An Analysis of Land Use Change using GIS and Spatial Analysis:

A Case Study of the Seoul Metropolitan Region Perimeter

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Abstract

This thesis is concerned with analytical and technical capability in using Geographical Information Systems (GIS) and spatial analysis as relevant to the policy challenge of urban fringe management, taking as a case study the Seoul Metropolitan Region Perimeter. The primary purpose of this study is to analyse land use change using the tools of GIS and Spatial Analysis as a spatial decision support system for the task of managing the fragmented development of the urban fringe caused by the policy changes introduced by the Korean government in 1994.

The case study analysed in this research shows whether GIS and spatial analysis can be applied to manage and monitor land use change in the urban fringe area at a very detailed level using municipal parcel data which occupies about 80% of administrative affairs, especially at the local government level in Korea. The major determinants of land use change in the study area have been investigated in an attempt to enhance the knowledge of how to provide decision support information for local government in Korea using GIS and spatial analysis. The results of the analysis represent the distribution of land use change from 1994 to 1998, the distribution of parcels with more than 50% of their neighbours in urban use and the transition probability of land use

within a GIS, etc. The analysis using GIS and spatial analysis proved to be effective ones when providing the information base for modelling land use change in the urban fringe of the Seoul Metropolitan Region in Korea, to enable informed decisions to be made about land management policies in such areas.

The lesson which could be drawn from this study is that a GIS and spatial analysis capacity is quite useful for local government to understand where and why land use change is concentrated, how the pattern of land use has changed, and which areas are susceptible to land use change. This study represented the results of analysis as a map, showed the significant patterns of land use change in the study area, displayed the relationship between neighbouring land use and the pattern of land use change, and suggested the transition probability of land use in the urban fringe in the future. Better understanding of the results may enhance the capability of local government to predict future land use change dynamics and devise more effective land use management strategies. This study brings a new approach to understanding the evolution of development patterns using the methods of combining spatial statistical analysis techniques with GIS application at site level.

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CHAPTER ONE

INTRODUCTION

1.1 The background of the Study

Most large cities around the world have experienced rapid growth in the past decades. Since 1960, Korea has also experienced rapid urbanisation due to fast economic development. Population and industry have been concentrated within urban areas. As a result, the inner and outer areas of the cities have undergone serious changes in land use. This phenomenon is clearly evident within metropolitan areas.

During the 1960s, a sizable amount of immigration from rural areas resulted in the gradual expansion of Seoul, the capital city. In 1971, the government had established a green belt around the Seoul boundary to limit unrestricted spreading of the urban community and to preserve the natural environment in rural areas. However, although the spread of urban development was controlled, Seoul continued to grow regardless. Urban growth in the 1970s continued with 'leap-frogging' development across the green belt into satellite cities around Seoul, resulting in a redistribution of the population into a metropolitan area. (Lee, G.Y., 1995)

During the 1980s, a marked change occurred; the process of population de-concentration. Seoul's outlying districts began to show a higher rate of growth, as they received overspill population and resultant economic growth from Seoul's saturated centre. This rapid urban extension has taken place further into remote and sparsely populated urban fringe areas. (Park, 1995b)

During the 1990s, deregulation of city planning was a major policy goal of President Kim Young Sam. Rapid land use change occurring around the Seoul Metropolitan Region (SMR) has become one of the most serious issues at present in Korea. Particularly in the Quasi-Agricultural and Forest Area (QAFA) the change has brought out very serious disorderly development.

This deregulation has contributed to the national economy by increasing the supply of developable land, consequently stabilising the price of land, and encouraging the production activities of enterprises (Sim, 1997). However, there has been bitter controversy over the policy since the deregulation was introduced because it has produced many kinds of negative side effects. Many agricultural and forestry areas around the Seoul Metropolitan Regions have changed, for various reasons, to hotels, restaurants, and factories without harmony with the neighbouring environment.

The keyword in government administration, the economic and social arenas in the 1990s, was 'relaxation of the rules and globalisation'. As a result, since 1993, each government department has devoted energy to relaxing the strict rules (Lee, S.D., 1997). The regulations in the real estate market have become the principle target for relaxation. This deregulation particularly focuses on the national land use zoning system, the green belts, market transaction controls, and farmland conversion regulation (Lee,T.I., 1995).

The first moves in this direction have been the simplification of the National Land Use Zoning System; 10 zones have been reduced to 5 zones. With this change, a vast amount of raw land especially in the QAFA has been opened up for possible development. The percentage of the nation's landed area where many urban land uses can be allowed increased from a mere 15.6% to 41.7% (Lee, T.I., 1995).

Several modifications have also followed in other relevant legislation and policy measures under this general trend. The Capital Region Growth

Management Plan, which was first prepared in 1982 to strictly control new developments within the region, has also been relaxed. The Building Codes have also been revised to allow more freedom for individual building activities in urban areas. The landowners who plan to build on their land now simply have to report to local ward offices rather than applying for construction approval (Lee, T.I., 1995).

As the choice of a planning approach, government policy makers in Korea seem to focus on a deregulated environment to encourage market functions, combined with technical approaches to defining regulatory standards, targets and criteria (Healey 1995, Suh 1998). Clearly, the relaxation has moved in one direction to make access to land much easier. As a result, development on the urban fringe has expanded rapidly changing much land from non-urban to urban uses.

Land use change is a complex phenomenon which differs greatly from place to place. Causes of change include personal choice, legislation, government polices and plans, decisions of developers or transportation entrepreneurs, the nature of the land itself, or the availability of technology to develop the land (Hill, 1989).

In addition, it is very difficult to trace the process of land use change because of the complexity of the situation compounded by a lack of comprehension of the range of the information needed. (Ganderton, 1994)

To better understand the rapid land use change occurring in these urban fringe situations, a number of studies have sought to quantify the extent and rate of agriculture and forestry loss. Such studies have lacked a way of displaying the results of analysis because of insufficient development of computer hardware and Geographical Information Systems (GIS) software. However, local governments need to know more than the extent and rate of agriculture and forestry loss. They want to know not only the rate and extent of land use change for a given region but also the location of changed land, the pattern changed, and the probability that given areas of land will change in use.

In accordance with these purposes of local governments, this study focused on the applications of GIS and spatial analysis to land use change analysis. Therefore, the main point of the research is whether the successful application of GIS and spatial analysis in the urban fringe will give local government a better understanding of the issue. To do this, a number of existing applications and solutions are reviewed. In particular, the problem of integrating spatial analysis and GIS is explored.

GIS is now a leading tool in the development and application of contemporary urban planning. In the past, local governments believed that computer technology would provide a technological solution to complex and difficult issues of public policy (Michalak, 1993). Unfortunately, the current techniques and commercially available systems are not entirely satisfactory. The study therefore examines and evaluates existing approaches and suggests possible solutions and a further research agenda for improving the integration and analysis process.

1.2 The purpose of the Study

This research is concerned with analytical and technical capability in using GIS and spatial analysis as relevant to the policy problem of urban fringe management. The purposes of the research are as follows. Firstly, this research is to examine the relationship between government policy change and land use change in the urban fringe.

Secondly, the study will focus on examining the relationship between the nature of the land itself and land use change in order to discover the determinants of the change in the study area. It is imperative that local governments understand the determinants of land use so that future patterns of land use can be projected, planned, and managed under sustainable conditions. Not surprisingly, however, those variables were already investigated by existing studies such as highway proximity, distance to urban centres, elevation, slope, and soil suitability, etc. (Pierce 1981, Firman 1997). Among the site characteristics the variable in which the thesis will be most interested is neighbouring land use. Therefore, thirdly, this research will focus more on the impact of neighbouring land use. Many studies, such as cellular automata theory, related to analysis of neighbouring land use have been conducted by using cell based raster GIS. However, the study is concerned with cadastral maps used by local governments for a number of purposes, including greater manipulation of single parcels. Therefore the study will analyse the impact of neighbouring land use by using vector model and spatial analysis.

Fourthly, this research will develop an analysis of the transition probability of land use, i.e. which areas are most susceptible to land use change. This will be also useful to local governments when formulating a plan to protect the lands from further unplanned development.

Finally, the results of analysis will be visualised by using GIS so that local governments can view where a specific change takes place, how the patterns of land use have changed, and what conditions lead to disorderly development. The representation will be useful for local government to assess the impact of policy change.

1.3 Research Questions

The question inherent in this research, therefore, is whether Geographic Information Systems and Spatial Analysis technology can help local governments, faced with urban fringe management, to formulate a plan or assess decision options by emphasizing the important features of the environment.

The research question is also whether the integration of Geographic Information Systems and Spatial Analysis technology can enhance the ability of local government in making an analysis of land use change in the urban fringe at a very detailed level using municipal parcel data which occupies about 80% of administrative affairs, especially at the local government level in Korea.

1.4 The scope of the research and methodologies

This study employs data for three time-points, 1991,1994, and 1998, thus enabling a dynamic perspective on the research questions. The particular year 1994 was the first year of deregulation mentioned above. 1991 was the year a database of surveys of land characteristics at national level was set up.

The research employs two main methodologies: Logistic Regression and Geographical Information Systems.

Logistic Regression is a form of regression which is used when the dependent variable is a dichotomy and the independents are continuous variables, categorical variables, or both. With this fundamental concept, Logistic regression is used to examine the main determinants of land use change. The dependent variable is the changed or unchanged use of land in a parcel. The independent variables are area, land category, zoning, height, direction, forest cover, neighbouring land use, accessibility to main roads, land price etc.

GIS analysis is used to verify spatially the close statistical relationship between the dependent variable and the independent variables selected by the logistic regression analysis. The results of the analysis are visualised using GIS (ARC/INFO and ArcView) to improve the understanding of the land use change in the Seoul Metropolitan Region Perimeter. The GIS also supports storage, analysis, querying, browsing and display of various geographical data available for the study area.

1.5 The organisation of the study

Chapter 2 will first review theories providing important insights related to the purposes of the thesis such as land use change theories, California Urban Futures (CUF) Model and Cellular Automata (CA) model. Then experimental studies provided to help local governments with timely information on current issues and related to the purpose of the thesis will be reviewed. Finally, this chapter will discuss the distinctive approach of this thesis in relation to the theories and experimental studies.

Chapter 3 reviews the definition of terms, then the historical background of Korea's urbanisation and deregulation, as well as the serious problems of the urban fringe. Specifically, it reviews who needs information about land use change.

Chapter 4 reviews the general research strategies such as the case study approach used and data collection. Then the methods using GIS and spatial analysis will be reviewed in detail. It presents two main methodologies: Logistic Regression and Geographical Information Systems.

Chapter 5 represents what data are now available and how to transform that data into a GIS format and which variables are appropriate for the analysis. This chapter will present the study area in terms of collecting data, data building, and data classification.

Chapter 6 presents the analysis procedure of spatial phenomena from the study area. This chapter will attempt to find the relationship between government policy change and land use change, to examine the determinants of land use change, to estimate the role of the neighbouring land use variable in the model, and to investigate the transition probability of land use.

Chapter 7 visualises the results of analysis and posits probable reasons and development tendencies with respect to the patterns. Then this chapter will suggest policy messages result by result so that policy makers and planners can refer to them when evaluating and deciding on the land use management strategy change. Also, this study demonstrates the usefulness of the application of GIS and spatial analysis in land use change research.

Chapter 8 concludes the thesis. It represents an overview of the research by summarising the research background, methodological approach, analysis results and findings, and some policy implication of the results, etc. It demonstrates the study's contributions to this field. Finally, it identifies limitations and future research which could develop from this study.

1.6 The contribution of the study

The study contributes to significant advances on the integration of GIS and spatial analysis. In addition, it is the first study analysing the impact of neighbouring land use at a site level by using vector GIS and spatial analysis. It is also the first analysis of land use change regarding every parcel in the study area using cadastral maps manipulated by local government. The results of this study will assist planners in determining appropriate land use for Korean urban growth areas. These should help local governments understand the effects of land use change in the urban fringe in Korea.

CHAPTER TWO

URBAN MODELLING REVIEW

2.1 Introduction

There are a number of theories on urban growth and land use conversion. Each of them develops the issue from a particular theoretical perspective, but there is a trend to merge, or at least to mix, concepts and perspectives in an attempt to establish a synoptic view (Gottdiener, 1991; Stanilov, 1998). However, there is little agreement on some major subjects related to urban growth and land use conversion theory including a lack of commonly agreed terminology. Many times these terms are also applied interchangeably or interpreted rather freely according to the purpose of the author (Stanilov, 1998).

Another viewpoint is that there have been great advances in the last twenty years in the scientific understanding of complex phenomena and a vast increase in the availability of cheap computing power that has helped facilitate this understanding. These have provided urban theorists with a range of new tools for analysing and modelling urban systems. However, due to the geographical complexity of real cities, most urban modelling applications have still failed. This is because they have mostly focused on a limited descriptive analysis of particular attributes of the urban system (Erickson and Lloyd-Jones, 1997).

With these limitations in mind, this chapter will find related theoretical concepts for guiding the present research and see what existing studies related to the present study have already been done. This chapter has paid particular attention to several essential elements related to the purpose of this thesis: unit of analysis; temporal analysis; the application of GIS and spatial analysis; raster or vector based format analysis; transition probability of land use; neighbouring land use effects. Therefore, the chapter will firstly review theories providing important insights related to the purposes of the thesis such as land use change theories, California Urban Futures (CUF) Model and

Cellular Automata (CA) model. Then experimental studies provided to help local governments with timely information on current issues and related to the purpose of the thesis will be reviewed. Finally, this chapter will discuss the distinctive approach of this thesis against the theories and experimental studies.

2.2 Urban Modelling

The forecasting, simulation, and prediction of urban growth and land use change are being undertaken within the framework of a dynamic modelling approach. These theories have emerged over the last decade, particularly in complexity theory and in the study of chaos (Batty, 1995).

2.2.1 Theories explaining land use change

There are three traditional theories on how to view land use patterns and dynamics: economic theory; sociological theory; and the public interest-oriented approach. Economic theory views land use as a result of economic competition for limited space based on equilibrium theory (Hurd, 1903; Ratcliff, 1949; Wingo, 1961; Alonso, 1964; Muth, 1969). Sociological theory views land use in the context of urban ecology and social structure (Chapin, 1965). The public interest-oriented approach views land use in the context of health, safety, and general welfare (Kaiser & Weiss, 1970).

These traditional land use theories are connected with theories explaining land use changes. Land use change theories generally focus on the conversion of land from non-urban to urban uses. The land use conversion as usual occurs in the urban fringe, along with urban expansion (Fisher, 1954; Bourne, 1969). These land use change theories have been based on three different approaches: factors affecting land use change, leading actor's behaviour, and process oriented approaches (Chang, 1986).

The approach related to factors affecting land use change is concerned with the causal relationships between land use change regarding it as urban growth, and land use change caused by exogenous factors such as proximity between land uses, accessibility to work areas, compatibility between land uses, availability of public facilities, and proximity to ethnic group areas (Chapin, Donnelly, & Weiss, 1962; Chapin and Weiss, 1962a). The studies related to a leading actor's behaviour suggest that the conversion of land use is determined by the decisions of leading actors such as the predevelopment landowner, developer, land speculator, facilitator, local government, and household consumer (Kaiser, 1966; 1968a; 1968b; Clawson, 1971; Rolph, 1973; Baerwald, 1981). The process oriented approach stresses that the conversion process of land use is a sequence of stages brought about by a series of key decisions which include those of both key decision agents and supporting agents in each stage, and which are influenced by decision factors and local public policies (Kaiser & Weiss, 1970).

A number of land use theories mentioned above have contributed to a better understanding of land use and land use change. These theories can be thought of as an aggregate system of land use and economic activities, or as determinants of city structure based on the difference between the intentions and the behaviour of individuals. They have been the predominant theoretical approaches to the understanding and forecasting of the structure of cities for the last 50 years (Batty, 1994a). However, although these theories explain urban expansion and evolving land use patterns, they can hardly serve as tools to simulate, forecast or predict future urban developments. White argues that Land use theories are static models and that they assume rational actors interacting in a market which remains in a stable equilibrium state (White and Engelen, 1993).

2.2.2 The California Urban Futures (CUF) Model

The California Urban Futures model really shows what this study is interesting in such as the application of GIS and spatial analysis and neighbouring land use effects. The Model is a metropolitan simulation model to provide a framework on how realistic growth and development policies at various levels of government might alter the location, pattern, and intensity of urban development in the fourteen-county Northern California Bay Region (Landis, 1994).

The CUF Model was developed as a planning model "to help planners, elected officials, and citizen groups create and compare alternative land use policies" (Landis, 1995; Kramer, 1996). It is a model which forecasts urbanisation at the regional scale (Landis, 1994). The analytical unit of the CUF Model is Developable Land Units (DLUs). DLUs are generated as the spatial union of multiple GIS layers. DLUs are made up of one-hectare (100m x 100m) grid cells (Landis and Zhang, 1998a).

The CUF Model includes spatial database between 1985 and 1995 as follows: i) local population and employment growth; ii) proximity to regional job centres; iii) site slope; iv) whether the site is within or beyond city boundaries or spheres of influence; v) the uses of surrounding sites; vi) the availability of vacant land; vii) site proximity to freeway interchanges and transit stations; viii) site proximity to major commercial, industrial, and public land uses (Landis and Zhang, 1998a).

The Model is one of the first urban models to utilise GIS technology (Wegener, 1994). The CUF Model incorporates a GIS to "assemble, manage, display, and make available millions of pieces of information describing land development potential" (Landis, 1995:p454). The Model is very complex and extremely "data hungry" (Landis, 1995). The results of the CUF Model simulation present three alternatives for growth policy/ land-use planning for the San Francisco Bay and Sacramento areas (Landis, 1995). The three alternatives are a “Business-as-Usual” scenario, a “Maximum Environmental Protection” scenario, and a “Compact Cities” scenario. This Model also demonstrates evaluation of alternative policies on agricultural protection and zoning at the county, or sub-regional, level.

The CUF Model requires an extensive GIS database because the model is developed to make choices based on the knowledge that planners have (Kramer, 1996). In addition, Landis (1995) explains that the CUF model can be applied at the subregional or county level for local growth planning. Landis and Zhang (1998a, 1998b) extended the database by new data categories such as housing prices, employment growth forecasts distributed to individual DLUs, and major new infrastructure investments. However, the model requires a constant and very knowledgeable interaction to be of use for planners (Kramer, 1996).

2.2.3 Cellular Automata (CA) Theory

The cellular automaton approach is to model urban areas and land use temporally and spatially. The Cellular Automata theory is developed to visualise rural to urban transition as a physical process. A cellular automaton is an array of cells, whose states depend on the states of the neighbouring cells (White and Engelen, 1993; Kramer, 1996). Cells of a cellular automaton respond in a mechanical way to surrounding cells. Due to these interactions, cellular automata are considered as discrete dynamic systems with simple construction but complex self-organising behaviour (Wolfram, 1984; Kramer, 1996; Clark et al., 1997). Each point in a regular spatial lattice, called a cell, can have any one of a finite number of states. The states of the cells in the lattice are updated according to a local rule. That is, the state of a cell at a given time depends only on its own state one time step previously, and the states of its nearby neighbours at the previous time step. All cells on the lattice are updated synchronously. Thus the state of the entire lattice advances in discrete time steps (White and Engelen, 1993).

The concept of cellular automata was initiated by physicist Stanislaw M. Ulam (1962). John von Neumann (1966) soon used the theory to investigate the logical nature of self-reproducing systems. The research on cellular automata has increased rapidly since John Horton Conway invented the 'Game of Life'. This game became widely known when it was mentioned in an article published by the Scientific American in 1971. The game is played on a field of cells, each of which has eight neighbours (adjacent cells). A cell is either occupied (by an organism) or not. The rules for deriving a generation from the previous one are these: (Conway et al, 1982)

Survivals: If an occupied cell has two or three neighbours, the organism survives to the next generation.

Deaths: If an occupied cell has 0, 1, 4, 5, 6, 7, or 8 occupied neighbours, the organism dies (0, 1 neighbours: of loneliness; 4 thru 8: of overcrowding).

Birth: If an unoccupied cell is surrounded by exactly three occupied neighbours, the organism is a birth cell and becomes occupied (Conway et al, 1982).

A further important step from mathematical theory towards a broad range of applications of cellular automata came with Wolfram's research regarding the universality and complexity in cellular automata (Kramer, 1996). Wolfram concluded that the recognition of the complexity contributed to techniques exploring theoretical issues of the origin, dynamics, and evolution of structures in various fields (Wolfram, 1984).

The dynamic urban modelling approach developed by Batty (1992), White (1993), and Clarke et al (1996) has its main roots in the cellular automata theory (Kramer, 1996). They developed new computational dynamic cellular models of urban growth. Their approach has been described as a new school of urban modelling (Clarke et al, 1997).

Batty and Longley (1994) used a dynamic systems model called "Diffusion-Limited Aggregation"(DLA) to model the growth of an urban area. The model of Batty is based on only two cell states: vacant and occupied. Only vacant cells which are in contact with an occupied cell can be converted to occupied cells. The DLA model was applied to demonstrate the historical growth of Cardiff, Wales, and Savannah, Georgia.

Batty (1994) addressed how the simulation of the suburban development of Amherst in metropolitan Buffalo, New York, might be applied to the growth dynamics of real cities (Batty and Xie 1994b). They had an excellent historical data set of development sites. The model started in 1880 and used the 259 developed sites as 'seeds' from which growth is spawned for the next 110 years. They considered that these seeds already reflect the position of Amherst within the wider urban growth pattern of Buffalo, on existing villages in the rural hinterland and showing the emergent pressures for suburbanisation (Batty and Xie, 1994b).

The model on a Carribean island developed by White is of special interest because it integrates a cellular automaton with a GIS. In the integration of a cellular automaton model and a GIS, the cellular model can take advantage of the detailed GIS database and at the same time undertake spatial analysis, which is not part of GIS. White sees the ultimate goal in building cellular modelling tools into a GIS in order to create a GIS with dynamic capabilities (White and Engelen, 1993). With this vision White comes close to his objective to develop a theory that offers solutions for the local and specific problems of planners and other practitioners (White and Engelen, 1993; Kramer, 1996).

The self modifying cellular automaton urban growth model developed by Clarke et al. (1997) is designed to predict urban growth within a defined study area in order to estimate the impact of urbanisation on the San Francisco Bay area's climate. The model is dynamic and future oriented. It is designed to predict urban growth on a regional basis 100 years into the future. The predictability was necessary in order to evaluate the impact of urban growth on the ecology of the area. The validity of the model is due to a complex GIS based cellular automaton and to rigorous past to present calibration. Making the intensive calibration approach an integral part of the model development is an important new feature of computational cellular automaton urban growth models. Intensive calibrations of the model ensure a high degree of probability with regard to the prediction of future urban growth (Kramer, 1996).

2.3 Existing studies on land use and urban growth

Existing studies on land use and urban growth have developed rapidly with the advent of GIS and remote sensing technologies. Many metropolitan governmental agencies in the U.S. have begun to formulate land use strategies and growth management strategies in their regions using these new technologies. These studies have been used in a variety of themes such as to estimate land supply and potential for future urban development, to analyse environmental quality issues, to determine changes in vegetation cover, and to investigate potential hazard impacts. Three such projects which were provided to help local governments with timely information on current issues and were related to the purpose of the thesis have been identified and are described briefly below (Stanilov, 1998).

2.3.1 Association of Bay Area Governments (ABAG)

ABAG is owned and operated by the cities and counties of the San Francisco Bay Area. It was established in 1961 to help solve problems in areas such as land use, housing, environmental quality, and economic development. In the ABAG region there are 100 cities and nine counties. More than 6 million people live in this area. Since 1975, ABAG has collected information on current land use and development policies of local governments in this region (ABAG, 1997).

The study, 'Bay Area Futures: where will we live and work?' (ABAG,1997), was produced cooperatively by the San Francisco District Council, ABAG, and the Bay Area Council. The report examines how the region's land use patterns are evolving. Medium altitude air photographs were used to identify land use changes in those areas. The digitised coverages were converted to a grid format with a cell size of one hectare (2.5 acres) (ABAG, 1997).

The first section of the report traces the historical development of the region. It also maps current land uses and identifies land designated for future development. The next four sections examine recent development activity and provide forecasts of future growth in each of four sub-regions: South Bay, West Bay, East Bay, and North Bay. The maps in these sections illustrate relative levels of activity for cities and sub-city (census tract) areas. The maps are colour-coded based on activity per square mile of land area and are intended as a tool for visualizing the geographic distribution of activity. The concluding section examines issues that emerge from the detailed forecasts but are more regional in scope: the affordability of housing and the spatial relationships between housing, jobs, and transportation (ABAG, 1997).

Today's land use changes are typically large-scale housing, commercial, and light-industrial infill projects. The Bay Area's traffic forecast could spur planner or decision makers to develop creative land use strategies to solve these problems. The very scale of the challenges confronting the Bay Area could create the conditions in which imaginative and far-reaching solutions might be realized (ABAG, 1997). Projections 2000, the latest edition, has provided current estimates of the population, employment, income, and households for the San Francisco Bay area from 1995 to 2020 (ABAG, 1999).

2.3.2 Twin Cities Metropolitan Council

Today, the Twin Cities is one of the most sprawling major metropolitan areas in the U.S.A. The report, called 'Two Roads Diverge: Analysing Growth Scenarios for the Twin Cities Region' (1999), was prepared by The Centre for Energy and Environment (CEE), Minnesotans for An Energy-Efficient Economy (ME3) and 1000 Friends of Minnesota. The framework of the study uses a 'Sprawling Scenario' and 'Smart Growth Scenario' to describe options for the region's growth from 1995 to 2020. The goals of this study are to apply the scenarios to address the following issues (ME3, 1999a):

How should the region accommodate its inevitable growth?

Can the region grow and retain its unique character at the same time?

What are the costs and benefits to the region of sprawling and smart growth? (ME3, 1999a)

The Sprawling and Smart Growth Scenarios are used not only to analyse growth impacts inside the seven-county metropolitan area but also to analyse growth impacts in the six outlying counties by using St. Michael, Minnesota as a case study (ME3, 1999b).

The study has used Traffic assignment zones (TAZs) and Geographic Information Systems (GIS) software. In addition, the study has used land use layer by interpreting aerial photography to determine land available for development outside the Metropolitan Urbanised Area (ME3, 1999c).

The significant point of the study is to use Traffic assignment zones (TAZs) used in the traffic modelling process as the common geographic unit for data summary. The system of TAZs covers the entire seven-county, Twin Cities metropolitan area. There are 1,165 TAZs assigned in the seven-county Twin Cities metropolitan area (ME3, 1999c).

For these scenarios, the study has used GIS to determine how many new households would be located in each TAZ outside urbanized areas and for the placing of these households to determine the environmental impacts of each scenario (ME3, 1999c).

2.3.3 San Diego Association of Governments (SANDAG)

18 cities and the county government make up SANDAG which serves as a forum for regional decision-making. SANDAG has produced both short-range and long-range growth forecasts in the region since 1971. In addition, SANDAG has been developing and enhancing its Geographic Information

Systems (GIS) since the 1970s. Complex data sets have been provided to local agencies in a format compatible with GIS (SANDAG, 1998b).

SANDAG's most recent forecasting effort is the 2020 Cities/County Forecast for San Diego Region, with a timescale of 1995-2020. This forecast is based on 1995 land use, population, housing, income, and employment data (SANDAG, 1998b).

The recent Growth Forecast uses two distinct modelling systems: Demographic and Economic Forecasting Model (DEFM) and Urban Development Modelling System (UDM). UDM distributes the regional forecast to smaller geographic areas according to attractions and constraints provided by existing and planned land use policies, transportation networks, and population, housing, and economic concentrations (SANDAG, 1998c).

The 2020 Cities/County Forecast relies heavily on land use characteristics that reflect current or simulated policies of the local jurisdictions. The availability of land for future development depends on the status of existing, planned, and constrained lands. Land use data is collected for 97 planning areas within the San Diego Region and incorporated into SANDAG's Geographic Information Systems (GIS) database. Data from the 1990 Census included here in several formats. There is also information about the upcoming 2000 Census (SANDAG, 1999).

All of SANDAG's GIS data bases are in ArcInfo and all information contained in the GIS data sets are generated at scales of 1:24,000 (1" = 2000') and have categorical and positional accuracies associated with the scale (SANDAG, 1998a).

In the early 1990s, SANDAG also developed techniques to utilize remotely sensed data as a cost efficient means of updating land use databases. Satellite images were used to automatically detect land cover changes, to create and update vegetation and road network databases between two years (SANDAG, 1998a).

2.4 Conclusion

This review does not purport to provide a comprehensive list of all the research conducted up until now, nor to evaluate all studies in detail. Furthermore, the characterisation of the literature on urban growth theories and existing studies offered here is undoubtedly incomplete. Its categories inevitably partially overlap, and the specific examples presented under each heading can only hint at the broad array of studies that each category subsumes.

Nevertheless, the characterisation may prove useful in so far as the categories demonstrate the characteristics of research on urban growth theories and existing studies carried out in the fields of urban planning as relevant to urban fringe growth management.

To conclude, it is hard to divide the mass of literature on urban growth theories and existing studies into clear-cut categories. However, some characteristics can be discovered, as outlined above. The main purpose of the literature review on urban growth theories and existing studies is not to discuss and critically evaluate all the publications, but to make clear that the studies relating to the thesis have been partial, rather than addressing the issues addressed in this thesis directly.

The following section contains a characterisation of the literature on urban growth theories and existing studies and also includes the distinctions between this thesis and said literature. Firstly, much of the research on urban growth theories has been characterised by the use of aggregate level census data. Furthermore, the experimental studies were carried out on the basis of large aerial units (TAZs, census tracts, even jurisdictions). Due to this large scale and the particular way in which area boundaries are defined, smaller and medium size clusters of activity become impossible to identify. Most of the studies are also based on aggregate gross area data which assumes an even spread of population and employment throughout the unit of analysis. In addition, most of the research typically excludes site level information. However, this thesis will choose a small study area around the Seoul Metropolitan Region to identify the pattern of land use change in detail within particular municipal boundaries and will analyse spatial relationships between the dependent variable and the independent variables of each parcel. This is because it will be helpful for local authorities around Seoul in managing and monitoring urban fringe areas.

Secondly, many of the studies on urban growth theories and existing studies have been limited due to a lack of available data and including longitudinal analysis only rarely. The few existing longitudinal studies typically employ data from two time periods which makes the detection of trends, cycles, or fluctuations in urban development patterns difficult. In addition, most of the research has focused on theoretical and ideological discussion (Stanilov, 1998). However, this thesis will employ data from three time periods to make the detection of trends, patterns, or fluctuations in land use change more obvious for practical analysis.

Thirdly, much of this body of literature is based on the application of GIS. Despite its recent popularity, GIS has contributed little to methodological innovation in urban analysis. This is because GIS is weak on the analytical capabilities of urban models. The studies mentioned above are still far from making this link between GIS and spatial analysis (Hayashi and Kenji, 1989; Mackett 1990a; 1990b; Wegener, 1994). Therefore, this study will explore what forms of analytical models can interact with the data structures provided in GIS.

Fourthly, most studies favour using a grid format, cell based raster GIS, because in a planning context, the raster model is a very effective and cheap method of producing land use strategy maps for a number of purposes. In addition, the raster model is best suited to proximity analysis. However, the grid format imposes some limitations on the treatment of land use change. For example, the minimum size for some developments, such as large industrial sites or airports, may be substantially larger than one cell (White and Engelen, 1993). The parcel is the ideal unit of analysis for studying land use change because the parcel can have a wide range of information such as area, location, price, neighbouring land use, direct regulation, and single land use. Therefore, this thesis will apply vector-based GIS which is favoured for greater manipulation of single parcels.

Fifthly, forecasting of land use change is a necessary and important part of proper land use management. A number of studies on urban growth theories and existing studies have conducted forecasting, simulation, and prediction of urban growth. Clarke et al. (1997) argue that the traditional urbanisation models omit any examination of the physical characteristics of urban expansion. Almost none of these models have examined in detail the rules of the rural to urban transition as a physical process. These models were developed to explain rather than to forecast urbanisation. However, this thesis will focus on transition probability of land use, i.e. which areas are most susceptible to land use change.

Finally, urban growth theories such as Cellular Automata and CUF model are concerned with neighbouring land use effects. As David Adams (1994) pointed out, the potential use and value of any one parcel of land is directly affected by the activity taking place on neighbouring land. Existing studies consider that land use patterns evolve through the effect of the neighbourhood. Cells take on new values depending upon what is in their neighbourhoods and, as this is continually changing, the process of evolution is immediately responsive. In addition, the spatial extent or size of the neighbourhood affects the speed of propagation through the system. Many variants of these neighbourhood effects allow the approach to be made applicable to real problems (Batty, 1994). The study recognise it is useful to look at the neighbouring land use effects using vector GIS and spatial analysis. Apart from existing studies, the thesis focuses on cadastral maps used by local government for a number of purposes. Furthermore, each parcel has a rich database such as the address, the cadastral number, the plan number, the land price, zoning, slope of land, accessibility to main road, the size with its boundary, land use and so on.

In the next chapter the study will reflect on several specific characteristics unique to Korea, and which are distinct from those found in existing literature, which is predominantly from the U.S.A. The study will then review the definition of terms, then analysis the state of urbanisation and deregulation in Korea, as well as the serious problems of the urban fringe. Specifically, it reviews who needs information about land use change.

CHAPTER THREE

LAND USE CHANGE IN THE KOREAN URBAN FRINGE

3.1 Introduction

This chapter explains why the research should be carried out by showing examples of the seriousness of land use change in the Korean urban fringe. In the 1990s the context of the political and social environment within urban policy changed drastically. Along with the worldwide movements of deregulation started in the early 1980s, the Korean government also strongly advocated the relaxing of many existing regulative measures. Land use planning and regulations have been recognised as a major area for change. As a result, while urban areas are controlled stringently by urban planning law, urban fringe areas can be easily developed with minimum conditions.

In addition, the local autonomy system was revived in the early 1990s, which gave more power to local government. Local government chiefs, elected by and answerable to local residents, would propose much too numerous development projects in order to enhance tax revenue as well as to keep campaign promises.

In these circumstances these kinds of developments affected the urban fringe in various ways. This is because development at the urban fringe is attractive in the sense that the price of land is comparatively low and developers can avoid the cost of infrastructure. Many land uses in the Korean urban fringe thus changed rapidly from rural to urban uses after deregulation in 1994. There were also many negative side effects in these areas.

As a result, it is imperative that local government manages and monitors these areas to prevent negative side effects. Local government has to address this kind of difficult issue that can occur in local areas. For this, local government will need to use comprehensive methods with computer support which should avoid, as far as is possible, any unintended negative consequences of planning decisions.

With this in mind, the study will reflect on several specific characteristics unique to Korea. This chapter will firstly review the definition of terms, then examine the urban growth and spatial policies from an experimental and historical point of view, and review the state of land use change in the urban fringe. Specifically, it reviews who needs information about land use change. One of the key assumptions of the thesis is the recognition that government policy change directly affects land use in the urban fringe. Therefore, this chapter will examine the relationship between government policy change and land use change in the urban fringe through data collected over a number of years.

3.2 Basic features of Korea

3.2.1 Physical Environment

The Korean peninsula, located in northeast Asia, is bordered on the north by China and Russia and just toward Japan to the southeast as shown in Figure 3.1. The Korean peninsula and its surrounding 3,200 islands is approximately 220,000 Km^2, almost the same size as the U.K. The administrative area of South Korea is about 99,000 Km^2, 45 percent of the total area. South Korea is composed of nine provinces, with Seoul as the capital city. Other major cities include Pusan, Taegu, Inchon, Kwangju, Taejeon and Ulsan. The landscape of the country is spectacular in its variations and about 70 percent of the land is mountainous. The main mountain range is skewed towards the east, forming steep eastward slopes and gentle westward slopes. Most of the agricultural land has been supplied by the eroded plains. There are several major rivers in the south, one of which is the Han river which cuts through Seoul.

Korea has four distinct seasons. In spring and autumn, the weather is superb: clear, blue skies and warm, gentle sunshine. Summer is relatively hot and humid, with heavy rainfall occurring during the monsoon season. Winter is cold and dry, with occasional snow. Annual average temperature is 13 - 15°C. Annual precipitation is 500mm - 1,500mm (NSO, 2001).

3.2.2 Social-economic environment

As of 2000, the total population was 47.3 million, with a density of 475.4 people per square kilometre. With the inclusion of North Korea, the total population was about 69.5 million (North Korea 22.2 million) as of 2000. Annual growth rate of the population is decreasing: 2.3%('60s) to 1.5%('70s) and presently, 0.89%. It is expected to further decline to 0 percent in 2028 (KOIS, 2001; NSO, 2001).

Figure 3.1 Location of Korea

Source: Korean Information Service (2001)

In the 1960s, the structure of population formed a pyramid shape, with a high birth rate and relatively short life expectancy. However, the distribution is now shaped more like a bell with a low birth rate and extended life expectancy. The young population under age 15 has decreased from 42% in 1970 to 22% in 2000, while the population of 65 and over has increased from 3% in 1970 to 7% in 2000 (NSO, 2001). The rapid industrialization and urbanization in the 1960s and 1970s has been accompanied by a continuing migration of the rural population into urban areas, particularly Seoul, resulting in heavily populated metropolitan areas. However, in recent years, an increasing number of people have begun moving to suburban areas of Seoul (KOIS, 2001).

Korea has undertaken economic development in earnest since 1962. An outward-oriented economic development strategy, which used exports as the engine of growth, contributed greatly to the radical economic transformation of Korea. Based on such a strategy, many successful development programs were implemented. As a result, Korea's Gross National Income (GNI) increased from US$2.3 billion in 1962 to US$474 billion in 1997. Per capita GNI is drastically increasing from US$87 in 1962 to about US$10,307 in 1997. However, due to the Asian financial crisis of 1997-99, GNI and per capita GNI drastically dropped to US$312 billion and US$6,723 in 1998. In 2000 these figures have returned to US$455 billion and US$9,628, the pre-economic crisis level (KOIS, 2001; NSO, 2001).

