✓
	ANTH10	✓	✓	✓	✓	✓	✓
	Ind Labour %	✓					
	Service Labour %	✓					
	Rule of Law	✓					
	Urban Population	✓					
2	Real GDP Growth	✓	✓	✓	✓	✓	✓
	Agr GDP %	✓	✓	✓	✓	✓	✓
	Agr Labour %	✓	✓	✓	✓	✓	✓
	Service GDP %	✓	✓	✓	✓	✓	✓
	ANTH 40	✓					
	Urbanization Rate	✓					
	Industrial GDP %		✓	✓	✓	✓	✓
	Service Labour %		✓	✓	✓	✓	✓
	Urban Population		✓		✓		✓*
	ENROL				✓		✓*
	Rule of Law				✓		✓*
3	GR2050		√	√	√	√	√
	Urbanization Rate		√	√	√	√	√
	Industrial Labour %		√	√	√	√	√
	PECR		√				
4	Income Inequality		✓	✓	✓	✓	✓
	NBI		✓	✓	✓	✓	✓
	Fear of Crime		✓	✓	✓	✓	✓
	Rule of Law		✓				✓*
	Agr Labour %						✓*
	Service Labour %						✓*
5	Regional Unemployment Gini	✓	✓	✓	✓	✓	✓
	PECR		✓			✓*	
	Regional GDP Gini			√			✓*
6	ANTH 40		✓	✓	✓	✓	✓
	Population Density		✓	✓	✓	✓	✓
7	Satisfactory		✓	✓	✓	✓	✓
	Permanent land use		✓			✓*	
	Victimization			✓		✓*	

only considered significant in one of two matrixes oblique style rotation generated.

Matrix 6.2 **The Characteristics of Components**

Original With All the Indicators			Original																				
			1			2			3			4			5			6			7		
Component	Nature of Measurement	Abbreviation	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO
Ecological	Direct measurement	ECORISK	🟩																				
	variation	NBI																					
Land	Direct Measurement	ANTH40				🟩																	
		ANTH10	🟩																				
	Variation	Permanent Crops % (2005)																					
		Others % (2005)	🟩		🟦																		
		Arable Land % (2005)	🟩		🟦																		
Population	Direct Measurement	GR2050																					
		Population Density																					
	Variation	Regional Population-Index of Geographic	🟩	🟧	🟦																		
		Elderly Population - Index of Geography		🟧	🟦																		
Urbanization	Direct Measurement	Urban Population	🟩	🟧																			
		Urbanization Rate				🟩	🟧																
Economy	Direct measurement	Real GDP growth						🟦															
	Variation	Agr GDP %						🟦															
		Ind GDP %																					
		Service GDP %						🟦															
		Regional GDP-Gini Index																					
		Income Ineuqality																					
Employment	Direct measurement	Long-Term Unemployment		🟧	🟦																		
	Variation	Agr Labour %					🟧	🟦															
		Ind Labour %		🟧	🟦																		
		Labour service %		🟧	🟦																		
		Regional Unemployment-Gini Index														🟧	🟦						
Education	Direct measurement	PECR																					
		ENROL																					
Crime	Direct Measurement	Victimization Prevelance																					
		Fear of Crime																					
		Rule of Law		🟧																			
Satisfactory	Direct measurement	Subjective Satisfactory of Life																					

			Varimax Rotation																				
			1			2			3			4			5			6			7		
Component	Nature of Measurement	Abbreviation	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO
Ecological	Direct measurement	ECORISK	🟩																				
	variation	NBI										🟩											
Land	Direct Measurement	ANTH40																🟩					
		ANTH10	🟩																				
	Variation	Permanent Crops % (2005)																			🟩		🟦
		Others % (2005)	🟩		🟦																		
		Arable Land % (2005)	🟩		🟦																		
Population	Direct Measurement	GR2050							🟩	🟧	🟦												
		Population Density																🟩	🟧	🟦			
	Variation	Regional Population-Index of Geographic	🟩	🟧	🟦																		
		Elderly Population - Index of Geography		🟧	🟦																		
Urbanization	Direct Measurement	Urban Population				🟩	🟧																
		Urbanization Rate							🟩	🟧													
Economy	Direct measurement	Real GDP growth						🟦															
	Variation	Agr GDP %						🟦															
		Ind GDP %						🟦															
		Service GDP %						🟦															
		Regional GDP-Gini Index																					
		Income Ineuqality											🟧	🟦									
Employment	Direct measurement	Long-Term Unemployment		🟧	🟦																		
	Variation	Agr Labour %					🟧	🟦															
		Ind Labour %								🟧	🟦												
		Labour service %					🟧	🟦															
		Regional Unemployment-Gini Index														🟧	🟦						
Education	Direct measurement	PECR								🟧						🟧							
		ENROL																					
Crime	Direct Measurement	Victimization Prevelance																					
		Fear of Crime											🟧										
		Rule of Law											🟧										
Satisfactory	Direct measurement	Subjective Satisfactory of Life																				🟧	

6.4.2.2. Component Consolidating based on the Communalities

The variables with low value of communalities are less relevant to the concept the collection of variables represents. Therefore, eliminating these variables from the analysis should not affect the general structure of the PCA. To consolidate the component in the original analysis, the variables with communalities lower than 0.7 were eliminated. Three variables (Gross Tertiary Enrolment Rate (ENROL), Permanent Land Use Percentage (permanent), and Victimization Prevalence (VitPre)) were deleted. The communalities of eliminated variables are bold in Table 6.8. PCA process was repeated after deleting the three variables.

Table 6.8 The Communalities Extracted from the Collection of Selected Factors

Variable	Communalities		Variable	Communalities		Variable	Communalities	
	Initial	Extraction		Initial	Extraction		Initial	Extraction
POP_DEN	*1.000*	*.960*	**GDPind**	*1.000*	*.842*	**Real_GDP**	*1.000*	*.738*
GDPagr	*1.000*	*.916*	**GR2050**	*1.000*	*.840*	**NBI**	*1.000*	*.719*
Geo_Pop_Conc	*1.000*	*.905*	**Urban_rate**	*1.000*	*.828*	**PECR**	*1.000*	*.701*
LABser	*1.000*	*.903*	**Urban_pop**	*1.000*	*.819*	**ENROL**	**1.000**	**.684**
ANTH40	*1.000*	*.903*	**Others**	*1.000*	*.803*	**permanent**	**1.000**	**.648**
GDPser	*1.000*	*.899*	**Unemploy_Gini**	*1.000*	*.801*	**VitPre**	**1.000**	**.646**
Rule of Law	*1.000*	*.888*	**GDP_Gini**	*1.000*	*.792*			
Eld_Pop_Conc	*1.000*	*.882*	**L_UNEMP**	*1.000*	*.773*			
LABagr	*1.000*	*.870*	**ECORISK**	*1.000*	*.757*			
LABind	*1.000*	*.864*	**Arable**	*1.000*	*.757*			
ANTH10	*1.000*	*.849*	**FearCrime**	*1.000*	*.751*			
Income_Gini	*1.000*	*.846*	**Satisfactory**	*1.000*	*.743*			

Extraction Method: Principal Component Analysis.

Seven major components were extracted using Kaiser's criterion (Table 6.9). However, only the first three components were considered significant in the scree test (Figure 6.3).

The original PCA obtained similar patterns (Matrix 6.3) to the initial PCA analysis (Matrix 6.1). After the rotations, the influential variables in each component (Table 6.10) did not alter considerably compared to the original analysis using all 30 variables (Table 6.7).

In this analysis, the communalities of all 27 variables were higher than 0.7 (Table 6.11). Thus, no variable was deleted and the iteration terminated.

Table 6.9 The Extraction of Components after Deleting Three less Extracted Variables

Total Variance Explained

Component	Initial Eigenvalues			Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.454	27.609	27.609	7.454	27.609	27.609	5.888	21.806	21.806
2	6.221	23.040	50.649	6.221	23.040	50.649	5.063	18.753	40.559
3	2.758	10.217	60.865	2.758	10.217	60.865	3.314	12.273	52.831
4	2.124	7.866	68.732	2.124	7.866	68.732	3.109	11.514	64.345
5	1.758	6.511	75.243	1.758	6.511	75.243	2.128	7.883	72.228
6	1.247	4.617	79.860	1.247	4.617	79.860	1.959	7.255	79.483
7	1.107	4.101	83.961	1.107	4.101	83.961	1.209	4.477	83.961

Extraction Method: Principal Component Analysis.

The influential variables in the components from the results of Varimax rotation were also put to test of perceptive judgements (Table 6.3) to make sense of the relation of each component to the aspects of sustainability (Matrix 6.4).

Similar to the initial PCA, the first component in this result was highly relevant to environmental aspect, the second economic, and third and fourth social. Furthermore, the first four components of Varimax rotation in this PCA represented the three aspects equally (Table 6.9). Each aspect explained roughly 20% of variances in the analysis (environmental 21.81%, economic 18.75% and social 23.78%).

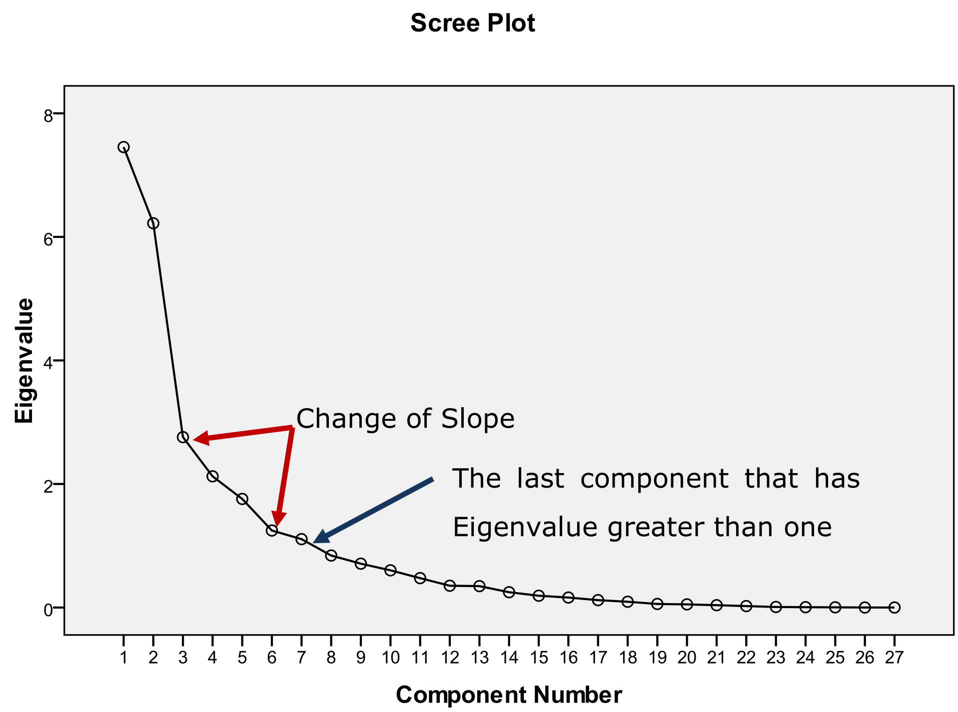


Figure 6.3 The Scree Plot between the Extracted Components and Eigenvalues

Matrix 6.3 The Composition of Components (Consolidating Based on Communality)

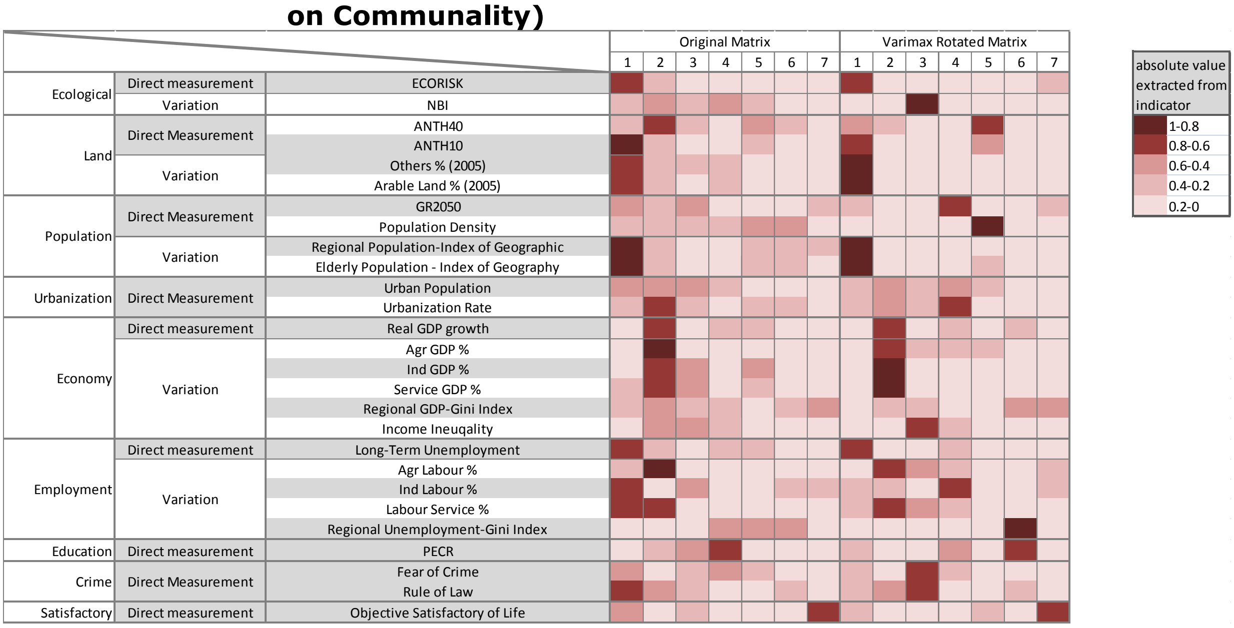


Table 6.10 The Major Variables in Components Using Different Rotating Method after Deleting Variables with Low Communalities

Component	Variable	Rotation					
		No Rotation	Varimax	Equimax	Quartimax	Oblimin	Promax
Env 1 (Comp. 1)	ECORISK	✓	✓	✓	✓	✓	✓
	Regional Population-Index of Geographic	✓	✓	✓	✓	✓	✓
	Elderly Population - Index of Geography	✓	✓	✓	✓	✓	✓
	Arable Land %	✓	✓	✓	✓	✓	✓
	Long-Term Unemployment	✓	✓	✓	✓	✓	✓
	Others %	✓	✓	✓	✓	✓	✓
	ANTH10	✓	✓	✓	✓	✓	✓
	Ind Labour %	✓					
	Service Labour %	✓					
	Rule of Law	✓					
	Urban Population	✓					
Eco 1 (Comp. 2)	Real GDP Growth	✓	✓	✓	✓	✓	✓
	Agr GDP %	✓	✓	✓	✓	✓	✓
	Agr Labour %	✓	✓	✓	✓	✓	✓
	Service GDP %	✓	✓	✓	✓	✓	✓
	ANTH 40	✓					
	Urbanization Rate	✓					
	Industrial GDP %		✓	✓	✓	✓	✓
	Service Labour %		✓	✓	✓	✓	✓
	Urban Population		✓		✓		✓*
	ENROL				✓		✓*
	Rule of Law				✓		✓*
Sco 1 (Comp. 4)	GR2050		✓	✓	✓	✓	✓
	Urbanization Rate		✓	✓	✓	✓	✓
	Industrial Labour %		✓	✓	✓	✓	✓
	PECR	✓	✓				
Sco 2 (Comp. 3)	Income Inequality		✓	✓	✓	✓	✓
	NBI		✓	✓	✓	✓	✓
	Fear of Crime		✓	✓	✓	✓	✓
	Rule of Law		✓				✓*
	Agr Labour %						✓*
	Service Labour %						✓*
Comp 5	Regional Unemployment Gini		✓	✓	✓	✓	✓
	PECR		✓			✓*	
	Regional GDP Gini			√			✓*
Comp. 6	ANTH 40		✓	✓	✓	✓	✓
	Population Density		✓	✓	✓	✓	✓
Comp. 7	Satisfactory	✓	✓	✓	✓	✓	✓
	Permanent land use		✓			✓*	
	Victimisation			✓		✓*	

**only considered significant in one of two matrixes oblique style rotation generated.*

Table 6.11 The Communalities Extracted from the Collection of Variable after Three Low Extraction Variables Deleted

Variable	*Communalities*		*Variable*	*Communalities*		*Variable*	*Communalities*	
	Initial	*Extraction*		*Initial*	*Extraction*		*Initial*	*Extraction*
POP_DEN	*1.000*	*.946*	**ANTH10**	*1.000*	*.871*	**arable**	*1.000*	*.770*
GDPser	*1.000*	*.923*	**LABind**	*1.000*	*.859*	**L_UNEMP**	*1.000*	*.770*
ANTH40	*1.000*	*.915*	**Income_ Gini**	*1.000*	*.857*	**Real_GDP**	*1.000*	*.759*
GDPagr	*1.000*	*.914*	**GR2050**	*1.000*	*.855*	**Unemploy_ Gini**	*1.000*	*.746*
LABser	*1.000*	*.911*	**Urban_rate**	*1.000*	*.840*	**FearCrime**	*1.000*	*.743*
Eld_Pop_Conc	*1.000*	*.896*	**GDP_Gini**	*1.000*	*.840*	**PECR**	*1.000*	*.742*
Geo_Pop_Conc	*1.000*	*.896*	**Satisfactory**	*1.000*	*.833*	**NBI**	*1.000*	*.726*
Rule of Law	*1.000*	*.896*	**Urban_pop**	*1.000*	*.820*			
LABagr	*1.000*	*.889*	**others**	*1.000*	*.809*			
GDPind	*1.000*	*.873*	**ECORISK**	*1.000*	*.771*			

Extraction Method: Principal Component Analysis.

Matrix 6.4 **The Characteristics of Components (Consolidation based on Communalities)**

Original With All the Indicators			Original							Varimax Rotation						
			1	2	3	4	5	6	7	1	2	3	4	5	6	7
Component	Nature of Measurement	Abbreviation	ENV SOC ECO	ENV SOC ECO	ENV SOC ECO	ENV SOC ECO	ENV SOC ECO	ENV SOC ECO	ENV SOC ECO	ENV SOC ECO	ENV SOC ECO	ENV SOC ECO	ENV SOC ECO	ENV SOC ECO	ENV SOC ECO	ENV SOC ECO
Ecological	Direct Measurement	ECORISK														
	Variation	NBI														
Land	Direct Measurement	ANTH40														
		ANTH10														
	Variation	Permanent crops % (2005)														
		others % (2005)														
		arable land % (2005)														
Population	Direct Measurement	GR2050														
		Population Density														
	Variation	Regional Population-Index of Geographic														
		Elderly Population - Index of Geography														
Urbanization	Direct Measurement	Urban Population														
		Urbanization Rate														
Economy	Direct Measurement	Real GDP growth														
	Variation	agr GDP %														
		ind GDP %														
		service GDP %														
		Regional GDP-Gini Index														
		Income Ineuqality														
Employment	Direct Measurement	Long-Term Unemployment														
	Variation	agr Labour %														
		ind Labour %														
		labour service %														
		Regional Unemployment-Gini Index														
Education	Direct Measurement	PECR														
		ENROL														
Crime	Direct Measurement	Victimization Prevelance														
		Fear of Crime														
		Rule of Law														
Satisfactory	Direct measurement	Subjective Satisfactory of Life														

6.4.2.3. Component Consolidating based on the Component Loadings

The variables with low component loadings in a component are considered unimportant in that component. In initial PCA, three variables did not have influential component loadings among all seven components before and after rotation (Matrix 6.4 in Section 6.4.2.1.): 'GDP Gini Index', 'Gross Tertiary Education Enrolment' and 'Victimisation Prevalence'. These three factors were deleted from the PCA analysis in this section.

The procedures were repeated for three times based on the component loadings in the results of un-rotated and Varimax rotated PCA (Figure 6.4). 'Subjective Satisfactory of Life' was deleted in the second analysis and 'Urban Population' was deleted in the third analysis.

After three iterations, the remaining variables were considered influential in at least one of the components (Matrix 6.5). In the last iteration of the PCA, six components had eigenvalues bigger than one (Table 6.12). However, in the scree plot, the slope still changed after the third component (Figure 6.5).

After deleting the five variables, there were influential variables in the first four components in the un-rotated PCA. In the rotated results, all of the components had one or more influential variables.

The deletion of the five variables also had minor effects on the general compositions (Matrix 6.6). However, before rotation, the first component still showed stronger environmental characteristics and the second had stronger economic characteristics. After rotation, some variables with stronger social characteristics were rotated to component 3 and 4. Given the first component represented the environmental aspect, the second represented the economic aspect and the third and fourth represented the social aspect, the three aspects explained roughly 20% of variance in the collection of variables (Table 6.12).

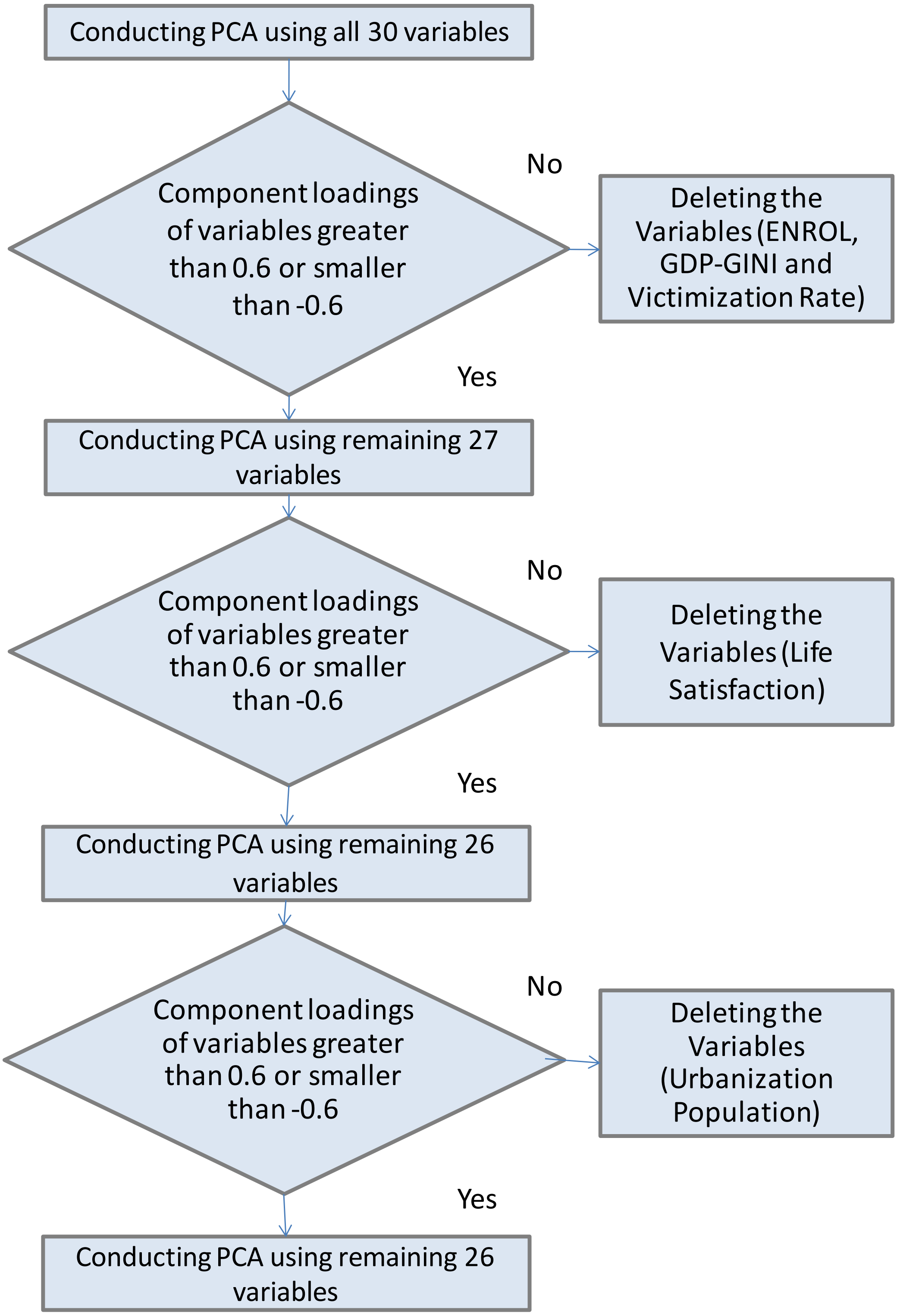


Figure 6.4 The Flow-Chart of the Iterations to Delete Variables based on Component Loadings

Matrix 6.5 The Composition of Components after Five Factors Deleted

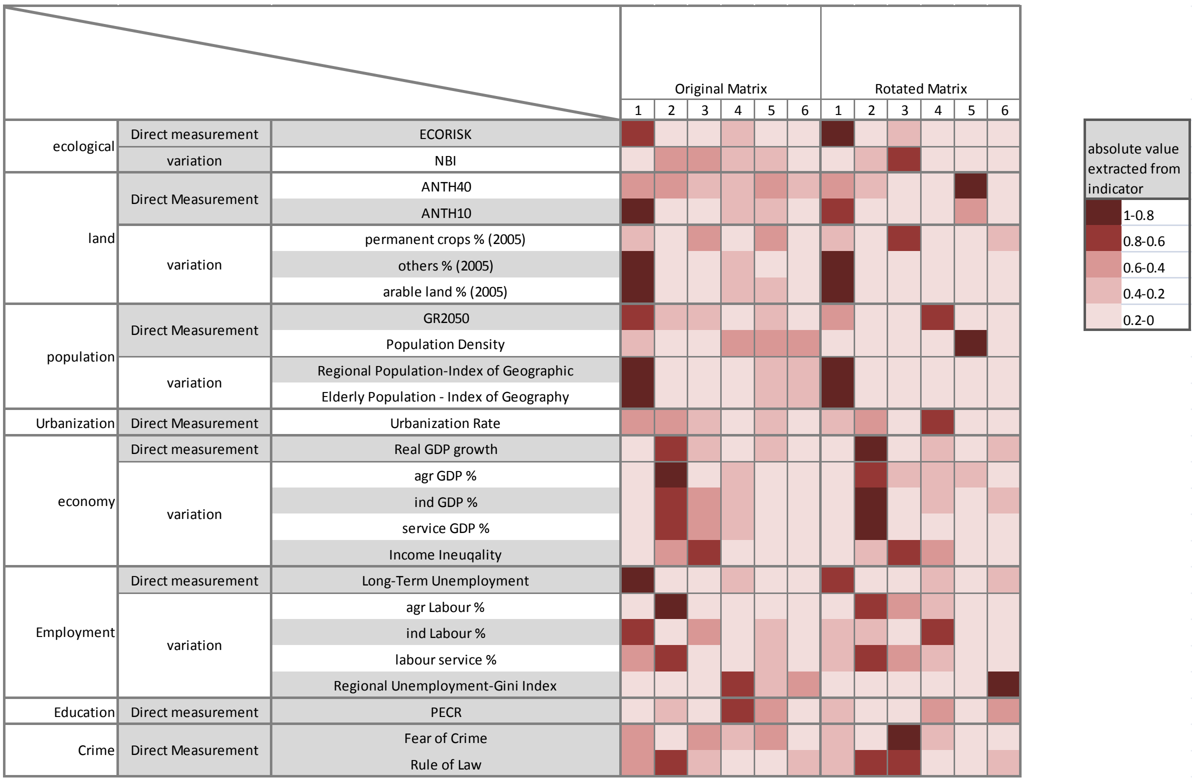


Table 6.12 The Extraction of Component after Fiver Variables Deleted

Total Variance Explained after Deleting Five Indicators

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**7.059**	**28.237**	**28.237**	**7.059**	**28.237**	**28.237**	**5.718**	**22.873**	**22.873**
2	**5.767**	**23.068**	**51.305**	**5.767**	**23.068**	**51.305**	**5.005**	**20.021**	**42.894**
3	**2.604**	**10.416**	**61.721**	**2.604**	**10.416**	**61.721**	**3.088**	**12.352**	**55.246**
4	**2.011**	**8.044**	**69.765**	**2.011**	**8.044**	**69.765**	**2.956**	**11.823**	**67.068**
5	**1.878**	**7.513**	**77.278**	**1.878**	**7.513**	**77.278**	**1.997**	**7.989**	**75.058**
6	**1.131**	**4.526**	**81.803**	**1.131**	**4.526**	**81.803**	**1.686**	**6.746**	**81.803**

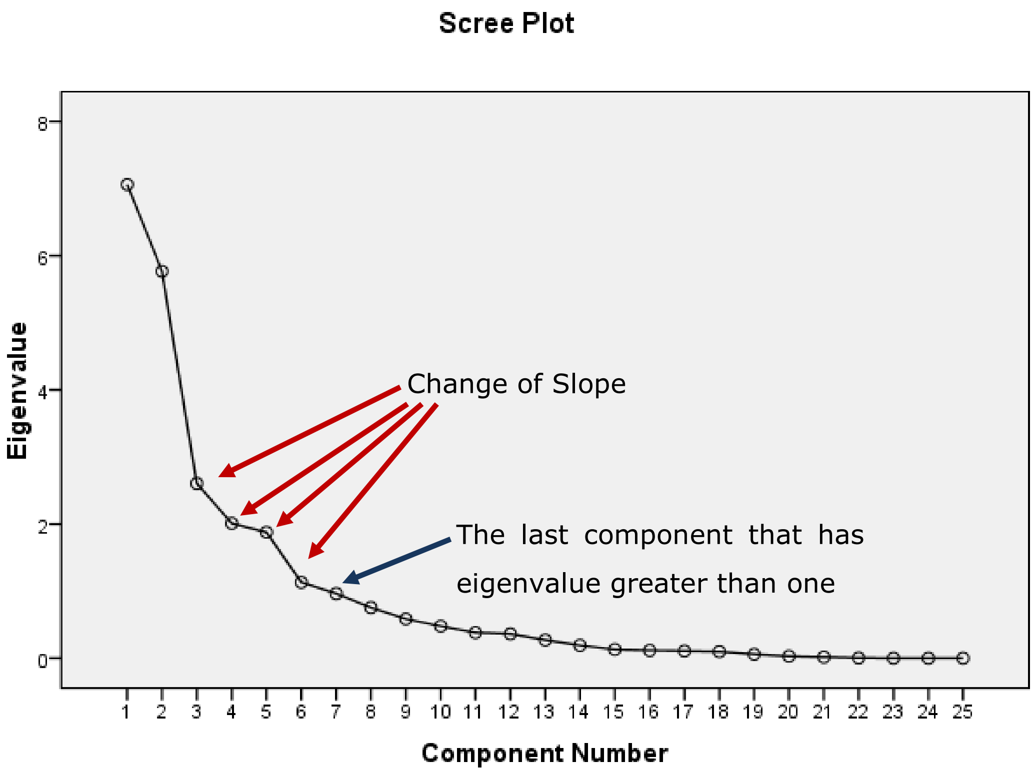


Figure 6.5 The Scree Plot between the Extracted Components and Eigenvalues

Matrix 6.6 **The Characteristics of Components (Consolidation based on the Component Loadings)**

Final With Some Indicators Deleted			Original																		Varimax Rotation																	
			1			2			3			4			5			6			1			2			3			4			5			6		
Component	Nature of Measurement	Abbreviation	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO	ENV	SOC	ECO
ecological	Direct measurement	ECORISK																																					
	variation	NBI																																					
land	Direct Measurement	ANTH40																																					
		ANTH10																																					
	variation	permanent crops %																																					
		others % (2005)																																					
		arable land % (2005)																																					
population	Direct Measurement	GR2050																																					
		Population Density																																					
	variation	Regional Population-																																					
		Elderly Population -																																					
Urbanization	Direct Measurement	Urban Population																																					
		Urbanization Rate																																					
economy	Direct measurement	Real GDP growth																																					
	variation	agr GDP %																																					
		ind GDP %																																					
		service GDP %																																					
		Regional GDP-Gini Index																																					
		Income Inequality																																					
Employment	Direct measurement	Long-Term																																					
	variation	agr Labour %																																					
		ind Labour %																																					
		labour service %																																					
		Regional																																					
Education	Direct measurement	PECR																																					
		ENROL																																					
Crime	Direct Measurement	Victimization																																					
		Fear of Crime																																					
		Rule of Law																																					
Satisfactory	Direct measurement	Subjective Satisfactory of Life																																					

6.4.3. Comparison between the Two Consolidation Methods

In general, the two approaches to consolidate the index did not alter the results significantly. The rotation procedures maximised the loadings in the result and separated the variables from the first two components to the components followed. Different rotation techniques produced similar results. Overall, the characteristics of the dataset were not very sensitive to different consolidation approaches.

The consolidation based on communalities did not reduce the number of the major components (comparing Table 6.5 and 6.8). The consolidation based on the component loadings, on the other hand, eliminated the seventh component, which is relevant to Subjective Satisfaction of Life. However, the result of consolidation based on the communalities was selected to build the index. This is because the variables that considered not influential in any of the components may still play small parts in more than one component and affect the evaluation of sustainability as a whole. The deletion based on the communalities eliminates the factors considered less important to the overall component structure. This was in line with the idea that the three aspects interact and interconnect with each other; they represent sustainability collectively.

Additionally, the result based on Varimax rotation was used since different rotation techniques did not significantly change the result and Varimax rotation is the most often used rotation technique (Abdi, 2003).

6.5. Evaluation of Countries Based on the Analytical Result

6.5.1. The Characteristics of Components

This section discusses the association of each component to the sustainability in the PCA. The Varimax rotation in PCA results after deleting three variables (Matrix 6.5 in Section 6.4.3.2) was the basis of the discussion. The discussion about each component was based on the component loading of each variable (the number presented in the bracket followed the name of the variable in the following discussion), and the perceptive judgement (Table 6.3) of the influential variables.

All of the loadings of the variables are inserted in the table 'Rotated Component Matrix of PCA results' in Appendix A.

The **first component** explained 21.81% of the variance (the result in the last column of 'Rotation Sums of Squared Loadings' in Table 6.9). This component had more variables related to the environment (Matrix 6.5).

The component loadings of the variables in this component showed strong negative correlations with 'Ecorisk' (Percentage of country's territory in threatened ecoregions) (-0.787), 'long term unemployment rate' (-0.744), and 'percentage of arable land' (-0.848). It also had strong positive correlations with 'ANTH10' (Percentage of total land area having very low anthropogenic impact) (0.767), 'percentage of other land use' (0.855), and two geographic distributions of general population (0.905) and elderly people (0.877). Based on the negative correlation of 'Ecorisk' and the positive correlation with 'ANTH10', it was considered countries have higher scores in this component have better environmental sustainability. It also meant that the 'long term unemployment rate' and 'percentage of arable land' had negative impact on environmental sustainability; higher 'percentage of other land use' (presumably commercial, industrial and residential land use and undeveloped land) and the more uneven population distribution would improve the scores of this index in environmental sustainability.

The **second component** explained 18.75% of the variance showed strong economic connection (Table 6.9). It was positively related to 'GDP growth' (0.772), 'GDP percentage in agriculture' (0.766), 'GDP percentage in industry' (0.892) and 'labour percentage in agriculture' (0.695). It was negatively correlated to 'GDP percentage in service sector' (-0.952), and 'labour percentage in service sector' (-0.702). Conventionally, GDP growth was a positive sign of economic sustainability. Therefore, the component was considered positively related to the concept of economic sustainability. The implications of negative correlation between this component and service sectors (both the GDP and the labour force) remain to be explored.

The **third component** was considered relevant to social sustainability. It explained 12.27% of the variance. The relevance was based on the three variables that dominate this component ('Income Gini Index', 0.798; 'Fear of Crime', 0.742; and 'Rule of Law', -0.660). The component was considered negatively correlated with social sustainability based on the positive correlation with 'income Gini Index' (income inequality), and 'Fear of Crime', and negative correlation with the 'Rule of Law'. Interestingly, 'National Biodiversity Index' (NBI) was also positively correlated to this component (0.803). Some possible explanation is proposed in Section 6.7.3.

The **fourth component** consisted of three major variables: 'Percentage change in projected population 2004-2050' (GR2050) (0.792), 'percentage of labour in industrial sector' (-0.760) and 'urban population growth rate' (0.732). All three variables were relevant to social sustainability. However, there were also strong environmental and economic relevance: these three variables could be viewed as the indicators of the distribution of human resources. Particularly, 'GR2050' and 'urban growth rate' represent the movement of population over time. Whether the population changes are negative or positive factor for sustainable development is debatable (Section 5.1.2 and Section 6.2.1). Therefore, it is difficult to determine whether this component was positive or negative correlated with social sustainability based on the three influential variables.

'Female primary education completion rate' (PECR) had a value of component loading (-0.529) in this component. The education completion rate should be positively relevant to social sustainability. Therefore, the negative correlation of component four with the primary education completion rate implied the component is negatively related to the social sustainability. Accordingly, in this index, the population growth and urbanisation are considered not good for social sustainability; a higher percentage of industrial workers is good for social sustainability.

Fifth, sixth and seventh components had less than three influential variables. Therefore, the nature of the components cannot be easily analysed. The fifth component was positively related to the percentage of total land area having very high anthropogenic impact ('ANTH40') (0.784), and 'population density' (0.946). The anthropogenic impact should be considered negative to the environmental sustainability so this component was considered negative correlated with sustainability. The sixth component was negatively related to PECR (-0.624) and positively related to unemployment Gini index (0.820). Therefore, it was also considered negatively correlated to sustainable development. The quality of life is the only indicator dominant the seventh component (component loading 0.698). It was considered positively correlated to sustainable development. Additionally, each of the three components did not explain more than 10% of the variance (Table 6.9).

Therefore, they were considered less significant for evaluating land use sustainability.

6.5.2. Evaluating Sustainability of Land Use Based on the PCA

This section summarises the numerical index established based on the discussion of component characteristics and their positive or negative relations with sustainability (Section 6.5.1.

The component score coefficients were estimated by SPSS. The coefficients were the weights assigned to the corresponding variables (Table 6.13). The weights were applied to the corresponding variables to calculate the factor scores for each country using SPSS. The negative signs were then assigned to the components exhibited negative correlation to the sustainability (Section 6.5.1) to make the higher scores in the result reflect better conditions. The final scores of each country are presented in Table 6.14.

The scores of countries in components were analysed based on their clusters in ESI 2005. The economic advanced Cluster 1 countries have higher scores in component 2 (economic) and 4 (the social aspect relevant to population distribution) (Table 6.14); the economic advanced Cluster 3 countries have higher scores in component 1 (environment) and component 3 (social aspects relevant to equality) (Table 6.14).

However, there are significant variations within clusters. For example, the average high score of Cluster 3 countries in component 3 was due to the good performance of North European countries (Scandinavia). The scores of the U.S. and Australia were not as impressive.

Clusters 4 and 7 countries are mostly emerging economies. They usually exhibited relatively high scores in economic component (component 2) (such as Turkey and Slovak Republic) or component 7 which relevant to life satisfactory (such as Greece), or both (such as Poland, Hungary, Czech Republic and China).

Table 6.13 Weight Assigned to Each Variable

Component Score Coefficient Matrix

	Component						
	1	2	3	4	5	6	7
ECORISK	-.154	-.074	.032	.027	-.131	.027	.130
NBI	.017	-.078	.313	-.010	-.049	-.087	-.111
ANTH40	-.003	-.011	-.010	.035	.368	.001	.008
ANTH10	.127	-.021	-.027	-.031	-.142	.094	.141
GR2050	-.039	-.025	.034	.269	-.014	-.017	-.189
POP_DEN	.122	.074	.003	-.040	.538	.067	.084
PECR	.102	.001	.094	-.202	.030	-.279	.057
L_UNEMP	-.124	-.029	-.010	-.062	-.133	.065	.090
Real_GDP	-.008	.176	-.102	.067	.041	.122	-.041
arable	-.186	-.032	-.030	.084	-.055	.021	.002
others	.180	.050	-.001	-.070	.079	-.024	-.042
GDPagr	-.019	.132	-.005	.102	-.081	.020	.167
GDPind	.045	.253	-.125	-.058	.134	-.087	-.063
GDPser	-.032	-.249	.109	.025	-.092	.068	.010
LABagr	-.005	.097	.096	.061	-.047	-.016	.164
LABind	.015	.056	.018	-.272	.033	.087	-.224
LABser	-.009	-.103	-.097	.115	.023	-.039	-.010
Geo_Pop_Conc	.239	-.038	.072	-.108	.063	.142	.170
Eld_Pop_Conc	.216	-.063	.084	-.104	-.001	.152	.136
GDP_GINI	-.016	.009	.098	.014	.116	.309	-.439
Unemploy_GINI	.115	-.023	-.041	-.164	.045	.487	.118
Income_GINI	.032	-.046	.270	.108	.039	-.050	.025
Urban_pop	.009	-.084	-.065	.164	.162	.110	-.075
Urban_rate	-.040	.078	.009	.269	-.019	-.139	.072
FearCrime	.028	-.112	.297	-.115	-.003	-.038	.056
RuleofLaw	-.029	-.046	-.169	.054	-.096	-.151	.019
Satisfactory	.019	.046	-.038	.033	.112	.031	.632

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Component Scores.

Table 6.14 Scores of Each Component

Cluster in ESI 2005	Country	Components 1	2	3*	4*	5*	6*	7
Cluster 1	**Austria**	*-0.08*	*0.02*	*0.50*	*0.26*	*0.40*	*0.86*	*-0.99*
	Belgium	*-0.79*	*-1.12*	*0.27*	*-0.03*	*-1.31*	*-1.09*	*-0.98*
	Denmark	*-1.53*	*-0.71*	*1.10*	*-0.79*	*0.24*	*0.63*	*-0.57*
	France	*-1.07*	*-0.98*	*0.16*	*-0.78*	*0.67*	*0.48*	*1.31*
	Germany	*-0.67*	*-0.57*	*0.55*	*0.89*	*-0.12*	*-0.63*	*1.24*
	Ireland	*-0.20*	*1.79*	*0.88*	*-0.32*	*0.04*	*1.53*	*-1.28*
	Israel	*-0.10*	*-0.01*	*0.00*	*-2.44*	*-1.61*	*-0.08*	*0.21*
	Italy	*-0.27*	*-0.75*	*-0.60*	*1.40*	*-0.35*	*-1.05*	*1.25*
	Japan	*0.62*	*-0.61*	*-1.14*	*1.34*	*-0.98*	*1.34*	*0.24*
	Netherlands	*-0.83*	*-0.65*	*0.81*	*-1.26*	*-1.28*	*1.09*	*1.57*
	Portugal	*0.07*	*-0.65*	*-1.18*	*0.89*	*0.63*	*-0.31*	*0.43*
	Slovenia	*0.13*	*0.41*	*-0.04*	*2.22*	*0.55*	*0.39*	*-0.99*
	South Korea	*0.80*	*0.92*	*0.17*	*0.31*	*-2.39*	*-0.19*	*0.58*
	Spain	*-0.18*	*-0.36*	*-0.42*	*0.45*	*0.40*	*0.10*	*0.24*
	Switzerland	*0.03*	*-0.07*	*0.31*	*-0.11*	*-0.16*	*0.45*	*-0.73*
	Taiwan	*0.56*	*0.16*	*-0.28*	*0.78*	*-3.00*	*0.13*	*-0.63*
	United Kingdom	*0.29*	*-1.21*	*-0.02*	*-0.67*	*-1.07*	*-0.43*	*-0.51*
Cluster 3	**Australia**	*1.71*	*-1.03*	*-0.74*	*-0.21*	*1.23*	*0.16*	*0.22*
	Canada	*2.38*	*-0.60*	*0.47*	*0.30*	*0.61*	*-1.40*	*0.47*
	Iceland	*1.81*	*0.29*	*2.26*	*-0.66*	*0.53*	*-2.66*	*0.83*
	United States	*0.26*	*-1.35*	*-0.85*	*-1.16*	*0.87*	*0.84*	*-0.81*
	Sweden	*0.82*	*-0.22*	*1.13*	*0.07*	*0.79*	*1.00*	*-0.22*
	New Zealand	*0.34*	*-0.59*	*-0.42*	*-0.92*	*1.01*	*0.91*	*-0.29*
	Finland	*0.78*	*0.45*	*1.21*	*0.51*	*0.87*	*0.59*	*-0.11*
	Norway	*0.79*	*0.79*	*1.59*	*-0.34*	*0.34*	*1.32*	*-0.77*
Cluster 4	**Turkey**	*-1.24*	*1.20*	*-1.09*	*-2.10*	*0.75*	*-2.24*	*-0.99*
	Greece	*-0.72*	*-0.61*	*-1.18*	*0.08*	*0.85*	*0.48*	*1.63*
	Hungary	*-1.64*	*0.20*	*0.47*	*0.44*	*0.45*	*-0.28*	*0.43*
	Poland	*-1.23*	*0.38*	*-0.52*	*0.49*	*0.47*	*-0.11*	*0.82*
	Czech Republic	*-1.12*	*0.96*	*0.69*	*1.23*	*-0.06*	*-0.39*	*0.11*
	Slovak Republic	*-1.45*	*0.65*	*0.13*	*1.17*	*0.50*	*-1.54*	*-1.93*
Cluster 7	**Mexico**	*1.12*	*0.20*	*-2.75*	*-0.48*	*-0.15*	*-0.38*	*-1.81*
	China	*0.57*	*3.66*	*-1.44*	*-0.58*	*0.29*	*0.50*	*2.04*

**values have been adjusted to reflect positive correlation with the concept of sustainable development*

The scores of countries in the first four components were added up and ranked (Table 6.15). The weight assigned to each component was the percentage of variance explained by each component. In this index, the percentages are roughly about 20% for each of the three aspects of sustainability (Table 6.9, described in Section 6.4.2.2).

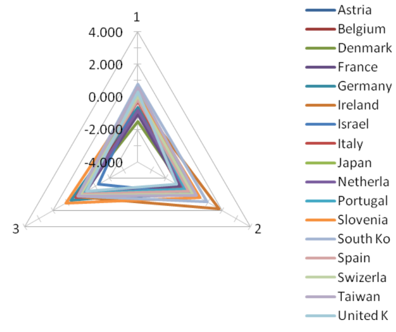
Figure 6.6 presents the comparison of the results of clusters. The Cluster 1 countries had significantly lower average environmental scores (t-test, $p<0.01$) than Cluster 3, while no significant difference is observed in economic scores and social scores. The average economic scores of emerging economies (Cluster 4 and Cluster 7 countries) were significantly higher than the advanced economies (Cluster 1 and Cluster 3) (t-test, $p<0.05$). Furthermore, social sustainability was particularly bad in China and Mexican (the Cluster 7 countries included in this analysis).

Some Cluster 1 countries, although could not score high in environmental component, still achieved higher scores in total (for example, South Korea in Table 6.15). This implies countries with different population densities may achieve equal level of sustainability by different land use approaches. However, based on the overall ranking, the countries with more environmental resources (lower population densities) still have advantages over the countries with less environmental resources (higher population densities).

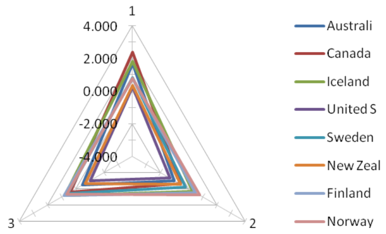
Furthermore, the ranking of the scores based on the first 4 components were quite consistent with the ranking of the scores based on all 7 components (Table 6.15). The correlation coefficient between these two results was 0.89. Therefore, the last three components were not too influential to change the result of assessment drastically.

Table 6.15 The Result of Total Scores

Cluster in ESI 2005	Country	component 1 to 4		Overall Score	
		Score	Rank	Score	Rank
Cluster 1	*Austria*	*0.076*	*12*	*0.126*	*12*
	Belgium	*-0.351*	*28*	*-0.578*	*33*
	Denmark	*-0.422*	*31*	*-0.383*	*30*
	France	*-0.486*	*33*	*-0.340*	*28*
	Germany	*-0.083*	*17*	*-0.083*	*18*
	Ireland	*0.363*	*7*	*0.420*	*6*
	Israel	*-0.303*	*26*	*-0.427*	*31*
	Italy	*-0.112*	*20*	*-0.161*	*21*
	Japan	*0.036*	*14*	*0.067*	*13*
	Netherlands	*-0.349*	*27*	*-0.300*	*26*
	Portugal	*-0.149*	*21*	*-0.103*	*19*
	Slovenia	*0.355*	*8*	*0.383*	*8*
	South Korea	*0.403*	*6*	*0.228*	*9*
	Spain	*-0.107*	*18*	*-0.058*	*16*
	Switzerland	*0.020*	*15*	*0.006*	*14*
	Taiwan	*0.208*	*10*	*-0.048*	*15*
	United Kingdom	*-0.243*	*25*	*-0.381*	*29*
Cluster 3	*Australia*	*0.066*	*13*	*0.184*	*10*
	Canada	*0.498*	*3*	*0.466*	*5*
	Iceland	*0.650*	*1*	*0.536*	*4*
	United States	*-0.434*	*32*	*-0.340*	*27*
	Sweden	*0.284*	*9*	*0.409*	*7*
	New Zealand	*-0.193*	*22*	*-0.061*	*17*
	Finland	*0.463*	*5*	*0.569*	*2*
	Norway	*0.477*	*4*	*0.565*	*3*
Cluster 4	*Turkey*	*-0.420*	*30*	*-0.568*	*32*
	Greece	*-0.407*	*29*	*-0.232*	*25*
	Hungary	*-0.213*	*24*	*-0.179*	*22*
	Poland	*-0.205*	*23*	*-0.139*	*20*
	Czech Republic	*0.164*	*11*	*0.136*	*11*
	Slovak Republic	*-0.044*	*16*	*-0.203*	*23*
Cluster 7	*Mexico*	*-0.110*	*19*	*-0.230*	*24*
	China	*0.569*	*2*	*0.719*	*1*



a.



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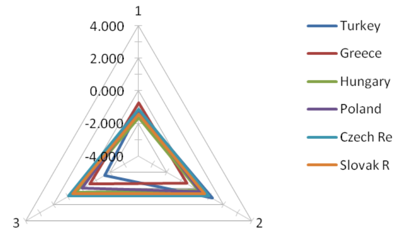

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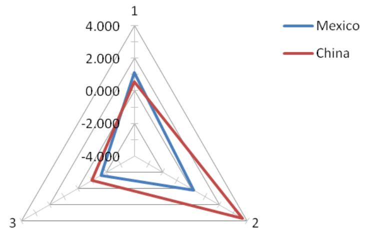

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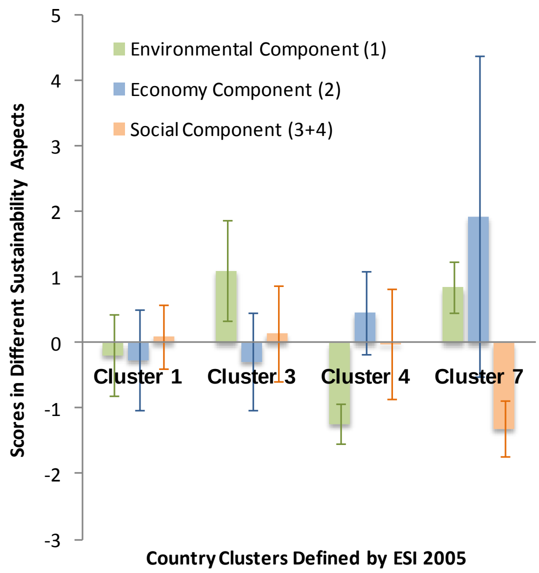


e.

Figure 6.6 The Distribution of Scores in Three Dimensions of Sustainability in 4 Clusters of ESI 2005 Countries (In 6.6a to 6.6d, the axis 1, scores of environmental components; axis 2, scores of economic component; axis 3, scores of social components; 6.6a. Cluster 1; 6.6b. Cluster 3; 6.6c. Cluster 4; 6.6d. Cluster 7, 6.6e. average scores with standard deviations)

6.6. Discussion-the Characteristics of the Index

In this chapter, an index was built to reflect the current level of the sustainability in land use. The index represented the three aspects of sustainability equally and took regional variations in human and land resources into consideration. The variables relevant to the issues of brownfields and land use were selected for the index (Section 6.3.1). The evaluation based on this index becomes the starting point to discuss how brownfield regeneration may improve the sustainability.

The weight (component scores coefficients presented in Table 6.13) assigned to each variable in the index was determined by statistical method to reduce bias. However, the relevance of the components to sustainability (environmental, social, and economic aspects) was determined based on the perceptions to the variables (Table 6.3). Therefore, a degree of subjectivity is still involved in the evaluation. The characteristics of the index and possible future studies to improve the evaluation are discussed in this section. In the next section (Section 6.7), the scores of Taiwan and the UK are compared and the recommendation regarding how brownfields regeneration can be used to improve sustainability is offered.