3.3 Definition of terms

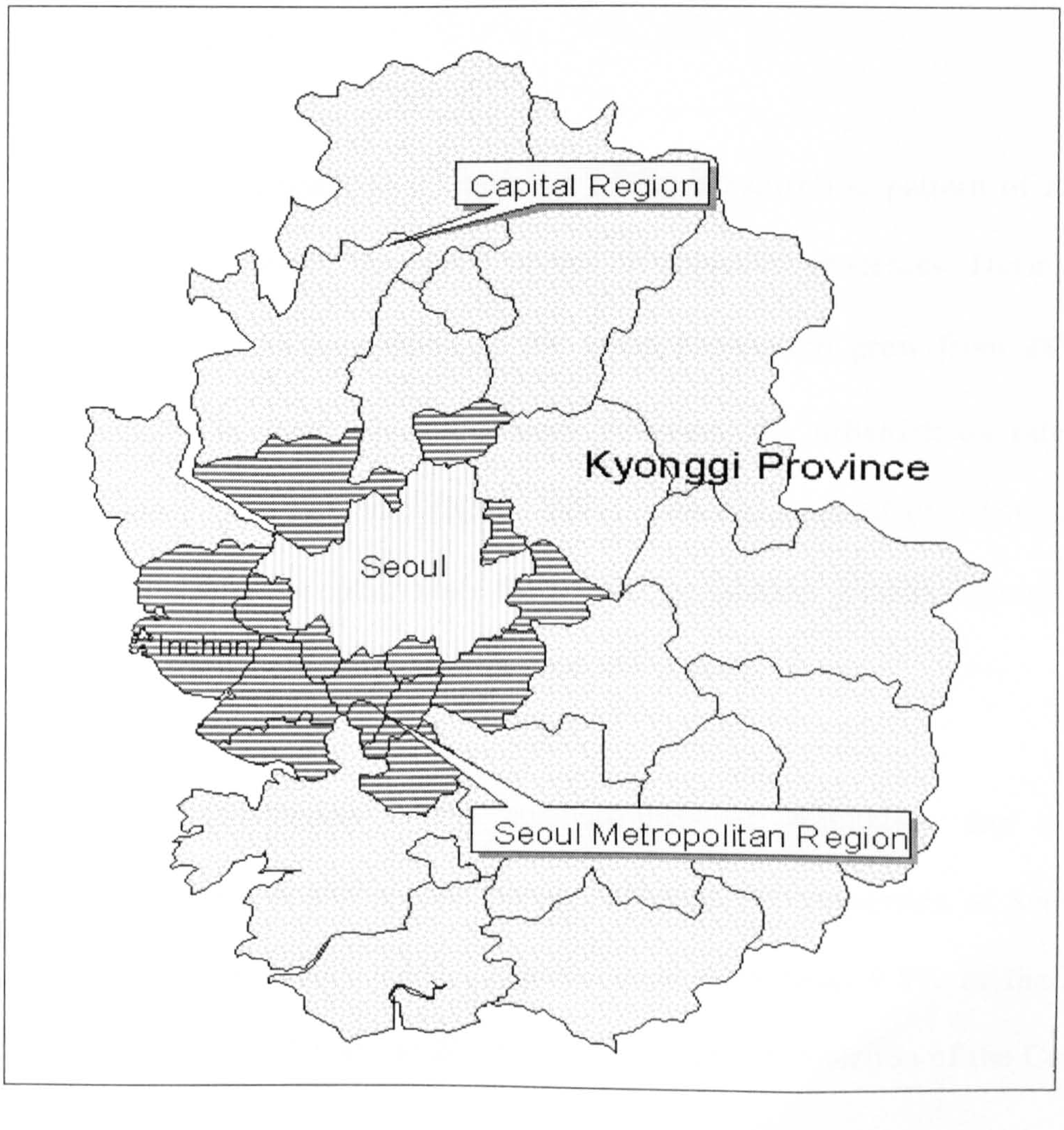
Prior to the discussion, it is necessary to briefly define some key phrases; land use change, urban sprawl, and urban fringe. There are varying definitions. In general, land use change in this thesis refers to the conversion of land from non-urban to urban uses, rather than the changes in the same types of land uses or shift within already urbanised land (Chang, 1986).

While there is no universally accepted definition of urban sprawl as to its extent, severity, or existence, it is common to think of urban sprawl as low-density, dispersed development outside of compact urban and village centres along highways and in rural countryside. Urban sprawl usually encompasses issues relating to growth, development patterns, and land use (ILGRG, 1998).

The urban fringe was defined by Pryor (1968) as ' the zone of transition in land use, social and demographic characteristics, lying between (a) the continuously built-up urban and suburban areas of the central city, and (b) the rural hinterland, characterised by the almost complete absence of non-farm dwellings, occupations and land use'. Browder and his colleagues (1995) suggest that despite the apparent diversity of fringe communities, over the last 30 years the conceptualisations of urban fringe have depicted this space as a 'transitional zone' between rural and urban areas.

It is also necessary to define the physical boundary of the Seoul Metropolitan Region. This administrative area consists of the jurisdictions of the Metropolitan Government of Seoul, parts of the Kyonggi Province and the city of Inchon as Figure 3.2 shows. Another term, the Capital Region, is the most extensive geographical area within a 30-40 mile radius from the centre of Seoul. It acquired an official definition from the early 1980s. This area covers the entire Kyonggi Province including Seoul (Park, S.Y., 1995).

Figure 3.2 The Seoul Metropolitan Region



3.4 Urban growth and spatial policy in Korea

3.4.1 Processes and patterns of urbanisation

Korea has strongly pursued a self-supporting economy through industrial modernisation since the 1960s. For this, the Korean government adopted unbalanced development strategies by converging investments on manufacturing sectors to achieve efficient resource allocation. Since then, Korea has experienced a drastic concentration of economic activities as well as rapid spatial changes.

There are three distinct characteristics of the urbanisation pattern of Korea since the 1960s. Firstly, the speed of the urbanisation processes. During the 1960～95 period, the proportion of the urban population grew from 28% in 1960 to 78.5% in 1995. During a mere 35 years, the urbanisation rate has increased more than two fold (NSO, 2001). The rapid speed of urbanisation could not adequately accommodate the natural population growth, immigration levels or maintain stable supply of the industrial sites.

The second distinction is the concentration of population and socio-economic activities in and around Seoul. Although the proportion of Seoul to the nation in area is only 0.6%, its population grew from 9.8% of the total population in 1960 to 21.4% in 2000. In addition, the proportion of the Capital

Region to the nation in area is 11.8%, but its share in population grew from 20.8% in 1960 to 46.3% in 2000. Besides population, the concentration of other socio-economic activities such as manufacturing, university and medical facilities is also noticeable (Kim, H.S. et al, 1998; NSO, 2001). The rapid and heavy concentration of population and industrial activities in the Seoul Metropolitan Region has vastly accelerated the demand for urban development and infrastructure facilities.

The final characterisation is the direction of migration. It mostly results from the migration of the rural population into urban areas rather than a more natural growth dynamic. This rapid urbanisation trend can be better explained in relation to industrialisation processes. The rapid expansion of the manufacturing sector and induced service industries has resulted in a large influx of rural population into urban areas (Joh et al, 1989). A rapid increase of the rural population into urban areas has caused most large cities, particularly the Seoul Metropolitan Region, financial and administrative trouble as well as physical and environmental degradation. Moreover, a large influx of rural people has led to an environmental deterioration of rural areas through urban development and construction of social infrastructure facilities.

3.4.2 The Evolution of Urban Policies

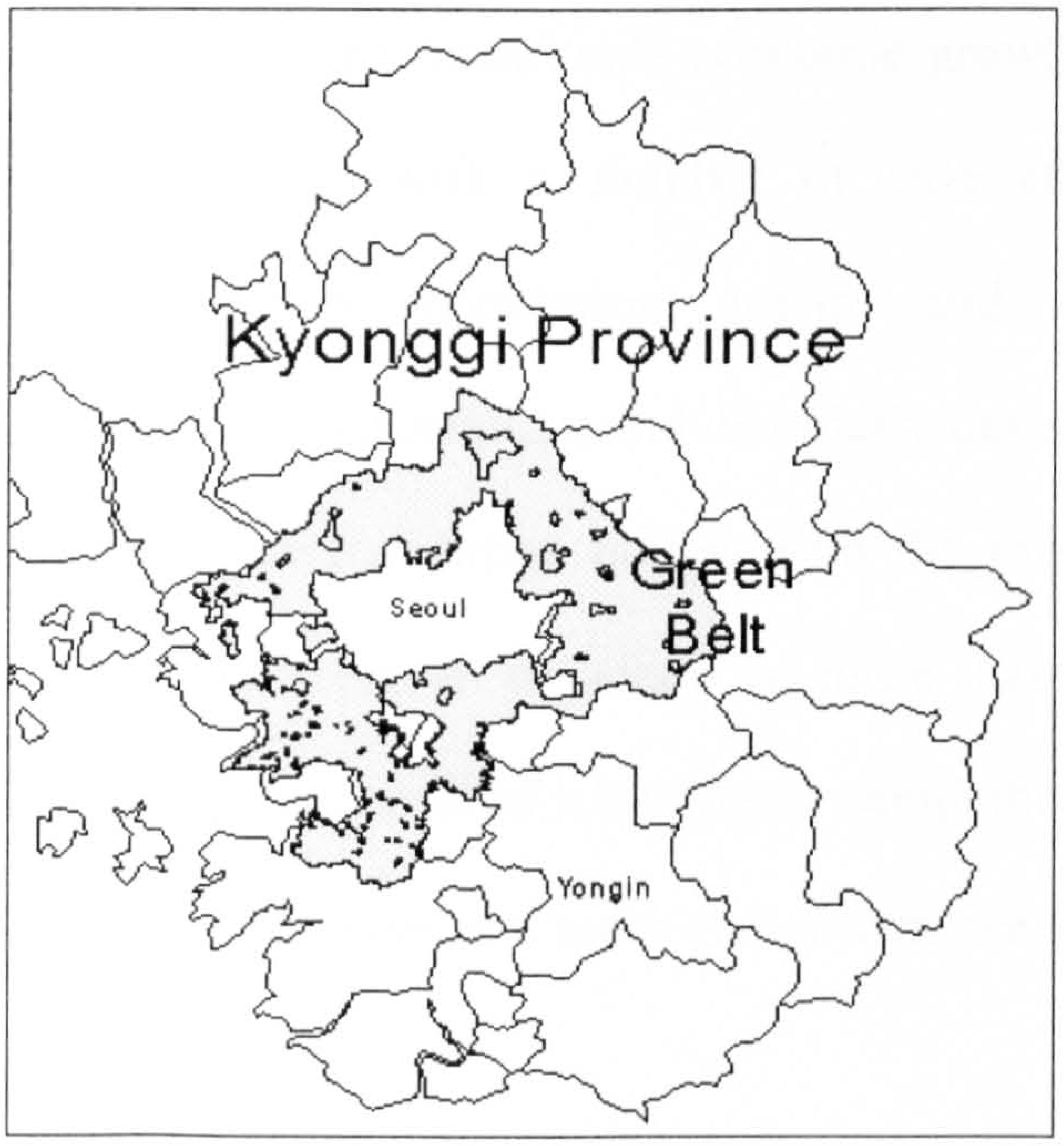
After the Korean War in the early 1950s, formal urban planning was formulated in 25 cities, essentially to secure the accommodation of refugees and to recover the damage to infrastructure. The war broke down most urban facilities. Therefore, urban planning focused on recovery from wartime damage during this period.

Since the 1960s, Korea began to obtain a tremendous impetus for growth and structural transformation, in parallel with the government's industrialisation policy. At the same time, many problems were created in the course of fast growth and change. Government thus needed a new legal system to efficiently deal with urban problems caused by rapid industrialization and urbanization. For this, the Urban Planning Act and Architecture Act was established in 1962, in place of the Chosun Town Planning Ordinance which was enacted during the Japanese colonial period. Government policies for industrialization, however, gave priority to the individual cities while limiting local government's voluntary urban policy-making powers. This resulted in the establishment of standardized urban planning and policies, and the implementation of mostly unified central government guidelines.

Since the 1970s the concentration of development to Seoul has gradually decreased, and satellite cities around Seoul have been growing very quickly. Therefore, the aim of government policies in the 1970s was to strictly control the expansion of metropolitan areas.

In addition, and in order to prevent urban sprawl, Greenbelts were established on the urban fringe of major cities in 1972 as Figure 3.3 shows. The Greenbelt policy was implemented to protect the natural environment and open spaces near large cities. However, the Greenbelt policy did not reduce the concentration of population and economic activities, particularly in the Seoul Metropolitan Region. It actually provoked urban development outside the boundary of the green belt.

Figure 3.3 Green belt around Seoul



During this period, another important feature was the introduction of land use regulation, particularly the zoning system, to restrict development by a variety of restrictive land use. Due to a serious imbalance of demand and supply of land due to economic growth as well as the constraints in land supply caused by the zoning system, the price of land and housing increased rapidly. Rapid increases of land and house prices triggered land speculation, which then boosted land prices up again, leading to a vicious cycle of land price hike and speculation. In order to solve these problems, special laws were established in 1977, such as the Housing Construction Promotion Act and the Industrial Estate Development Promotion Act. According to these laws, construction of housing and industrial estates was to be speeded up (Kim, H.S. et al, 1998).

In the 1980s the remarkable economic growth and rapid urban development continued along with a number of side effects in local areas such as concentration of population, urban land shortages, high land prices, environmental degradation, and disorderly development, etc. Therefore, central government shifted urban policy from the existing growth poles to growing multi-nuclear centres to attain a more balanced regional growth. Local government also adopted a long-term comprehensive urban master plan to deal with urban problems in a more comprehensive manner.

At the same time, the government enacted the Law on Growth Control and Management in the Capital Region in order to provide an effective guideline for physical development, land use, arrangement of infrastructure and to induce a balanced regional growth. This Law divided the Capital Region into 5 sub-regions as shown in Figure 3.4. According to this Law, new colleges and universities, industrial establishments and large scale office buildings were prohibited in the Capital Region except the development inducement sub-region where industries and people would be encouraged to move in. This law, however, was revised by new deregulation policies on land-use control in 1994. Five sub-regions were reduced to three sub-regions as Figure 3.5 shows.

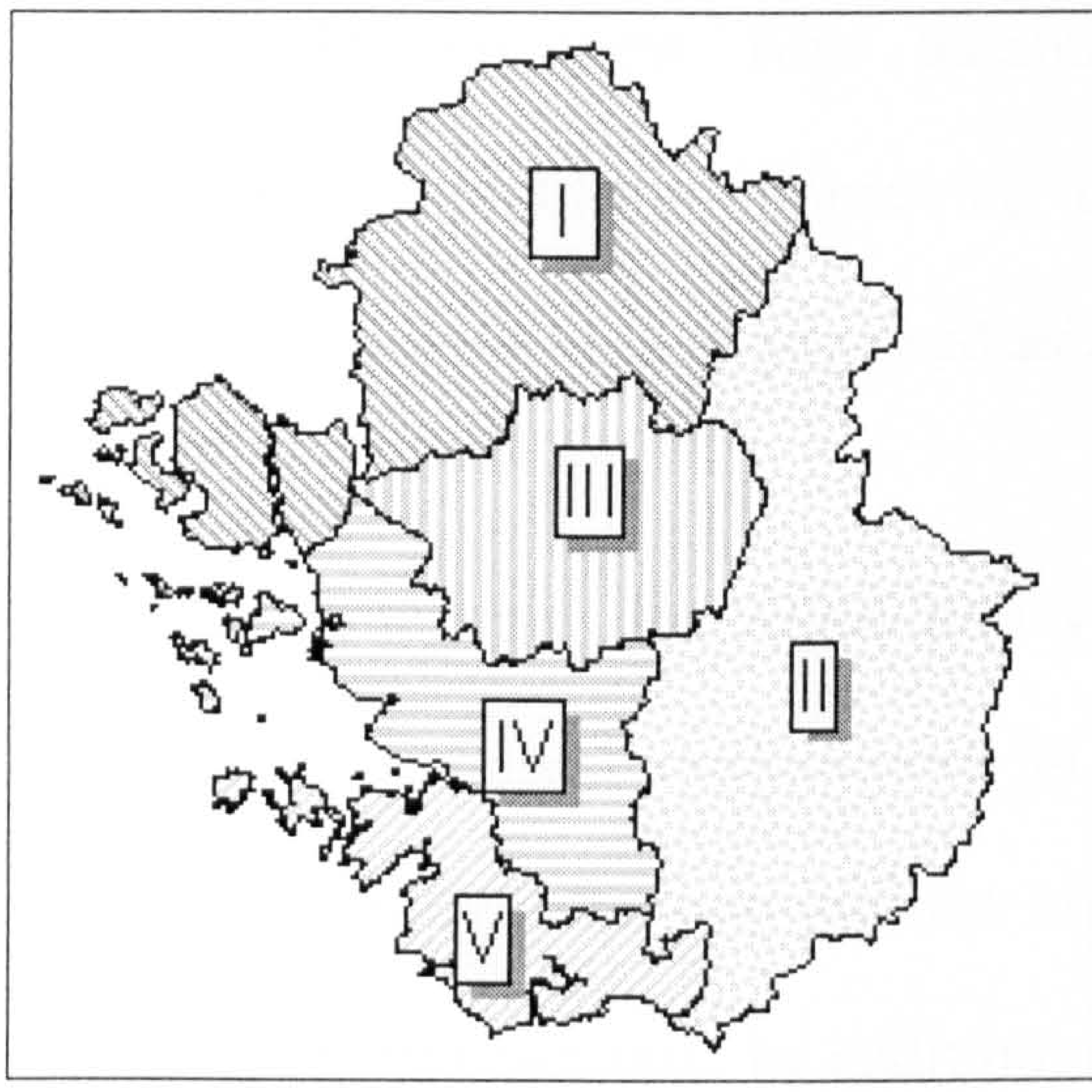


Figure 3.4 The Zonal Division of the Capital Region

I: The development reservation sub-region

II: The natural environment protection sub-region

III: The relocation promotion sub-region

IV: The restricted rearrangement sub-region

V: The development inducement sub-region

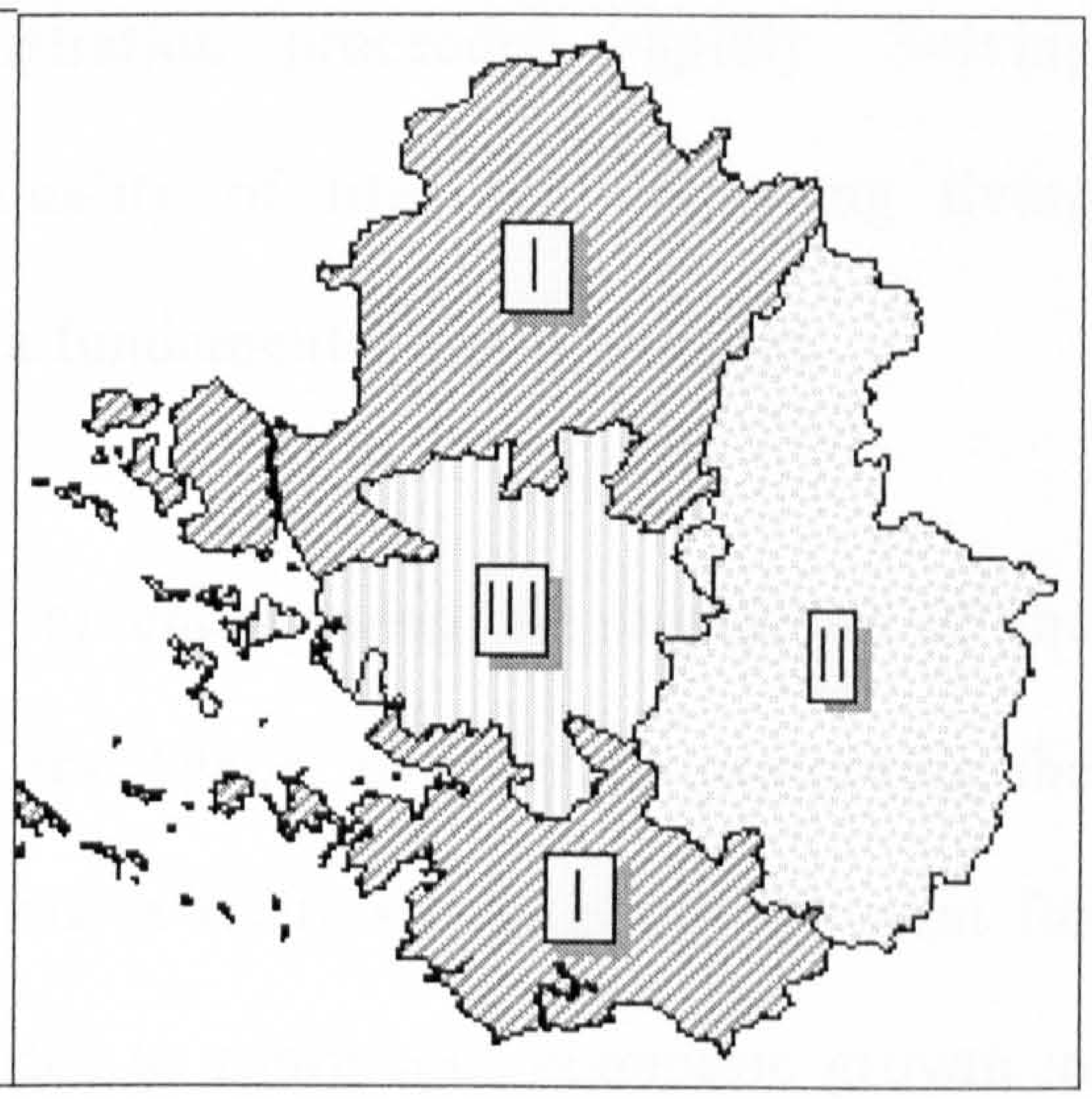


Figure 3.5 The Revised Zonal Division

I: The growth management sub-region

II: The natural environment protection sub-region

III: The over-concentration restriction sub-region

The over-concentration restriction sub-region is equivalent to the previous relocation promotion sub-region, whereas the growth management sub-region is equivalent to the previous restricted rearrangement, the development reservation, and the development inducement sub-region. It means that the levels of growth control in the Capital Region were considerably reduced (Park, S.Y., 1995, Kim, Y.W., 1995).

In the 1990s the context of the political and social environment within urban policy changed drastically once more. The local autonomy system was revived and it gave more power to the local government. Movements towards an open economy by the new Kim administration proceeded rapidly. Solving environmental problems, improving quality of life, and enhancing living environments were also emphasised as a fundamental policy concept.

At the same time, the urban policy of encouraging the expansion of the multi-nuclear centers, implemented in the 1980s, changed to promoting the competitiveness of the metropolitan areas as well as coastal development for international transactions. In addition, due to continuous economic growth in the 1960s, 1970s, and 1980s, the demand for infrastructure increased as well. For this, the government induced private sector participation in urban development projects in order to make up for the shortage of funds.

Another remarkable change in the 1990s is globalization and localization. The era of unlimited competition has come in which people, capital, technology and products are encouraged to move freely across borders. Enhancing competitive power of the economy has emerged as one of the significant national strategies. As competition is emphasized between cities and localized areas, as well as between nations, a change in the perspective of establishing human settlement systems from a closed and hierarchical systems to an open and autonomous living space is required in Korea.

In addition, as the era of localization has begun in its real sense, strengthening competitiveness on the basis of regional specialities have emerged as one of the major considerations in the regional development. It is expected that there will be more conflicts and competitions between local governments, which are caused mainly by the increasing desires for local developments. Although local government is experiencing the limitations of local authority, fiscal weakness, and the deteriorating economic circumstances, the power of local government is gradually increasing to take an active role in accomplishing independent industrial development and welfare policies (Kim, H.S. et al, 1998).

3.4.3 The deregulation policy

Along with the worldwide trends of deregulation of the early 1980s, the Kim Administration strongly advocated the relaxing of many existing market regulative measures to strengthen the nation's economy in the early 1990s. In line with the relaxation of interventions in the financial markets and the lifting of various market-entry restrictions, land use planning and regulations were also recognised as a major area for change (Lee, T.I., 1995).

This deregulation particularly focuses on the national land use zoning system. In 1993, the Kim Young Sam Administration revised the National Land Use and Management Act in order to simplify the zoning system and facilitate land supply for urban uses. This Act was constituted in 1972 to efficiently deal with the problems of land use and the rapid increase in land prices caused by industrialization and urbanization since 1960s.

As shown in Table 3.1, 10 zones were reduced to 5. The revised Law adopted five zones across the nation; Urban Areas, Quasi-Urban Areas, Agricultural and Forest Areas, Quasi-Agricultural and Forest Areas, and Natural Environment Preservation Areas.

'Urban Areas' are intended to designate current or likely urban planned areas as well as industrial estates and energy development sites. 'Quasi-Urban Areas' are similarly intended, but its zoning system includes residential facilities, land for athletic and resort facilities, agro-industrial parks, collective cemeteries, and other facilities. 'Agricultural and Forest Areas' include agricultural promotion and forest conservation sites. On the other hand, 'Quasi-Agricultural and Forest Areas' are mainly designed to provide land for urban uses, although this area can also be utilised for agricultural cultivation and forest conservation. Finally, 'Natural Environment Preservation Areas' are defined as a site for protecting natural scenery, water resources, waterfronts, ecosystem, cultural properties, and marine resources (Lee,J.S., 1997).

Table 3.1 Revised National Land Use Zoning System in Korea

	Before revised	Current	
Development	• Urban • Industrial • Rural residential • Development promotion • Tourism & Leisure	o Urban Areas (13.7%) o Quasi-Urban Areas (1.9%)	Development
Preservation	• Agricultural - Agriculture promotion - other • Forest preservation - Quasi-forest preservation forest - Forest preservation	o Quasi-Agricultural & Forest Areas (26.2%)	Development & Preservation
	• Natural environment preservation • Marine Resource preservation	o Agricultural & Forest Areas (51.3%) o Natural Environment Preservation Areas (7.0%)	Preservation
• Reserved		Abolished	

Source: the Ministry of Construction and Transportation

The total area of South Korea is about 99,268 Km^2. Half of this area is Agricultural and Forest, while the remaining half is made up of 26% of Quasi-Agricultural and Forest Areas, 7.0% of Natural Environment Preservation Areas and 15% of Urban Land Use as seen in Table 3.1.

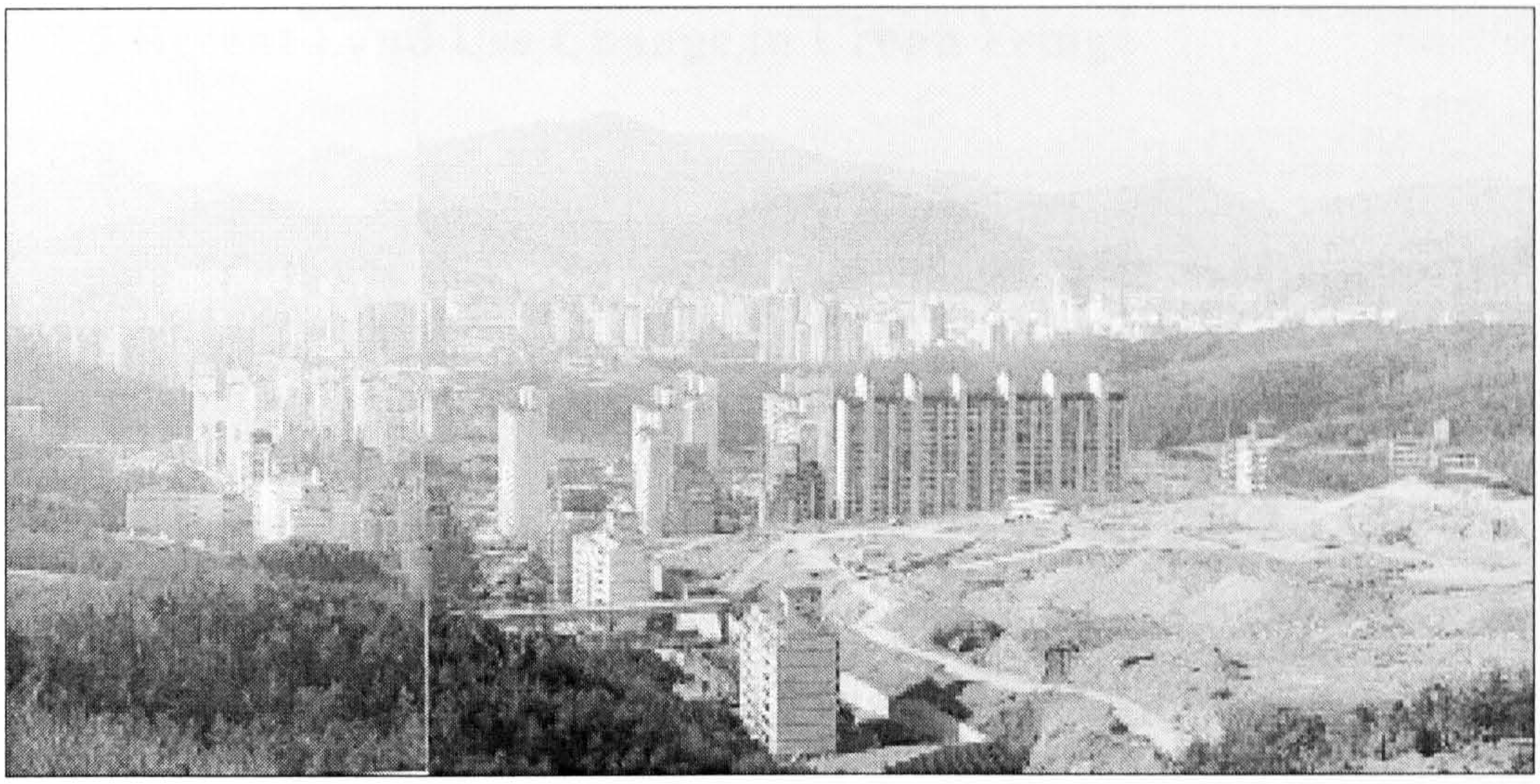


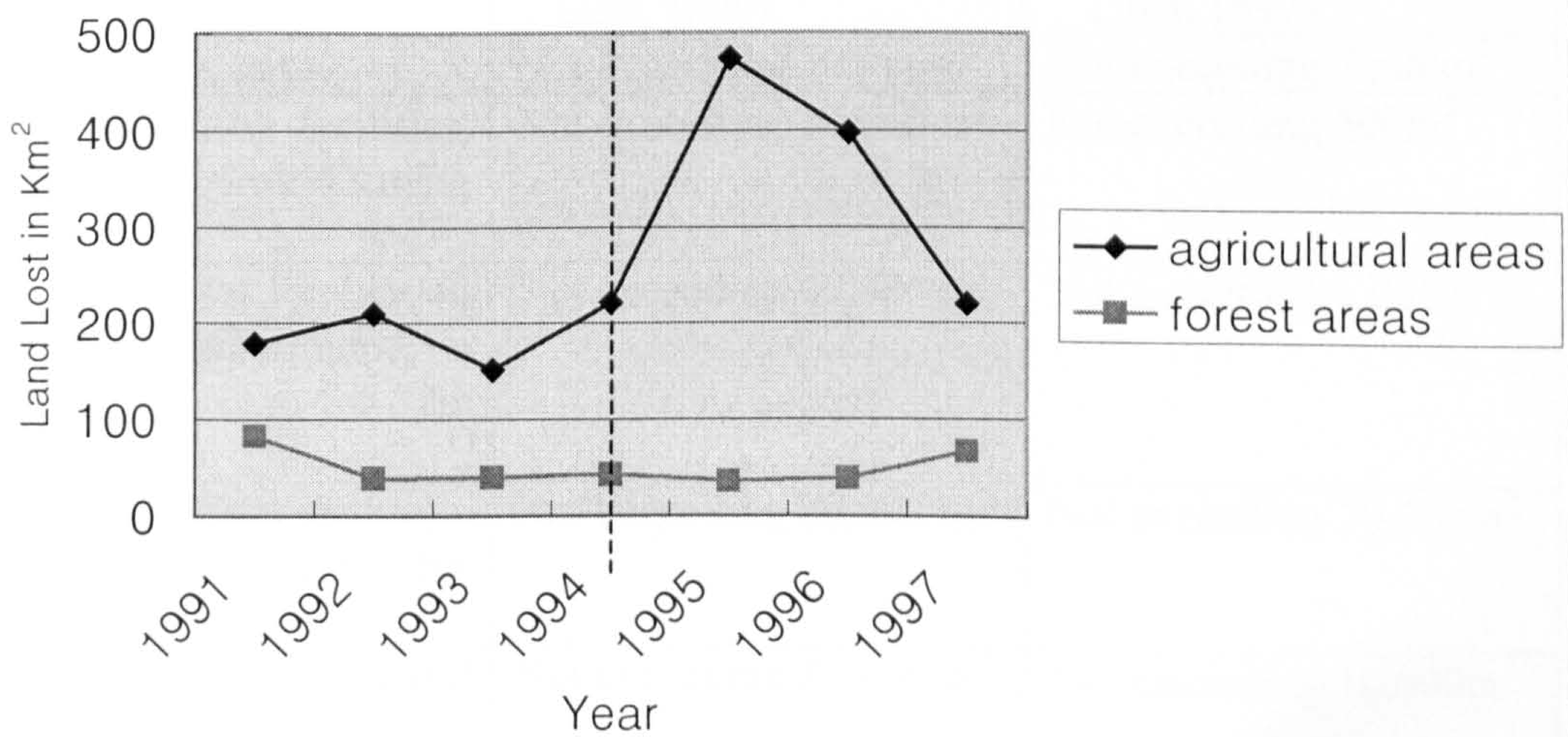
Figure 3.6 Rapid land use change in the QAFA of the Seoul Metropolitan Region Perimeter

As a result of deregulation, since 1994 many Quasi-Agricultural and Forest Areas (QAFA) around the large cities have been rapidly converted into urban land uses without sufficient public facilities and infrastructure like roads, schools, and parks. Density in these developed areas is often too high in relation to their surroundings. This is because development at the urban fringe is attractive in the sense that the price of land is comparatively low and developers can avoid the cost of infrastructure. For these reasons, rapid land use change in the urban fringe has become one of the most serious issues in Korea today, particularly in the Quasi-Agricultural and Forest Areas (QAFA), and has resulted in uncontrolled development.

3.5 Recent Land Use Change in Urban Fringe

Figure 3.7 shows that a number of agricultural areas were lost to land development at the national level between 1991 and 1997. After deregulation in 1994, the amount of agricultural areas lost increased steeply in comparison with pre-deregulation levels. As of January 1997 the loss decreased because central government took a measure in order to prevent disorderly development in the agricultural areas including, for example, a reduction in the size of areas permitted for development (Table 3.2). In addition, Korea has unfortunately suffered unexpected financial crises since the end of 1997.

Figure 3.7 Loss trends of agricultural & forest areas over entire country



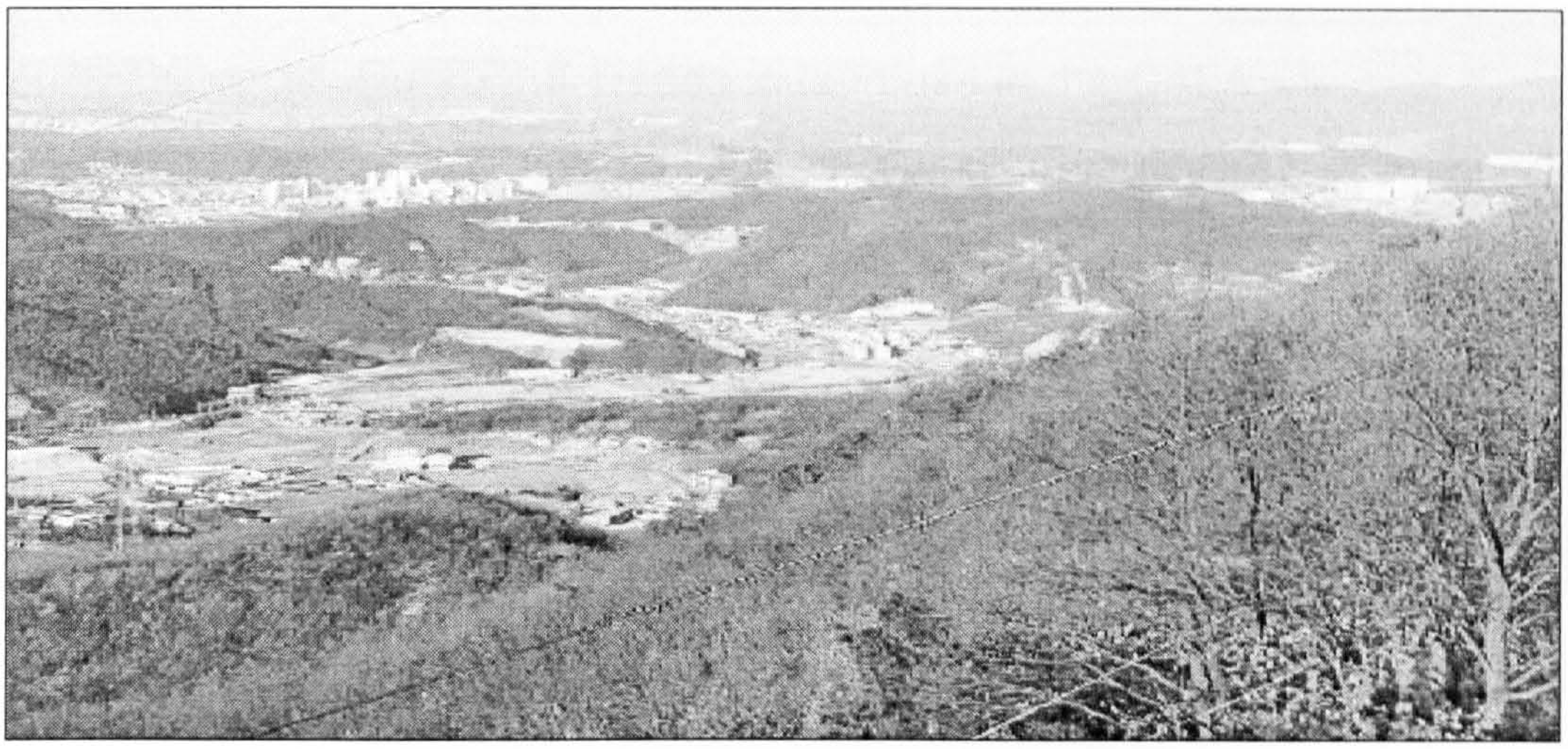


Figure 3.8 Agricultural land change in Yongin city

The loss of forest land was not as much as of agricultural land because the forest areas are on more steeply sided slopes, and so are less attractive for building due to high construction costs. This means that most agricultural land around large cities has become the principle target of developers.

Table 3.2 The revision of land area permitted for agricultural land conversion

Facilities	The before revision (Jan. 1994)	The after revision (Jan. 1997)
Collective Housing	Not exceeding 10,000m^2	Not exceeding 7,500m^2
Accommodation facilities, Restaurants, Golf Driving Range	Not exceeding 30,000 m^2	Not exceeding 500m^2
Facility for the livelyhood of the neighbourhood, a training facility for the youth	Not exceeding 30,000 m^2	Not exceeding 1,000m^2
A factory, A warehouse, a building constructed for the purpose of sale	Not exceeding 30,000 m^2	Not exceeding 20,000m^2
Facilities as education and research	Not exceeding 30,000 m^2	Not exceeding 10,000m^2

Source: Korea Research Institute for Human Settlements, 1999

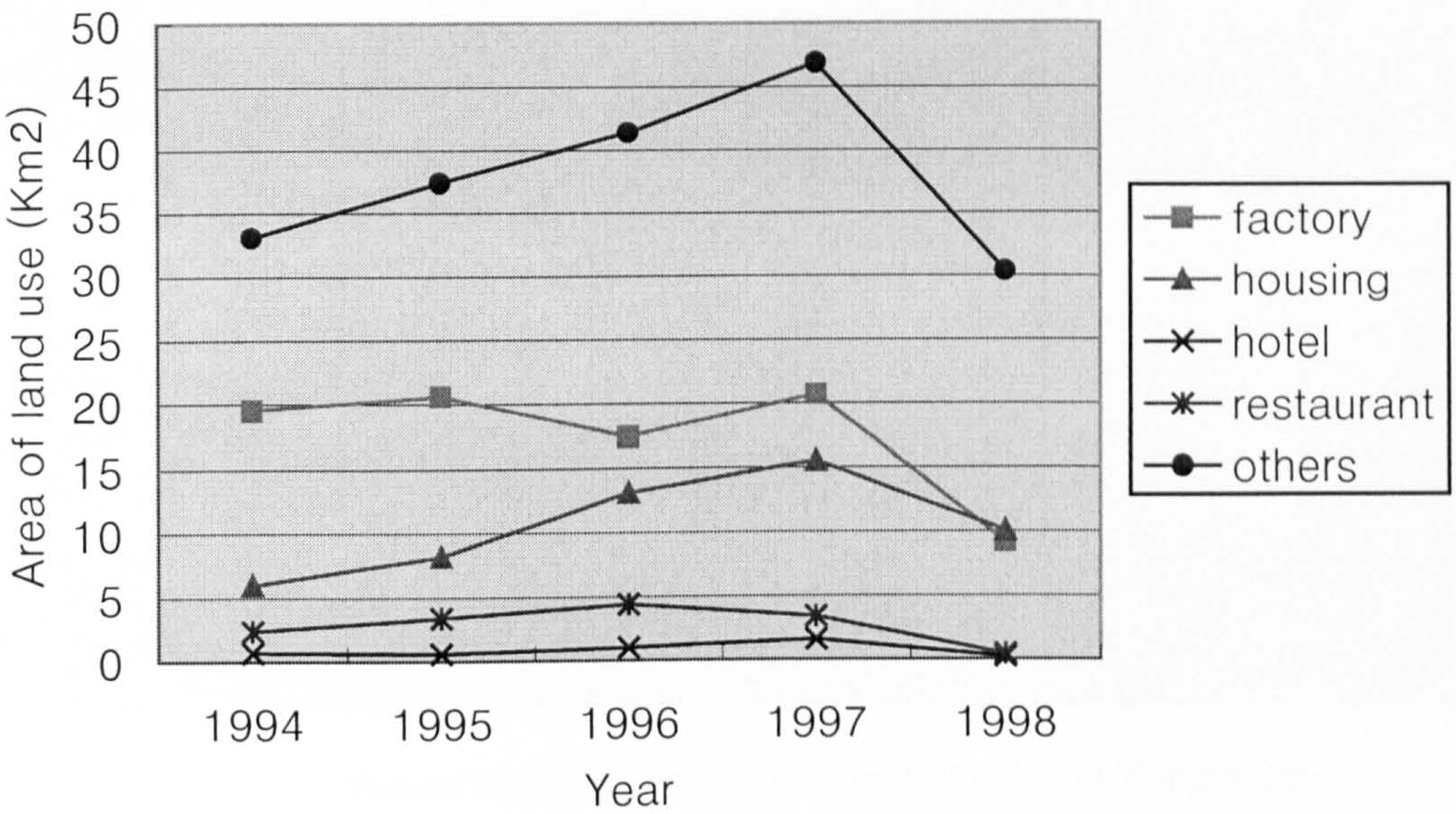


Figure 3.9 Trends in land use in the QAFA

* Others: barn, warehouse for farming, gas station, convenience facilities for farming and fishing villages, religious facilities, and athletic facilities

Source: the Ministry of Construction and Transportation 1999

Figure 3.9 shows the fluctuation in size of each land use type in the Quasi-Agricultural and Forest Areas between 1994, when the revised law was adopted, and 1998. During these years, about 347 Km^2 (1.3%) of the whole Quasi-Agricultural and Forest Areas were developed. It is remarkable that this amount of land, a quarter of Seoul's total area, was developed into urban uses during only 5 years.

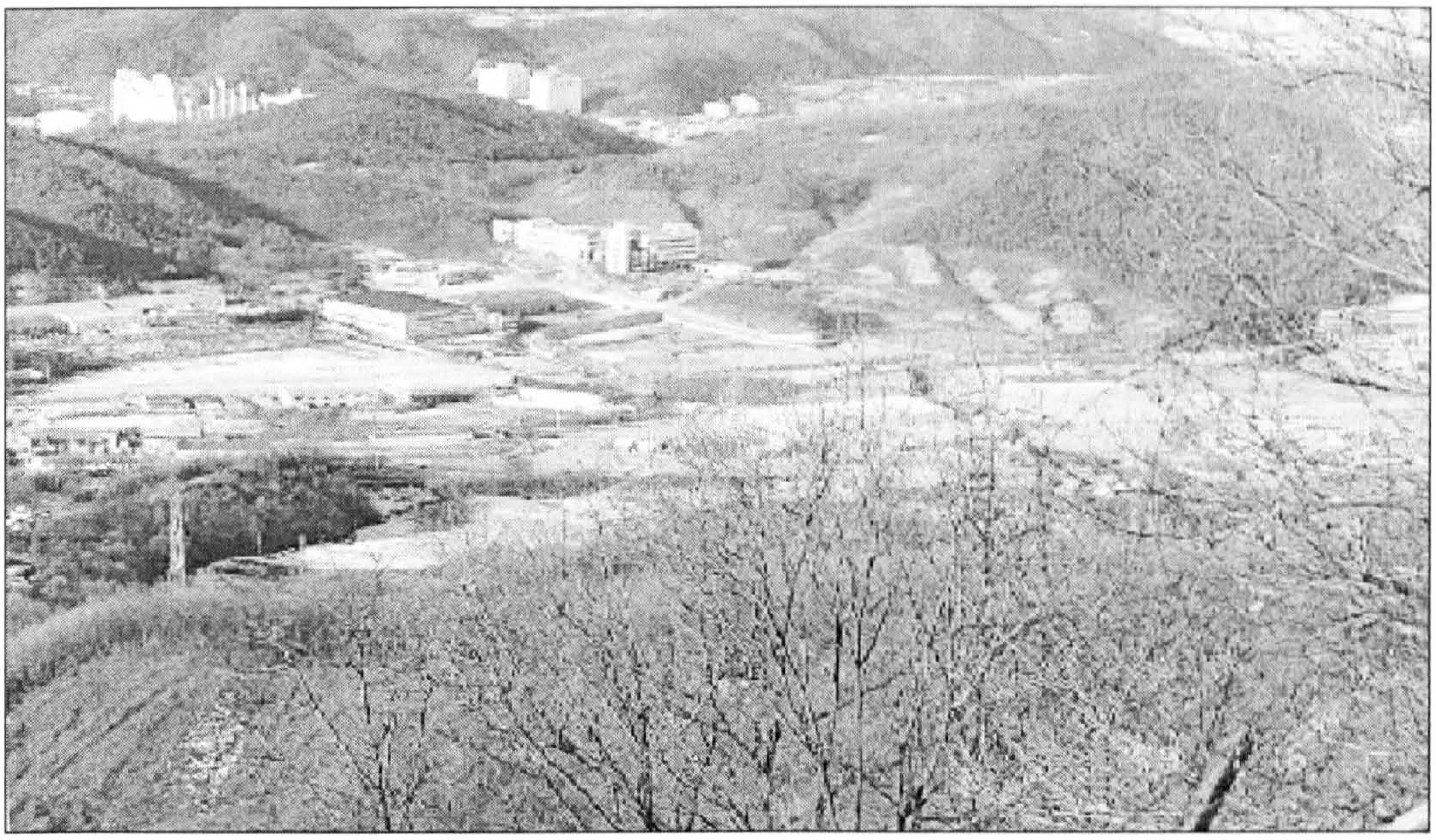


Figure 3.10 The distribution of factory and housing in the QAFA of Yongin City

Of the land that was developed, the highest proportion was converted into 'other' uses (54.4%). 87.4 Km^2 (25.2%) was converted into 'factory' uses and 52.9 Km^2 (15.2%)into 'housing' uses from 1994 to 1998, which led to many kinds of problems in the urban fringe area. As from 1998 land use conversion decreased rapidly due to the stagnation of the real estate market and the reduction of private investment as a result of financial crises in Korea. In addition, regulation of the size of land areas permitted for development in the QAFA was more strict than that of 1994.

In addition, land use change in the QAFA between 1994 and 1997 in every province at the national level has been examined as Figure 3.12 shows. What is remarkable here is that the highest proportion of land conversion took place in Kyonggi Province adjoining Seoul. This means that after deregulation the highest demand for development land was concentrated in the area immediately surrounding Seoul. Kyonggi province shows a higher rate of land use change because it received overspill as a result of development pressure from the Seoul Metropolitan Region and the development of the urban fringe is attractive in the sense that the price of land is comparatively inexpensive.

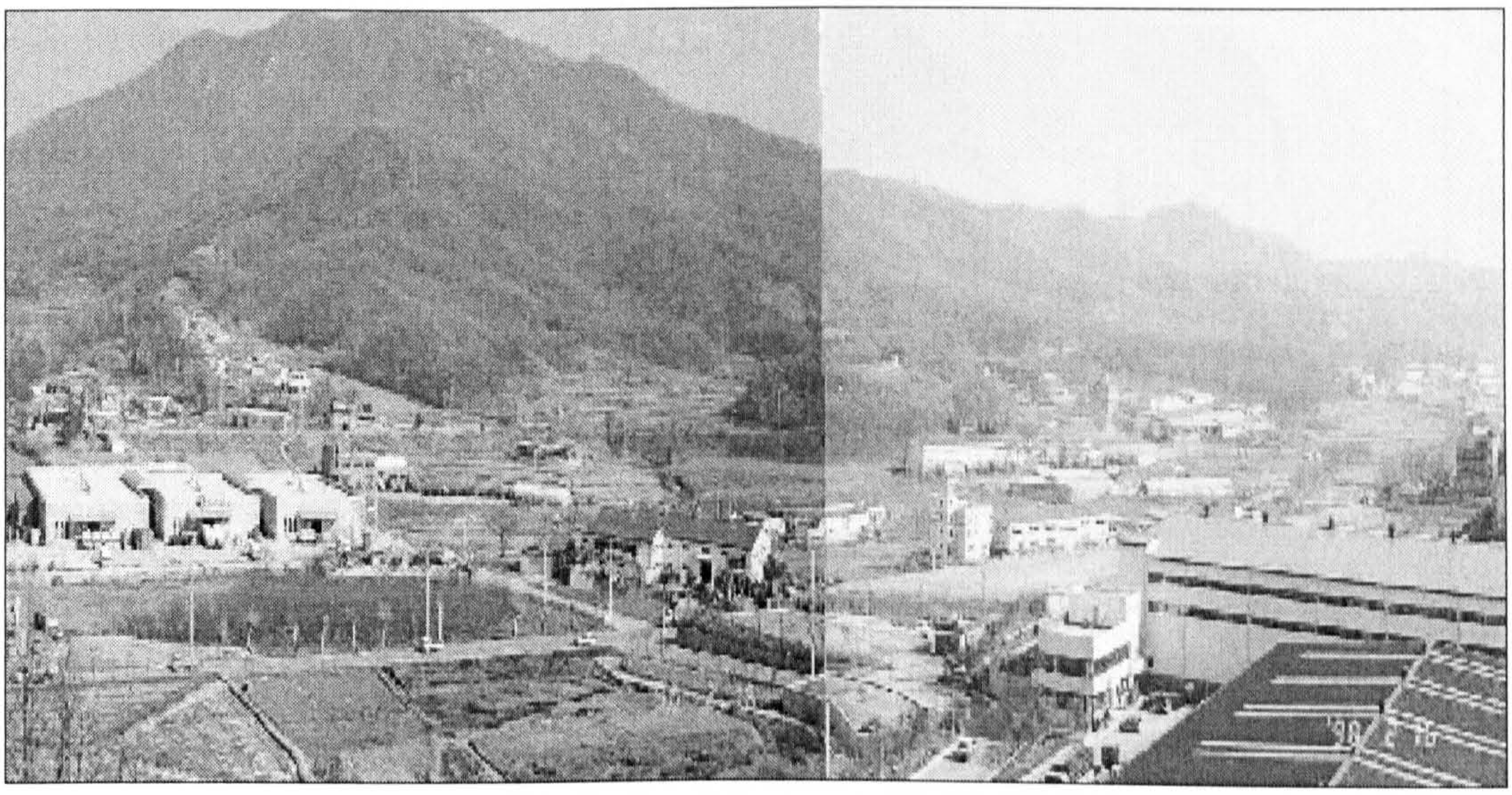
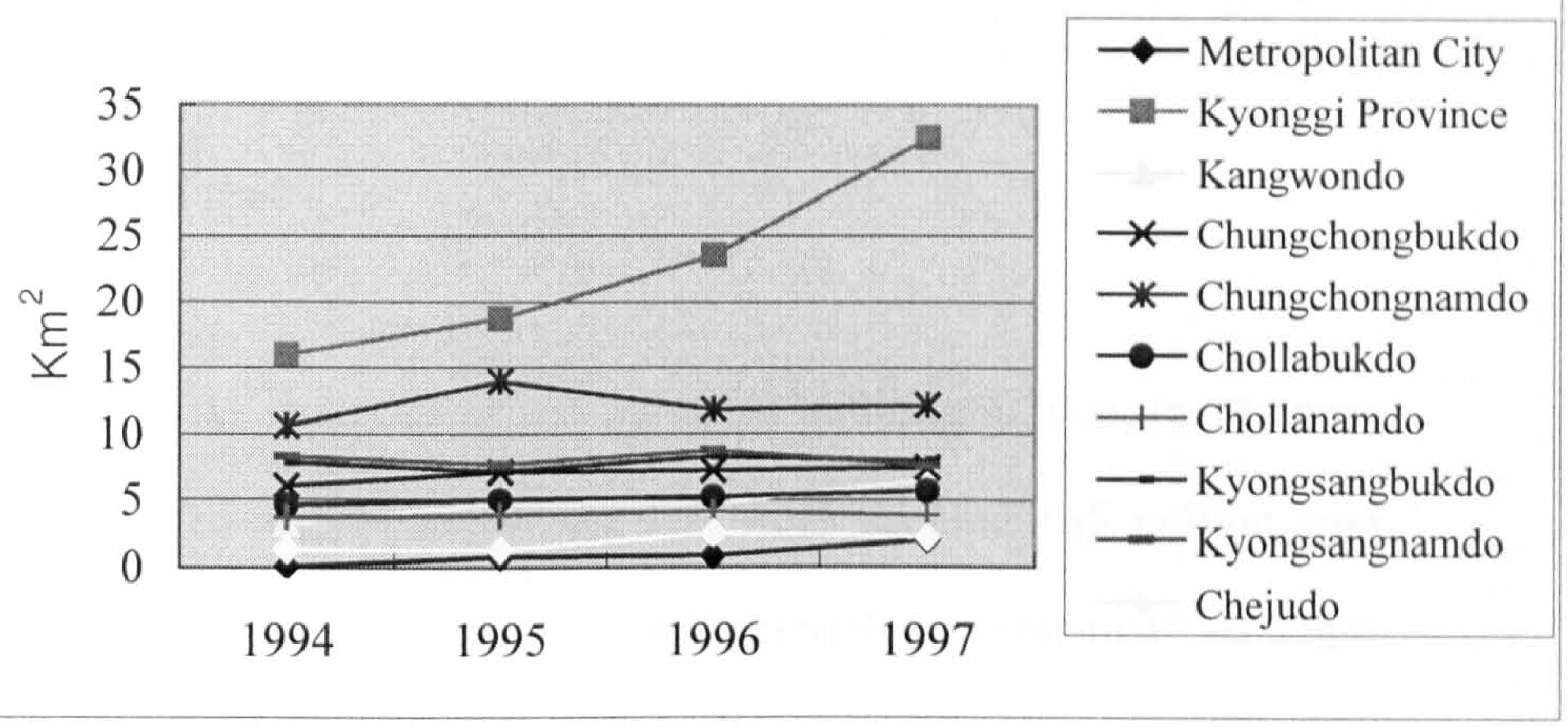
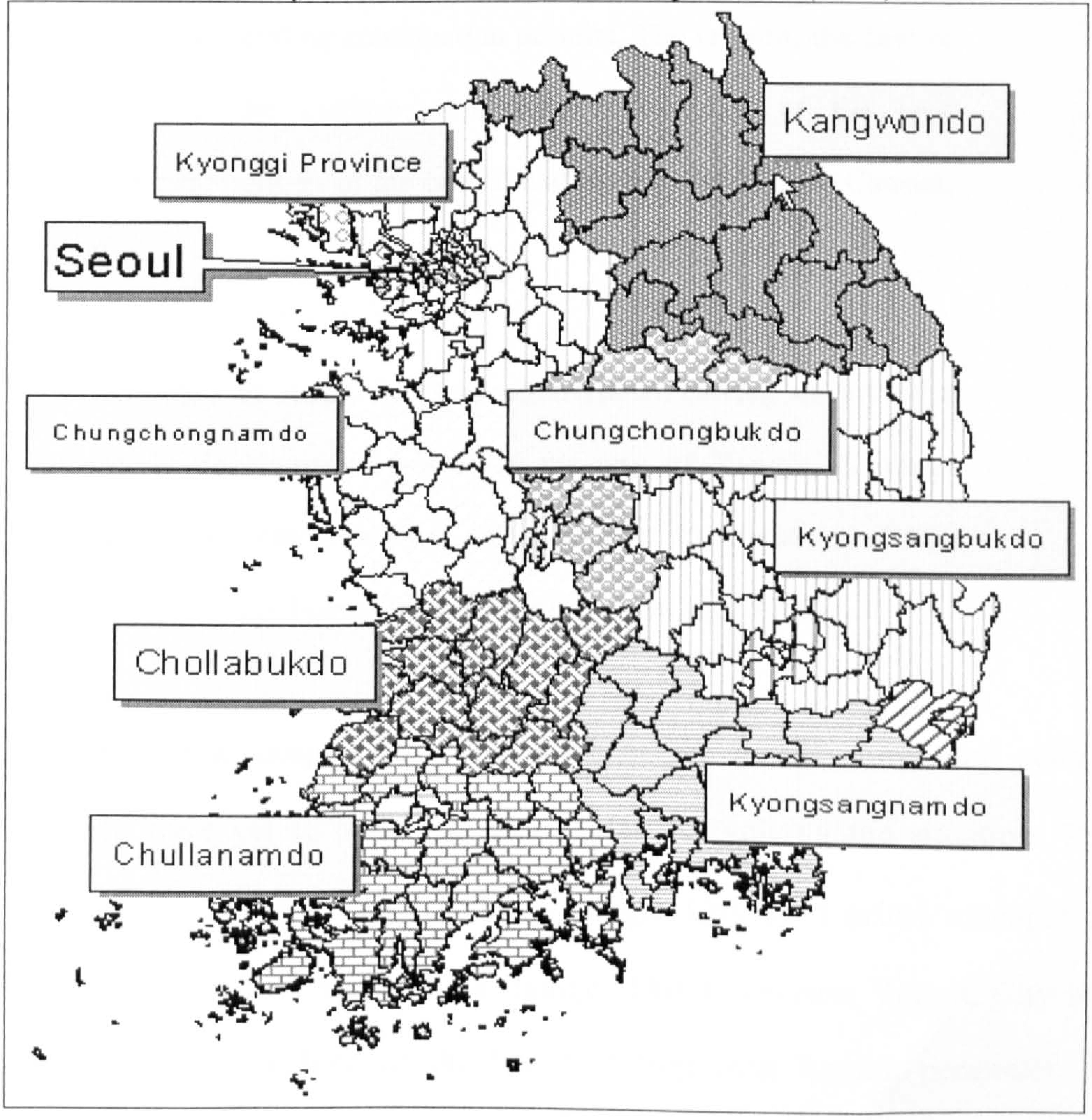


Figure 3. 11 The case of disorderly development in Yongin City

Figure 3.12 Trends in conversion of land to urban use in province of Korea



Source: The Ministry of Construction and Transportation (1999)



Another example of the seriousness of the situation in the urban fringe can be seen in two news reports related to Yongin City within Kyonggi Province.

They stated that:

> Fifty-five residents of an apartment building in Yongin city near Seoul filed a class action suit last week seeking 165 million won ($147,000) in compensation for "material and spiritual" damages they claim to have suffered from their city government's unprincipled building construction permits. The lawsuit, the first of its kind in the country, represents a criticism of the land development policies of the central and local governments (Chosun, 2000).

> The Board of Audit and Inspection (BAI), having unearthed a disorderly development project in the city of Yongin, Kyonggi Province, has embarked on an extensive investigation of the Construction and Transportation Ministry (Chosun, 2000).

This shows that despite the seriousness of the matter, local and central government have yet to come up with a plan for solving the situation. The news media has already taken note of Yongin City as a prime example of disorderly development in the urban fringe. This is because Yongin City has the most developable land of the Seoul Metropolitan Region perimeter. In other words, Yongin city has suffered from an enormous amount of development demand. This is why this study chooses a small area of Yongin City as a case study area. This will be explained in detail in chapter 5.

3.6 Who needs information regarding land use change in the urban fringe area?

Users of land use information can be divided into several categories such as local government, evaluators, planners, decision makers, individuals, firms, and agencies. Among them, this chapter focuses on local government because nowhere is the management of land use information more needed than in local government.

The circumstance of local government in the 1990s changed drastically. In 1991, the local autonomy system was revived, and the local assembly was reconstituted. In 1995, the administrative head of local government that used to be appointed by the President was elected by a direct vote of local residents. This circumstance has enabled the local governments to regain their nominal political decision-making power, though there still remains a substantial amount of central control in the central-local government relations.

In the meantime, central government determined the geographic boundary of the urban planning area and permitted urban planning applied by local government. For several decades, local government was given only limited autonomy to execute urban planning projects within the boundary authorized by central government. However, local government now has more mature circumstances so that local government can carry out urban planning by themselves. In addition, at the local level, local public corporations and public organizations have been established to carry out urban development, housing construction, and management of urban facilities (Kim, H.S. et al, 1998).

Under these mature circumstances, local government should also address many issues caused by industrialisation and urbanisation. However, it is impossible to propose the necessary information in good time using conventional methods. The development of computer technology has made it possible to address the difficult issues. In general, local government is responsible for the day-to-day management of cities and counties, including the collection and maintenance of land use data. Local government needs timely and accurate land information because it is basic to planning, regional policy, and resource management. Decisions about land use are also mainly made by local government. Local government needs to understand more fully how its decisions are made and what impacts its decisions have had.

Of the many approaches to spatial analysis, Geographic information systems have been widely recognised as a planning tool capable of providing reliable information for local government. The improvement of the planning and decision making processes depend on the quality of the data, and if they are appropriately and efficiently handled. GIS allows local governments to make better decisions and improve the efficiency of their work. For this reason, the national and local bureaucracies tend to use GIS much more often than the private sector, although the gap between them has narrowed in recent years (Craglia et al, 1996).

3.7 Conclusion

Land use change in the urban fringe is a natural progression of urban growth in developing countries as well as in developed countries. But there is some difference between them. The consequences of land use change in the urban fringe in Korea also have several idiosyncratic characteristics as follows.

Firstly, rapid land use change in the urban fringe in Korea at present can be summarized as being a result of deregulation. In the process of deregulation, many kinds of land use changed from rural to urban use. Central government has given local government little direction about how to control rapid land use change in the urban fringe areas. Instead, government policy change has been a powerful contributor to rapid land use change. From this point of view, it is acceptable to consider that government policy change directly affects land use in the urban fringe.

Secondly, many negative side effects in the local areas were produced. This is because while urban areas are controlled strongly by urban planning law, urban fringe areas can be developed easily with a minimum of conditions required. Although government policies do exist to prevent urban sprawl, one feature of the Seoul Metropolitan Region perimeter seems to be a state of chaotic development. Rapid land use change in the urban fringe has imposed a serious infrastructure burden on local government. In addition, these developments have deteriorated the quality of urban life as well as the urban scenery in the urban fringe (KDI, 1996; Kim, W.H., 1997; KRIHS, 1999). Furthermore, expansion will continue into the outer fringe area unless proper complementary measures are taken.

Thirdly, the decision-making power of local government in Korea is now under more mature circumstances since the local autonomy system has revived and the local assembly has been reconstituted in the 1990s. Under these mature circumstances, therefore, local government needs to understand more fully how its decisions are made and what impacts its decisions have had because local government mainly make decisions about land use. The rational results analysed using cadastral maps that occupy about 80% of administrative affairs at the local authority can help a local government see the need for GIS (SDI, 1993).

Lastly, it is important for local government to better understand the process of urban sprawl so that they can reduce the serious problems in their areas. In practice, the prevention of disorderly development has probably been one of the most frequent issues for local government. As urban fringe areas show dramatic change from rural to urban land use, local government needs to be involved to manage and monitor urban development. It is imperative that local governments understand the determinants of land use change so that future patterns of land use can be projected, planned, and managed under sustainable conditions. To do this, local government has to be able to handle their data appropriately and efficiently. Local government needs to view where a specific change takes place, how the patterns of land use have changed, and what conditions lead to disorderly development. Therefore, the results of this study might be used to make better decisions and improve the ability of local government.

CHAPTER FOUR

RESEARCH METHODS

4.1 Introduction

As was stated in Chapter 3, many agricultural and forestry lands in urban fringe areas were developed in a disorderly manner for urban use during the last 5 years since deregulation in 1994. In order to minimise these problems, local government must be able to plan management strategies that are appropriate for individual fringe areas. A precondition for this planning is adequate information about ongoing land use changes in such areas, which requires the ability to evaluate and map such areas based on the potential change probability of land use (Chou, 1997).

However, until recently, as shown in chapter 2, urban models in association with urban change processes are quite limited in explaining spatial relationships and processes, and their representation. The recent advances in GIS technology have made it possible to represent, collect, store, manage, analyse, and model spatial data, although they can not be used to undertake a wide range of spatial analysis. Most recently, there has been a trend for experts to come together to make the linkage between GIS and methods for the statistical analysis of spatial data as a key issue in research agendas. The linkage of GIS and spatial analysis may help decision making activities for the solving of spatial problems. Thus, this thesis is studied as a part of this trend.

In this chapter, general research strategies will be reviewed such as the case study approach used, data collection, and parcel approach. The methods using GIS and spatial analysis will be reviewed in detail. The next chapter will present the case study area in terms of collecting data, data building, and data classification.

4.2 A case study approach

A wide range of differing circumstances may affect land use change in the urban fringe areas. This means that the land use change process is complex and needs to be examined in detail. Case study should be capable of identifying those characteristics and complex processes. Moreover, the complexity of the process requires intensive analysis. This should ensure that the key components of the land use change process are not overlooked (Yin, 1994).

Case study in this research is employed to identify the main factors affecting land use change in the urban fringe areas, to analyse particularly the impact of neighbouring land use on the propensity for a land use to change, to view the result of analysis, and to develop an analysis of the transition probability of land use. However, for these analyses, this study could not assemble all the data for the urban fringe around the Seoul Metropolitan Region. Instead of this, it is necessary to examine in detail a small part of the Seoul urban fringe, where land use change pressures are known to be great. Therefore, a single case rather than a multiple case was selected. The capacity of data handled is huge even in a single case and the same case study deals with many independent variables. However, this is not a statistically representative sample of all fringe areas, but was selected to ensure that three main reasons are taken into account: ease of data collection in a digital format, the frequency of land use change, and the adjacency of the Seoul Metropolitan Region. The single case study in this research may offer an insight into the influence of the main variables involved in the land use change process.

There are four criteria used to choose a case study area in this study. The first case study criterion requires the intensive examination of a selected case study in order to detect complex processes of land use changes at the parcel level.

The second case study criterion chooses a small area to identify the process of land use change and analyses in detail spatial relationships between different land uses of each parcel within particular municipal boundaries. As mentioned in chapter 2, studies have been limited due to a lack of available data and lack of computer capacity. These studies have usually been characterised by the use of aggregate level census data or large aerial units. Until recently, a few smaller and medium size clusters were studied. In addition, most of the existing research typically excludes site level information.

The third criterion needs to choose a case study area rapidly converted from rural land uses to urban land uses at present. This is because this study needs to estimate the seriousness of land use change in the urban fringe in order to efficiently deal with these issues.

The final criterion is a key element and will involve considering the possibility of temporal data collection when choosing a case study area because the key components in the chronology of change must not be missed. The few existing longitudinal studies typically employ data from two time periods which makes the detection of trends, cycles, or fluctuations in urban development patterns highly suspect. In addition, most of the research has focused on theoretical and ideological discussion. A case study in this research thus employed data from three time periods to make the detection of trends, patterns, or fluctuations in land use change for practical analysis.

Therefore, this study was applied to a single case (see Figure 4.1), encompassing a small part of the Seoul urban fringe, in order to investigate a case study at the parcel level from 1991, 1994 to 1998. This will be explained in detail in chapter 5.

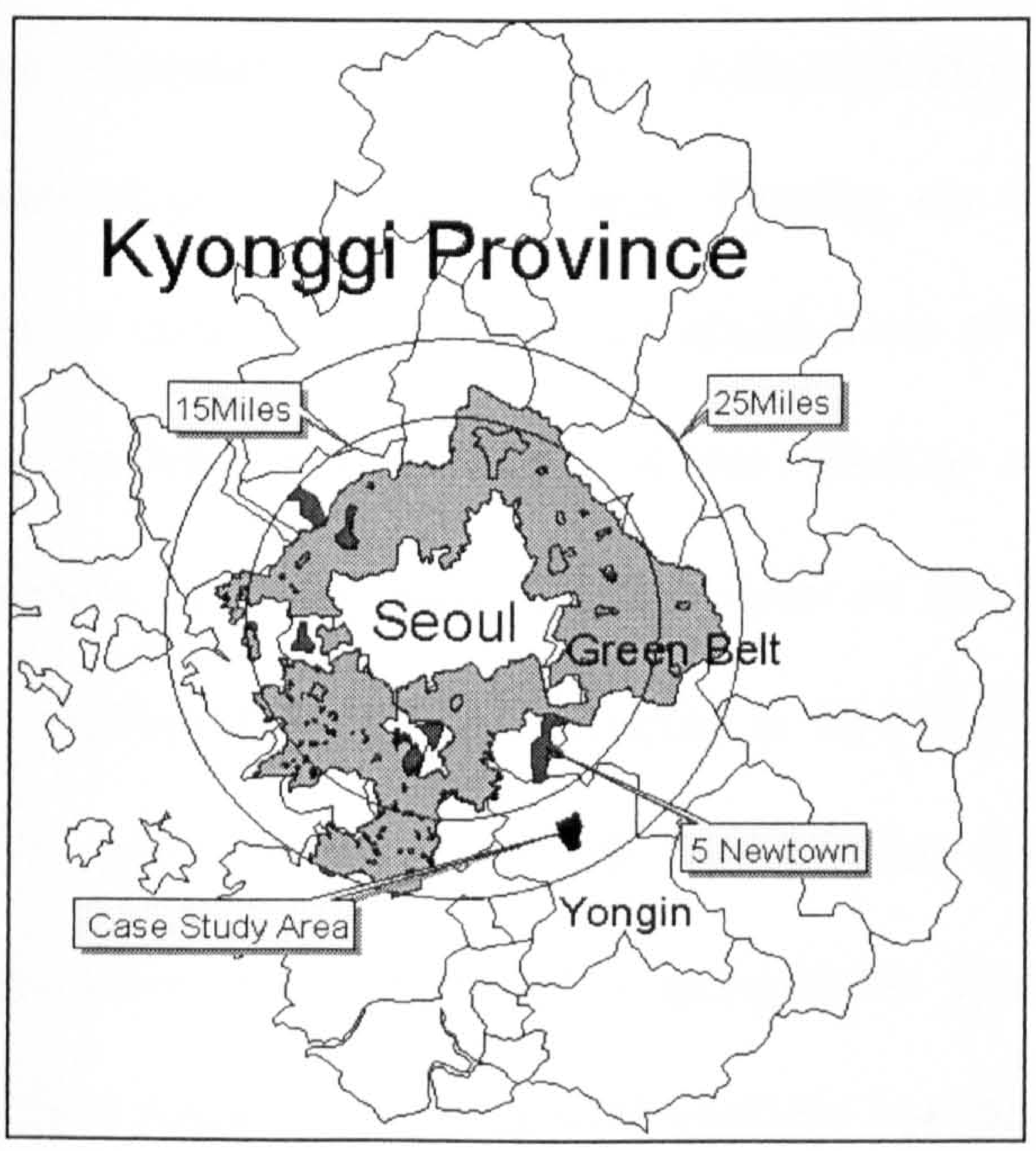


Figure 4.1 Location of study area

4.3 Data collection

The method of data collection depends on the characteristics of the research. Local governments in Korea handle much of the data for their own work. The problem is that most data local government use is not made with the use of GIS in mind. The method of data collection in this study is thus limited to data made with such information.

With these limitations in mind, this study will utilise four basic components of data collected. Firstly, all data is represented in a digital format for application through GIS. Secondly, the boundary used is that used for administrative purposes. Administrative units define the fundamental units of available spatial data. Thirdly, the database format is used with the vector data, which shows an abstraction of the real world. This is because the vector data is favoured for greater manipulation of single parcels. Finally, in vector data, the basic unit of spatial information is polygons used to represent areas. A polygon is defined by the lines that make up its boundary and a point inside its boundary for identification. Polygons have attributes that describe the geographic feature they represent (Burrough, 1998). Area units for spatial analysis can be defined in different ways. The grid and polygon methods are common.

Most tasks of local governments are related to maps. Maps provide an effective, two-dimensional representation of spatial distribution for detecting spatial relationships between map features (Chou, 1997). For fitness to the four basic components mentioned above as a basic map, this study employed the Land Price Status Map on which is recorded land characteristics and prices in each parcel and is digitised using AutoCAD by local government. It is based on the Public Notice of Value and Appraisal of Lands, etc. Act. It is a record of land characteristics and prices in each parcel such as parcel numbering, land category, determined land price per year, individually assessed official land prices of previous year, and public land prices of the reference land of this year in order to verify the appraised land price since 1996. However, this AutoCAD map needs to be converted to GIS format. The next chapter will explain the quality and errors within this data.

For attribute data, this study explored the various sources that provide data on land for using in GIS. Each of these sources provides data on land with respect to a specific need (Navratil 1998). Therefore, this study employed the Land Utilisation Character Surveys which can explain characteristics related to parcels of land using the data produced by local government. The Surveys have been carried out in South Korea to assess land prices since 1990. They are based on the Public Notice of Value and Appraisal of Lands, etc. Act. The purpose of the surveys is, that 'by helping to appraise and make public reasonable prices of lands, to use them as the benchmark for the assessment of land prices, and by stipulating matters relating to the appraisal of lands, buildings and movable property, etc., to help contribute to forming reasonable prices thereof and to the efficient utilisation of national lands and to the development of the national economy' (Article 1, the Act). They contain locational data as well as place attributes, information describing the characteristics on land. In addition, it is easy to link to the basemap because they already have locational data as the relational database. The next chapter will explain these sources in more detail.

4.4 The parcel approach

The parcel is the ideal unit of analysis for studying land use change because it can have a wide range of information such as parcel numbers, the classification of land category, and the boundaries and ownerships of land parcels. The importance of the parcel approach at the local level is that most administrative affairs in the local authority are associated with cadastral services such as land address information, land characters, land price, the limitation of use, and the resource management of parcels.

The parcel approach can use an administrative code which consists of province code, city code, ward code, block number, parcel number, etc. Local governments maintain many documents for their own local needs such as a land register, an agricultural land register, a forest register, a building register, etc. All of them recorded by each department of local authorities in Korea are based on the same administrative network code. This attribute data can thus be linked easily to the cadastral map by including additional attributes in each record.

One of the purposes of this study is to examine the impact of neighbouring land use. To do this, this study used a new method to capture all the surrounding parcels as neighbours of the current parcel. To use this method, this study employed a cadastral map as a basic map. For this reason, other approaches such as CA approach and CUF model based on the grid cell, as explained in Chapter 2, are distinct from the cadastral approach that can link easily with related databases using the administrative network code.

There are, however, some technical restrictions on the wide use of the parcel approach. For example, it should deal with very large parcel data at the regional and national level and take much time and expense to analyse, manage, and edit the related database. In addition, the various changes to the cadastral map occur when a new subdivision is created, annexation occurs between parcels, or land development and redevelopment in older areas occurs (Williamson and Ting, 2001). In this case, the changes should be updated by each department of local government but it is not easy to update them promptly. Thus, when analysing large databases, the error of the database may be high.