6.6.1. Regional Variations and Sustainability

The degree of sustainability has often been linked with regional variations (Section 6.2). For example, the richness in regional biodiversity and the variety of ecological habitats are desirable features because increasing diversity usually means less vulnerable to the disturbance. The ecosystem is therefore more sustainable. By contrast, unequal distribution of wealth or opportunities among people implies the existence of deprivation, a sign of an un-sustainable society. The differences of regional population, although may not necessarily indicate a sustainable or un-sustainable situation, are relevant to both the distribution of wealth and the pressure of developing greenfield land. To account for these factors, the analysis incorporated as much statistics that reflect the variations in land and socio-economic conditions as possible.

Sometimes the national averages may also reflect the variations within a country. For example, the index showed that the ‘rule of law’ and the ‘fear of crime’ in countries are two of the influential variables in the social sustainability. It is likely that these crime related variables within a country reflect the degree of social justice and the sense of fairness. These issues are relevant to resources distribution. Therefore, although the average values (but not the values assess the regional variations) in a country were utilised in the index, they might reveal part of the unwanted variations in a society.

The influences of biodiversity and income distribution have been discussed and measured in many indexes of sustainability (for example Esty, Levy, Srebotnjak, & de Sherbinin, 2005). The index established in this study intended to integrate more regional variations that potentially affect sustainability. The following paragraphs discuss the results of integrating these variables into an index of sustainability.

The variables evaluating **socio-economic resources distribution** in this index are usually based on the concept of Gini coefficient. These include 'regional GDP Gini index', 'household income inequality', 'regional unemployment Gini'. Among them, the income inequality appeared to be most influential in the index, especially in social sustainability (the loading of 0.798 in the component 3 of the index). Unemployment Gini index was influential in component 6 (0.820), which is not the major component in the index. Furthermore, the regional GDP Gini index was not influential in all 7 components. It appeared that the individual differences in income and employment status are more relevant to the land use sustainability compared to the differences of collective production in regions. According to this, a sustainable brownfield regeneration project should emphasise creating job opportunities for local people rather than attracting people from other regions.

The **distribution of resources in different sectors** is the other form of variations evaluated in this index. The sector distributions were described based on types of land uses (agricultural or non-agricultural), wealth production (GDP in different sectors), and human resources (labours in different sectors). The progression of development usually moves from agriculture dominant to industry dominant, and then to service sector dominant economy. Correspondingly, the material and human resources shift from agriculture, to industry and then to service sectors. Since the countries included in this analysis were either advanced economies or emerging economies, the GDP and labour percentages in agriculture were constantly low. Therefore, the negative correlations between the remaining two sectors are somewhat unavoidable (Figure 6.1).

Furthermore, the countries with higher percentages of industrial GDP and labour resources usually have higher GDP growth and thus score higher in the economic aspects in this index; the countries with higher percentages of service GDP and labour resources, however, usually have lower GDP growth (but higher GDP per capita). Therefore, this index emphasised economic growth and resources distributions but overlooked the accumulated economic power (GDP per capita).

On the other hand, this also revealed the possible risks and opportunities of the further development among the earlier industrialised countries. It is less possible for them to follow the old pattern of developments emphasises economy growth to sustain. They need to be innovative to establish new patterns of development. This is further elaborated in the final discussion in Chapter 10.

The dominance of the industrial and service sectors indicates the similarity of the stages of the development of the countries considered in this study. Therefore, this sustainable index reflects mainly the situation of industrialising and industrialised countries. The majority of these countries had high environmental sustainability scores, and high human development scores; they also were recognised to be economic competitive (Table 6.4). This suggests that the view expressed by the index was restricted. However, since the problems of brownfield land usually appear in these two types of countries, the relatively narrow spectrum of development stages in this study should be acceptable.

The linear relationship between the ‘percentage of arable land’ and ‘percentage of other land use’ (Figure 6.1) also represented the stages of development but in a different way. The negative relationship between the two was the result of constantly low percentages of permanent cropland. Both permanent cropland and arable land are the result of agricultural practices. ‘Percentage of other land use’ is essentially the proportion of non-agricultural land use in a country. It includes the areas for service and industrial sectors, and the areas that have not yet been developed. Therefore, the country with higher percentages of other land use could be highly developed or undeveloped.

Countries with high arable land percentage may have low agricultural GDP percentage and low agricultural labour percentage such as Denmark, or vice versa such as China. The land resource requirements in service sector and industrial sector are more flexible than agricultural practice. Therefore, in the case of Denmark, the lower percentage of non-agricultural land use and high percentage of

GDP and labour in industry and service sectors indicate the country has used its land effectively to produce wealth. In the case of China, the higher percentage of agricultural GDP and the high percentage of non-agricultural land may imply China has not used the non-agricultural land to produce as much wealth as Demark or other developed countries.

This argument may be further validated by looking into countries' GDP per capital. The 1.4% agriculture GDP to the total GDP per capital ($56,115) in Demark in 2009 means $785 GDP per capital was obtained from the agricultural sector. This is twice of the agricultural GDP per capita of China. The 10.60% of total GDP per capital in China was only $390 in 2009.

Therefore, the land use variations, combined with the GDP and labour percentages by sectors may reveal the efficiency of turning land resources into economic and social benefit. This might explain why in the index, arable land, agricultural GDP and agricultural labour all have negative correlation to the environmental component. The lower the land use efficiency, the more undeveloped land has to be converted into developed or agricultural land. Therefore, it is bad for environmental preservation.

6.6.2. Triple Bottom Line

The three aspects of sustainability could compliment or contradict each other. This reflects in some contradictory relationships between variables and components in this index. For example, biodiversity, believed to be positive to environmental sustainability, showed negative correlation with social sustainability (Section 6.5). Therefore, the land use sustainability may be compromised by overly emphasising one of the three aspects.

However, the danger of overly emphasising one of the three aspects has not been measured using this index. No thresholds were set as a minimal requirement for each of the aspects (or variables). For example, based on this index, China had quite high total scores (Table 6.15). One of the reasons was the impressive GDP growth of China in recent years. China might also have advantages of relative abundant environmental resources not yet to be explored. However, its social conditions are not as impressive. The good performance in the economic aspect masked the poor performance in the social aspect in this index. This is one disadvantage of using the composite index. The only possible compensation for the extreme emphasis on one aspect could be variables affecting more than one aspect in the opposite directions.

The problem of overlooking the extreme development of one aspect may be resolved by implementing the principle of triple bottom line (the concept established by John Elkington for the practice of sustainable development in enterprises) (Elkington, 1999). However, establishing the social, economic and environmental thresholds to evaluate the brownfield regeneration policy at strategic level in a nation has not been intensively discussed. Which variables to pick and what numerical standard to apply merit further research. One such benchmark for socio-economic sustainability could be the maximum acceptable value(s) of income Gini index. Countries exceeding the benchmark would be considered un-sustainable in land resources regardless the result of overall scores in the sustainability index. Another candidate could be the absolute poverty line: Countries should not be considered sustainable in any ways if their populations living below absolute poverty exceed certain percentage.

6.6.3. Psychological Well Being and Material Wealth

The indexes measuring sustainability were mostly composed of variables from statistics of material or physical conditions (for example the variables in EPI 2008 and HDI). These measurements may be easier to obtained and have better comparability across countries. However, diverse historical and culture backgrounds of countries render their people perceive these external conditions differently. The perception interacts with the external conditions to form the overall life satisfaction or well-being. Low satisfaction of life might affect the stability of society and thus sustainable development. Therefore, the subjective measurement of environmental, social and economic conditions may not entirely reflect the 'real' sustainability.

Zidansek (2007) demonstrated that there is a positive but weak correlation between individual happiness and environmental sustainability. Economic conditions such as GDP only enhance the degree of happiness to certain extent (Vemuri & Costanza, 2006; Zidansek, 2007). Vemuri and Costanza (2006) demonstrated that the self-reported life satisfaction is significantly correlated to human development and environemntal service. However, they also showed that the social and environmental variables cannot succesfully predict the life satisfaction of some asian and african countries. Schimmack (2002) pointed out that the subjective well-being was partly influenced by culture. Therefore, although the feelings of well being can be related to wealth creation, resources preservation and social justice that sustainable development aim to improve, the relationship between well being and the material prosperity may not be straightforward or universal.

Additionally, the data measuring the self-reporting happiness in Vemuri and Costanza (2006) were collected during 1990s. The progress of globalisation and speedy development of communication techonology may have facilitated exchanging value and culture among countries. The consideration of what constitutes satisfactory well being may have changed, and continue changing. The 'needs' for the furture generations are not the same with the 'needs' for the present generations. Therefore, the index to measure the performance of sustainable development may need to be constantly revised.

To investigate the effect of life-satisfaction on sustainability, in this index, I included the data of self-reported subjective well-being (satisfaction with life index, data obtained from White, 2007). Depite White (2007) reported that the subjective well-being was 'correlated most strongly with health (0.7) closely followed by weath (0.6) and access to basic education (0.6).' The result in this index indicates that the satisfcation of life is quite independent from the rest of the variables. It was the only dominant variable in the seveth component of the index. This component explained the least variability of the dataset. This could be the result of considering relatively wealthy countries in the analysis. As showed in the previous studies, once the economic condition exceed certain level, it becomes irrelvant to the satisfaction of life (Wilkinson & Pickett, 2010).

In addition to the subjective well being, the other two variables measuring perceptions in the index are the 'fear of crime' and 'rule of law'. Both are relevant to the sense of secuity. These two variables, togather with income Gini index, were influential to social sustainability (component 3). Interestingly, the victimisation rate, another crime related variables that present the 'real' degree of law violation, was eliminated from the final index because of the low extraction during the PCA. It seems the percetion of social stability becomes more important than the actual crime rate under the consideration of sustainable development. This echos the viewpoint and the examples about risk perception presented by Gardner (2009): various human behaviors and policy decisions are the products of preceived risk but not the real risk.

The isolation of 'satisfactory well-being' could also result from variable selections. Only 3 out of 27 variables were based on perception. In this view, the sustainability described by this index is heavily based on measurements of material and physical conditions and less based on the assessments of feeling or public opinions.

However, the perception and real world are intertwined. The policymakers and the general public both have perceptions. The policy based on the 'solid' statistics affects the way people or stakeholders think and behave. Understanding perception may be crucial to deliver the desired results of policies. Thus, an evaluation tool primarily relies on the real world measurements alone may not give the policymaker the whole story. Further research to explore the interaction between perception and physical environment is needed for better quality of policymaking.

6.6.4. The Effects of Missing Data

The missing data points were concentrated on eight specific variables in eleven countries (Table 6.16). The variables describing regional variations were frequently missed in non-OECD countries in the analysis. The missing data was replaced by the average value of collected data (Section 6.4.1). However, replacing missing values with means might be one of the reasons that some variables become less influential in the analysis, especially the variables describing regional variations.

Furthermore, using the mean to replace unavailable 'true' value could be problematic for those countries with considerable amount of missing data points. China, Taiwan, Israel and Slovenia missed roughly one third of data points. Therefore, the scores of these countries may not reflect the true evaluation of the land use sustainability. The evaluation of these counties may require a closer look at the values of those variables that were not missing.

Table 6.16 Summary of Missing Data Points

Perspectives Related to Brownfield Regeneration and Land Use	Nature of Measurement	Abbreviation	Component in PCA	Countries											Number of Variables a Country Missed
				China	Czech Republic	Iceland	Israel	New Zealand	Slovak Republic	Slovenia	South Korea	Switzerland	Taiwan	Turkey	
Ecological	Variation	NBI	The first component (Environment)										✓		*1*
Population	Variation	Regional Population-Index of Geographic	The first component (Environment)	✓			✓			✓			✓		*4*
		Elderly Population - Index of Geography	The first component (Environment)	✓			✓			✓			✓		*4*
Economy	Variation	Regional GDP-Gini Index	No dominancy in any component	✓		✓	✓	✓		✓		✓	✓		*7*
Employment	Direct measurement	Long-Term Unemployment	The first component (Environment)	✓											*1*
	Variation	Regional Unemployment-Gini Index	The sixth component	✓			✓			✓			✓		*4*
Crime	Direct Measurement	Victimisation Prevalence	Eliminated	✓	✓		✓		✓	✓	✓			✓	*7*
		Fear of Crime	The third component (Social)	✓	✓		✓		✓	✓	✓	✓	✓	✓	*9*
Numbers of Missing Data Point in Countries				*7*	*2*	*1*	*6*	*1*	*2*	*6*	*2*	*2*	*6*	*2*	*37*

6.7. Comparisons between the United Kingdom and Taiwan

Since Taiwan is one of the countries this study focuses on, this section discusses possible rooms for improvement based on the results of the index as well as the effect of missing data on Taiwan's score. The UK, on the other hand, had no missing data. It is also one of the advanced economies with high population density. Therefore, it is considered a benchmark to compare against. The variables to be discussed were elected based on the component scores coefficients (Table 6.13). The coefficients higher than 0.1 and lower than -0.1 are discussed because they are considered more influential to the values of scores.

6.7.1. Component 1 (Environmental Aspects)

Taiwan has higher scores in Component 1 than the UK (Table 6.14). Table 6.17 shows this component values high population density and uneven population distribution (Regional Population-Index of Geographic). It also assigned positive values to the land areas that have low anthropogenic impact (ANTH10 and percentage of other land use).

The population density of Taiwan is about two and half times more than the population density of the UK. The two countries both have very low ANTH10 percentages. Between the two countries, the population density may make considerable differences in the resulting scores. Furthermore, the data of the population concentration in Taiwan were not available and replaced by the average values. The effect of this might not be as influential as the overwhelmingly high population density.

The high population density could mean high land use efficiency, or imply the scarceness of land resources that requires better management strategies. Jumping into conclusion that Taiwan's environmental performance is better based on the population density may not be correct.

Table 6.17 Component 1 Variables of Taiwan and United Kingdom

Component 1 Influential Variables	The Weights of the Variables	Taiwan	United Kingdom
Regional Population-Index of Geographic	*0.239*	*39.31**	*49*
Elderly Population - Index of Geography	*0.216*	*37.75**	*46*
Arable land %	*-0.186*	*24*	*23.23*
Other land use %	*0.180*	*75*	*76.57*
Ecorisk	*-0.154*	*0*	*18.72*
ANTH10	*0.127*	*0.1*	*0.13*
Long-Term Unemployment Rate	*-0.124*	*19.6*	*22.4*
Population Density (Person/km$^{2)}$	*0.122*	*636*	*246*
Unemployment Gini	*0.115*	*0.18**	*0.19*
Female primary education completion rate (PECR)	*0.102*	*100*	*96.07*

** This data in for Taiwan is not available. During the factor analysis, the mean substitution method was used.*

Moreover, it is surprising that Taiwan has better Ecorisk score (0) than the UK (18.72). Owing to the original rich biodiversity and intensive industrial development, Taiwan has had high percentage of endangered species and was linked to some internationally known environmental protection violations such as overfishing and damaging the habitat of migrating birds or native species. According to the statistics in ESI 2005, 4.2% of avian species, 27.27% amphibian species, and 17.14% of mammal species in Taiwan are considered endangered. At the same time, the UK has no endangered amphibian, but 0.87% of avian species and 24% of mammal species are considered endangered. Comparatively speaking, Taiwan's extinction crisis should be much more serious. Intuitively, it should score worse than the UK in ecological conditions.

However, the variable 'Ecorisk' does not evaluate species extinction crisis. The calculation is based on the ratio of land in anthropogenic use to land has been designated as protected area (ESI 2005; Hoekstra, et al., 2005). Taiwan covers 3 out of 876 ecoregions compiled by World Wildlife Fund (WWF): South China Sea Island, South Taiwan Monsoon Rain Forest, and Taiwan Subtropical Evergreen Forest. The three ecoregions all belong to Tropical/Subtropical Moist Broadleaf Forests biome (Olson & Dinerstein, 2002). Among countries belong to the same group such as Malaysia, Philippines, and Vietnam, Taiwan designated highest percentage of area as National Park (about 8.5% of the land within the country)[5]. Moreover, according to Hoekstra et al. (2005), none of the three ecoregions of Taiwan were consdiered vulnerable at the global scale. Therefore, Taiwan has 0% of territory in threatened ecoregions. The UK, by contrast, has 18.72% of terriery in south east considered vulnerable ecoregions (Hoekstra et al., 2005). This type of regions has more than 20% area converted into anthropogenic use globally but less than 10% of the area protected. Based on these analyses, Taiwan seems to have a better balance between development and environmental protection. However, it should be noted the variable does not consider the effectiveness of regulations enforced within the designated protection area. Moreover, the consideration of Ecorisk is based on global scale, not specifically for a country.

Taiwan has slightly higher percentage of arable land (24%) and slightly lower percentage of other land use (75%) compared to the UK (23.23% and 76.57%, respectively). Although Taiwan bettered the UK in these two variables, the degree of differences may not be significant.

The UK has slightly higher percentage (0.13%) of total land area having very low anthropogenic impact (ANTH10) than Taiwan (0.10%). The variables is positively correlated with component 1. The percentage of land with low human impact is considered quite important to maintain environmental sustainability. On the global scale, the two counrties both have very little land unaffected by human impact (Table 6.5). The policy implication based on this comparison is that greenfield land should be carefully preserved. This reinforces the importance of land recycling.

Dwyer and Childs (2004) indicated that the anthropogenic land use may be returned back into natural or green space if the previous usage becomes unnecessary. At the same time, the population may migrate from current city centre to suburb. The new social-economic activity centre may be formed. In this case, if the current anthropogenic land use boundary cannot be upheld, the policy should at least keep the dynamic of land use balanced. The total amount of anthropogenic land use should be maintained, if not reduced.

[5] The percentages of Malaysia, Philippines, and Vietnam are 0.6%, 0.7% and 3%, respectively based on a rough calculation based on the statistics on Wikipedia and available official information on the internet.

Component 1 is positively correlated with index of geographic concentration of population and index of geographic concentration of elderly population. These two variables are calcaulated based on the concept of Gini index (OECD, 2003b). The higher values of the indexes indicate uneven population distribution. The uneven distribution possibly reflects human activities are retained within limited areas so that current natural environment may be less affected.

The UK has 'Index of geographic concentration of population' of 49(%). It is higher than the average among most of the OECD countries. The uneven distribution may be the result of more than 10 times of population residing in England than Northen Ireland, Scottland and Wales. Applying similar concept of Gini index to the population and area at county level in Taiwan yields value of 47% (Statistic Data obtained from Ministry of Interior, 2010). This indicats that Taiwan also has quite an uneven population distribution. However, the calcaultion does not take into account of the differences of the size of the country as suggested by the OECD (2003b). Therefore, the number of 47% cannot be directly compared to the OECD indexes. However, it might be safe to say that the uneven population distirbution of Taiwan is more significant than the average value showed. Adjusting the value would lead to higher scores in the environmental component.

Overall, in terms of land use sustainability, the high population density and uneven population distribution are encouraged, and higher percentages of undeveloped land are appricated. For the counrties with high population densities and uneven population distributions such as the UK and Taiwan, retaining, if not reducing, the anthropogenic land use within current boundary is the key to maintain the level of land use sustainability in the environmental aspects.

6.7.2. Component 2 (Economic Aspects)

Taiwan also had better score in the second component which is highly economically relevant. The influential variabels in this component are listed in Table 6.18.

Taiwan's GDP growth has been consistently higher than the UK in recent years. It also has higher percentages of GDP in agriculture and industry. Therefore, Taiwan had higher scores in this component. The UK, however, has higher percentage of GDP and labour in service sectors. These are negatively correlated with the economic component (The implication has been discussed in Section 6.6.1).

Table 6.18 Component 2 Variables of Taiwan and United Kingdom

Component 2 Influential Variables	The Weights of the Variables	Taiwan	United Kingdom
GDP Industry (%)	*0.253*	*27.80*	*22.80*
GDP Service (%)	*-0.249*	*70.70*	*76.20*
Real GDP (%)	*0.176*	*3.80*	*2.10*
GDP Agriculture (%)	*0.132*	*1.50*	*0.90*
Fear of Crime	*-0.112*	*25.29**	*31*
Labour Service (%)	*-0.103*	*58.5*	*79.95*

** This data in for Taiwan is not available. During the factor analysis, the mean substitution method was used.*

'Fear of crime' has negative correlation with economic sustainability. This indicates a better sense of safety is an advantage for the economic development. However, Taiwan does not have the survey data. Therefore, the actual perception of the public regarding crime is not clear. The perception of security in Taiwan may need to be studied to aid for sustainable economic development

The comparison in Table 6.18 also implies the land use policy in the UK and Taiwan should no longer aim to aid the traditional path of economic development. Taiwan may learn the lessons from the early industrialised countries regarding the limitations of expanding service sectors and should develop a new way for economic sustainability. It should consider what type of land use policy is essential to maintain the economic status when moving towards deindustrialisation.

6.7.3. Component 3 (Social Aspects)

Component 3 is relevant to social sustainability. It is interesting that biodiversity was included into this category. The variable has negative correlation with the social sustainability (Table 6.19). This suggests that countries rich in biodiversity may need to restrict development to a greater degree. This is consistent with a conventional view that there are conflicts between development and natural conservation. For example, since 2008, during spring time, one section of a Taiwanese motorway would close at short notice for hours to allow one species of butterfly (Double-branded Black Crow, one variation of *Euploea sylvester*) to migrate through, when the density of passing butterfly reached certain level (the Liberty Times, April 3, 2011). This brings inconvenience to the road users and can be considered a conflict between development and natural conservation.

However, this migration of Double-branded Black Crow has also attracted people to the local communities for recreational or research purposes. This becomes an opportunity for community development. Therefore, nature conservation and development could be reconciled through good policymaking and implementation.

Table 6.19 Component 3 Variables of Taiwan and United Kingdom

Component 3 Influential Variables	The Weights of the Variables	Taiwan	United Kingdom
NBI	*-0.313*	*0.48**	*0.32*
Fear of Crime	*-0.297*	*25.29**	*31*
Income Inequality	*-0.270*	*33.8*	*34*
Rule of Law	*0.169*	*0.95*	*1.81*
GDP Industry (%)	*0.125*	*27.80*	*22.80*
GDP Service (%)	*-0.109*	*70.70*	*76.20*

** This data in for Taiwan is not available. During the factor analysis, the mean substitution method was used.*

Other variables in this component consist of 'GDP in industrial sector', 'GDP in service sector', 'Income Inequality' (income Gini index), 'Fear of Crime' and 'Rule of Law' (Table 6.19). Therefore, the degree of development (GDP in industrial sector and GDP in service sector), the degree of equality (Income Inequality), and the public perception on society (Fear of Crime and Rule of Law) concern the social sustainability.

Overall, the UK has lower biodiversity and higher degree of rule of law. Therefore, it bettered Taiwan in this component. The National Biodiversity Index value of the UK used in calculation is lower than the value of Taiwan. However, Taiwan did not have actual estimation of biodiversity in the ESI 2005 database where the majority of data was obtained. The number utilised is the average value. A much higher estimation of biodiversity in Taiwan might be expected (Section 6.7.1). The lack of data might be the result by the lack of the estimation of the abundance of each species in Taiwan, because Taiwan has kept track of total number of species in the island. As of March 09, 2011, the database maintained by Sinica has identified 53,094 species in Taiwan (http://taibnet.sinica.edu.tw/home_eng.php). The number covers about 2.5% of world species and Taiwan only has about 0.025% land in the world (http://taibnet.sinica.edu.tw/eng/taibnet_statisitc.php). Given the negatively correlation between social sustainability and the biodiversity, the underestimation implies Taiwan needs to put much more effort to balance between the preservation of the biodiversity and maintaining the social sustainability than the results of the index suggest.

Besides, the UK also has better degree in ‘rule of law’. The evaluation of 'rule of law' is based on the survey of the public about their beliefs of the enforceability of established laws within their countries (Esty et al., 2005). Thus, the lower score of Taiwan in this variable reflects room for improvement on law enforcement and confidence of public in governing. This could be relevant to the efficiency on managing the potentially high criminal rate in deprived communities, as well as on enforcing the regulation related to brownfield regeneration.

The score of the ‘fear of crime’ cannot be compared between the two countries due to the lack of data from Taiwan. However, the ‘fear of crime’ has a significant but weak correlation with ‘rule of law’ (correlation coefficient=-0.472, p=0.01 from the correlation Matrix of this analysis in Appendix A). Therefore, substituting average value in the analysis might underestimate the ‘fear of crime’ in Taiwan.

Overall, the result in Component 3 indicates that the in Taiwan, the considerably high biodiversity demands higher level of efforts to balance the social development and environmental protection. However, the relatively low performance in the rule of law and predictably higher level of fear of crime indicates that there are rooms for the improvement in the social aspects of sustainable development.

6.7.4. Component 4 (Social Component)

The fourth Component is also highly relevant to social aspect, particularly to the population distributions. The variables considered important in this component are ‘population growth projection’, ‘labour in different sectors’, ‘regional population distributions’, ‘urban population’ and ‘urban population growth’ (Table 6.20). Although the uneven distribution of population is considered ‘good’ for environmental sustainability, the urbanisation (both the percentage of urban population and urban population growth) is not. This might reflect the argument that the urbanisation in a country does not necessarily indicate the uneven distribution of population. It depends on the size of the country (briefly discuss in Section 5.1.1 more detail may be found in Bertinelli & Strobl, 2003). Therefore, agglomerations in special locations are considered positive to the social sustainability. It could be other the effects make urbanisation un-sustainable.

Moreover, the human growth projection is considered negative to the social sustainability although population density is considered positive in the other component. This implies the population size might soon reach the point that when the resources are evenly distributed, no one can have enough to sustain on acceptable quality of life.

Table 6.20 Component 4 Variables of Taiwan and United Kingdom

Component 4 Influential Variables	The Weights of the Variables	Taiwan	United Kingdom
Labour Industry	*0.272*	*36*	*18.65*
Urban Population Growth Rate	*-0.269*	*0.0014*	*0.0050*
Population Growth Projection	*-0.260*	*-3*	*10*
Female primary education completion rate	*0.202*	*100*	*96.07*
Unemployment Gini Index	*0.164*	*0.18**	*0.19*
Urban Population Percentage	*-0.164*	*0.81*	*0.90*
Labour Service	*-0.115*	*58.5*	*79.95*
Fear of Crime	*0.115*	*25.29**	*31.00*
Income Gini Index	*-0.108*	*33.8*	*34*
Regional Population-Index of Geography	*0.108*	*39.31**	*49*
Elderly Population - Index of Geography	*0.104*	*37.75**	*46*
GDP Agriculture	*-0.102*	*1.50*	*0.90*

** This data in for Taiwan is not available. During the factor analysis, the mean substitution method was used.*

Another way to look at resources distribution may further reflect on the negative correlation of 'income Gini index' to the social sustainability. Curiously, the 'unemployment Gini' becomes positive correlated with this component. This required further investigation.

Primary education is also important in social sustainability. Higher education (represented by gross tertiary enrolment rate), however, was eliminated from the index during the PCA analysis. This may imply that the higher education is not a 'need' for everyone but the primary education is.

Overall, the relationships between the abovementioned variables and Component 4 indicates that denser developments (such as building a compact city) may improve social sustainability given the economic resources distribution would not be sacrificed by such development. This is the issue brownfield regeneration can and should address.

Taiwan has negative population growth projection and a smaller urban population. Therefore, the future development pressure should be less. However, Taiwan has about the same level of uneven distribution of income as the UK. Therefore, the issue of resource distribution requires attention.

Finally, Taiwan scored higher than the UK in this component because it has higher percentage of labour in industry sector than service sector. However, the lack of statistics of Taiwan in fear of crime, regional population concentration make the comparison of score inconclusive.

6.8. Conclusion

An index has been established in this chapter to evaluate the sustainability of land use (Section 6.5). The variables were grouped to represent the three aspects of sustainability on balance. It is found that the three aspects sometimes support each other and sometimes contradict each other.

The result of the PCA showed that the wealth and human resource distributions as well as limiting anthropogenic impact are important to the sustainability of land use. The compact city, therefore, may seem like a plausible solution to the problem of sustainable development given the inequality issues are dealt with (Section 6.7).

It is suggested that, upon evaluating the sustainability, some bottom lines may be needed to prevent the development being dominated by only one aspect (Section 6.6.2). For this reason, the index built in this study may not be a good tool to rank the overall performance in sustainable use of land resources. However, it may be a good tool to compare and contrast the styles of development in different countries and to contemplate the relationships between variables representing sustainability.

The development stage of a country is important to the scores of this index. The negative relationship between service sectors and land use sustainability indicates innovative economy styles need to be explored in order to maintain the sustainability of human society among the de-industrialised countries (Section 6.6.1, Section 6.7.2 and Section 6.7.3). For these countries, more efforts in policymaking should be put into improving environmental and social aspects of sustainability.

Taiwan and the UK both face the challenges to retain the anthropogenic impact with limited land resources. Further planning policies should focus on retaining the anthropogenic land use within current boundary (Section 6.7.1). This makes brownfield regeneration a valuable tool. Specifically, Taiwan has much higher population density as well as biodiversity (Section 6.7.1 and Section 6.7.3). Balancing the environmental protection and social development could be tricky but is important in pursuit of sustainable development. Moreover, the rule of law in Taiwan has not been well established in comparison to the early industrialised countries such as the UK (Section 6.7.3). The appropriateness of policymaking and law enforcement is particularly relevant to brownfield regeneration. It is addressed in the chapters to follow.

Chapter 7 Brownfield Policymaking and Target Setting – England Experience

Two types of distinct brownfield regeneration concepts emerged by comparing how the term 'brownfields' is defined by different nations (Chapter 4). Population density appeared to be an important factor in determining which approach should be applied to improve sustainability. On the other hand, the interpretations of 'sustainability' vary dramatically (Chapter 2). The numerical indexes that evaluate sustainability should, therefore, be used with care (Chapter 5 and Chapter 6).

New dwellings built on previously developed land (PDL) were the indicator that the UK Government utilised to monitor the land use sustainability. A target of more than 60% of new dwellings have been established on PDL in England since 2003. This was considered major political achievement in practicing sustainable development by the Labour Government before 2010. However, the reduction of PDL did not necessarily improve social and economic sustainability in England (Figure 4.6 in Chapter 4). This raises the question of whether defining PDL as brownfield land is sufficient for pursuing sustainable development. Furthermore, it is unclear whether the target that more than 60% of new dwellings should be established on previously developed land actually improves land use sustainability.

Therefore, this chapter investigates how English brownfield regeneration policy has affected brownfield recycling and sustainability. Several parliamentary debates on back garden development revealed various controversies surrounding the current definition of brownfields. From a combined analysis of parliamentary debates, parliament voting results, land use statistics, and a review of survey on local authorities' attitudes, I concluded that to make brownfield regeneration a suitable tool for sustainable development, the definition of brownfields in England should be narrowed down to derelict and vacant land in deprived areas. The target set on the number of new dwellings to be established on the PDL should also be reconsidered as this target has firstly failed to encourage more brownfield sites to be reused effectively and secondly failed to reduce the greenfield developments. A mixed-used target is suggested to replace the target specifically focusing on residential development. The revised definition and targets should help to allocate resources for regeneration to the areas where derelict and abandoned properties have resulted in deprivation hot spots.

7.1. The Definition of Brownfields in the United Kingdom

Based on the availability of land resources in a country, the definitions of brownfields emphasise either pollutants left on the land or the lack of effectiveness in land recycling (Alker et al. 2000, Oliver et al., 2005, Adams et al., 2010). Within a country, this can could also change over time. For example, Adams et al. (2010) noted that since the 1960s, the focus of brownfield regeneration in the UK (mainly England and Scotland) has shifted from the presence of contamination to the potential for redevelopment, and from derelict land to including more types of previously developed land.

The UK is a deindustrialised country with a high population density. It defines brownfields as previously developed land (PDL) (Alker et al. 2000; DCLG 2006a). However, it covers more than the term 'brownfields' originally intended to characterise (the origin of brownfields discussed in Section 2.2). This national definition of brownfields is further interpreted by devolved administrations.

7.1.1. England

In England, Planning Policy Statement 3 (PPS3) defines PDL as that land 'which is or was occupied by a permanent structure, including the curtilage of the developed land… (DCLG, 2006a).' However, on June 9, 2010, the definition in England was revised to exclude residential gardens (DCLG 2010a). This study mainly addresses the situation before 2010.

The NLUD-PDL has kept track of PDL in England since 2001. Local authorities register PDL and vacant buildings with the NLUD-PDL in one of six categories (NLUD, 2000; also discussed in Section 2.3 and Section 4.3.1). These categories cover unused and underused land.

7.1.2. Scotland

Recognising brownfields may cover more than derelict and vacant land, the Scottish government only include 'vacant and derelict land' in the survey (Scottish Executive, 2001). According to the Scottish Government, vacant land is the 'land within urban settlements (with a population over 2000), or within 1km of settlements, which is vacant e.g. unused, unsightly, or which would benefit from development or improvement (Scottish Executive, 2001, p.3).' Derelict land is the 'land in urban and rural areas which is so damaged by development or use that it is incapable of development for beneficial use without rehabilitation, or which is not being used for the purpose for which it is being held or for a use acceptable in the local plan, or land which is not being used and where contamination is known or suspected (Scottish Executive, 2001).' In addition, the devolved administration does not apply targets to brownfield recycling (Dixon 2006).

7.1.3. Northern Ireland

By contrast, in Northern Ireland, PDL is defined as that land 'which is, or was occupied by, a permanent structure within a defined settlement limit. The term may encompass vacant or derelict land, infill sites, land occupied by redundant or under-used buildings, a piece of industrial or commercial property that is abandoned or under-used and often environmentally contaminated (The Department for Regional Development, 2008).' Specifically, the definition of PDL excludes the gardens of dwellings and apartments and other open spaces. Like England, Northern Ireland has used the brownfield recycling target that 60% of residential building to be built on previously developed land, to encourage redevelopment (Dixon, 2006).

7.1.4. Wales

Wales defines PDL similar to England with minor differences: 'Previously developed land is that which is or was occupied by a permanent structure (excluding agricultural or forestry buildings) and associated fixed surface infrastructure. The curtilage … of the development is included, as are defence buildings, and land used for mineral extraction and waste disposal … where provision for restoration has not been made through development control procedures (The Welsh Assembly, 2002).' Accordingly, the Welsh Assembly has included mining and waste areas in its PDL definition. Additionally, in Wales, there is no national target for PDL recycling (Dixon 2006).

7.1.5. Comparison between Definitions

Table 7.1 summarises the essential aspects mentioned or implied in the definitions of brownfield land in the devolved administrations. The CABERNET (2006) definition may be viewed as the general interpretation of brownfields in European Union countries (Section 2.3.2). The USEPA definition may represent a view of brownfields more typical of those countries with lower population densities (Section 2.3.1 and Section 5.4.3). They are listed as benchmarks for the four definitions of devolved administrations.

Table 7.1 Comparison of Brownfield Interpretations

	CABERNET	USEPA*	United Kingdom			
			England	Scotland	Northern Ireland	Wales
Derelict or Unused	✓	✓	✓	✓	✓	✓
Under used	✓	✓	✓	–	✓	✓
Contaminated	Δ	✓	–	Δ	Δ	–
Previously Developed	✓	✓	✓	✓	✓	✓
Urban	✓	–	–	Δ	✓	–
Require Interventions for Beneficial Use	✓	✓	–	✓	–	–

√ essential element in the definition
Δ optional element in the definition
-no mention of the element
** This is based on Small Business Liability and Brownfields Revitalization Act, 2002, which defines brownfields as "real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant." Based on this definition, brownfield land could be derelict, vacant or underused. It is less possible for land to have planning permission when unacceptable contamination levels are present.*

All devolved administrations stress that the land must be previously developed to be considered as a potential brownfield site. Some of them recognise that contamination is likely to be present or previously used land. One administration (Northern Ireland) considers that previously developed land as potential brownfield land only if it is located in urban areas.

The devolved administrations have different opinions on the degree of dereliction that qualifies land as brownfield land. Scotland only considers derelict and vacant land as brownfields while the other three administrations include both unused and underused land. Northern Ireland, although including underused land, excludes house gardens from the definition. This is not the case for England and Wales. Additionally, Scotland is the only administration that includes the necessity of interventions into the definition.

The population density of England is 10 times higher than that of other three administrations (ONS, 2010). This may be one of the reasons why England's definition of brownfields covers the widest range of land resources: As long as the land is previously developed and not used to its full potential, it counts as brownfields. Because the necessity of interventions is not mentioned in the definition, any forms of redevelopments can be considered as brownfield regeneration. This justifies reusing every possible piece of previously developed land in any way possible. However, the loosely defined brownfield areas in England do not necessarily correlate with the degree of socio-economic deprivation (Chapter 4). Thus, the brownfield redevelopment in England might not improve sustainability as generally perceived.

In Section 7.3, I use records of debates in the UK Parliament regarding garden land development as an example to present different points of view on brownfield definitions on land use sustainability.

7.2. Efforts to Facilitate Brownfield Regeneration

Facilitating redevelopment of previously developed land has been on the then Labour Government Agenda since 1998 (Oatridge, 2007). Therefore, parallel to the debates of definition of brownfields and the garden land development in the Parliament, other relevant policies were also made by the government. The establishment and reform of Land Remediation Tax Relief (LRTR) in England and the English Partnership's Recommendation of National Brownfield Strategy are two important examples.

The LRTR was established in 2001 to encourage private sectors to remediate the contaminated land. It was hoped that the redevelopment may follow the remediation. However, it is subsequently found that the LRTR has not had impact as hoped (HMRC, 2006). Therefore, in 2007, the reform expands the tax relief to the work on reclaiming the derelict land. This is one of the efforts the government made to channel private resources into regenerating derelict land.

In 2007, English Partnerships (EP) submitted recommendations regarding how to manage brownfield land in England to the government (EP, 2007). The recommendations aim to provide strategy of brownfield regeneration between 2007 and 2013 (EP 2007). This is considered the National Brownfield Strategy for England. In 2008, the government responded to the recommendations outlining and highlighting the corresponding implementations and plans (DCLG 2008a).

Before the recommendations, the stock of derelict and vacant land has decreased for consecutive years (EP, 2007, and DCLG 2008a). However, the speed of reusing vacant and derelict land was decreasing in the same period (DCLG, 2011). There are 2,321 hectares vacant and derelict land developed in 2001. However, there are only 1,260 hectares vacant and derelict land developed in 2007 (DCLG, 2001).

Overall, EP's recommendation has covered all three aspects of sustainability. EP suggested using land use statistics for analysing policies and planning brownfield regeneration. EP stressed the importance of considering the regional variation during the implementation of brownfield regeneration policies. Some areas in need of help (for example, the contaminated industrial sites in the North) may not be financially attractive; Soft-end use on part of the brownfield land is necessary to prevent flood risk, or to provide public infrastructure that supports development in the neighbourhood or enhances sustainability. For these, public investment is unavoidable. EP also suggested that the regulations should be in place is to ensure the environmental quality during and after the brownfield redevelopment. To achieve these, EP proposed bringing qualified practitioners and relevant stakeholders together for brownfield regeneration.

The recommendation of EP aimed to provide a holistic approach in dealing with brownfield issues. Using brownfield regeneration as a mean to provide affordable housing was not in the major recommendation. EP has identified some deprived neighbourhoods in 74 local authorities and aimed to help them improve the situation through brownfield regeneration. The government, in response, also acknowledge the importance of repairing damaged brownfields and the deprivation observed in areas with more previously developed land. However, it is clear that the government's approach primarily is through brownfield redevelopment to provide "more home to meet growing demand to make housing more affordable (p6.

DCLG 2008a)." Considerable amount of work through programmes and NGOs such as National Coalfield programmes, Land Restoration Trust and Cl:AIRE have been mentioned as evidence that the government has put effort on the issues identified by EP. However, the target of the 60% dwellings built on PDL was the only numerical target mentioned in the government response to the National Brownfield Strategy.

The government as well as EP, in addition to consider the vacant and derelict land, also considered facilitating recycling the areas that are low in development densities (latent brownfield)(EP, 2007 and DCLG, 2008a). This may be due to the amount of vacant and derelict land that is more suitable for hard end redevelopment is decreasing (EP 2003, and EP 2007). However, this argument might not be suitable if including soft end use in the consideration of regeneration.

The government's downplaying the contribution of brownfield regeneration through encouraging biodiversity and the alleviation of flood risk (soft-end development) had some consequences, for example, the struggle of Land Restoration Trust to keep up with its promised target (section 7.7.3). The separation of the soft-end use from the idea of redevelopment, may affect the implementation of the recommendation by EP.

A year before the government's response, a review by Sustainable Development Commission concluded that "delivery of genuinely sustainable communities is not sufficiently widespread in a programme that seems to be increasingly focussed on building houses rather than enabling sustainable communities to develop (Sustainable Development Commission, 2007, p.102)." The review also indicated, "this still leaves a significant amount of previously undeveloped land (greenfield) being taken for housing use. (Sustainable Development Commission, 2007, p.9)"

Therefore, it seems the strategy has become yet another justification for the government to pursue high-density residential development on all types of previously developed land. Other aspects of sustainability were discussed but no corresponding policy targets were established to push the agenda forward.

7.3. Controversies of the Brownfield Definition over Back Garden Development – A Review of Parliamentary Debate

With a continuous growth in population, the UK needs many more affordable houses (Whitehand and Larkham, 1991; DETR, 1999). Therefore, specifically for residential land use, the 60% target was established to enhance land recycling in England. According to the definition of PDL before the election in 2010, houses built on both post-industrial and domestic garden land count towards the 60% target. Besides meeting the housing demand, the target was also considered a tool to stimulate brownfield regeneration (DETR, 1999).

The legislative and administrative bodies have discussed the appropriateness of treating garden land as PDL during the past few years. Matters came to a head in a debate in the House of Commons in 2005 and the issue has rumbled on ever since. Several Bills attempted to remove garden land from the PDL definition (for example, by *the Land Use (Gardens Protection etc) Bill* proposed by Caroline Spelman in 2006 and by *the Protection of Garden Land (Development Control) Bill* proposed by Paul Burstow in 2009). The declaration to eliminate 'garden grabbing' appeared in the manifestos in two of the three major political parties during the general election of 2010 (The Conservative Party, 2010, p174; The Liberal Democrat, 2010, p82). On the other hand, some opinions specifically welcomed the inclusion of infill redevelopment (sic) (Rice, 2007) in brownfield policy.

In response to MPs' questions on the effect of the PDL definition on housing development, the UK Government before May 2010 consistently pointed out that the government has given the power to local authorities to decline un-sustainable PDL development (Secretary of State for Communities and Local Government, Ruth Kelly, 2006) (HC Deb (2005-6) 447 col. 1395) (Minister of Local Government, John Healey, 2008) (HC Deb (2007-8) 483 col. 535) (Parliamentary Under-Secretary of State for Communities and Local Government, Iain Wright, 2009) (HC Deb (2008-9) 487 col. 198WH). However, the refusal to grant planning permissions was often overruled following appeals (Conservative MP for Newbury, Richard Benyon, 2006) (HC Deb (2005-6) 447 col. 1396) (Liberal Democrat MP for Oxford, West and Abingdon, Evan Harris, 2009) (HC Deb (2008-9) 487 col. 182WH). This was because PPS3 has included garden land within brownfield classification. A refusal based on the undesirability of garden land redevelopment become invalid (Conservative MP for Newbury, Richard Benyon, 2006) (HC Deb (2005-6) 447 col. 1396). Since the appeals have been granted on behalf of the State of Secretary, 'The matter is [effectively] centrally controlled (Conservative MP for Newbury, Richard Benyon, 2006) (HC Deb (2005-6) 447 col. 1396).' The local and central government seem to have a different understanding of sustainable development (Conservative MP for Meriden, Caroline Spelman, 2008) (HC Deb (2007-8) 483 col. 543). Furthermore, the opinions are also divided between MPs. These different points of view are set out in detailed below.

7.3.1. Back Garden Development and Housing Demand

Proponents for including house garden within the definition of PDL stressed that it is important for countries with limited environmental resources like England, to recycle land impacted by anthropogenic activities. This includes garden land in urban areas. Therefore, garden land should remain part of the definition of PDL.

Making a city compact prevents urban sprawl and preserves greenfield sites from being developed (Ganser & Williams, 2007). For a city that has been saturated with residential houses, to constrict development within the greenbelt, 'sensitive and sympathetic infill development is the only way… (Labour MP for Denton and Reddish, Andrew Guynne, 2006) (HC Deb (2005-6) 447 col. 1398).' Limiting the development of garden land may endanger undeveloped greenfields in some constituencies where housing demands are high (Labour MP for Bishop Auckland, Helen Goodman, 2006) (HC Deb (2005-6) 447 col. 1389) (Labour MP for Denton and Reddish, Andrew Guynne, 2006; Labour MP for Luton, Margaret Moran, 2006) (HC Deb (2005-6) 447 col. 1398).

7.3.2. Back Garden Development and Quality of Life

Opponents pointed out that most garden land development has not considered the resources required to support livelihood in local area. Therefore, garden land should be eliminated from the definition.

Domestic gardens in England's urban areas are considered essential to the quality of life and are a unique habitat that enriches biodiversity (Conservative MP for Meriden, Caroline Spelman, 2006a) (HC Deb (2005-6) 447 col. 1388). Building on garden land brings extra population to the area. This can overload public infrastructure and services causing problems such as congested traffic and decreased water quality (Conservative MP for Castle Point, Bob Spink, 2006) (HC

Deb (2006-6) 447 col. 1383) (Conservative MP for Meriden, Caroline Spelman, 2006b) (HC Deb (2005-6) 447 col. 1382). In accordance with Section 106 (S106) of the Town and Country Planning Act 1990, the local planning authority may give planning permission on the condition that the developer contributes to the development of infrastructure. However, developers may avoid this by strategically limiting the scale of development (Liberal Democrat MP for St. Ives, Andrew George, 2009) (HC Deb (2008-9) 487 col. 182WH). Since garden land developments are usually small unit developments, the developer may avoid the obligation to provide social housing units (Liberal Democrat MP for Richmond Park, Susan Kramer, 2008) (HC Deb (2007-8) 483 col. 539). Even with a Section 106 Agreement, local authorities still find it difficult to 'address the real infrastructure implication of many such developments (Liberal democrat MP for St. Ives, Andrew George, 2009) (HC Deb (2008-9) 487 col. 182WH).'

Furthermore, garden land developments usually take place in relatively prosperous areas for better prices. Such developments are not helpful to the government's objective to provide more affordable houses (Conservative MP for Meriden, Caroline Spelman, 2006b) (HC Deb (2005-6) 447 col. 1382). On the other hand, building new residential establishments in poorer deindustrialised areas are unpopular among developers because of the poor outlook for a financial return (Labour MP for Birkenhead, Frank Field, 2006) (HC Deb (2005-6) 447 col. 1385) (Labour MP for Sunderland, Chris Mullin, 2006, and Labour MP for Durham, Roberta Blackman-Woods, 2006) (HC Deb (2005-6) 447 col. 1397). Ideally, sustainable development should provide affordable housing and sufficient public facilities to disadvantaged people. All these issues brought up by MPs seem contrary to the criteria of sustainable development, which should be the ultimate goal of the government's PDL recycling strategy (DETR, 1999).

7.3.3. The Central Government's Attitude

The Labour government before the general election of 2010 maintained that inconsistent attitudes towards garden land development between the central government and local authorities are 'not a widespread, national or growing problem (Minister for Housing, John Healey, 2010) (HC Deb (2009-10) 504 col. 6ws)'. It based this statement on a study commissioned by the Minister. The said study stated '… garden development is revealed as being within pockets of settlements rather than being a national issue… (DCLG, 2010b, p7).' Therefore, the Labour government believed that the cases mentioned by MPs against garden land development are anecdotes. It required more evidences to validate the argument that the definition at the time (before the general election 2010) has encouraged inappropriate garden land development.

However, the Minister for Housing also stressed that there is no presumption that 'land that is previously developed is suitable for development, or that all of the curtilage should be developed.' Judgement should be made on a case-by-case basis.
On 9 June, 2010, the newly elected coalition government announced that the definition of PDL now excludes private gardens (Minister of State, Communities and Local Government, Greg Clark, 2010) (HC Deb (2010-2011) 511 Col. 9ws). PPS3 was revised accordingly (DCLG 2010a).

7.4. Parliament's Attitudes to Garden Land Developments – An Analysis of Parliamentary Voting Results

The debates have revealed both sides of the argument regarding the development of garden land. It seems that garden land development is needed in the areas of dense development. It may not be possible to maintain the green belt without allowing the development of house gardens (Section 7.3.1). However, the statements of MPs do not necessarily reflect the density of settlements in their own constituencies. For example, the population densities in the four constituencies of those MPs seemed to be in favour of garden land development cited in Section 7.3.1, range from relatively high to low (49.56/hectare to 0.92/hectare) amongst all the UK constituencies (Figure 7.1) (The House of Commons Library, 2004). The argument that the developments within the constituencies have saturated does not seem to apply to all of them. Additionally, these MPs all belonged to the Labour Party. This seems to reflect that MPs do not express their opinions based on the needs of their constituencies, but based on whether their party is running the government.

On the other hand, the MPs who made speeches in favour of eliminating back garden land from brownfield designation came from all three major parties (Section

7.3.2). The population densities of their constituencies range from 1.57 person/hectare (ranked 548th of all 659 constituencies) to 28.61 person/hectare (ranked 170th). The availability of land resources within their constituencies seemed not to be the major consideration for these MPs when supporting or disapproving the idea of garden land as brownfield land.

Moreover, England is often considered as politically divided between north and south (Section 4.2.2). There is also a possibility that the opinions of MPs on the issues depend on the regions of their constituencies rather than the actual densities of developments in their constituencies.

Overall, the actual reasons for MPs to support or reject the idea of garden land development cannot be clearly identified on the basis of their sporadic statements in the Parliament.

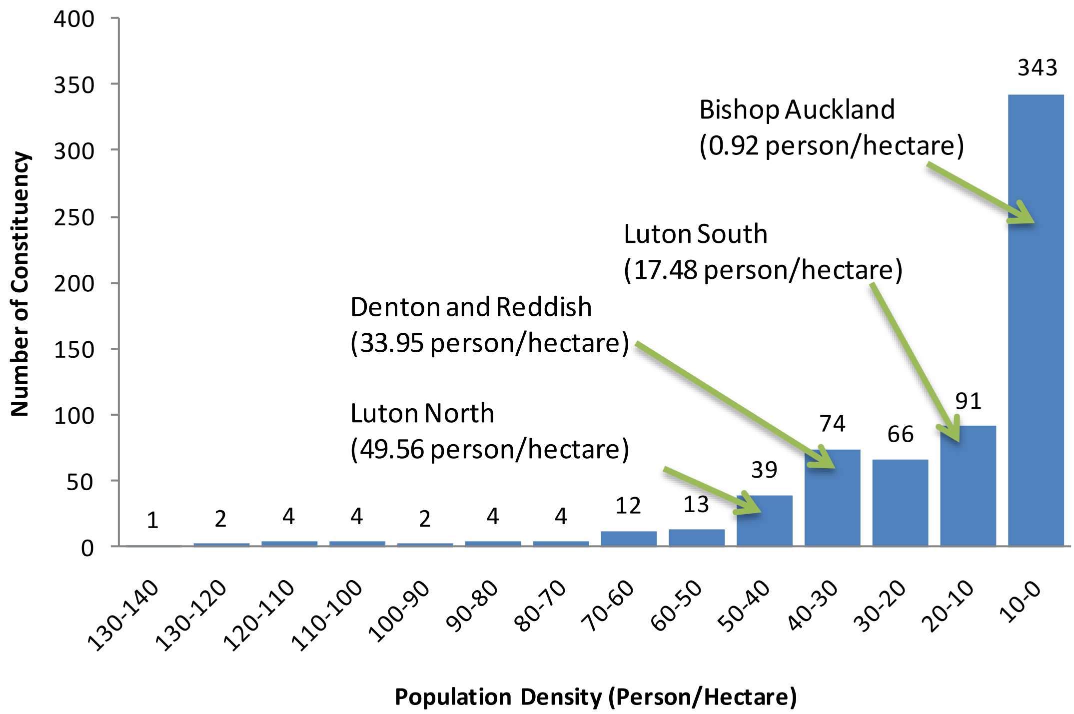


Figure 7.1 The Distribution of the Population Density among Constituencies in the United Kingdom (data obtained from The House of Commons Library, 2004)

To examine comprehensively whether MPs' support for or opposition to garden land development is based on party orientation or the conditions in their constituencies, voting results from 2006 in the House of Commons and from 2008 in the House of

Lords are analysed and presented in this section. The voting results are viewed as comprehensive opinion 'surveys' among MPs.

7.4.1. Voting Results and Parties

Table 7.2 show the voting pattern cast in the House of Commons on June 21, 2006. The House of Commons voted on the motion tabled by Caroline Spelman MP (Conservative). She suggested that the Government should 'amend all relevant planning guidance to remove gardens from the definition of PDL and thereby return decisions over proposed garden land developments to the discretion of local planning authorities (HC Deb (2005-6) 447 col. 1382)(Spelman, 2006b).'

Table 7.2 The Voting Result on Carolina Spelman's Motion Regarding Garden Land Development on June 21, 2006

Elected Party	2006		
	Voted Yes	Voted No	Did not Vote
Conservative	*157*	*0*	*41*
Liberal Democrat	*48*	*0*	*16*
Labour	*0*	*271*	*68*
Labour/Co-operative	*0*	*15*	*2*
Democratic Unionist	*2*	*0*	*7*
Health Concern	*1*	*0*	*0*
Plaid Cymru	*2*	*0*	*1*
Independent	*0*	*0*	*1*
None - Speaker	*0*	*0*	*1*
RESPECT	*0*	*0*	*1*
Scottish National Party	*0*	*0*	*6*
Sinn Féin	*0*	*0*	*5*
Social Democratic and Labour	*0*	*0*	*3*
Ulster Unionist	*0*	*0*	*1*
Total	*210*	*286*	*153*

The results indicate that voting on this issue is overwhelmingly based on party politics. The MPs representing the Labour Party, or the Labour/Co-operative group, if they voted, all rejected the motion. Labour MPs who had expressed the concerns about garden land development nonetheless voted 'No' to the Bill or did not vote (for example, Labour MP for Birkenhead, Frank Field, Labour MP for Sunderland, Chris Mullin and Labour MP for Durham, Roberta Blackman-Woods). At the same time, the Conservative or the Liberal Democratic MPs who casted their votes all supported the motion. Other MPs from smaller parties that voted, all sided with the opposition parties.

Notwithstanding the rejection of the notion, Spelman introduced *the Land Use (Garden Protection etc) Bill* in the same year. Spelman's Bill called for further measures for preserving garden and urban green spaces and for eliminating interventions from the Secretary of State on the issue of proving or refusing planning applications by local authorities. The Bill also covered issues of mixed-use development. Essentially, it required that commercial developments must be accompanied by residential developments. This Bill has been brought up for discussion on 13 December 2006 and 2 February 2007 but never been voted on.

Efforts to changing the regulation on urban garden land designation have continued. For example, on 12 November 2008, some new Clauses were tabled in the House of Lord to be inserted into *The Town and Country Planning Act 1990*. The new Clauses aim at revising the definition of green space so that garden land can be better protected, and at reducing the power of the Secretary of State to overrule local authorities' decisions on planning. The proponent argued that 'gardens are under attack' and current planning regulation 'encourages a mismatch between infrastructure and development (Cathcart, 2008) (HL Deb (2007-8) 705 Col. 691).'

The votes were cast after some exchanges between Baroness Andrews who was the Parliamentary under Secretary of State of DCLG at the time and other peers who supported the revisions.

The voting result rejected the motion (Table 7.3). Similar to the voting results from 2006 in the House of Commons, the opinions were divided based on party affiliations: peers affiliated with the Labour Party were 'not content' (disagree) with the revision while peers affiliated with the Conservative Party or the Liberal Democratic Party were 'content' (agree) with the motion. More crossbenchers were 'content' with the revision than 'not content', but most crossbenchers did not vote at all.

Table 7.3 The Voting Result on Earl Cathcart's Motion Regarding Garden Land Development on November 12, 2008

Party or Group	2008		
	Contents*	Not Contents**	Did not Vote
Bishops	*0*	*3*	*24*
Conservative	*73*	*0*	*115*
Conservative Independent	*0*	*0*	*1*
Crossbench	*19*	*5*	*159*
Independent Labour	*1*	*1*	*0*
Labour	*0*	*116*	*103*
Liberal Democrat	*40*	*0*	*33*
Other	*2*	*3*	*43*
Social Democratic party	*0*	*0*	*1*
Democratic Unionist	*0*	*0*	*3*
UK Independence Party	*0*	*0*	*2*
Ulster Unionist Party	*0*	*0*	*3*
Total	*135*	*128*	*487*

**content: agree with the motion.*
***not content: oppose the motion.*

7.4.2. Voting Result and Regions

The voting result from 21 June 2006 is further analysed in regard to the location of the constituencies. The voting result in the House of Lords is not analysed because peers are not elected locally.

Figure 7.2 shows the voting results for each devolved administration. Voting rates were the highest in England and Wales. The issue of garden land development concerned the two devolved administrations the most. The MPs from Scottish constituencies were less enthusiastic to vote on this Bill. Furthermore, Northern Ireland had a considerably higher percentage of PMs that did not vote at all, partly due to the MPs who gave up the right to vote when refusing to take the oath of office upon taking their seats in parliament. Scotland's definition is distinctively different (Section 7.1.2) and Northern Ireland has excluded garden land from the definition (Section 7.1.3). This issue may thus not concern them as much.

Higher percentages of MPs from England, Wales and Scotland voted 'No' to change the definition while none of the MPs from Northern Ireland voted 'No'. Interestingly, England also had the highest percentage of MPs voting 'Yes'. Wales had the second highest. Scotland and Northern Ireland had about 10% of MPs voting yes. However, overall, more MPs voted 'No' in three of the four administrations.

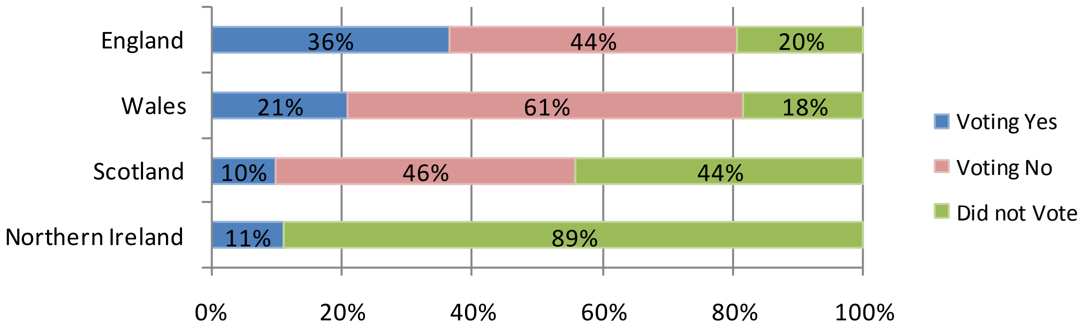


Figure 7.2 The Percentages of Votes on June 21, 2006 in Four Devolved Administrations

The voting results for England were further broken-down into nine administrative regions (Figure 7.3). The percentage of votes for excluding garden land from the PDL increased from north to south. The London Region was an exception to this trend.

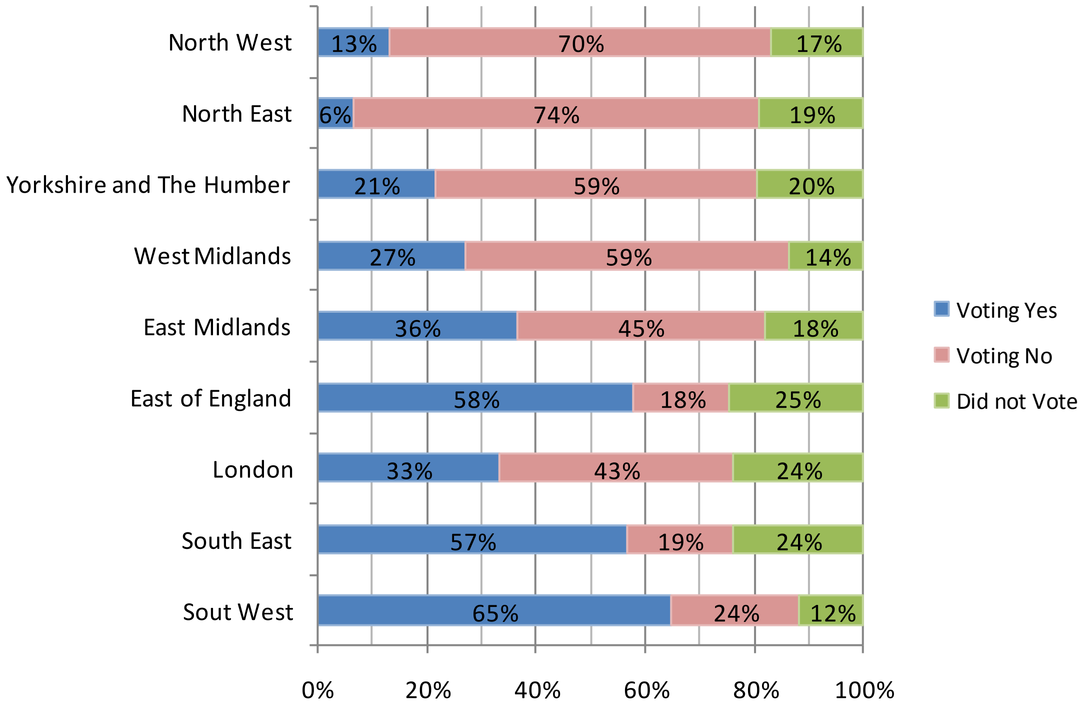


Figure 7.3 The Percentages of Voting on June 21, 2006 in Nine England Regions

Figure 7.4 presents the regional distributions of the parties MP represented. Similar to the voting percentage of the brownfield definition, the percentages of the Conservative and Liberal Democratic MPs increased from north to south with the exception of the London Region. This suggests the regional differences may also result from party politics.

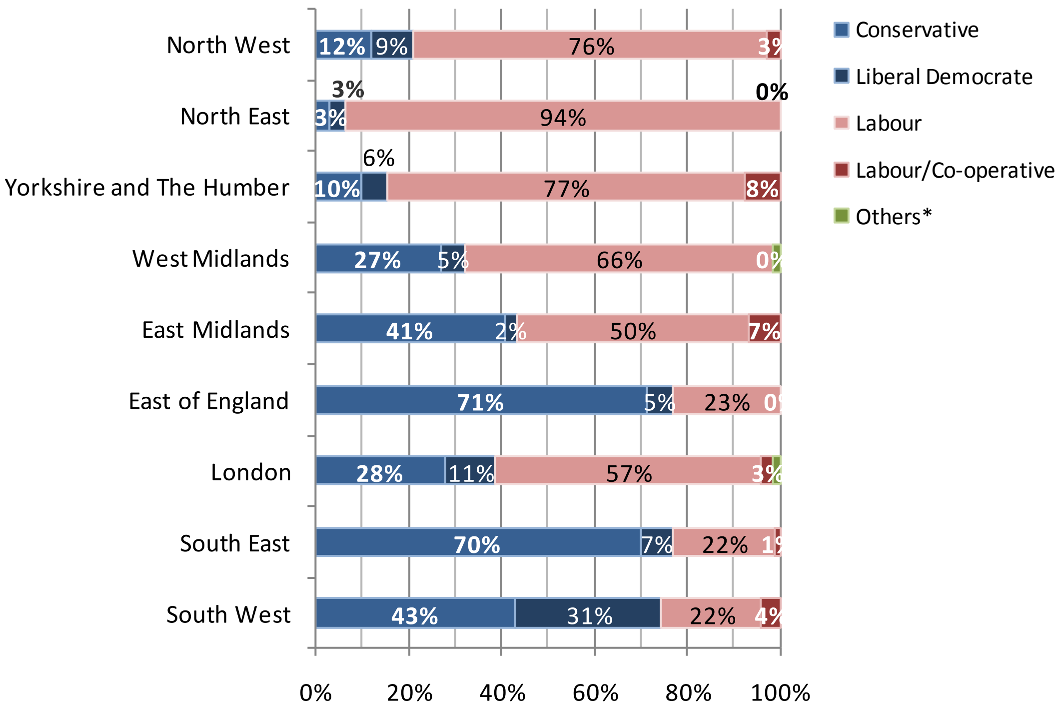


Figure 7.4 The Percentages of MPs in Different Parties on June 21, 2006 in Nine England Regions

Figure 7.5 presents the voting results and the population densities of constituencies sorted by regions. Overall, the distributions of the population density seemed to differ between the groups who vote 'Yes' and the groups who voted 'No'. The constituencies with relatively high densities prefer including garden land in the definition of PDL, while those with relatively low densities prefer excluding garden land from the definition. T-tests also showed that except the North West Region, the averages of population densities sorted by voting results were significantly different within regions. However, it should be noted that since the distributions of population density are sometimes highly skewed, the result of the t-test should only be taken as a reference but not a definite conclusion.

Additionally, it is clear that the voting result depended more on the relative difference of population density than on absolute values of population density. For example, the population densities in the constituencies of the London Region of which MPs voted 'Yes' to the issues are much higher than those of the North East who voted 'No'.

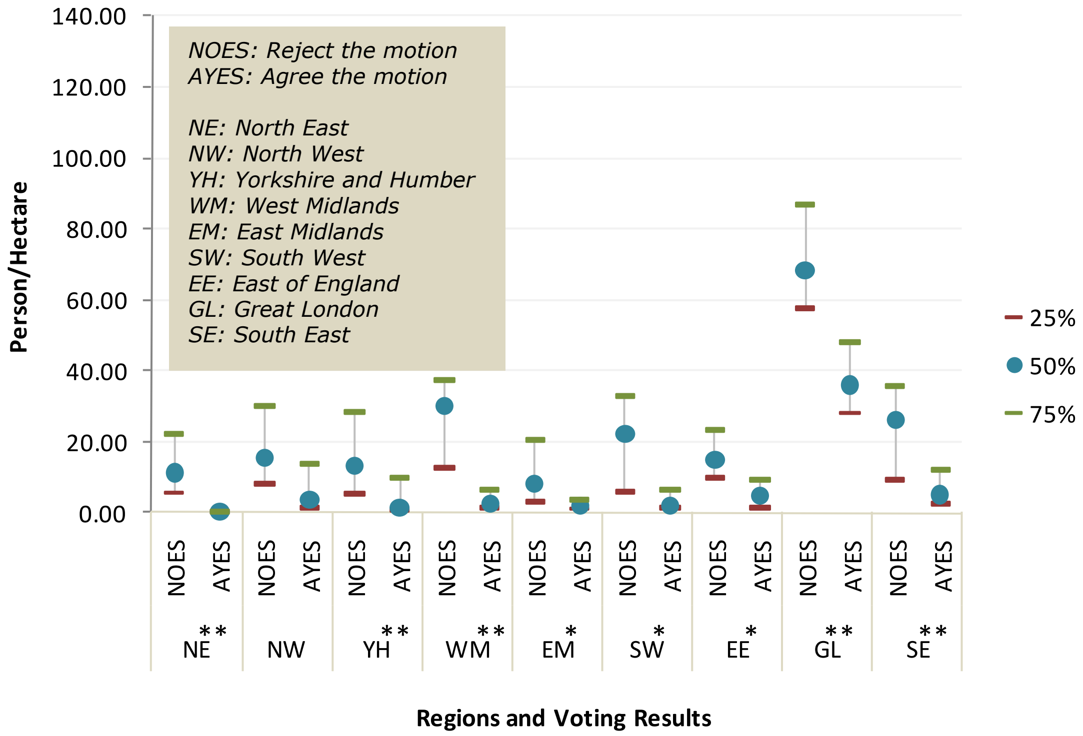


Figure 7.5 The Population Densities and Voting Results Sorted by Regions in England (population density data obtained from the House of Common Library 2004, the voting data obtained from HC Deb (2005-6) 447 col. 1430, **p≤0.001, *p≤0.05 in t-test[6])

[6] The null hypothesis of the t-tests are that there is no difference of average population density between the group of constituencies voted in favour of excluding garden land from the PDL definition (AYES) and the group of constituencies voted to reject excluding garden land from the PDL definition (NOES) within the same region.

Therefore, within a region, this result seems to be in agreement with the argument that the constituencies with higher density of developments need garden land to be developed to fulfil land-use demands. The constituencies with lower density of development can preserve the urban green spaces, as they are under less development pressure. On the other hand, the statistics indicates that a definite value of population density that makes MPs votes 'yes' or 'no' does not exist.

However, the significance of population densities of constituencies within a region may also result from the fact that the Labour Party is usually elected in the constituencies with higher population densities within a region, while the Conservative and Liberal Democrat are usually elected in the constituencies with lower population densities within a region.

7.5. Inconsistencies between PDL Supply and the Voting Results

During parliamentary debates, MPs used examples (anecdotes) from their constituencies to back up arguments regarding whether to exclude the garden land from the definition of PDL. It seems they believed that the issue is strongly associated with local development. However, the analyses of the voting results indicate that the final decision was strongly based on party politics (Section 7.4). At that time, the Labour Party had a majority in Parliament and the voting result allowed garden land to stay within the definition of brownfields, consistent with the Labour Government Policy.

On the other hand, specific political parties dominate specific regions and constituencies (Section 7.4.2). Generally, the Labour Party dominates the north while the Conservative Party usually wins more seats in the south. The Labour Party also wins more support from highly urbanised constituencies, while the Conservative Party gains more support from relatively rural areas. London is the only exception. Given this situation, it is likely that in general, the views of the political parties reflect the conditions and cultural background within their own local communities. However, for the brownfield issue, the analyses conducted in this section further shows that this is not the case.

Figure 7.6 shows the proportions of derelict and vacant land to the total PDL in the nine regions in England in 2004. The percentages of vacant and derelict land in

PDL descended from the north to the south. In the northern regions, the proportions of derelictions to the total PDL were higher than 65%. In the Midlands, the percentages were between 65% and 60%. In the south, the percentages were always below 60%. The figures reconfirm the observation in Chapter 4 (Figure 4.12) that the composition of PDL was quite different between the north and the south in England. Although the South Eastern regions showed a similar amount of total PDL as the North West, the South East possesses much less derelict or vacant land.

From the brownfield regeneration point of view, where more derelict and vacant land is available, garden land development should be less necessary. The constituencies in the north should feel less pressure on garden land development than the south. This is just the opposite to the voting results summarised in Section 7.4.2.

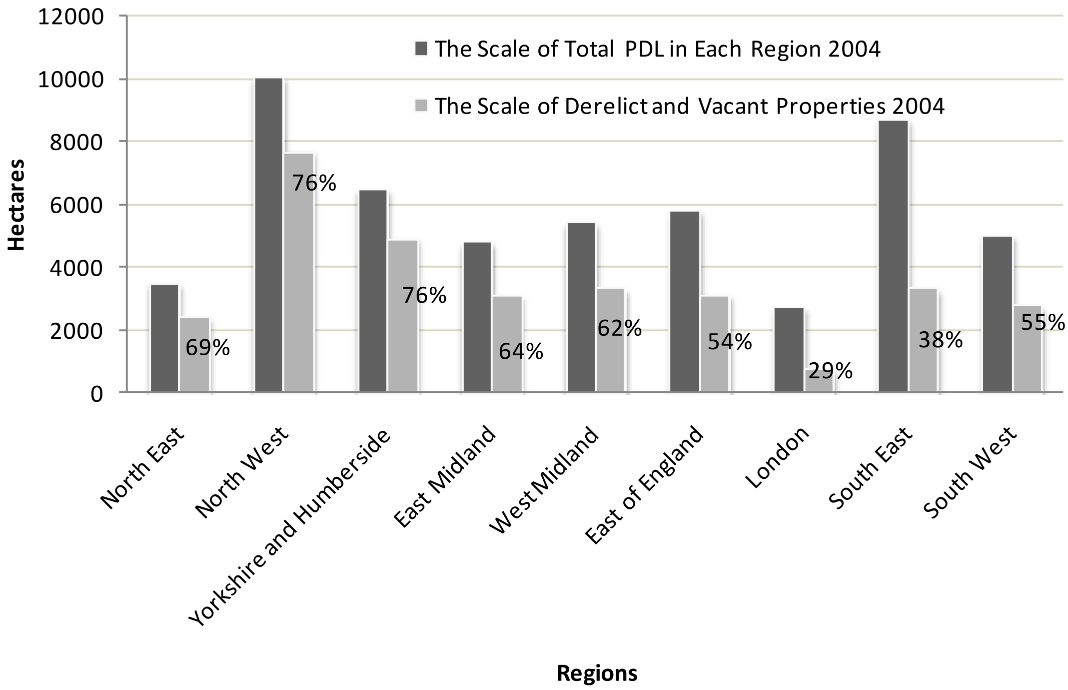


Figure 7.6 The Distribution of PDL and Vacant and Derelict Land (Data obtained from the NLUD-PDL, detailed in Section 4.3.1.)

In summary, on the issue of garden land development, the MPs voted according to their party orientations. Although the voting result is also related to the densities in the constituencies within a region, this is likely to result from the distribution of the parties. The Labour Party is usually elected in the constituencies with relative high population densities in a region. Additionally, the availability of derelict land in regions indicates that the voting result did not reflect the land demand and supply within England. Therefore, party politics have neglected the needs of local communities on the issues of PDL redevelopment.

7.6. Relationship between Government Target and PDL Dynamic

The voting results on the revision of the brownfield definition do not appear to be consistent with the regional supply of brownfield land (Section 7.5 and Figure 7.6). In this section, the analysis then focuses on whether the government's target of building 60% of new houses on PDL improved sustainability.

7.6.1. Dwellings and Degree of Deprivation

The then Labour government's aimed to build '60% of new housing in England on previously developed sites by 2008 (hereafter referred as the 60% target, DETR, 1999, p65).' In practice, this means more than 60% of residential dwellings have to be built on PDL annually, as some greenfields developments will occur.

Figure 7.7 shows the percentages of new dwellings on the PDL in four periods within 10 years (1992 and 1995, 1996 and 1999, 2000 and 2003, or 2004 and 2007) in local authorities; they have no clear relationships with deprivation conditions in 2007. The numbers of local authorities meeting the 60% target increased during these periods (from 130 to 256). However, the increasing percentage of dwellings on PDL over the 10-year period has not affected current deprivation conditions. There were cases in all four plots in Figure 7.7 where high deprivation scores (worse deprivation conditions) appeared in local authorities who had 100% residential dwellings built on PDL.

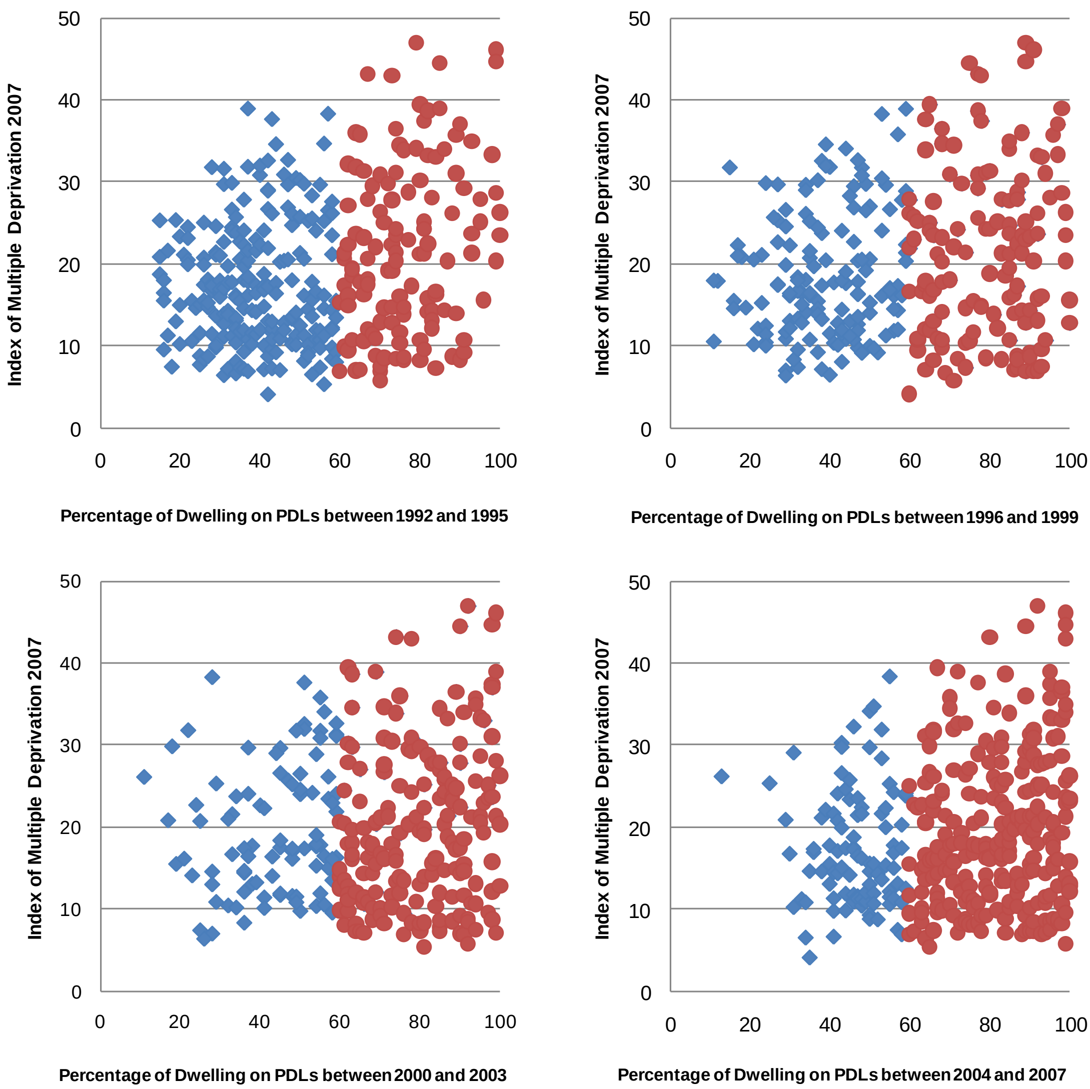


Figure 7.7 The Relationships between Dwellings on PDL and Deprivation Scores in England (◆ less than 60% dwellings on PDL annually; • equal or more than 60% dwellings on PDL annually; data after DCLG, 2008b and DCLG, 2009)

Furthermore, the percentages of dwellings in the 10-year period did not affect the changes of the deprivation conditions between 2004 and 2007 (Figure 7.8). Difference in the deprivation score between 2004 and 2007 in each local authority was calculated. Positive values indicate that the conditions improved; negative values indicate that the deprivation worsened. The differences had no clear correlation with dwellings established on PDL (Figure 7.8).

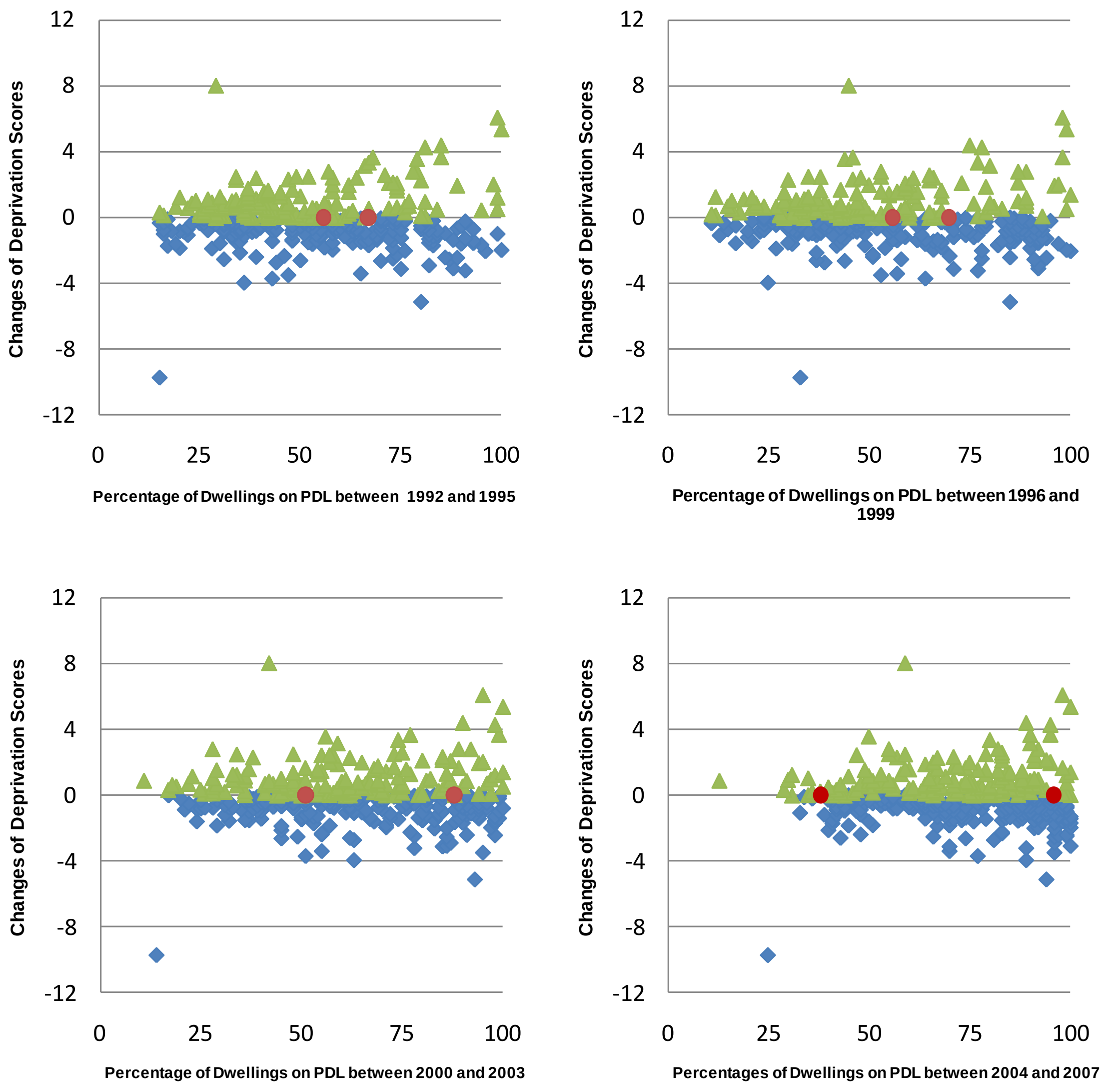


Figure 7.8 Changes of Deprivation Conditions between 2004 and 2007 and Percentages of Dwellings during Different Periods
(♦condition worsen; •no changes; ▲condition improved, calculation based on data in ODPM 2004b and DCLG, 2008b, dwelling statistics after DCLG, 2009)

7.6.2. Land Developed Each Year and PDL Supply

Between 2001 and 2006, the areas of new redevelopment (including residential and non-residential developments) on PDL accounted for 61% to 52% total new development annually (green columns in Figure 7.9). On the other hand, the amount of PDL that was redeveloped (for residential or non-residential purposes) each year ranged from 17% to 7% (blue columns in Figure 7.9). More than half of the land developments were on PDL each year but they only accounted for less than one-fifth of PDL available at the time. The amount of PDL was more than the total amount of areas that were developed annually. Although there were more PDL areas than needed for development, more than 40% of development was often established on greenfield sites.

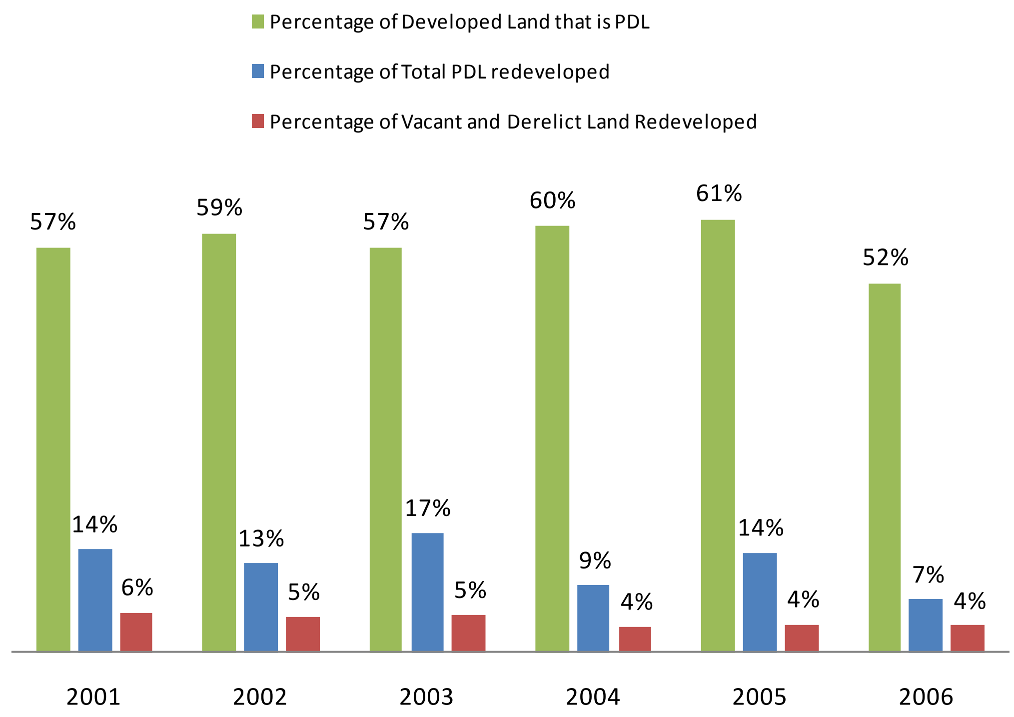


Figure 7.9 Different Percentages based on Different Description of PDL Recycling Performance (data after DCLG 2009)

Moreover, the percentage of derelict land and vacant land (Categories A, B and C) that was redeveloped (for residential or non-residential purposes) each year is even lower than that of total PDL (red column in Figure 7.9). Therefore, most redevelopments on PDL were on the land that is considered underused but not unused.

Since the statistics showed similar patterns between 2001 and 2006, the excessive amount of PDL and derelict land in England awaiting redevelopment is unlikely to be a single incidence, but a persistent phenomenon.

The statistics of the land developed each year were also broken-down for each region in England. The pattern observed in Figure 7.9 is repeated in eight of the nine regions in England with the exception of the London Region. The PDL left undeveloped exceeded significantly the areas developed in each region. Outside of the London Region, considerably lower proportions of derelict and vacant land have been reused. In the London area, about equal percentages of PDL and derelict land are recycled. Moreover, nearly 90% of new establishments in the London Region are on PDL. Other regions seldom exceeded 70%.

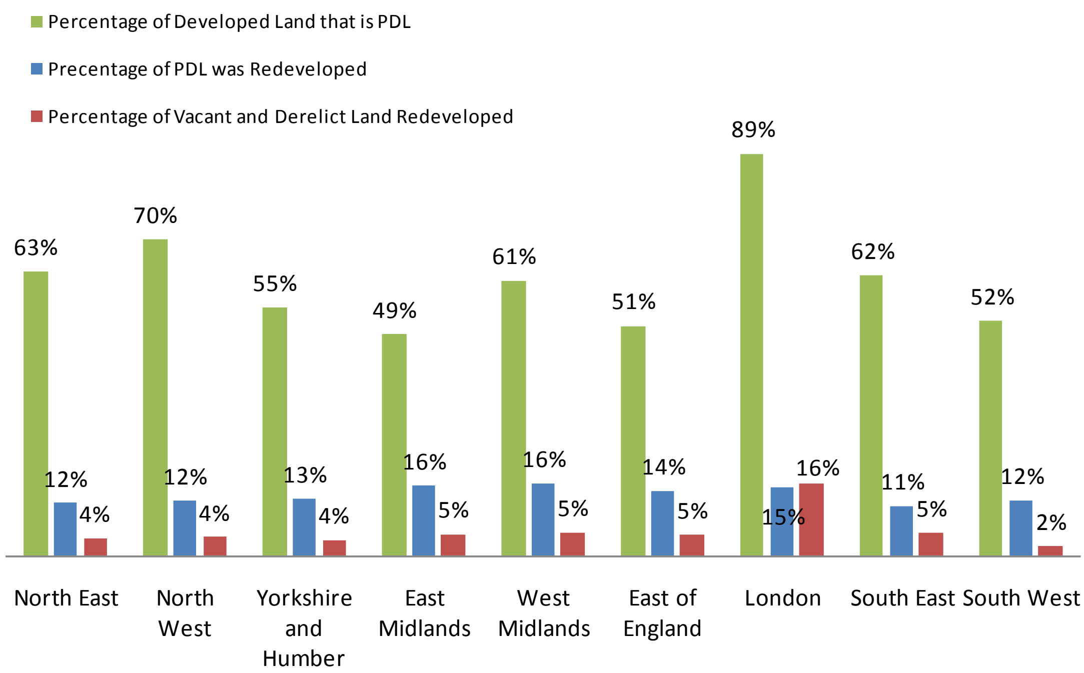


Figure 7.10 Regional PDL Recycling Performance (data after DCLG, 2009, Life Table P263 Land Use Change: Previous use of land changing to developed use, by region, annual average: 2002 to 2005)

7.7. Discussion

7.7.1. PDL Definition and Sustainable Development

In England, the definition of brownfields is based on the efficiency of PDL recycling. The practices based on the definition cause concerns for urban green space preservation, deprivation alleviation and urban infrastructure upkeep.

Two brownfield models based on potential profit return (The CABERNET A-B-C Model) and recycle rate of land (CABERNET Bath Model) may help to clarify the controversies concerning the definition of PDL (CABERNET, 2006).

In the CABERNET A-B-C model, private developers may voluntarily redevelop those brownfield sites with potential for highly predictable returns (A sites) as long as there are demands for land. A brownfield site that costs more to redevelop than its expected financial return (C sites) requires legislative instruments or financial support to stimulate regeneration. For those brownfield sites that were borderline profitable (B sites), a public and private cooperation scheme may be a more appropriate development pattern.

Garden land developments usually locate in rather prosperous areas. Therefore, garden land fits the profile of the 'A site' given it is considered part of brownfield land. Alternatively, a deprived de-industrialised urban area is more likely to be the 'C site'. Current definitions of PDL and the 60% target do not differentiate between sites. This may encourage developers to take advantage of both financial and legislative benefits of 'A-sites'.

The CABERNET Bath Model uses water flow in and out of bathtub as a metaphor to demonstrate two types of brownfield land. Some brownfield land may rapidly come in and go out of the 'pool of brownfield sites' as they continue being recycled. However, another type of brownfield land remains in the 'pool' for prolonged period of time ('hardcore sites'). In 2003, about a quarter of brownfield land in England (16, 500 hectare out of 66,000 hectare) remained derelict for more than nine years (Dixon, 2006). This 25% of PDL requires more attention in terms of regeneration. This is unlikely to contain garden land since garden land development is usually profitable.

Governments should focus on regenerating 'C-sites' in the A-B-C Model, or hardcore sites in the Bath Model. Alternatively, governments should create a friendly environment to nurture private-public partnerships for regenerating 'B sites'. Particularly, the European Investment Bank is aiming for investment to regenerate 'B sites' both to attract private investment and to comply with the EU regulations (Kreuz & Nadler, 2010). Including garden land in PDL reduces the incentive for redevelopment on 'C sites' and 'B sites' or hardcore sites, and does little to improve sustainability in social and environmental aspects.

Wong and Schulze-Bäing (2010, p16) indicated that in the deprived neighbourhoods of England, 'the developer cherry-picked areas with stronger gentrification potential and the highest profit yield in the earlier period.' The area where incomers arrived from similar or more deprived areas has been overlooked. Therefore, although during the period between 2001 and 2008, residential developments on PDL increased most rapidly in the most deprived areas in England, the original residents living in conditions of deprivation may not enjoy the fruits of growth as hoped. The result implies government's policy did not provide affordable houses to people in need.

Currently, more than 60% of residential developments have been on the PDL in England. However, more than half were just rebuilt residential areas (66% of residential development was on brownfield sites and 35% was on the vacant and derelict land, Wong and Schulze-Bäing 2010). This included garden land developments.

Moreover, only 16% of these residential developments were on vacant and derelict land (Wong and Schulze-Bäing 2010). The areas of these vacant and derelict sites only occupied less than 6% of the total area of available vacant and derelict land in England (Figure 7.9[7]). Therefore, residential developments may not contribute towards sustainable brownfield regeneration as the government has claimed. A definition of brownfield that narrows down the targeted sites in planning policy is required to adjust attitudes on selecting locations for redevelopment.

[7] The percentages in figure 7.9 include residential and non-residential development and therefore, the actual percentages for residential development should be even lower.

7.7.2. Target Setting and Sustainable Development

Long before the 60% target was set, it was predicted that the pressure of population growth would inevitably lead to garden land development in England (Whitehand and Larkham, 1991). For the constituencies where garden land development is essential, garden land development may not be avoided regardless of its designation as brownfield or greenfield land. Furthermore, the number of dwellings on PDL does not alleviate deprivation (Figure 7.7 and 7.8). The target of more than 60% of new homes built on PDL each year cannot in itself improve socio-economic conditions effectively. Therefore, the PDL designation of England's garden land only serves the purpose of fulfilling national targets without improving sustainability.

However, Wong and Schulze-Bäing (2010) demonstrated that residential brownfield reuse has improved income and employment conditions in the most deprived neighbourhoods in England. They also argued that a higher than average increase of house prices in these areas had a positive effect on brownfield regeneration. Controversially, the increase in house prices might worsen the availability of affordable housing. Therefore, whether this type of residential brownfield reuse improves the sustainability of deprived communities is inconclusive.

Scotland does not consider setting a national target an appropriate policy because of regional variations in land-use demand (Scottish Executive, 2001; and Dixon 2006). Between 1993 and 2001, the areas of derelict land and vacant land have reduced from 15,400 hectares to 10,607 hectares (an 31% reduction) (The Scottish Government, 2006). In comparison, England's derelict and vacant land was reduced from 41,130 to 33,600, (an 18% reduction) between 2001 and 2007 (DCLG 2009) after the target of PDL recycling had been established. This suggests that target setting may not be the only way to enhance the performance.

7.7.3. Mismatches between Policy Objectives and Target Setting

The debates in the House of Commons did not discuss some of the negative consequences that the 60% target may bring. For example, Ganser (2008) indicated that focusing the target on residential dwellings may result in high density housing developments in small brownfield area to achieve the target. At the same time, one dwelling spaciously constructed on a greenfield site could still be allowed. This danger can be verified by the statistics showing that the density of new dwellings has been constantly higher on PDL than non-PDL sites (Table P231 in DCLG, 2009a). Bibby (2009, p.55) also pointed out 'two fifths of all land in residential use lies in rural contexts but only 24.55 per cent of dwellings.' In this case, the greenfield land may not be preserved by the target setting.

Furthermore, the 60% target does not consider commercial and industrial development as part of PDL recycling efficiency. Therefore, industrial and commercial development may be established on greenfield land without affecting the 60% target of residential development. This scenario happened in the 'peri-urban areas' in England between 2000 and 2006 (Bibby 2009). This is another demonstration that building flats or new houses on garden land in inner cities to fulfil the 60% target may not necessarily help preserving greenfield land.

Sufficient urban infrastructure is essential to maintaining the general functions of a compact city. A specific target of land recycling for housing does not provide incentives for constructing or upgrading public infrastructure. Converting garden land into flats or new houses without compatible infrastructure such as water supply, water treatment and transportation may compromise the quality of life in a community.

Besides urban infrastructure, the 60% target may discourage mixed-use developments in urban areas. Mixed-use developments facilitate conserving energy, reduce the expense of commuting, and enhance the 'liveability' of the city. The design may decrease the desire of citizens to move to suburbs where segregated residential areas are located (The U.S. Green Building Council, 2009). Thus, mixed-use planning encourages the development of a compact city and improves the quality of life simultaneously. However, '…in England where high density mixing remained common until a decade ago, many new suburban areas show tendency to separate use, with residential development dominating and traditional mixing becoming less frequent. (Grant, 2007, p. 61)' Setting the 60% target on residential development overlooks the additional facilities and commercial establishments needed to accommodate the increased population brought in by an influx of residents. Without these additional facilities in place, the redeveloped communities may not be sustainable.

Several governmental bodies in England collectively established The Land Restoration Trust in 2004. This Trust transformed derelict land previously being used by industry into green open spaces for recreational uses that benefit nearby communities. It aims to 'acquire, own and manage 10,000 hectares of previously derelict and under-used land to deliver environmentally informed, community-led regeneration (www.landrestorationtrust.org.uk accessed in June, 2010).' This effort was not counted in the PDL recycling 60% target since the end use of the redeveloped land is not residential housing. As of 2010, the list of sites the Trust owned encompassed about 800 hectares (the estimation is based on the areas of sites listed on www.landrestorationtrust.org.uk/sites.asp?|1=4 retrieved on 04 June 2010). It is estimated to become 1,000 hectares before the end of 2010 (speech of the chief exacutive, Euan Hall in SustainabilityLive, May 2010, http://www.edie.net/tv/play.asp?id=1028112). Either way, it is less than 10% of its set target for 2014. A PDL recycling target that includes land use such as green spaces for public recreational use could facilitate the work of the Trust. The Trust has now been re-organised into The Land Trust in 2010 (http://www.thelandtrust.org.uk/). The aim was broaden to manage public open space and green infrastructure.

In summary, achieving the 60% target failed to improve deprivation conditions. The lacks of well-maintained infrastructure and public service facilities may worsen deprivation in an area where the local authority achieves high PDL recycling rate (or has low percentage of PDL). This could be addressed by including different land uses into the PDL recycling target. In fact, the PPS3 has declared government's intention to improve mixed-use development of the land (DCLG 2006a, DCLG 2010a). Target setting for different types of land use could make current policy statements consistent with practice. Achieving a target based on mixed land use might better improve the sustainability. The relationship between the percentage of PDL and deprivation might than become clearer.

7.7.4. Party Politics on Local Issues

An investigation (DCLG, 2010b) among local planning authorities stated that of the local authorities that responded, most local authorities do not consider garden land development an issue (Figure 7.11)

Figure 7.11 Local Authorities' Responses to Government Survey on Garden Land Development (Data after Survey Recorded for DCLG 2010b on http://www.communities.gov.uk/publications/planningand building/gardendevelopments)

The ratios of authorities who expressed that garden land development is an issue in their administrative territories are high in the South East, London and the West Midlands. These three regions have more highly urbanised local authorities (Table 4.8). The regions where a high ratio of authorities considering that it is not an issue (the Yorkshire and the Humber and the South West) are relatively rural. In DCLG's analysis based on the degree of urbanisation, the issue was considered most serious by authorities with a medium degree of urbanisation.

Further investigation into the survey data of the local authorities indicates that the answers of local authorities might not be as clear-cut as claimed in DCLG's report. Some authorities said garden land development is an issue but agree that garden land development is needed. They recognised the conflicts between local communities and developers but did not clearly take sides. On the other hand, some authorities who said garden land development is not a general issue, but added that they had problems with some applications of garden land development. Other local authorities stated that they have their own policies for dealing with garden land developments. These policies ranged from allowing garden land developments at acceptable levels, or to actively decline garden land development for the negative impact it may bring. Therefore, the degrees and reasons of concern for garden land development varied among local communities. When local authorities declared that the development is not an issue, this does not mean that there is no such development within their territories. They may have difficulties in some cases, but still do not consider it a serious issue. Therefore, the results of the report probably mean that garden land development is not the first priority of the authorities, rather than that it is not a problem at all.

Most authorities mentioned the impact on local appearances resulting from garden land development (DCLG, 2010b). For example, the planning authorities in Hillingdon considered whether the development is 'integrated into the character of the local area' a very significant factor when reviewing applications. The impact of gentrified areas on the capacity of the existing infrastructure was also identified as a negative result of garden land development by many authorities. Several authorities mentioned the issue of developers' appealing to the Secretary of State when planning permission was rejected by the local authority (for examples: Mansfield, Mole Valley, Rotherham Metropolitan, and Southampton). This is an issue that was also discussed in the Parliamentary debates. Some considered that the central government was encouraging garden land developments according its planning policy documents (for example, Redditch). This could mean that local authorities would grant the development application without a second thought just to be consistent with the policy of central government.

The MPs have voted on the garden land development based on party orientation (Section 7.4 and 7.5), but it is possible that the elected party reflected local opinions. However, the trend of considering garden land development an issue among local authorities (Figure 7.11) is not completely consistent with the trend observed among MP's voting results (Figure 7.4). This could be due to the low responding rate of local authorities to the survey (127 out of 363 local authorities responded to the survey). On the other hand, this may also indicated that to some extent, the party politics in Parliament are disengaged from local land use conditions as well as opinions from the constituencies.

Furthermore, the opinions of local authorities on garden land development may also not reflect the land use effectiveness within their administrative territories. The worst recycling efficiencies have been observed in the north and the best in London (Figure 7.10). The possible explanation for this is that land in London is very precious due to the high population density and the active economic activities, while local authorities in the north have struggled to provide affordable housing and to stimulate the economy. For the latter, any form of redevelopment can be claimed to be positive to regenerate the communities by the local authorities.

The public media have presented the garden land development issues in the context of affordable housing supply (for example BBC Radio 4, Today Programme, June 9, 2010; The Economist Vol. 396, Issue 8689, p53). They worried that the change of garden land designation may delay or make obsolete the promise to increase affordable housing. This however, totally ignores that the garden land development often takes place in the wealthy areas where land prices are high and thus unaffordable to less affluent people.

The 60% target might also have unwanted effects on implementing the regeneration policy. As the parliamentary debates revealed, the brownfield definition and target setting are also connected to power balancing issues between central and local government when approving planning applications. Central government claims that it has empowered local authorities to refuse inappropriate garden land developments. In a region with excessive category C PDL, local authorities may prevent garden land developments by disapproving the planning applications. However, local governments have complained that their refusals to grant planning permission are usually overruled during the appeal process (Richard Benyon, 2006, Conservative MP for Newbury,) (HC Deb (2005-6) 447 col. 1396). Statistical data are not available to quantify the frequency of such cases, but the possibility remains that the level of garden land development may have partly resulted from the pressure to achieve the 60% target. In fact, some local authorities have considered the definition as the government’s declaration of approving garden land development (DCLG 2010b). Eliminating garden land from the definition of PDL will erase both unwanted incentives to develop garden land and a misunderstanding from the local authorities.

7.7.5. Implications for the Government's Policymaking

It has been argued that derelict and vacant land has not been effectively reused while greenfield areas are still being converted into built-up areas. The MPs and local authorities from the northern regions where redevelopment efficiency was lowest have considered garden land development not a major issues while the MPs and local authorities in the South East, where the recycling rate is relatively high, considered garden land development an important issue. The regional variations of opinion on garden land development contradict the land use statistics (comparing Figure 7.3 and Figure 7.6). The land use statistics also show that, areas with previously developed land awaiting redevelopment are considerably larger than the greenfield developed each year.

With this oversupply of derelict land, it is curious that pressure of housing development has been often a political issue in England. One of the possible explanations may be the consideration of land quality. Part of the previously developed land may be considered unsuitable for housing development or any types of redevelopment because of its locations, conditions (for example flood risk), or the lack of financial incentives. Some of these issues may be addressed by providing sufficient infrastructure or a more comprehensive planning and zoning strategy. Through effectively reusing derelict and vacant land, the pressure on garden land development can be reduced.

Additionally, it is understood that every local authority has different percentages of greenbelt areas under their care (DCLG, 2010b). The authorities with higher percentages of green belt experience higher pressure to develop garden land and thus have more cases of complaints regarding the inconvenience the developments have caused. Although garden land development is a sporadic issue and more prevalent in the south, the central government may ease pressure on developing garden land by providing incentives to develop 'C sites' in the CABERNET model and by initiating regeneration projects to attract people to migrate to the north. This would also increase land use efficiency in the north.

Overall, the garden land development may be a sporadic problem. However, this is just the tip of the iceberg showing the way party politics operate has resulted in the lack of precision of regeneration policies. According to the land use statistics, the definition of brownfields and the 60% target has not delivered the desired results of brownfield regeneration. Additionally, the custom-made regional plans for re-development allowing for the mixed-use planning may be equally important as adopting the 'right' definition of brownfields. This promises a better application of the target setting on redevelopment.

7.8. Conclusion

'The lack of a universally agreed and accepted definition of brownfield has resulted in the production of a number of interpretations of the term, many of which encapsulate an emphasis that reflects the requirements of the particular stakeholder group within which it is applied (Alker et al., 2000, p50).'

The target of 60% new residential dwellings to be built on PDL has not effectively encouraged the regeneration of brownfield sites in areas where it is most needed (Section 7.7.2). PDL is defined broadly allowing developers to strategically develop land that is economically beneficial in the short term, such as garden land (Section 7.7.1). On the other hand, to reach the 60% target, it is likely that the government approved PDL development projects that do not contribute towards reaching the goal of sustainable development. The brownfield definition and the target set by the previous Labour government (and eradicated by the succeeding coalition government) in England created a mixed understanding among local authorities and Members of Parliament (Section 7.4 and Section 7.7.4). Therefore, although it is claimed that the policy was a success in brownfield development, it might serve political interests better than it encourages sustainable development.