Therefore the CA approach and CUF model may be more useful at the regional or national level than the parcel approach. The parcel approach can be used efficiently at the local level to monitor and manage specific local issues. The parcel approach combined with GIS can not only represent the particular local site characteristics that affect land development, but also present a realistic method on very local and specific problems that the local authority must deal with on a daily basis. In conclusion, both methods will be chosen according to needs and scale.

4.5 Analysis methods

The aim of this section is to address the analysis methods employed in this study. The research employs two main methods. One presents the Geographical Information Systems. The GIS database in this study was built using Arc/Info and Arcview software which can support storage, analysis, querying, browsing and display of various geographical data available for the study area. The other employs spatial analysis: Logistic Regression, which is used when the dependent variable is one of two change possibilities and the independents are continuous variables, categorical variables, or both. Statistical packages, SPSS 10.0 for windows, were mainly used for data analysis.

4.5.1 GIS Analysis

4.5.1.1 The need of GIS

As mentioned in chapter 3, local government needs to improve its ability in using GIS in order to efficiently deal with urban problems caused by rapid industrialisation and urbanisation in local areas. This is because GIS can help to describe a situation and contribute to a better understanding of urban problems.

The basic principle of GIS in this study is to show spatial characteristics of the data needed for the management of urban fringe areas. This spatial visualisation of the data is so attractive for local government because in the decentralisation process referred to in chapter 3, local government has greater responsibility in terms of urban management in addition to the land survey control which it had always handled (Laterasse and Pauchard, 1995).

4.5.1.2 Spatial data and spatial relationships

Maguire (1991) defined that " GIS are systems which deal with geographical information. Geographic (or spatial) information is any measurement that is geographically referenced (i.e., that can be tied to a specific location on the earth's surface, such as a street address or census tract)." Burrough (1998) explains that GIS is a special type of information system that handles spatial data. Spatial data is one of the most important concepts in understanding GIS. The GIS glossary (ESRI, 1994) defines "spatial data as data that occupies cartographic (mappable) space and that usually has specific location according to some geographic referencing system (e.g., Latitude-Longitude) or address." (Davis, 1996). Spatial data is displayed in terms of points, lines, and areas for visualisation.

One of the most useful data structure concepts in GIS is topology[1] (i.e., formal representation of spatial relationships). Users can easily recognise spatial relationships (such as where it is, what is around it, understand its environment, how to get around) among geographic entities (Davis, 1996).

[1] 'The relative location of geographic phenomena independent of their exact position. In digital data, topological relationships such as connectivity, adjacency and relative position are usually expressed as relationships between nodes, links and polygons. For example, the topology of a line includes its from- and to-nodes, and its left and right polygons. Topology is useful in GIS because many spatial modelling operations don't require co-ordinates, only topological information. For example, to find an optimal path between two points requires a list of the lines or arcs that connect to each other and the cost to traverse each line in each direction. Co-ordinates are only needed for drawing the path after it is calculated' (ESRI, 1994).

There are many GIS software products used to represent spatial relationships using a topological vector data model. These usually use distance, directional orientation, and connectivity as the basic spatial elements (Maguire, 1991). Topology is important for a wide range of spatial analyses and query functions, for example, overlay, buffering, distance, adjacency, and proximity analysis, routing and minimum path analysis (Landis, 1993).

4.5.1.3 GIS Functionality

A Geographic Information System is a complete system with various integrated functions. That is, a GIS is a tool for storing, managing, analysing and displaying spatial data. The principles and methods of GIS have been described in detail by many books such as Maguire et al (1991), Martin (1996), Craglia and Couclelis (1997), Burrough and McDonnell (1998), Heywood et al (1998). For this study, the several functions of GIS are important for the following reasons:

Visualisation: Visualisation is the most essential step in the whole process because of its ability to map the results of spatial analysis to understand them in the context of the process occurring in the study area. There is the old adage 'a picture speaks a thousand words'. Therefore decision makers will like this capability. Visualisation is a term that attempts to address both analytical and communicative issues of visual representation. Visualisation in GIS often refers to the visual representation of geographic data. Display of the results of spatial analysis in visual form has an important role as a medium for communication (Martin, 1996). Therefore, the visualisation can help the decision makers accurately interpret and understand the actual situation in the urban fringe.

Spatial database management: Spatial database management is an important function that GIS is able to perform. The functions discussed in this section are the fundamental classes of operations performed by a GIS such as reclassification, overlay, distance/connectivity measurement and neighbourhood characterisation. They have been characterised as a 'map algebra'[2] (Tomlin and Berry, 1979; Berry, 1982, 1987; Tomlin, 1991, Martin, 1996) in which context primitive operations of map analysis can be seen as analogous to traditional mathematical operations. Reclassification operations are related to attribute information. This can be thought of as a simple recolouring of features in the map. In this study, for example, a map of land prices may be reclassified into classes such as 'low price' or ' high

[2] 'Used within cartographic modelling as a means of combining two or more input map layers to produce a final map output layer. Both the maps and the operations performed upon them can be expressed as a kind of quasi-algebraic expression, since the processes of manipulation and the operators used are reminiscent of mathematical operations such as add, difference, divide and union' (Berry, 1987, 1991).

price' without reference to any other data. Overlay operations are related to the combination of two or more maps according to Boolean[3] conditions (e.g. if A is greater than B and A is less than C). They may result in the delineation of new boundaries. Distance and connectivity measurements are related to both simple measures of distance from a parcel to roads and more complex operations between locations. Neighbourhood characterisation involves affecting values to a parcel according to the characteristics of the surrounding parcels. Sequences of manipulation above labelled as 'cartographic modelling' by Berry (1987) note that 'each primitive operation may be regarded as an independent tool limited only by the general thematic and spatial characteristics of the data'.

Spatial Analysis: Spatial analysis offered in commercially available GIS software is not as high as the previous two functions. The current stage performed is just on database management and mapping. The current GIS are widely recognised as a major deficiency of analytical and modelling fuctions (Fischer, et al, 1996). Recently, there are issues that need to be resolved within GIS packages to make them more efficient in coupling with spatial analysis.

[3] 'A number of set based operations which are part of the standard functionality of GIS. Used to combine a series of input map layers into a single output layer through the use of and, or and not operators' (Berry, 1987, 1991).

All these three ways in which GIS can assist spatial modelling are used in this study. GIS has been a powerful tool in visualisation and spatial database management though it provides limited support for spatial analysis. Therefore, in this study, statistical software will supplement the weakness of spatial analysis in GIS. The following sections provide a brief overview of GIS spatial data structures

4.5.1.4 Spatial data structure

This section explains that the spatial data structure is important to an understanding of how GIS operates. These form the basic foundation of data construction and function along with topology which is a special characteristic of spatial data that establishes powerful relationships among features. Raster and vector formats are a way of defining spatial data in the computer (Davis, 1996).

There have been many debates on the relative merits of raster and vector formats throughout the history of GIS. In the first stage, most researchers considered these two types of data as mutually exclusive. More lately, both have been considered as complementary by the advent of raster-vector algorithms. Today, advanced raster processing techniques are available either as a self-contained system, or within traditional vector based GIS

(Burrough, et. al., 1998). As separate entities, however, the two models have differing merits, particularly associated with environmental and socio-economic applications, such as their use in a planning context (Martin, 1996).

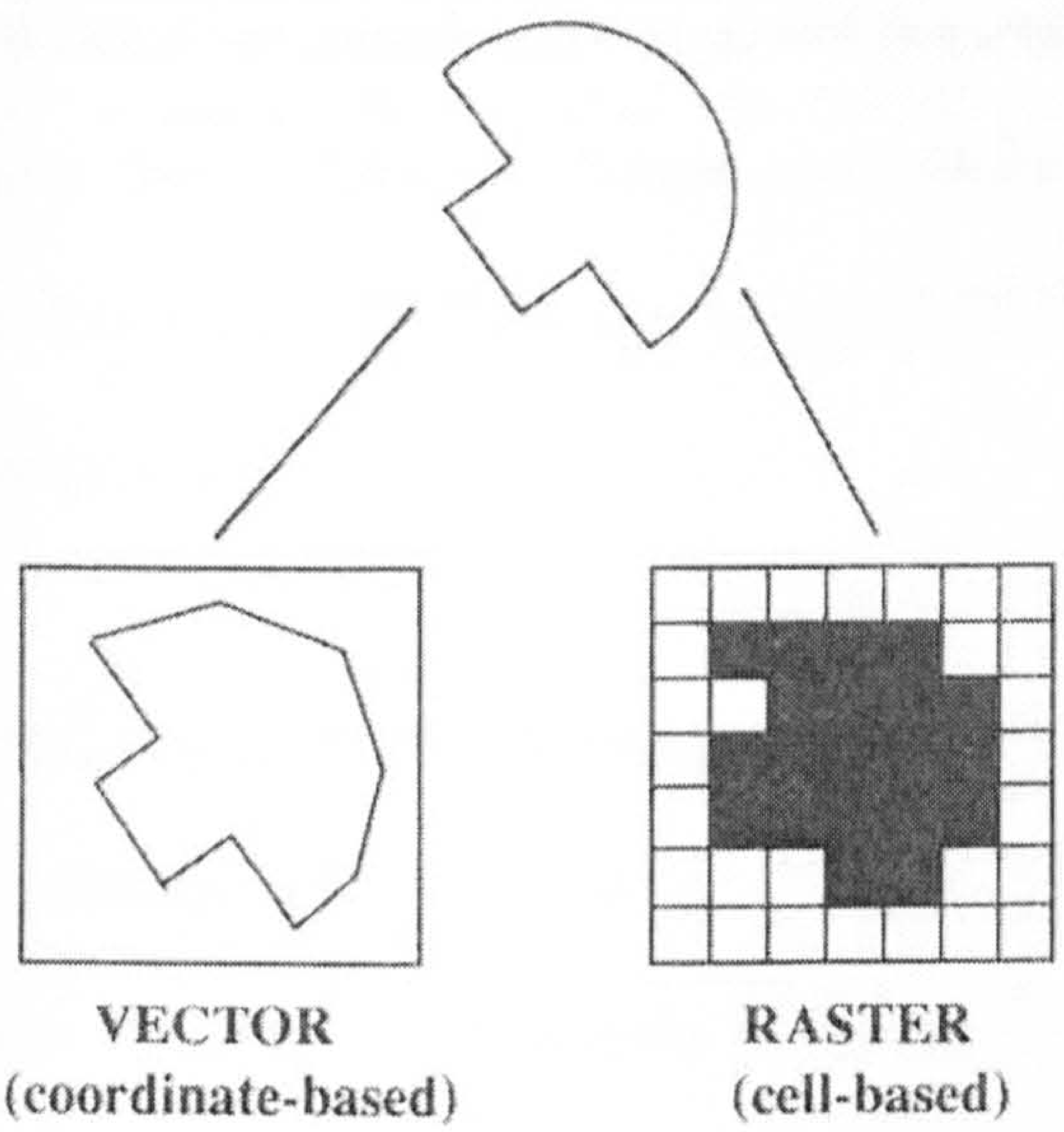


Figure 4.2 The representation of geographical data using the raster and vector spatial data models. Top: Analogue model of reality; Left: digital vector model; Right; digital raster model

Source: Martin (1996)

Combining a digital picture of ground features with regular vector GIS data is useful in zoning and land use planning decisions, cadastral mapping, basemapping, and plan updating, while enabling industrial site and economic development planners to simultaneously access digital imagery and numerous GIS vector layers (hydrography, property lines, soil types, etc.) and related tabular information (stream class, parcel attributes, soil characteristics) (Huxhold, 1991).

Most studies favour using raster GIS data, because in a planning context, the raster model is in many ways a superior tool in land use identification, particularly over large areas where raster data storage is simpler and more cost effective than vector storage. In addition, the raster model is best suited to proximity analysis.

However, the grid format imposes some limitations on the treatment of land use change as mentioned in chapter 2. This raster model has some restrictions for the representation of residential, commercial, or industrial information because of the discrete nature of socio-economic space, although it is appropriate for representation of spatially continuous surfaces, such as soil types and elevation.

Information on land parcels in Korea is usually recorded as administrative units whose boundaries are defined and change over time. A parcel which is a basic unit of land information is an ideal unit of analysis for studying land use change because it can have a wide range of information such as area, location, price, neighbouring land use, direct regulation, and single land use.

For these reasons, this research will apply vector based GIS at a site level. In the next chapter how to build and classify these kinds of digital parcel maps will be explained. The vector model is favoured for greater manipulation of single parcels.

4.5.2 Spatial Analysis

Spatial analysis in this study mainly refers to spatial statistical analysis. Today, GIS incorporates many state-of-the-art principles such as relational database management, powerful graphics algorithms, interpolation, zoning and simplified network analysis, yet what is termed spatial analysis and modelling is often no more than map data manipulation such as polygon overlay[4] and buffering[5]. The lack of analytical and modelling functions is widely recognised as a major deficiency of current systems (Openshaw, 1994, Fischer et al., 1996). Most existing applications focus heavily on spatial database management and visualisation of the results of GIS, with little emphasis on its spatial analytical capabilities. There is a wide agreement in both the GIS and the spatial analysis communities that the future success of GIS technology will depend, to a large extent, on

[4] 'An overlay procedure which determines the spatial coincidence of two sets of polygon features and creates a new set of polygons based upon overlay operating, for example, ARC/INFO supports operators known as identity, intersect and union' (ESRI, 1994).
[5] 'In spatial information systems, a buffer zone is a polygon enclosing an area within a specified distance from a point, line or polygon. Accordingly, there are point buffers, line buffers and

incorporating more powerful analytical and modelling capabilities (Fischer et al., 1996).

GIS have tabular and textual data, which may be transferred directly into statistical software. Although GIS contain analytical functions such as overlay, buffering and neighbourhood analysis, they do not possess the extensive analytical capabilities of statistical packages. GIS provide the environment for handling spatial data and spatial analysis provides analytical functionality. So it can be expected that linking spatial analysis with GIS will lead to improved tools for analysing spatial problems (Prastacos & Diamandaks, 2000). This is why this study has to use statistical software. Spatial analysis is required to enable us to understand more fully the determinants of land use change and the potential transition probability of land use.

The advantages of spatial analysis in this study are as follows. Firstly, spatial analysis can describe the distribution of patterns of land use change in the urban fringe. Secondly, they can explore the relationships between various variables and land use change in order to gain a better understanding of the processes. Thirdly, they can improve the ability to predict and control

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polygon buffers. Buffers are useful for proximity analysis, for example, find all stream segments within 300 feet of a proposed logging area' (Burough, 1998).

land use change occurring in the urban fringe. As already noted above, these kinds of things cannot be done just using GIS.

The analysis method used is logistic regression because land use change is a discrete rather than continuous phenomenon. Traditional techniques such as regression analysis are poorly suited to modelling discrete processes such as parcel or site-level land use change. Logistic models are a more appropriate choice. Changes between land categories, for example, the change that occurs when an agricultural land use parcel is developed to a residential use, are more appropriately modelled using a non-linear logistic, or logistic model. Logistic models typically come in two forms: binomial models, in which the dependent variable can take one of only two change possibilities and multinomial models, in which there are three or more choice or change possibilities (Landis and Zhang, 1998a). In this study, the binomial logistic model is an appropriate model because this study is objectifying changes into two choices; changed and not changed. In addition, the multinomial logistic model is typically much harder to calibrate and interpret than the binomial model.

Examples of the application of logistic regression include habitat suitability modelling in terms of presence or absence of species (Pereira and Itami, 1991, Narumalani et. al. 1997), and deforestation (Ludeke et. al.

1990). In the Urban models and urban modelling applications, efforts have lagged much further behind (Landis & Zhang, 2000).

Logistic regression allows the use of categorical as well as continuous data as independent variables. It also allows dependent variable to be treated as categorical. The Logistic regression techniques were developed in a non-spatial context. It is therefore essential that the data be examined where appropriate when applied in GIS (Sikder, 1998). A logistic regression is used to investigate patterns related to different variables. The logistic model then generates coefficients associated with independent variables such as land categories, neighbouring land use, elevation, land price, road accessibility etc., to dependent variable. These coefficients are used to estimate how independent variables affect land use change.

The success of the logistic regression can be assessed by looking at the table of the observed value versus the predicted value, called a classification table. Goodness-of-fit[6] tests are also important as indicators of success (Garson, 2000). The maximum likelihood method[7] relies on the number of response samples for each observed combination of x variable. Many of the

[6] 'A measure of how well the model fits the data. It is based on the squared differences between the observed and predicted probabilities. A small observed significance level for the goodness-of-fit statistic indicates that the model does not fit well' (SPSS help).
[7] 'Maximum-likelihood methods attempt to estimate the values of the parameters that would result in the highest likelihood of observing the data actually observed. These methods often require iterative solutions' |(SPSS, Help).

tests involved in a logistic regression, such as the Wald test for each coefficient and the corresponding confidence intervals, or the goodness of fit tests, rely on chi-square approximation. These approximations make sense only when the number of parcels sampled is reasonably large (Hosmer & Lemeshow, 1989).

GIS and spatial analysis present considerably different fields of expertise. However, since the end of the 1980s, there is a trend for the experts of the two fields to come together for the linkage between GIS and spatial analysis. Unwin (1995) suggests the issue of error and uncertainty in GIS results is best resolved by adopting a suitable statistical model of the spatial variation involved and then estimating the parameters of this model. The reason for the need for integration is that it will be beneficial to both fields and will achieve a better understanding of the spatial problems. The lack of analytical capabilities has been a major obstacle to widespread applications of GIS into a research tool. GIS and spatial analysis can be made stronger by their linkages.

This study used SPSS 10.0 for a statistical analysis method of Logistic regression mentioned in the previous section. Linkage with SPSS 10.0 was conducted through DBF files exported from ArcView. The results of analysis were converted to GIS format files again through several steps. The results of the analysis can be displayed in a GIS environment.

4.6 Spatial decision support

Land use planning issues are basically related to an area's spatial structure. Thus, GIS has been recognised as an invaluable tool for planners and decision makers (MacDonald, 1997). The effectiveness of decision support may depend critically on the visualisation of spatial data and the presentation of documents. To support spatial decision-making effectively, GIS tools should be supplemented with spatial analysis and spatial decision support developed in the spatial and management sciences (Arentze, et. al., 1997).

In the coming decade, most planning and management involving spatial problems will use GIS in both the public and private domains. In addition, GIS technology will provide a framework for handling large volumes of spatial data, and this requires a new tool for analysis, modelling and design within these frameworks (Batty and Xie, 1998). So far, few applications of GIS have had correlation to do with the tools and methods used by planners and managers to support their decision-making. Therefore, during the next decade, it is essential for researchers to study more of these activities in adapting GIS related with spatial decision support.

4.7 Conclusion

This chapter proposed general research strategies with respect to a case study method and data collection, and a methodological outline which was applied to a case study of the urban fringe.

Urban models in association with urban change processes are limited to explaining spatial relationship and processes, their representation. The recent advances in GIS technology have made it possible to organise complex topological relationships among map features, although most contemporary GIS packages lack the necessary functionality for undertaking a full range of spatial measurements and spatial analysis. Most recently, there is a trend for experts to come together for the linkage between GIS and methods for the statistical analysis of spatial data as a key issue in research agendas. Efforts to link GIS with spatial analysis have made greatest progress in the area of environmental modelling. (Landis & Zhang, 2000).

This study employed database management and geographical display capabilities in GIS. In addition to these, spatial analysis capabilities and the concept of spatial decision support system are included in this study. This will provide this study with more powerful ability than existing GIS.

CHAPTER FIVE

A STUDY AREA AND DATA BUILDING

5.1 Introduction

The study area represents one of the serious cases of rapid land use change in the Seoul Metropolitan Region Perimeter. It is located at the urban fringe area of northern Yongin City, Kyonggi Province, about 35Km south of Seoul, 10Km from the edge of a built-up area, Bundang Newtown. This area of Yongin city has been making headlines in recent years due to disorderly development as noted in chapter 3.

This study used a single case example in order to make a detailed investigation at the parcel level from 1991 to 1998, as explained in the previous chapter. This study attempts to explore the determinants, patterns and probability of land use change in the urban fringe using GIS and spatial analysis. To do this, all data collected has to be available to be used in a GIS environment. This chapter thus represents what data is now available, how to transform that data into a GIS format, and which variables are appropriate for the analysis. This chapter will present the case study area in terms of collecting data, data building, and data classification.

5.2 Description of study area

The study area lies to the north of Yongin City, 35Km south of Seoul. The administrative names are Dongbagri and Joongri. Two administrative boundaries are adjacent. The area has a total population of 3,483 and 1,244 households (1998). It has an area of about 10 Km^2 and a total of 3,995 parcels. About 64.5% of the total area (2,576 parcels) are Quasi-Agricultural and Forest Areas (QAFA) and 12.7% (508 parcels) are Quasi-Urban Areas as classified in the National Land Use and Management Act. Therefore, the study area will be able to explore in detail the pattern of land use change in the QAFA due to deregulation in 1994.

The main reasons why this area has been chosen as a study area are; that it has developed into one of the most rapidly growing areas around Seoul, is undergoing significant land use change as a result of deregulation since 1994, and is of particular interest because the study area falls within the zone of many QAFA in the area (see Chapter 4).

Owing to its location, the study area is under constant pressure to be developed. In the last five years, the area has experienced unusually marked land use change. The government has also allocated some parts of the area to be developed for a new town.

Figure 5.1 shows the surroundings of the study area. This figure was obtained from synthesis of TM data of Landset (30m x 30m) and IRS data of India (5m x 5m) based on DEM (digital Elevation Model).

Geophysically, Yongin City lies within the mountains and valleys of the Kwangju range, and covers an area of $592km^2$, similar in size to Seoul. Yongin City is bordered to the north by Icheon City, Seongnam City and Kwangju District; to the south by Ansung District and Pyongtaek City; to the west by Suwon City and Hwasung City.

In addition, it is linked to the three Highways as well as with Provincial Highways 42 and 45 going through the centre of the city. Ten colleges, sixty four research & training organizations and over 1,000 industrial units are located here, including electronics and semi-conductor industries.

Figure 5.1 Description of study area

5.3 Data collection

5.3.1 Base maps

The Korean cadastral map is a kind of cadastral records where the addresses of parcel, land use category, boundary and the specification made by the Ministry of Government Administration and Home Affairs (MOGAHA) are registered. It is also a map for managing land and for protecting land ownership (Articles 1 and 10 of the Cadastral Law).

The records and maps have been written and drawn mostly during the 1910s and stored in paper forms, and photocopied for public users until 1990. As one of the types of administrative information system of government, the land records and house records in text forms were computerised from 1982 and completed in 1991. This has begun to be provided to the users from 1991. The Korean government has begun to digitalise cadastral maps and inputted the attribute information of cadastral maps since 1999. For this, the Korean government conducted a pilot project in Yusung-gu, Taejeon in 1997, of which the areas for digitalising cadastral maps were 176 km^2 and 75,000 parcels. The total number of maps to be digitised in Korea is about 750,000 sheets, which hold about 34 million parcels. The Korean cadastral maps are scheduled to be complete through 2003 (Kim et al., 2001).

This study required a digital cadastral map as a basic map. A parcel in a cadastral map is the smallest unit for spatial analysis in this study. There are two methods of choosing a base map for research purposes; one is to use digital topographic maps and the other is to use digital cadastral maps. The former are much harder to edit because of their complexity, but they are used as occasion demands. The latter are comparatively easy to edit due to the small quantity of information on each map although they have diverse scales, and there is a mismatch of the boundaries between maps. In this study, the cadastral map will be used as the base map. To do this, a cadastral map built in GIS format needs to be obtained. Unfortunately, it is impossible currently to obtain a digital cadastral map because it is under construction in GIS format by the national government in Korea at the moment.

Actually, it is very difficult to construct a cadastral map anew for this research as it is time-consuming and expensive. Thus, this study searched available data appropriate to the purpose of the research. The result was a Land Price Status Map (LPSM) built by local government and digitised by AutoCAD. It is based on the Public Notice of Value and Appraisal of Lands, etc. Act. It is a record of land characteristics and prices in each parcel in order to verify the appraised land price since 1996.

The purpose of the LPSM is to enable landowners to have information relating to the appraised land price of their land, if they need to question local government about it. In this case, the head of local government is required to offer a LPSM and land price survey data for verification. The report is forwarded to a committee for independent verification. The map made for this purpose is a LPSM. It is a cadastral map digitised by AutoCAD. Thus, for use in a GIS environment, this map has to be transformed into GIS coverage[1] and from digitiser coordinates into real world coordinates.

When local governments create a LPSM, it has to clearly record some items in each parcel on the map as shown in Table 5-1. As well as a cadastral map as a base map, this study needs another basemap called a digital topographical map relating to the physical features and boundaries on the Earth's surface. This map is available due to the development of Korea's National Geographic Information System (NGIS)[2], with a timescale of 1995-2010. In this study, the map will be matched with the Land Price State Map based on the outlines of road and blocks.

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[1] 'A term that refers to a layer of spatial data within a Geographical Information System' (Maguire, 1991)

[2] 'The Korean government is taking a leadership role in developing a public and private national GIS program for the country. Korea initiated The First National GIS Master Plan in 1995. Based on this plan, several GIS projects and research works have been initiated such as digital topographic and thematic mapping, GIS technology development, GIS standardization and human resource development, GIS application system, and others. "The Second National GIS Master Plan," a five-year master plan that starts in 2001, is actively taking shape. The second five-year plan will focus on eight areas, such as establishment of a distribution system for spatial data and the use of GIS applications, among others.

The Korean NGIS structure was reformed in 2000 with the objective of using GIS in all public and private disciplines within the next five years. Now under the Minister of Construction and Transportation, the NGIS consists of seven subcommittees responsible for areas such as human resource development, development of data distribution technologies, cadastral systems, standards development, surveying, and related technologies.

Building on the first master plan, which focused on the development of key public utilization systems, data standards, and human resource development, the Korean national GIS effort is fast becoming one of the most visible and progressive national GIS programs worldwide' (ESRI, 2000).

An administrative boundary map is also required to restrict all collected data within the study area. To obtain this, there are two methods; First, by digitising the existing administrative boundary map, second, by taking the boundaries from a cadastral map and digitising it. In this study, the administrative boundary map is obtained by the latter method.

Table 5.1 Recorded items in the Land Price State Map

Item	**Description**	**Type**
Map number	The map's number	N
Section number	Represent the section number within the map number	N
Administrative number	Administrative network area code	N
Scale	The ratio of the distance measured on a map to that measured on the ground between the same two points	N
Legend	The reference area on a map that explains the colours, symbols, and annotation used.	C
Parcel block number	Parcel block number	N
Parcel number	An individual parcel within the block	N
Land price	Price per unit area of the land	N
Land category	Land categories	C
Facilities or restriction	Urban planning facilities or restriction by other individual Acts	C
Other	Such other matters as determined by the head of city or district	C

N: numeric field
C: character field

For measuring the distance from a road to the boundary of a parcel, Road Network Maps are needed. There are three methods for making a road network map; extracting the road layers in topographic maps, using the aerial photographs, or by field-surveys. The purpose of the road network map in this study is mainly related to the change of neighbouring land use. Therefore, a road network map is made by field-survey, that is, through the Land Utilisation Character Surveys, because of the time and cost taken to make road network maps.

As a main task in this study, it is essential to obtain a Land Use Map. Three methods for making the digital land use maps have been considered. Firstly, by digitising the existing land use maps, secondly, by field-surveys of local government, and thirdly, by using remotely sensed data. The first method takes a long time and is expensive. The last method does not recognise parcel data. After carefully comparing these three methods, this study concluded that the second method, that is, making the land use maps by field-survey of local government, is the most appropriate because this study already employs a method utilizing the Land Utilisation Character Surveys.

As the study area is related to deregulation, a National Land Zoning Map is also important in order to analyse the impact of deregulation. Two methods have been considered in creating the national land zoning maps. One is to digitise the existing national land zoning maps. The second method is to use the cadastral maps linked with the Land Utilisation Character Surveys. This study used the latter method.

5.3.2 Attribute data

As attribute data, this study employed the Land Utilisation Character Surveys utilised annually by local authority planning departments. They contain locational data as well as place attributes, information describing the characteristics of each parcel within the boundaries of the city as shown in Table 5-2. The results of the surveys are published as statistical standard codes on the land characteristics.

Since 1990 Land Utilisation Character Surveys have been carried out to assess land prices in South Korea. They are based on the Public Notice of Value and Appraisal of Lands, etc. Act. The purpose of the surveys is, that 'by helping to appraise and make public reasonable prices of lands, to use them as the benchmark for the assessment of land prices, and by stipulating matters relating to the appraisal of lands, buildings and movable property, etc., to help contribute to forming reasonable prices thereof and to the efficient utilisation of national lands and to the development of the national economy' (Article 1, the Act).

Moreover, this study carried out field investigation to supplement missing data in some parcels and to observe the condition of buildings and work spaces and neighbourhood of parcels changed. This study also referred to documents related with the purpose of the study such as a land register, an agricultural land register and a forest register, etc.

Table 5.2 File layout of the Land Utilisation Character Surveys

Field name	Description	Type	Length
Province_Co	Province administrative network area code	N	2
City_Co	City and District administrative network area code	N	3
Ward_Co	One of the areas into which a city or district is divided	N	5
Classify	To divide into groups according to state of parcels	N	1
Block_No	Parcel block number	N	4
Parcel_No	An individual parcel within the block	N	4
Land_Pr	Price per unit area of an individual parcel	N	8
Land_Ct	Land categories	C	2
Area	Area of a parcel	N	8
Zone	Urban planning zone	C	2
District	Urban planning district	C	2
FAC	Urban planning facilities	C	5
OTHR	Restriction by other individual Acts	C	2
AGRI	Classification of agricultural areas	C	1
FERT	The fertility of the soil	C	1
PLOW	The level of ploughed areas	C	1
FORST	Classification of forest areas	C	1
Land_Use	Land use	C	2
HEIT	Land height	C	1
SHAP	The outer form that land have	C	1
DREC	The position towards which land faces	C	1
ADOD	The condition of adjacent road to land	C	2
DROD	The straight line from road to boundary of land	C	1
RWAY	The distance from rail to land	C	1
WAST	The distance from waste matters to land	C	1
The rest	Individually assessed official land prices of previous years and public land price of the reference land of this year and so on	-	-

N: numeric field
C: character field

5.3.3 Data quality and errors

It is very important for the data user to fully understand data quality. Good quality data produces the results and output; then decision makers can make well-founded final decisions. If the user inserts poor quality data into his analysis, he will obtain poor quality results. If data collected in previous sections has poor quality or errors, it may be compounded during analysis and may create misleading interpretations (Heywood et. al., 1998).

The weakness of data collected in this study is that it is impossible to obtain cadastral map of the case study area before 1998. This is because cadastral maps are constantly being updated and the outdated maps are not usually kept. Therefore, it is more difficult to trace when a parcel divided or integrated over time, for example, or when existing parcels disappeared or new parcels were created.

Moreover, these are problems that occur with a cadastral map and errors in parcel numbers. In this study, these appear under 'No data'. This study has thus to explore analysis based on the change over time of attribute data where the parcel numbering is the same. In the study area, 'No data' were left blank or input as 0 at the data entry stage. In this case, to input as 0 due to the labels of the variables, there is no problem. For example, the forest variable is divided into only two labels such as preserved forest land and quasi-preserved forest land. The rest are input as 0. The problems are the cases left blank and input as 0. In this case, they are not easy to trace. They are thus counted as missing values.

In addition, most of the data derived from the Land Utilisation Character Surveys did not include the national and public parcels because the administrative purpose of the surveys is to impose national and local taxes. Therefore such data was entered as 0. This study will need to be convinced that with so many 0 parcels, any analysis that this study carries out is not likely to be affected.

These kinds of problems may still happen when applied elsewhere using the cadastral map. The above problems can be the obstacles in applying the cadastral map as the basis for GIS and spatial analysis in the urban planning field. These problems can prevent data users producing accurate and reasonable results using cadastral maps. Cadastral maps should be accurate enough to become a base map when applied to other applications. This weakness of missing data should thus be supplemented using both field surveys and each kind of register such as a terrier, a forestry book, etc. because these registers are managed and updated by the appropriate department of local government on a daily base. In addition to the variables, socio-economic variables such as population and employment, etc are excluded for the analysis because they are recorded at county or jurisdiction level rather than site level.

5.4 Data Building

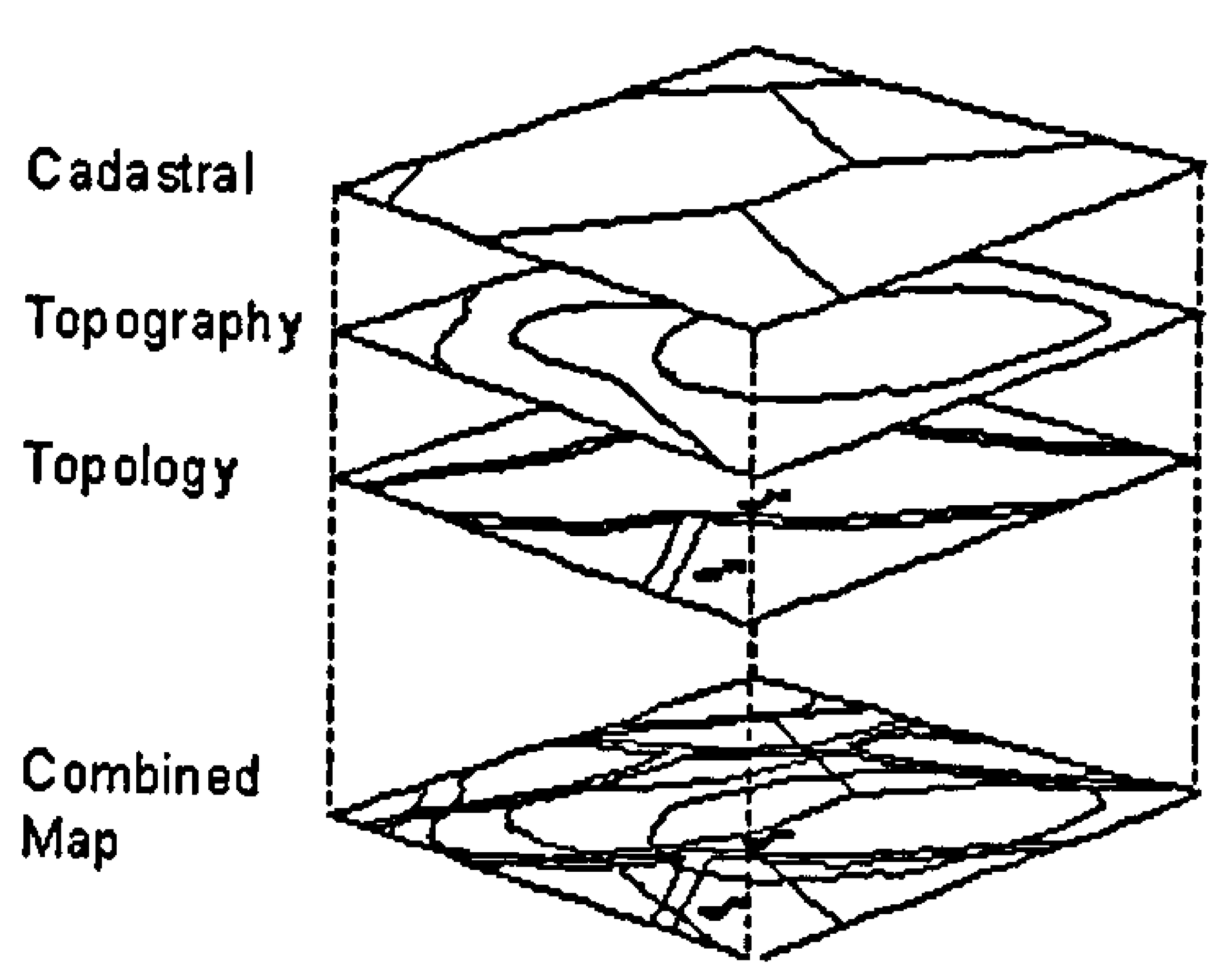
5.4.1 Software environment

To carry out this work, the software used is Arc/Info or ArcView platform (UNIX – HP and NT based) from ESRI, one of the most common GIS software packages. AutoCAD 14, SAS, SPSS and MS Office applications are also needed to do this work.

5.4.2 Data building from the Land Price State Map

With the condition of data collection in mind, the procedure of data building is divided into two parts; map data building and attribute data building as shown in Figure 5-2. The first task of this section is to overlay[3] both maps; the Land Price State Map (LPSM) and the digital topographical map. The purpose of this is to adjust the location of specified features in the LPSM to match features in the digital topographical map. This is mainly adjusted based on the outline of road and block, including scale change on AutoCAD as shown in Figure 5-3. If there are no roads and blocks, it can be referred through the configuration of the ground within the

[3] 'The process of superimposing two or more maps, through registration to a common co-ordinate system, such that the resultant maps contain the data from both maps for selected features. Although the term overlay can be applied to paper based maps, more often it applies to the use of digital data, nevertheless, the principal is the same' (ESRI, 1994).



area. It should also be fixed to a digital topographical map wherever possible according to documentary reference such as a cadastral map or a topographic map.