A narrower definition of brownfields specifically targeting derelict or vacant land to be developed as mixed-use communities may remove the confusion among local authorities (Section 7.7.5). This may also enhance the proper redevelopment of deprived areas and prevent unnecessary greenfield development. It may pave the path to sustainable brownfield regeneration.

Chapter 8 Differences between Plan and Reality – Taiwan's Land Use Conditions

Using limited land resources effectively is crucial for the countries with high population densities such as Taiwan to preserve their natural environment and to optimise social capacity (Section 6.7). Furthermore, the agglomeration and uneven distribution of population were considered positively correlated with sustainability of land use (Section 6.5.1 and Section 6.7). Therefore, to make sense of the distributions and migrations of people in Taiwan, this chapter reviews current land use condition and population statistics. The results show that sprawls of built-up areas have taken place. The degrees of sprawl are higher in the counties than the cities. It is suggested that the sprawls should be further prevented by a well-designed brownfield policy.

Additionally, in this chapter, I investigate whether the use of land resources follow the plan by the planning authorities. By comparing the current land use statistics and planning statistics, I find that although the 'planned' built-up areas increased over recent years, the actual built-up areas expanded even faster than the planned. Among the local governments, the planning designations of built-up area were followed better in the cities than the counties.

On the other hand, more and more greenfield land has been incorporated into the planning system. This might reflect the increasing awareness among planning authorities of the importance to manage the natural resources and/or to protect the environment. A brownfield regeneration policy should be a suitable tool to address these issues.

8.1. Brief Description of the Geography of Taiwan

Taiwan and its associated 85 islands (Figure 8.1) are located off the southeastern coast of mainland China in the western Pacific Ocean. The total area of the territories is 36,006 km^2. Taiwan proper occupies 35.868 km^2. This area is the focus of this study. The island situates between tropical and subtropical area (northern tip 25°18'20"; southern tip 21°53'50"). The highest point of the island, located in the central region, is 3,952 meters above the sea level. Thus, the vegetations of the island range from tropical southern plain to the snowy central mountains. The uneven landscape contributes to rich biodiversity as well as limited land resources suitable for agricultural and urban development. There have been conflicts between biodiversity and social development (also described in Section 6.5.1 and Section 6.7.3)

The territories of Taiwan are usually divided into five or four regions, depending on whether the remote islands are included in the discussion (Hsiao, et al., 2005). The five regions are the North Region, the Central Region, the South Region, the East Region and the Remote Islands (Table 8.1 and Figure 8.1). The region of the Remote Islands is limited in areas and populations. Therefore, the region is not included in the analysis of this chapter. However, it should be noted that these islands are important in terms of natural resources management and preservation (especially marine resources such as coral reef surrounding the islands in the south). Figure 8.2 shows the names and locations of the local governments that the analysis of this chapter includes.

Table 8.1 The Regions and Local Governments in Taiwan*

Regions	Name of Local governments
North	*Taipei County, Taoyuan County, Hsinchu County, Keelung City, Hsinchu City, Taipei City*
Central	*Miaoli County, Taichung County, Changhua County, Nantou County, Yunlin County, Taichung City*
South	*Chiayi County, Tainan County, Kaohsiung County, Pingtung County, Chiayi City, Tainan City, Kaohsiung City*
East	*Yilan County, Taitung County, Hualien County*
Remote Islands	*Penghu County, Kinmen County, Lienchiang County (Matsu)*

**Hsiao, et al., 2005*

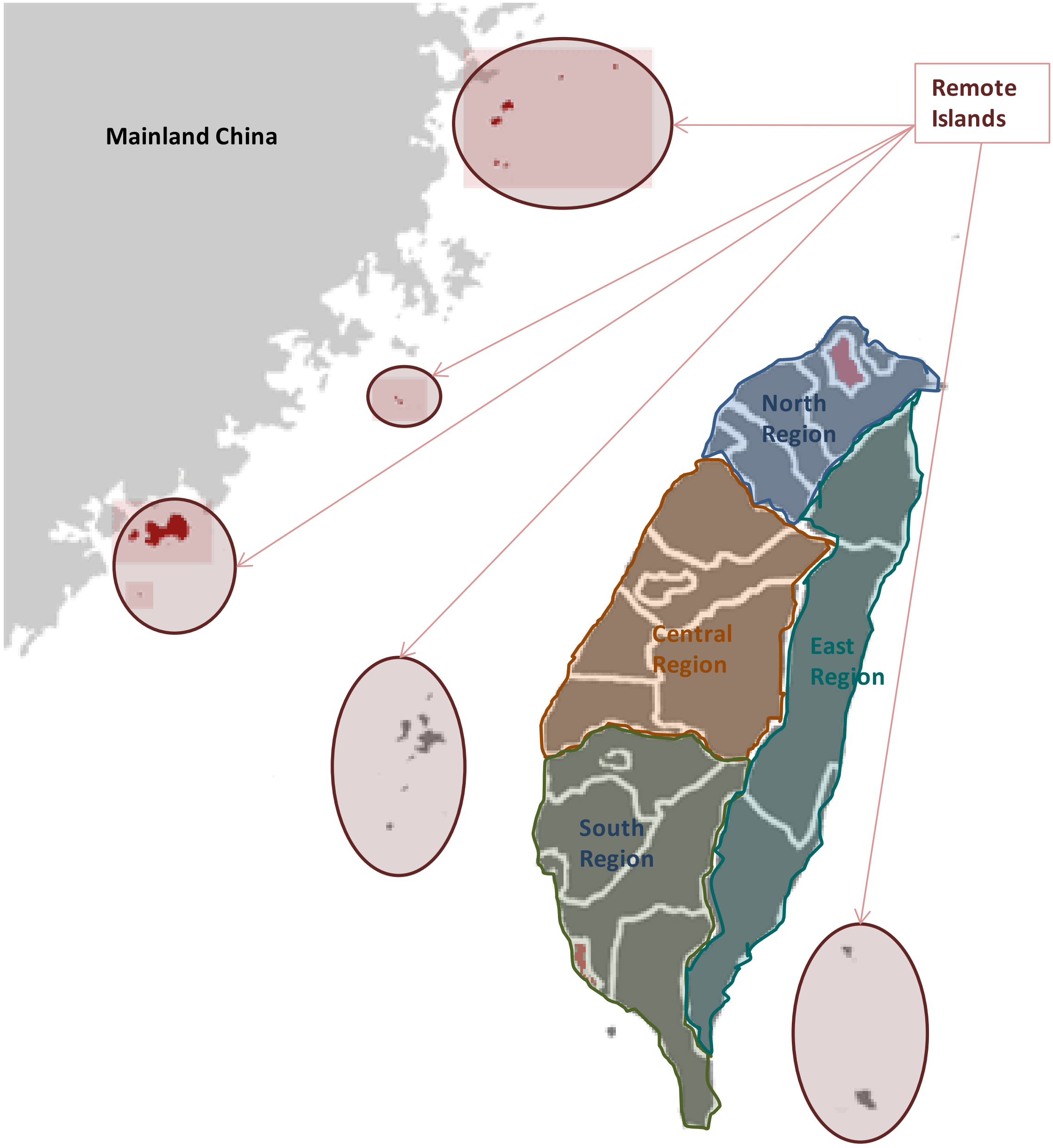


Figure 8.1 The Regions in Taiwan (drawn after Hsiao, et al., 2005)

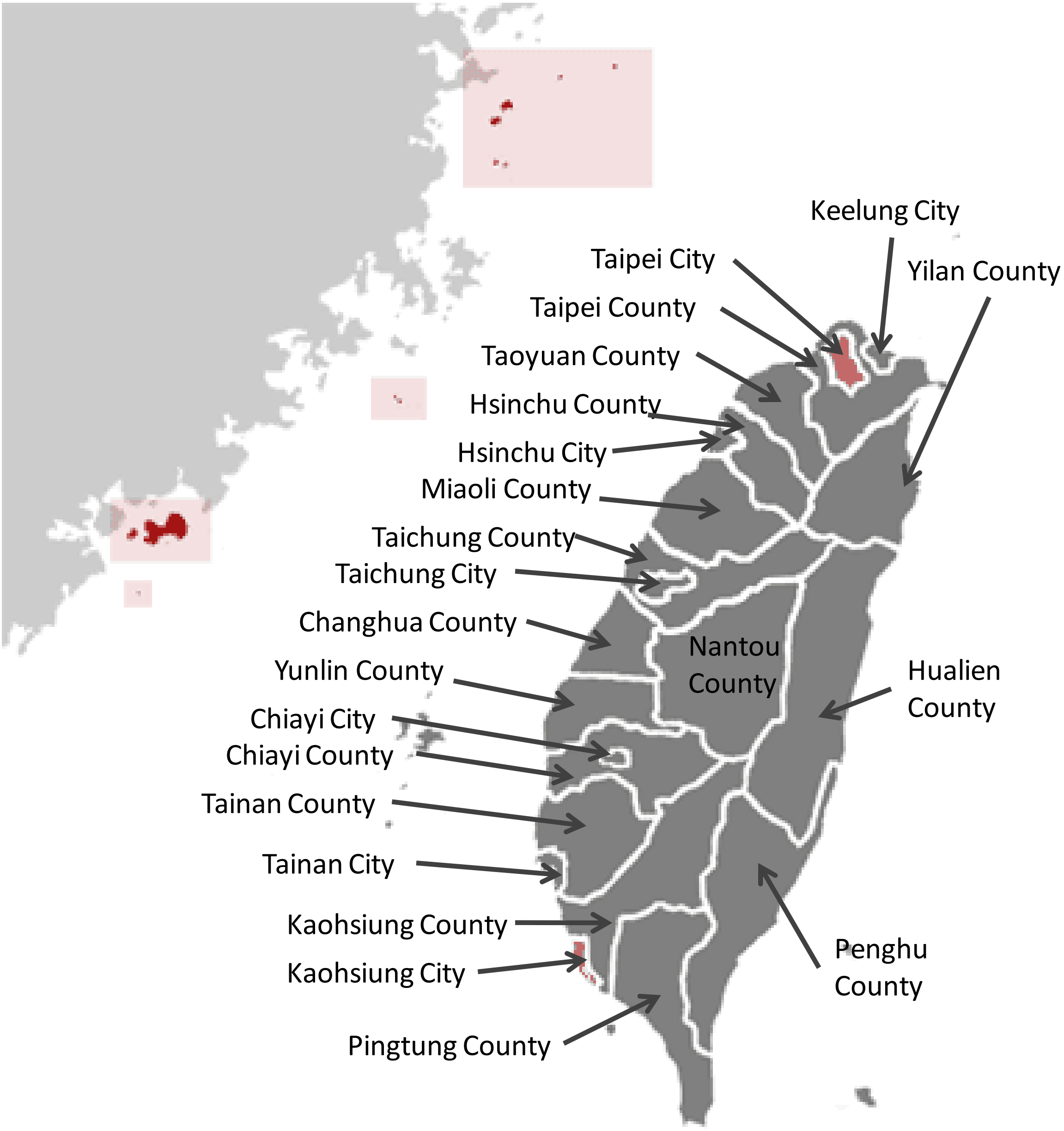


Figure 8.2 Local Governments Included in the Analysis (drawn after Hsiao, et al., 2005)

8.2. The Databases Describing Land Use and Population Changes in Taiwan

This section introduces and reviews the official statistics of land use and statistics of population growth in Taiwan. The changes in land use and population are the bases for analysing the sprawl of built-up areas.

8.2.1. Land Use Surveys

The Taiwanese government has surveyed and documented land use in Taiwan in two separate periods. The first survey was conducted between 1992 and 1995; the second one was conducted between 2006 and 2008.

The surveys were carried out by government officials, or by the professional bodies contracted by the government officials. The tasks of survey included map reading, field investigation, map editing, and area estimation. The procedures of the field investigation were standardised and the investigators were trained prior to perform the investigation based on standard procedures. In this study, the statistics based on these surveys are treated as the records of 'actual' land use at the time of the surveys.

8.2.1.1. The First Land Use Survey (1992-1995)

Information of the First Land Use Survey was obtained by conducting fieldwork and by examining aerial photos. In plain areas, the field survey was the major method of investigation. In mountain areas, land use was mostly determined by examining aerial photos; a field survey was conducted only if necessary (Taiwan Provincial Government, 1995). The survey only covered 52% of the territory of Taiwan. The ownerships and use of the surveyed areas were usually registered.

There were 10 major classes (hereafter referred to as the primary classes) in the land use classification of this survey. Each of them had two levels of sub-classifications (hereafter referred to as the secondary classes and the tertiary classes). In total, there were 45 secondary classes and 93 tertiary classes. The analyses in this study are mainly based on the quantitative area estimation of the primary and the secondary classes. The descriptions and definitions of the tertiary classes aides the determination of built-up areas and the interpretation of the analytical results. The classification is detailed in Section 8.2.1.3, where the two land use surveys are compared.

8.2.1.2. The Second Land Use Survey (2006-2008)

At the time of the Second Land Use Survey, the Geographic Information System (GIS) had become a common tool used by the government agencies as well as private organisations. Therefore, the GIS information became an important point of reference for the second survey. For example, detailed forest distribution data were mostly obtained from the 'National Forest Land Data Collection'; water management facility information was obtained from the land use summary from 'Land Use Result of Water Resource Agency' (National Land Surveying and Mapping Center, 2009a). The areas of specific land uses in the survey were determined by consulting the GIS databases and the aerial photos. For the areas where land use could not be determined by the available data, fieldwork was then conducted. The fieldwork was carried out most frequently in urban areas for clarifying types of buildings.

The Ministry of Interior contracted this survey to consultants and the non-governmental organisations with sufficient capacity (list of organisations in Appendix B). These professional bodies were responsible for gathering data, drafting maps and presenting statistics.

Hierarchically similar to the first survey, the land use classification used in this survey has 9 primary classes, 41 secondary and 103 tertiary classes (Table 8.2). However, several rearrangements of land uses into different levels of classification were made (Section 8.2.1.3).

8.2.1.3. The Land Use Classification Comparison

Table 8.2 compares the primary and secondary classifications between the two land use surveys. The comparisons are based on the detailed description in the 'Table of Current Land Use Classification' in the report in 1995 (Taiwan Provincial Government, 1995), and the 'Table of Land Use Classification System' in the report from the official website of land use investigation (National Land Surveying and Mapping Center, 2009b). The classes of land use are considered the same as long as the descriptions under those classes matched. The major changes of the classification are listed below:

1. Forestland use was upgraded from the secondary to the primary class.
2. At the tertiary class level, 'high speed railway' and 'additional harbour facilities' were added under the primary class of transportation land use. This is due to the development of new means of transportation between the two surveys.
3. The secondary class of 'flood prevention path' in the first land use survey was expanded into three classes in the second survey: in 'canal sandbar beach place', 'water conservation structure' and 'flood prevention path'. A secondary class of 'sea level' was added in the second land use survey Howerer, the areas under 'sea level' classification were eliminated when conducting the analysis.
4. The land categorised as 'built-up land', 'industry', and 'recreational area' in the first land use survey was rearranged into the primary classes of 'built-up land', 'public land' and 'recreation and leisure' in the second land use survey:
   a. The primary class of 'industry' was downgraded to secondary class under 'built-up area'. Several secondary classes under 'built-up area' in the first survey were moved to a newly created class 'public land'.
   b. Some secondary classes ('religious', 'funeral', and 'land under construction') under 'built-up area' were merged into one secondary class of 'other structure purpose place'.
   c. The secondary class of 'fire extinction' was eliminated from the second land use survey.
   d. The secondary classes of 'culture heritage' and 'culture facilities' under the primary class of 'built-up land' were merged into 'culture facilities' under the primary class of 'recreation and leisure'.
   e. The secondary classes of 'terrestrial recreation', 'water recreation' under the primary class of 'recreational area' became part of the secondary class of 'culture facilities' or 'leisure facility' under the primary class of 'recreation and leisure'.

f. The secondary class of 'relative service facilities' under 'recreational area' was changed to a secondary class of 'trade' under 'built-up land'.

g. In the first land use survey, the residential buildings were classified based on the number of floors. In the second land use survey, the criteria applied to classify housing establishments were based on the purpose of their use.

5. The primary classes of 'mineral' and 'salt industry' were merged into one primary class of 'minerals'.

6. The primary class of 'military use' became a secondary class under the primary classification of 'miscellaneous-used land'.

These changes can be interpreted as reflecting the change of the views of the surveyors. The importance of forestlands and public facilities has increased and that of industrial and military land use has decreased. Some recreational facilities became valued higher as part of commercial and service entities. The functionality of the residential buildings concerned the new classification more than their vertical expansion.

Table 8.2 Comparison of Land Classifications between Two Land Use Surveys

Technocratic Survey				Built-Up Areas in this Study		Planning Designation	
Classification of 1992-1995		Classification of 2006		Strictly Defined Built-up Area	Generally Defined Built-up Area	Use Assignment of **Non-urban Land**	Land Use District Area of **Urban Planning Districts**
Primary Classification	Secondary Classification	Primary Classification	Secondary Classification				
Agriculture	Farm Crops	Agriculture	Farm crops	-	-	Special Agr. Zones	Agricultural District
	Aquaculture		Aquaculture	-	-		
	Poultry		Poultry	-	-	General Agr. Zones	
	The Agriculture Supplements the facility		The agriculture supplements the facility	√	√		
	Forestry	Forest	Natural forest	-	-	Forestry Zones	Protected Districted
			Planted forest	-	-	National Park Zones	
			Others	-	-	Slope Land Conservation Zones	
Transportation	Airport	Transportation	Airport	√	√		Public Faci. Land (Road, Pedestrian Mall, Car Park, Civil Air Terminal, Harbor, MRT, Traffic Station, Railroad)
	Railroad		Railroad	√	√		
	Path		Path	√	√		
	Harbour		Harbour	√	√		
Water conservancy	River Course	Water conservancy	River Course	-	√	River Zones	River Bank & Area
	Drainage Ditch		Drainage Ditch	-	√		Public Facility (Drainage Channel)
	Reservoir		Reservoir	-	√		
	Flood Prevention Path		Canal Sandbar Beach Place	-	√		
			Water Conservation Structure	-	√		
			Flood Prevention Path	-	√		
	NA**		Sea level	eliminated from the analysis	eliminated from the analysis		
Built-up Land	Trade	Built-up Land	Trade	√	√	Industrial Zones	Commercial District, Public Facility - Market
	Housing		Housing	√	√	Village Zones	Residential District
			Industry	√	√		Industrial District
			Other Structural Purpose Places	√	√		For Specific-Purpose
	Government, Non-for-Profit, and Non-government Organization	Public Land*	Governmental Agency	√	√		Administration District
	School		School	√	√		Education District
	Medical health care		Medical Health Care	√	√		Public Faci. Land (Gas Station, School, Social Educational Organization, Health Services, Administrative Authorities, Cemetery, Power Substation, Post, Telecom.)
	Social Welfare Facility		Social Welfare Facility	√	√		
	Public Utilities		Public Utility	√	√		
	Environmental Safety Facilities		Environmental Safety Facilities	√	√		
	Religious			√	√		Other District (Urban Developed Area)
	Funeral			√	√		
	Land under Construction			√	√		
	Fire Extinction			√	√		
	Culture Heritages			√	√		
	Culture Facilities			√	√		
Industry	Industry			√	√		
	Relevant Facilities			√	√		
	Warehouse			√	√		
Recreational Area	Terrestrial Recreation	Recreation and Leisure	Cultural Facilities	-	√	Scenic Zones	Landscape District
	Water Recreation		Leisure Facility	-	√		Puablic Facility (Park, Green Space, Square, Play Ground, Athletic Complex)
	Related Service Facilities			-	√		
Minerals	Mining	Minerals	Mining Industry	-	-		
	Sand and Gravel		Earth Stone (sand and gravel)	-	-		
Salt Industry	Salt Field		Salt Industry	-	-		
	Salt Facilities			-	-		
Military Use	Military Use	Miscellaneous Land	Military-use land	-	√		
Miscellaneous Land	Wet Land		Wet Land	-	-	Scenic Zones, National Park, Slope Land Conservation Zones	Proctected District
	Grass Fresh		Grass Fresh (grass land)	-	-		
	Exposed (Land)		Exposed (Land)	-	-		Others (non-urban developed area)
	Bush Open Land		Bush Open Land	-	-		
	Disaster Place		Disaster Place	-	-		
	Builds the Surplus Cubic Meter of Earth and Stone		Builds the Surplus Cubic Meter of Earth and Stone	-	-		
	Vacant		Vacant	√	√		

√ Considered Built up area

- Considered non-built up area

**The macted class no avaiable

8.2.1.4. Resolutions of the Data

The documents of the first land use survey were not explicit about the method(s) relied on to estimate areas. The actual resolution of the data is not clear. The numbers in the documents are presented to the digit of 0.000001 hectare (or 0.01 square meters). However, it is unlikely that this is true precision of estimation, given that the second land use survey used better technologies and documented the resolution clearly; the resolution the second survey reported is far from this precision.

The resolution of data in the second survey varied depending on the sources of maps. The resolution of the road was at least as precise as 4 meters; the estimation of the area was at least as precise to the unit of 2,500 square meters. In some areas (especially urban areas), the precision can be as good as 25 square meters.

8.2.2. Urban Planning Districts (2001 - 2009)

The statistics in the Land Use District Area of Urban Planning Districts were downloaded from the website of the Ministry of Interior (Ministry of Interior, 2010). The classification and definition of the district are based on the *Urban Planning Act* and related regulations. Accordingly, the urban planning districts can be further divided into two different categories: 'Urban Developed Area' and 'Non-urban Developed Area'. The 'Urban Developed Areas' include districts for residential, commercial, industrial, administrative, educational, public facility, specific and other purposes. This study considers these areas as a part of built-up areas. On the other hand, the 'Non-urban Developed Area' includes agriculture, protected, landscape, riverbank and other uses. Here, these are generally considered non built-up areas. The description of each designation is translated as follow[8]:

[8] The name of designation in English was directly digested from the *Statistic Yearbook of Interior* (Ministry of Interior, 2010). The description was translated by the author of this thesis based on the description of how statistics was made by Construction and Planning Agency.

- **Residential District**: The district designates the areas where quality of living should be maintained. The use of buildings and land within the district should not undermine tranquillity, safety and hygiene.
- **Commercial District: The district designates the areas where business and commercial activities are promoted. The use of buildings should not hinder business development.**
- **Industrial District**: The district designates the areas where industrial activities should be conducted. The use of buildings and land should be based on industrial purposes.
- **Administration District**: The district designates the areas where the buildings and land should be used for (governmental) administrative purpose.
- **Education District**: The **district** designates the areas where the buildings and land should be used for education purposes.
- **Landscape District**: The **district** designates the locations where the landscape should be preserved.
- **Public Facility Land**: The district designates areas where public facilities should be allocated. The type of facilities should be specified in the designation as well as the content, areas and locations. The specification is made concerning the trend of demography, land use and transportation. The purpose of the designation is to improve the quality of citizens' activities and the quality of urban environment.
- **[District] for Specific Purpose**: The district is designated to allocate areas for the specific types of production, commercial-industrial activities, technology development, business activities or other purposes.
- **Agricultural District**: The district is designated for special geography, current (agricultural) use, or national (food) security purposes. The uses of buildings in the area are restricted.
- **Proctected [sic] District**: The area may be designated depending on special needs because of geographical consideration, current use, or military consideration. The usage of buildings in such area is limited.

- **River Bank & Area**: The area is **designated** in accordance with the Water Act.

The descriptions of education district and administration districts partly overlapped with the descriptions of the public facility land. The staff employee in the Ministry of Interior has however confirmed that the areas under these two classes do not in fact overlap with the other two districts (see the printed out of the email communications between the staffs in the Ministry of Interior and the Author is inserted in Appendix C).

8.2.3. Non-urban Land Zoning (2001 - 2009)

Non-urban land refers to the areas excluded from urban planning. The zones are designated in accordance with the article 13 of *Regional Planning Act*. The Act is the basis of the non-urban zoning.

The statistics for the *Use Zone Designation of Non-urban Land* were downloaded from the website of The Ministry of Interior (Ministry of Interior, 2010). The statistics composed of ten zoning designations[9] described land use outside the areas of urban planning districts:

- **Special Agricultural Zone**: These areas are specifically designated for the quality land for agricultural practices, or for the locations where advanced agricultural facilities or infrastructure are established.
- **General Agricultural Zone**: This designation is for the areas outside the special agricultural zones where **the** agricultural practices are ongoing.
- **Industrial Zone**: An industrial zone is the area that can be utilised for advanced industrial development. It is delineated by the authorities in charge of planning and industrial development.
- **Village Zone**: The village zone includes the areas that may be utilised to improve quality of life of the village residences, to facilitate the productivity

[9] The designation was directly digested from the Statistic Yearbook of Interior. The description is translated by the author of this thesis from the description of how statistics was made by Construction and Planning Agency. The web link of this information is http://www.land.moi.gov.tw/chhtml/newpage.asp?cid=259

of villages, and to accommodate housing capacity allocated by governments. The area is designated by authorities in charge of relevant policies and their implementation.

- **Forestry Zone**: The designation is for preserving forest resources, maintaining ecological systems, and protecting water resources. Planning and other relevant authorities designate the areas in accordance with the *Forestry Act*.
- **Slope Land and Conservation Zones**: These areas are designated to preserve natural resources, to prevent land erosion, and to protect water resources. Planning and other relevant authorities designate these areas in accordance with relevant regulations.
- **Scenic Zone**: **These** areas are designated for protecting natural scenery, and improving recreational conditions. Planning and other relevant authorities designate the area in accordance with relevant regulations.
- **Natural Park**: The areas are designated in accordance with *National Park Act* to preserve natural sceneries, historic heritages, wildlife, and habitats for recreation and research purposes.
- **River Zone**: The **areas** are designated to protect waterways and reduce floor risks. It is determined in accordance with the *Water Act*.
- **Special Zones and Others**: The zone is delineated based on various specific needs. The areas are determined by the relevant authorities.

According to *Regional Planning Act*, local governments are obligated to investigate, to record and to enforce the allowed usages based on the Article 15 on a property-by-property basis. The allowed usage in each zoning designation is summarised in Table 8.3 based on *the Use Assignment of Non-urban Land*. Local government should document the current land uses on site or planned uses if the site is currently unused. If the current use does not fulfil the requirement of the zoning, local government should enforce the appropriate use of the land.

Although *the Use Assignment of Non-urban Land* gives a more detailed description, it blends current land use and planned land use together. It can therefore not fulfil the need for the comparison this chapter set out to draw. However, it shows that within the zone considered non built-up areas, certain built-up areas can still exist to facilitate specific human activities on the land (for example, construction land is allowed in agricultural and forestry zones).

8.2.4. Possible Time Lag in Implementing Urban Planning

Article 17 of the *Urban Planning Act* allows maximum 7 years for implementing plans (2 years for detail planning plus 5 years for establishing public facilities). According to this, the results in land use survey between 2006 and 2008 should reflect the planning in the late 1990s and early 2000s. The available planning statistics can be traced back to 2001. Therefore, this analysis verified the planning in 2001 with the land use condition between 2006 and 2008 (Section 8.3.2; Section 8.4.5). The planning statistics in the following years, however, are referenced when necessary.

8.2.5. Completeness of Data

In year 2001, the designated land uses covered more than 70% (71.77%) of the area in Taiwan. The designated area has been increasing. In 2009, only about 15% of the administrative areas in Taiwan have not yet been incorporated into the planning system; 3,190,647 hectares of land were zoned or designated (85% designated as non-urban zones and 15% designated as urban districts).

8.2.6. Population Data (1991 - 2008)

The population statistics between year 1991 and 2008 were obtained from '*Statistical Yearbook of Interior*' published in the website of The Ministry of Interior (Ministry of Interior, 2010). The downloaded Excel spreadsheets displayed population statistics by years, ages and administrative territories (city or county). The statistics were done by Department of Household Registration Affairs, the Ministry of Interior (http://www.ris.gov.tw/web_eng/eng_intro_3.html). The Department of Household Registration Affairs has kept all the household registration data in Taiwan.

Table 8.3 The Usages of Zoning Designation (Land Use Registry)

The Use Zone Resignation \ Use Assignment of Non-urban Land**			The Use Assignment of Non-urban Land (Local governments)																	
			Type A Construction Land	Type B Construction Land	Type C Construction Land	Type D Construction Land	Farming and Pasturable Land	Forestry Land	Land for Fish Culture	Salt Industry Land	Land for Mine Industry	Land for Kiln Industry	Land for Comm. and Trans.	Land for Irrigation & Drainage	Land for Recreational Use	Land for Historical Preservation	Land for Ecological Conservation	Land for Protection & Conservation	Cemetery Land	Land for Special Enterprise
Zoning According to the Regional Planning	Special Agr. Zones	Not Mountain Area	✓	×	×	Δ	✓	×	Δ	×	Δ	×	✓	✓	Δ	✓	✓	✓	Δ	✓
		Mountain Area	×	×	✓	Δ	✓	×	Δ	×	Δ	×	✓	✓	Δ	✓	✓	✓	Δ	✓
	General Agr. Zones	Not Mountain Area	✓	×	×	Δ	✓	✓	✓	Δ	Δ	Δ	✓	✓	✓	✓	✓	✓	✓	✓
		Mountain Area	×	×	✓	Δ	✓	✓	✓	Δ	Δ	Δ	✓	✓	✓	✓	✓	✓	✓	✓
	Village Zones		×	✓	×	Δ	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	Δ	✓
	Industrial Zones		×	×	×	✓	✓	✓	×	×	×	Δ	✓	✓	✓	✓	✓	✓	×	✓
	Forestry Zones		×	×	Δ	Δ	✓	✓	✓	×	Δ	×	✓	✓	✓	✓	✓	✓	Δ	✓
	Slope Land Conservation Zones		×	×	Δ	Δ	✓	✓	✓	×	Δ	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Scenic Zones		×	×	Δ	Δ	✓	✓	✓	×	Δ	×	✓	✓	✓	✓	✓	✓	Δ	✓
	River Zones		×	×	×	×	Δ	✓	×	×	×	×	Δ	✓	×	Δ	Δ	Δ	×	Δ
	Special Zones & Others		✓	×	×	Δ	✓	✓	✓	Δ	Δ	Δ	✓	✓	✓	✓	✓	✓	✓	✓

[*] The table does not contain national park as the statistics in the Ministry of Interior does.

[**] The table does not contain three classes: "Not-Specified", "Others" and "Urban Land and Others" that the statistics in the Ministry of Interior does.

[ˇ] Registered based on current land use.

[Δ] Registered based on current land use if authorities approve the uses; if not legitimate, registered based on what zoning allowed.

[×] Register based on what zoning allowed.

[#] The table is adapted and translated from table presented in the website of (Taiwanese) Department of Land Administration, MOI.

8.3. Methods to Analyse the Sprawls

Based on the synchronised land use classifications (Table 8.2), two quantitative comparisons of built-up areas are conducted: the comparison between the two land use surveys, and the comparison between the statistics of planned land use in 2001 (Section 8.2.2 and 8.2.3) and land use surveyed between 2006 and 2008 (Section 8.2.1, for the choice of timeframe, please see Section 8.2.4). The analyses were to observe these issues:

1. What is the change of the built-up areas in Taiwan in relation to the change of population?
2. How different was the statistics of the current built-up areas to the planning?
3. The reasons of any actual land use deviated from the planned land use.

The comparison between the two land use surveys was to evaluate whether the built-up areas have expanded faster than population growth. The procedure is described in Section 8.3.1.

The comparison between statistics of planned land use and land use survey was to investigate whether the changes of built-up areas were based on the planning. The procedure and some clarifications before conducting this analysis were described in Section 8.3.2.

8.3.1. Analysing Land Use Change

The steps to analyse land use change are described below:

1. Download land use survey documents from the National Land Survey and Mapping Center (National Land Surveying and Mapping Center, 2009b); or obtain the unpublished data via email communication with the staffs of the Center (Appendix C);
2. Establish spreadsheets for this analysis: key in the areas under different land use designations in local governments based on the documents obtained in step 1;
3. Add up the areas under defined built-up areas (summarised in Table 8.2 and detailed in Section 8.3.1.1) for each local government;

4. Calculate the percentages of the built-up areas to the administrative areas, the percentages of the built-up areas to the survey areas, and the percentages of survey areas to the administrative area in each local authority.
5. Evaluate the quality of data based on the percentages of investigated area to the administrative area (Section 8.4.2, Figure 8.6).
6. Discuss the changes of the built-up areas over time (Section 8.4.2).
7. Download the population data from 1991 to 2008 for counties and cities from the *Statistical Yearbook of Interior* (Ministry of Interior, 2010).
8. Analyse the trend of population growth or decline (Section 8.4.1).
9. Calculate the ratio of built-up area to population in corresponding years within the administrative territory of each local government (Section 8.4.3).
10. Discuss whether urban sprawl has been progressing in counties and cities.

8.3.1.1. Defining Built-up Area

The terms 'urban land' and 'built-up area' have been used interchangeably in many studies (for example, Alig & Healy, 1987; Longley & Mesev, 2000). Apart from land uses, the designation of built-up area is usually based on the size of population, the population density, the area of settlement, 'community like clustering of people', or distance between the two clusters of settlement (Alig & Healy, 1987; DCLG, 2008d; Geymen & Baz, 2008; EEA, 2009).

Recently, studies of built-up areas started to include the rural built-up area (Alig & Healy, 1987) and the transportation facilities built in rural areas (Liu, et al., 2005; Deng, et al., 2008). Some studies further include water management facilities (Alig & Healy, 1987; Wackernagel, et al., 2002). These changes approximate the built-up areas to the areas where the surfaces or vegetations have been altered by artificial pavement. However, urban green space was still included in the analysis. The scale of built-up area varied depending on the criteria of the land use survey (Alig & Healy, 1987). Agricultural land use, apart from recognisable facilities (such as farmsteads or ranch headquarters), was not considered built-up areas although the vegetation could be altered artificially.

The result in described in Section 6.7 suggested the needs of Taiwan to limit the artificial impact on land. The artificial impacted land should include the built-up areas in rural areas. Therefore, this study adopted the idea of built-up areas from the recent studies: the built-up area refers to the area where the surface has been artificially paved so that the it is no longer 'green'. By using this definition of built-up area, however, the analysis in this chapter assessed the sprawl of built-up areas but not necessarily 'urban sprawl'. The issue of agricultural land use was not addressed in this study.

The idea of built-up areas was applied to the definition of land use classification in Taiwan to determine which classes of land use should be included in the built-up areas (Table 8.2). However, the areas under some of the classes may contain both built-up and non built-up areas. No quantitative estimation of the built-up and non built-up areas is available to differentiate the areas. Therefore, it is not possible to quantitatively calculate the 'exact' built-up areas. Under this consideration, the steps described in Section 8.3.1 were repeated two times: one with all the secondary classes that may contain built-up areas (hereafter referred as generally defined built-up area); another with the classes that only contain built-up area (hereafter referred as strictly defined built-up area). The classes included in these two types of built-up areas summarised in Table 8.2.

8.3.1.2. Analysing Built-up Area and Population

Two variables were calculated according to the extent of built-up areas and population sizes. One was the changes of built-up area between two land use surveys; another was the changes of ratio of population to the built-up area.

The ratio of population to the built-up area ($Ratio = Population / Built - up\_Area$) was different from population density. A low population density region may have high ratio of population to built-up area. In this case, some public facilities (such as advanced medical care facilities) that usually exist in urban setting would be shared by larger part of people in the rural areas.

8.3.2. Analysing Planned Land Use and Current Land Use

The steps to analyse differences between actual land use and planning are described below:

1. Synchronise the classification of land use surveys and planning district or zoning (Table 8.2).
2. Compare differences between land use survey and planning designation (some considerations are presented in this section, more in Section 8.5.3).
3. Calculate built-up areas based on classifications of the recent land use survey as well as the planning statistics in counties and cities in Taiwan.
4. Compare the difference of built-up areas between actual land use and planed land use in counties and cities in Taiwan (Section 8.4.5).

The classifications in the surveys and the planning do not match perfectly. Planning or zoning usually reflects the transition between current land uses to the future land uses. The land use survey presents contemporary land use and the legacy of land use in the past. For example, the mining and salt industries were no longer prominent in Taiwan. These land uses were not put in the classification of planning but they were in the land use survey classification (Table 8.2). The analyses were conducted based on the matches showed in Table 8.2. The possible effects of the imperfect matches on the analysis were considered in the discussion section (Section 8.5).

8.4. Results

8.4.1. The Change of Populations

The population in Taiwan increased 7.80% between 1995 and 2008, from 21,357,431 to 23,037,031 (Figure 8.3). However, the trend of increasing has slowed down in the more recent years and the population projection from now to 2050 is negative (Esty et al., 2005).

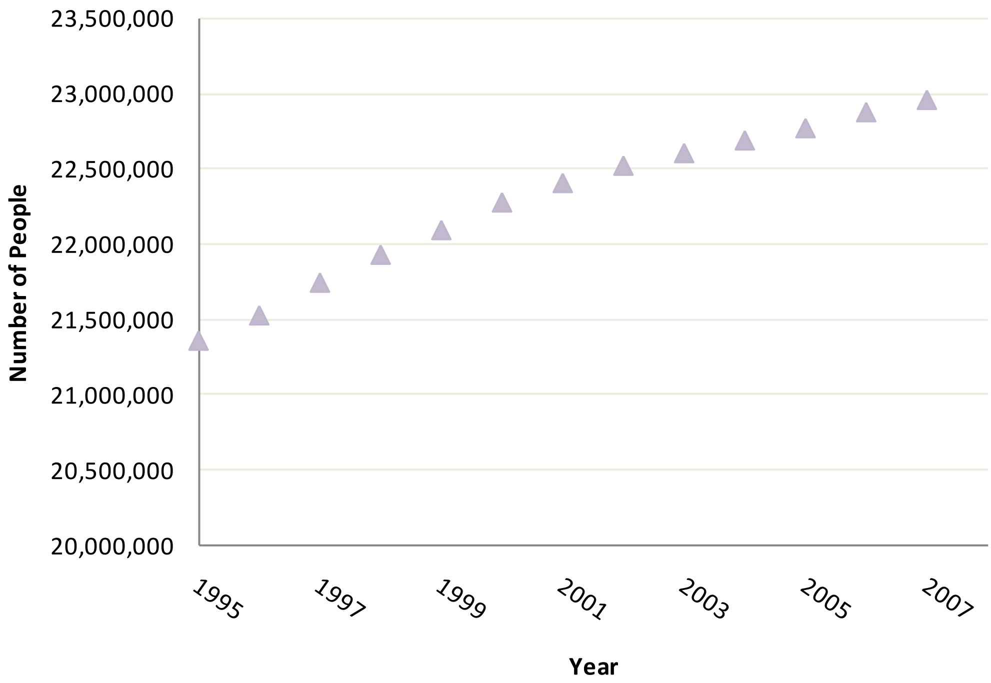


Figure 8.3 The Population Change between 1995 and 2008

Albeit the overall increasing trend, during this period, the populations changed in different directions among counties and cities, and between regions (Figure 8.4). Generally, the population densities increased more significantly in the cities than counties. The only exception was the capital city, Taipei. The population growth of Keelung City was also considered low. These two cities are both in North Region. By contrast, two of the counties in the North Region experienced relatively high population growths: Taipei county and Taoyuan county. Furthermore, two of the three cities in the North Region (Keelung and Hsinchu) have positive population growth. Therefore, despite of the population decrease in Taipei City, the North Region experienced the most population growth.

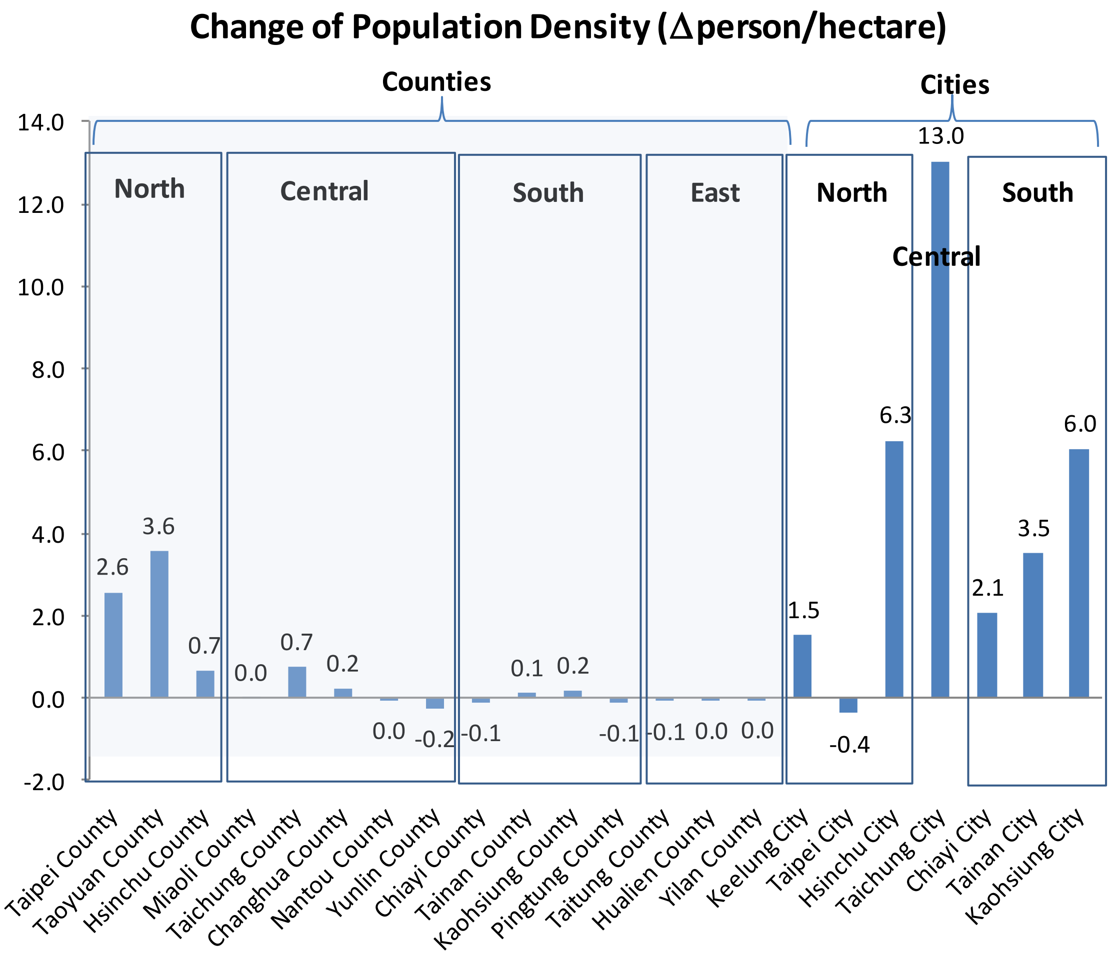


Figure 8.4 Changes of Population Densities in Different Local Governments (between 1995 and 2008)

In the central region, the population density of Taichung City escalated while other counties' population growths and declines were relatively minor. Similarly, the south region has seen increasing population densities in the three cities (Chiayi City, Tainan City, and Kaohsiung City) but the population densities of the surrounding counties do not vary as much. The population densities of the counties in the east region do not vary significantly over time.

The agglomeration observed in the cities in Taiwan resemble the distributions of the degree of urbanisation observed among local authorities in England (Figure 4.7) and the study of Garmestani, et al. (2007) about the cities in the U.S.

8.4.2. The Change of Built-up Area

The changes of built-up areas were presented in Figure 8.5. Overall, both types of built-up areas (defined in Section 8.3.1.1) in all the local governments have increased over time except Keelung City. For the entire island, the strictly defined built-up area increased from 256,332.26 hectares (7% of total area) to 370,013.34 (10% of total area). Thus, based on the data, a further 3% area of the island was converted to built-up area between 1995 and 2008.

However, the area investigated (1,858,773.89 hectare) in year 1995 only covered 52% area of Taiwan, while in 2008, the survey almost covered 100% of Taiwan (Section 8.2.1). Therefore, the conclusion was made under the assumption that the survey in 1995 covered most built-up area at the time.

This assumption was made under the consideration that the land surveyed in 1995 was the land that has registered. The built-up area was more likely to be registered because it usually closely related to frequent human activities. The assumption was supported by the distinct percentages of investigated areas in counties and cities during the first land use survey (Figure 8.6). The percentages were quite high in all the major cities in the survey in 1995. The counties that cover more areas that are rural and mountain areas such as Nantou, Yilan, Hualien and Taitung have much lower percentages of surveyed land. Furthermore, the cities with high percentage of surveyed areas also had high percentages of built-up areas (Figure 8.7). Therefore, it appears that the built-up areas were better surveyed in 1995 than the non-built up area. Thus, the estimation of built-up area based on the survey should not be far from the reality.

Since it is reasonable to assume the built-up areas in 1995 land use survey was relatively accurate, it is less possible that the increase of built-up areas between 1995 and 2008 was the effect of underestimation of built-up area in 1995.

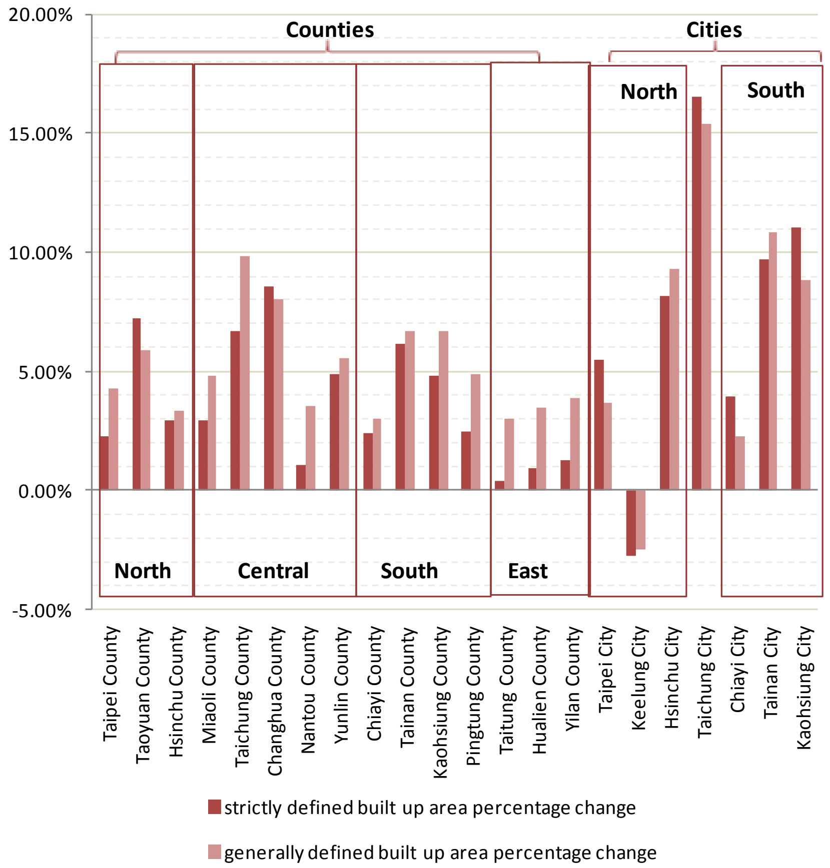


Figure 8.5 The Change of Built-up Area between 1995 and 2008

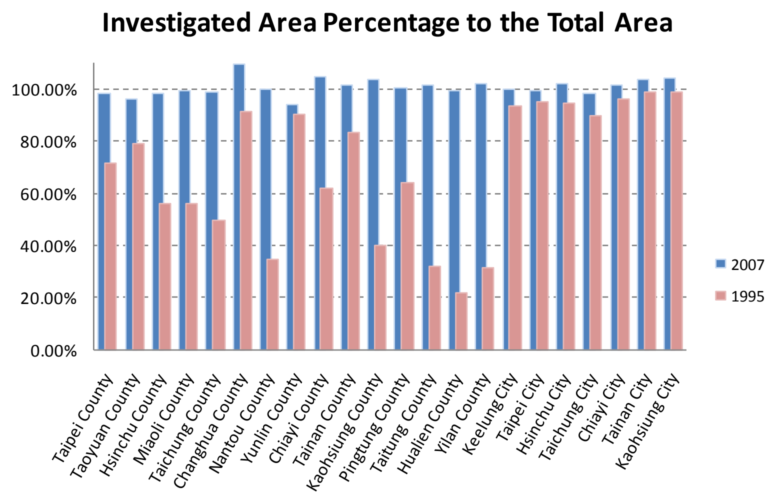
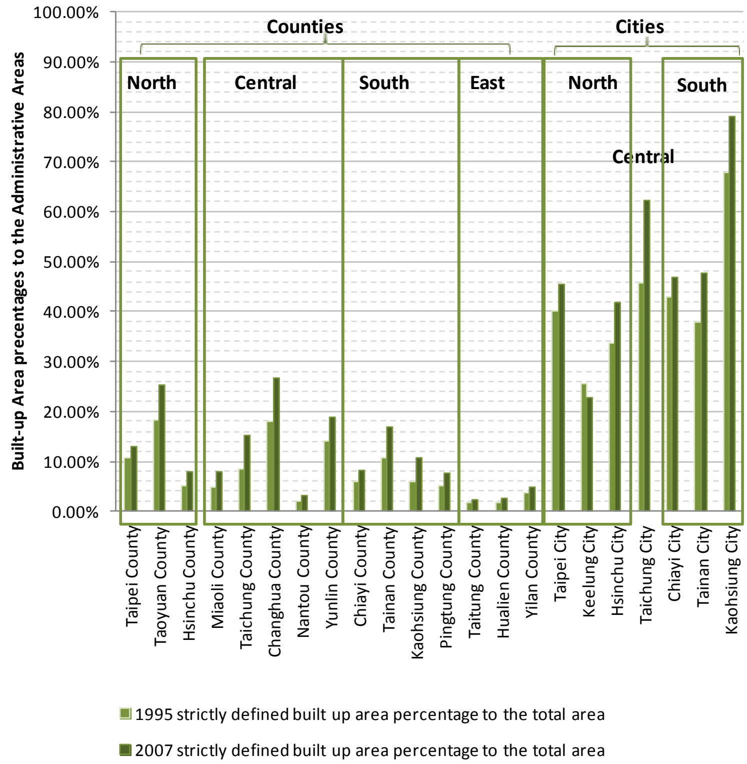
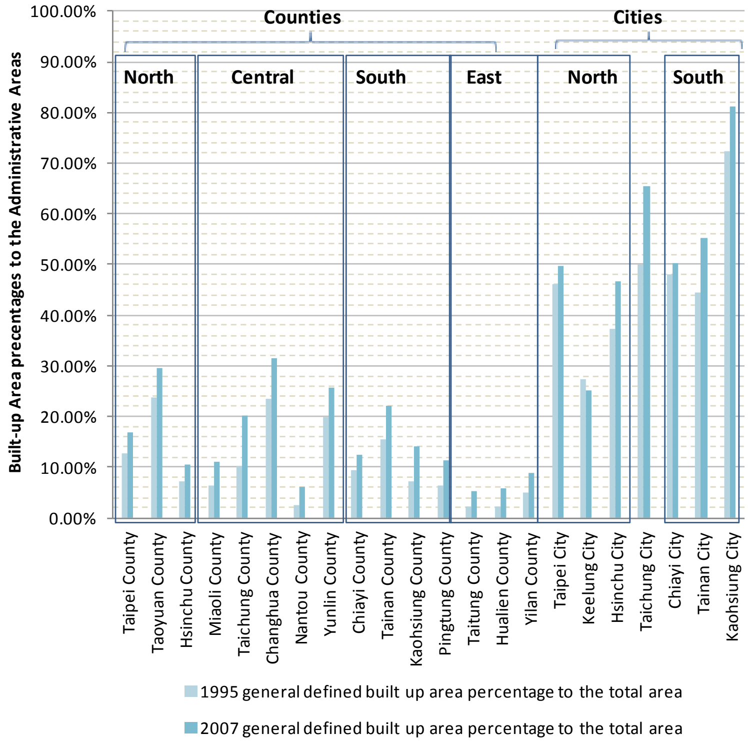


Figure 8.6 The Percentage of Area Surveyed in Each Local Authority (Some percentages exceed 100% due to the change of administrative boundaries.)



a.



b.

Figure 8.7 The Percentage of Built-up Area in Each Local Authority

8.4.3. The Change of Ratios between Built-up Area and Population

The built-up areas and the population in Taiwan both increased over the past decade. There were also distinct differences of the distributions of built-up areas and populations between the counties and cities (Section 8.4.1 and Section 8.4.2). This section further analyses the changes of ratios between the populations and built-up areas. The changes of the ratios indicate whether the built-up area became more compact.

8.4.3.1. Population to Built-up Area Ratio

The ratio of population to the strictly defined built-up area between 1995 and 2008 were decreasing among all local governments except the Keelung City (Figure 8.8). This meant that the strictly defined built-up areas increase in faster rates than the growth rates of population.

For the generally defined built-up area, the ratios mostly decreased except Keelung City and Taoyuan County (Figure 8.8). The generally defined built-up area contains water management facilities and recreational facilities in addition to the areas covered by the strictly defined built-up areas. Therefore, in these two local governments, more people were sharing each unit areas of water management facilities and recreational facilities.

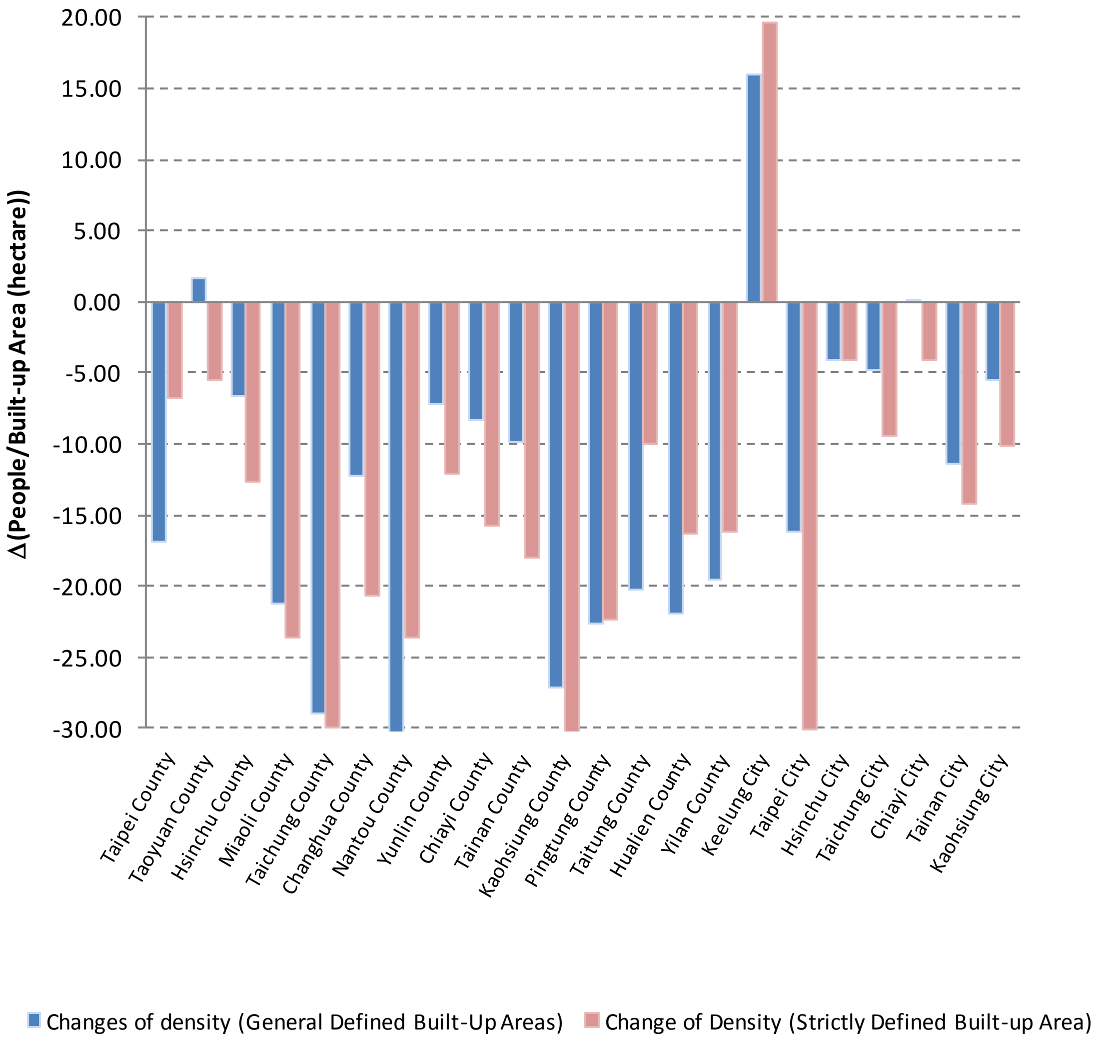


Figure 8.8 The Change Population to Built-up Area Ratio between 1995 and 2008

Figure 8.9 positions the percentages of changes in population growth in x-axis and strictly defined built-up areas between 1995 and 2008 in y-axis. The green line with arrows depicts the place in the plot where the ratios between populations and built-up areas have been maintained. The area in the left of the green line indicates the population increase faster (or decrease slower) than the built-up area. In this case, the built-up area has accommodated higher intensity of human activities. In the case of Taiwan, only the Keelung City fitted this criterion. The built-up area in Keelung City has been shrinking while its population grew about 5%

between 1995 and 2008. The area in the right of the green line indicates the intensity of human activities has been decreasing on the built-up area. This is the case in the majority part of Taiwan. The populations either increased slower than the expansion of the corresponding built-up areas, or decreased while the built-up area was still expanding.

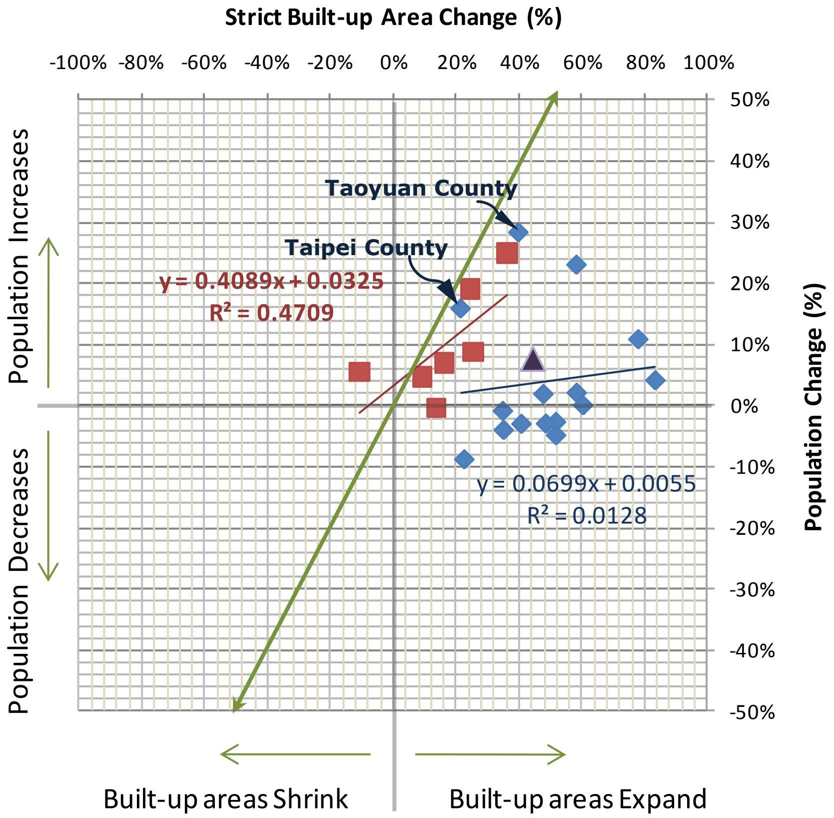


Figure 8.9 **The Changes of Populations and Strictly Defined Built-up Areas in Countries and Cities in Taiwan between 1995 and 2008 (■ cities, ♦ counties, ▲ Taiwan population data after year book of The Ministry of Interior, Section 8.2.6; land use data after two land use surveys Section 8.2.1).**

In addition, in the relationships between percentages changes of population and built-up areas in the cities followed the green line more closely in comparison with the counties. The positive correlation between the changes of populations and built-up areas can be observed and explained about 47% of the variation (R^2=0.4709). The data points of counties located further right of the green line.

This implied the issues of urban sprawl may be more serious in counties. Little correlation between the change of population and built-up areas in the counties was found. Furthermore, it is noted that the change of the ratios in two of the counties in the North Region were also close to the green line. They behaved more like cities.

Figure 8.10 shows the analysis using the generally defined built-up area has produced similar results to Figure 8.9: Besides Keelung and Taoyuan, the built-up area in counties and cities in Taiwan have accommodated less intensity of human activities over time. However, general built-up area, by definition, includes water conservancy and recreational land use. The land use classes covered both built-up areas and some unaltered vegetations. Further, these two facilities were highly likely to be shared across counties and cities. It may not be fair to make firm conclusions on the differences between cities and counties. Additionally, countries in the North Region (Hsinchu, Taipei and Taoyuan) constantly behaved more like cities than rest of the counties.

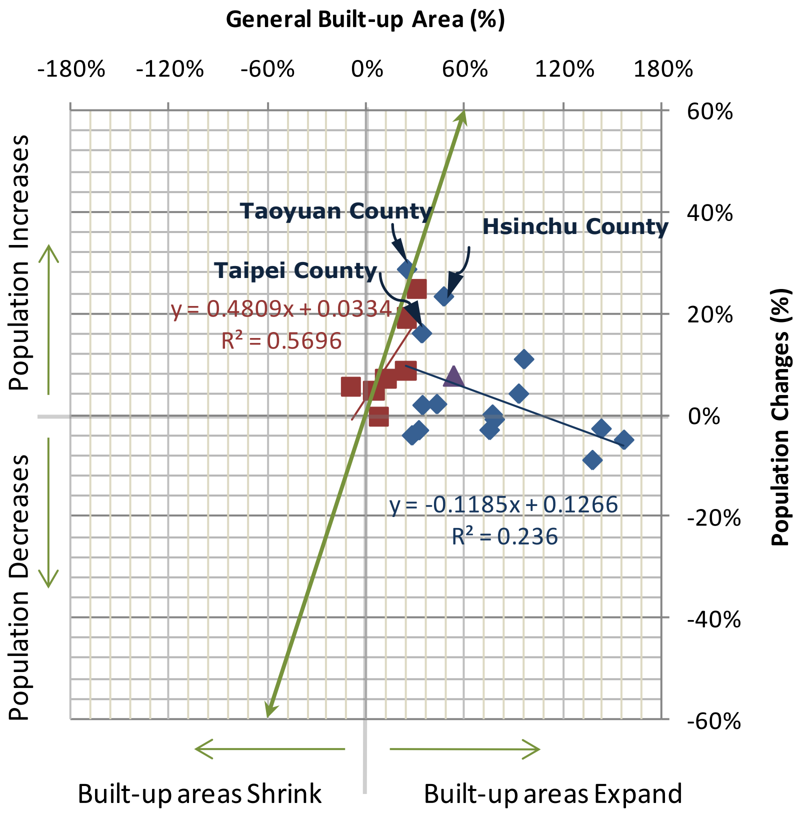


Figure 8.10 **The Changes of Populations and Generally Defined Built-up Areas in Countries and Cities in Taiwan between 1995 and 2008 (■ cities, ♦ counties, ▲ Taiwan population data after year book of The Ministry of Interior, Section 8.2.6; land use data after two land use surveys Section 8.2.1).**

8.4.4. The Change of Areas in Zoning

The areas covered by both urban districts and non-urban zones have been increasing. The designated urban land increased at the rate between 0.2% and 0.3% annually while that of non-urban land at the rate between 0.3% to 0.4%.

Within the urban district, built-up areas (Table 8.2) were mostly expanding (commercial district, education district, public facility land, [District] for Specific-Purpose) (Figure 8.11). The designated residential and industrial areas fluctuated at the same level (residential area between 62,954 and 64,580 hectares and industrial area between 22,235 and 22,622 hectares) since 2001. On the other hand, [District] for Specific-Purpose increased almost 10 times since 2001. Accordingly, in the [District] for Specific Purpose, the variety of developments such as the mass transportation, commercial opportunities, high-tech industries, and so on are integrated. The content in the district was quite flexible. It is possible that some additional residential and industrial areas are hidden in this district.

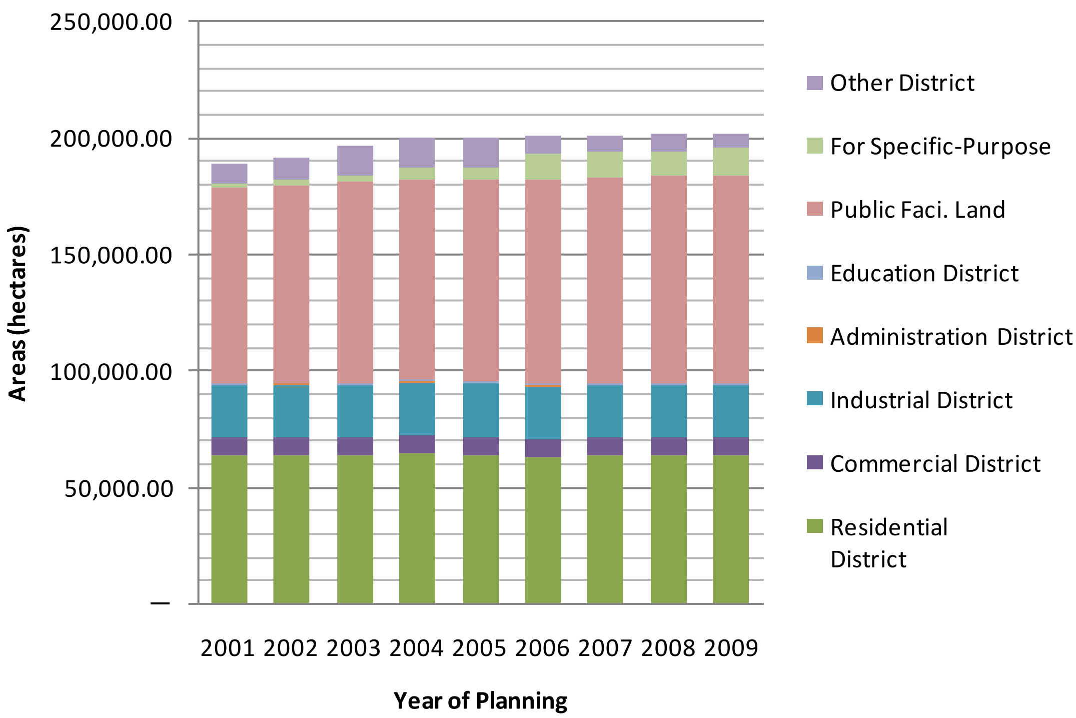


Figure 8.11 Built-up Area changes in Urban Planning of Taiwan

Figure 8.12 shows that although the areas under urban planning are growing, the districts (agricultural district, protected district and landscape district) contain mostly non built-up areas (Table 8.2) were shrinking. This indicated the planning authorities foresaw much denser urban areas in Taiwan as the population increased (Figure 8.3).

On the other hand, the expanding non-urban zoning is mostly due to increased designated forest areas (Figure 8.13). Ten percent more forest zone was designated each year. The designations of National Park (10% annually) and river zones (98% annually) have also increased dramatically. However, the actual areas in these two zones increased were less significant compared to that of the forest zone.

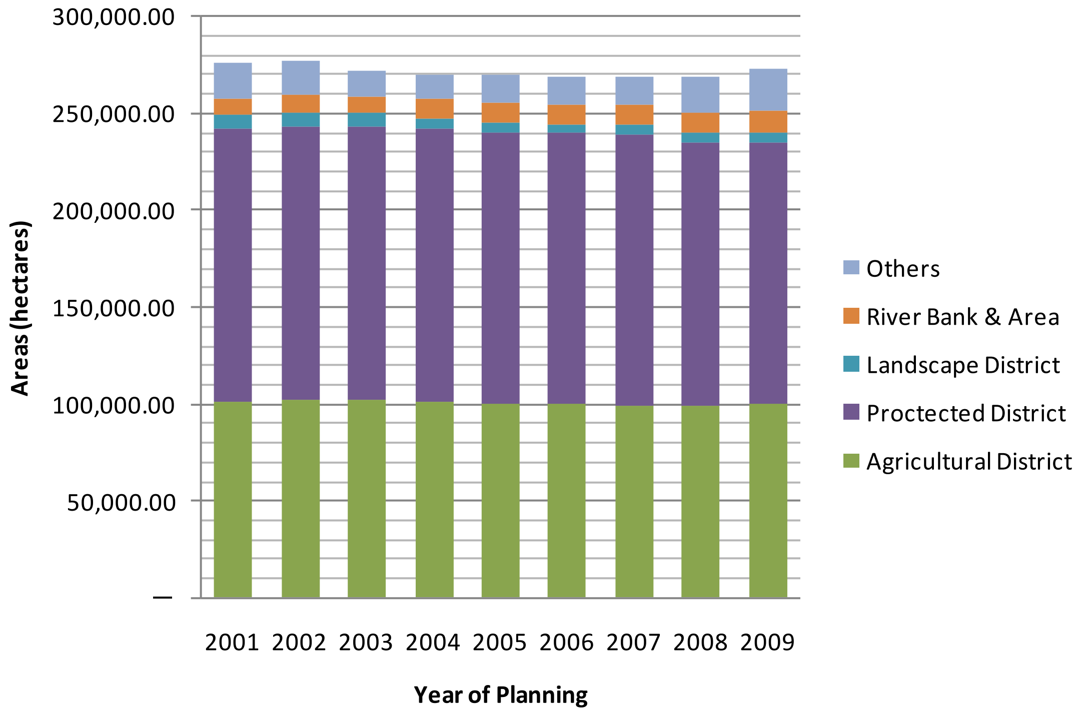


Figure 8.12 Non Built-up Area Changes in Urban Planning of Taiwan

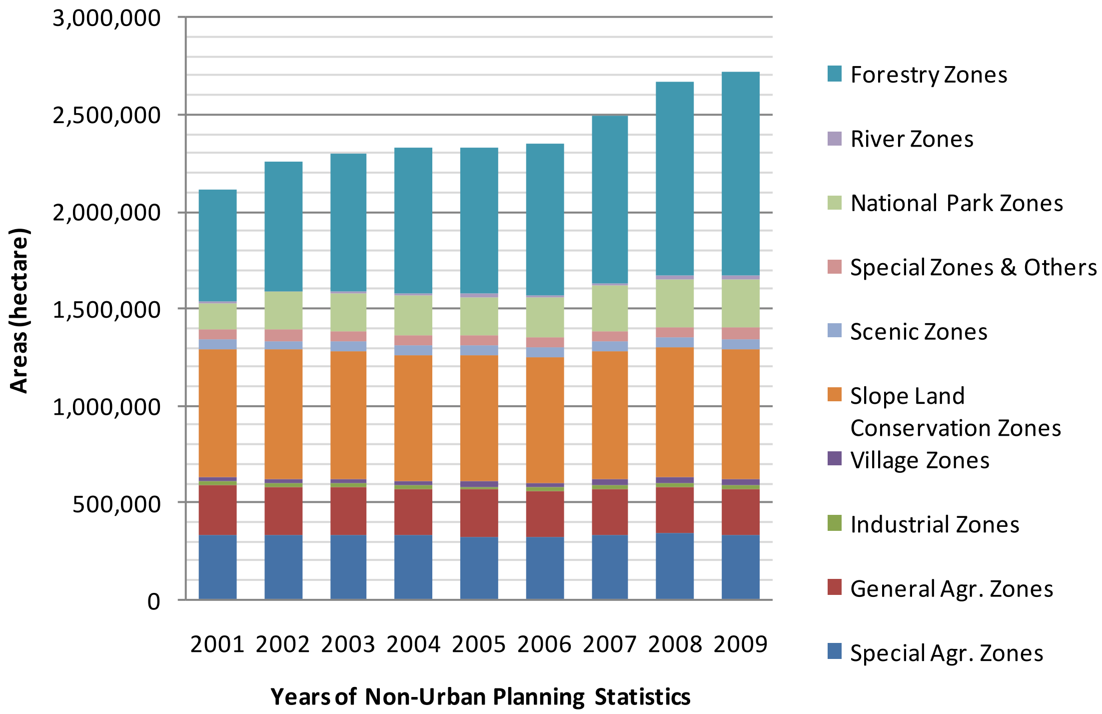


Figure 8.13 Changes of Zoned Areas in Taiwan between 2001 and 2009

Village zone and industrial zone under the non-urban designation are considered built-up areas. They increased at the rate of 0.2% annually, much slower than that of built-up land in urban land (1% annually).

8.4.5. The Difference between Planning and Actual Land Use

Figure 8.14 displays the relationship between planned strictly defined built-up areas in 2001 and surveyed strictly defined built-up areas between 2006 and 2008 among counties and cities in Taiwan. The planned and surveyed areas formed positive correlation. Particularly, the linear relationship between the planned areas and areas of actual land use was quite clear among the cities (R-square=0.9453). The positive correlation among counties (R-square=0.8225) was also high but not as strong as that among the cities. Moreover, the slope of the regression line of cities is quite close to 1. This means the amount of areas that planned in 2001 to be strictly defined built-up areas was generally followed. The slope of the regression line of the counties is about 10% higher than 1. This means on average, more than 10% of strictly defined built-up areas was established among counties than planned in 2001.

Additionally, although the counties in northern regions behaved more like cities in the analysis between built-up areas and population changes (Section 8.4.3), they established more built-up areas than the planning intended, especially Taoyuan county. The agglomeration and development in Taoyuan country seem not to be the intended results of planning. Furthermore, the counties with smaller planned built-up areas followed the planning better. For the bigger counties, the expanding of built-up areas was faster than population growth (Section 8.4.3) and wider than planned.

The positive linear relationship among counties in generally defined built-up areas was still significant among cities (R-square=0.9032), but not so much among counties (R-square=0.4179 and the value of the intersection is also considerable bigger than that in Figure 8.14) (Figure 8.15).

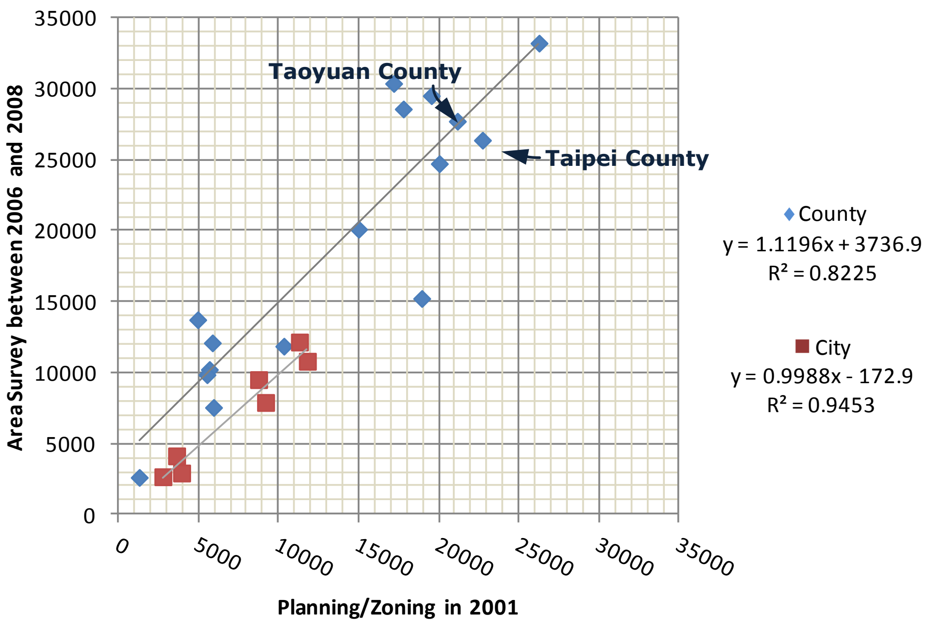


Figure 8.14 **Changes of Strictly Defined Built-up Areas in Taiwan between 2001 and 2009 (■ cities, ♦ counties data after statistics described in Section 8.2.1.2, 8.2.2, and 8.2.3)**

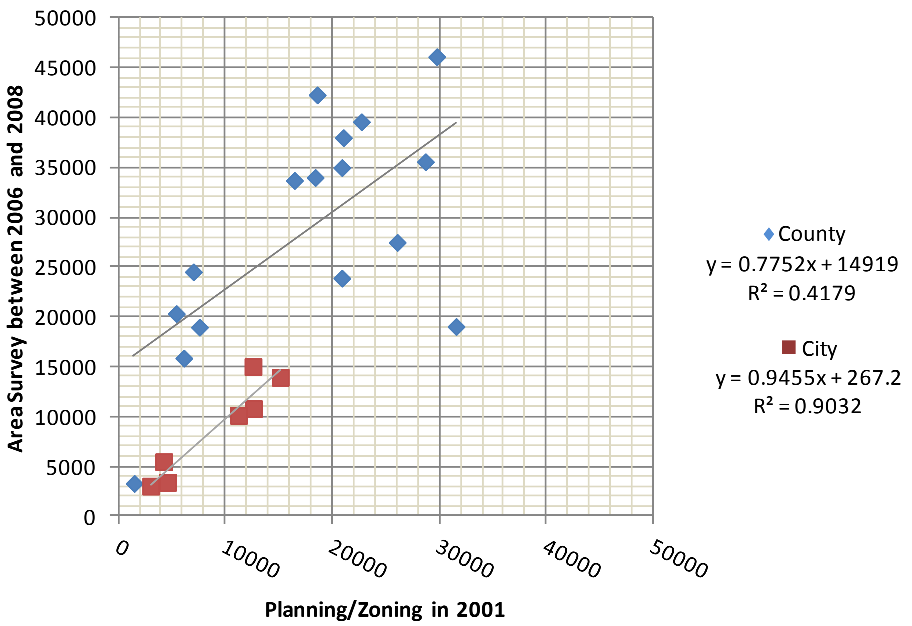


Figure 8.15 **Changes of Zoned Areas in Taiwan between 2001 and 2009 (■ cities, ♦ counties data after the statistics described in Section 8.2.1.2, 8.2.2 and 8.2.3)**

To evaluate the reasons for the discrepancies observed in Figure 8.15, the comparisons of areas under the corresponding planning designations and land use survey classes were conducted based on different land use classifications.

The scales of the discrepancies between planned areas and actual land uses were smallest in the 'built-up area' (-15%), 'public land' (51%), 'agriculture' (15%) and 'forest' (-28%). By contrast, the actual 'water conservancy' and 'miscellaneous' land uses cover much larger areas than planned. The actual 'recreational and leisure' land use occupies much smaller areas than planned. However, the differences in 'recreation and leisure' become less significant comparing to the differences in 'water conservancy'.

The 'built-up area' and 'public land' were the two major contributors to the strictly defined built-up area while 'water conservancy' and 'recreational use' were the two additional classes in general built-up areas. The scales of discrepancies somewhat explained the weak correlation in counties in Figure 8.15 since the water conservancy and recreational facilities are more likely to locate in counties.

Table 8.4 The Difference in Areas based on Land Uses

Area / Classification of Survey in 2006	Areas under Corresponding Classification		Difference	
	Surveyed	Planned or Zoned	Hectares	Percentages to the Surveyed Areas
Agriculture	806951.18	682992.28	-123958.90	-15%
Forest	2115633.10	1514149.86	-601483.24	-28%
Transportation	107069.34	35780.76	-71288.58	-67%
Water conservancy (total minus sea level)	128196.03	11867.17	-116328.86	-91%
Built-up Land	169680.31	194697.32	25017.02	15%
Public Land	26206.38	39635.69	13429.31	51%
Recreation and Leisure	21044.97	64449.89	43404.92	206%
Minerals	7912.72	0.00	-7912.72	-100%
Miscellaneous Land	240757.77	13495.16	-227262.61	-94%
Total	3623451.80	2557068.14	-1066383.66	-29%

The discrepancies might also be partly due to different interpretation of the land use between land use surveys and planning regulations. For example, the land use survey depicted water bodies and artificial construction in the entire island. Given the surveyed areas of the water bodies are about 1.5 times of planned water zone, it is quite likely that many water bodies are left un-zoned. The planned water zone may only be designated because the water bodies were within the areas for 'anthropogenic uses'. Large part of these water bodies designated in the zoning may have undergone some artificial alteration or have been created artificially.

Accordingly, the planned river zone is designated based on the *Water Act* and its derived regulations. Articles 4 and 5 of *Enforcement Rules for Water Act* (last amended on November 13, 2009) define the terms 'waterway' and 'reservoir' as following: *The water way is 'areas run through by rivers, lakes, reservoir storage area, drainage facility area, canal distributaries detention ponds or water flow of diversion route'*[10] *; the term 'reservoir' refers to 'weir, dam, artificial lake and ancillary facilities and water storage area thereto significantly associate with use of water resources or flood control, and announced as such by the central authority-in-charge'*[10]*.* The planned river zone would be more likely associated with use of water resources and flood control. Thus, it might cover more 'reservoirs'. On the other hand, the land use survey has covered entire 'waterway'.

Additionally, while land use survey documented 38446.43 hectares less of 'built-up areas' and 'public land' combined than the corresponding planning statistics, it recorded 71,288.58 hectares more transportations areas than the planning statistics. This implies there may be bigger discrepancies than observed in the strictly defined built-up area if the comparison is breaking down to the specific land use class.

8.5. Discussion

This chapter summarised and analysed land use changes, population changes and planning changes in Taiwan between 1995 and 2008. The transition of the demography and the effectiveness of planning were evaluated. This section discusses the implications of these results.

8.5.1. The Implication of Population Changes

The statistics indicated that population between 1995 and 2008 has been increasing in Taiwan (Figure 8.3). The increase is due to the growth of urban population; the non-urban population remains stationary after 1991 (Figure 8.4 and additional evidence in Chang 2009). However, the projection of population growth between 2005 and 2050 has been negative (Esty et al., 2005).

There are some regional variations embedded in the general trend of population growth: Between 1995 and 2009, the populations grew significantly in the cities in

[10] The translated texts were digested directly from the website Law & Regulations Database of the Republic of China: http://law.moj.gov.tw/Eng/LawClass/LawContent.aspx?PCODE=J0110002

Taiwan except Taipei. The populations in the counties have not varied significantly expect Taipei counties and Taoyuan counties. The two counties locate in the North Region. Overall, in the north part of Taiwan, the urbanisation has been increasing in both cities and counties. However, in other regions, the agglomeration mostly concentrates on the major cities (Figure 8.4).

The differences between counties and cities seem to correspond to the distributions of industrial sectors in Taiwan. The North Region of Taiwan, especially Taipei, once heavily industrialised, is now the political, economic and culture centre. Chang (2009) indicated that Taipei exhibited urban primacy in terms of commercial, service and cultural sectors but not the manufactory sector. 'Taipei City today is a city existing based on 'consumption' but not 'production' (translated from Hsiao, et al., 2005).'

Additionally, Taipei County has been considered the hinterland of Taipei City. Most of the industries with the potential of pollution have moved from the city to the county. An investigation in 2000 indicated the county has highest concentration of factories in Taiwan (Hsiao et al., 2005). Moreover, most of the working-class labourers working in Taipei City reside in Taipei County because of expensive rentals or property prices in the city. Thus, the increasing population in Taipei County may represent the continuous expansion of the urban area of the city. This may explain the slight population decrease in Taipei City after late 90s and the dramatic population increase of Taipei County between 1995 and 2008. This may also explain the resemblance of the county with the cities in Taiwan in its changes of population and built-up areas (Figure 8.9 and Figure 8.10).

The population increase in the northern part of Taiwan may also be due to the establishment of many science parks started from 1980s. With policy support, these science parks were specifically established for semiconductor and telecommunication industries. The two industries contributed to the impressive GDP growth in Taiwan for decades. The success of the early science parks in the North Region encouraged the installation of similar science parks in the South and later in the Central Region of Taiwan. The science parks in the North Region also expanded to the border of the North and Central Regions, and the North and East Regions (Table 8.5). These newer science parks have not been fully occupied. Whether these science parks will pull population to the vicinity remains to be seen. Because the transportation in Taiwan has improved, workers may choose to commute to the workplaces for longer distance. Furthermore, many telecommunication manufactories have moved large part of their factories to China and South East Asia for cheaper labour. The demand for manpower in these industries may no longer high.

Table 8.5 The Science Park Development in Taiwan

Science Park Development*							
Science Park		Total Area	Regions	Industry Type	Year of Establishment	Rentable Area	Area no Rented (%)
Hsinchu Science Park	Hsinchu Campus	653.00	North	telecomunication, semi-conductor, and bioscience	1980	274.3	0.15%
	Bioscience Campus	38.00	North	pharmaceutical and medical device	2008	22.8	9.52%
	Chunan Campus	123.00	Central	telecomunication, semi-conductor, and bioscience	1998	69.68	5.37%
	Tongluo Campus	350.00	Central	-	Developing	4.31	0.00%
	Longtan Campus	76.20	North	telecomunication, semi-conductor, and bioscience	2004	NA	NA
	Yilan Campus	70.63	East	-	Developing	NA	NA
Central Taiwan Science Park	Taichung Campus	412.86	Central	telecomunication, semi-conductor	2003	186.94	0.32%
	Huwei Campus	96.52	Central	telecomunication, semi-conductor, bioscience	2003	42.15	20.81%
	Howli Campus	255.67	Central	telecomunication, semi-conductor, bioscience	2005	142.07	17.25%
South Taiwan Science Park	Tainan Campus	1,043.15	South	telecomunication, semi-conductor, bioscience, solar energy	1996	517.00	30.41%
	Kaohsiung Campus	570.00	South	telecomunication, semi-conductor, bioscience, solar energy	2004	194.14	26.04%

*information digested from Table A-1 Science Park Development and Table A-3 Science Park Land Use updated on November 03, 2009 and Deceomber 10, 2009 in National Science Concuil w
(https://nscnt12.nsc.gov.tw/WAS2/sciencepark/AsSciencePark.aspx)

8.5.2. The Intensities of Human Activities in Built-up Areas

The landscape of strictly defined built-up area is considered highly manipulated by artificial construction (Section 8.3.1.1). These are the areas where busiest human activities happen. The ratio of population to the strictly defined built-up area represents how the general public shared the public facilities and service in mostly urban areas. The decrease of population sharing the strictly defined built-up area might indicate decreased effectiveness of public infrastructure.

The generally defined built-up areas include the areas where artificial construction and nature landscape blend together (Section 8.3.1.1). The water management facilities such as trenches usually interweave with the natural water bodies (Section 8.4.5). Some recreational facilities are built to increase the opportunities for visitors to appreciate the natural landscape nearby. Although human beings are 'consuming' these land resources, the vegetation may not be significantly altered. Therefore, the ratio of population to generally defined built-up area might reflect how general public shares wider land resources in supporting urban life style. This, however, did not include farmland in this analysis.

Furthermore, in Taiwan, it is common that different local governments share the same water resources. People also travel to different counties for recreational purposes. Thus, the ratio of population to the generally defined built-up area may not be as indicative as ratio of population to the strictly defined built-up area in reflecting the conditions within the boundaries of local governments.

The strictly defined built-up area increased among local governments in Taiwan between the two land use surveys. The only exception is Keelung City. Keelung City's generally defined built-up area is also shrinking. The ratio of population to both types of built-up areas is increasing. This means the city becomes smaller and the land use is more intense. Taoyuan County, although expanding the strictly defined built-up area, has been accommodating proportionally more people. The population to generally defined built-up area ratio of the county has also slightly increased. This indicates more people are sharing the recreational facilities and water management facilities. For other counties and cities, the generally defined built-up areas are expanding faster than population increase.

8.5.3. Regional Variation in Taiwan

The issues of regional variations on sustainability discussed in previous chapters (for example, Section 4.4.3 and Section 7.5) can also be observed in Taiwan. The conditions in the four major regions differ. Therefore, one regeneration strategy may not be fit for all. Most counties with expanding strictly defined built-up areas experienced population decline. These counties are comparatively rural. Their major economic activities are agricultural. At another extreme, Taipei City also experienced population decrease. It is probably the most urbanised area in Taiwan. The decreasing populations in Taipei City and these agricultural counties should not be viewed in the same way.

The population decrease in Taipei may be due to the high land prices. People may just move to the adjacent counties (i.e. Taipei counties) for cheaper accommodations but may still work in the city. The major function of the city has not broken down.

On the other hand, the decreased populations in the counties may be the result of the decline of agricultural sector in Taiwan. The percentages of economic output from agricultural sector in Taiwan decreased from 7.10% in 1991 to 1.51% in 2007 (Lee, 2009). As the result, people may out-migrate to a more industrialised or urbanised area for job opportunities.

In the cases of the agricultural counties, there may be higher chances that unwanted vacant and derelict properties are prevalent. However, in the case of Taipei City, the vacant properties, if any, may be held for better prices to sell in the future. This is much similar to the situation observed in the PDL distributions in England. The Taipei City, like the southern regions and the London regions in England, has more underused land in stock, whereas the agriculture counties, like the northern regions in England have larger ratios of derelict land.

Chang (2009) noted that in western societies, migrating out from city centres may not only base on the consideration of economy but also the quality of life. However, in Taiwan, economic consideration is the key consideration for out-migration. The expansion of built-up areas is usually the continuation of urbanisation. Phenomena of suburbanisation or gentrification in western countries were less likely to happen. These observations are consistent with the conclusions of Drakakis-Smith (1995, 1996) on his research of the urbanisation of Asian cities. The significantly higher population increase in Taipei County and Taoyuan County may be part of this continuous urbanisation extending from Taipei City.

Keelung City is an interesting case. Its population is increasing while the built-up area is decreasing. It was a major city and trading port (the seventh largest container terminal in 1984.) when mining was one of the major industry in Taiwan. However, this is no longer the case. The reason of its shrinking built-up areas could be the result of its geology and updated building regulation. Buildings, especially high buildings, may no longer considered appropriate in some of the rocky steep slopes surrounding the city. The industrial history and the demographic change of the city should be further investigated to see whether it provides implication for policymaking to encourage compact city building. Alternatively, this could just be the declining process of the city.

8.5.4. Actual Land Use and Planning

The results showed that the distributions of strictly defined built-up areas follow the planning better than the general built-up areas (comparisons between Figure 8.14 and Figure 8.15). The results also show that planning was followed better in cities than counties (Section 8.4.5).

The discrepancies between actual land survey and planning statistics partly represented the transition of land use. The land use surveys recorded the snapshot of contemporary land uses; their classifications reflect the types of land use that are quantitative significant or qualitative important in surveyors' view (Section 8.2.1). On the other hand, the planning or zoning statistics reflect the types of land that are important for regulating purposes. This represents the view of planning authorities on what should be in places to maintain social and economic activities. High agreement between the planning and actual survey in the strictly defined built-up areas indicates that areas under higher anthropogenic impact are more likely to be used according to the plan.

Interestingly, the deviation between planning and actual land use were also small in forestland designation (Section 8.4.5) which does not belong to built-up areas. The forest zoning or designation grew dramatically between 1991 and 2009 (Table 8.4). Since the forest is not the habitat easily re-established within a short period, the expanding of the designation is more likely to be the result of incorporating previously un-zoned forest vegetations. Therefore, the planning in this part is not for the future but for approximating the current land uses or vegetations. The objective for this approximation may be to increase the control over current greenfield land or natural environment as the importance of environmental protection and the awareness of environmental preservation intensify. This could be the part of the efforts from the government to prevent further unreasonable destruction of the natural environment.

Furthermore, in the proposed revision of *Regional Plan Act*, the Ministry of Interior has planned to merge part of forest zone, together with other zones that cover environmentally sensitive areas, into one land use 'national land preservation area'. The resources to preserve areas under this designation will be further prioritised based on the importance of preservation (Huang, 2010). These represent a transition of views on forestry management in Taiwan. Forests were once viewed as economic resources; the view has been gradually shifted to consider forests providing wider 'environmental service'. Therefore, it needs to be preserved rather than harvested.

8.5.5. The Objectives in Land Use Sustainability

Taiwan needs to restrict, if not reduce, its anthropogenic impacts within limited area to maintain or improve land use sustainability (Section 6.7.1). However, the built-up area in Taiwan has been expanding even faster than the population growth (Section 8.4.3). The planning authorities were allowing more built-up areas within their administrative territories (Section 8.4.4). Taiwanese government has not inhibited overall greenfield development. This is not sustainable.

Additionally, the anticipated population densities have been more than 35% higher than the actual population densities in the urban planning district between 2000 and 2010 (Ministry of Interior, 2010). Therefore, the discrepancies between planned and actual built-up areas (Section 8.4.5) revealed that the government have planned for compacter cities but have not actively delivered the plan.

On the other hand, conflict between socio-economic development and environmental protection on the subject of land use sustainability could be exacerbated because of the rich biodiversity in Taiwan (Section 6.7.3). The increasing built-up area could imply the socio-economic development might have been prioritised over environmental protection. However, in Taiwan, the continuation of converting greenfield land into built-up area did not improve the social equality. The proportion of people lived under the poverty line (lower than the medium of 60% of accessible income) have increased from 11.8% to 15% between 1981 and 2000 (Chiu, 2009, p483).

These conditions can be alleviated by a well-designed brownfield regeneration policy. The policy can improve land use effectiveness and therefore reduce greenfield development. It can also address the social equality issues through the regeneration process to create a more sustainable community.

8.6. Conclusion

The built-up area and population in Taiwan both grew between 1995 and 2008 (Section 8.4.1 and Section 8.4.2). However, the built-up area expanded faster than the population growth in general (Section 8.4.3). The expansion of built-up areas, though to some degree agrees with planning (Section 8.4.5), contradicts the needs to maintain greenfields (Section 6.7.1). It is not consistent with the principle of sustainable development. Furthermore, the projection of population in the future is negative. Therefore, the expansion of built-up area should be strictly controlled.

Although the ratio of population to built-up area decreases in Taiwan, there are regional differences. Most cities in Taiwan and some counties in the North Region have observed higher than average population increases together with the fast expansion of built-up area (Section 8.4.3). The expensive property prices in the city centre may have encouraged this continuous urbanisation (Section 8.5.3). For these local governments, brownfield regeneration may mean encourages recycling of underused land resources more effectively.

On the other hand, the populations in the counties with more rural areas in the Central, South and East Regions are slightly decreasing while the built-up areas are still expanding (Section 8.4.3). For these local governments, out-migration may result in some vacant and derelict properties in the existing built-up areas, while new establishments were built on undeveloped areas (Section 8.5.3). Brownfield regeneration may focus on reclaiming the abandonment properties in the town centre. For the derelict land in a rural location, allowing them to return to greenfields may be a better option. Overall, greenfield development should be further restricted.

Therefore, in the next chapter, I examined the effectiveness of *Soil and Groundwater Pollution Remediation Act*, the regulation already in place to deal with the recycling of 'brownfields' perceived by Taiwanese.

Chapter 9 The Effects of Brownfield Definition on Dereliction in Taiwan

The cities in Taiwan have become more compact, while the built-up areas in the counties have spread much faster than the population growth (Section 8.4.3). This led to the conclusion that to preserve the greenfield land in Taiwan, the brownfield regeneration policy should encourage using brownfield recycling in the counties.

The understanding of brownfields in Taiwan is different from that in majority of countries with high population densities (Section 5.4.3). A site polluted by industrial practice is generally understood as brownfields in Taiwan. In Taiwan, specific contaminants detected on land have been one pre-requisite to be designated as a polluted site.

Brownfield regeneration has been considered a tool to prevent sprawl. However, regulations dictating the management of the polluted sites in Taiwan were believed to hinder the progress of brownfield redevelopment (Section 1.1). No comprehensive analysis has been conducted on the overall condition of the vacancy of the designated polluted sites in Taiwan. This chapter, therefore, investigates the status of the designated polluted sites in Taiwan, to understand the effects of the designation on the chances of a site being vacant.

The result of the investigation indicated that the probabilities of the dereliction of polluted sites between cities or counties were not significantly different. Factors such as the regions, the previous land uses of the sites, and the attitudes of the local governments towards designating a site as polluted may be more relevant in determining whether a site is in use or not.

Therefore, the designation of polluted sites has not significantly contributed to the sprawl of the built-up areas in Taiwan; neither has the designation been sufficient to achieve the objectives of brownfield regeneration. Additionally, the influences of regional variations in previous industrial practices and the effects of the implementation by the local governments have outweighed the regulation itself on the polluted land recycling. These differences should be addressed in the strategies of reclaiming the polluted sites in Taiwan.

9.1. The Perception of Brownfields in Taiwan

The general perceptions of brownfields in Taiwan were often linked with the presence of industrial pollutants. The planning studies in Taiwan discuss the stigmatisation of the brownfields as a result of industrial contamination (for example, Yung, 2004; Dun, 2006; Lin, 2006 and Yung, 2006); environmental engineering studies consider remediation as the major challenge of brownfield regeneration; communities care about the compensation they may receive from the environmental and health impact of the contamination (Huang 1994, Lee, 2010).

These impressions were reinforced by the reporting of several infamous cases, including the An-Shun factory (Huang, 2008) and the RCA Taoyuan factory (Huang, 1994). The proposed redevelopments ceased because of the contamination on these two sites. These two cases are also significant in terms of the types of the contaminants, the scales of the impact to the vicinities, and the allocation of the liabilities. Because of these, the two cases were reported by various news media in Taiwan. For example, between 1995 and 2009, hundreds of news items about the An-Shun and the RCA have been reported in the four newspapers published by the China Times Group (Table 9.1). The group has been one of the major news publishers in Taiwan since 1960s. The four publications in the archive include the *China Times*, the *Commercial Times*, the *China Times Express* and the *China Times Interactive*. The *China Times* newspaper was first published in 1950 in Taiwan. It remains one of the major newspapers until to date. The *Commercial Times* newspaper started in 1978. This was the first and leading newspaper specialising in analysing the industrial and financial aspects of the news relevant to Taiwan. The *China Times Express* was an evening newspaper. It has been replaced by the internet real time news report '*China Times Inter-actives*' in 2006. Therefore, the archive covered various perspectives of the reports targeting different audiences. Most of these news items are related to the pollution. These items also reflected how the public was told about 'brownfields' or the polluted sites in Taiwan. Based on these news reports and other reports or research, the site histories are reviewed in this section to reflect how stakeholders have shaped the management of the sites.

Table 9.1 The News Items Obtained from Keyword Search

Newspapers \ Sites	An-Shun	RCA
China Times (CT)	*290*	*104*
Commercial Times (ICT)	*13*	*19*
China Times Evening News (CTEN)	*11*	*26*
China Times Interactive (CTI)	*1*	*1*

9.1.1. The Review of News Reports

The news reports reviewed in this chapter were obtained from the China Times Group archive using the key words 'An-Shun' and 'RCA'.

The news items listed in Table 9.1 were further sorted into one of the seven issues that often associated with brownfield redevelopment (Table 9.2). Irrelevant news items were eliminated at this stage.

In the case of the An-Shun factory, each perspective was relatively evenly reported. In the case of the RCA, the reporting of the opinions of public and communities (31%, 25 out of 80) outweighed other perspectives. The extent of contamination (19%, 15 out of 80) was second frequently reported. These two perspectives occupied 50% of the news reports.

Table 9.2 The Criteria and Screening Results

Classification	Criteria	Newspapers	Au-Shun	RCA	Total
Contamination	• *Significance of the Contamination on Environment and Public Health* • *Type of Contaminants* • *Site Investigation*	***CT***	*51*	*11*	*62*
		ICT	*1*	*0*	*1*
		CTEN	*1*	*4*	*5*
		CTI	*0*	*0*	*0*
Remediation	• *Methods of Remediation* • *Institutional Control* • *Measures in Restoring Public Health*	***CT***	*49*	*5*	*54*
		ICT	*0*	*0*	*0*
		CTEN	*1*	*0*	*1*
		CTI	*0*	*0*	*0*
Enforcement	• *Government's Action or Inaction.* • *Government's Policy Declaration.* • *Public Opinion (mostly academia) on Policy*	***CT***	*21*	*4*	*25*
		ICT	*0*	*0*	*0*
		CTEN	*3*	*2*	*5*
		CTI	*0*	*0*	*0*
Public and Residence	• *Opinions Expressed by Public or the Residences* • *Protest Conducted by Public or the Residence on the Contaminated Land Issues*	***CT***	*49*	*18*	*67*
		ICT	*1*	*1*	*2*
		CTEN	*0*	*5*	*5*
		CTI	*0*	*1*	*1*
Liability	• *Whom to be Blamed* • *Who Should or Have Conducted the Remediation*	***CT***	*37*	*7*	*44*
		ICT	*4*	*1*	*5*
		CTEN	*1*	*3*	*4*
		CTI	*0*	*0*	*0*
Brownfields and Land Use	• *Issues of Redevelopment* • *Comments on City Planning*	***CT***	*29*	*2*	*31*
		ICT	*7*	*1*	*8*
		CTEN	*0*	*4*	*4*
		CTI	*0*	*0*	*0*
Others	• *Other News Relevant to the Cases*	***CT***	*26*	*3*	*29*
		ICT	*0*	*6*	*6*
		CTEN	*4*	*2*	*6*
		CTI	*0*	*0*	*0*
Total		***CT***	*262*	*50*	*312*
		ICT	*13*	*9*	*22*
		CTEN	*10*	*20*	*30*
		CTI	*0*	*1*	*1*

CT-China Times
ICT-Industry and Commerce Times

CTEN-China Times Express

CTI-China Times Inter-actives

9.1.2. The An-Shun Factory

An-Shun factory situates in Tainan City, located in southern region of Taiwan. The location is near a wetland habitat that was recently announced to be the eighth national park in Taiwan. The industrial activities on the An-Shun factory had persisted since Japanese colonisation in 1938 until 1982 (the *Commercial Times*, 18 February 2000) long before the importance of wetland habitat was recognised. The industrial practices have left dioxins, mercury, pentachlorophenol (PCP) on site. Over time, the pollutants also entered the food chain through natural processes and agricultural practices. The dioxins have resulted in the greatest concerns to date. The blood concentrations of dioxins in some of the residents nearby reportedly have set a world record. In the survey conducted in 2009, the concentration ranged from 6.9 to 951.0 pg WHO98-TEQDF/g lipid (Center for Environmental Trace Toxic Substance, National Cheng Kung University, 2009).

The ownership of the site changed many times throughout the period of the industrial uses. In 1938, the Japanese established the factory for the productions of Alkali-Chlorine and related chemicals. Mercury was used in the process of the productions. After World War II, the factory was transferred to the Taiwanese government. In 1946, a government-owned company, Tai-Chien, started to run Alkali production on site using renovated facilities. During 1960s and 1970s, the establishment was a landmark for economic prosperity (TEPA 2009a). At the time, the factory was also the biggest PCP producer in the South East Asia (Huang, 2008). The PCP production ceased in 1980 because of the serious pollution issues but with some 5,000 tons of PCP still stored within the factory (Huang, 2008). The entire factory was shut down in 1982 out of economic considerations (TEPA 2009a). In 1983, the ownership of the site was transferred to the China Petrochemical Development Corporation (CPDC) as the result of several reorganisations of government-owned businesses. In 1995, the CPDC was privatised after government sold majority of their shares in the stock market.

The site was designated as Remediation Site in 2004 after the promulgation of the *Soil and Groundwater Pollution Remediation Act* in 2000. Because of the complex ownership transitions, the liabilities of clean up and compensations have been fought in the courts. Meanwhile, remediation and compensations were made by the local government (The Tainan City Government). The degree of compensation was based on the dioxin blood concentrations of the residents. In addition, the Department of Economy in Taiwan collected 1,300,000,000 New Taiwan Dollars (approximately £26 million) to aid medical care for the affected communities. In 2005, the high court ruling indicated that the CPDC should succeed the financial liabilities of the remediation and the compensations made by the local government. The court also ruled that the company is liable for further clean-up of the site. After the appeal in 2007 failed (Supreme Administrative Court, ruling number 01953 and 01954 in 2007), the CPDC have submitted a two-phase remediation plan that cost 165,000,000 new Taiwan dollars for approval. The company aimed to complete the clean-up within 15 years.

Although the plan has been approved by the government, this proposal was not entirely agreed by some scholars who initiated the investigation of the pollution. They worry about the secondary contamination during the clean up process, and suggested the contaminants remain on the site for the time being (Huang, 2008). By contrast, the local authority's attitude was that everything needs to be done in accordance with the approved plan and the timetable. The local authority will fine the company if the remediation is not conducted accordingly (the report 'the lament of Luerhmen', the Health Magazine, vol. 57, 01 August, 2003). This position remained up to date as presented in the Taipei International Conference 2010 by the Director-general of Environmental Protection Bureau of Tainan City. My visiting during October 2010 saw the pilot phase of remediation on site. The approved plan has been implementing regardless of the controversy.

In the news archive, the reports related to the An-Shun started in 1995 (Figure 9.1). The *China Times* first reported that the site have been derelict for years, and suggested that the redevelopment of the site should be accelerated (14 July, 1995, the *China Times*). Eight following reports, however, described the contamination in the area. Additionally, another report in 1996 in the *China Times* portrayed the contrast of site between current dereliction and previous prosperity. No mention of redevelopment again until 2002 (Figure 9.1).