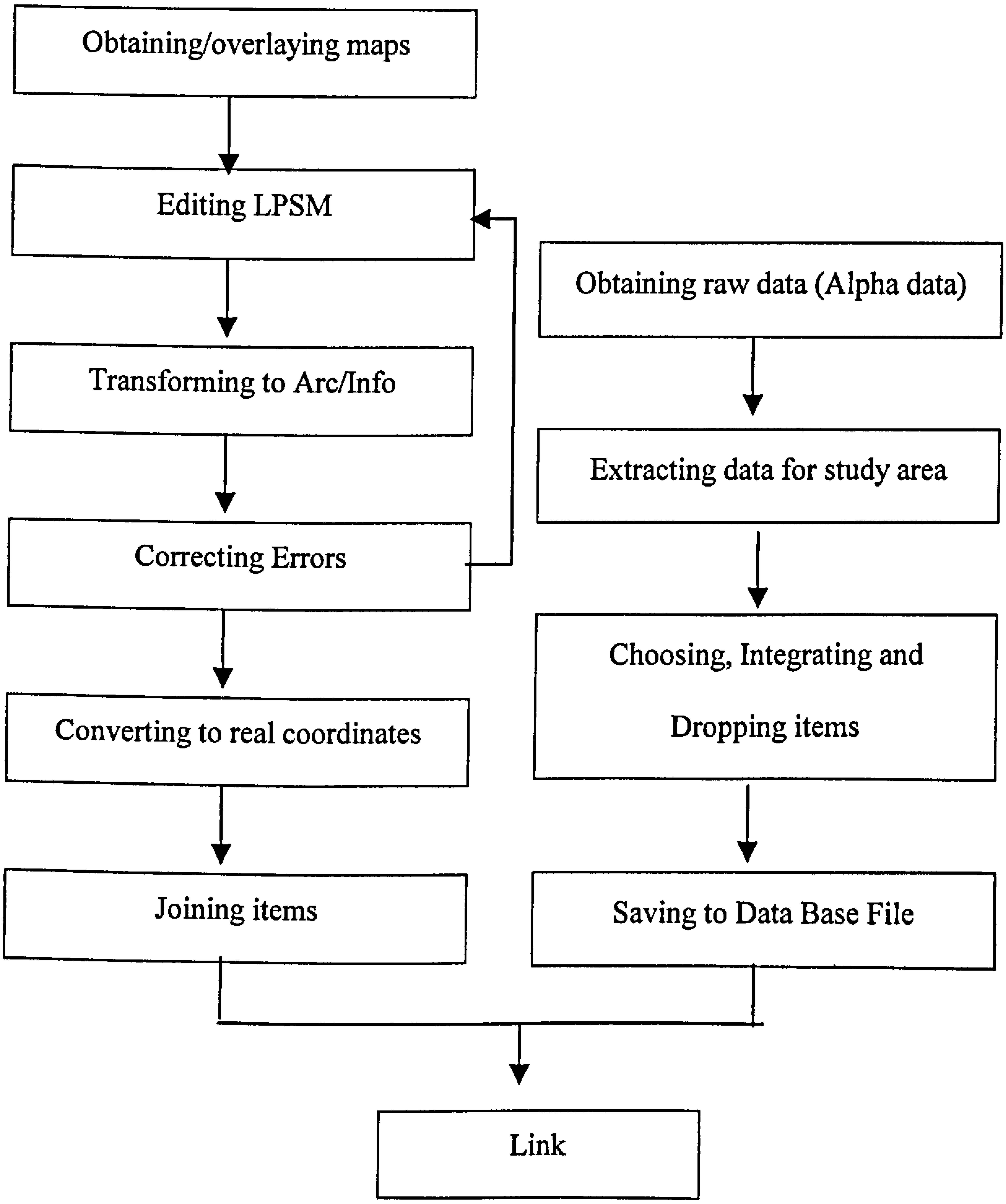


Figure 5.2 The procedure of data building

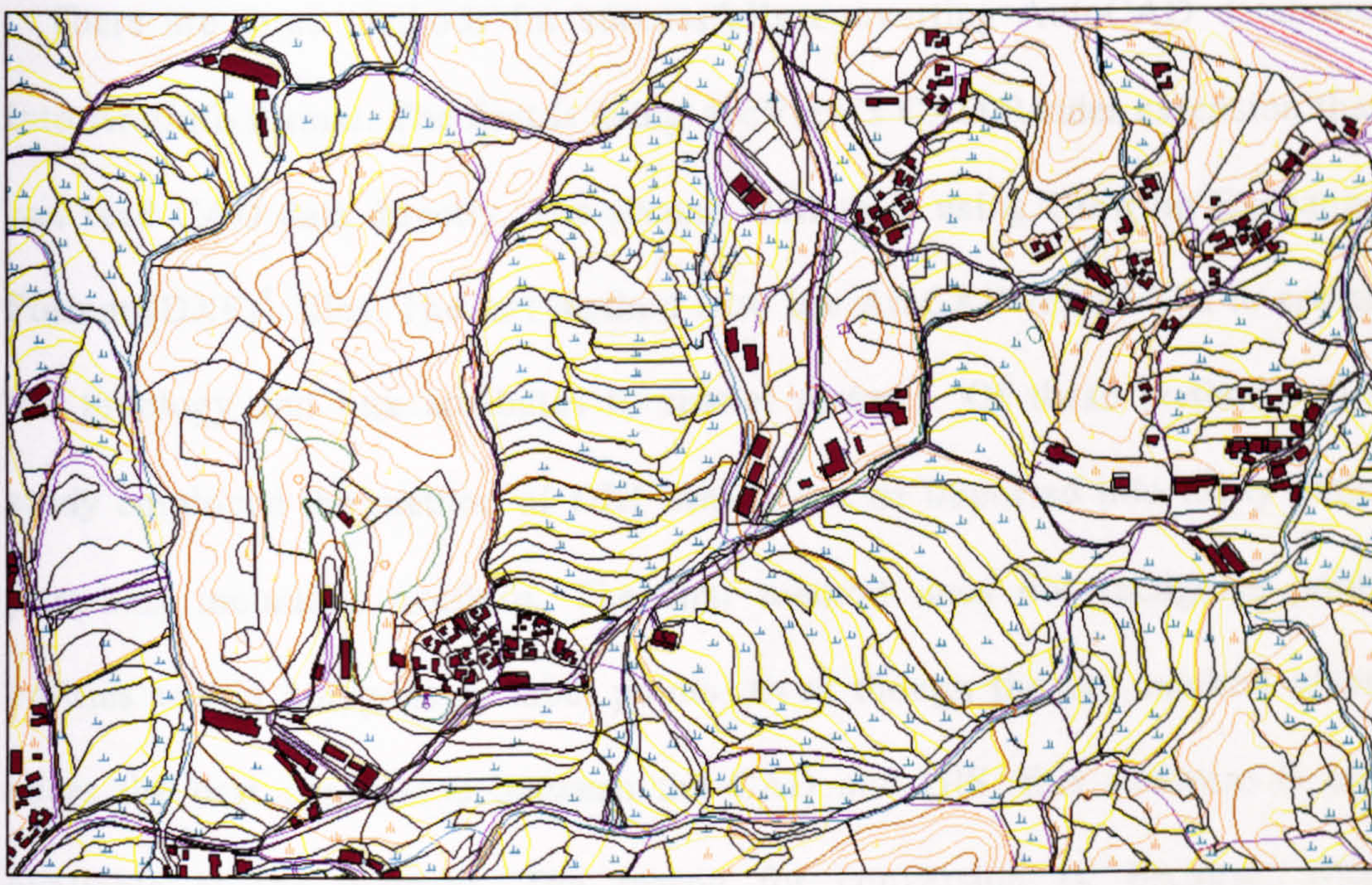


Figure 5.3 The example of overlaying Land Price State Map on the topographical map in the case study area (Black lines are the cadastral map.)

After finishing overlaying and editing maps, the next step deals with the transformation of AutoCAD into Arc/Info coverages. Before this, it is important to understand the differences between CAD and GIS. This study will usually focus on AutoCAD, produced by AutoDesk, and ArcView and Arc/Info GIS packages from ESRI. Schaeffer (1998) explains 'the key difference is that AutoCAD is designed to create and edit graphic entities, while GIS is a spatial database that uses graphics to display the results of analysis'.

There are three methods for successfully converting AutoCAD databases into Arc/Info format. The first is using ArcView's CAD Reader extension that can read CAD data directly. The second method is using Drawing Exchange Format (DXF)[4] files. The last method is to use ArcCAD from ESRI to create the topology and link attributes to spatial features. Of these methods, this study employed the method of DXF which can be imported into many other programs including Arc/Info. The first method does not recognise point entities within polygons as label points. Even though the last method gives users the best conversion between the CAD and GIS, this software is not available at the moment. The reason for conversion is, because, with AutoCAD, data is attached indirectly, layer names, colour, width, or length, this data is not readily available in a tabular format within the AutoCAD program. But a GIS is designed to directly link each graphic entity with a record in a data table (Schaeffer, 1998). In this procedure, AutoCAD files have to be exported to AutoCAD R12 DXF because AutoCAD R14 DXF cannot be read in Arc/Info Version 7.1.2.

After finishing the transformation process successfully the coverages transformed in Arc/Info have to be edited and then completed using the 'Clean'[5] command. To do this, this study will use 'ARCEDIT' at the Arc

[4] DXF (Digital Exchange Format); 'A format for transferring drawings between CAD systems, widely used as a de facto standard in the engineering and construction industries' (Walker, 1993)

[5] An Arc command that is without topological errors

command prompt in Arc/Info. In this work, errors such as line errors (overshoot[6] or undershoot[7]) need to be checked and polygon errors related to labels. It is possible to revise line errors using the 'ARCEDIT'. In the case of label errors, a label represented on a parcel is the case of two or more or nothing as Figure 5.4 shows. A parcel should only have a single parcel number on the map and exist certainly within its boundary. In GIS format, it is very important to have a single label (parcel number) in single polygon (parcel) while this does not matter in the AutoCAD. This is because AutoCAD does not create topology. It cannot recognise that a point within that polygon is related to that polygon, or that this polygon may share lines with an adjacent polygon (Schaeffer, 1998). These cases particularly occur when a map is joined to another adjacent map and when drawers draw a map. For revision of these errors, all parcels were investigated carefully. Some feedback between AutoCAD and Arc/Info is required to produce GIS data in a useable form.

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[6] 'A topological error where a line projects beyond the true intersection with another line' (ESRI, 1994)

[7] 'A line feature which is short of its true intersection with another line feature' (ESRI, 1994)

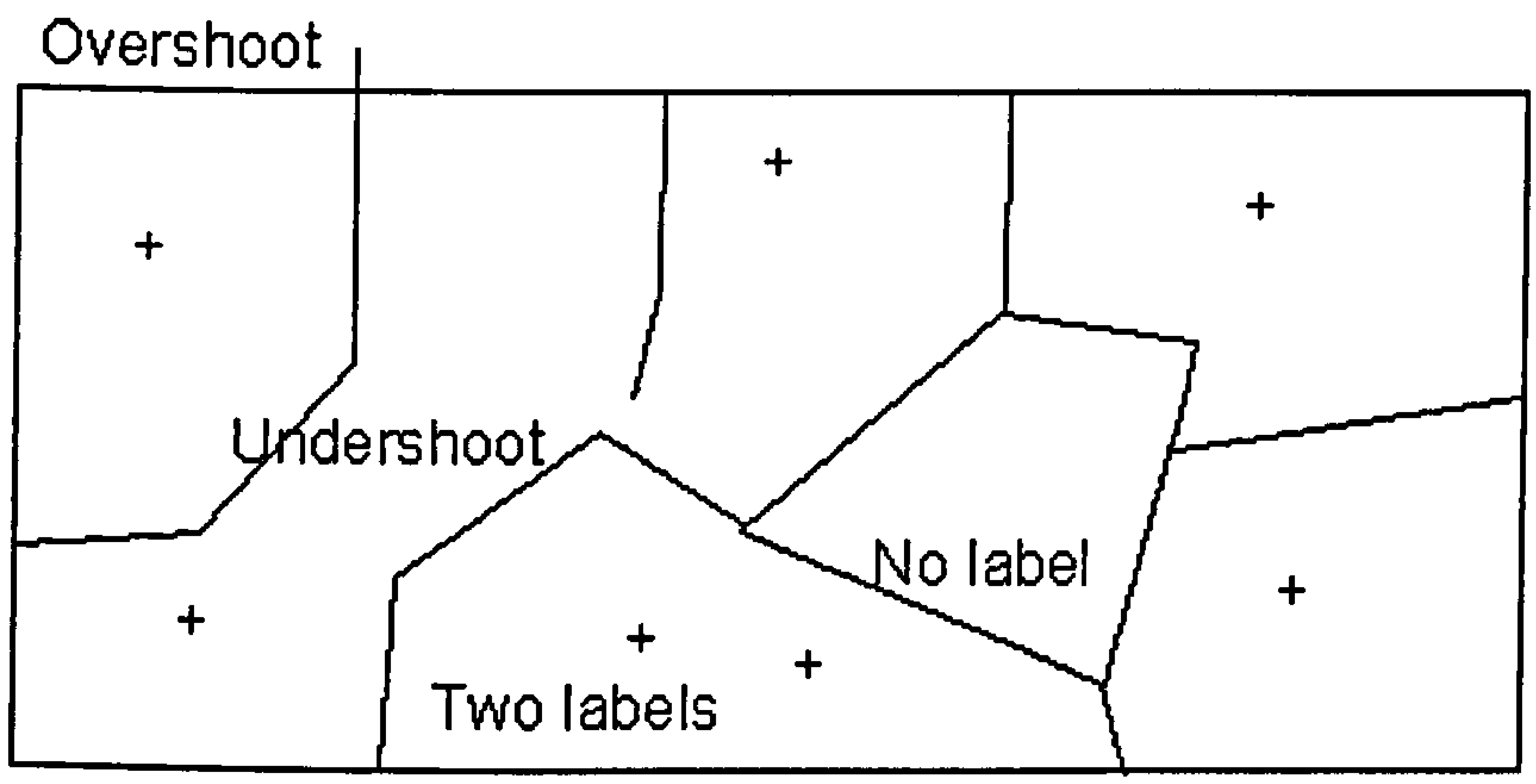


Figure 5.4 The example of errors

As AutoCAD drawings are not geo-referenced, it is possible to bring them into a geo-referenced coordinate system. To transform the spatial coordinates of these coverages from digitiser coordinates into real world coordinates, benchmark points, which are known as real world coordinates, are needed. For this, 4 identifiable points are taken from a digital administrative boundary map used for existing research. Thus, the drawing can be moved by selecting the benchmark point as the base point.

The final step of map data building is to join items. The values in one table can match the values in another. This is the method to get all attribute data of AutoCAD, as shown in Table 5-1, into Arc/Info. For this, this study used the "JOINITEM" command at the Arc command prompt in Arc/Info to add the attributes from the ACODE (for line attributes) and XCODE (for point/label attributes) into the AAT

(Arc Attribute Table) and PAT (Point Attribute Table), respectively. Thus, AML[8] (Arc Macro Language) in Arc/Info is used as is given in Appendix 1. To do this, two AMLs are made; the makerun.aml and the makekey1.aml. The makerun.aml also consists of three amls; makecv.aml for making coverage from dxf_file; makejoin.aml for joining coverage.pat and coverage.xcode by coverage-id item; makehcode.aml for adding hcode items to coverage.pat. Then, the makekey1.aml operates for making keyID-item from dxf-text.

5.4.3 Database building from Land Utilisation Character Surveys

The first task is to extract data related to the study area from the whole raw database, including data for each year required as shown from the SAS[9] program in Appendix 2. Then, of the items noted in Table 5-2, some items that this study requires are chosen and some items classifications are simplified. In addition, many items are deleted as the study area deals with the urban fringe. That is, some urban factor items in Table 5-2 are unnecessary (such as District, FAC, OTHR, RWAY, and WAST). Some items that have the

[8] 'A high-level language for generating end-user applications in conjunction with ARC/INFO. Features include the ability to create on-screen menus, use and assign variables, control statement execution, and get and use map or page unit co-ordinates. AML includes an extensive set of commands that can be used interactively or in AML programs (macros) as well as commands that report on the status of ARC/INFO environment settings' (ESRI, 1994).

[9] Integrated software to access, manage, analyse, and present data. The SAS System can be used to perform data entry, retrieval and management; report writing and graphics design; statistical and mathematical analysis; business forecasting and decision support; operations research; project management and applications development (FOLDOC, 1998).

same value on the field in each parcel (such as SHAP, PLOW, AGRI, and FERT) were deleted as well.

After this process, extracted attribute data was entered in Excel spreadsheets and then saved as DBF files. The files were then uploaded into INFO tables of Arc/Info.

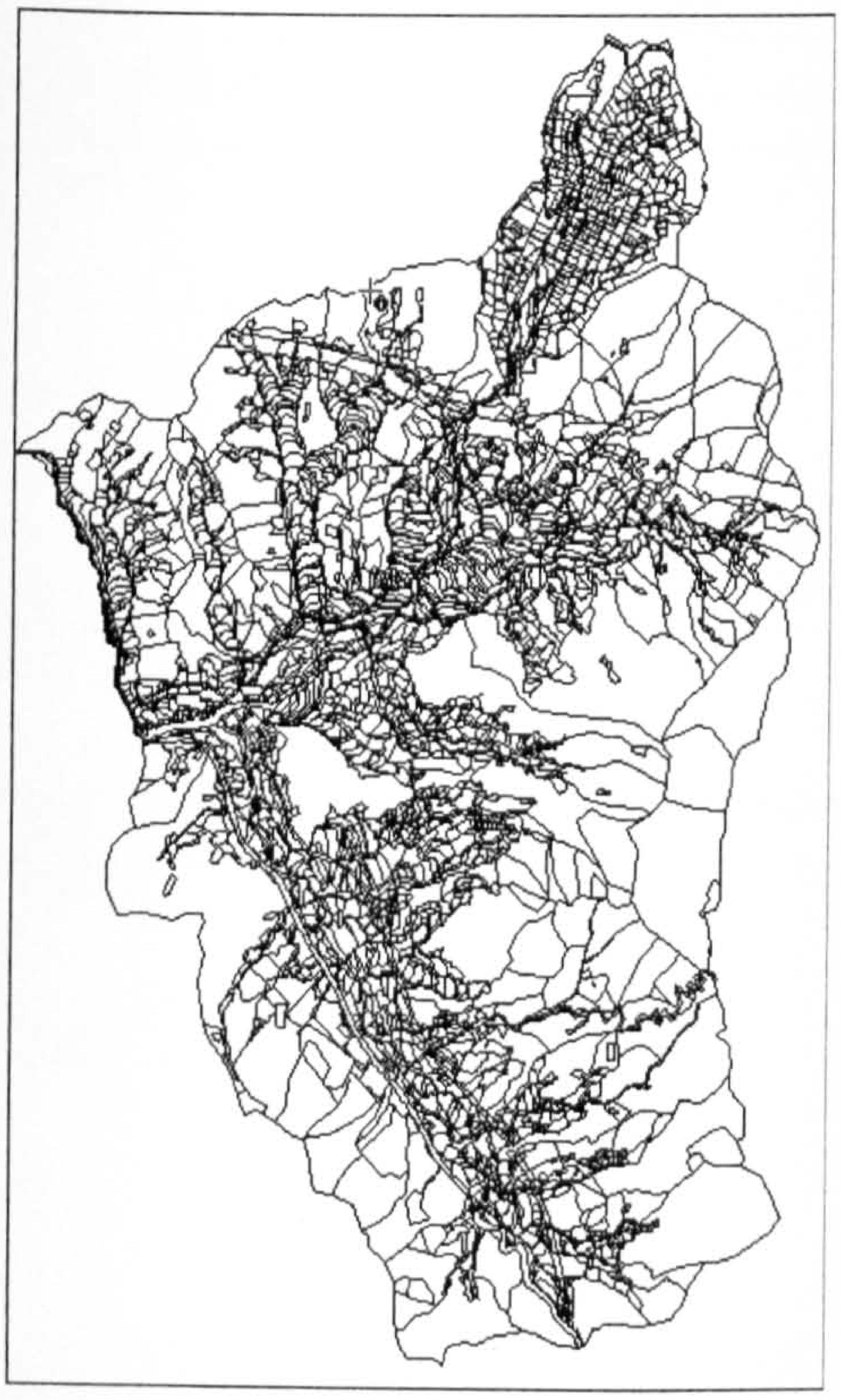
5.4.4 Linking attribute data to a basemap

The most important contribution of GIS technology is the logical link between map features and attribute data. By incorporating together map and attribute data, GIS provide a powerful environment within which to measure spatial identities, explore spatial relationships, and ultimately, to model spatial processes. Efforts of link have been employed successfully in other studies (Ludeke et. al. 1990; Pereira and Itami, 1991; Chou et. al, 1993; 1996; Narumalani et. al. 1997; Landis, 1998a:1998b).

The method of link in this study is as follows; all data mentioned in previous sections contains information about the same features. That is, both the cadastral map as a base map and the Land Utilisation Character Surveys as attribute data have the same administrative network code, called keyid. These attribute data can thus be linked to the cadastral map by including additional attributes in each record. Once that association is made, many various analyses are possible.

5.5 Data reclassification

As a result of data building, this study can now use a digital cadastral map and attribute data linked by keyid as shown in Figure 5-5.



Area	Keyid	Zond	Lus	and	Land_F	Fores
8786.21	4149033024100750002	0	0	0	0	0
2391.60	4149033024100750500	0	0	0	0	0
30719.26	4149033024100750235	0	5	3	39900	2
12341.27	4149033024100750031	19	5	3	41100	2
5630.42	4149033024100750150	0	0	0	0	0
3672.21	4149033024100750007	21	1	6	193000	0
2112.14	4149033024100750029	21	5	3	56700	2
2047.14	4149033024100750032	21	5	3	56700	2
1992.84	4149033024100750033	21	5	3	56700	2
2094.71	4149033024100750028	21	5	3	56700	2
2160.51	4149033024100750030	21	5	3	56700	2
12861.44	4149033024100750016	0	0	0	0	0
2067.66	4149033024100750027	21	5	3	56700	2
363.82	4149033024100750021	0	0	0	0	0
2055.90	4149033024100750034	21	5	3	56700	2
2095.89	4149033024100750020	21	5	3	56700	2
2104.38	4149033024100750035	21	5	3	42000	2
2006.02	4149033024100750022	21	1	3	160000	0
2310.70	4149033024100750026	21	5	3	56700	2
2242.39	4149033024100750149	0	0	0	0	0
1140.56	4149033024100750204	21	6	3	40700	0
7673.52	4149033024100750040	21	5	3	41100	2
2592.69	4149033024100750184	21	1	3	39400	0
674.92	4149033024100750019	21	6	3	144000	0
2120.40	4149033024100750025	21	5	3	56700	2

Figure 5.5 A Cadastral map and attribute data

There are so many 0 values that were left blank or input 0 at the data entry stage in the attribute data as shown in Figure 5.5. They should be counted as missing values, called 'No data'. This will be explained in the next chapter with a cross-tabulation which is designed to show the proportion of each land use change among cases with land use from 1994 to 1998.

All data linked between a base map and attribute data will have the following fields: Perimeter, KeyID, LndCtg, Zone, Area, Forest, Heit, Drec, Road, and Lndprc as shown in Table 5-3.

Table 5.3 The list of variables

Name	Value	Label
Perimeter		The length of a parcel's outer edge
KeyID		Administrative network code
LndCtg		Land Category in 1991, 1994 and 1998
	0	Missing Value
	1	Dry Field
	2	Paddy Field
	3	Forest Land
	4	Residential Area
	5	Factory
	6	Public Facilities
Zone		Zoning; Special land use Areas in 1991, 1994 and 1998
	19	Quasi-urban areas
	20	Agricultural and Forest Areas
	21	Quasi-Agricultural and Forest Areas
Area		Size of land
Forest		Forest Land
	1	Preservation forest lands
	2	Quasi-preservation forest lands
Heit		Slope of land
	1	Lowlands
	2	Flatlands
	3	Gentle grade
	4	Steep grade
	5	Highlands
Drec		Direction
	1	Facing the South
	2	Facing Southeast
	3	Facing Southwest
	4	Facing the East
	5	Facing the West
	6	Facing the North
	7	Facing Northeast
	8	Facing Northwest
Road		Accessibility to main road
	1	Adjacent Areas
	2	Within 50m
	3	Within 100m
	4	Within 500m
	5	Over 500m
LndPrc		Land Price in 1991, 1994 and 1998

The process of data reclassification in this section is based upon the characteristics of data. For example, the land categories of the Land Utilisation Character Surveys were divided into 24 land use divisions. This study is reclassified into 6 large groups such as dry field, paddy field, forestry land, residential area, factory, and public facilities. In this way, data reclassification based on data constructed is shown in Table 5-3 and the following Figures (5.6, 5.7, 5.8, 5.9, 5.10 and 5.11).

5.6 Conclusion

This chapter presents data collection methods in relation to the purpose of this study, how to build the collected data within a GIS environment, and how to classify the data as an appropriate type for analysis. The key in data collection is deciding what data to use for analysing land use change in the urban fringe. This study employed a cadastral map as a basemap because it deals with basic units that experience land use change carried out by landowners and are managed with respect to the land affairs of local government. As attribute data, this study used the Land Utilisation Character Surveys, including field investigation and various kinds of documents to complement data missing. For correct use in a GIS environment, the collected data is transformed into a GIS environment, converted into real world coordinates, and a link is made between a cadastral map and attribute data. Finally, this study reclassified the data based on the characteristics in order to reduce complexity.