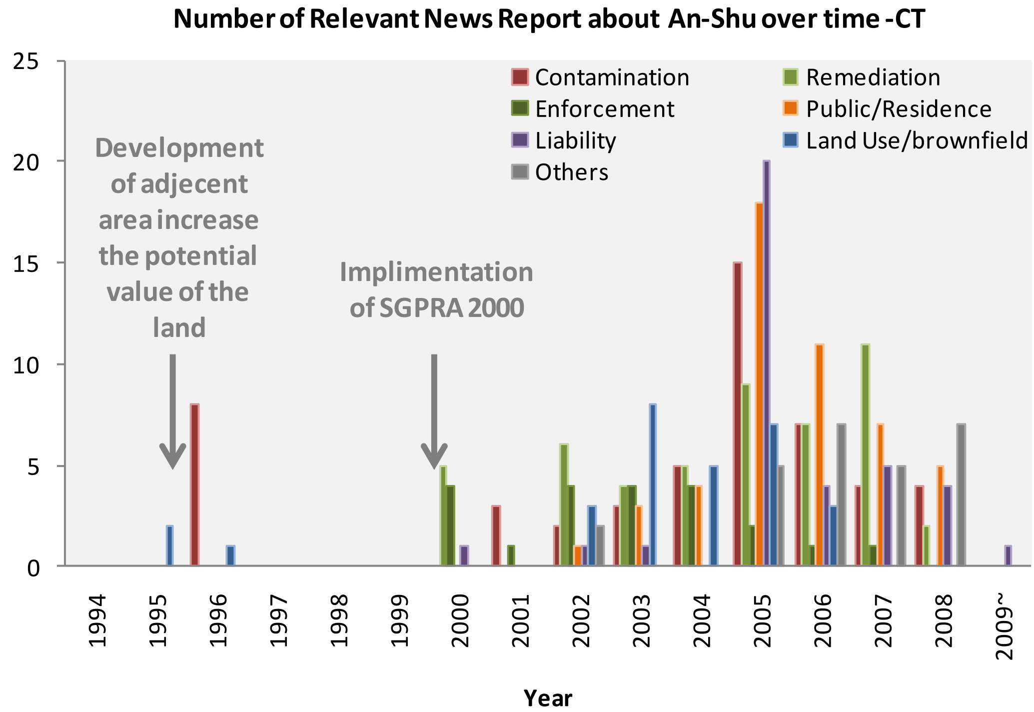


Figure 9.1 The Number of News Reports Appeared in the China Times News Archive on the An-Shun Sites

In 2000, the SGPRA was promulgated and the reports about An-Shun reappeared (Figure 9.1). The remediation, enforcement were discussed at first and considerable amount of the reports in these perspectives maintained for several years. The news discussing the potential of redevelopment and the reports of local resistance surfaced in 2002.

The number of reports peaked at 2005 and gradually faded away. The decrease coincided with the announcement of the 13 billion New Taiwan Dollars programme (roughly £26 million) funded by the Department of Economy (one of the potential responsible parties) to run a compensation and rehabilitation plan (TEPA 2007b, TEPA 2009a). The compensation plan was first addressed in the *Yearbook of Soil and Groundwater Remediation* by the TEPA in 2007. The article in the yearbook was the first full summary of the site published by the TEPA despite the remediation and the institutional controls have been implemented for more than 5 years. In the previous yearbooks, the status of the An-Shun site was only documented in a chronology table accompanied with several sentences.

In the *Commercial Times*, the reports relevant to An-Shun only appeared after 2000 and the number of the reports was much fewer than the *China Times*. These reports specifically addressed the liabilities and potential for the future developments (Figure 9.2). This suggested that after the promulgation of the SGPRA in 2000, there were hopes that the liabilities could be sorted out based on the law so that the cost of redevelopment can be evaluated. This makes the assessment of the cost and benefit of redevelopment plausible. The relevant news items reappeared after 2005 when the compensation plan of Department of Economy was announced. This could be viewed as another milestone that the actual amount of compensation was settled and the public resistance was weakening. The uncertainty of redevelopment reduced. Therefore, the business sector started to consider the possibility of redevelopment. The situation of this site is also relevant to the evaluation of the financial conditions of the current owner, CPDC. CPDC is one of the major petrochemical companies in Taiwan.

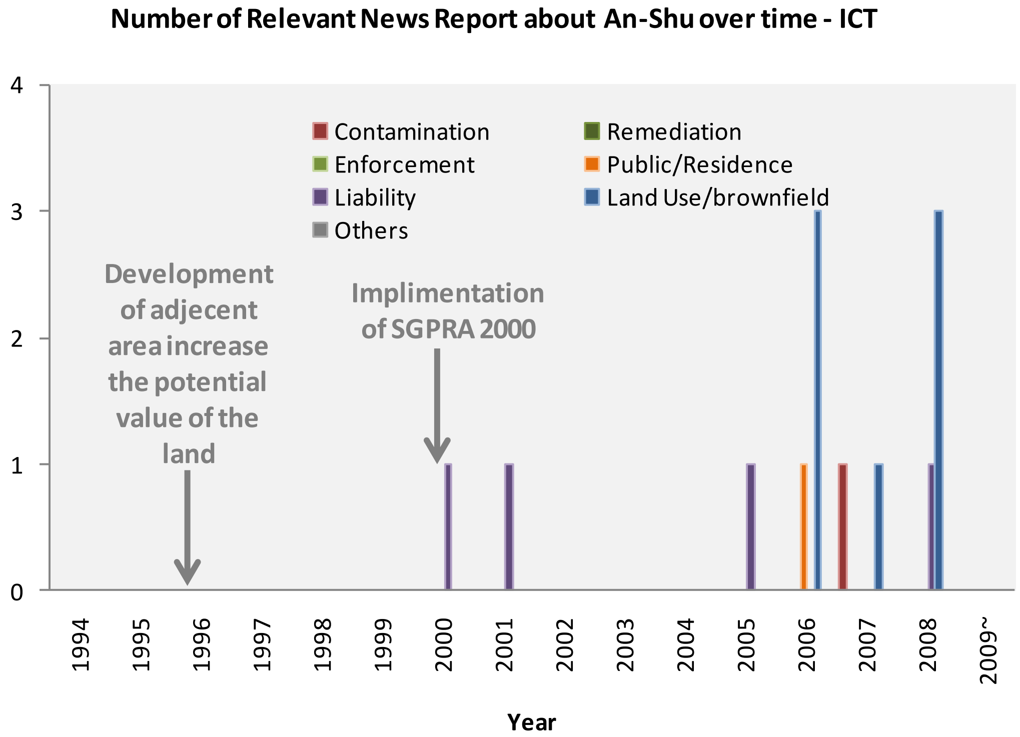


Figure 9.2 **The Number of News Appeared in Industrial Commerce Times News Achieve on the An-Shun Sites**

9.1.3. The RCA Factory

The case of the RCA factory in Taiwan is almost equivalent in notoriety to the 'Love Canal' cases in the U.S. (Huang 1994). Many news reports and quite a few pieces of research used this case to illustrate the impacts of industrial pollution to the communities as well as the workers on site (Huang, 1994).

The site was located in the Taoyuan County, in the Northern Region of Taiwan. In 1970, the Radio Company of America (the RCA) built a factory on the site for the production of TV remote controls (Huang 1994, TEPA 2009a). The company merged into GE in 1986, and then was bought by a French company (Thomson) in 1988. The production continued during the transactions of the assets. In 1992, the land was bought by a Taiwanese developer, who applied for planning permission to change the land use for mixed residential and commercial development.

The issue of pollution was brought up by a legislator, Mr. Jaw, Shao-Kong[11]. He held a press conference on 2 June, 1994 to openly accuse Thompson and GE of dumping toxic wastes on the site and called for government investigation (14 June, 1994 in the *China Times*). The journalist posted the question in the report of this press conference: 'Is there any clean areas left in Taiwan?' Two months later, in the evening post, a report revealed that the purpose of Jaw's press conference was to stop the approval of converting the site from industrial land use to commercial or residential land use.

The pollutants in this site according to the official documents, however, were not heavy metals as described in the news reported the press conference in the *China Times* on June 14, 1994[12]. It was chlorinated solvents in the groundwater. The type of solvent was utilised in the electronic industry and chemical industry (The Department of the Environment, 1996). This group of chemicals is one of the prevalent causes of contamination in Taiwan (TEPA, 2009a).

[11] He was the minister of environmental protection administration in Taiwan in between 1991 and 1992.
[12] Heavy metals, however, could be the potential pollutants in an electronic works (The Department of the Environment, 1996).

Not only was the development project on-hold after the expose of the pollutions on site, but also the protests and the legal actions were initiated. The companies who had operated on the site were accused damaging the health of communities in the vicinity and the workers who worked in the factory. In 2004, the *China Times* reported that the workers who worked for the RCA were suing the RCA for the liability of damaging their health without providing proper health and safety measures during the operation. However, not until 12 November 2009, for the first time, the court called one of the workers diagnosed with cancer to be a witness (Taiwan Environmental Information Center, 2009). The lawsuit is still an on-going even to date. However, the developer bore the liability of remediation.

While the development on site has been on hold, development in the adjacent areas was on going. In 2007, a county councillor indicated that the site had been derelict for a long time (May 3, 2007, *the China Times*). In the same years, local communities exclaimed they need a proper road wide enough for fire drill to access their residential establishments (June 6, 2007, *the China Times*). This showed that the public facilities were not properly planned to accommodate the growing communities. Whether the on hold redevelopment of RCA site played a role on the poor development of road system was not clearly addressed. However, a search on the Google map demonstrated that the density of the road is significantly lower near the RCA site compare to other areas in the vicinity (Figure 9.3).

Figure 9.3 The Aerial Photography of the RCA Site and the Vicinity (The blue line circled the boundary of the RCA Site based on the description of TEPA website http://sgw.epa.gov.tw/public/0602_RCA.asp)

The site was designated as a 'Control Site' in 2002 in accordance with the SGPRA promulgated in 2000. Under this designation, the land transaction is allowed. In fact, the RCA could have been the first and the only case to date that stakeholders have attempted to incorporate remediation into the redevelopment process (information obtained from interview with Mr. Cheng, the original content is inserted in Appendix D). However, in 2002, the developer experienced financial problems. As the site was one of the securities for the developer's loans, the ownership of the site was therefore transferred to the bank (August 6, 2002, the *China Times*). In 2004, because the initial remediation did not fulfil the regulatory requirement, the site was further designated as a 'Remediation Site'. The land transaction became forbidden by law.

The media started to follow the situation of RCA on 1994 after Jaw's press conference. This was three years after the land was sold to the developer. The reports before 2000 were mostly relevant to the protest from the public and communities, discussion of contamination and the lack of enforcement on industrial pollution (Figure 9.4). The discussion of liability and brownfield redevelopment appeared after the promulgation of the SGPRA 2000. In fact, the case of RCA facilitated the establishment of SGPRA regime (January 14, 2000, the *China Times*).

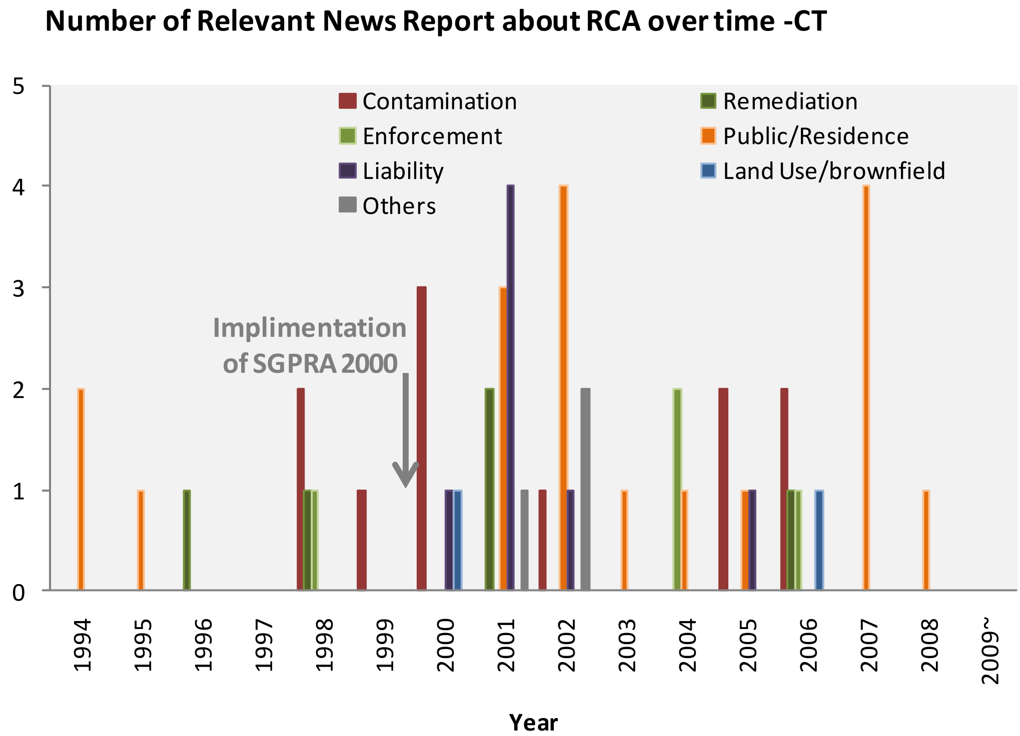


Figure 9.4 The Number of News Appeared in *the China Times* News Achieve on the RCA Site

Beside the effect on the lawmaking, the RCA also became the case that was most often mentioned when discussing industrial pollution. For example, the film *Behind the Miracle*[13] documented the psychological effects of the inappropriate industrial practices on the workers along-side with the taking-off economy in Taiwan. The communities who protested the plan to install a new waste transferring station used

[13] The film was directed by Mr. Tsung-lung Tsai in 2002. It won the Excellent News Award at the same year.

the RCA as an example to argue that the potential contamination will affect public health as well as land prices (08 January, 2008, the *China Times*).

The first three reports mentioned the RCA in 1999 in the *Commerical Times* were not about the site itself (Figure 9.5). One of the news reports showed that the communities in the areas raised concerns over the location where another factory (Morningstar Technology International Corp.) was to be built (22 October, 1999, the *Commercial Times*). Another two news reports promoted waste recycling to protect the environment. The RCA was mentioned as an exmaple of industrial contamination. These illustrated the RCA case has become the icon of the industrial prollution or even the general environmental protection in Taiwan.

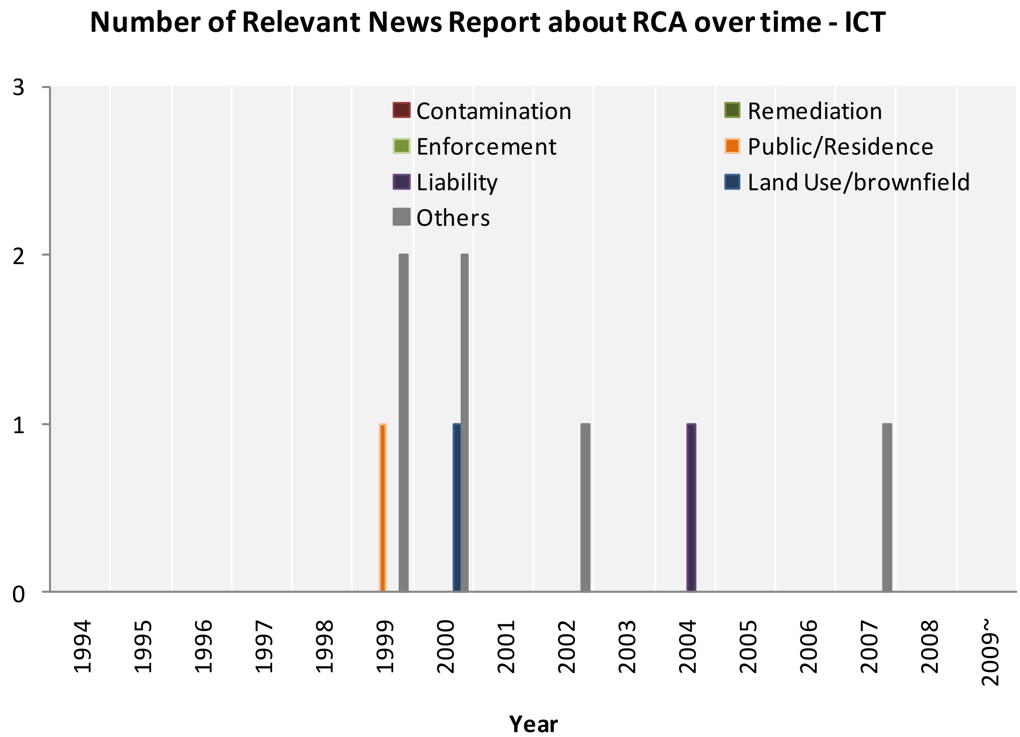


Figure 9.5 The Number of News Appeared in *the Commercial Times* News Achieve on the RCA Site

After the promogulation of SGPRA in 2000, in the *Commerical Times*, the reports of the RCA was mostly about valuation of the land. Possibily, this reflected the consideration of profit gain from the land or properties transaction during the redevelopment process. The amount of profit might save the developers who has been in financial difficulties. One report in 2002 mentioned that the site has potential to be developed into commerical and industrial mixed-use areas. However, there is no forseable development project for the site so far.

9.1.4. The Two Cases and SGPRA 2000

The SGPRA 2000 helped delineate the extent of pollution and enforce the remediation and compensation. The increasing number of news reports started from 2000 indicated the promulgation of SGPRA 2000 created hope for stakeholders to resolve the issues of liability, compensation, and redevelopment for the seriously polluted sites.

However, the SGPRA 2000 prohibits the land transaction for the seriously polluted sites. This could result in financial difficulties of owners or responsible parties. To complicate matters, the SGPRA 2000 required a significant percentage of profits obtained from the redevelopment of polluted sites if the remediation standards are site-specific[14]. The related Article has stimulated many discussions regarding the redevelopment of the polluted sites among the administrations, developers and polluters. The article was one of the examples that the regulation aimed for punishing the polluter rather than promoting the reuse of contaminated land (Bell & McGillivray, 2006). The same attitudes can be observed in the ways the Taiwanese view industrial pollution. The liability of remediation and compensation is the major concern.

Moreover, the reporting of the two pollution cases in the *China Times* and the *China Time Express* seems to promote a general perception that any industrial developments to communities are the potential threats of public health and land values. The speculation affected some development cases unrelated to the reported sites. This reflected the power of the news reports over the public perception.

On the other hand, my experiences have been that the news media usually are interested in the cases considered extraordinary in terms of conflicts between the parties involved as well as considered scandalous, tragic or dramatic. It is unclear

[14] The updated Act was promulgated in 2010. Because the sites reviewed here and listed in the TEPA database were designated before 2010, the discussion here was based on the old regulations.

whether the serious conditions such as these two cases applied to most of the designated polluted sites under the SGPRA regime.

Moreover, the information provided in the reports might not always be correct. As demonstrated in the case of the RCA, the contaminants were incorrectly reported (Section 8.1.2, the mistakes was made in *China Times*, 2 June, 1994), and the rhetoric but rather irrelevant questions that may stir the emotions was put into the reports. This view may be further verified by many critics on the ways Taiwanese media portrayed the earthquake, tsunami, and nuclear crisis in Japan in 2011 (The *China Times Interactive*, March 16, 2011).

This chapter investigated whether the use of the designated polluted sites in general has been hindered as two of the most reported cases showed given the areas contaminated by industrial practices are perceived as brownfield sites in Taiwan. The types of the polluted sites (Section 9.2) and the relevant regulations (specifically, SGPRA) (Section 9.3) are reviewed before the statistical analysis on the designated polluted sites are conducted (Section 9.4, 9.5).

Based on the results of the investigations, whether the sprawls observed in Chapter 8 can be resolved by the implementing SGPRA 2000 is discussed (Section 9.6).

9.2. Types and Conditions of Polluted Sites in Taiwan

The TEPA categorised the polluted sites in Taiwan into six types: agricultural land, factories illegal dumping site, gas station, storage tank and miscellaneous. The majority of polluted agricultural sites in Taiwan were the result of industrial wastewater discharge (TEPA, 2009b). The pollutants detected on the farmland are mostly heavy metals. Therefore, although the agriculture sites are not considered built-up area, they were included in the analysis of this chapter. Nevertheless, the summary in this section focused on the other five types of polluted sites and their chances to become derelict. The information of the sites was mainly obtained from the website of the TEPA (http://sgw.epa.gov.tw/public/)[15].

[15] The summary was mostly digested from the description in Chinese on the internet, but there was an official English briefing on the polluted sites in http://sgw.epa.gov.tw/public/En/index.htm.

9.2.1. Factories

The factories with perceived or actual contaminants have been the sites considered brownfields by the TEPA (TEPA, 2009c). The TEPA suggested there were about 30,000 factories that have ceased operation with high pollution potential to date.

On the other hand, the turnover rate of land that used to be factories is high (TEPA, 2009c). Some of them were reused for different industrial practices; some of them were converted into the commercial or residential establishments and became part of the expanded urban areas. Several recently discovered polluted sites resulted from the previous industrial practices were already blended into urban landscape (24 March, 2010, *The Liberty Times*). The RCA site was also planned to be redeveloped as commercial and residential establishments before the issues of pollutions were brought to attention.

The TEPA has investigated soil and groundwater quality near some of the factories. The systemic investigation of heavy metals in soils was initiated in 1983 long before the promulgation of SGPRA 2000 (TEPA 2009b); the investigation of petrochemicals or chlorinated solvents, however, was not started until the promulgation of SGPRA 2000 (TEPA 2009c, TEPA 2009d and TEPA 2009e). Via the proactive investigation, the TEPA hoped to raise the awareness of the liability of pollutants left on the sites amongst interested parties, such as banks and potential buyers.

To conduct an effective investigation into old factories is difficult as the documentation of operations is often incomplete. Moreover, it is quite common that the ownerships of these sites has changed many times. Additionally, after the complex transactions of ownership, a site could be owned by many people; obtaining the consensus among all parties to access the sites can be problematic. Therefore, the investigation to date only was completed for the prioritised locations. There has been no comprehensive statistics regarding the extent of pollution of the estimated 30,000 factories (TEPA, 2009c), neither the comprehensive survey on the land uses after the factories ceased to operate.

As of 25 November, 2010, eighty-one polluted sites were identified to be affected by factories previously or currently operated on sites (checked the website http://sgw.epa.gov.tw/public/0401.asp). Eleven of the sites were delisted (TEPA website http://sgw.epa.gov.tw/public/0401.asp) after the completing the remediation.

9.2.2. Illegal Dumping

Illegal dumping co-existed with the industrialisation of Taiwan. The act of dumping externalises the cost of waste treatment and disposal. The dumping was conducted in various forms: discharging wastewater without permits, dumping by-products on the land of factories without proper pre-treatment or containment, or dumping the industrial wastes to some remote locations (TEPA 2009d). The dumped materials could be contained in bottles, bags or without any form of package. Since the dumping was not conducted based on proper safety procedures, no maintenance or monitoring in place. Therefore, dumped materials are highly likely to affect the soil and groundwater.

Between 1999 and 2002, the TEPA conducted an exhaustive investigation on the areas where dumping could potentially happen. As the result, one hundred and seventy-five locations were listed as previously illegal dumping sites (TEPA 2009d). As of November 25, 2010, fourteen of these dumping sites were designated as the soil and groundwater polluted site in the TEPA database. One of the sites has been delisted (checked the website http://sgw.epa.gov.tw/public/0401.asp).

9.2.3. Gas Station and Storage Tank

Leakage of storage tanks in gas stations or petrochemical factories are one of the major sources for soil and groundwater contamination in Taiwan. The gas stations are distributed sporadically in Taiwan, while the petrochemical factories have been concentrated in the souther part of the island. The TEPA estimated there are more than 10,000 underground storage tanks operated by the gas stations in Taiwan. Additionally, more than 3,000 large storage tanks were located in the petrochemical factories in Taiwan (TEPA, 2009e).

Between 2001 and 2009, the TEPA comprehensively investigated the storage tanks in Taiwan to screen for any contaminants resulted from the leakage of the storage tanks and the related pipelines. As a result, sixty-five of the gas stations and 7 of the large storage tanks have been designated as polluted sites (the database can be located at http://sgw.epa.gov.tw/public/0401.asp, last check on Dec. 1, 2010). Additionally, there were already 11 gas stations and 1 large storage tank delisted after the result of remediation approved by the administration.

Similar to the situations of the factories (Section 9.2.1), the transitions of the ownerships of gas stations were often complex. Consequently, the documents of original pipeline installation and subsequent alterations might not be well preserved. Not only does this cause problems of allocating liabilities, but this also result in the difficulties of identifying potential hot spots. Additionally, some business owners would manipulate the soil and groundwater conditions right before the TEPA personnel enter the sites for investigations. Therefore, the existence of soil and groundwater contamination might be masked.

9.2.4. Miscellaneous

There was no description regarding the types of sites would be categorised as 'miscellaneous' by the TEPA. Besides factories, storages tanks and illegal dumping sites, there are many more types of industrial and commercial settings that could cause pollutions in soil and groundwater. A list of industrial profiles and their associated pollutant from the web page of the Environmental Agency of the UK[16] demonstrated the diversity of the practice and pollutants that could likely be in the miscellaneous category.

However, some shared characteristics of the current miscellaneous sites in the TEPA database were observed: While the land uses showed on the aerial photos or recorded by the TEPA varied, the miscellaneous sites were mostly located near industrial establishments or gas stations. Figure 9.6 shows one example that a cluster of miscellaneous sites in the Kaohsiung City distributed among a group of factories. Several factories in this area were also designated as polluted sites. Similar situations were observed among the sites near Hsin-Chu industrial campus. Additionally, no soil pollutants exceeded legal standard in 9 of the 13 miscellaneous sites. Only the uses of groundwater on these sites were restricted; the sources of the contamination are likely to come from the vicinity. These observations suggested that most of the miscellaneous sites were the result of industrial practice in the adjacent areas.

[16] They are DoE Industry Profiles can be accessed from http://www.environment-agency.gov.uk/research/planning/33708.aspx

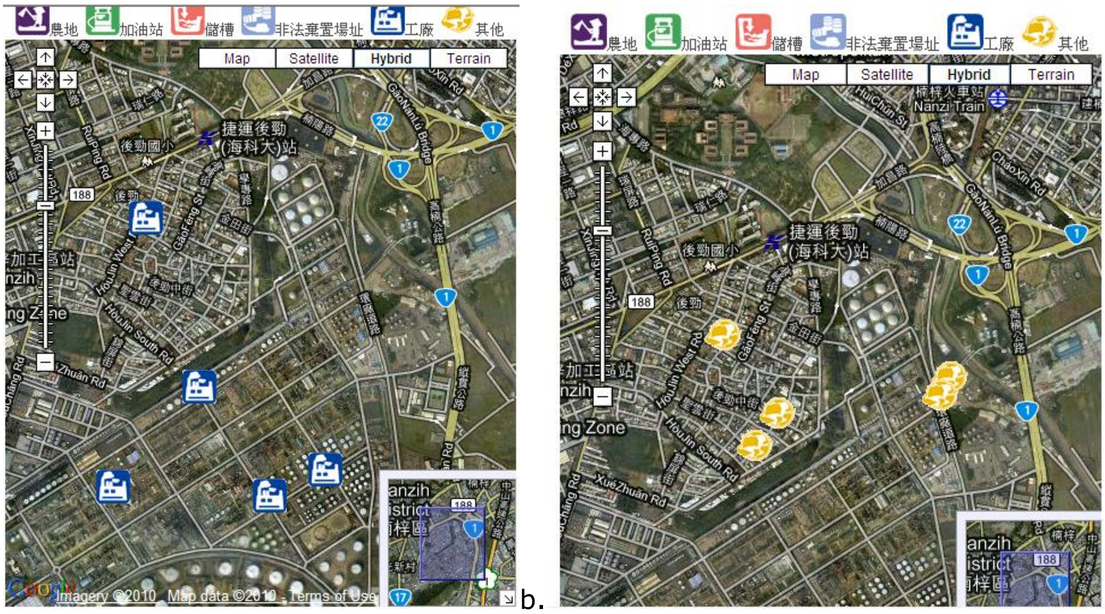
a.  b.

Figure 9.6 The Factory and the Miscellaneous Sites Designated as Polluted Sites in the Kaohsiung City as of November 25 2010. (The search focused on the same industrial park near the intersection between highway number 1 and local motorway number 22. The blue squares in Figure 9.5a indicated the locations of polluted factories and the yellow circles in Figure 9.5b indicated the polluted sites designated as miscellaneous.)

Interestingly, the An-Shun factory was also considered a miscellaneous site. This might be the result of the unique contaminants on site, the liability issues, and the complex site history. It has been the only polluted site in Taiwan designated based on the presence of dioxin that exceed the standard. The contamination was further complicated by the agricultural and aquacultural practices in the vicinity.

9.3. Soil and Groundwater Pollution Remediation Act

Taiwan's brownfield policy has been heavily influenced by the U.S. However, the difference in population density may have made learning from the U.S. unsuitable (Section 5.2). Taiwan and the UK belonged to the cluster of countries with high population densities in ESI 2005 (Section 5.1.2, or Table 6.4). The UK was also one of the countries that first experiencing deindustrialisation and post-urbanisation problems in the world. Therefore, the general trend of regulation of pollution control in the UK and Taiwan are compared (Section 9.3.1).

Moreover, since the concept of brownfield land has been associated with contamination in soil and groundwater in Taiwan. The regulation most relevant to brownfield regeneration in Taiwan would be the *Soil and Groundwater Pollution Remediation Act* (SGPRA). Therefore, this section also reviews the background of environmental law making and the content of the SGPRA regime (Section 9.3.2). The SGPRA was revised in year 2010; however, the discussion would focus on the earlier regulation because it is more relevant to the current designated polluted sites. The regulation of the Contaminated Land in the UK is discussed in comparison to the SGPRA 2000 in Taiwan.

9.3.1. General Trend of Environmental Regulations in the United Kingdom and Taiwan

Figure 9.6 shows the frequencies of the establishment and revision of the legislations (or in the translation of Taiwanese government as 'Act') and statutory instrument (or in the translation of Taiwanese government as 'Regulation') that are relevant to pollution control in Taiwan and the UK. The frequency of establishing legislations reached its highest during early 1990's in the UK. It was most frequent between late 1990s and early 2000s in Taiwan. Using the frequency of law making as an indicator of the importance of relevant issues viewed by a country, there seems to be a 10-year leg regarding the awareness of pollution control in Taiwan in comparison to the UK. It is not until 2000, has Taiwan officially announced the *Soil and Groundwater Pollution Remediation Act* (hereafter referred as SGPRA 2000) (Figure 9.6). The equivalent regulation is *Part 2A of the Environmental Protection Act* (1990), which was inserted by the Environmental Act (1995). However, Part 2A was not formally enacted until 2000 with the publication of associated statutory guidance.

At the level of statutory regulatory instrument, the most active law-making periods of Taiwan and the UK was at about the same time (Figure 9.7). At this period, the UK was mostly revising the relevant technical guidelines (for example CLR10, and SR2), which are not the legally bounding documents, while Taiwan was revising the regulations and drafting technical guidelines simultaneously. Therefore, the progress of Taiwan's environmental law making started later but has been gradually catching up.

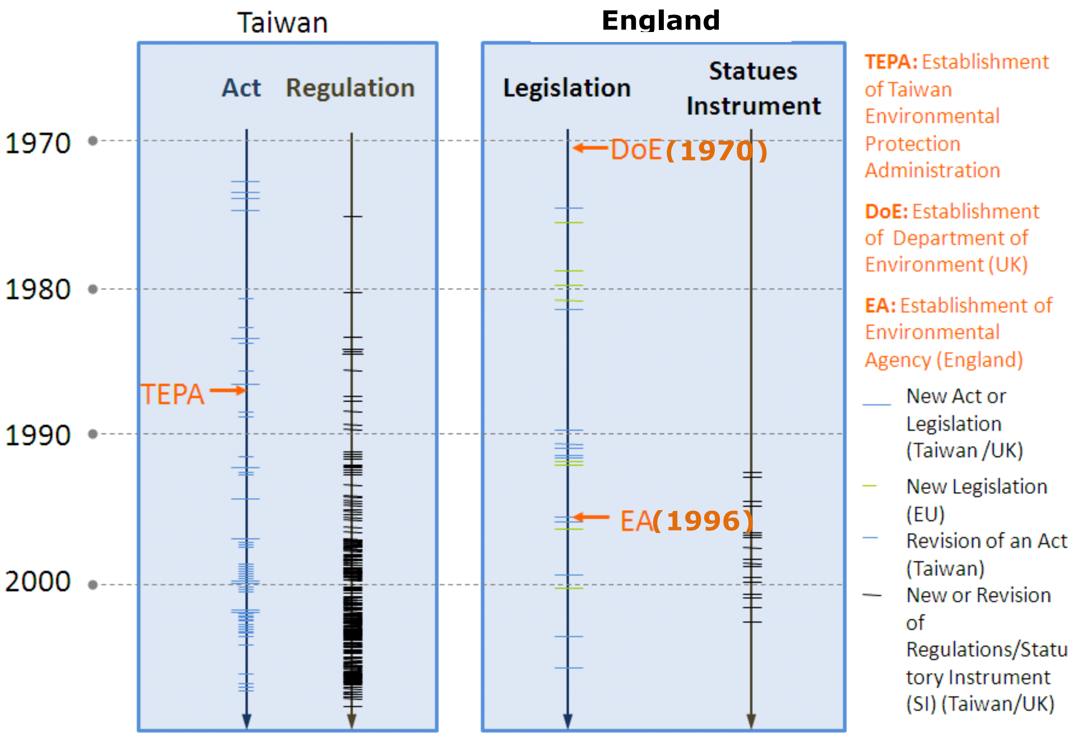


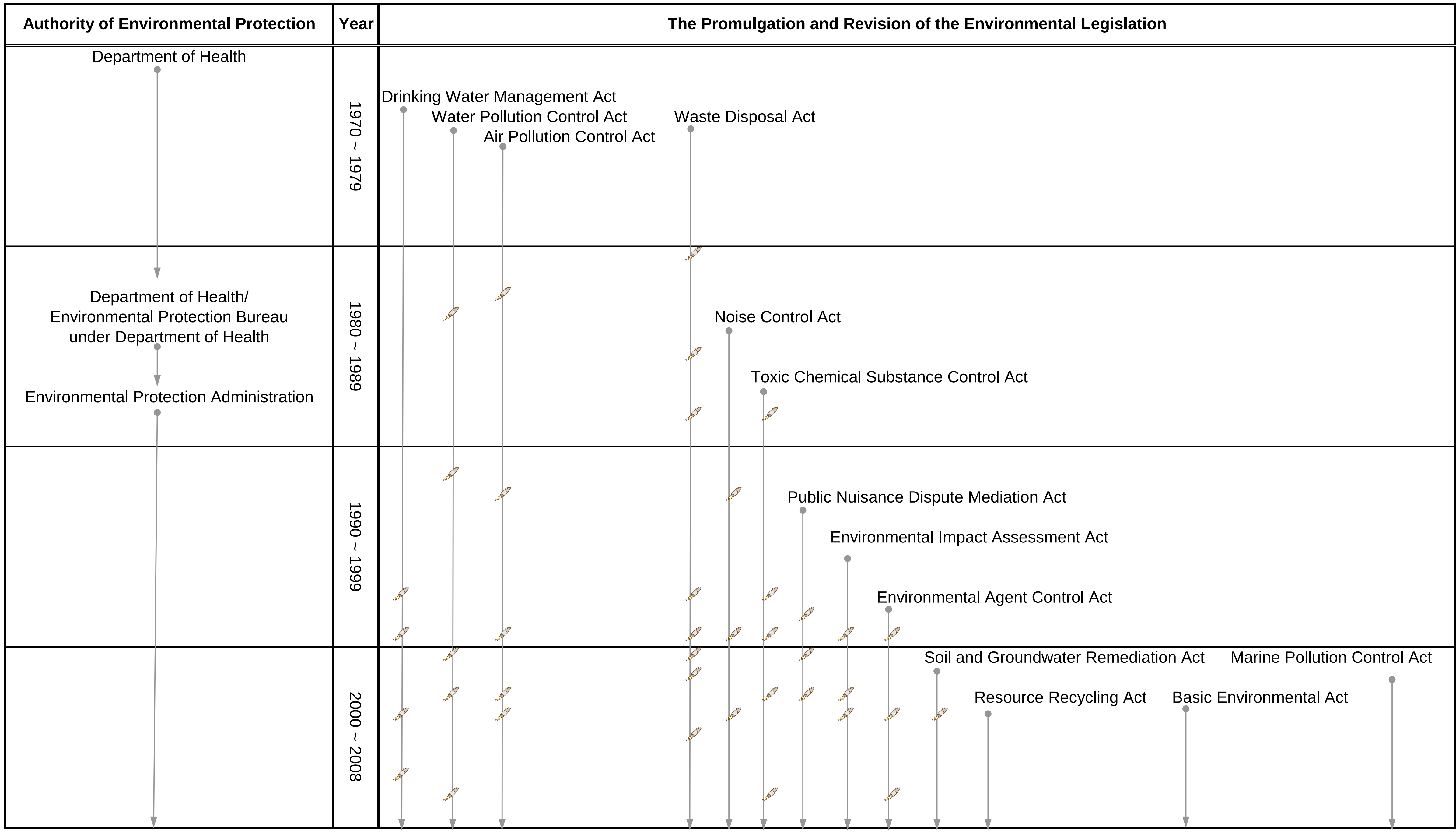
Figure 9.7 **The Frequency of Environmental Law Making in the United Kingdom and Taiwan* (after R.O.C (Taiwan) Environmental Law Library (http://law.epa.gov.tw/ en/) and Stephens, 2007 Table 2.1.**

Regardless of the slower progress, the pattern of environmental lawmaking in Taiwan resembles western industrial countries. It started to make regulations relevant to the public health issue affected by pollution in single environmental media (such as drinking water or air) and gradually moved to the issues of more specialised and integrated problems (such as soil and groundwater pollution or dispute mediation) (Figure 9.8) (Luo, 2006).

The environmental regulatory authority was first under the economic department, then department of health before becoming an independent department (Figure 9.8). In recent years, there has been a discussion that departments such as Environmental Protection Administration, Council of Agriculture, Water Resources Agency and so on should be merged to form a 'Department of Environmental

Resources' in the government. If this happens, it symbolises yet another shift of the emphasis of governmental administration from economic growth to environmental management.

The environmental lawmaking in Taiwan is still in the transition stage between the command and control model and the concept of cost effectiveness (Shaw, 2002). Few economic incentives were given to encourage voluntary action. It heavily relied on technocratic management and administrative control. Only 2 of 13 environment related regulations have declared the objective of pursuing sustainable development.



Number of Law		
Established	Revised	Total
0	0	0
0	0	0
1	0	1
2	0	2
1	0	1
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	1	1
0	0	0
0	1	1
1	1	2
0	0	0
0	1	1
1	0	1
0	0	0
0	2	2
0	0	0
0	0	0
0	1	1
1	2	3
0	0	0
1	0	1
0	0	0
0	0	0
1	3	4
0	1	1
0	7	7
2	3	5
0	0	0
2	5	7
0	6	6
0	1	1
0	0	0
0	1	1
0	3	3
0	0	0

revision of the regulation

Figure 9.8 The Chronology of Environmental Legislation in Taiwan (After R.O.C Environmental Law Library law.epa.gov.tw/en)

9.3.2. A Regulatory Review of SGPRA 2000 and a Comparison between Taiwan and the United Kingdom

Taiwan is demographically and economically similar to Western European countries (Figure 5.4) but Taiwan's current environmental performance is not as good as those countries (Figure 5.5).

In terms of brownfield regeneration policy, the intention of Taiwanese government to borrow the experience from the U.S. was rather obvious. To tackle the problem of groundwater and soil remediation, a foundation under TEPA resembled the structure of the Superfund (a.k.a CERCLA) of the U.S was established. TEPA stated that 'This Soil and Groundwater Pollution Remediation Fund was created by consulting the U.S. Superfund, and other similar environmental institutions from European countries [17].' Although 'other European countries' were mentioned, besides the U.S., no organisation with similar structure and intention was observed.

Wang (2004) and Luo (2006) indicated that the SGPRA 2000 aims more to facilitate the remediation of previously polluted land than to prevent future pollution, similar to the CERCLA established in the U.S. in early 80s. Under the SGPRA regime, the regulations (such as *Remediation Site Scope of Pollution Survey*, *Environmental Impact Assessment*, and *Cleanup Priority Ranking Regulations*) and technical guidance (such as the *Evaluation Method and Preparation Guide for Soil and Groundwater Human Health Risk Assessment*) also resembles the Hazardous Ranking System and Risk Assessment Guidance documents under the Superfund regime. Furthermore, for the newly promulgated SGPRA in 2010, government has advised to reference USEPA guidance when relevant statutory instrument or guidelines have not been established or updated (documented in '*The Principles to Follow during the Transition Period after the Promulgation of Revised SGPRA*' announced on 25, January, 2011. The document was obtained from a personal communication with a TEPA staff).

[17] http://sgw.epa.gov.tw/public/En/index.htm, last accessed at 25, March 2011

Despite of similarities in structures and objectives, the context of the SGPRA 2000 does not strongly resemble the superfund regulations. The Act was reviewed and revised in the Legislative Yuan (the equivalent of the House of Commons in the UK) before promulgation. The original drafted articles of the regulation prepared by the TEPA and invited scholars might have undergone significant changes. These regulations might reflect the compromise reached by influential interests groups during the lawmaking process.

The performance of this compromised regulation did not appear to be satisfactory. There are still many criticisms from the industrial sectors as well as the general public. During meetings with a group of British experts in contaminated land reclamation on January 2008, different stakeholders in Taiwan expressed their opinions on the problems of implementing the SGPRA 2000. The lack of incentive to remediate (especially the site with complex liability issues) and the lack of properly trained governmental officials were the two issues raised by most stakeholders (Table 9.3). A more cost-effectiveness approach to encourage land reclamation, and more knowledge input on the relevant field are needed.

The practice or the enforcement of environmental regulations appeared to be the major barriers of the implementation of SGPRA 2000 (Table 9.3). Therefore, I specifically focused on several areas relevant to the difficulties of implementation when comparing the regulations between the UK and Taiwan (Section 9.3.2.1: Determination of Land, Liability, Remediation and Risk Assessment.

Table 9.3 The Barriers Perceived by Stakeholders to Implement the Brownfield Regulations

Problems Identified		***Stakeholders***			
		Government	***Consultant***	***Industry***	***Academia***
Regulatory Issues	*Strict and not Risk Based Remediation Standard*		✓		✓
	Uneven Distributed Environmental Tax Base	✓		✓	
Practical Issues in Government	*Lack of Proper Trained Gov Official to Handle the Contaminated Land Issues*	✓	✓		✓
	Lack of Government Budget	✓			
	Lack of Interdepartmental Consistency				✓
Practical Issues in Industry/ Consultant	*Lack of Incentive to Remediate the Historical Pollution, Remediating the Site that is Currently Operating without Supervision*	✓	✓	✓	✓
	Lack of Proper Site Investigation and Monitoring			✓	✓
Others	*Uncertain About Environmental Liability*			✓	
	The Issues Related to General Public such as Risk Perception and Food Safety				✓
	The Risk of Using Novel Chemicals				✓

9.3.2.1. Determination of Contaminated Land

SGPRA 2000 gives a polluted site one of the two designations. The 'Control Site' refers to the contaminated land that has one or more chemicals exceeding the Soil or Groundwater Control Standard. After being designated as a 'Control Site', the site undergoes a preliminary assessment to determine whether the designation should be change to 'Remediation Site'. The 'Remediation Site' refers to the site on which soil and groundwater contaminants potentially 'endanger public health and the living environment (Article 2 of SGPRA 2000).' Technically, the site should be designated as 'Remediation Site', if the sum of the ratios of chemical concentrations to their corresponding Control Standards exceeds 20 (*Regulations Governing the Preliminary Assessment of Soil and Groundwater Pollution Control Sites*, 2006). This is the most often used criterion in the preliminary assessment.

Environmental bureaus at county or city level are responsible for designating the Control Site. TEPA, the central government authority, is responsible for announcing the Remediation Site after obtaining and evaluating the evidence submitted from the local governments (Article 11 of SGPRA 2000). The major difference in land use between the two designations is that the land ownership of a Remediation Site cannot be transferred (Article 15 of SGPRA 2000). The ban for transaction is believed to hinder the redevelopment process. One such example could be the RCA factory (Section 9.1.3).

For the area where groundwater quality has been compromised by the pollutants, local governments may designate the area as 'Groundwater Use Restriction Area' with specified restriction of using groundwater (Article 21 of SGPRA 2000). The legal status of this designation is equal to the 'Control Site'.

Coincidentally, the UK also has two levels of designation: 'Contaminated Land' and 'Special Site'. The designation of the 'Contaminated Land' should base on the identification of the 'pollutant linkage' and 'significant harm' (78A (2) and 78B of Part IIA and Statutory Guidance Part 4, DERFA 2006) during inspection. After designating a site as a 'Contaminated Land', a local authority should further examine whether the site should be designated as 'Special Site'. In the case of England, the 'Special Site' should be handed to Environmental Agency. The criteria of designating a site as 'Special Site' are mostly based on the land use, including the natural of the water use, the type of industrial facilities on site, the military defense function of the site, and the existence of radioactive materials (Article 7 to 16 in A Guide to the Contaminated Land (England) Regulation, DERFA 2006). Environmental Agency can also proactively change the designation of a site from 'Contaminated Land' to 'Special Site' if necessary (Annex 2, DERFA 2006, pp77).

However, the purposes of the two-level designation systems in the two countries are different. In the case of the UK, the designation of 'Special Site' is base on the convenience of management; some of the conditions are better handled by a central government agent. On the other hand, in Taiwan, the concentrations of contamination were the primary concern of designation unless the location is designated as a preservation area or military basis.

9.3.2.2. Liability

The liability here refers to the responsibility to remediate contaminated site. SGPRA 2000 generally follows the 'polluter pays' principle. If the polluter cannot be traced or cannot perform the proper remediation work, the local governments will take over the remediation work using the funding from Soil and Groundwater Pollution Remediation Fund. The involvement of other interested parties is not essential.

The use of retrospective liability in the environmental regulations are controversial in both countries (Wang, 2004, Bell and McGillivray 2006, Crowhurst and Davidson 2006). To reduce the impact of the retrospective liability, the UK developed a detailed system to allocate the liability within a group of possible beneficiaries from the land resources (Chapter D of Annex 3 in DEFRA, 2006). These tests have also been further clarified after some court rulings (e.g., Crowhurst and Davidson, 2006). On the other hand, in Taiwan, there is no clear rule to allocate the responsibility among interested parties. This can be problematic if the original polluter cannot be traced. This is the case of An-Shun site in Taiwan. The oldest polluters were operating during Japanese colonisation. Since then, the land has been transferred between governmental and private sectors. The liability is very difficult to allocate in accordance with SGPRA 2000. The court ruling for this case does not delegate responsibility among all the stakeholders involved in the events, but allocates responsibility to only one responsible party (Section 9.1.2).

This difference between the two countries might result from the considerations of fairness which the environmental lawmaking was based on. In the UK, it is considered who obtains the benefit from the action of polluting should pay for the remediation (Bell and McGillivray 2006), while in Taiwan, punishing the person releasing the pollutant is the key issue (Shaw, 2002). In Taiwan, the liability could also be attached with considerable amount of compensation and long term health care expanses to the residents in the vicinity.

9.3.2.3. Remediation

In Taiwan, the responsible party should prepare the remediation plan for the authority to approve. After the approval, the remediation action will be ordered by the local government and implemented by the responsible party. The general public may express their opinions about the remediation plan during the review of the plan (Article 19 of SGPRA 2000). The public participation during the remediation process is usually limited.

In the UK, a more complicated system is designed to encourage voluntary remediation. Three types of administrative documents may be prepared under different situations in the phases of remediation of the Contaminated Land or Special Site. Local authority may issue a Remediation Notice to enforce the remediation activities on the Appropriate Person (78E of Part II A). The Remediation Notice should clearly state the 'cost which is likely to be involved', 'seriousness of the harm', 'what is to be done', 'the extent of the remediation', and 'the standard of the remediation'. It also explains the allocation of the liabilities between the responsible parties. Under the condition that the government is responsible to remediate a site, the authority, instead of issuing the 'Remediation Notice', prepares 'Remediation Declaration' to explain what government plans to do to clean up the site. If the Appropriate Persons have taken actions that satisfied the enforcing authorities before the 'Remediation Notice' is served, they should prepare a 'Remediation Statement' to specify the tasks done to clean up the site.

The rule of serving 'Remediation Notice' and preparing 'Remediation Statement' encourages voluntary action since the responsible party could conduct the remediation in the ways that may be more cost effective before the methods of remediation are specified by the government in the Remediation Notice. Therefore, through proactively cleaning up, the responsible party can potentially reduce remediation cost while still achieving the remediation objectives.

Additionally, by specifying the requirement of the consultation prior issuing the Remediation Notification (78H, Part IIA), the exchange between the authorities and responsible parties are more transparent. In Taiwan, although the responsible parties and authorities would negotiate before and after the designation of Remediation Site or Control Site, the exchanges have never been explicitly regulated. Therefore, the authority has power to designate the site with or without consultation.

The content in the newly promulgated SGPRA in 2010 shows that the regulation has moved towards the direction to encourage voluntary redevelopment. An obligation of surrendering 30% of estimated land value after redeveloping a polluted site to the Soil and Groundwater Remediation Fund (Article 46 of SGPRA 2000) can be voided if the developers intending to redevelop the polluted sites and conducted remediation before local authorities prepared for the remediation (Article 51 of SGPRA 2010).

9.3.2.4. Risk Assessment

Risk assessment is an optional procedure in SGPRA 2000. Without conducting risk assessment, a responsible party should clean up a site to the Control Standard.

For the Remediation Site, applying risk assessment to develop alternative remediation goals is only allowed when at least one of the factors specified in Article 17 existed (Article 17). These factors, for the polluters or interested parties are the 'geological conditions', 'pollutant properties' or 'remediation technologies' (Article 17 of SGPRA 2000). For a local government who become responsible for cleaning up a site, these factors may be 'financial situation' and 'environmental situation.' Thus, the financial difficulty is not considered a justifiable reason for the polluters or interested parties to opt for using site-specific risk based remediation standards but it is for the local government. This is another example that the regulation was designed under the idea of punishing the polluters. This could sacrifice the effectiveness of land recycling.

In addition, the SGPRA 2000 allows the alternative remediation goal 'specifically approved by the central competent authority' for 'a land within a Remediation Site to be utilised for land development (Article 17, SGPRA 2000).' Accordingly, the responsible parties have to propose a follow up monitoring and control plan after the remediation. This rule provides the opportunity to use risk assessment to develop a remediation goal if a redevelopment plan is in place. However, this rule has never been applied to any Remediation Sites in Taiwan.

On the other hand, though not explicit, the risk assessment methodology is also allowed to be used as a way to appeal the designation of Remediation Site (Article 11 of SGPRA 2000 and *Regulation Governing the Preliminary Assessment of Soil and Groundwater Pollution Control Site*, 2006). Thus, this is a way to remove barriers for land recycling given the risk posed by the contamination on site is acceptable.

The updated SGPRA in 2010 has allowed risk assessment to be used in additional stages of contaminated land reclamation. The risk-based remediation was once restricted to be conducted only for groundwater and soil under specified conditions. Now, it may be done for preparing control plans and remediation plans for wider range of environmental media such as sediment and surface water.

In the UK, the existence of 'pollutant linkage' is an important indication of Contaminated Land. This is consistent with the principle of risk assessment (no exposure, no risk). Risk assessment is a required process in identifying 'Contaminated Land'. During the investigation process, the principle is applied to investigate whether pollutant linkage exists and can potentially cause significant harm to the designated receptors. The risk assessment could be qualitative or quantitative under the consideration of cost-effectiveness. If, after the assessment, a remediation is required, the result of risk assessment becomes one of the important references to plan the remediation.

In summary, Part IIA of the UK has described the process and the requirement of the designation of polluted sites in detail compared to Taiwanese regulations. The Part IIA regulation is risk-based and cost-effectiveness based. This encourages voluntary action and promotes the 'suitable for use' principle; the principle is frequently applied in countries with high population densities (section 5.4.3). By contrast, Taiwanese regulation emphasises the chain of command, the legally bound numerical standard, and the penalty on who is responsible for the release of the pollution. Although risk assessment procedure is inserted into the regulation, it is optional with many limitations.

The UK regulations encourage using site-specific risk assessment. The land is considered contaminated after the discovery of the site specific 'pollution linkage'. Therefore, there is no specific legal standard of concentration to be strictly enforced. The soil guideline values (SGV) are just values for references. On the other hand, the designation of the polluted sites in Taiwan depends on legally bound standard. If the concentrations of listed pollutants in soil or groundwater exceed the standards, the site is considered polluted. However, no mechanism is established to evaluate the significance of the chemicals that are not listed in the standard. Furthermore, the unlisted chemical usually will not be reported since there is no standard to compare with and there is no 'standard method' to analyse. One such chemical that has been discussed for a while is MTBE, the man-made chemical often detected in aquifer underneath petrochemical factories or gas stations. Overall, SGPRA 2000 is a law applying command and control model. The rules applying cost-effective consideration can be found in the Act but the they are usually optional; the use of the rules are often restricted. Furthermore, the idea of punishing the polluters is clearly expressed in the SGPRA 2000. Because of these, using the regulations to facilitate land recycling is not given sufficient consideration.

9.4. Statistical Analysis

Section 9.1 described situations that the redevelopment of the two seriously polluted sites was on hold because of the uncertainty of remediation as well as complex liability. The promulgation of SGPRA in 2000 did not help facilitate the redevelopment and effectively resolve the issues of liability for these two cases. Section 9.3 reviewed the SGPRA 2000 and summarised the possible hindrances in the SGPRA 2000. To investigate whether the situation of the RCA and An-Shun can be generalised to all the designated polluted sites, a logistic regression is conducted using the databases of polluted sites maintained by TEPA. The regression method, the use of databases, and steps of conducting the regression are described below.

9.4.1. Database of Designated Polluted Sites

The polluted sites listed in the database are designated by the government officials in accordance with SGPRA 2000. The TEPA regularly updates the database. The attribute of the database are summarised in Table 9.4. This database provided a comprehensive list of up-to-date designated polluted sites in Taiwan and their usages upon being designated. The data used in this analysis was downloaded on October 1, 2010.

The objective of this analysis was to identify the factors that affect the probabilities of designated site to be vacant. The identification of the factor may clarify whether the designation of polluted sites contributed to the sprawls in the counties of Taiwan described in Section 8.4.3.

Table 9.4 The Information in the TEPA Database

Attributes in TEPA Databases		Type of Data	Used in Analysis	Data Conversion	Type of Converted Data
English Translation	**Original Chinese Characters**				
Name	場址名稱	*Text*	*No*	-	-
GPS Coordinates	場址坐標	*Numerical*	*No*	-	-
Address	場址地址	*Text*	*Yes*	*The information was used to establish three parameters: Type of Local Governments, Local Authority Names and Regions*	*Categorical*
Parcel Number	場址地號	*Text*	*No*	-	-
The Type of the Site	場址種類	*Categorical*	*Yes*	*The information was used without modification.*	*Categorical*
The Areas of the Site	場址面積(平方公尺)	*Numerical*	*Yes*	*The information was used without modification.*	*Numerical*
Date Designated as Polluted Sites	公告日期	*Numerical*	*No*	-	-
Document Numbers	文號	*Text*	*No*	-	-
Current Designation	場址列管狀態	*Categorical*	*Yes*	*The information was used without modification.*	*Categorical*
The Contaminants	土壤/地下水污染物	*Categorical*	*No*	-	-
Descriptions of Contamination	污染情形	*Text*	*No*	-	-
Summary of Current Condition	場址現況概述	*Text*	*Yes*	*The information was used to determine whether the site was currently in use.*	*Categorical (Binary)*
Additional Notes	重要注意事項	*Text*	*No*	-	-
Remediation Progress	改善整治進度	*Text*	*No*	-	-

9.4.2. The Use of Binary Logistic Regression

The database recorded some numerical as well as categorical descriptions of a polluted site (Table 9.5). The description of current land use of a site cannot be subjectively quantified the intensity of the land use but can be used to determine whether a site is vacant or in use. Since the information of dependent variables is dichotomous, the binary logistic regression became a suitable method to evaluate the relationship between the current land use and other characteristics of a polluted site.

Furthermore, the binary logistic regression makes no assumption about the distributions of the independent variables. The independent variables could be categorical or numerical. Therefore, this method is appropriated to be applied to the database without examining the actual distributions of each variable.

A generalised binary logistic regression model is described below:

$$\log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_0 + \beta_1 x_{1,i} + \beta_2 x_{2,i} + \ldots + \beta_k x_{k,i} \quad \text{(EQ 9.1)}$$

Based on this generalised model, the model for this study was established:

$$\log\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1(type\_a) + \beta_2(type\_site) + \beta_3(authority\_n) + \beta_4(area\_site) + \beta_5(designation) \quad \text{(EQ 9.2)}$$

Where π is the probability of a site being vacant; 'type_a' represents the types of local governments (city or county); 'type_site' refers to the six possible categories of a site (Section 9.2, factory, storage tank, oil station, illegal dumping, agriculture, or miscellaneous); 'authority_n' is the name of the local governments; 'area_site' is the size of the designated polluted site; 'designation' is the legal status of a site (Remediation Site, Control Site or Groundwater Usage Restriction area, Section 9.3.3.2).

Before the regression was conducted (Section 9.5.3), the descriptive land use conditions of the sites in the database need to be converted into a dichotomous type of information: in this study, a site could be either 'vacant (1)' or 'in use (0)'. Then, independent variables were also converted according to the descriptions or numbers in the TEPA database (Table 9.5). Among the independent variables, only the 'area of site' was a numerical parameter. Others were categorical. The reasons for including these parameters in the analysis are listed in Table 9.5. Finally, the converted variables were organised into SPSS spreadsheet to perform the logistic regression. The regression was repeated twice: one with the designated agricultural polluted site, another without.

9.4.3. The Consideration of Polluted Agricultural Land

The agricultural land was not considered a built-up area in this study. Therefore, whether the agricultural land was effectively in use is not relevant to the result observed in Section 8.4.3. Moreover, the contaminated agricultural land was not considered brownfields in all the definitions of brownfields reviewed so far. Therefore, the agricultural land should not be included in the analysis related to brownfield regeneration.

On the other hand, none of the designated polluted agricultural sites in the TEPA database was contaminated by pesticides, nitrate, or nitrite. Most of the designated agricultural land in the TEPA database was contaminated by heavy metals. Therefore, it was highly likely that most of the pollution on agricultural land was resulted from industrial practices, not agricultural practices. Moreover, the Taiwanese government has been in the position to clean up the polluted agricultural land. This was because the source of contamination was not easy to locate and the scale of the contamination was too large for a single private responsible party to handle. Additionally, the farmers whose land was affected have been considered vulnerable. The government has been compensating the farmers while the land is awaiting remediation. Therefore, comparing the results with and without agricultural land might reveal whether the government's attitude has altered when they are in the position to remediate.

Table 9.5 Variables Utilised in the Binary Logistic Regression

	Abbreviation in the SPSS Output	Definition	Natural of the Parameters	Data Organisation	Consideration
Independent Variables	*type_a*	*type of authorities*	*categorical (city or county)*	*The sorting is based on the addresses listed in the database*	*The type of authorities could affect the need for and the attitudes towards reusing contaminated land.*
	type_site	*previous land use of the site*	*categorical (defined by the database)*	*The category was established in the database.*	*The types of sites could leave various impressions (stigmas) and contaminants. These may affect the willingness and the feasibility of using the land.*
	region	*the region (Table 7.1) where the site is located*	*categorical (four regions used in the analysis in Chapter 7)*	*The sorting is based on the addresses of the sites listed in the database*	*Different histories and progresse of regional development could affect the need for land use.*
	authority_n	*the name of authority*	*categorical (names of the authorities)*	*The sorting is based on the addresses of the site listed in the database*	*Each authority could have different considerations and attitudes regarding whether a site is designated as a contaminated site and whether the use of the land should be*
	area_site	*the area of the site*	*numerical (m^2)*	*The size of the area are listed in the database*	*The size of the contaminated site could affect the consideration of using the site*
	status	*the types of designation*	*categorical (type of designations on the contaminated sites based on the natural and the concentrations of pollutants)*	*One of the three official designations is listed in the database for a site.*	*Different designations mean different degrees of liabilities, and seriousness of contamination.*
Dependent Variable	*vacancy*	*current use of the site*	*categorical (vacant or in use)*	*The sorting is based on the descriptions in the database. The intensity of land use is difficult to quantify. Therefore, the parameters are binary.*	*The use of the land is considered the indicator of land use efficiency in this study.*

9.5. Result of Database Analysis

9.5.1. The Summary of the Control Sites

There are three types of designations for the polluted sites in accordance with the SGPRA 2000: Remediation Sites, Control Sites and Groundwater Use Restriction Areas (Section 9.3). The Remediation Site is banned from land ownership transfer while the other two types of sites are not. Furthermore, the degree of contamination is higher on the Remediation Site. The Control Site and Groundwater Use Restriction Areas have similar degree of contamination and similar legal status. Therefore, the Groundwater Use Restriction Areas were treated as Control Sites in this analysis.

As of October 1, 2010, there were 723 Control Sites, and 13 Groundwater Use Restriction Areas in Taiwan. The agricultural land use occupied the largest number among the Control Sites (Figure 9.9a). Most of the agriculture land was located in Taoyuan County and Changhua County (Figure 9.9a and 9.9b). However, the areas of the polluted agricultural land were smaller than the areas of factories or large tank farms (Figure 9.9b).

Among the Control Sites and the Groundwater Use Restriction Areas, the areas currently in use were larger than the areas that were vacant. The ratios of vacant Control Sites seemed to differ among the local governments (Figure 9.9c).

The statistics showed in Figure 9.9 indicates the different ratio of land vacancy could be the result of differences in implementing SGPRA 2000 among the local governments, or the types of land use on sites.

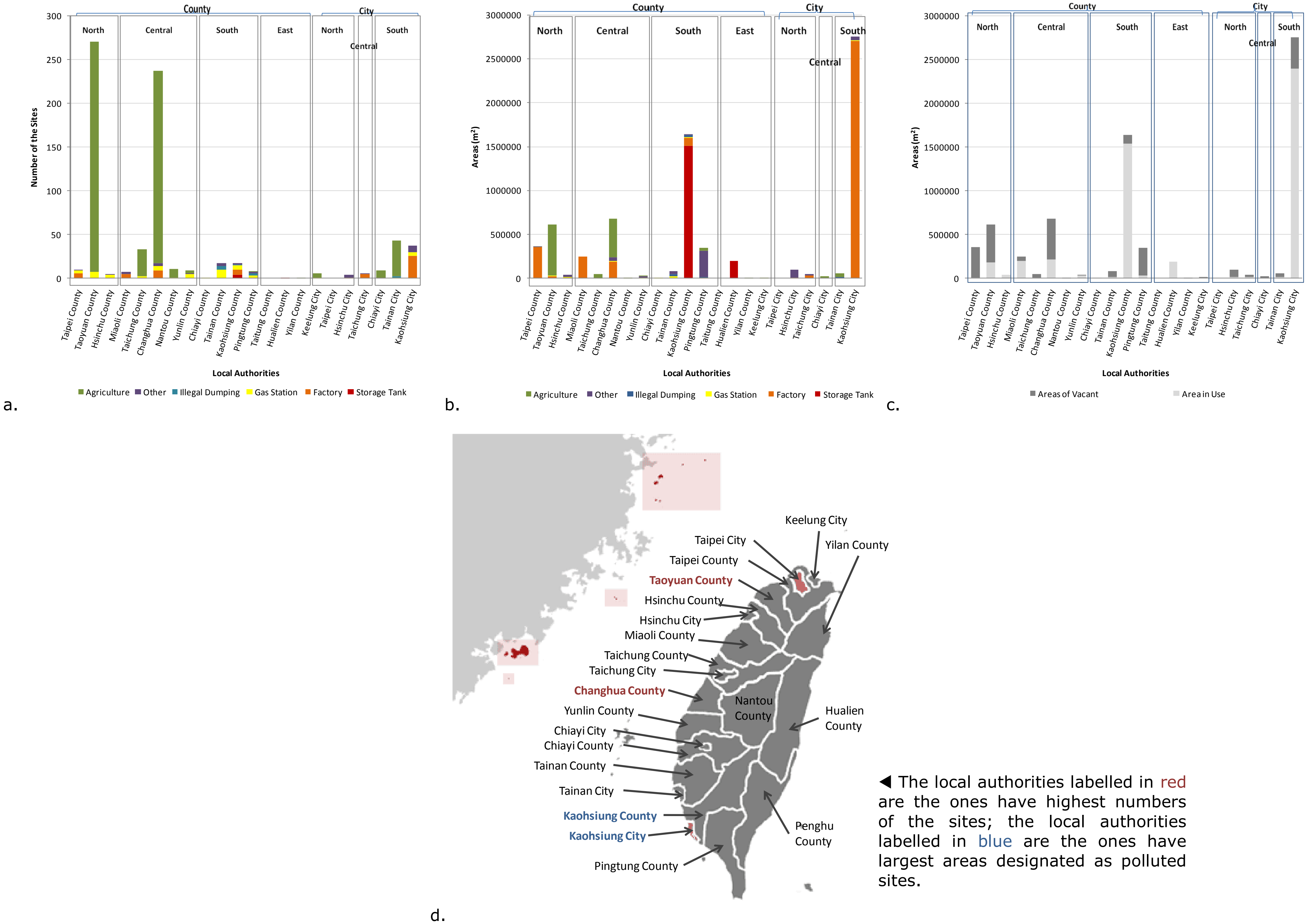
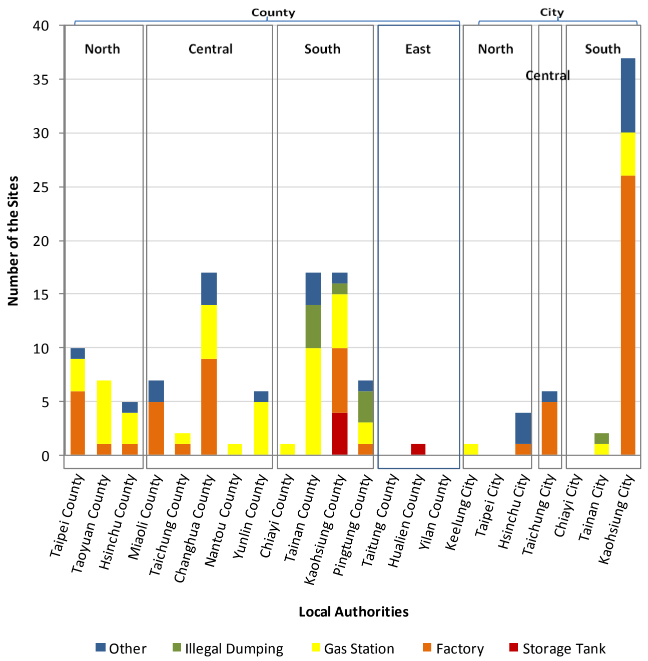
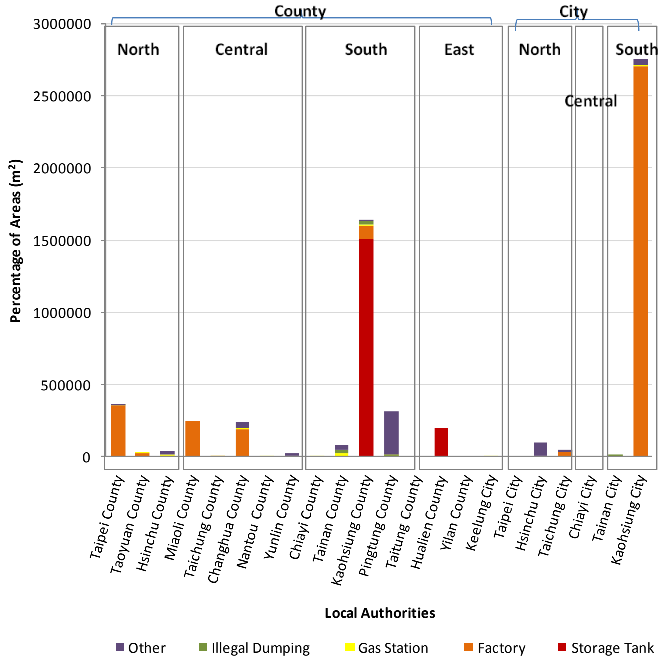


Figure 9.9 **The Distributions of Designated Control Sites**

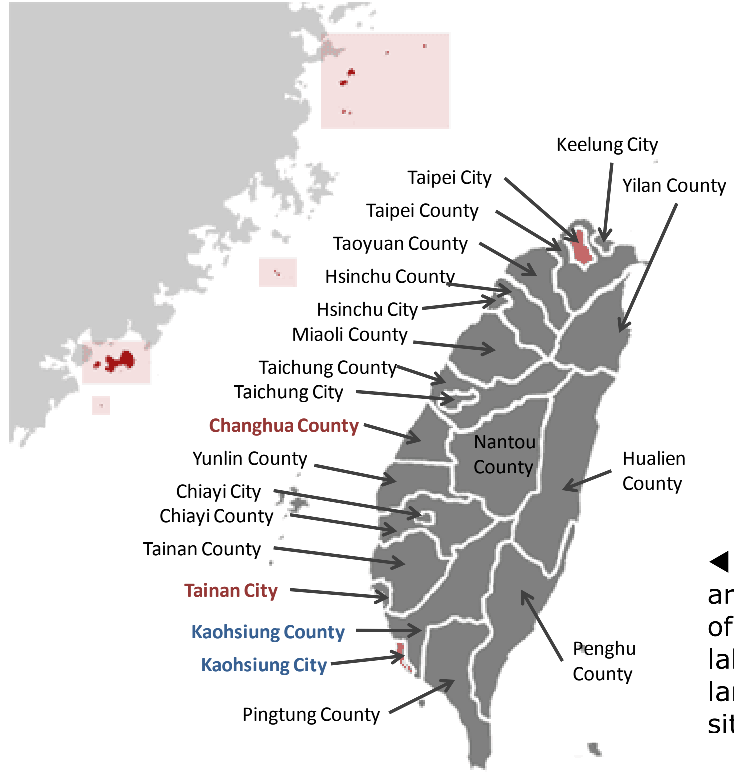
Local governments in the south had more Control Sites and larger polluted areas that are not in agricultural use (Figure 9.10). This was the case for both the cities and the counties. On the other hand, although there were considerable numbers of gas stations designated as Control Sites (showed in yellow blocks in Figure 9.9), the designated polluted factories and large storage tanks occupied larger areas (showed in orange and red in the columns in Figure 9.10). These two types of sites also concentrated in the South Region.



a.



b.



◀ The local authorities labelled in red are the ones have highest numbers of the sites; the local authorities labelled in blue are the ones have largest areas designated as polluted sites.

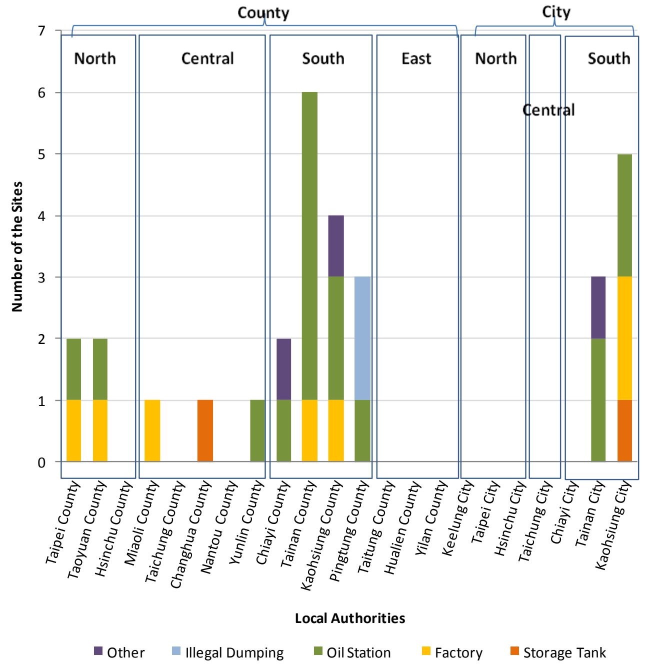
c.

Figure 9.10 The Distributions of Designated Control Sites Excluding Agricultural Land.

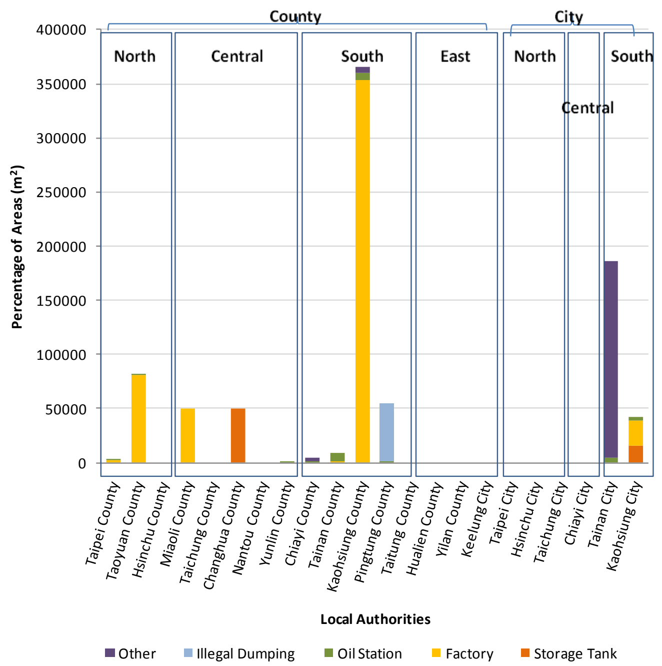
9.5.2. The Summary of the Remediation Sites

There was no agricultural land designated as the Remediation Site. The distribution patterns of the Remediation Site in both numbers and areas (Figure 9.11a, and Figure 9.11b) were similar to that of the Control Site excluding agricultural land (Figure 9.10a, and Figure 9.10b): The numbers were higher and areas were bigger in the south.

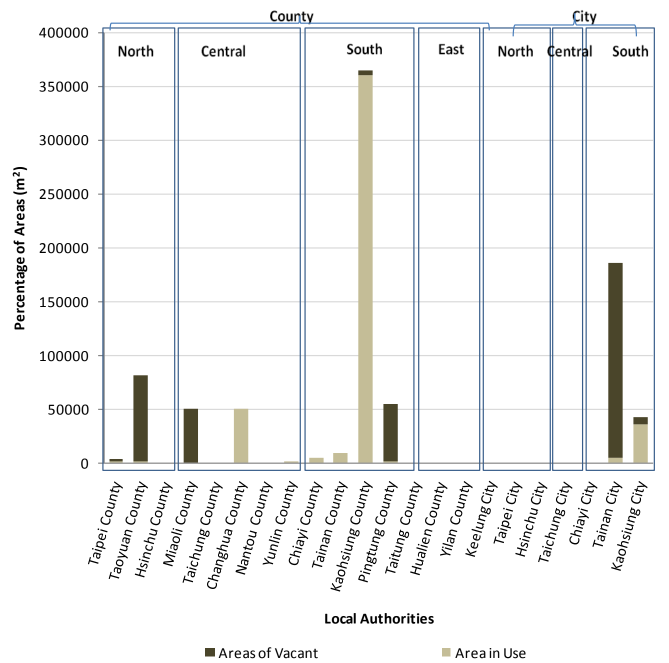
The ratios of vacant Remediation Sites were quite different among local governments (Figure 9.11c). However, the numbers of Remediation Sites were considerably fewer than the Control Sites. The status of one Remediation Site could influence the ratio between vacant sites and sites in use significantly. Therefore, it was not clear whether the difference was the result of limited number of sites, or the result of different local governments.



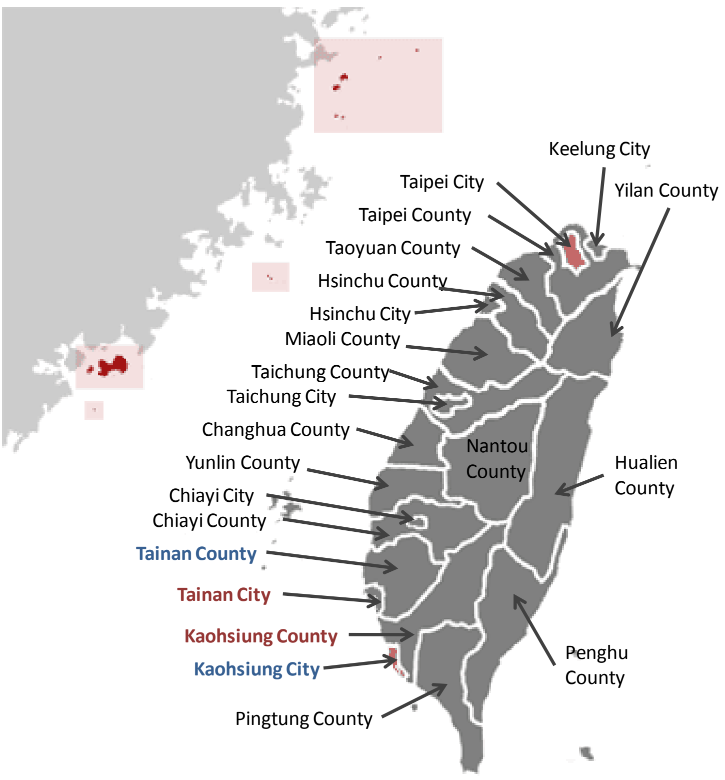
a.



b.



c.



d.

◄ The local authorities labelled in red are the ones have highest numbers of the sites; the local authorities labelled in blue are the ones have largest areas designated as polluted sites.

Figure 9.11 The Distributions of Designated Remediation Sites in Different Land Use Types.

9.5.3. Logistic Regression on the TEPA Databases

The probabilities of a site being vacant among the local governments seemed to be different (Section 9.5.1 and Section 9.5.2). However, the descriptive statistic in the previous two sections could not distinguish exactly which factors made the polluted land vacant. Therefore, the logistic regression (described in Section 9.4.2) was conducted to identify the factors affected the land use.

The independent variables selected in the regression analysis are displayed in Table 9.5. The analysis was carried out two times, one with the data of agricultural land (763 sites) and one without (178 sites). Both forward and backward stepwise regressions were performed to make sure the alternative procedures did not affect the results (Section 3.6).

Table 9.6 shows the results of stepwise regression on the database including polluted agricultural sites. Both forward and backward procedures obtained the same final model. The significant independent variables in the model were the type of the site (land use when the land was designated), the region where a site located, and the authority (the local government). Whether an authority was a city or a county and whether a site was designated as Remediation Site, Control Site, or Groundwater Use Restriction Areas did not affect the probabilities of vacancy. The size of the site did not matter, either.

Table 9.6 The Results of Logistic Regression Including Designated Polluted Agricultural Land

		Variable	Model Log Likelihood	Change in -2 Log Likelihood	df	Sig. of the Change
Forward Stepwise	Step 1	*type_site*[b]	*-459.200*	*152.314*	*5*	*.000*
	Step 2	*type_site*[b]	*-422.329*	*162.256*	*5*	*.000*
		region[c]	*-383.043*	*83.682*	*3*	*.000*
	Step 3	*type_site*[b]	*-364.088*	*103.077*	*5*	*.000*
		region[c]	*-323.280*	*21.461*	*3*	*.000*
		authority_n[d]	*-341.202*	*57.304*	*17*	*.000*
Backward Stepwise	Step 1	*type_a*[a]	*-311.269*	*.007*	*1*	*.934*
		type_site[b]	*-357.700*	*92.868*	*5*	*.000*
		region[c]	*-320.472*	*18.412*	*3*	*.000*
		authority_n[d]	*-334.518*	*46.504*	*16*	*.000*
		area_site[e]	*-311.991*	*1.449*	*1*	*.229*
		status[f]	*-311.809*	*1.086*	*2*	*.581*
	Step 2	*type_site*[b]	*-365.454*	*108.369*	*5*	*.000*
		region[c]	*-332.863*	*43.187*	*3*	*.000*
		authority_n[d]	*-334.821*	*47.102*	*16*	*.000*
		area_site[e]	*-311.998*	*1.457*	*1*	*.227*
		status[f]	*-311.847*	*1.155*	*2*	*.561*
	Step 3	*type_site*[b]	*-372.148*	*120.602*	*5*	*.000*
		region[c]	*-334.514*	*45.334*	*3*	*.000*
		authority_n[d]	*-340.542*	*57.390*	*16*	*.000*
		area_site[e]	*-312.597*	*1.500*	*1*	*.221*
	Step 4	*type_site*[b]	*-373.275*	*121.357*	*5*	*.000*
		region[c]	*-335.034*	*44.874*	*3*	*.000*
		authority_n[d]	*-341.202*	*57.209*	*16*	*.000*

a.type_a: the types of local governments, cities or countries.
b.type_site: the land use of the site when the pollutants was discovered.
c.region: the region in Taiwan where a site located
d.authority_n: the names of the local governments
e.area-site: the area of the designated sites
f.status: the designation of a site

When the sites with agricultural land uses were excluded, the region where a site located became no longer relevant to the vacancy of a designated polluted site (Table 9.7). The type of the sites and the local governments where the site located remained the factors to determine whether a designated polluted land was in use or not.

Table 9.7 The Results of Logistic Regression Excluding Designated Polluted Agricultural Land

		Variable	Model Log Likelihood	Change in -2 Log Likelihood	df	Sig. of the Change
Stepwise Forward	Step 1	*type_site*[b]	-118.847	42.947	4	.000
	Step 2	*type_site*[b]	-96.585	44.999	4	.000
		authority_n[d]	-97.374	46.577	18	.000
Stepwise Backward	Step 1	*type_a*[a]	-73.093	1.324	1	.250
		type_site[b]	-93.904	42.945	4	.000
		region[c]	-75.485	6.108	3	.106
		authority_n[d]	-89.306	33.750	14	.002
		area_site[e]	-73.377	1.890	1	.169
		status[f]	-73.047	1.230	2	.541
	Step 2	*type_a*[a]	-73.870	1.646	1	.199
		type_site[b]	-96.031	45.969	4	.000
		region[c]	-75.863	5.632	3	.131
		authority_n[d]	-93.478	40.862	14	.000
		area_site[e]	-74.085	2.077	1	.149
	Step 3	*type_site*[b]	-96.496	45.254	4	.000
		region[c]	-76.347	4.955	3	.175
		authority_n[d]	-95.966	44.193	14	.000
		area_site[e]	-75.116	2.494	1	.114
	Step 4	*type_site*	-99.850	47.005	4	.000
		authority_n[d]	-96.712	40.730	14	.000
		area_site[e]	-77.520	2.345	1	.126
	Step 5	*type_site*[b]	-100.508	45.975	4	.000
		authority_n[d]	-97.374	39.707	14	.000

a.type_a: the types of local governments, cities or countries.
b.type_site: the land use of the site when the pollutants was discovered.
c.region: the region in Taiwan where a site located
d.authority_n: the names of the local governments
e.area-site: the area of the designated sites
f.status: the designation of a site

The model in Table 9.7 was validated by comparing the model prediction of land vacancy and the actual land condition (Table 9.8). The percentage of correct prediction was about 72%. If the rate of correct prediction is close to 50%, the result is likely to be generated based on random data. Therefore, the correction rate at 72% (43.8% for the correct prediction of non-vacant and 28.7% for the correct prediction of vacant) indicated that this model was not generated by chance. However, it should be noted that the model might not be used in future prediction.

If it was used, the prediction rate could be lower because of technical considerations (Chatterjee & Hadi, 2006) and the revision of regulations. This is further elaborated in Section 9.6.4. Furthermore, 72% is not a perfect prediction rate. This implies the factors identified by the model cannot completely explain the probabilities of a site to be vacant.

Table 9.8 The SPSS Output of Vacancy and Predicted Group Cross-Tabulation

Vacancy * Predicted group Cross-tabulation

			Predicted group		
			0[c]	1[d]	Total
vacancy	0[a]	Count	*78*	*31*	*109*
		Expected Count	*58.8*	*50.2*	*109.0*
		% within vacancy	*71.6%*	*28.4%*	*100.0%*
		% within Predicted group	*81.3%*	*37.8%*	*61.2%*
		% of Total	***43.8%***	*17.4%*	*61.2%*
	1[b]	Count	*18*	*51*	*69*
		Expected Count	*37.2*	*31.8*	*69.0*
		% within vacancy	*26.1%*	*73.9%*	*100.0%*
		% within Predicted group	*18.8%*	*62.2%*	*38.8%*
		% of Total	*10.1%*	***28.7%***	*38.8%*
Total		Count	*96*	*82*	*178*
		Expected Count	*96.0*	*82.0*	*178.0*
		% within vacancy	*53.9%*	*46.1%*	*100.0%*
		% within Predicted group	*100.0%*	*100.0%*	*100.0%*
		% of Total	*53.9%*	*46.1%*	*100.0%*

a.land actually in use.
b.land that is derelict
c.land predicted to be in use
d.land predicted to be derelict

Overall, the result indicated the types of local governments did not affect the land use efficiency of designated polluted sites. Therefore, the sprawl of the built-up areas in counties in Taiwan was irrelevant to the designation of polluted sites. The promulgation of the SGPRA 2000, at least so far, has not significantly resulted in urban sprawl. The assumption (as discussed in Wu 2008 as well as Wu 2009) that the regulations created barriers to brownfield regeneration has not yet happened at the national level.

9.6. Discussion

The land use of the sites when pollution was discovered, and the local governments where the sites located affected the probabilities of a designated polluted site being vacant. The difference between cities and counties, the areas of the sites, and the types of designations did not significantly affect the probabilities of a site being vacant. The result contradicts several general perceptions. This section discussed these contradictions.

9.6.1. The Polluted Sites and Urban Sprawls

The polluted sites, especially the sites utilised for industrial purposes, have been generally considered as brownfields in Taiwan. These areas usually located near or within the urban settlement (Section 9.2.1). Therefore, the brownfield regulation enforcing generic remediation standards could hindered the urban regeneration and cause further development of greenfield land (Section 9.3.2).

On the other hand, between 1990s and 2000s, the degree of the sprawl of built-up areas in the counties was more serious than in the cities in Taiwan (Section 8.4.3). Therefore, it was assumed the designated polluted sites could have enhanced, if not resulted in, the sprawl in the counties. Under this hypothesis, the probabilities of a polluted site to be vacant should be higher in the counties than in the cities.

The results of logistic regression in this chapter, however, showed that there is no significant difference of the probabilities of the polluted sites being derelict between the cities and the counties. Therefore, the designation of the polluted sites has not been the major factors to cause the sprawl. Although the remediation of the polluted sites and the redevelopment of the vacant polluted sites could still benefit public health and local economy on a case-by-case basis, overall it has no significant contribution to the sprawl, nor preserving the greenfields.

Preserving land that has not experienced heavy anthropogenic impact is one of the important tasks for Taiwan to maintain the land use sustainability (Section 6.7.1). Based on the result in this chapter, to prevent sprawl and protect the greenfield land in Taiwan, dedicating the efforts solely to regenerating the polluted site seems insufficient. The approaches of brownfield regeneration should be revised in order to pursue sustainable development.

The first thing to revise may be the definition of brownfields. The definition in the policy should direct some attention to derelict or vacant land within the settlements that has no pollution. This is further discussed in Chapter 10.

9.6.2. The Regulatory Barriers to Regenerating a Site

The results of the logistic regression also indicated the status of the designation did not affect the land use efficiencies. This is also a counter-intuitive result. The designation of 'Remediation Site' has been considered a major hindrance to the redevelopment, because once a site is designated to be the Remediation Site, the land transaction is banned until it is cleaned up to the satisfactory condition and delisted (example of the RCA in Section 9.1.3 and regulatory review in Section 9.3.2).

One possible explanation for this result is that many designated polluted sites, regardless the status, have maintained their current land uses. Therefore, there is no urgency of land transactions. Consequently, the ban of land transaction has not affected the land use on site in general. The hindrances are not as serious as showed in the stories of RCA and An-Shun.

On the other hand, it is also possible that these sites could have yielded better socio-economic benefit if they were redeveloped for other uses. This 'what if' question cannot be answered by the logic regression in this study. Furthermore, this regression analysis cannot evaluate the effect of the stigmatisation of the designation to the vicinity. The changes of the land prices in the adjacent areas after the designation may be a good indication. This requires further investigation because brownfield regeneration is not only about the site, but also about the communities in the vicinity. If the designation has caused out-migration of residences or brought down the land prices in the surrounding areas, the regulation is affecting local social and economic conditions. These effects cannot be evaluated using the regression in this study.

Furthermore, the insignificant differences between designations of 'Remediation Site' or 'Control Sites' might be the result of the different ways of implementation. Based on the observation in my previous working experience, before TEPA or local governments officially designate a site, there were usually negotiations between responsible parties and enforcement bodies for possible alternative solutions. For example, some short-term efforts to reduce the concentration and extent of pollutions might be done without the site being designated. After the reduction of concentration, the site might no longer qualify the designations. The current land use and impact of designation might also have been taking into account during the negotiation process. The impact of the designation on land use can be reduced in this way.

The An-Shun and the RCA cases are two special and much more serious cases. They drew public attention because of the contamination and the obvious effects on public and occupational health (Section 9.1.2 and 9.1.3). The government, therefore, had no choice but to designate the sites. However, it should also be noted that although the pollution of the two sites happened long before the promulgation of the SGPRA 2000, they were not designated as Polluted Site immediately after the promulgation. This implies that certain degrees of negotiation and remediation might have happened between the stakeholders and the government agencies prior to the designation.

On the other hand, the histories of the two cases also demonstrate the significant effects of one serious case to the society. The logistic regression model in this study cannot evaluate the degree of impact of one seriously polluted site to the vicinity. It would be interesting to conduct further research on the effects of the extents of contamination and the toxicities of contaminants to the probabilities of a site to be vacant.

Furthermore, the designated sites may only be the tip of the iceberg judging from the ratio of designated gas stations and the number of the gas station in Taiwan (Section 9.2.3). The average rate of UST leaking is usually higher than this rate of designation. Likewise, the investigated and designated number of polluted factories is also disproportionally low. The impact of the 'hidden' contaminated sites on the land use in Taiwan remains to be assessed. In addition, if in the future, these hidden contaminated sites are uncovered and designated, the impact of designation could become more significant than now.

9.6.3. The Differences among Local Governments

The regression results showed the local government where a site locates affects the probability of the site to be vacant. Since the type of an authority does not make significant difference, the differences can be the result of other characteristics of the local governments. The nature of land use within administrative territories of local governments could be one reasonable explanation since the different land use on site affects the probability of a site to be vacant after designation. Furthermore, the effect of the type of land use of a site was not eliminated after removing agricultural land (comparison between Table 9.6 and Table 9.7). This means agricultural land use is not the only land use that affects the chance of a site being vacant. The chances of being vacant are different among the remaining five types of land use. Therefore, the central government's responsibility to remediate the agricultural land (Section 9.4.3) was not the only factor affect the land use effectiveness. Furthermore, if the distributions of the land uses among local governments are different, the probability of a designated site within one local government being vacant could be different.

The other explanation is the willingness of a local government to designate a site as polluted may vary. In accordance with the SGPRA 2000, the processes of designation have always involved the input from local governments. Therefore, upon designating a site, if a local government has taken the land use on site into consideration, the probability of the site being vacant may be lower. On the other hand, if a local government designates Control Site solely based on the concentration of pollutants detected on site, the probability of the site being vacant could be higher. Further in-depth investigation on local governments may be needed to verify the attitudes regarding designating polluted sites.

Overall, the implementations of the regulation by the local governments have been a significant factor affecting the contaminated land (re)use effectiveness. Therefore, the policymakers and lawmakers need to take the attitudes of local governments into consideration upon making policies and laws to improve the identification of the polluted site as well as to encourage redeveloping the designated sites.

9.6.4. The Applicability of the Regression Model

The regression model established in this chapter may not be suitable for predicting or analysing the land use effectiveness in the future. First, the SGPRA has been significantly revised in 2010. Therefore, the consideration of designation may change among local governments. Additionally, the structure of Taiwanese local governments has been through a significant change in 2010. Several cities and counties merged to form three new local governments with the 'direct-controlled municipality' status (the other two local governments already with such designation are Taipei City and Kaohsiung City). These may change the procedures and attitudes towards designating polluted sites. Consequently, the effects of the regulation on land use efficiencies may change. The restructure of central government is also expected soon (Section 9.3.1). The combination of TEPA and several other departments may bring changes to the attitudes of enforcing SGPRA 2010.

In addition, the validation of the regression has utilised the dataset used to build the model so the (correct) prediction rate is likely to be higher (Chatterjee & Hadi, 2006). If a new set of data was put in the model, the accuracy of prediction might be reduced.

9.7. Conclusion

Several important industrial pollution incidences have constructed the general understandings of brownfields among different stakeholders in Taiwan (Section 9.1 and Section 9.3). These cases also facilitated the establishment of SGPRA regime.

The polluted sites resulted from previous industrial practice in Taiwan have been considered brownfields. However, the related regulatory regime (SGPRA) has been considered a barrier to encouraging brownfield regeneration (Section 9.3). Therefore, the analysis in this chapter examined the effects of the regulations on urban sprawl.

It is observed in Section 8.4.3 that the sprawl is a more significant phenomenon in the counties than in the cities in Taiwan. However, the logistic regression model established in this chapter revealed that the types of the authorities (cities or counties) have not affected the land uses of designated polluted sites (Section 9.5.3). Therefore, the regulations have not affected the land use efficiencies. The decreased intensity of land use of unpolluted built-up areas may be responsible for the sprawl.

Based on this result, it is suggested that the concept of brownfield regeneration in Taiwan should be updated. In the policy of brownfield regeneration, the un-polluted vacant and derelict land should be incorporated into the definition of brownfield land. In this way, the brownfield regeneration may help to protect the undeveloped areas in Taiwan.

Chapter 10 Discussion

This study has analysed the relationship between brownfield policy and sustainability in different ways: I investigated the relationships between percentages of PDL and socio-economic deprivation (Section 4.4 and Section 4.5); I matched the approaches of countries to achieve sustainability and the types of brownfield definitions (Section 5.4.2, Section 5.4.3 and Section 6.5.2); two country cases (Taiwan and England in Chapter 7, Chapter 8 and Chapter 9) were analysed to verify the recommend brownfield definitions to pursue sustainable development.

In this final discussion, I summarise the observations based on the characteristics of countries that might affect the effectiveness of using the definitions (Section 10.1); I draw the study results together to obtain a framework on defining brownfields in regeneration policies to improve sustainability (Section 10.2); I comment on the policy implementation of these definitions (Section 10.3). Additionally, I highlight the dilemmas about analysing the data collected from various sources and for different purposes (Section 10.4).

10.1. Definitions

This thesis has explored the issues of defining 'brownfields' and 'sustainable development' (argued as the ways to achieve 'sustainability'). I investigated the effects of brownfield percentages on socio-economic sustainability (Section 4.5). I also investigated the effects of the demographic differences on brownfield regeneration as well as sustainability (Section 5.4). Particularly, I am interested in how the definitions of brownfields affect the sustainability in the countries with high population densities.

The *Brundtland Report* definition of 'sustainable development' has (possibly intentionally) left room for countless interpretations, some eco-centric and others anthropocentric (section 2.4). Governments' interpretations of the definition of sustainable development usually intend to reconcile current governmental operation and the new concept (Hopwood, Mellor, & O'Brien, 2005, and further discussed in Section 2.4.2). The vagueness of the definition in the *Brundtland Report* has made it easy for the governmental organisations to maintain the relatively traditional view of development but still claim to pursue sustainable development (Section

2.4.2). For example, as discussed in Section 2.4.2, sustainable development interpreted by the Clinton Administration in the Executive Order 12852 emphasises economic growth (Eisner, 2007). On the other hand, the Taiwanese government directly adopted the *Brundtland Report* definition but its interpretation may be embedded within sustainability indicators established in 2010 *(*National Council for Sustainable Development Network, 2009*)*. These indicators may be highly technical and less easily understood by the general public.

The diverse interpretations and the uncertainties of future projections create controversies in evaluating progress in sustainable development among countries. The results of ESI 2005 and EPI 2008 can be one example. One index (ESI 2005) evaluates environmental sustainability in the future; another (EPI 2008) evaluates current performance in environmental quality and carbon emissions. The rankings of countries in these two indexes are strikingly different (Table 6.1, gives detailed analyses and explanations as provided in Esty, Levy, et al., 2008). It is dangerous to use the results of these 'ready-made' sustainability indexes to look for policy transplantation from peer countries without knowing the content in the indexes.

Different approaches have been adapted to achieve or maintain sustainability by countries at different stages of development (Section 5.5). This is true with or without considerations of regional variability within a country. (Section 5.5 demonstrated the results from the data that did not include many indicators measuring regional variability, and Section 6.5.2 demonstrated the results from the data that did). The diverse interpretations of sustainability by countries categorised using stages of economic development showed that the definition of ambiguous concepts such as sustainability might continue evolving (Figure 5.6 in Section 5.5.1 and Figure 6.6 in Section 6.5.2). However, due to the globalisation increasing the interactions between countries, the development of emerging economies is significantly faster than the earlier industrialised countries (some examples on urbanisation can be found in AECOM, 2010). The further development of advanced economies is full of uncertainties (Section 6.6.1). Anticipating the precise 'needs' of future generations is challenging (Section 2.4.2). Therefore, the definition of sustainability is expected to evolve as 'needs' of new generations emerge. The definition of brownfields, as part of brownfield regeneration policy in a country, is likely to evolve to fulfil the contemporary understanding of the sustainable use of the land resources. The definition in England has been through such a transition (Adams, et al., 2010 and section 7.1).

Moreover, depending on the stages of economic development and the demographic differences (mainly the differences in population density), countries use different strategies to achieve the same level of sustainability. Deindustrialised countries either protect their environmental resources or enhance their social capacity (Section 5.4.2, 5.5.1 and 6.5.2). Emerging economies mainly score high in the economic aspects of sustainability (Section 6.5.2); they might have better environmental scores given their environmental resources have not yet been exhausted (Section 6.5.2). Furthermore, the countries that have not joined the emerging economies may rank high in the environmental aspects of sustainability because of their relatively unaltered natural environments. For example, Guyana in South America ranked 8th out of 146 in ESI 2005 and Central African Republic ranked 25th out of 146. Guyana and Central African Republic were categorised as medium human development and low human development, respectively, by HDI of the UN in 2010. It is suggested, upon preserving the flexibility of which approaches to use in pursuing sustainable development, some basic thresholds should be established when evaluating the level of sustainability (Section 6.6.2).

Therefore, for a government, the definitions of sustainability, sustainable development, or brownfield land may be changeable because under the new circumstances, the old definitions may not sufficiently serve the policy objectives. Moreover, if new information becomes available, the measurements dictated by the definition of sustainable development or brownfield land may also be changed accordingly. Via changing the composition of the measurements (such as sustainable indexes), the definitions of sustainability may be tuned. Because of these complexities in defining a term, it is vital to compare the definitions before adapting policies from other countries.

10.1.1. Approaches to Sustainable Development

In this thesis, I suggested the ‘needs’ described in the *Brundtland Report* should cover three aspects: economic, social and environmental (Section 2.5). It is commonplace that countries may not achieve all three of them at the same level (Section 2.4.3, Section 5.4.2 and Section 6.5.2). Some of them enhanced the social capacity to cope with the relatively limited resources; some of them improved environmental quality to better the quality of life; some of them strived to maintain economic prosperity. Usually, the emerging economies put more efforts on economic development, while the advanced economies elect to enhance social capacity or recover environmental quality depending on the density of the developments (Table 10.1). However, there are considerable variations among countries under this simplified deduction.

Table 10.1 Strategies of Sustainable Development

	High Population Density	***Low Population Density***
Advanced Economy	*Achieving by increasing social capacity to cope with limited resources*	*Achieving by increasing social capacity or maintaining environmental quality*
Emerging Economy	*Achieving by economic improvement, fulfilling basic life standard*	

In some models describing sustainable development, the economy is considered the part of least concern (Giddings, Hopwood, & O'Brien, 2002). However, the economy has been the primary consideration when a country is entering the stage of industrialisation (Section 2.4.2 and Section 2.4.3). It could still be the major emphasis in the politics of industrialised countries. Even in the *Brundtland Report*, there is an 'ideal' set of annual GDP growth for the developing (3%) and the developed (1.5%) worlds (WCED 1987 quoted by Common and Stagl 2005, p.255). The recent struggles of the UK Prime Minister David Cameron persuading the public of the necessity of the budget cut, and convincing the public that the 'index of happiness' is more important than the economic indicators can be a good example. By contrast, the recent movement to protect old trees in Nanching City from being cutting down because of the new construction of public transportation demonstrated the awareness of environmental preservation in an emerging economy such as China (the *Liberty Times*, March 19, 2011). These examples present the variations in the 'needs' among countries at specific development stages.

Moreover, the three aspects that collectively represent sustainability are neither always complimenting nor contradicting each other (Section 6.5.1). The conflicts between economic development and environmental protection, or social equality might have been exaggerated more than they actually are.

On the other hand, there is an interesting pair of potentially contradicting concepts within the idea of sustainability: the principle of achieving equality while preserving diversity. Some examples of the types of equality and diversity to be considered in the three different aspects are presented in Table 10.2.

Table 10.2 The Contrast between Equality and Diversity in Pursuing Sustainable Development*

	Equality	**Diversity**
Environment	*Valuing ecologic environment and anthropogenic environment equally*	*Preserving diversified ecological environment, and species (maintain or increase biodiversity)*
Economy	*Decreasing differences in income distributions*	*Diversifying economic activities*
Society	*Protecting social justice, public health, and access to public facilities*	*Protecting culture diversity*

**Esty D. C., Levy, Kim, de Sherbinin, Srebotnjak, & Mara, 2008; Esty D. C., Levy, Srebotnjak, & de Sherbinin, 2005; Hopwood, Mellor, & O'Brien, 2005*

Curiously, although the importance of enhancing equality has been researched and stressed (for example Wilkinson and Pickett, 2010), not many indexes included the variables measuring the regional socio-economic differences within a country. The lack of measurement on socioeconomic equality may be due to the issues of data accessibility. This can be seen in the human development index by the UN. Not until 2010, had the UN provided the 'inequality adjusted' human developed index. It still struggled to provide any analysis on the trend of inequality. Many countries have not provided the inequality data required to calculate the adjusted index. The evaluations, therefore, miss some important aspects of sustainability.

This thesis has attempted to incorporate some variables measuring the degree of inequality into the index (Section 6.2, Table 6.2 and Table 6.3). Consequently, this limited the sample size. However, the index provided a different view of sustainability that no other indexes have provided (discussed in Section 6.6.1).

The analysis revealed the potential contradiction between social equality and biodiversity (Section 6.7.3). The conflict may result from the allocation of (political) resources between social development and environmental preservation. However, such conflict could be handled by better and more integrated policy to allocate resources equally within a society.

10.1.2. Approaches to Redevelop 'Brownfields'

The definitions of brownfields among those economically successful countries may be divided into two different groups depending on the demographic characteristics (Table 10.3).

Table 10.3 The Summary of Brownfield Definition

	High Population Density	**Low Population Density**
Advanced Economy	*Legacy of past industrialisation and urbanisation; 'brownfields' is defined based on its intensity of land use (reduce vacant and dereliction)*	*Legacy of past industrialisation and urbanisation; 'brownfields' can be defined based on perceived contamination*
Emerging Economy	*Industrialisation and urbanisation is on-going; 'brownfields' may be produced now and in the future. However, the negative impact may be prevented from the different styles of definitions in advanced economies (Figure 5.6)*	

Besides the comparisons among countries, the comparisons among local authorities in England revealed that the development density affects the stock of the different types of PDL (Section 4.4.2). This implies the need to consider different styles of brownfield regeneration based on the development density within a country. This has been considered and implemented by some local authorities with the help of the Home and Communities Agency in England (previously English Partnerships) (Syms, 2010). To facilitate brownfield redevelopment, these local authorities might need to have their own priorities and policies to encourage specific types of previously developed land to be reused. This may also be the case for Taiwan, where the phenomenon of sprawl has progressed at different rates between the cities and the counties.

In Taiwan, to reduce the impact on greenfield land, preventing sprawl may be urgent in the counties but less so in the cities (Section 8.4.3.1). In this study, it is found that the definition of brownfields in Taiwan is not sufficient to tackle the problems because it has chosen a definition that would normally be adopted by those countries that have low development densities (Section 9.6.1). Taiwan, is however, a country with an extremely high population density.

10.2. A Proposed Framework

In this section, I further discuss the important factors affecting the performance of brownfield regeneration. These factors may determine the degree to which the definition of brownfields would work to successfully improve sustainability. Based on the discussion, a framework regarding how to define brownfields in policy is proposed.