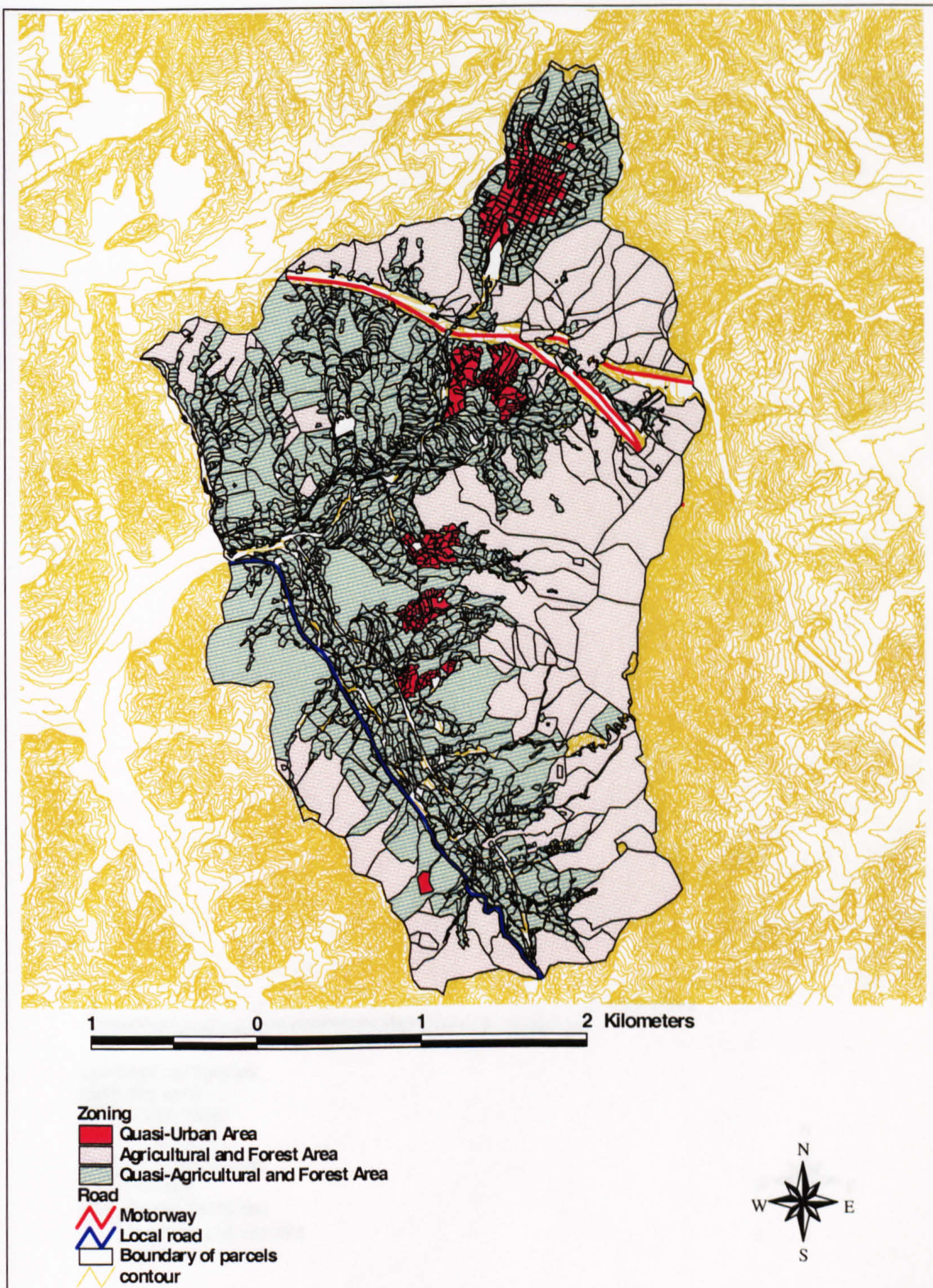


Figure 5.6 Zoning in 1998

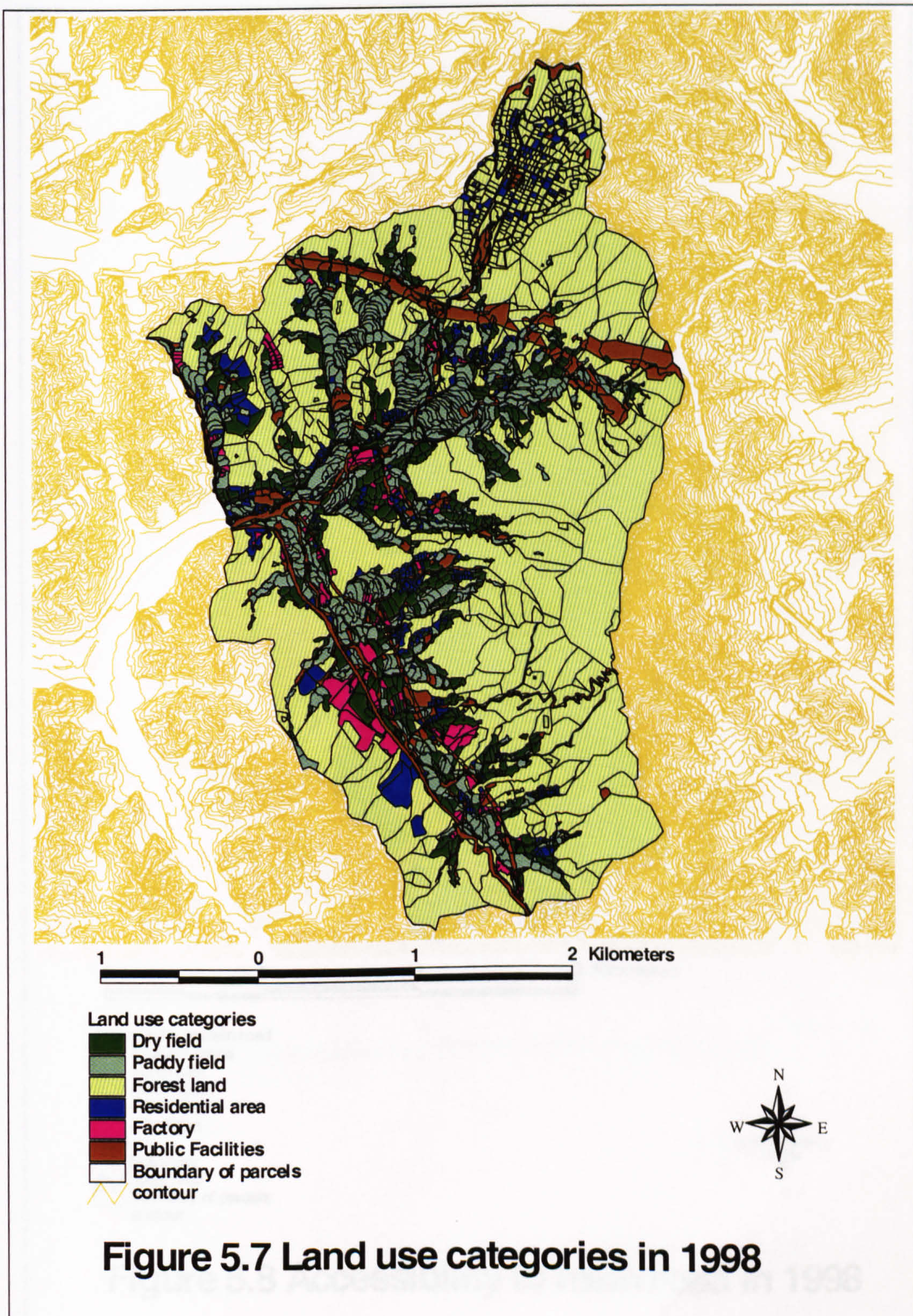


Figure 5.7 Land use categories in 1998

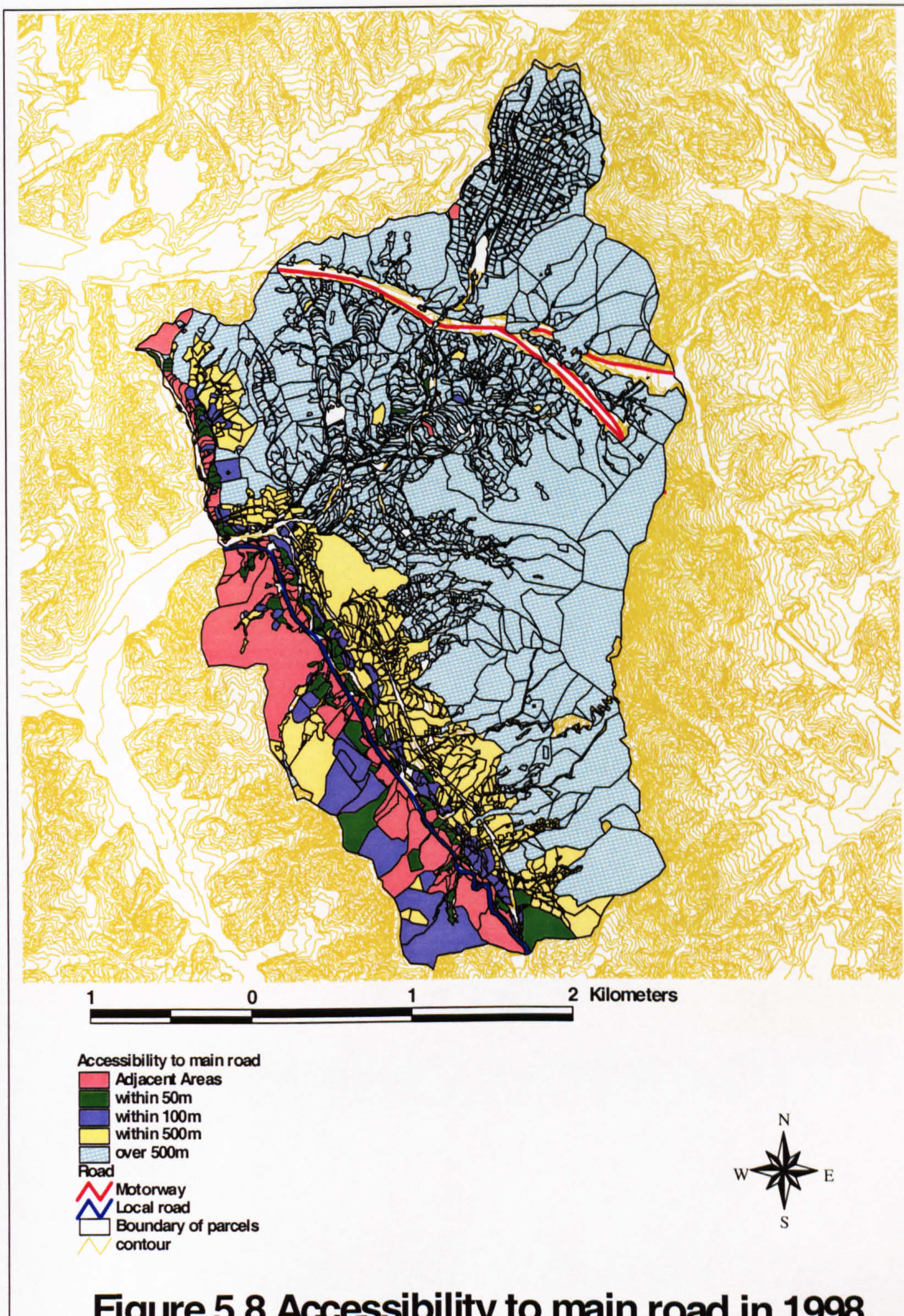


Figure 5.8 Accessibility to main road in 1998

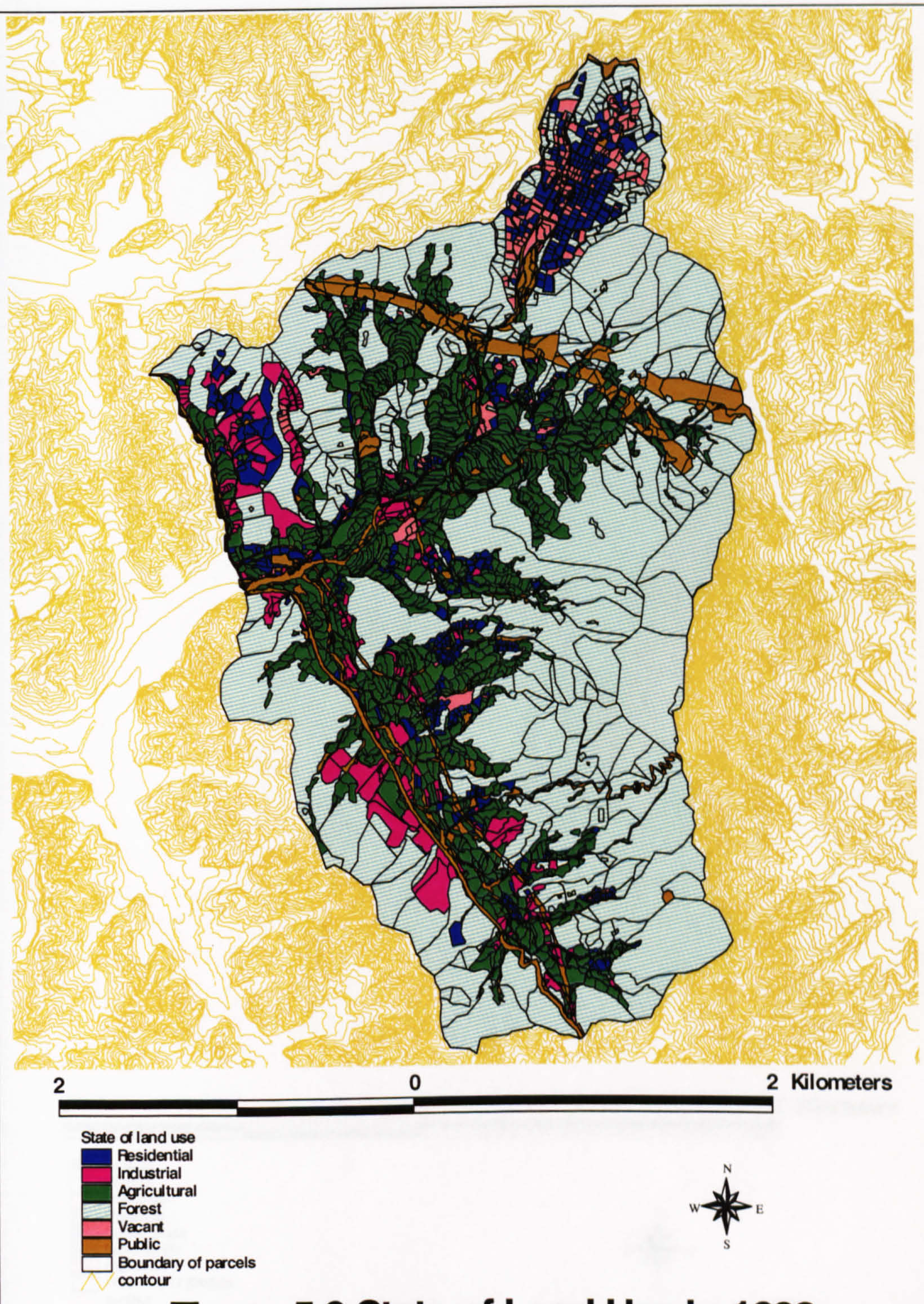


Figure 5.9 State of Land Use in 1998

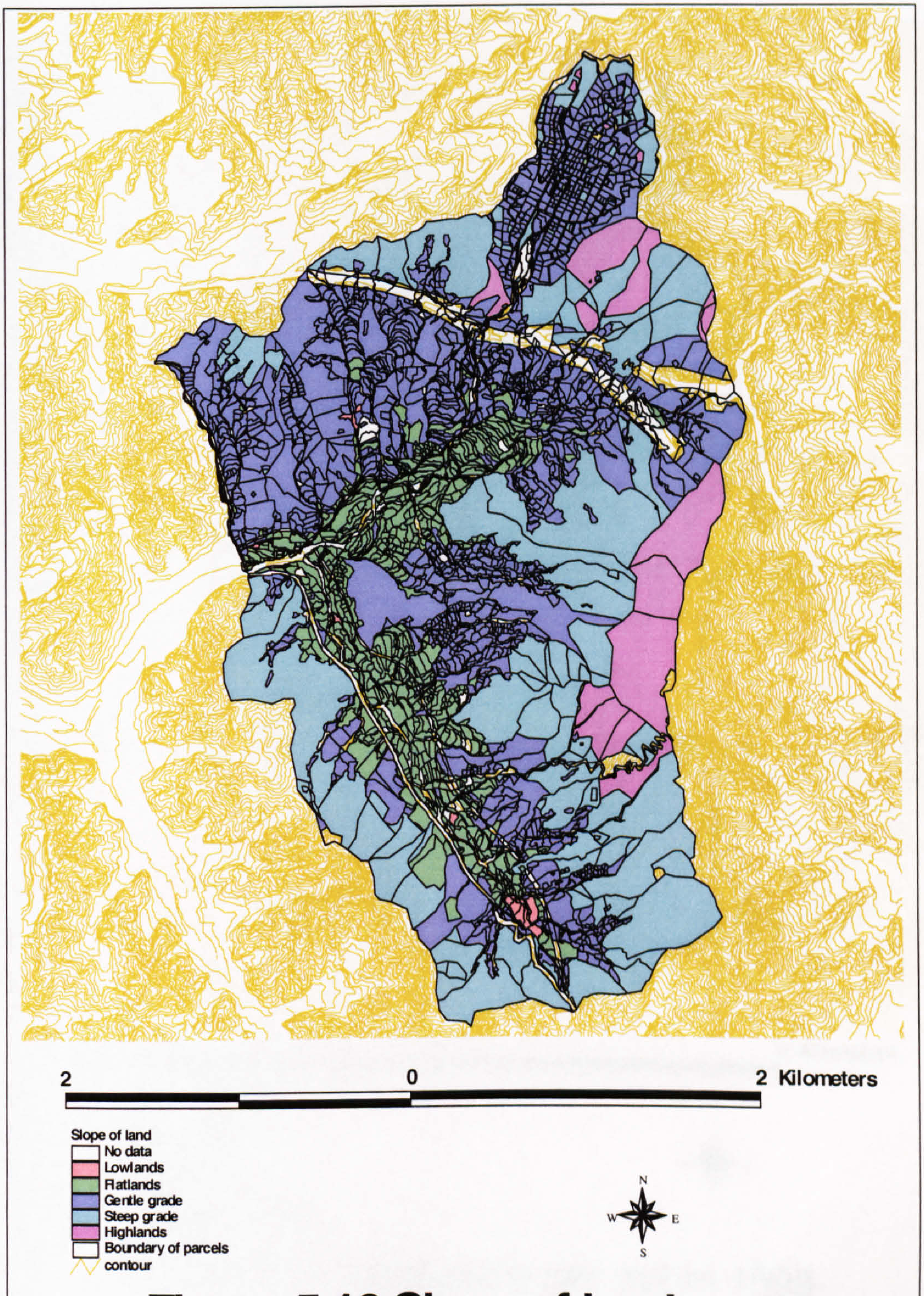


Figure 5.10 Slope of land

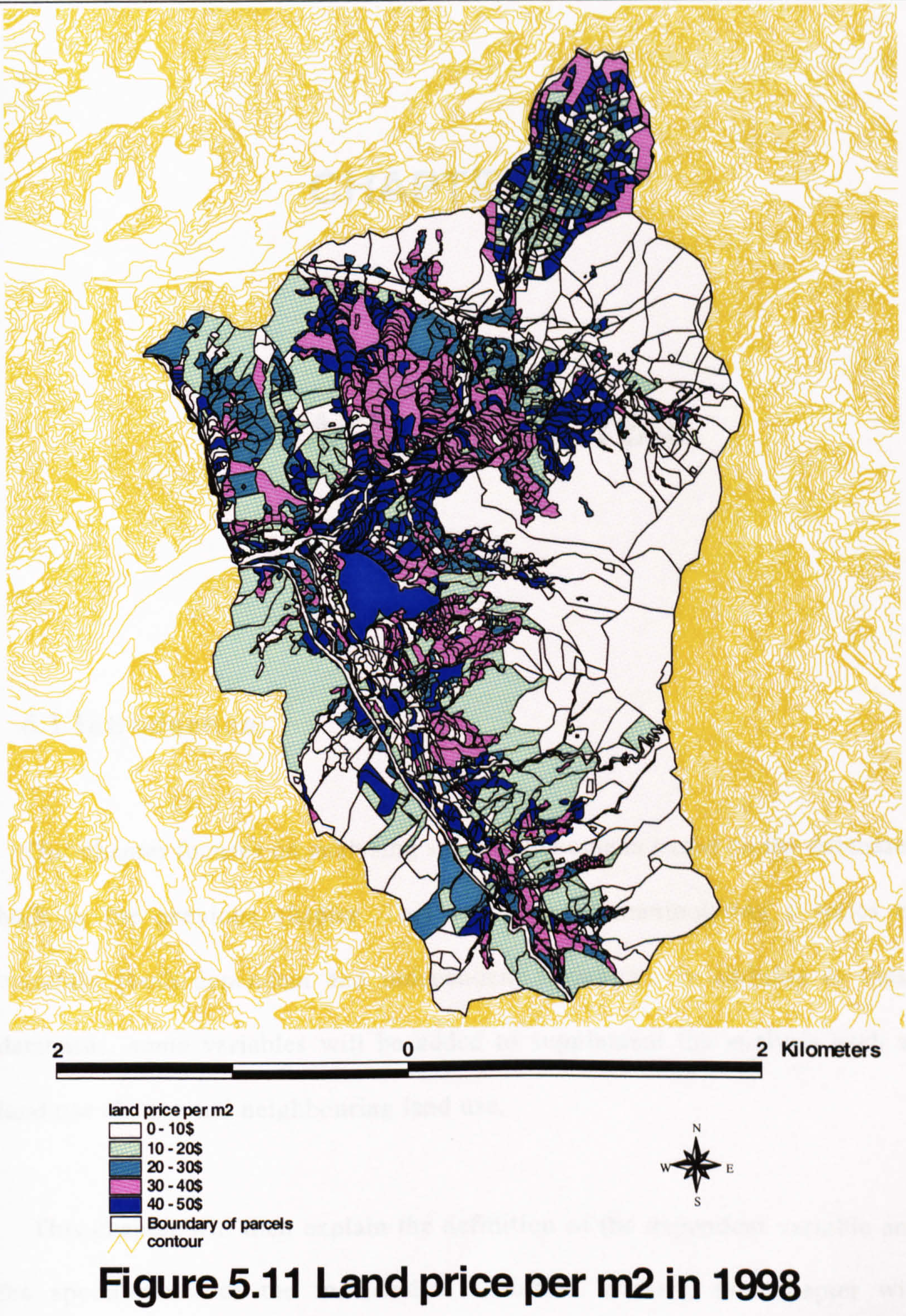


Figure 5.11 Land price per m2 in 1998

CHAPTER SIX

SPATIAL ANALYSIS

6.1 Introduction

This chapter focuses on analysing spatial phenomena based on the databases built in the previous chapter. This will involve manipulating a series of variables (both dependent and independent variables). In addition to these databases, some variables will be added to supplement the analysis such as land use change and neighbouring land use.

This chapter will then explain the definition of the dependent variable and the specification of the independent variables. Finally, this chapter will attempt to find the relationship between government policy change and land use change in the study area, to examine the determinants of land use change, to estimate the role of the neighbouring land use variable in the model, and to investigate the transition probability of land use.

6.2 Adding variables

This section added some variables such as land use change over time and neighbouring land use. The change of land use was dealt with as a dependent variable and neighbouring land use was dealt with as an independent variable. These variables are added to evaluate the extent to which neighbouring land use as an independent variable is associated with land use change as a dependent variable.

6.2.1 The change of land use

The change of land use was dealt with as a variable associated with the dependent variable in the logistic regression model. Each parcel was coded as changed or not changed in regard to land use regardless of the size and shape of the parcel.

There are two variables related to land use in the database: 'land category' and 'state of land use'. Land category is a legal concept defining the title given to the kind of the land, classified and expressed according to its primary aim and purpose of use. Land category change is a change of land category registered in a cadastral record from one category into another. State of land use is the state when a parcel was surveyed. The land categories in the Land Utilisation Character Surveys were identified into 24 land use divisions such as a dry field, a paddy field, an orchard, a pasture, a forest area, a mineral spring site, a building site, a factory site, a school site, a road, a railroad site, rivers, a bank, a ditch, marsh, a water supply site, a park, a gymnastic site, a recreation area, a religion site, historic site, a burial site and miscellaneous land. In this study the land categories are reclassified into 6 large groups in order to be as simple as possible with consistency of classification such as a dry field, a paddy field, forestry, a building site, a factory site, and public facilities. The state of land use in the LUCS was identified; 10 major land uses and 43 divisions. This study reclassified the state of land use into 7 large groups, that is, residential, commercial, industrial, agricultural, forestry, vacant use, and public facilities.

Owing to the difference of the time related to surveying and recording, there are some gaps between land category and the state of land use. To investigate the difference, this study examined Cross-tabulations in SPSS to obtain the relationship between the two variables in 1994 and 1998 as shown in Table 6.1and Table 6.2.

Table 6.1 State of Land Use in 1998 * Land Category in 1998 Crosstabulation

Count

		Land Category in 1998							
		0	Dry Field	Paddy Field	forestry	building site	Factory site	Public Facilities	Total
State of Land Use in 1998	0	726							726
	Residential use		37	36	131	387		38	629
	Commercial use			1		13		1	15
	Industrial use		18	18	3	29	139	24	231
	Agricultural use		669	873	23		1	6	1572
	Forest use		4	6	477	1		14	502
	Vacant use		17	14	159	45		28	263
	Public Facilities		14	13	18	2		9	56
Total		726	759	961	811	477	140	120	3994

Table 6.2 State of Land Use in 1994 * Land Category in 1994 Crosstabulation

Count

		Land Category in 1994							
		0	Dry Field	Paddy Field	Forestry	Building site	Factory site	Public Facilities	Total
State of Land Use in 1994	0	871	4		8			1	884
	Residential use		24	31	309	231		13	608
	Commercial use					1		3	4
	Industrial use			1	1	2	6	3	13
	Agricultural use		779	991	19	13	1	11	1814
	Forest use		6	10	462	11		19	508
	Vacant use		2	3	69	53		26	153
	Public Facilities		3		1			6	10
Total		871	818	1036	869	311	7	82	3994

In the case of 1998, for example, 629 parcels in 'State of land use' are in residential use at present but of those 629, 131 parcels are in the forestry category as classified by land category, 37 are in the dry field category, and 36 are paddy field category. This is because it was not possible to update a terrier or a forestry book at the same time as when land use was surveyed. In addition, in cases of vacant use in the state of land use, there are many gaps due to the method of investigation of the survey. For example, if a parcel was used as dry field, paddy field, or forestry land and the main land use of its surrounding areas was residential, commercial, and industrial uses, it was recorded as vacant use due to its development possibility. All else being equal, if the main land use of surrounding areas of a parcel was agricultural or forestry, it was recorded under agricultural or forestry uses in spite of it being used for residential, commercial, and industrial uses. It depends on the judgement of surveyors when the survey is carried out. Land category based on land transaction may be more stable than state of land use combined with the surveyor's intuitive power.

Therefore, the change of land use, the variable associated with the dependent variable, is extracted from the land category in the LUCS. However, this study will include both land category and state of land use as variables for analysing the relationship between dependent and independent variables.

6.2.2 The variable of neighbouring land use

The variable of neighbouring land use was dealt with as an independent variable and was added to measure the partial contribution of neighbouring land use to the dependent variable.

For examining neighbouring land use, in this study, all polygons that share edges or corners in their perimeter were considered adjacent. Although grid cells can easily use the distance between centroids as one way of implementing the method of selecting adjacent polygons, this study needed a general solution for any polygon theme due to using vector cells.

This study used the Avenue programme in ArcView to obtain neighbouring land use. The first task in the method of selecting adjacent polygons is to examine neighbouring parcel numbers on all polygons. For this, this study used ArcView's avenue programming which will visit each polygon in turn and produce an outfile containing the parcel record ID and the contents of each of the adjacent parcels (including the 'current' polygon).

This study found 'the neighbour script' which suits the requirements of this study already written on the internet. The avenue script which was found in the ESRI website made for calculating the difference between an area's own score and the mean of its neighbours' deprivation scores as a study of relative deprivation. The script was refined quite a bit for looking at the relationship between socio-economic deprivation and premature mortality (death before the age of 65) for the whole of England. Avenue was used ue to identify what we are calling concordant and discordant census wards (roughly equivalent to US census tracts) i.e. wards which are surrounded by wards with very similar or very dissimilar deprivation scores to their own.

This study refined the script again in order to suit the purpose of this study as shown in Appendix 3. The most important issue is how the resulting data is formatted. The simplest output solution is probably to output a text file with the parcel record ID and the contents of adjacent parcels. This is because a text file can usually be imported into any software though it will probably appear unformatted. The parcels of the sample data set in Table 6.3 name selected parcels and their neighbours. Streets have a lot of neighbouring parcel numbers.

Table 6.3 The parcel list

Parcel #	Neighbour parcel record Ids
2061	2038 2043 2049 2087
2062	1936 2001 2051 2073
2063	2023 2058 2065 2070
2064	1996 2047
2065	2022 2026 2058 2063 2070
2066	1971 2060 2080 2086 2088
2067	1945 1964 2052 2078 2098
2068	2013 2030 2069
2069	2013 2030 2068 2104
2070	2023 2026 2044 2058 2063 2065 2077 2084 2085 2097

The second thing is to translate the record Ids of neighbouring parcels into land use. For this, this study used the Lookup[1] function in Excel to obtain neighbouring land use. Table 6.4 shows the sample data set with the parcel record Id and the contents of neighbouring land use.

Table 6.4 The land use of neighbouring parcels in 1994

Parcel # & land use	Neighbouring land uses
2061 P	R D F D
2062 R	N P F D
2063 R	R N P D
2064 D	P D
2065 P	P N N R D
2066 P	P N D D P
2067 P	P D R N N
2068 P	P N D
2069 D	P N P D
2070 D	R N N N R P D D D D

N: no data
D: A dry field
P: A paddy field
F: Forestry
R: A building site
I: A factory site
U: Public facilities

[1] 'The LOOKUP function has two syntax forms: vector and array. The vector form of LOOKUP looks in a one-row or one-column range (known as a vector) for a value and returns a value from the same position in a second one-row or one-column range. The array form of LOOKUP looks in the first row or column of an array for the specified value and returns a value from the same position in the last row or column of the array' (Help in Excel).

After obtaining neighbouring land uses, the next step is to deal with how to calculate the ratio of each land use to neighbouring land uses. For this, this study used Visual Basic as shown in Appendix 4. This study thus obtained the total number of neighbouring land uses and the ratios of neighbouring land uses using Visual Basic. The sample data set is shown in Table 6.5.

Table 6.5 The ratio of neighbouring land uses

Id	Land use		Total No[1]	The ratio of neighbouring land use							Urban use[2]	Land use change[3]	Spatial pattern[4]
	1994	1998		D	P	F	R	I	U	N			
2061	P	I	4	0.50	0.00	0.25	0.25	0.00	0.00	0.00	0.25	1	PI
2062	R	R	4	0.25	0.25	0.25	0.00	0.00	0.00	0.25	0.00	0	RR
2063	R	R	4	0.25	0.25	0.00	0.25	0.00	0.00	0.25	0.25	0	RR
2064	D	D	2	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0	DD
2065	P	P	5	0.20	0.20	0.00	0.20	0.00	0.00	0.40	0.20	0	PP
2066	P	I	5	0.40	0.40	0.00	0.00	0.00	0.00	0.20	0.00	1	PI
2067	P	I	5	0.20	0.20	0.00	0.20	0.00	0.00	0.40	0.20	1	PI
2068	P	P	3	0.33	0.33	0.00	0.00	0.00	0.00	0.33	0.00	0	PP
2069	D	D	4	0.25	0.50	0.00	0.00	0.00	0.00	0.25	0.25	0	DD
2070	D	D	10	0.40	0.10	0.00	0.20	0.00	0.00	0.30	0.20	0	DD

For symbol key, see, Table 6.4

1 : Total No: the total numbers of neighbouring land uses

2 : Urban use: the ratio of urban neighbouring land uses (R+I+U)

3 : Land use change: whether or not changed from rural to urban use 1994-1998

4 : Spatial pattern: the pattern of land use change between 1994 and 1998

Finally, this study considered a term of neighbour land use as the ratio of the number of urban use adjacent parcels to the total number of adjacent parcels.

6.3 Variables

This section shows that the database will be divided into dependent and independent variables in order to examine spatial patterns of land use changes, the impact of neighbouring land use, and the transition probability of land use.

6.3.1 The dependent variable

The dependent variable in this analysis is the change of land use based on the classification of land category from rural use to urban use, being relevant when considering the changed or unchanged use of land in a parcel. Each parcel value for the 1994 land use survey was compared to its corresponding parcel location on the 1998 land use survey. The result was a new variable made up of '1' and '0'. Values of '0' denoted parcels where no change in land use has occurred, while '1' values represented parcels where change has taken place in land use.

Each parcel was coded regardless of the size and shape of the parcel. Land use change focuses on the conversion of land from rural to urban uses. Rural uses are defined as dry field, paddy field, or forestry land categories. Urban uses are classified into building sites, factory sites, and public facilities. The variable is measured at a nominal scale where parcels are classified into one of two categories; changed or not changed.

6.3.2 The Independent variables

The decision for the conversion of land use is not always easy. The alternatives for the landowner when considering land use change are affected by a wide range of differing circumstances. Owing to the difficulty of collecting together all the relevant data and the storage space this would require, the number of variables which could be used in this study was restricted. Therefore independent variables used in the study were limited by some variables such as area, perimeter, state of land use, land categories, height, zoning, direction, neighbouring land use, accessibility to main road, land price, etc.

Independent variables used in this research were mainly derived from Land Utilisation Character Surveys, field survey and the application of the data using SPSS and Excel. Appendix 5 lists the dependent and independent variables used in this study. Each set of independent variables will be discussed in more detail in the following sections.

In this study there are some variables related to physical characteristics: area; forest; height; and direction. Physical characteristics of a parcel are closely connected with its development. Gore & Nicholson (1985: p187) point out that " Physical constraints ... do not necessarily prevent development, as they can normally be expressed in terms of extra preparation or construction costs." Similarly, Adams (1994: p51) states that "any delay to the development timetable caused by physical constraints can be as serious as the cost of treatment." Therefore, this study expects to observe a negative relationship between the variables of physical characteristics and the change of land use.

Area variable: This has various kinds of shape and size in a cadastral map. The area is surveyed originally from a terrier and a forestry cadastral book when the LUCS was investigated. The area which was registered in the registers was determined with the unit of a square meter. In the existing studies on land use change, the area was not considered as a variable because all the area is the same in a raster-based GIS.

Forest variable: Forest land is characterised by a predominance of tree cover and is further divided into preserved forest land and quasi-preserved forest land. This data was derived from a forestry book.

Height variable: Height is identified to five height classifications: (a) lowlands; (b) flatlands; (c) gentle grade; (d) steep grade; (e) highlands. The criteria of height when it was surveyed are usually decided in relation to a main road and the surrounding topography. It is a flatland when the height of a parcel is similar to the height of main roads and the surrounding topography. It is a lowland if it is lower than the height of main roads and the surrounding topography. When it is generally higher or more sloped than main roads and the surrounding topography, it is divided into two categories; gentle grade (less than 15%) or steep grade (more than 15 %). The highland is remarkably higher than main roads and the surrounding topography.

Direction variable: Direction is classified into 8 parts: (a) south facing; (b) southeast facing; (c) southwest facing; (d) east facing; (e) west facing; (f) north facing; (g) northeast facing; (h) northwest facing. Direction is examined only for residential areas and forest areas; residential areas were looked at based on main access roads and forest areas were examined based on the direction of slope.

Land use variables: As explained in the previous section, the variables associated with land use were divided into two parts; land categories and state of land use. These factors are regulated by Acts such as the City Planning Act and the National Land Use Management Act. Land categories consist of six parts: (a) a dry field; (b) a paddy field; (c) forestry; (d) a building site; (e) a factory site; (f) public facilities. State of land use classifies to seven parts: (a) residential use; (b) commercial use; (c) industrial use; (d) agricultural use; (e) forest use; (f) vacant use; (g) public facilities.

Zoning variable: Only 3 zoning categories was included under the National land use management Act because the case study area was located in the urban fringe areas. Urban areas and Natural environment preservation areas are excluded. The three zones relevant to the study area are classified as quasi-urban areas, agricultural and forest areas, and quasi-agricultural and forest areas. The Act defines these three classifications as follows;

Quasi-urban areas: "areas corresponding to the urban areas, which have been or are to be used as the collective living base of residents requiring the utilisation and development of land, land to be used for sports, tourism and recreation facilities to make the best use of the leisure time of citizens and enable them to enjoy sight-seeing and recreations, agricultural and industrial complexes, collective burial grounds, and land to be used for other various facilities". Agricultural and forest areas: "areas for promoting agriculture and forestry, and preserving forests, such as agriculture promotion areas, reserved forestry land, etc". Quasi-agriculture and forest areas: "areas which are not only used for promoting agriculture and forestry and preserving forests, but also used for the purpose of development, such as farmland, quasi-reserved forest land, etc., in areas other than the agriculture promotion areas".

Landis (1998b: p801) points out that "most constraints to development are political, not physical." He stated that in his research, however, zoning categories were not included in the model, "because of the cost and difficulty of obtaining, digitising, and coding accurate up-to-the-minute zoning maps for every jurisdiction." However, this study is able to include zoning variable.

This study focuses particularly on the change of parcels within Quasi-agriculture and forest areas which are changing rapidly at present.

Land price Variable: Land price employed in this study does not represent the market value of land. The implication of this variable for this study is to examine the change of land price based on the estimated land price from three time periods (1991, 1994, and 1998) and measure the partial contribution of land price to land use change using spatial analysis. The land price of a parcel used in this study is 'the individually assessed official land price', which the Minister of Construction and Transportation and local government has surveyed, assessed and made public in accordance with the procedure stipulated under the Public Notice of Values and Appraisal of Lands, etc. Act. The head of local government uses the assessed land prices for the purpose of imposing charges on a national tax and a local tax related to lands.

The land prices can be applied to various uses wherever appropriate. Whenever land is evaluated, the official land price should be applied (the article 9 of the Act). When calculating the price of a parcel for the purpose of administration, the official land price should be applied (the article 10 of the Act). This policy has successfully contributed to stabilising the land price for administrative purpose. However, this appraisal method does not cope effectively with changes in the circumstances of the market like the currency crisis in 1998 (Lee, 2001).

Land price has been regarded as a signal of the market mechanism, which many economic agents utilise in their decision-making. Land price also reflects political, social, economic, and urban structures, by which the land market moves (Chae, 1997). In this study socio-economic variables could not be examined for the analysis because these were not recorded at site level. Even though the official land price does not represent accurately the market value of land, it is close to the market value. Thus this study considered land price as a variable reflecting socio-economic characteristics.

The neighbouring variable: To show the degree of relationship that exists between two or more spatial variables, such that when one changes, the others also change, the spatial autocorrelation is used. This change can either be in the same direction, which is a positive autocorrelation, or in the opposite direction, which is a negative autocorrelation. Technically speaking, this is to measure the similarity of neighbouring parcels (GIS dictionary).

For measuring spatial autocorrelation, there are many methods suitable for polygons. These methods can be used with two types of data: nominal and interval/ratio data. For nominal data, joint count statistics can be used to measure spatial autocorrelation for polygons. Moran's I Index, the Geary Ratio, Local Indicators for Spatial Association, and the G-statistics can be used for interval/ratio data (Lee and Wong, 2001). These techniques in spatial analysis depend on "a matrix of proximity measures between zones where each proximity measure represents the degree of influence of one zone upon another. Clearly all these ways of measuring spatial proximity have some validity and there appears to be no one commonly accepted measure" (Fotheringham et.al., 2000: p244).

Apart from the above methods, this study used a new method to capture the neighbouring relationship among parcels (refer to section 6.2.2). To define the neighbouring relationship, all the surrounding parcels in the study area can be identified as neighbours of the current parcel as long as they touch each other even at a point.

Studies of neighbouring use effects related to a site level have been paid little attention. This is because at site level, it is particularly difficult to measure and collect data. Common encoding in a form convenient for use with statistical models is particularly difficult. Thus the neighbouring land use variable has been neglected in analysing determinants of land use change. The recent studies merely addressed issues pertaining to neighbouring use effects as a raster-based GIS (Chou et. al, 1993; Clark et al., 1996; Landis and Zhang, 1998a:1998b). However, as mentioned in the previous section, the analysis of neighbouring land uses in cadastral maps has not been considered due to the complexity and the difficulty of data collection.

The pioneering work of Tobler (1970: p236) shows that " everything is related to everything else but near things are more related than distant things." Boots and Getis (1988) explain that when attraction among individual entities dominated a spatial process, the resulting distribution would be clustered. If repulsion is the main driving force of the process, individual entities force away one another, resulting in a scattered pattern. Chou and Soret (1993: p675) has summarised that "neighbourhood effects in the distribution of a phenomenon are defined as the aggregate influences of adjacent entities on the occurrence of each feature of the phenomenon". Recently, with advances in GIS, neighbourhood effects can be evaluated and incorporated into probability models explaining the spatial distribution of any phenomenon (Chou & Soret, 1993). In this study, the significance of neighbouring land uses will be evaluated in order to measure the partial contribution of the neighbouring land use variable in the model.

Road variable: The variable associated with accessibility in this study is the presence of roads. According to the nearest distance from each parcel to a road, this study breaks the road variable down into five general categories: (a) adjacent areas; (b) within 50m; (c) within 100m; (d) within 500m; (e) over 500m. The terms for a road in this study are classified into national road, local road, and the current road that the public transport system is using. Areas classified as 'adjacent' bordered on roads. If there are several main roads near a parcel, a road that is the nearest and the most easily accessible is chosen. This study expects to observe a positive relationship between the accessibility variables and the change of land use.

6.4 Spatial analysis

6.4.1 The relationship between government policy and land use change

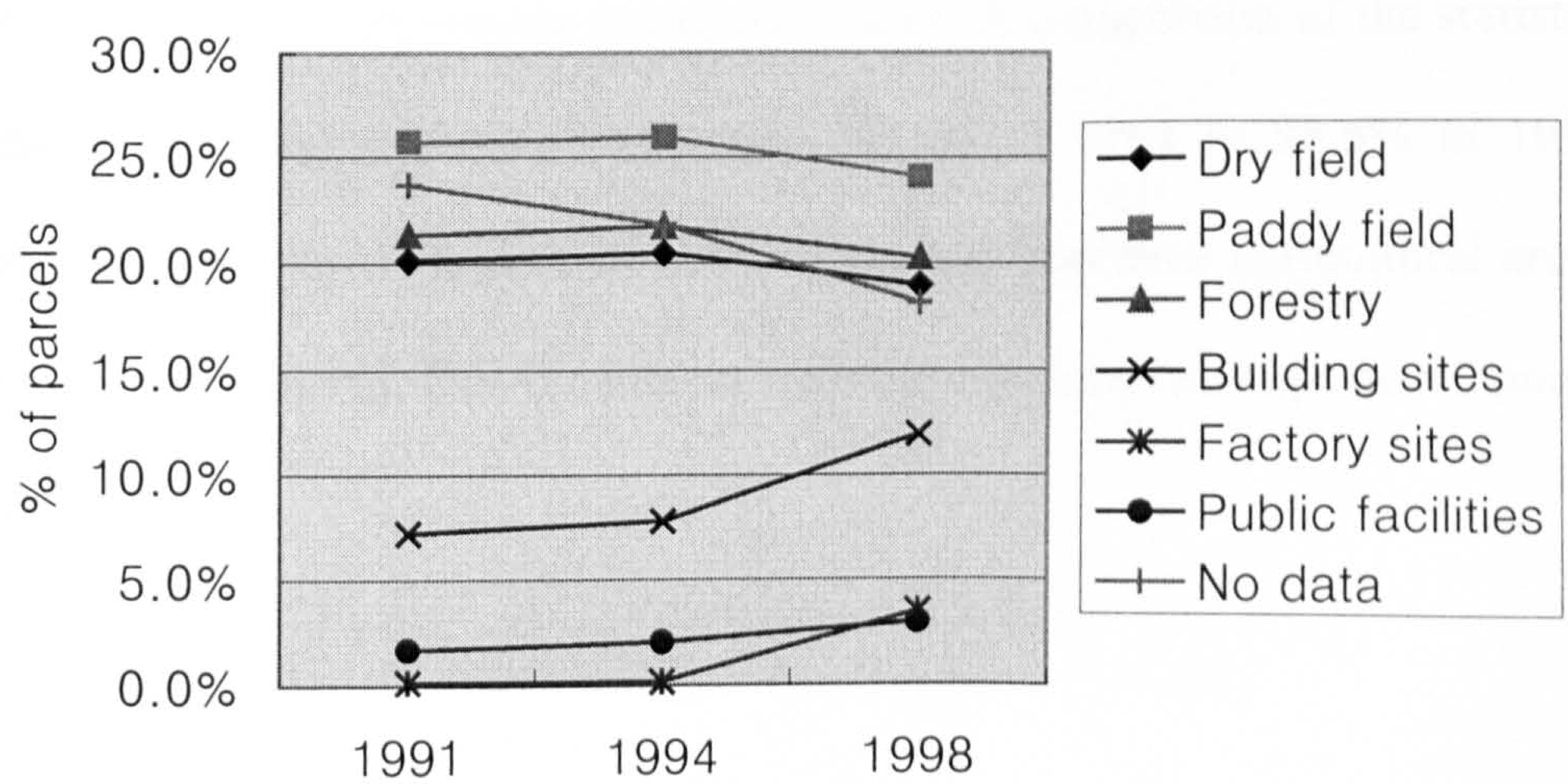
In the previous section the dependent variable and independent variables were defined. For spatial analysis, this research will examine the relationship between a dependent variable (changed/ not changed) and independent variables. The study has a dataset of 3994 parcels with land characteristics.

First of all, one of the purposes of this study is to examine the relationship between government policy change and land use change in the study area. As explained in chapter 3, government policy change has been a powerful contributor to rapid land use change at the national level. This section will investigate whether government policy change still affects land use in the case study area level, i.e. whether it is observable in a small area.

Land use change in this study focuses on the conversion of land from rural to urban use. As shown in Figure 6.1, it is clear that dry field, paddy field, and forestry decreased from 1994 to 1998, while the area of building sites and factory sites have jumped dramatically during the period.

Subsequent analysis using a statistical approach generated Table 6.6 and Table 6.7 which display the land use change of the study area for the two years. Table 6.6 and Table 6.7 present a frequency distribution of land use changes in the study area. The following command, a cross-tabulation, sees how land use of 1991 or 1994 transfer the proportion of 1994 or 1998.

Figure 6.1 Land use change trends



The cross-tabulation is designed to show the proportion of each land use change among parcels with land use between two periods, and does not include any statistical tests because none are appropriate for the way that the cross-tabulation has been requested. Two periods were analysed using statistical analysis that cross-tabulated the land use at each parcel location in 1991 or 1994 with the land use at the same parcel location in 1994 or 1998. Most parcels in the study area in 1991 were still in the same land use in 1994. After deregulation in 1994, the land use of many parcels in the study area had changed considerably by 1998, as shown in Table 6.7.

Of the dry field uses (818 parcels) that did change land use between 1994 and 1998, 50 parcels (6.1%) were converted into building sites, 49 parcels (6.0%) into factory uses. 55 parcels (5.3%) of the paddy field uses was converted to building sites and 58 parcels (5.6%) to factory uses. This means the erosion of agricultural areas is increasing in the study area. A comparison of the statistics revealed a decline in forest lands from 98.6% in 1994 to 88.5% in 1998. Forest lands were converted into urban use much less than agricultural areas. As might be expected, this is because forest areas required high development costs.

Table 6.6 Land Use Changes from 1991 to 1994

		1994							
		Dry	Paddy	Forest	Building	Factory	Public	No data	TOTAL
1991	Dry	**787**	7	0	6	1	1	3	805
	(%)	**97.8%**	0.9%	0.0%	0.7%	0.1%	0.6%	0.4%	100.0%
	Paddy	5	**1006**	2	7	0	3	5	1028
	(%)	0.5%	**97.9%**	0.2%	0.7%	0.0%	0.3%	0.5%	100.0%
	Forest	1	0	**841**	9	0	1	1	853
	(%)	0.1%	0.0%	**98.6%**	1.1%	0.0%	0.1%	0.1%	100.0%
	Building	1	6	1	**280**	0	0	0	288
	(%)	0.3%	2.1%	0.3%	**97.2%**	0.0%	0.0%	0.0%	100.0%
	Factory	0	0	0	0	**6**	0	0	6
	(%)	0.0%	0.0%	0.0%	0.0%	**100%**	0.0%	0.0%	100.0%
	Public	2	0	1	0	0	**59**	5	67
	(%)	3.0%	0.0%	1.5%	0.0%	0.0%	**88.1%**	7.5%	100.0%
	No data	22	17	24	9	0	18	**857**	947
	(%)	2.3%	1.8%	2.5%	1.0%	0.0%	1.9%	**90.5%**	100.0%
	Total	818	1036	869	311	7	82	871	3994
		100.0%	100.0%	100.0%	100%	100.0%	100.0%	100.0%	100.0%

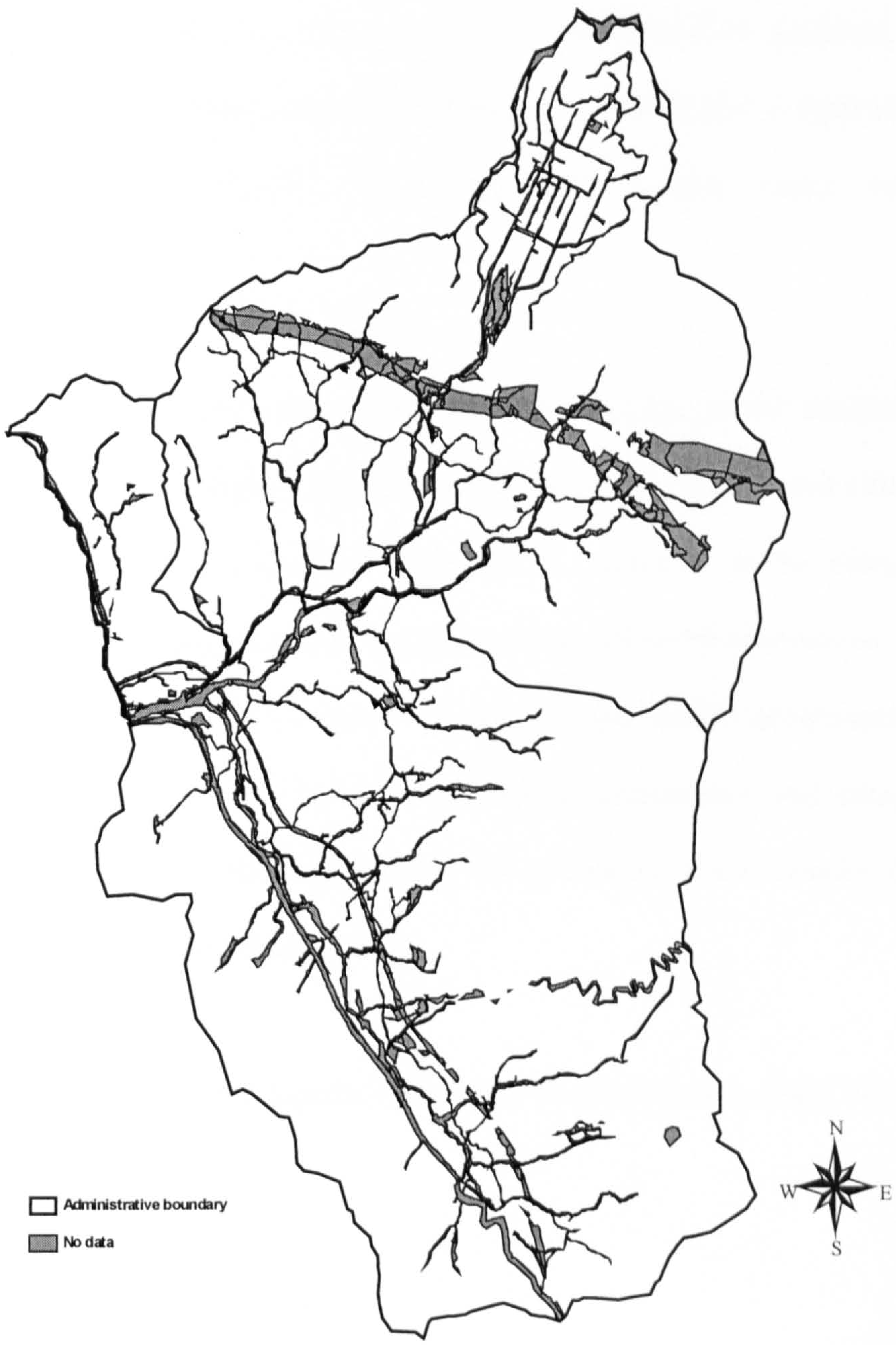
Table 6.7 Land Use Changes from 1994 to 1998

		1998							
		Dry	Paddy	Forest	Building	Factory	Public	No data	TOTAL
1994	Dry	**687**	1	6	50	49	13	12	818
	(%)	**84.0%**	0.1%	0.7%	6.1%	6.0%	1.6%	1.5%	100.0%
	Paddy	4	**884**	3	55	58	16	16	1036
	(%)	0.4%	**85.3%**	0.3%	5.3%	5.6%	1.5%	1.5%	100.0%
	Forest	0	1	**769**	66	16	2	15	869
	(%)	0.0%	0.1%	**88.5%**	7.6%	1.8%	0.2%	1.7%	100.0%
	Building	1	3	0	**301**	6	0	0	311
	(%)	0.3%	1.0%	0.0%	**96.8%**	1.9%	0.0%	0.0%	100.0%
	Factory	0	0	0	0	**7**	0	0	7
	(%)	0.0%	0.0%	0.0%	0.0%	**100%**	0.0%	0.0%	100.0%
	Public	0	2	0	2	1	**75**	2	82
	(%)	0.0%	2.4%	0.0%	2.4%	1.2%	**91.5%**	2.4%	100.0%
	No data	67	70	33	3	3	14	**681**	871
		7.7%	8.0%	3.8%	0.3%	0.3%	1.6%	**78.2%**	100.0%
	Total	759	961	811	477	140	120	726	3994
		100.0%	100.0%	100.0%	100%	100.0%	100.0%	100.0%	100.0%

In conclusion, the study area is changing rapidly from rural use to urban use during two periods as shown in Table 6.7, similarly to the changing trends in Kyunggi province as have already been mentioned in Chapter 3. This suggests strongly that government policy change has an effect directly in the study area.

The list of values in Table 6.6 and Table 6.7 has so many '0' values that were left blank or input as 0 at the data entry stage. The problem is that, in the cases shown as 0, what was going on could not be traced. For this reason, they should be counted as missing values. In addition, most of the data collected from the Land Utilisation Character Surveys did not survey the national and public lands particularly such as roads, dry river-beds, etc. because the administrative purpose of the surveys is to impose national and local taxes. Therefore, such data was entered as 0. This study will need to be convinced that with so many 0 parcels, any analysis that this study carries out is not likely to be affected. Figure 6.2 shows the distribution of parcels with 0 Values. As shown in Figure 6.2, most of the 0 data are roads, reservoirs, schools, dry river-beds, etc. This study thus integrated 0 data to public facilities in order to make analysis as simple as possible. Furthermore, this did not affect the results of the analysis because this study mainly focuses on the change from rural use (a dry field, a paddy field, and a forestry) to urban use (a building site and a factory site).

Figure 6.2 The distribution of parcels with no data



6.4.2 The logistic regression model

To evaluate the relationship between independent variables and dependent variable, more generally, we need to consider a multivariable problem. In the analysis of such a problem, some kind of mathematical model is typically used to deal with the complex interrelationships among many variables (Kleinbaum, 1992)

The various techniques such as discriminant analysis, probit analysis, log-linear regression, and logistic regression are applicable in different situations: for example log-linear regression requires all variables to be categorical, whilst discriminant analysis strictly requires them all to be continuous. In this study, logistic regression is easier to use in the SPSS programme than discriminant analysis when it has a mixture of continuous and categorical variables, because it includes procedures for generating the necessary dummy variables automatically (Hinde, 2001).

The specific form of the logistic regression model that this study will use is as follows:

$$P_i = \frac{e^z}{1 + e^z}$$

or equivalently

$$P_i = \frac{1}{1+e^{-z}}$$

where P_i is the probability for land use change to occur in the i th parcel;
e is the base of the natural logarithms, approximately 2.718;
z is the linear combination;

$$Z = Bo + B_1X_1 + B_2X_2 + \ldots\ldots. + B_pX_p$$

where X_i is the independent variable associated with each parcel;
Bo is the coefficient on the constant term;
B_i is the estimated coefficients associated with each parcel;

The equation notices that when Z is $-\infty$, the logistic function P_i equals 0 [2] and when Z is $+\infty$, the P_i equals 1[3]. Thus, the range of P_i is between 0 and 1, regardless of the value of Z (Kleinbaum, 1992).

---

[2]

$$P(-\infty) = \frac{1}{1+e^{-(-\infty)}} = \frac{1}{1+e^{\infty}} = 0$$

[3]

1

The fact that the logistic function P_i ranges between 0 and 1 is the primary reason the logistic model is so popular. The model is designed to describe a probability, which is always some number between 0 and 1(Kleinbaum, 1992). In this study, such a probability gives the potentiality of land use change in the urban fringe.

6.4.3 The land use change model

Identifying the variables useful in making the prediction, as well as predicting whether land use change will or will not occur, is very important in this study. However, it is difficult to separate modelling stages because they are often interdependent rather than consecutive. After all, it is impossible to explain the distribution of any phenomenon unless one can describe the distribution, and it is impossible to predict a spatial pattern unless one can explain the effects of significant factors. Therefore, this study will explain the overall process of spatial analysis organically.

$$P(+\infty) = \frac{\quad}{1 + e^{-(+\infty)}}$$

$$= \frac{1}{1 + e^{-\infty}}$$

$$= 1$$

In this study, a two-scenario modelling approach was adopted to separate the neighbouring land use variable from other independent variables in order to examine the role of neighbouring land uses in the pattern of land use change. In scenario I, this study examined each variable's significance level except the neighbouring land use variable. The model is called a basic model in this study. Only the variables that are statistically significant were employed. In scenario II, such significant variables were incorporated with the neighbouring land use variable. This study called it the modified model.

As scenario I, Figure 6.3 shows coefficients and related statistics from the logistic regression model that predicts land use change from the variables and a constant. In the logistic regression, the criterion for a variable to enter the model is each variable's significance level (under column heading *sig.*). Other variables in this analysis such as perimeter, land category 94, land category 98, state of land use 94, state of land use 98, zone 94, land price 98 and height were insignificant. Such variables were excluded in a scenario I. The determinants of land use change in this model thus was reduced to six variables, that is, area of parcel (Area), zone in 1998 (Zone98), land price in 1994 (LndPrc94), forestry (Forst), direction (Drec), and accessibility to main road (Road).

Figure 6.3 Variables in the Equation based on basic model

		B	S.E.	Wald	df	Sig.	R	Exp(B)	95.0% C.I.for EXP(B)	
									Lower	Upper
Step 1	AREA	.000	.000	7.079	1	.008	.0455	1.000	1.000	1.000
	ZONE98	.085	.011	64.906	1	.000	.1600	1.089	1.066	1.112
	FORST	-2.163	.435	24.730	1	.000	.0782	.115	.049	.270
	DREC	.263	.038	48.948	1	.000	.0962	1.301	1.208	1.400
	ROAD	-.131	.022	36.317	1	.000	.1383	.877	.841	.916
	LNDPRC94	.000	.000	17.014	1	.000	.1182	1.000	1.000	1.000
	Constant	-2.671	.159	282.042	1	.000		.069		

a Variable(s) entered on step 1: AREA, ZONE98, FORST, DREC, ROAD, LNDPRC94.

Given these coefficients, the logistic regression equation for the probability of land use change in the basic model can be written as:

$$P \text{ (land use change probability)} = \frac{1}{1+e^{-z}}$$

$$Z = Bo + B_1AREA_i + B_2ZONE98_i + B_3LNDPRC94_i + B_4FORST_i + B_5DREC_i + B_6ROAD_i + e$$

where $AREA_i$ is the area of the i th parcel;
$ZONE98_i$ is one out of the zoning classification of i th parcel in 1998;
$LNDPRC94_i$ is the land price of i th parcel in 1994;
$FORST_i$ is one out of the forest classification of i th parcel;
$DREC_i$ is one out of the direction classification of i th parcel;
$ROAD_i$ represents the distance between i th parcel and the nearest road;
e is a random error term;

To incorporate the neighbouring land use variable in the land use change model, this study defined a term NBRLU as the ratio of the number of urban use adjacent parcels to the total number of adjacent parcels. The estimated coefficients and statistics of the modified model are listed in Figure 6.4. Compared to that of the basic model in Figure 6.3, the modified model improved considerably due to the inclusion of the neighbouring land use variable as shown in Figure 6.4. This means that the neighbouring land use variable can play an important role in determining the pattern of land use change.

Figure 6.4 Variables in the Equation based on modified model

		B	S.E.	Wald	df	Sig.	R	Exp(B)	95.0% C.I.for EXP(B)	
									Lower	Upper
Step 1	AREA	.000	.000	6.277	1	.012	.0417	1.000	1.000	1.000
	ZONE98	.082	.011	58.861	1	.000	.1522	1.085	1.063	1.108
	FORST	-2.153	.434	24.650	1	.000	.0729	.116	.050	.272
	DREC	.260	.038	47.608	1	.000	.0960	1.297	1.205	1.396
	ROAD	-.120	.022	29.926	1	.000	.1363	.887	.850	.926
	LNDPRC94	.000	.000	15.067	1	.000	.1066	1.000	1.000	1.000
	NBRLU	.768	.238	10.463	1	.001	.0587	2.156	1.354	3.435
	Constant	-2.992	.190	248.330	1	.000		.050		

a Variable(s) entered on step 1: AREA, ZONE98, FORST, DREC, ROAD, LNDPRC94, NBRLU.

Given these coefficients, the logistic regression equation for the probability of land use change in the modified model can be written as:

$$P \text{ (land use change probability)} = \frac{1}{1+e^{-z}}$$

$Z = Bo + B_1AREA_i + B_2ZONE98_i + B_3LNDPRC94_i + B_4FORST_i + B_5DREC_i + B_6ROAD_i + B_7NBRLU_i + e$

where $NBRLU_i$ represents the ratio of urban neighbouring land use;

The coefficient *B* must be interpreted with care. As shown in Figure 6.3 and Figure 6.4, two variables (Forest and Road) are negative. This may mean that the probability of land use change will occur with a small change when each variable changes by one unit. This can be affected by the labels of the two variables. In the case of the Forest variable, it is divided into preserved forest land, quasi-preserved forest land and the rest is input as 0 (see the Appendix 5). Most of the land used in the analysis were changed in parcels input as 0. Thus the sign of the coefficient may show negative. Even though the Forest variable changes one unit, it may be harder to predict if the event will occur or not. In the case of the Road variable, the label is divided into five general categories according to the nearest distance from each parcel to a road such as: (a) adjacent areas; (b) within 50m; (c) within 100m; (d) within 500m; (e) over 500m (see the Appendix 5). Showing a negative sign for the Road variable may thus be a correct result when taking into account a positive relationship between the accessibility and the change of land use. However, this explanation is not very intuitive. An interpretation of the coefficient which is usually more intuitive is the odds ratio. Exp *(B)* shown in the column in Figure 6.3 and Figure 6.4 is the effect of the independent variable on the odds ratio. In the following section, this will be explained in detail.

As shown in the column labelled Wald in Figure 6.3 and Figure 6.4, the Wald statistic is commonly used to test the null hypothesis that a coefficient is 0. When a variable has a single degree of freedom, the Wald statistic is just the square of the ratio of the coefficient to its standard error. For example, the coefficient for Zone98 is 0.082, its standard error is 0.011(under column heading S.E. in Figure 6.4). The Wald statistic is $(0.082/0.011)^2$, or about 58.861. Unfortunately, there is a flaw in the Wald statistic so that very large coefficients may lead to large standard errors and small Wald chi-square values. Whenever one has a large coefficient, one should not rely on the Wald statistic for hypothesis testing. Instead, one should build a model with and without that variable and base its hypothesis test on the change in the log-likelihood (Hosmer and Lemeshow, 1989).

The contribution of individual variables in logistic regression is difficult to determine because the contribution of each variable depends on the other variables in the model. There is a problem, in particular, when independent variables are highly correlated. To estimate the partial correlation between the dependent variable and each of the independent variables, the R statistic is used, shown in Figure 6.3 and Figure 6.4. The R statistic can range in value from −1 to +1. If R is a positive value, the variable increases in value and the likelihood of the event occurring increases as well. If R is negative, the opposite is true. That is, the value of R indicates that the variable has a partial contribution to the model (Kleinbaum, 1992).

In this study, among the values of R, Zone98 variable has the largest partial contribution to the model, shown in Figure 6.3 and Figure 6.4. This means that in the study area, zoning has a much higher influence on land use change in the urban fringe than other independent variables. This may be associated with the deregulation in 1994 because rapid land use change in the Quasi-Agricultural and Forest Area occurred after the deregulation.

As mentioned in the above, the logistic model can be rewritten in terms of the odds of an event occurring.

The logistic model can be rewritten in terms of the odds of an event occurring. The odds of an event occurring are defined as the ratio of the probability (p) that an event occurs to the probability (1-p) that it does not: odds[4]=p/(1-p).

4

$$\text{Odds} = \frac{\frac{1}{1+e^{-z}}}{1-\frac{1}{1+e^{-z}}} = e^{z}$$

$$= e^{Bo + B1X1 + B2X2 + \ldots\ldots + BpXp}$$

$$= e^{Bo}\, e^{B1X1}\, e^{B2X2 + \ldots\ldots +}\, e^{BpXp}$$

'Then *e* raised to the power B_i is the factor by which the odds change when the *i*th independent variable increases by one unit. If B_i is positive, the factor will be greater than 1, which means that the odds are increased; if B_i is negative, the factor will be less than 1, which means that the odds are decreased. When B_i is 0, the factor equals 1, which leaves the odds unchanged' (SPSS, 1997: p43). For example, when NBRLU changes one unit, the odds are increased by a factor of 2.156, as is shown in the *Exp(B)*column in Figure 6.4. This implies that the more urban land use parcels there are at the neighbouring location, the higher the transition probability of land use in the study area. In this way the odds ratio is a measure of the strength and direction of relationship between two variables, here between land use change and urban neighbouring land use.

Also, goodness-of-fit tests are available as indicators of success as is the Wald statistic and other tests of the model's significance. Figure 6.5 and Figure 6.6 show the goodness-of-fit statistics for the model with all of the independent variables. For the current model, the value of *–2LL* is 2253.931, which is smaller than the *–2LL* for the model containing only a constant (2455.968), a reduction of 202.036 on 6 degrees of freedom in Figure 6.5. 'The *Cox & Snell* R^2 *and the Nagelkerke* R^2 are statistics that attempt to quantify the proportion of explained "variation" in the logistic regression model' (SPSS, 1997: p47).

There are three additional chi-square entries which are labelled *Model, Block*[5], and *Step*[6] in Figure 6.5 and Figure 6.6. 'The model chi-square is the difference between *–2LL* for the model with only a constant and *–2LL* for the current model. Thus, the model chi-square tests the null hypothesis that the coefficients for all of the terms in the current model, except the constant, are 0' (SPSS, 1997: p48). In this example, *-2LL* for the model containing only the constant is 2455.968, while for the complete model, it is 2253.931. The model chi-square, 202.036, is the difference between these two values (SPSS, 1997).

For seeing whether the independent variables as a whole significantly affect the dependent variable, this is addressed by the Model Chi-square statistic. As shown in Figure 6.5 and Figure 6.6, two models in this analysis were analysed to be statistically significant. The comparison between Model Chi-square in the basic mode (Figure 6.5) and that of the modified model (Figure 6.6) indicates that the modified model included the neighbouring land use variable increased from 202.036 to 212.444. This means the modified model provides

[5] 'The entry labelled *Block* is the change in *–2LL* between successive entry blocks during model building. In this example, we entered our variables in a single block, so the block chi-square is the same as the model chi-square. If we enter variables in more than one block, these chi-square will be different' (SPSS, 1997).

[6] 'The entry labelled *Step* is the change in *–2LL* between successive steps of building a model. It tests the null hypothesis that the coefficients for the variables added at the last step are 0. In this example, we considered only two models: the constant-only model and the model with a constant and six or seven independent variables. Thus, the model chi-square, the block chi-square, and the step chi-square values are all the same. If we sequentially consider more than just these two models, using either forward or backward variable selection, the block chi-square and step chi-square values will differ. The step chi-square test is comparable to the *F*-change test in stepwise multiple regression' (SPSS, 1997).

much higher explanation and prediction on land use change, compared to that of the basic model.

Figure 6.5 The basic model of land use change

Iteration History[a,b,c]

Iteration		-2 Log likelihood	Coefficients Constant
Step 0	1	2628.095	-1.631
	2	2462.185	-2.154
	3	2455.984	-2.281
	4	2455.968	-2.288

a. Constant is included in the model.
b. Initial -2 Log Likelihood: 2455.968
c. Estimation terminated at iteration number 4 becau: log-likelihood decreased by less than .010 percen

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	202.036	6	.000
	Block	202.036	6	.000
	Model	202.036	6	.000

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	2253.931	.049	.107

Figure 6.6 The modified model of land use change

Iteration History[a,b,c]

Iteration		-2 Log likelihood	Coefficients Constant
Step 0	1	2628.095	-1.631
	2	2462.185	-2.154
	3	2455.984	-2.281
	4	2455.968	-2 288

a. Constant is included in the model.
b. Initial -2 Log Likelihood: 2455.968
c. Estimation terminated at iteration number 4 becau: log-likelihood decreased by less than .010 percen

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	212.444	7	.000
	Block	212.444	7	.000
	Model	212.444	7	.000

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	2243.523	.052	.113

The probability of land use change in each parcel will always be between 0 and 1, regardless of the value of Z. In general, if the estimated probability of the event is less than 0.5, the event will not occur. If the probability is greater than 0.5, the event will occur (Hosmer and Lemeshow, 1989). In order to map land use change probability, it is necessary to construct a probability model of land use change based on variables that are significant (Chou, 1993).

Therefore, this study examined the transition probability of land use by the estimated coefficients from the logistic regression model. In this modified model, the independent variables that are statistically significant include the area of a parcel (Area), Zoning in 1998 (Zone98), land price in 1994 (Lndprc94), urban neighbouring land use (Nbrlu), direction (Drec), Forest lands (Forst), and accessibility to a main road (Road). The identification of such independent variables will be valuable in guiding the implementation of land use management.

6.5 Conclusion

In addition to the database built in chapter 5, this chapter added two variables: land use change as a dependent variable; and urban neighbouring land use as the ratio of the number of urban use adjacent parcels to the total number of adjacent parcels.

Then the dependent variable and independent variables were identified. The independent variables used in this chapter were limited to some variables such as Area, perimeter, state of land use, land category, height, zoning, neighbouring land use, direction, accessibility to main road, and land price, etc.

In the spatial analysis section, this chapter established four results associated with the objectives of this study. Firstly, this chapter examined the relationship between the shift of government land policy and the conversion of land use. The result was that government policy change directly affected land use change in the study area. After deregulation in 1994, the land use of many parcels was changed considerable from rural use to urban use. There was quite a substantial increase in building sites and factory sites at the expense of agricultural areas and forest areas.

Secondly, after this chapter extracted the transition probability equation using the logistic regression model, this chapter found the determinants of land use change in the study area based on the basic model which excluded the neighbouring land use variable. As a result, there were chosen five variables which was statistically significant such as Area, Land price in 1994, Zoning in 1998, Direction, Forest lands, and Accessibility to main road.

Thirdly, this chapter examined the role of neighbouring land use in the model. Such significant variables based on the basic model were incorporated with the urban neighbouring land use variable. The result was that the modified model improved considerably due to the inclusion of the neighbouring land use variable. This chapter shows that the neighbouring land use variable plays an important role in the pattern of land use change.

Finally, this chapter examined the transition probability of land use by the estimated coefficients from the logistic regression model. The result will be displayed using GIS in a transition probability map in next chapter.

CHAPTER SEVEN

RESULTS OF ANALYSIS

7.1 Introduction

This chapter, first of all, focuses on visualising the results analysed in the previous chapter, including the pattern of land use change from 1994 to 1998, the distribution of parcels with more than 50% of their neighbours in urban use, and the transition probability of land use. Then this study represents the distribution of a mixture of land uses, the pattern of residential building sites, and the pattern of factory sites. This chapter will then posit probable reasons and development tendencies with respect to the patterns that have happened in the study area. Then this chapter suggests policy messages result by result so that policy makers and planners can refer to them when evaluating and deciding on the land use management strategy.

Also, this study demonstrates the usefulness of the application of GIS and spatial analysis in relation to research on the land use change. The discussion section will deal with the strengths and weaknesses of the application of GIS and spatial analysis in the study area.

7.2 Results of analysis

The results of analysis were again converted to GIS format files from SPSS files through several steps. The findings thus can be displayed in a GIS environment. These results have six important implications for land use management in the urban fringe.

First, Figure 7.1 indicate spatial locations where land uses have changed from rural use to urban use from three time periods. When comparing the locations of the original land use in 1991 and the same locations in 1994 parcel by parcel using GIS, Figure 7.1 shows that there was change in only a few parcels. Figure 7.1 also represents quite a substantial increase in building sites and factory sites in the agricultural areas and forest areas between 1994 and 1998.

It can be inferred from the results of analysis that the government's land policy change directly affects land use change in the study area. Before deregulation in 1994, most parcels in the study area were still in the same land use (see Table 6.6). After deregulation in 1994, the significant changes on the study area have occurred. Many parcels were changed from rural use to urban use. Agricultural areas particularly decreased dramatically and most of the changes involved conversion to building sites and factory sites in 1998.

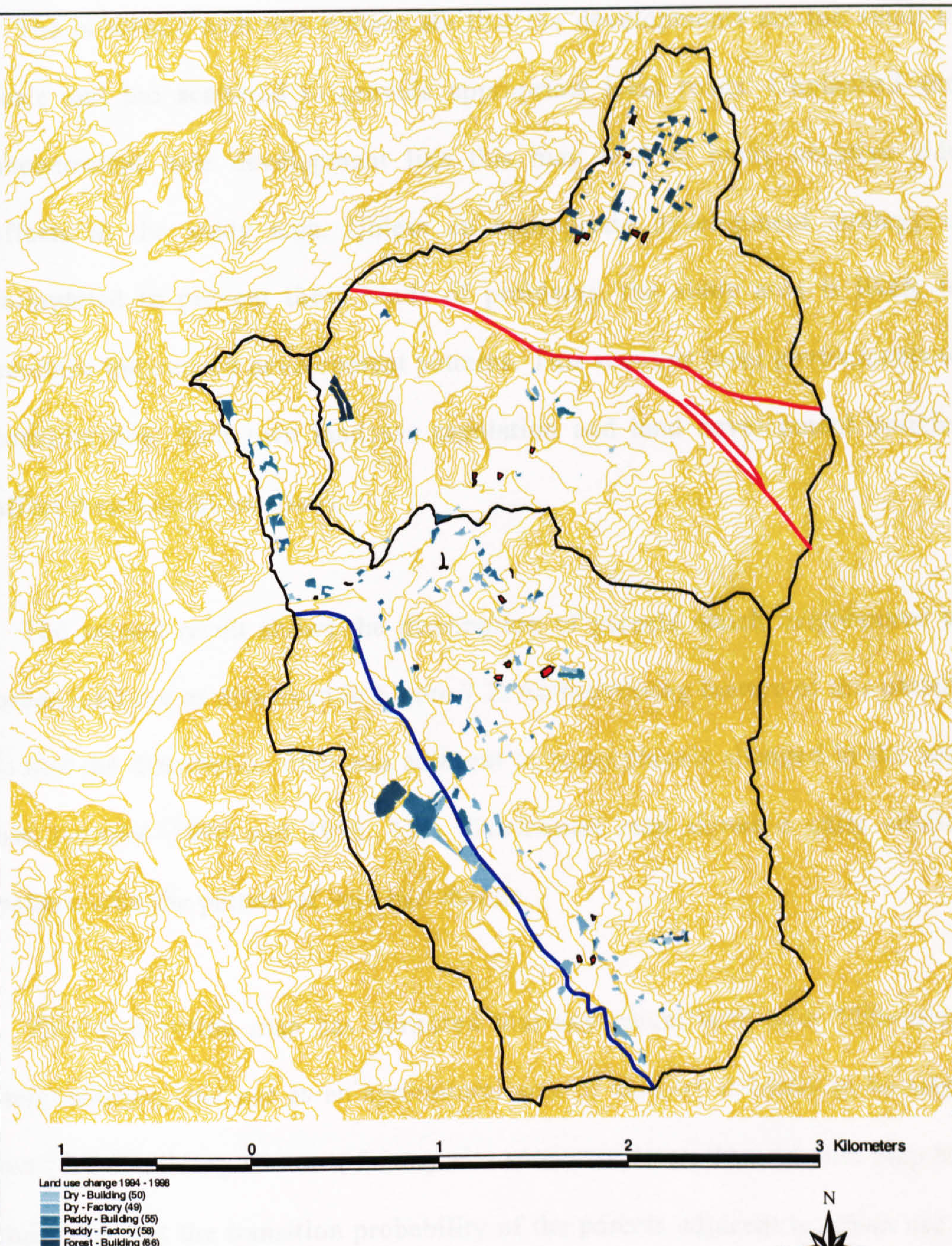


Figure 7.1 The distribution of land use change 1991 - 1998

The problems with this pattern are that the developments are too small in scale and too scattered to provide appropriate local roads. Unplanned and uncontrolled land development like this may lead to many negative side effects in the study area. Unless an appropriate development strategy is formulated to prevent these kinds of problems, the study area is likely to continue the current development patterns. This requires local governments to consider how their own land use regulation and land development policies affect their spatial locations.

The second result shows the distribution of parcels which neighboured to urban land use as displayed in Figure 7.2. An interesting feature of this pattern is that the distribution map was adjacent to many parcels changed in the land use between 1994 and 1998. This distribution map shows a quite similar pattern with the pattern of land use change.

This distribution map has indicated that any parcel with over 50% urban neighbouring land use as an agricultural area or forestry is likely to be taken over by a building site or a factory site sooner or later. That is, this map has indicated that the transition probability of the parcels adjacent to urban use is higher than that of the parcels adjacent to rural use.

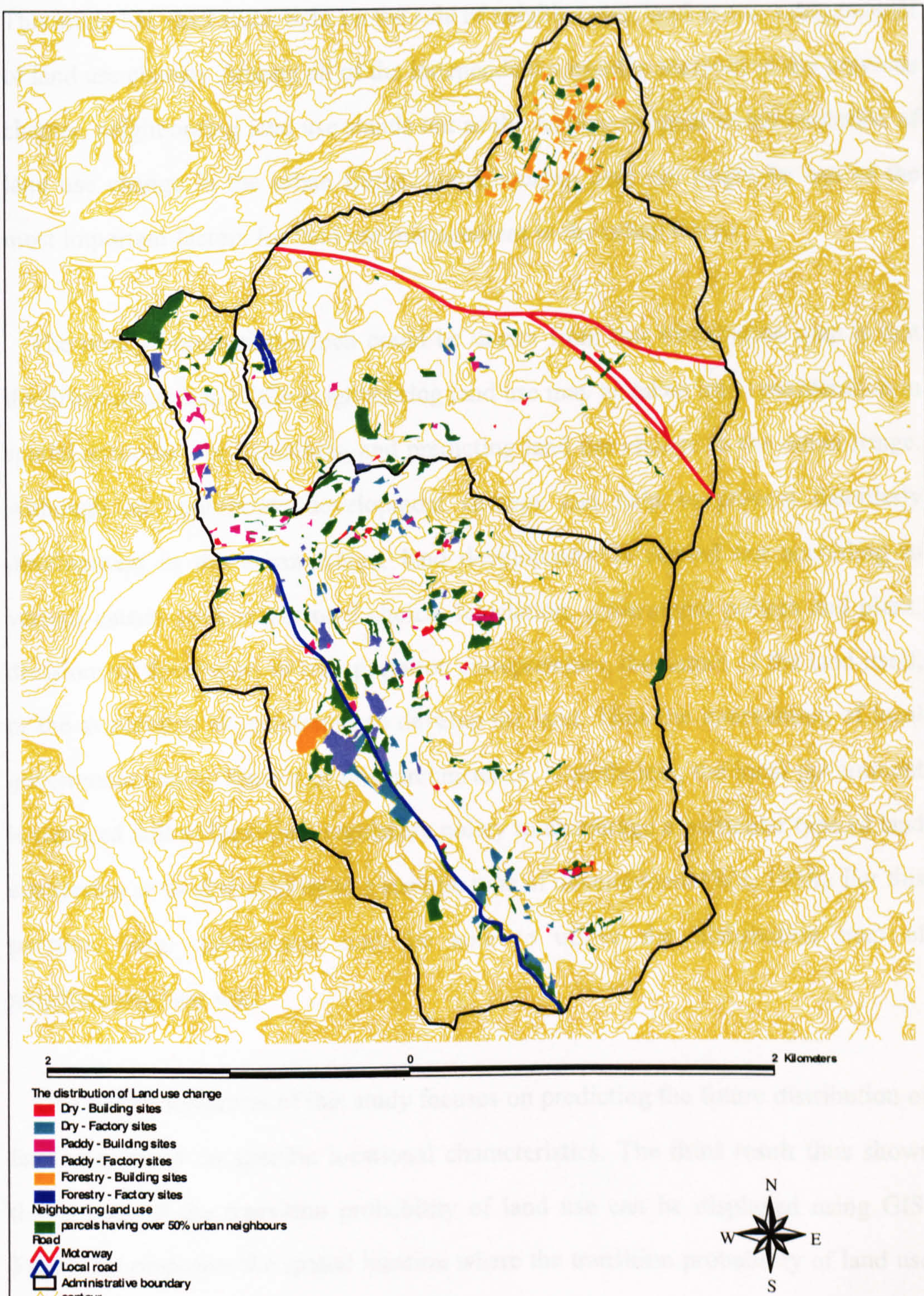


Figure 7.2 The distribution of parcels with more than 50% of their neighbours in urban use 1998

This study has shed some light on the role of neighbouring land use as a determinant of land use change. Among all of the independent variables analysed in the previous chapter, neighbouring land use stands out as the leading element in the evolution of land use change in the urban fringe. Neighbouring land use might be one of the most important factors for land use management in the urban fringe.

The policy implication which could be drawn from this distribution map is that the distribution map of the neighbouring land use may be taken into consideration in spatial processes for explaining and predicting land use change in the urban fringe. Although an appropriate development strategy can help to prevent disorderly development in the urban fringe, land development is carried out according to various causes such as personal choice, legislation, government polices and plans, decisions of developers or transportation entrepreneurs, the nature of the land itself, or the availability of technology to develop the land. Thus the intervention of local government can be limited in this circumstance. Nonetheless, the local government is required still to formulate regulatory policy to encourage a particular type of land conversion or to give priority to a specific type of development (Wu, 1998). For this purpose, local government may be able to utilise the distribution map of neighbouring land use.

One of the objectives of this study focuses on predicting the future distribution of land use, based on specific locational characteristics. The third result thus shows that a map of the transition probability of land use can be displayed using GIS. Figure 7.3 pinpoints the spatial location where the transition probability of land use is distributed. The transition probability map was derived from the logistic

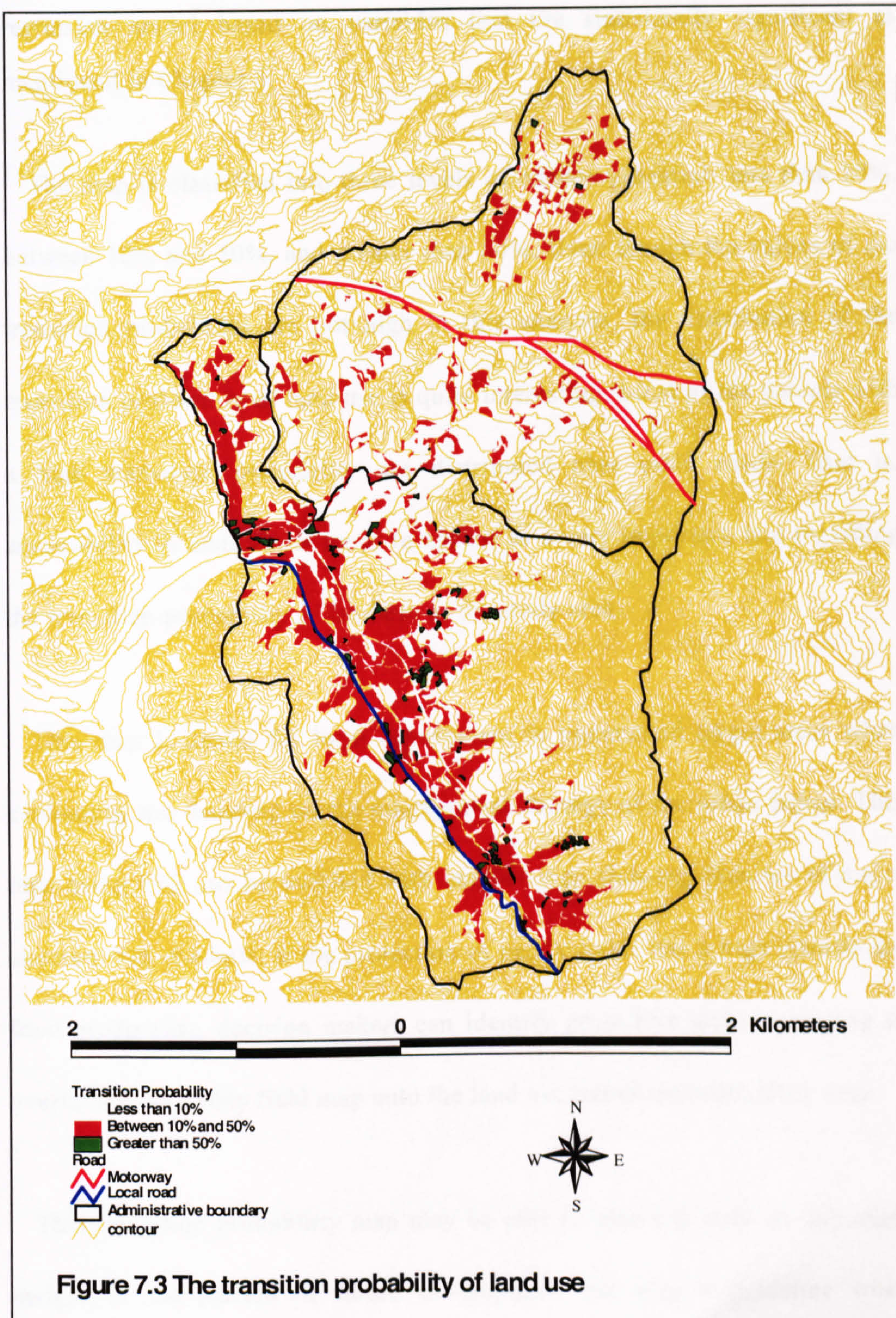


Figure 7.3 The transition probability of land use

regression model based on variables that are statistically significant as mentioned in Chapter 6.

The map is classified into three levels of change potential: less than 10%, between 10% and 50%, and greater than 50%. Even though the values of the transition probability are not high in this analysis, the distribution of the transition probability of land use is quite interesting. Most of the parcels with a high transition probability are distributed near main roads. That is, accessibility to main roads tends to appear as a very important fact regarding the transition probability of land use in the study area.

This map is useful for local government to understand target areas when evaluating and deciding on the management strategy of the urban fringe. This map using GIS can be overlaid with another map showing features of major concern. For example, if the protection of paddy fields has a high priority for food production, decision makers can identify protective areas according to overlaying the paddy field map onto the land use transition probability map.

This transition probability map may be able to give not only an important insight in the pattern of future development but also a guideline when evaluating and deciding on the management strategy of the urban fringe. Local government can know which areas are susceptible to land use change by utilising this transition probability map. This map thus can be used as a basic map when formulating an appropriate development strategy.

The fourth result of the analysis is that the study area represented a mixture of building sites and factory sites in the agricultural areas, which were readily interpretable from the output of results (Figure 7.4). House clusters in this area before deregulation represented the sites of the original rural residents. After deregulation in 1994, owing to rapid land use change, this area represented an amalgamation of house clusters, factory clusters, and agricultural clusters.

In other words, the land use mixture pattern in the study area means scattered development. This kind of development can be allowed with minimum requirement according to the development law as a result of the deregulation in 1994. The problem is that this conversion pattern does not provide any systematic connection with infrastructure. Therefore, many negative side effects might be produced in the study area such as increased congestion, more environmental pollution, insufficient public facilities and infrastructure, and too scattered development, etc.