10.2.1. Development Density

The strategies to improve sustainability vary depending on the population density of a country (Section 10.1.1). Development density may also affect the national policy performance at local level. The situations observed both in England (Section 4.4.2) and in Taiwan (Section 8.4.3. and 8.4.5) indicate that the ways to improve sustainability in urban areas should be quite different from the ways in rural areas. Therefore, the brownfield regeneration policy might need to be flexible to allow local authorities to optimise the outcome of sustainability. In the case of England, the lack of precision in brownfield definition has not provided the flexibility to local authorities but given excuses to the central government to grant short-term profitable developments (Section 7.6.1 and Section 7.6.2). This delivered the targets of brownfield policy for political purposes without regenerating truly sustainable communities.

Additionally, the evaluation of a proper development density could change from time to time, as well as from region to region. The improving technology may allow a unit of land resources to accommodate more people without sacrificing basic quality of life in the urban areas. Therefore, the variables and values defining dense developments may change over time and across regions.

10.2.2. Development Stages

The stage of the development of a country is another factor affecting the definition of sustainability and brownfield land (Table 10.1). However, it is argued that nowadays, we should no longer dichotomously divide countries into categories of 'developed' and 'developing countries' because the lines to differentiate 'developed' and 'developing' have become blurred. A series of TED talks by Hans Rosling between 2006 and 2010 with statistical data at global level have indicated that many stereotypical 'developing countries' have been catching up much faster than the countries industrialised earlier in the history[18]. Moreover, economic growth may not necessarily be the basis for the first step of the development. For example, Cuba had a high HDI score in 2003 and low Eco-footprint (Wilkinson & Pickett, 2010). The country seems to have done well in social development without excessive consumption. Additionally, China improved life expectancy significantly before boosting the economy (Hans Rosling's TED talk in June 2009). This diversity of development styles is more than likely to continue growing.

Furthermore, the dominancy of the service sector in the advanced economies compared to emerging economies can be a quick indicator of development progress (Rowthorn and Ramaswary, 1997). However, the variables representing the relative contribution of the service sector (GDP per capita or size of the labour force in service sector) do not provide qualitative content of the service sectors, which could be very different among countries and regions (Pandit, 1991).

With the emerging economies speedily catching up with the advanced economies, it is expected that their strategies to improve sustainability may change quickly from pushing economic growth to improving social equality or environmental quality. On the other hand, with such fast development, there has been considerable degree of urbanisation and industrialisation in these emerging economies. The issues of brownfields may soon become apparent. The scale of the dereliction may also be beyond imagination, as demonstrated by the empty estates in the urban areas of Ireland after the economic crisis of 2009. Brownfield regulations can be expected to soon rise to the top of the political agenda in emerging economies.

[18] The talks can be retrieved from http://www.ted.com/speakers/hans_rosling.html. The data can be located at www.gapminder.org.

10.2.3. A Framework based on Density and Progress

It is foreseeable that the phenomenon of brownfields will appear during the development process, and the existence of brownfields is often associated with negative effects such as blights, sources of contamination, crimes, poverty and a declining economy. Therefore, applying brownfield regeneration to achieving sustainability is an idea worth considering, albeit the possibility of applying the redevelopment incorrectly would spoil the sustainability (discussed in Section 4.5.1). For this reason, the thesis set to generate principles that can be followed to ensure that sustainability can be achieved via brownfield regeneration; at least, the redevelopment should not damage the sustainability.

I established that the strategies to achieve sustainability may depend on the density of development and the stages of development (Section 10.1). Likewise, the density of development may affect the brownfield definition. Combining the two conclusions, I suggest the following way to define brownfields in the pursuit of sustainable development:

- In a densely developed country, the definition of brownfields should emphasise the effectiveness of reusing brownfields (Table 10.3), especially for the land that has weaker market value. The redevelopment of these areas should aim to enhance the social capacity, advance public facilities, reduce deprivation and revitalise the local economy (Table 10.3);
- The less densely developed areas or countries may focus the regeneration on converting the land back to the condition before previous industrial use, given there is no immediate use benefiting the vicinity. In other words, brownfield regeneration policies in crowded areas priority should be given to the problem of urbanisation. In the less dense development settlements, the priority can be given to problems left by industrialisation.

Based on these considerations, I established a final framework (Figure 10.1) that divides the styles of brownfield policymaking into four groups based on the population density and the stage of economic development. Group 1 countries such as the UK or Taiwan should emphasise land use effectiveness so that the social issues of urbanisation or out-migration can be resolved. Group 2 countries such as the US or Scandinavia countries have the luxury to focus on concentrating on contamination left from past industrial practices, land use effectiveness, or both.

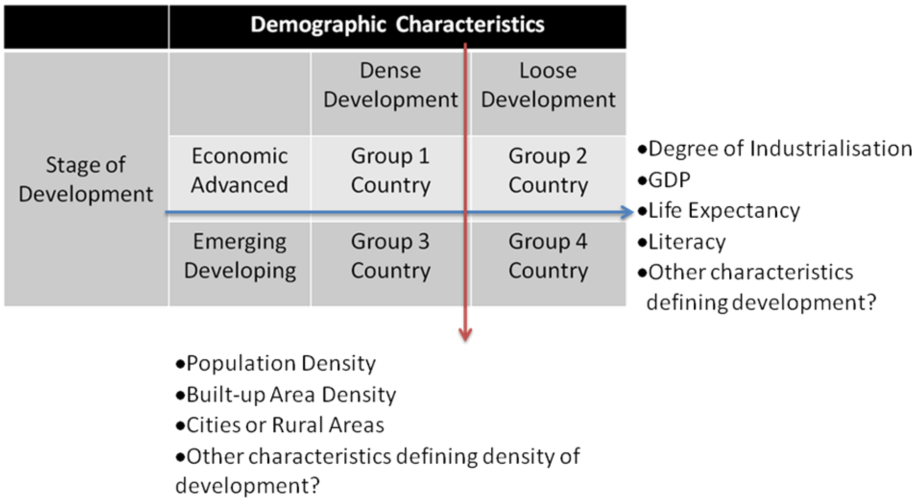


Figure 10.1 The Framework to Considered How to Define a Sustainability Related Terminologies

The case of Taiwan demonstrates that for a Group 1 country to adopt the brownfield definition suitable for the Group 2 countries (such as the U.S.), the issue of urban sprawl would not be effectively resolved (Section 9.6.1). The case of England, on the other hand, indicates numerical recycling targets do not necessarily enhance social capacity (Section 7.6.1) and solve the problem of greenfield development (Section 7.6.2). Although the target emphasises the recycling of land resources, the definition that the target is based upon misses the point that brownfields should be previously developed land requiring interventions to bring back beneficial use (detailed in Section 7.6.1 and 7.6.2). The methods and costs of the interventions are the issues to be addressed in the regeneration policy. This is true for all four groups in the framework. The previously developed areas that have sufficient financial incentive for redevelopment should not be considered brownfields.

For the emerging developing countries, the phenomena of brownfield land may be on-going (for example, Cao and Guan, 2007). They may adopt the brownfield strategies of their earlier industrialised counterparts with similar development densities (Section 5.5.1). Therefore, Group 3 countries such as Bangladesh or India may look for the lessons of the policymaking among Group 1 countries. Likewise, Group 4 countries such as Brazil can learn from the positive or negative experiences of the Group 2 countries. Based on the framework, the summary of brownfield definitions in Table 10.3 can be converted into a recommendation of brownfield definitions in Table 10.4.

Table 10.4 Recommendation of Elements Needed in Bornwifled Definition

	Elements in Definitions	High Density	Low Density
Advanced Economy	*Derelict*	✓	✓
	Underused	Δ	–
	Potential or Actual Contamination	–	Δ
	Previously Developed	✓	✓
	Urban/Built-Up Area	✓	–
	Require Interventions	✓	✓
Emerging Economy	*Derelict*	✓	✓
	Underused	?	?
	Potential or Actual Contamination	–	Δ
	Previously Developed	✓	✓
	Urban/Built-Up Area	✓	–
	Require Interventions	✓	✓

√ The necessary element for all countries in this group.

Δ The element could be considered but do not necessarily apply in this group.

- the element does not 'define' the brownfield in this group but could be frequently encountered during the regeneration process.

? The necessity of this element is yet to be investigated.

The elements described in Table 10.4 are the common elements among the definition reviewed (Table 2.1). However, I suggest the dereliction and underused land may be separated. This is based on the observation in England: The distributions of derelict and underused land are different among local authorities in regions at different development densities (Section 4.4). Furthermore, the socio-economic sustainability conditions were increasingly harsh in the authorities with higher degree of development densities (Figure 4.9); the deprivation issues are relatively serious both in regions in the north and in London (Figure 4.13). Therefore, to use brownfield regeneration to help develop sustainable communities, policymakers should differentiate the derelict land and underused land to deal with specific socio-economic problems. This discussion in Section 4.5.3 is specifically for the situation in England. However, the example could apply to greater international audiences as similar situation was also observed in Taiwan (Section 8.5.3).

Moreover, urbanisation in emerging economies is on-going, and how to differentiate or define 'underused' previously developed land from currently 'fully' used land merits further studies. For example, should the removal of 'Hutongs' (lower density developments) in Beijing city for high-rise buildings (higher density developments, to adapt to the rapidly growing population), be considered a sustainable development, or considered an un-sustainable development destroying the sense of community? Furthermore, compared to slum development densities, many built-up areas could be considered ‘underused’, but using policy interventions to ‘regenerate’ an area into a slum is unthinkable!

The point has been made that the perception or actual contaminates on site should not necessarily be an element in the definition of brownfields, especially for the countries with higher population densities (Section 5.4.3 and Section 9.7). However, the countries with lower population densities may elect to include such contamination as a necessary consideration. This restricts the number of sites qualifying for government funding for brownfield regeneration, but it allocates more resources to maintain the environmental quality, which is one of the strengths of these countries in most of the sustainability indexes (Section 5.4.2 and Section 6.5.2). If cleaning up the contaminants becomes the necessary criterion, the idea of regeneration may incorporate regenerating the ‘natural environment’. Following this line of thought, brownfield sites may be located in both rural and urban areas.

Furthermore, in the analyses from which the framework (Figure 10.1) was derived, the criteria of development progress were based on economic considerations (essentially GDP per capital, or economic competiveness) and the criterion of development density was based on population density (Section 5.4, and the result in Section 6.5.2 was analysed based on ESI 2005 clusters. Between the Clusters, there are also considerable differences in population densities). However, as noted in the previous discussions, the definitions of sustainability and of brownfields may not be fixed concepts (Section 10.1). They transform as the perceptions of the ‘needs’ change under the consideration of sustainable development. The framework can accommodate such transformation by using different indicators to represent development densities as well as the stages of development.

For example, the stages of development may not be delineated in the financial or economic terms but in social development terms such as life expectancies or literacy in countries. Alternatively, it can be the degree of Gini index or the degree of deprivation if higher degree of equality reflects a more ‘developed’ stage. Likewise, the values that divide the densely developed countries and less densely developed countries may change over time depending on population growth and the technology development (as to accommodate more people in a unit of land).

The criteria in the framework may also change to evaluate brownfield regeneration at different geographic scales. For example, development densities may also be differentiated by the types of settlements such as cities or rural authorities; the results in Chapter 4 showed (Section 4.4.2), there were differences in the distributions of the types of PDL among rural and urban local authorities. As long as the criteria are relevant to the causes of brownfields (urbanisation and industrialisation) or the goals of regeneration (social, economic or environmental sustainability), the framework can be used in a creative way.

10.2.4. Example of Applying the Framework

As an example of applying the framework, an exercise using the criteria of economic competiveness and population density to evaluate available brownfield definition produces the results show in Figure 10.2.

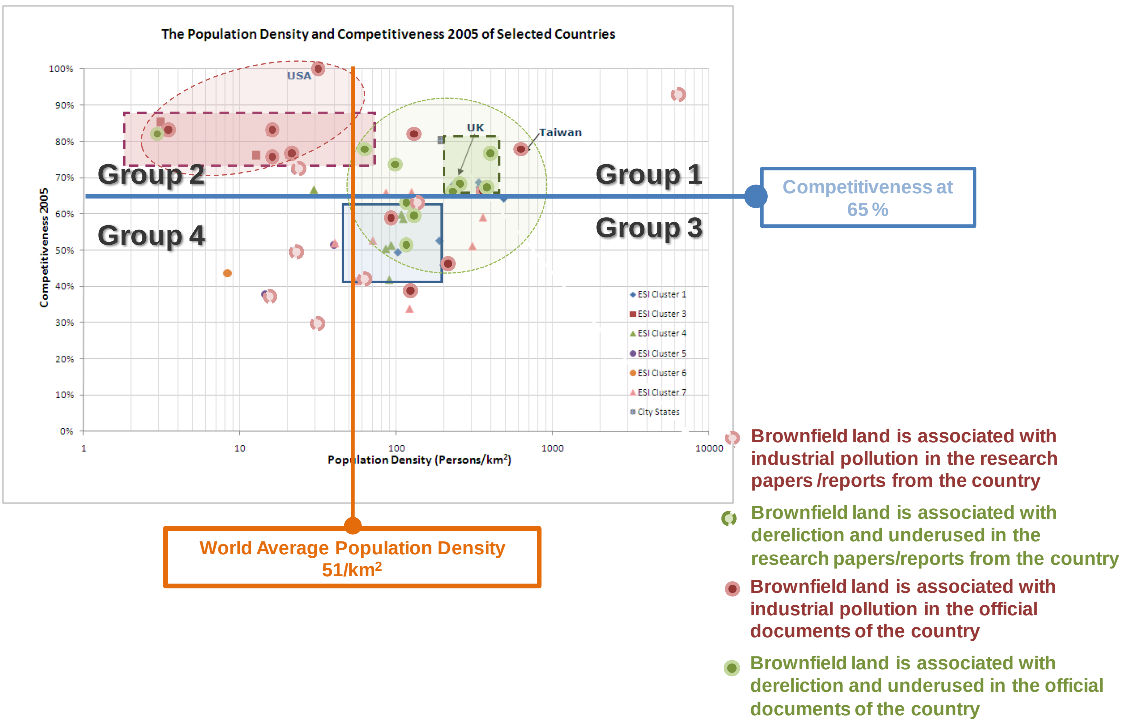


Figure 10.2 An Evaluation of Brownfield Definition Applying the Framework of Development Densities and Development Progress

Using the economic competitiveness of 65% (lower end of Box 2) as the criterion for development progress and the average population density of the world ($51/km^2$, based on statistics in 2010 from the UN: http://esa.un.org/unpd/wpp/Excel-Data/population.htm) as the criterion of development density, the available brownfield definitions among countries can be divided into four different groups (Figure 10.2). The official definitions or the general understanding of brownfields may be found either in Oliver et al. 2005 or in Section 5.4.3. Fewer official definitions in the less economic competitive countries can be found. However, academic papers and reports have discussed brownfield regenerations in some of these countries. These non-official definitions are used in this section. Based on the framework in Section 10.2.3, the names of the countries whose definitions do not fulfil the recommendations are listed in Table 10.5.

Table 10.5 The Exceptions of Brownfield Definitions

		World Average Population Density (51/km^2)	
		Higher	**Lower**
Economic Competitiveness of 0.65	**Higher**	Denmark (128.079, 0.83), Hong Kong (6348.641, 0.93), Japan(337.10, 0.69), Taiwan(634.439, 0.78)	Australia (2.9, 0.82)
	Lower	China(139.366, 0.63), Italy(199.789, 0.46), Mexican(54.92, 0.41), Poland (122.052, 0.39), Romania(90.046, 0.42)	-

The numbers in brackets after each country give the population densities (person/km^2) and competitiveness scores in 2005, respectively.

The exceptions of brownfield definitions, especially in those countries belong to Group 1 in this framework, could be explained by some historical and regional influences. For example, Denmark is one of the Scandinavia countries; most of the countries in the region associate brownfields with contamination. Japan and Taiwan were both politically influenced by American after World War II, and American associated brownfields with contamination. However, in considering policymaking of brownfield regeneration in pursuing sustainable development, the two cases in this study showed that development densities are better criteria than previous political influences considering implementing regeneration policies in pursuing sustainable development. Therefore, these countries may need to consider revising the definition of brownfields. The definition in the UK has not be considered exceptions in this example. This is because the comparison has concentrated on whether the concept of contamination has been included. If we also examine whether the definition have put the necessity of policy intervention into consideration (Table 10.4), the definition in the UK, especially practiced in England, can be considered as exceptions.

No exception has yet been found in Group 4 but there are several in Group 3. This could be explained by the progress of discovering problems associated with brownfields: The effects of pollution at brownfield sites on public health and safety have always been the first signs noted and acted upon (Bell and McGillivrary, 2006). Since most of the Group 3 countries in Table 10.5 can be considered emerging economies (Italy is the exception), the issues of brownfields may be appearing but not yet prevalent. As is typical of emerging economies, brownfields are associated with contamination. However, at this stage they should look for lessons from the advanced economies with high development densities. Revising definitions to reflect the needs to effectively use land resources may be beneficial to prevent urban sprawl and to improve social sustainability.

The definitions documented in the research papers from China, Hong Kong and Latin America (Cao and Hua, 2007; Mak, n.d.; Marker, 2007) shared some interesting characteristics. The definitions or the cases of brownfield regeneration described in the documents are all associated with contamination. However, they focused on regeneration in the urban areas. Essentially, they applied the concepts of urban regeneration to manage the contaminated land. While the Chinese scholars cared more about the quality of existing infrastructure and the methods of remediation, the regeneration case studies in Latin American cities concentrated on the issues of social equality. The scholars from Hong Kong University promoted using the 'precautions for the future brownfield remediation' as an education channel to increase the sense of social responsibility. From these discussions, it is believed that emerging economies are fast catching up on their more advanced developed peers using brownfield regeneration as a means to protect urban environment and to promote social equality. This suggests that the definition of brownfields in emerging economies may gradually transform to incorporate the recycling efficiency so that certain social issues such as quality housing and urban green space may be handled.

10.2.5. Possible Tension in Implementing the Framework

Using population density to represent development density overlooks the regional variation within a country (Section 5.1.1). This may be particularly true for countries with large areas. Therefore, in a larger country with considerable variation in landscape and demography, central governments need to leave more flexibility for regional or local authorities to define brownfield land that is suitable to redevelop. The local authorities may also need to plan how to reuse the brownfield land to pursue sustainable development. The framework can still serve as criteria for determining which types of brownfield land to be included in the region. High density regions should focus on derelict and vacant land for mixed development in the urban areas that can promote social interaction and economic activities, while it may be more beneficial for the low density regions to emphasise restoring environmental quality for the derelict land that is no longer in need.

The variation of the emphasis in regions, however, is expected to be dictated by the definition of brownfields in national policies. Possibly, this will become the source of conflict between the central governments and the local communities as the scale of their considerations differ.

The different considerations based on scales may further intertwine with the operation of party politics as observed in England (section 7.3 and section 7.4). As party politics is the essence of the democratic countries, it reflects opinions of general public on the direction of development in a country. However, this opinion can be influenced by media as well as by the governmental policy. For the issues that involve regional variation such as brownfield redevelopment, the party politics might reflect poorly on the local needs. Therefore, in defining a suitable definition for brownfields in the regeneration policies, the framework generated in this study needs to be considered in conjunction with the political situation as well as demographic characteristics. It should not be considered as a rigid frame but a general guideline. The issues of party politics and local needs are further discussed in section 10.3.3.

10.3. Brownfield Policy Implications from the Case Studies

In the second part of the thesis, I took a closer look at England and Taiwan regarding the effect of brownfield definition on the sustainability. Based on the investigation in the first part of the thesis, the two countries need to preserve their limited greenfield land to maintain land use sustainability (Section 6.3.4.1). On the other hand, the two countries have defined brownfields at the two ends of the spectrum. The definition of brownfields in England covers almost all the previously developed land, while Taiwan narrows the definition to only the land polluted by industrial practices.

To depict the effects of the definition on sustainable development, I borrowed the concepts of precision and accuracy often utilised in the works of measurement or in surveys (Figure 10.3). The centre of the target in the target illustration besides Figure 10.3 represents the brownfields that would benefit sustainability via regeneration. Only the definition that is both precise and accurate (the pink dots in the illustration and Figure 10.3) delivers the policy objectives.

		Precision	
		Low	High
Accuracy	High	Covering the target but also covering many other things	Very specific and close to the target
	Low	Coving a lot of thing and not covering the target	Very specific but does not cover the target

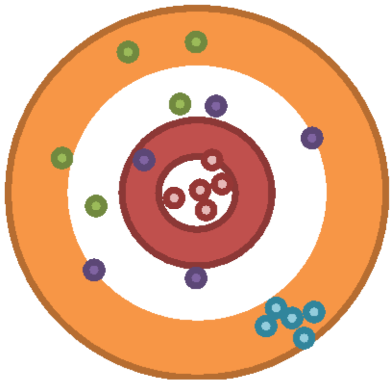


Figure 10.3 **The Concept of Precision and Accuracy**

The definition for brownfields given by the UK government covers more types of land than necessary for providing incentive of regeneration. It offers opportunities for the developers to cherry pick the spots that have already strong financial incentives to be redeveloped without improving sustainability (Section 7.6.1 and Section 7.6.2). Although it has covered the brownfield land of concern, the efficiency of improving sustainability is compromised. It is a definition with high accuracy but low precision (the purple dots in Figure 10.3). On the other hand, the definition of brownfields perceived by Taiwanese is less accurate but quite precise (the light blue dots in Figure 10.3) and thereby, it misses the opportunity to use brownfield regeneration to improve the land use sustainability.

Additionally, in this study, the statistical analyses, along with the qualitative analyses, have demonstrated that the success and the failure in these two countries are not as straightforward as perceived by public or as claimed by stakeholders. Both definitions of brownfields have not effectively delivered the claimed objectives of the policy.

The definition of brownfields by the CABERNE[19] (CABERNET, 2006) is recommended to be the more appropriate model of brownfield definition for regeneration, especially for the countries with high population densities. This is because the definition in CABERNET, ticks most boxes of the suggested elements in the definition of brownfields in the Group 1 country (Table 10.5).

The cases of the two countries may also demonstrate that policy 'transplantation' does not always work because of the difference in social and culture backgrounds between countries. Additionally, the policy in advanced economies may not be as successful as they advertised. It is inappropriate for Taiwan to focus brownfield regeneration exclusively on the polluted sites caused by the previous industrial practice as many countries with lower population densities do. It is equally inappropriate for Taiwan to follow the UK example to include all the previously developed land in the brownfield regeneration policy. Based on the results of this study, the definition of brownfields in Taiwan needs to consider enhancing the effectiveness of land reuse in urban areas to prevent unnecessary greenfield development. At the same time, the policymakers also need to consider the equality issues in the communities affected by the brownfield sites.

Furthermore, properly defined brownfields would be just the beginning of the policymaking (Adams, De Sousa, & Tiesdell, 2010). During the investigations into England and Taiwan, some factors emerged and appeared to be influential in the policymaking and its implementation. The factors include the social or economic differences (for example, the north and south divide described in Section 4.4.3), development densities (Section 4.4.2 and Section 8.4.3), political systems (Section

[19] CABERNET 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.

7.4, Section 7.6.3 and Section 7.6.4), and the local governments' attitude (Section 7.6.4, Section 9.5.3 and Section 9.6.3).

Moreover, the CABERNET jigsaw model (CABERNET 2006), suggested there may be optimal amount of brownfield areas that could be considered beneficial for urban renewal in a saturated urban area. This optimal area could not be found by analysing data from local authorities in England (Section 4.4). This might partially result from the lack of precision in the brownfield definition; partially, this might also due to the factors involved in implementing the regeneration policy. These factors are discussed below. They may be the topic for future research on brownfield regeneration.

10.3.1. Which Types of Brownfields Should be Targeted

Table 10.5 implies that there is an ideal type of previously developed land that should be targeted for redevelopment. This section uses the CABERNET A-B-C Model (CABERNET, 2006) to explain what types of brownfield land should be specifically addressed in the regeneration policy.

The definition of brownfields in the UK has provided incentive to redevelop all three types of brownfield sites in the A-B-C Model (Section 7.6.1). Consequently, developers favour the A-sites for better financial return and lower investment risks. The B-sites and C-sites that require regulatory interventions are overlooked. On the other hand, the definition of brownfields in Taiwan targets the C-sites but consequently misses the opportunities to prevent sprawls (Section 9.5.2 and Section 9.7). It is possible that the A-sites in Taiwan would still be redeveloped. However, that is not facilitated by regulation but purely by the market force.

Since developers are easily attracted by the opportunities of redeveloping A-sites, and redeveloping C-sites may be far from cost-effective, it may be mutually beneficial for the stakeholders (public or private) to focus on regenerating the B-sites.

This position has been endorsed by the World Bank and JESSICA (Joint European Support for Sustainable Investment in City Areas). The mission of the World Bank is to relieve poverty and the aim of JESSICA is 'to develop a framework for enhanced co-operation between the public, private and banking sector in the

European Union… (Kolivas, 2007).' The two institutes have invested considerable funds in sustainable development.

Redeveloping the B-sites may generate just enough profit to cover the cost of regeneration (CABERNET, 2006). The World Bank is particularly interested in this type of site because redevelopment of such sites may not be immediately economically attractive, but 'there may be other advantages that could justify incentives to attract private investment (The World Bank 2010, p3)'. JESSICA's consideration of the B-sites is also relevant to the financial cost and benefit. For JESSICA, 'B-projects at least produce moderate positive return… (Kreuz and Nadler, 2010, p22).' The use of the Urban Development Fund by JESSICA should generate sufficient revenue to retain the private partners. However, it shall not 'enable returns above a fair market rate to be earned because of EU regulations on State Aid (Kreuz and Nadler, 2010, p22).' This can be considered one of the examples to use regulatory power (at the EU level) to encourage redevelopment of the B-sites.

If governments formulate policy to encourage public and private partnerships in regenerating B-sites, it could direct the private resources into the less financially attractive sites and using less public resources in comparison to regenerating C-sites. The definition of brownfields in the policy, if purposely targeting B-sites, can channel the resources in more cost-effective directions towards sustainable development.

10.3.2. Unbalanced Regional Developments

In the comparison of the distribution of different PDL in England (Figure 4.12), it is noted that in the south, more 'underused land' was reported whereas in the north, more 'vacant and derelict land' was reported. In Chapter 7, it is argued that the definition of brownfield land by the previous Labour Government may have made cities more compact. It might also increased the land prices in the souther part of the UK and created more derelict industrial land and empty residential developments in the north (Section 7.6 and 7.7). Similar situations may also be described at smaller scales within local authorities. The definition might have made some prosperous urban districts more compact and expensive. At the same time, it enhanced the deterioration of some industrialised areas. The contrasts between north and south in England could also happen between the cities and counties in Taiwan (Section 8.4.1, Section 8.4.2, Section 8.4.3 and Section 8.5.3). It is suggested that the brownfield regeneration policy of Taiwan should avoid repeating the same pattern as observed in England.

10.3.3. Party Politics and Local Needs

It is suggested that the styles of lawmaking and enforcement, in regulating environmental issues, have gradually been transformed from highly centralised command and control models, to cost-effectiveness based upon voluntary approaches, and finally into community based designs (Pellizzoni, 2004; Bell & McGillivray, 2006). The transition expends the power of decision making from exclusively government, to include industrial sectors, and finally to include the general public. The incorporation of the different types of stakeholders legitimises the environmental governance (Pellizzoni, 2004; Wallington and Lawrence, 2008). In this way, the economic efficiency and the social justice are taken into account during managing environmental resources. In this way, the issues of sustainability are dealt with more comprehensively.

However, in the case of brownfield redevelopment, diverse community needs may be overruled by party politics (Section 7.6.4 and Section 7.6.5). Take garden land development in England as an example, the voting results on the issues (Section 7.4) indicated that the party politics play an important role in policymaking, even when the issues demand different considerations at the local level, and even when the MPs are elected by local people.

Several MPs of the Labour Party have spoken up for their constituencies indicating the current brownfield definition does not encourage the redevelopment of the deteriorated industrial areas (Section 7.3 and Section 7.4). However, these MPs mostly voted against the Bill that may revise the definition and improve the situations they have mentioned. This is party politics in action. Furthermore, the checking function of the House of Lords has been weakened because currently, a large part of the peers are the members of political parties, and the cross benchers were not interested in voting on this issue (Section 7.4). As the party politics may not be avoided during the democratic policymaking process, it is important to evaluate the possibility of delegating more responsibilities to local authorities (or regional governments) for those issues that may affect local communities in different manners. Conversely, in Taiwan, each local government has responded to the same brownfield regulations significantly differently (Section 9.5.3 and Section

9.6.3). The interaction between policymaking and implementation is intricate and warrants further research.

Governments (central or local) are not unbiased institutions (Anderson & Leal, 2001). Their decision-making is not always based on the best interests of the public, but could be based on the survival of the institutions. Therefore, there are risks to increasing the power of local governments. Although they may have better understanding of the specific needs for local people, the results of their decision regarding brownfield regeneration may not be better than that of the central government in terms of benefiting their communities.

Adams et al. (2010) suggested the policymaking process has been influenced by two directions of powers. The top-down power of party politics is strong however sporadic and short-lived; the bottom-up power from the local governments or local communities may be relatively weak but consistent (as long as the issues have not been resolved). Based on the discussion in Section 7.6.4, it is easy to assume that the bottom-up approach is more favourable for the issues such as brownfield redevelopment. This may be why many environmentalists have favoured the bottom-up styles of environmental governance.

However, from the observations of Taiwan in Section 9.1 and part of the discussion in Section 7.6.4, there is a worry that the opinions of the public and communities may be distorted by the media reporting or governmental campaign. Their perceptions regarding what the problem is and how the problem may be solved may not be precise or accurate (Section 10.3). In addition, the opinions may be divided between local people regarding development as demonstrated in a recent development cases in Taiwan (the *Liberty Times*, May 01, 2011).

Moreover, the decision-making at local level affects other regions as well. The decision of regenerating Canary Wharf to be a world financial centre did not only affect the local economy and land use. It might have affected the population migrating to the southern part of England and have left more derelict and vacant land to be dealt with in the northern part of England. In fact, one of the criticisms about the previous UK government has been that they only targeted the developments within the City of London and ignored other areas. More importantly, this decision has had international influences (for example, the immigration of international population described in Section 4.5.3). It is difficult to say, if the bottom-up approach is taken, which level of the 'bottom' should have the final say in this type of development.

10.3.4. Recommended Brownfield Definitions to England and Taiwan

In the framework (Section 10.2.3), Taiwan and England both belong to countries with advanced economic development and high development density. Therefore, both countries should concentrate on effectively regenerate brownfield land to prevent unnecessary development on greenfield and to promote the socio-economic sustainability in established settlements.

For England, the definition of brownfield land should only include the derelict and vacant land required policy interventions to bring back beneficial uses in urban areas. This definition should be used in combination with the policy that promotes mixed-use development including soft-end uses. This revision may channel the public regeneration resources to the urban areas in the Northern regions and Midlands and promote balanced development.

For Taiwan, the definition of brownfield land should expand to cover unpolluted derelict and vacant land in the urban areas that requires policy interventions to bring back beneficial uses. The definition should be used in conjunction with a planning policy that promotes mix-use development and with regulations that provide more flexibility in considering remediation standards based on suitable for use principle. Further, the implementation of the revised regulations may need to be accompanied with public education so that the brownfield land is no longer stigmatised. Redevelopment can then be supported by the public. This revision may encourage facilitating the redevelopment or derelict and contaminated land within settlement, particularly in the counties in Taiwan.

10.4. Issues with Data Analysis

10.4.1. The Use of Mixed Methods

This study has demonstrated the need to use both qualitative and quantitative methods to investigate issues such as sustainable development and brownfield development. The negative effects brought by brownfields are usually observed on a case-by-case basis (example can be found in Section 7.3 and Section 9.1), giving accumulating narratives. The case studies may offer a default hypothesis regarding how regenerating brownfields will improve the sustainability. However, to investigate whether the issues are universal and therefore require policy interventions at national level, some quantitative analyses are required to cover the entire region of concern.

For example, the Parliamentary debates in Section 7.3 presented views for both sides of the arguments of the garden land development with many stories brought up by the MPs. The arguments reflect the reality at local level, but may not necessarily reflect the reality in the entire region or country. Therefore, some investigations would be needed to check the arguments. In this case, the quantitative data of land use provided a good insight on the effectiveness of brownfield recycling (Section 7.6) and, therefore, deciphered the actual performance of brownfield policy. Moreover, a statistical analysis of the voting results in relation to regions and political parties revealed the incentive of voting (Section 7.5), which was not entirely based on the best interests of the communities.

The narratives of serious pollution cases in Taiwan shaped the perceptions of brownfields through media presentation (Section 9.1). The perceptions of the public as well as specific interest groups may influence policymakers. Whether the public perception reflects the actual situation, however, is another story. On the other hand, the stakeholders who were involved in the cases may also be biased although they might have observed the situation more closely and will be affected by the result of policy implementation in greater degrees (Table 9.3 in Section 9.3.2). The statistical analysis showed that the SGPRA 2000 neither facilitated the brownfield recycling, nor hindered the recycling (Section 9.5.3). This result contradicts the perceptions that the regulation has hindered the recycling (Section 9.6). It also shows that the perceived brownfield definition is not helpful in managing the sprawl observed in Taiwan (combining the result of Section 8.4.3 and Section 9.5.3).

Although the numerical or quantitative data may help to verify whether the qualitative narrative is universal, it sometimes could be superficial. For example, the rankings of countries in different sustainability indexes could be contradictory (for example Table 6.1 and Table 6.15 with discussion in 6.6.2) without looking into the indicators of which the indexes are composed. Furthermore, even when the meanings of indicators are understood, the values provided by each country may not base on one standard measurement procedure (examples given in 10.4.2). Sometimes, the high and low values do not necessarily indicate good or bad and, therefore, further analysis on qualitative information need to be in place to prevent misinterpretation of quantitative data.

Therefore, qualitative and quantitative analyse complement each other in the investigation of issues covering multiple aspects. The triangulation approaches 'enable you to counteract the weakness in both types of research (Dawson, 2007, p.22).'

10.4.2. Quantitative Data Availability

The analyses in this study heavily relied on the data or databases established by the international organisations (Section 5.3 and Section 6.3) and the central governmental statistics in several countries (Section 4.3, Section 7.5, Section 7.6, Section 8.2, and Section 9.4.1). The use of these data may have innate advantages as well as disadvantages.

Using data provided by the international organisation gives a degree of confidence in quality control. It is assumed that in these databases, and the values of variables in each country have been checked for their accuracy and consistency. Most of the international organisations have offered quality guidance or at minimal, provided the source of references (Section 6.3.2). Therefore, there is a degree of confidence that apples were compared to apples.

However, to maintain the quality of data, some countries were excluded from the statistics. Usually, the countries capable of providing high quality data are those who performed relatively well in socio-economic development. Therefore, the results of analyses in this study may not be applicable at a global level. The results may only reflect the part of the world that has experienced industrialisation and urbanisation. To some extent, it may also cover part of the view on the emerging economies that are experiencing industrialisation and urbanisation. For example, the countries included in these analyses mostly ranked on the first one-third (higher than average) of the ESI 2005 and EPI 2008 (Table 6.4). These countries also have higher economic development and social development. This can be reflected on the fact that most of the counties involved in this study belonged to

Cluster 1 and Cluster 3 countries grouped by ESI 2005. They have much higher GDP per capital than rest of the clusters. Most of the countries are considered in the group of 'very high human development' by Human Development Index (HDI) (Table 6.4).

However, the confidence of quality control may not be completely applicable to all the databases. For example, the land use percentages in the *CIA World Book* were obtained from various types of information sources. The precision and accuracy of these numbers may vary. The purpose of the *CIA World Book* was more for record keeping and information sharing rather than sophisticated statistical analyses. Therefore, there may be some issues of data precision. Therefore, the data in the CIA Factbook were only used when they were the lone source of information available.

Additionally, although the definition of indicators may be clear, the countries may try to report the numbers in favour to their positions. For example, Mexico has reported quite a low rate of unemployment. Although it has followed the definition of unemployment rate to make the survey (unemployed for more than six months), it allowed a more flexible range of part-time employee and younger workforce to be included in the employed population.

10.4.3. Data Collection

The data utilised in this study usually were obtained from the public databases. Since the data are readily available, the time spend on data collection was relatively short. It saved time on browsing or contacting different departments of countries regarding the variables needed for the analyses. Additionally, the languages may not be a huge barrier as it would be. To some degree, the data presented in the databases of these national or international organisations are consistent since the organisations also utilised data for their own statistical analyses.

However, the data collection by the databases themselves was not based on the research objectives of this study. Therefore, missing data points or missing ideal variables for this analysis were not uncommon. Hence, some possible correlations between variables may be overlooked by applying the MDT (Section 6.4.1).

Chapter 11 Conclusion

A framework to define 'brownfields' for regeneration policies has been established by analysing qualitative and quantitative evidence related to land use and sustainability (Section 10.2). The framework proposes using development densities and depending on development as criteria to look for suitable types of definition of brownfields in regeneration policies aiming for sustainable regeneration (Section 10.2.3). Among advanced economies with high development densities, the brownfield definition in the policy should encourage improving social sustainability through facilitating land recycling. For the advanced economies with low development densities, the brownfield definition can either aim for facilitating land recycling or concentrate on remediating contaminated land back to the previous natural state if possible. For the countries with lower development status where brownfield land starts appearing, lessons can be derived from their more advanced counterparts with similar development densities. Given high degrees of urbanisation (agglomeration) are also happening in these emerging economies, the development densities to be considered 'underused' may be contested (Table 10.4 and Section 10.2.3). The effort, therefore, may be focused on regenerating vacant land. This framework has been depicted in Figure 10.1, and recommended elements in definitions are listed in Table 10.4.

This chapter summarises the process of generating the framework through fulfilling research objectives (Section 1.3). Additionally, relevant research worth further pursuit is suggested.

11.1. Derivation of the Framework

The literature review revealed that concepts of sustainability and brownfields have been interpreted by institutions based on various viewpoints (Section 2.3 and Section 2.4, Section 10.1, 10.2 and 10.3). Because of these diversities, reducing brownfield land does not necessarily improve conditions for sustainability. This is demonstrated by the relationship between the percentages of PDL and the scores of socio-economic deprivation index among local authorities in England (Section 4.4). On the other hand, this study deduced that the primary factors affecting the definition of brownfields in the regulations or policies of a country are the demography and stages of development (Section 5.4 and Section 10.1).

Development densities are related to the available land resources. The availability of land resources dictates the strategies to use the land sustainably. This logic may be applied to different geographic scales. The policymakers of a country may consider regional differences and apply alternative strategies based on the criterion of development densities (such as urban and rural) (Section 10.2.3 and Section 10.2.5).

The countries with high population densities have to perform better in the socio-economical aspects to achieve similar levels of sustainability as the countries with low population densities, who can achieve the same level of sustainability based on their ownership of abundant environmental resources (Table 5.5, Figure 6.6). Since the definition of brownfield in the regeneration policy should aim for improving sustainability, the definitions of brownfields can be different between the countries with low and high development densities, not only because of the limited land resources, but also because of the emphases of different aspects of sustainability (Section 5.4, Section 10.1.2).

Moreover, recent global economic developments may have helped the emerging economies in their sustainability scores primarily via impressive economic development. However, the issues of brownfields are emerging in these countries. They may need to define brownfields in their policies in the foreseeable future to sustainably regenerate the brownfields produced during the process of industrialisation and urbanisation.

The abovementioned conclusions were further scrutinised using an index established to evaluate sustainability of land use based on variables covering social, economic and environmental aspects. The weighting of variables in the index suggested by a statistical method, PCA, indicated that the three aspects are interconnected (Section 6.4 and Section 6.5). Furthermore, the scores calculated based on the index verified the two styles of approaches to achieve land use sustainability among advanced economies depending on the development densities (Section 6.5.2). These results are consistent with the observations in the previous studies and earlier analyses in this thesis.

11.2. Case Studies on Countries with High Development Densities

The second part of the study investigated whether the definitions of brownfield land in England and Taiwan facilitate sustainable development. The two countries are both advanced economies with high population densities. They defined brownfields quite differently. Therefore, the investigations verified the recommendation of brownfield definitions to countries with high development densities and advanced stages of development.

Through an integrated analysis of parliamentary debates, quantitative land use data and indicators of socio-economic conditions indicated that in England, I have argued that defining brownfield land as previously developed land allows developers to 'cherry pick' the land with high market values for denser development without improving the quality of life in the neighbourhood (Section 7.5 and 7.6). Setting target of housing development on the defined brownfields (a.k.a. PDL) neither preserved greenfield land nor improved socio-economic deprivation conditions (Section 7.6). About 40% of the area developed in England each year has been on greenfields (Section 7.6.2). Although the definition of brownfields in England delivered high efficiency of land recycling, it did not deliver the overall objectives of brownfield regeneration: improving sustainability. This is because the brownfield land defined by the UK government (previously developed land) covers more than the specific land resources that regeneration should aim towards (Section 10.3). The resources to be focused are more likely to be vacant and derelict land or the marginal profitable B-sites (Section 10.3.1).

In Taiwan, analysing the changes of land use and demography between 1996 and 2008 revealed the sprawls of built-up areas were more severe in the counties than in the cities (Section 8.4.3). The planning policy in Taiwan did not intend for these sprawls to happen (Section 8.4.5). Therefore, to prevent further unintentional development on greenfields, Taiwan needs a brownfield regeneration policy focusing on reducing the sprawls in the counties.

In Taiwan, brownfield land has been generally perceived as land contaminated by previous industrial activities. The review in the news archive indicated that the news reports of the cases of industrial pollution promoted the negative impression of the brownfields (Section 9.1, and Section 10.3). The brownfield regulation under this definition dealt with the pollution on land instead of facilitating regeneration (Section 10.3). The binary logistic regressions on the designated polluted sites indicated that the designation did not significantly increase the chances of a polluted site in the counties to become vacant (Section 9.5). Given the sprawls are more severe in counties (Section 8.4.3), it is concluded that the brownfields related regulations have no significant effects on land use efficiency. Naturally, it has not contributed to the greenfield preservation or to regeneration.

To sufficiently improve or maintain the sustainability in countries with limited land resources, the definition of brownfields in regeneration policies needs to precisely and accurately channel the resources to enhance socio-economic capacity, and prevent urban sprawl (Section 10.3). Each of the two cases missed some important elements recommended based on the framework (Table 10.4). Therefore, the policy based on the definition did not completely deliver the objectives.

11.3. Further Research

This framework for defining brownfields is a simplified model, and defining brownfields is just the first step of developing regeneration policies. There are many more factors interacting with the definition of brownfields and thus, affecting the results of policy implementation. Further investigations of the interactions are needed to help countries tailor make the definition that is suitable for their own conditions.

11.3.1. Domains of Socio-Economic Sustainability and Types of Brownfields

The existence of 'brownfields' has been considered one of the causes of many un-sustainable conditions. The definition of brownfields should aim for solving the problems (un-sustainable socio-economic or environmental conditions) and fulfilling the 'needs' (sustainable conditions) of the regions. Further deciphering the relationships between existence of brownfields and these socio-economic problems may help develop principles of policymaking for brownfield regeneration.

One of the starting points may be statistically analysing the NLUD-PDL and different domains of IMD to elucidate the effects of brownfield land on different types of social issues. This may identify domains directly linking to the brownfields. Those specific domains may become better indicators to evaluate the success of brownfield regeneration. Alternatively, the analysis may identify suitable redevelopment targets for different types of PDL. Moreover, the chronological data in the NLUD-PDL and IMD can be useful in analysing the effects of the changes of the quantity and quality of brownfield land on the changes of deprivation conditions.

11.3.2. Different Types of Development Densities and Stages of Development

As discussed previously, the development density can be represented by different indicators such as the density of built-up areas, and the rural and urban division in a country (Section 10.2.3). Replacing the population density of a country with these indicators in the framework may be helpful for generating specific regeneration strategies for regions in a country.

Previously, economic development has always been the important criteria to tell the differences between 'developed', 'developing' and 'undeveloped' countries. However, it is acknowledged now that continuous economic growth is not a sustainable approach (Section 10.2.2). Therefore, the progress of development may no longer be evaluated based on purely economic terms. Since many social problems (for examples, poor primary education, curtailed life expectancy and unemployment) are considered associated with brownfields, using the progress of social development in the framework instead of economic development may offer new ways of thinking on brownfield regeneration.

Therefore, further research may play with different indicators representing development densities and stages of social development to see how current brownfield definition in a country fits in. This makes the framework an analytical tool to generate a policy that suits the needs for different aspects of development.

11.3.3. The Effects of Politics on the Decision Making Regarding Brownfield Regeneration

The study also noted the controversy between the central lawmaking process and local implementation in the debate of garden land development in England (Section 7.3). The issues of implementation are previously thought to be the problem unique to Taiwan (Section 9.6.5). It seems now, the controversy could be universal though the detail may be different for each country. Further research is need to look into more cases between lawmaking and the consequential implementation to deduce the pattern of the controversy and therefore to propose a better way to change the unwanted consequences of the policies.

11.3.4. More Case Studies to Validate and Refine the Framework

The terminology of 'brownfields' has not entered the lexicon of lawmaking in many emerging economies (Section 10.2.4). However, since academia has initiated the discussion and some individual projects have been conducted through international cooperation (example in Section 10.2.4), case studies in the emerging economies are expected to accumulate over time, and the brownfield regeneration may soon enter political discussion or lawmaking process. Further research may use these accumulating experiences to validate and refine the framework generated in this thesis.

11.4. Summary

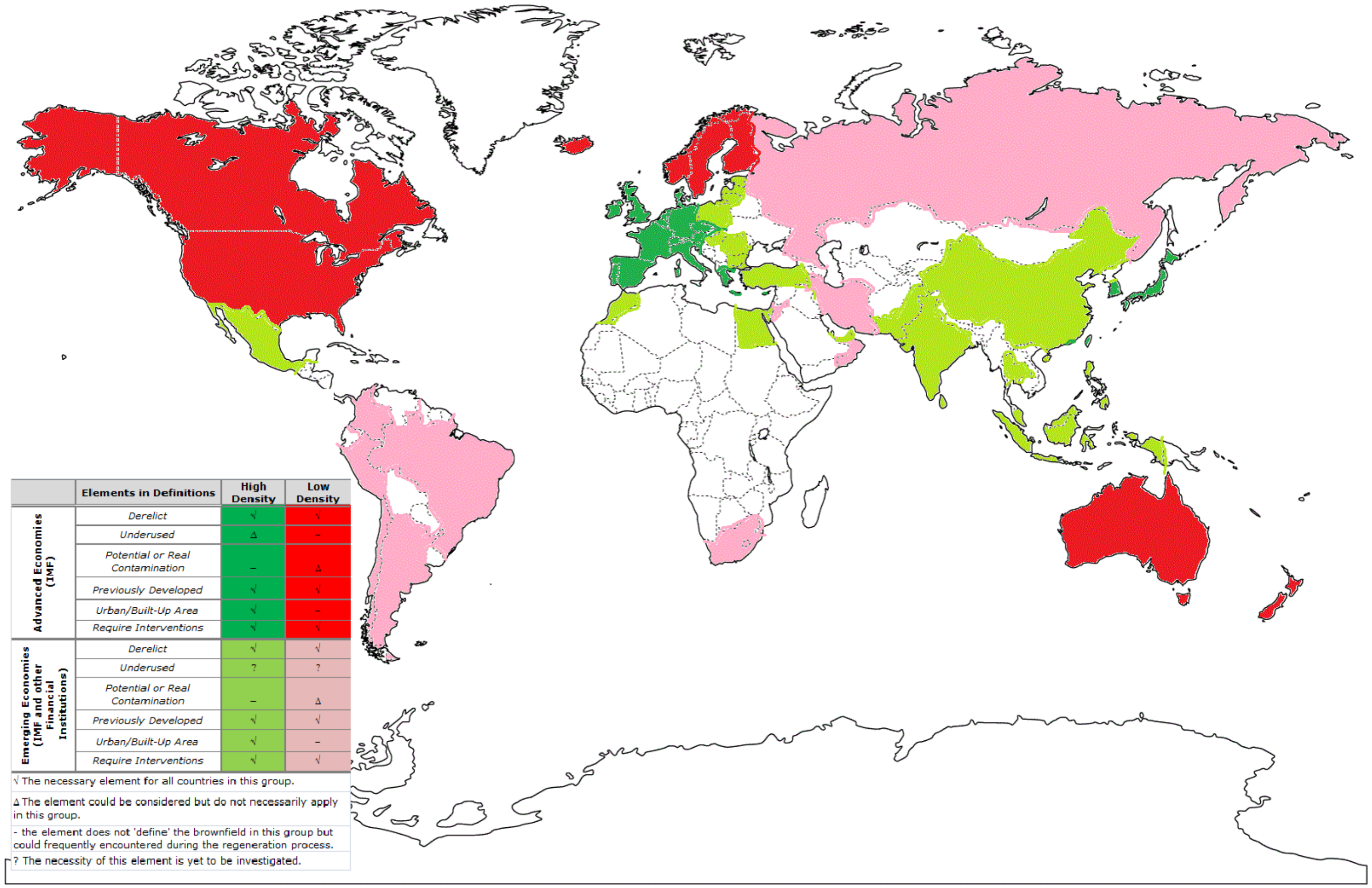
This study has established a framework to define brownfields in regeneration policy through the following findings:

1. The literature review revealed various interpretations of brownfields and sustainability from institutions depending on various schools of thought (Chapter 2);
2. The analysis of the relationship between PDL and deprivation conditions in England indicated brownfield reduction has not necessarily improved socio-economic sustainability (Chapter 4);
3. The comparison of the sustainability performances among countries demonstrated that population densities and the stages of development affect the approaches to pursuing sustainable development as well as brownfield regeneration (Chapter 5);
4. The index of land use sustainability established using PCA equally representing three aspects of sustainability showed the interconnectivity of the three aspects. Furthermore, the scores of countries reconfirmed that population densities and the stages of development affected the strategies to use land resources sustainably (Chapter 6);

5. The analyses of parliamentary debates, quantitative land use data, and the indicators of socio-economic conditions indicated the brownfield definition and the target of brownfield recycling did not encourage sustainable land use (Chapter 7); party politics have maintained this ineffective definition and targets.
6. The comparison of two land use surveys in 1990s and 2000s revealed the sprawls of built-up areas were more serious in the counties than in the cities in Taiwan (Chapter 8);
7. The evaluation of the consistency between planning policy and current land use indicated the sprawls in the counties in Taiwan were largely the unintended consequences (Chapter 8);
8. The review of the news reports indicated the perception of brownfields in Taiwan was shaped by several serious industrial pollution cases (Chapter 9); the brownfield regulation (i.e. SGPRA 2000) thus focused on dealing with contaminations on sites;
9. A regression analysis on the databases of designated polluted sites indicated the designation in accordance with the regulations (SGPRA 2000) did not affect the sprawls observed in the counties in Taiwan; the regulations neither improved the land recycling, nor hindered the land use (Chapter 9);

In conclusion, brownfield definitions in regeneration policies affect the results of brownfield regenerations. To make policy successfully facilitate sustainable brownfield regeneration, the first step is to define brownfields in the policy according to the development density and the development stage of a country. This study has built a framework as an analytical tool to develop suitable brownfield definition.

Based on the economic development (emerging and advanced economies) and population densities (world average), a general recommendation on the essential elements in defining brownfields is provided according to the framework (Table 10.4). Based on the same criteria, different types of brownfield definition are suggested to the advanced and emerging economies (Figure 11.1). The policymakers in countries may use the suggested definitions as the first step to establish regeneration policies. The policy based on the appropriate definition should channel the public as well as private resources to the brownfield regeneration projects that will improve socio-economic as well as environmental sustainability through land recycling.



	Elements in Definitions	High Density	Low Density
Advanced Economies (IMF)	*Derelict*	√	√
	Underused	∆	–
	Potential or Real Contamination	–	∆
	Previously Developed	√	√
	Urban/Built-Up Area	√	–
	Require Interventions	√	√
Emerging Economies (IMF and other Financial Institutions)	*Derelict*	√	√
	Underused	?	?
	Potential or Real Contamination	–	∆
	Previously Developed	√	√
	Urban/Built-Up Area	√	–
	Require Interventions	√	√

√ The necessary element for all countries in this group.

∆ The element could be considered but do not necessarily apply in this group.

- the element does not 'define' the brownfield in this group but could frequently encountered during the regeneration process.

? The necessity of this element is yet to be investigated.

Figure 11.1 The Recommendation of Brownfield Definition to Different Groups of Countries

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