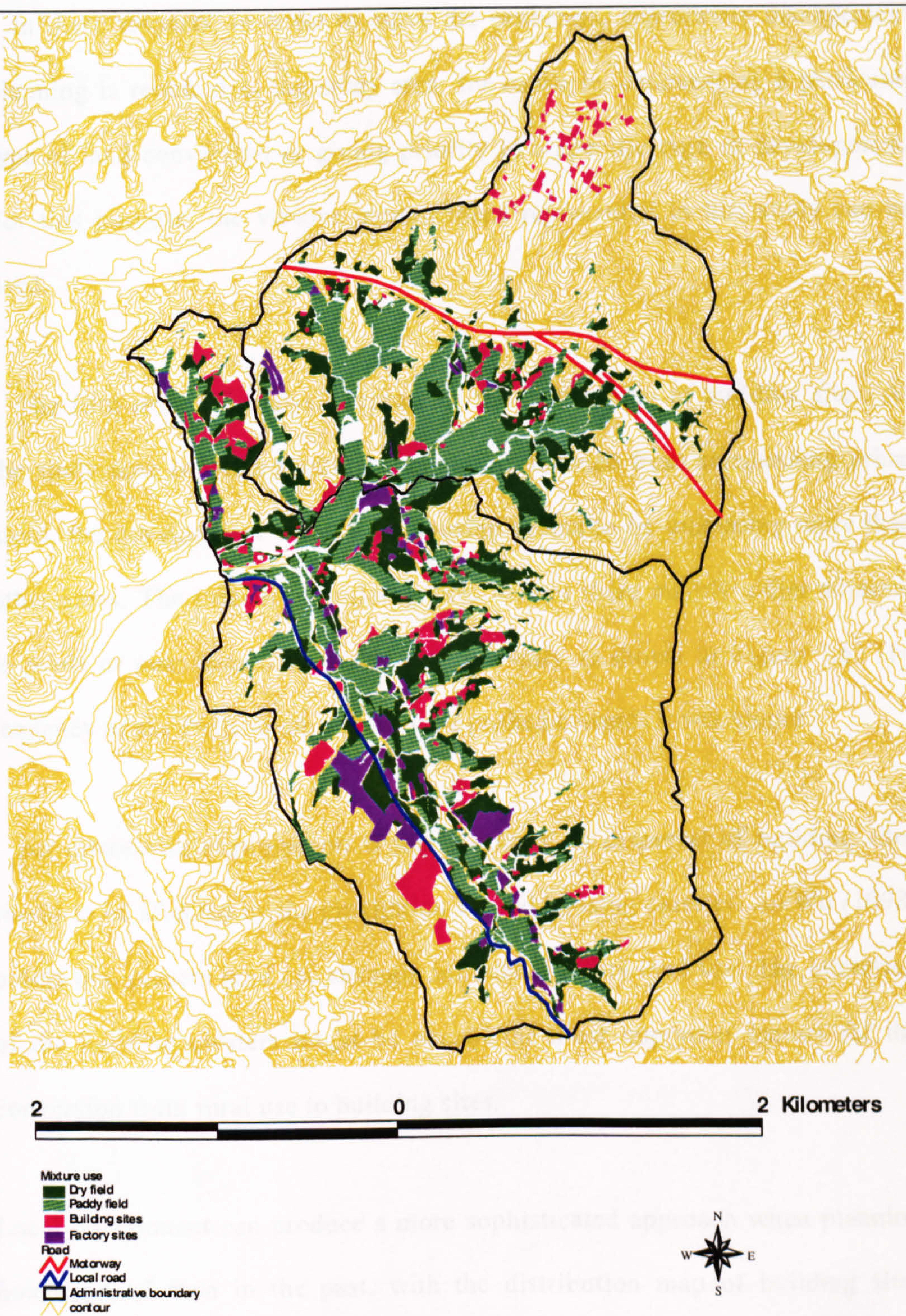


Figure 7.4 The distribution of the mixture of land use 1998

In these respects, in order to solve the problems, appropriate management planning is required in the study area, for example, encouraging a particular type of land conversion or giving priority to a specific type of development. For this purpose, the various pattern maps represented in this study can be used.

The fifth result of analysis represents the distribution of building sites. As the study area is located within commuting distance from surrounding urban areas, the development demand of housing seems to be increasing more than other areas. The pattern of building sites locates them mainly either adjacent to roads or near beautiful natural environments as shown in Figure 7.5. The tendency of the distribution seems to be pushed towards lower slopes.

An interesting phenomenon is that the trend of dispersal of building sites seems to be affected by the gravitation around housing clusters. As Wu (1998) points out, present land use strongly influences future land use. The attraction of the building clusters might be one of the most important factors for the conversion from rural use to building sites.

Local government can produce a more sophisticated approach when planning housing land than in the past, with the distribution map of building sites displayed from this study.

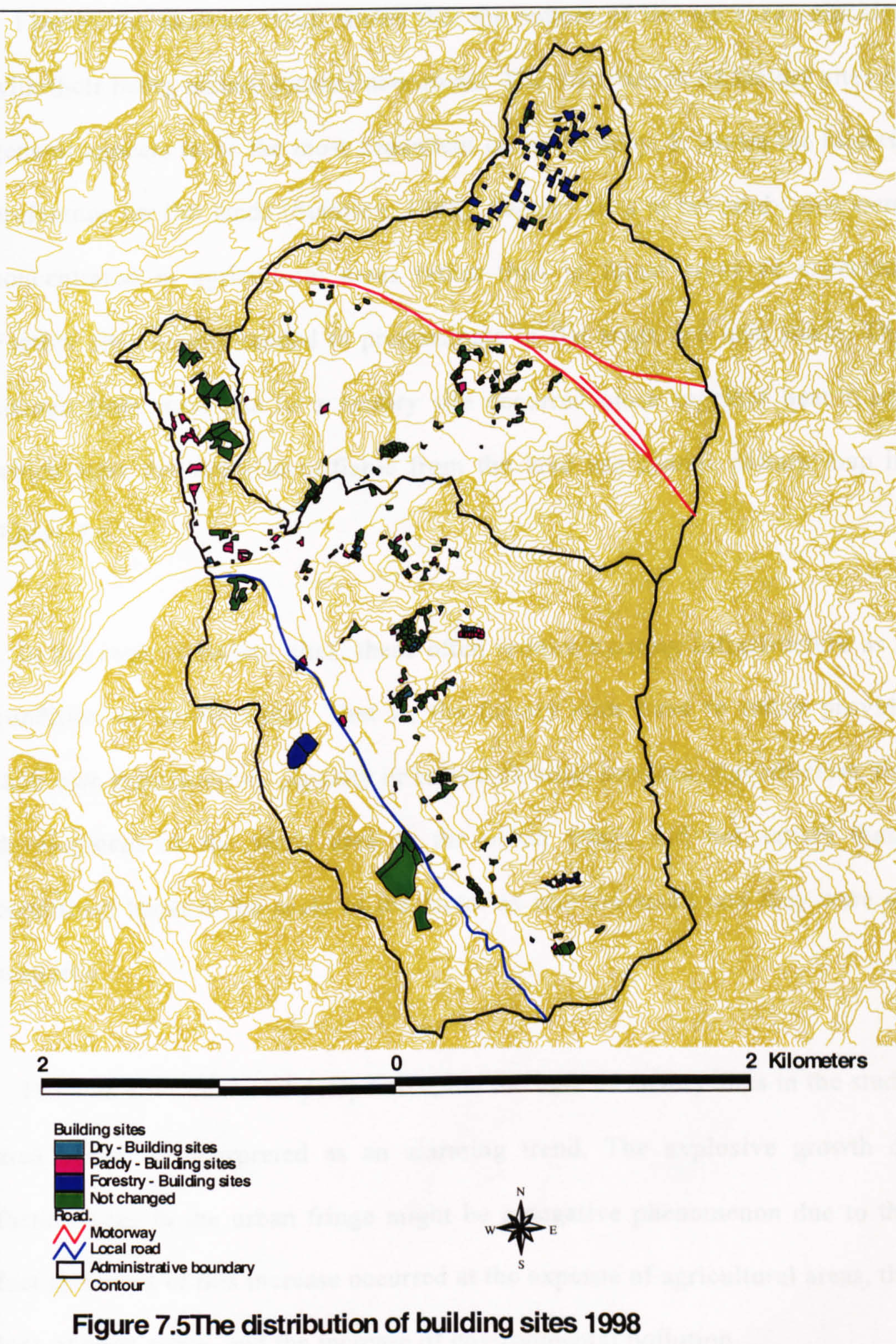


Figure 7.5The distribution of building sites 1998

Finally, the analysis result shows that the pattern of factory sites coincides with their being mainly located near roads. The distribution of factory sites in general appears to be the most dependent on topography. It shows the highest preference for flat lands (Stanilov, 1998). Factory sites in the study area were concentrated in agricultural areas rather than in forest areas as expected. Factory sites mainly tended to predominate in flat areas and near roads. The change from rural use to a factory site occurred close together near roads which were distinctly identifiable from the land use change pattern map in Figure 7.6.

In the case of factory sites, these often require existing infrastructure as a condition of development. That is, the factory sites have to either provide their own infrastructure capacity or extend existing services. Nevertheless, the development of the study area in the urban fringe did not satisfy these conditions because the scale of the factories was too small and they were so scattered.

From an environmental perspective, the increase of factory sites in the study area could be interpreted as an alarming trend. The explosive growth of factory sites in the urban fringe might be a negative phenomenon due to the fact that most of this increase occurred at the expense of agricultural areas, the loss of open space, and the increase of environmental pollution.

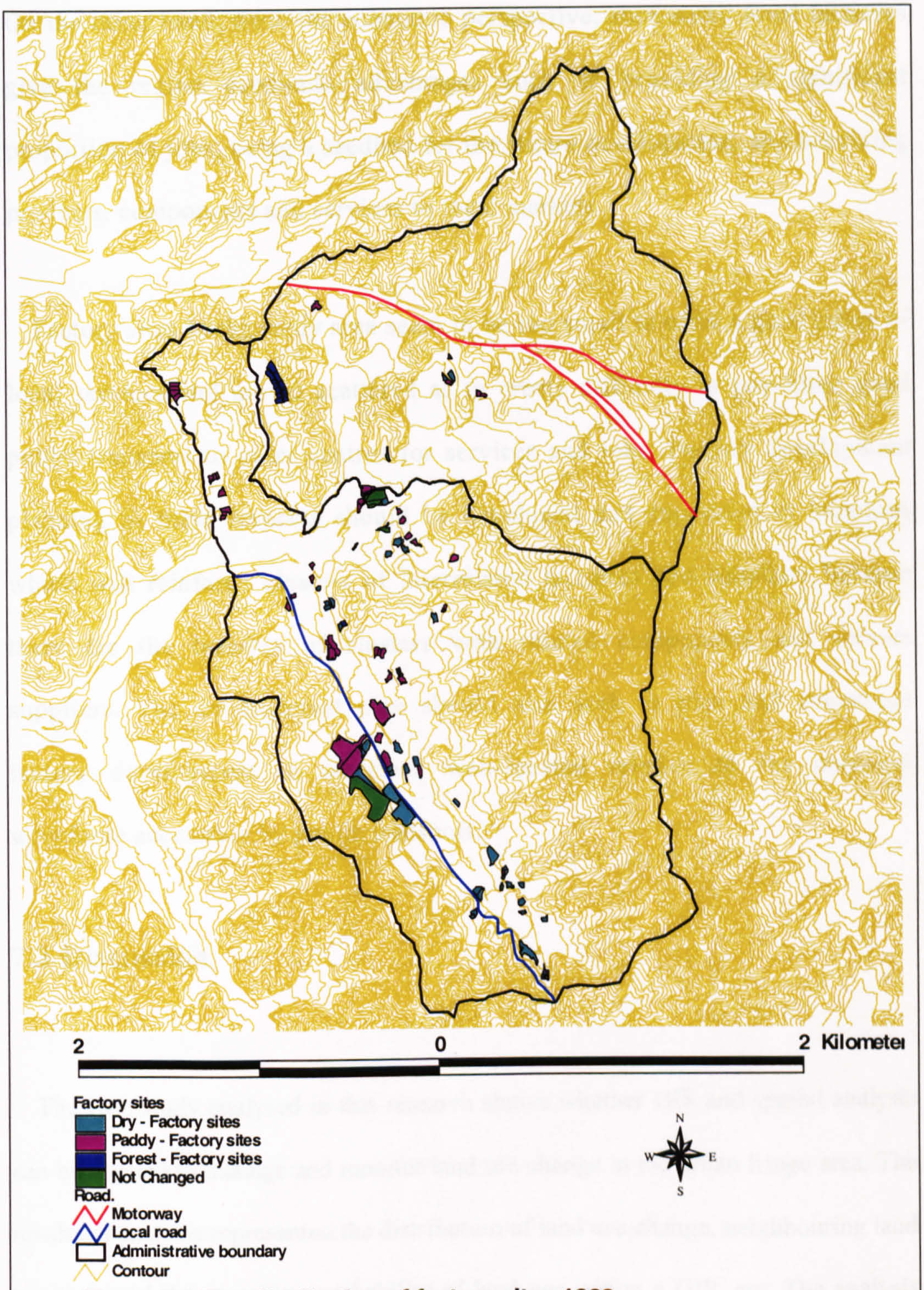


Figure 7.6 The distribution of factory sites 1998

On the other hand, from the economic perspective, such small local factories give the region economic advantages such as providing a significant proportion of jobs, being a seedbed for the future development, and providing products, components and services to local markets.

Factory sites in the study area seem to be too small to offer a good range of local services and are so scattered as to create difficulty in providing good public transport to other centres for services and jobs. Factory development planning in these respects should be developed and supported in locations which will reinforce clusters of interrelated factories and suppliers because there are the benefits of clusters with related components and service suppliers. The development plan should also seek to plan and encourage factory development in locations well-located relative to the potential workforce accessible by public transport.

7.3 Discussion

The case study analysed in this research shows whether GIS and spatial analysis can be applied to manage and monitor land use change in the urban fringe area. The results of analysis represented the distribution of land use change, neighbouring land use map and the transition probability of land use within a GIS, etc. The analysis using GIS and spatial analysis proved to be effective ones when providing the information base for modelling land use change in the urban fringe of the Seoul Metropolitan Region in Korea, to enable informed decisions to be made about land management policies in such areas as shown in the previous section.

The lesson which could be drawn from this study is that a GIS and spatial analysis capacity is quite useful for local government to understand where a specific change takes place, how the patterns of land use have changed, and what conditions lead to disorderly development. This study represented the results of analysis as a map, showed the significant patterns of land use change in the study area, displayed the relationship between neighbouring land use and the pattern of land use change, and suggested the transition probability of land use in the urban fringe in the future. Better understanding of the results may enhance the capability of local government to predict future land use change dynamics and devise more effective land use management strategies.

In the past, an analysis of land use change using GIS and spatial analysis was limited because of the difficulties of collecting data and the lack of computer capacity. This was the most time-consuming procedure. However, as this study has shown, nowadays, the analysis can be accomplished by statistical processing of the data and visualising of the results of analysis. The results of analysis using GIS and spatial analysis can therefore help to bring increasing rationality to the decision-making processes of local government. It is necessary for local governments to rethink their role in the supply of geographic information because GIS technology can provide many capabilities for managing and monitoring their areas (Masser, 1998).

The accuracy of the results of the analysis using GIS and spatial analysis depends on the reliability of the spatial databases. The findings of Masser and Campbell (1995) show that 'there is a considerable gap between expectations expressed in much of the literature and the realities of GIS implementation in a complex organisational environment' (Masser, 1998). The findings suggested that the question of database availability was not simply a matter of the information rich verses the information poor (Masser, 1998). The reliability of the spatial database depends on the data sources and the procedures of data extraction (Lo and Shipman, 1990). The level of adoption and utilisation of GIS in local government is closely linked to the availability of spatial database (Masser, Campbell and Craglia, 1996)

This study can be implemented due to the ease in obtaining spatial databases made out in a form which may be handled by the computerised data processing system related to cadastral maps and attribute data. As a cadastral map, this study employed a Land Price Status Map (LPSM) digitised by AutoCAD and managed by local government. It is a record of land characteristics and prices in each parcel such as parcel numbering, land category, determined land price per year. For use in a GIS environment, this map has to be transformed into GIS coverage and from digitiser coordinates into real world coordinates. As attribute data, this study employed the Land Utilisation Character Surveys utilised annually by local authority planning departments. They contain locational data as well as place attributes, information describing the characteristics of each parcel within the boundaries of the city. The results of the surveys are published as statistical standard codes on the land characteristics.

The spatial databases could not, however, trace the change related to subdivision or annexation of parcels over time. There is no standardised data model to analyse land use change. According to the availability of independent variables, the results of analysis can be examined in various ways. In particular, it is difficult to measure and to collect data at the site level based on a cadastral map. For example, socio-economic data are recorded at county or jurisdiction level rather than site level. Thus, there are several criteria related to spatial databases that must be addressed before the application of GIS and spatial analysis could be successfully used to examine land use change in the urban fringe. As pointed out by Michalak (1993), the criteria must be satisfied in analysing land use change such as high quality and accuracy of data (reliablility), frequency of monitoring which must mimic the pace of urban and regional change (periodicity), standardised data model (portability), and ease of use and retrieval (flexibility).

The responsibilities of management of the spatial databases are divided between central, regional, and local government in Korea. Central government maintains the spatial databases through government agencies such as the National Statistical Office (NSO), the National Tax Service (NTS), and the National Geographic Institute (NGI). The agencies provide a number of topographic datasets, cadastral information, and socio-economic data. Among the agencies, NGI has a key role in establishing and managing the spatial database. Regional and local government devolves power in matters of environmental monitoring and land use planning by legislation.

Today users demand much higher data quality and documentation. Faust et al (1991) point out that there is no doubt, considering the speed of the technological progress of computing and software development, that some of these problems will be overcome. However, as stated by Michalak (1993), significant research efforts must also be devoted to the automation and integration of the presently fragmented process of land use change detection, improvement of graphical user interfaces, simplification of the procedural tasks through expert systems and the artificial intelligence approach and, perhaps most importantly, improved error measurement and correction.

GIS and spatial analysis used in this study presents considerably different fields of expertise. Though the recent advances in GIS technology have made it possible to represent, collect, store, manage, analyse, and model spatial data, most contemporary GIS packages lack the necessary functionality for undertaking a full range of spatial measurements and spatial analysis. The lack of analytical capabilities has been a major obstacle to widespread applications of GIS as a research tool. GIS itself cannot analyse the relationship between a dependent variable and independent variables and estimate each variable's significant level to investigate the transition probability of land use. Spatial analysis itself cannot visualise the results of the pattern of land use change and the transition probability of land use. It is necessary that the linkage between GIS and methods for the statistical analysis of spatial data as a key issue in research agendas will be beneficial to both fields and lead to a better understanding of the spatial problems. In other words, GIS and spatial analysis can be made stronger by their linkages (Unwin, 1995)

This procedure of analysis offered here, although described in the context of the study area, may be applicable to a variety of modelling procedures. This study could be enhanced with the addition and refinement of the data and the inclusion of other variables describing land use. The patterns of land use change and the transition probability of land use could give local government valuable insights into the local specific land characteristics and the direction in which land uses are changing. These include insights on the relationships between land use change and important characteristics of the site such as area, zoning, land price, neighbouring land use, forestry, and accessibility, all of which have been addressed in the previous chapter.

Although many studies have used different mapping techniques to explain the pattern of land use change during the last few decades, this study brings a new approach to understanding the evolution of development patterns as the methods of combining spatial statistical analysis techniques with GIS application at site level.

However, the procedures required for successful integration of GIS and spatial analysis are highly fragmented and demanded a level of expertise and technical competence far beyond the average capabilities of an office of local government planning department. This study also employed various methods to get the results of analysis such as Arc Macro Language (AML) in ArcInfo, Avenue program language in ArcView, SAS, SPSS, Visual Basic, AutoCAD, and Excel, etc. It is very difficult for policy makers or planners to follow this procedure up.

In this sense, it is necessary for them to understand the basic concept of GIS and spatial analysis to improve their plans and decision processes rather than how to deal with these tools, how to convert data, and how to display. They will be able to be advised on the other parts by experts if necessary. There perhaps needs to be a regional level or even national level GIS and spatial analysis service which can provide analyses " on request" to local government.

7.4 Conclusion

The usefulness of integrating of GIS and spatial analysis is confirmed by the findings of this study. These findings have important implications for land use management in the urban fringe. Firstly, the distribution of land use change has indicated quite a substantial increase in building sites and factory sites in the agricultural areas and forest areas since 1994 indicating that the government's land policy change directly affects land use change in the study area. Therefore, local governments are required to consider how their land policies affect their spatial locations.

Secondly, the distribution of neighbouring land use is quite similar to the pattern of land use change. This distribution map has thus indicated that any parcel with over 50% urban neighbouring land use as an agricultural area or forestry is likely to be taken over by a building site or a factory site sooner or later. This map may be taken into consideration in spatial processes for explaining and predicting land use change in the urban fringe.

Thirdly, the transition probability map of land use shows that the areas that have a high transition probability are distributed near main roads. Areas of transition potential in the land use can be outlined from this map. This map is useful for local government to understand target areas when evaluating and deciding on the management strategy for urban fringe. Local government can know which areas are susceptible to land use change by utilising this transition probability map. This map thus can be used as a basic map when formulating an appropriate development strategy.

Fourthly, the distribution of land uses in the study area represented a mixture of house clusters, factory clusters, and agricultural clusters after deregulation in 1994. In accordance with these situations, many negative side effects were produced in the study area. In order to solve the problems, local government should plan and support development plans to encourage a particular type of land conversion or to give priority to a specific type of development.

Fifthly, building sites were mainly located either adjacent to roads or near beautiful natural environments. The trend of dispersal of building sites seems to be affected by the gravitation around housing clusters. Local government can produce a more sophisticated approach when planning housing land than in the past, with the distribution map of building sites displayed from this study. That is, local government may take into consideration for small scale housing growth as extending to around 'clusters' when formulating development plans.

Finally, the pattern of factory sites mainly tended to predominate in flat areas and near the roads. Factory sites in the study area seem to be too small to offer a good range of local services and are so scattered as to create difficulty in providing good public transport to other centres for services and jobs. Therefore, factory development planning in these respects should be developed and supported in locations which will reinforce clusters of interrelated factories and suppliers and well-located relative to potential workforce by public transport.

The results of analysis using GIS and spatial analysis proved to be effective ones. They are quite useful for local government to understand where and why land use change is concentrated, how the pattern of land use has changed, and which areas remain susceptible to land use change. They can also bring increasing rationality to the decision making processes of local government.

The accuracy of analysis depends on the reliability of the spatial database. For this, significant research efforts must be devoted to various ways of maintaining adequate information. Though the recent advances in GIS technology have made it possible to organise complex topological relationships among map features, most contemporary GIS packages lack the necessary functionality for undertaking a full range of spatial measurements and spatial analysis. It is necessary that the linkage between GIS and methods for the statistical analysis of spatial data will be beneficial to both fields and to a better understanding of the spatial problems.

The procedures required for successful integration of GIS and spatial analysis are highly fragmented and demanded a level of expertise and technical competence. Using GIS and spatial analysis is no simple answer to the challenge of understanding and analysing the dynamics of land use change at the urban fringe. This study also employed various methods to get the results of analysis. Thus, it is necessary for planners and policy makers to understand the basic concept of GIS and spatial analysis to improve their plans and decision processes rather than know how in technical detail to deal with these tools, how to convert data, and how to display it.

CHAPTER EIGHT

CONCLUSION

8.1 Introduction

This chapter provides an overview of the research by summarising the research background, methodological approach, the findings of the study, and some policy implications of the results. This chapter then identifies the study's contribution to this field. It also identifies limitations and future research which could develop from this study.

This study related to land use change in the urban fringe has revealed some of the spatial complexity of the conversion of land use. The major determinants of land use change in the study area have been investigated in an attempt to enhance knowledge of how to provide decision support information for local government in Korea using GIS and spatial analysis.

This study shows that GIS and spatial analysis can be applied to land use change in the urban fringe area and the results can be useful for local government to understand its situation and to manage land use efficiently in the urban fringe. The methodology developed in this study is especially useful for an empirical approach.

8.2 Overview of the research

Korea has experienced rapid industrialisation and urbanisation in the past decades. As a result, Korea has suffered from a chronic insufficiency in the supply of developable land. As the supply of land diminishes within the boundaries of large cities, it is expected that areas of land under rural use could be converted to urban use. This expectation is supported by the shift of land policy, as the supply of available land has been restricted through the regulation.

Since the deregulation was introduced in 1994, rapid land use change has occurred in the urban fringe areas around large cities. This is because development at the urban fringe is attractive in the sense that the price of land is comparatively low and developers can avoid the cost of infrastructure. In the Quasi-Agricultural and Forest Area (QAFA) particularly the change has brought about serious fragmented development. In the past, the pattern of development in the urban fringe in Korea was driven by public sector land development decisions with strong regulation. Now it is driven much more by market processes after deregulation in 1994.

As these areas show dramatic change from rural to urban land use, the public sector needs to manage and monitor these areas to prevent negative side effects. However, land use change monitoring at the urban fringe is highly complex, difficult and expensive. There are different development contexts and a different kind of information needed about land development processes.

With these considerations in mind, this research is concerned with the analytical and technical capability in using GIS and spatial analysis as relevant to the policy change of urban fringe management as a case study of the Seoul Metropolitan Region Perimeter. The primary purpose of this study is to analyse land use change using the tools of Geographical Information Systems (GIS) and Spatial Analysis as a spatial decision support system to manage the fragmented development of the urban fringe caused by the policy changes introduced by the Korean government in 1994.

The successful application of GIS and spatial analysis in urban fringes will create a better understanding of where a specific change takes place, how the patterns of land use have changed, what conditions lead to disorderly development, and which areas are susceptible to land use change. The research question for this study is, therefore, to evaluate the extent to which GIS and spatial analysis is helpful for local government to understand the situation occurring in the urban fringe area. A better understanding of the results will enhance the capability of local government to predict future land use change dynamics and devise more effective land use management strategies.

Many studies on land use change are based on the application of GIS (see chapter 2). Despite its recent popularity, GIS has contributed little to methodological innovation in urban analysis. This is because GIS is weak on the analytical capabilities of urban models. Therefore, this study explored what forms of analytical models can interact with the data structures provided in GIS.

GIS and spatial analysis present considerably different fields of expertise. However, since the end of the 1980s, there is a trend for the experts of the two fields to come together for the linkage between GIS and methods for the statistical analysis of spatial data as a key issue in research agendas. Unwin (1995) suggests the issue of error and uncertainty in GIS results is best resolved by adopting a suitable statistical model of the spatial variation involved and then estimating the parameters of this model. The reasons for the integration are that it will be beneficial to both fields and lead to a better understanding of the spatial problems. In other words, GIS and spatial analysis can be made stronger by their linkages. This thesis is thus undertaken as a part of this trend.

8.3 The research results

The results of analysis using GIS and spatial analysis are proved to be effective ones. They are quite useful for local government in the Korea context to understand where and why land use change is concentrated, how the pattern of land use has changed, and which areas remain susceptible to land use change. They can also bring increasing rationality to the decision-making processes of local government.

The research results represented important implications for land use management in the urban fringe. Firstly, the government's land policy change directly affects land use change in the study area. Therefore, local governments are required to consider how their own land policies affect their spatial locations.

Secondly, this study found the determinants of land use change in the study area using a logistic regression model. The result shows that the neighbouring land use variable among the determinants plays an important role in the pattern of land use change. The neighbouring land use map may be taken into consideration in spatial processes for explaining and predicting land use change in the urban fringe.

Thirdly, the transition probability map of land use was examined by the estimated coefficients from the logistic regression model. This map is useful for local government to understand target areas when evaluating and deciding on the management strategy of the urban fringe.

Finally, the results analysed were visualised by using GIS such as the pattern of land use change from 1994 to 1998, the distribution of neighbouring land use, and the transition probability of land use, the distribution of a mixture of land uses, the pattern of building sites, and the pattern of factory sites. These visualisations will give local government a better understanding of the issues and help the decision of the planner or policy maker.

8.4 Contributions and implications

The study contributes to significant advances on the integration of GIS and spatial analysis. As shown in the previous chapter, the findings using GIS and spatial analysis prove to be effective ones when providing the information base for modelling land use change in the urban fringe of the Seoul Metropolitan Region in Korea, enabling informed decisions to be made about land management policies in such areas.

The processes used in this study may be useful when applied to other areas which seem to be similar to the study area, if all related databases, such as digital cadastral map and digital attribute data, are provided. In particular, the map of neighbouring land use and the map of the transition probability of land use derived from GIS along with the logistic regression model based on variables that are at a statistically significant level will be useful in future research.

This thesis is the first study analysing the impact of neighbouring land use at a site level by using vector GIS and spatial analysis. The key concept of neighbouring land use presented in this study is that land use patterns evolve through the effect of the neighbouring land. The other recent studies merely addressed issues pertaining to neighbouring use effects as a grid cell (Chou, 1992, 1993, Clark et al., 1996, Landis, 1998,). The analysis of neighbouring land uses in vector format has not been considered due to the complexity and the difficulty of data collection. The results of this thesis are helpful because they enable us to understand better the nature of land markets and the impact of public investment, like roads.

The results of this study will assist planners in determining appropriate land use for Korean urban growth areas. These should help local governments understand the effects of land use change in the urban fringe in Korea. Additionally, the study is timely in the context of contemporary

Korean policy. A major project is underway to develop a National Geographic Information System (NGIS), with a timescale of 1995-2010. Therefore, this thesis will play a leading role in the application of the NGIS and be a widely-used approach in urban planning and land use management.

8.5 Limitations and future research

In this section, the limitations of the study and future proposals for study associated with the land use management in the urban fringe are discussed. Basically, future research is related to the limitations of this study, in that these limitations suggest some future research directions.

There are various shortcomings related to the analysis results. Firstly, the outputs of this study are useful in understanding realistic patterns of land use change on particular local site characteristics. However, it is not easy to apply this process to the large scale, like at the national or regional level, because so many parcels are included. Lately, the advent of raster-vector algorithms is available either as a self-contained system, or within traditional vector based GIS (Burrough, et. al., 1998). Thus, it is necessary to first decide the method to use according to scale and the context of applications.

Secondly, many problems may happen when applied elsewhere using the cadastral map. Particularly, the missing value can be the obstacles in applying the cadastral map as the basis for GIS and spatial analysis in the urban planning field. These problems can prevent data users producing accurate and reasonable results using cadastral maps. Cadastral maps should be accurate enough to become a base map when applied to other applications. This weakness of missing data should be supplemented thoroughly using both field surveys and each kind of register such as a terrier, a forestry book, etc.

Thirdly, this study was conducted under circumstances where the available data was restricted. It is hoped that the spatial database could be expanded in the future and utilised in research which will continue to explore land use change patterns, the transition probability of land use and the determinants of land use change. For this, there perhaps needs to be a regional level GIS and spatial analysis service which can provide analyses on request to local government.

This study could be enhanced with the addition and refinement of the data and the inclusion of other variables describing land use. For instance, the data could be further refined by breaking down of the building sites into several classes such as single family, multi-family, apartment, and condominiums. The distribution of these uses could form distinct patterns which should be studied in detail.

Fourthly, it is difficult to obtain digital cadastral maps of the study area before 1998 and to trace when parcels are divided or integrated over time, or when existing parcels disappeared or new parcels were created. For the successful application of the model of land use change, the database employed should be flexible for frequent updating in response to changes in land uses. Each time major changes occur in such conditions, the data must be updated and the model be tested for most current estimation of parameters (Chou, 1992b).

Fifthly, the low values of the transition probability of land use (see Figure 7.3) imply some limitations concerning the interpretation of the results. This leads us to pay more attention to interpreting the statistical results. The other variables which were not included in the analysis might be considered as independent variables in future study, in order to improve the explanatory power of the variables.

Finally, the chosen study area of this thesis was a small area around the Seoul Metropolitan Region to identify the pattern of land use change in detail within particular municipal boundaries and to analyse spatial relationships between the dependent variable and the independent variables of each parcel. For generalisation of the model, one needs to examine whether the analysis results can be transferred to other areas which are under the influence of rapid land use change in the urban fringe. The model also needs to be applied to several areas to determine the extent to which the factors that describe the conversion of land use in the study area could be extrapolated to other areas.

Therefore, one of my future research directions is to investigate the transition probability of land use in some areas that have changed rapidly from rural to urban uses in the Seoul Metropolitan Region Perimeter using the integrated approach of GIS and spatial analysis, in order to predict future land use change and devise more effective land use management strategies. Another direction is to expand the database in order to investigate and model the relationship between socio-economic variables, locational variables, and environmental variables at the city level.

GIS has not yet been applied properly at a local level as quickly as many suppliers hoped. Local authorities do not find it easy to make sensible decisions about GIS without seeking external advice. In addition, the availability of digital data is limited in some areas. Even though it can be obtained, it is expensive to continue with GIS. The first step can be much smaller than planners or decision makers expect and the analysis results may not be good enough to satisfy decision-makers (Rimscha, 1998).

Local government needs to see what will be needed in the future and make wise decisions based on GIS. The rational results analysed using cadastral maps that occupy about 80% of the administrative affairs at the local authority can help a local government see the need for GIS. Local authorities need system suppliers who understand their long-term objectives and who regularly help local authorities implement GIS. No one is familiar enough with all the systems on the market to evaluate them for every context.

Of the many technological and conceptual approaches to spatial data analysis, GIS is only useful for both planning and decision-making tasks of local government when it is combined with spatial analysis capability.

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Appendices

Appendix 1

<makerun.aml>

```
/* AML for running all make*.aml orderly.

/* ==== program START!! ====
/* Warning Message : Don't Use the TAB_key for which is not aml command.

/*0. Main program
&severity &error &fail
&args cover

&r makecv %cover%
&r makejoin %cover%
&r makehcode %cover%

&ty The whole process(3) done sucessfully!
&return
```

<makecv.aml>

```
/* AML for making coverage from dxf_file

/* The Result coverage name is same to the dxf_file name
/* If the origin dxf_file name is aaa then the result coverage is aaa
/* Usage :  &run makecv <dxf_filename> (without .dxf)

/* ==== program START!! ====
/* Warning Message : Don't Use the TAB_key for which is not aml command.


/*0. Main program
&severity &error &fail
&args dxfname
&s cover %dxfname%

&call check_cov
```

```
&call conv_cov
&call clean_cov

&ty The whole process(3) done sucessfully!
&return


/* 1. Check the coverage
&routine check_cov

&if [null %dxfname%] &then
    &return &inform Usage :  makecv  <dxf_filename>
&if ^ [exist %dxfname%.dxf -file] &then
    &return &inform %dxfname%.dxf file does Not exist!
&if [exist %cover% -cover] &then
    &return &inform %cover%_coverage aleady exist!
&ty Process.1. done sucessfully.

&return


/* 2. Convert dxf_file to coverage
&routine conv_cov

dxfarc %dxfname%.dxf %cover%
0pilgi
0jibun
end
y
&ty Process.2. done sucessfully.

&return


/* 3. Clean the coverage.
&routine clean_cov
clean %cover% # 0.1
&ty Process.3. done sucessfully.

&return
```

<makejoin.aml>

```
/* AML for joining coverage.pat and coverage.xcode by coverage-id item.

/* Usage :  &run makejoin <coverage>
```

```
/* Before run this Aml, CHECK this points
/* Check point 1. Did you create the coverage?
/* Check point 2. Did you made the topology by clean or build command?

/* ==== program START!! ====
/* Warning Message : Don't Use the TAB_key for which is not aml command.


/*0. Main program
&severity &error &fail
&args cover

&call check_cov
&call join_item

&ty The MAKEJOIN.AML done sucessfully!!
&return


/*1. Check the coverage
&routine check_cov

&if [null %cover%] &then
    &return &inform Usage :  makejoin  <coverage>
&if ^ [exist %cover% -cover] &then
    &return &inform The %cover%_coverage does not exist.
&if ^ [exist %cover%.pat -info] &then
    &return &inform The %cover%.pat does not exist. Clean First!!
&if ^ [exist %cover%.xcode -info] &then
    &return &inform The %cover%.xcode does not exist. Clean First!!
&ty Process.1. done sucessfully.
&return


/*2. joining coverage.pat and coverage.xcode by coverage-id item.
&routine join_item

&if [iteminfo %cover% -polygon dxf-text -exists] &then
    &return &inform The dxf-text item aleady exists.

&sys arc joinitem %cover%.pat %cover%.xcode %cover%.pat %cover%-id %cover%-id

&ty Process.2. done sucessfully.
&return
```

<makehcode.aml>

```
/* AML for adding hcode items to coverage.pat

/* This program will create some new items.
/* The made items are 'hcode1' 'hcode2'
/* Usage :  &run makehcode <coverage>

/* Before run this Aml, CHECK this points
/* Check point 1. Did you create the coverage?
/* Check point 2. Did you made the topology by clean or build command?
/* Check point 3. Did you join the coverage.pat with coverage.xcode?

/* ==== program START!! ====
/* Warning Message : Don't Use the TAB_key for which is not aml command.


/*0. Main program
&severity &error &fail
&args cover

&call check_cov
    &if ^ %result% = 1 &then
            &return &inform The process.1. failed. Check errors!
&call check_prog
    &if ^ %result% = 2 &then
            &return &inform The process.2. failed. Check errors!
&call add_hcode
    &if ^ %result% = 3 &then
            &return &inform The process.3. failed. Check errors!

&ty The whole process(3) done sucessfully!!
&return


/* 1. Check the coverage
&routine check_cov

&if [null %cover%] &then
    &return &inform Usage :  makehcode  <coverage>
&if ^ [exist %cover% -cover] &then
    &return &inform The %cover%_coverage does not exist.
&if ^ [exist %cover%.pat -info] &then
    &return &inform The %cover%.pat does not exist. Clean First!!
&ty Process.1. done sucessfully.
&s result = 1
```

```
&return


/*2. Check the program
&routine check_prog

&if [show program] = ARCPLOT &then
            &ty The current program is ARCPOLT
&else
    &do
            &ty The current program is NOT ARCPLOT
         arcplot
         disp 9999 1
    &end
mape [quote %cover%]
&ty Process.2. done sucessfully.
&s result = 2
&return


/*3. Add items to the coverage.pat file
&routine add_hcode

&if ^ [iteminfo %cover% -polygon dxf-text -exists] &then
    &return &inform There is Not dxf-text item. Joinitem(PAT with XCODE) First!

&do hcode &list hcode1 hcode2
    &if [iteminfo %cover% -polygon %hcode% -exists] &then
     &return &inform The %hcode% item aleady exists.
    &sys arc additem %cover%.pat %cover%.pat %hcode% 5 5 i
&end

     resel %cover% poly area <> 0
     calc %cover% poly hcode1 = [response 'Enter 시군구code (hcode1) : ']
     calc %cover% poly hcode2 = [response 'Enter 읍면동리code (hcode2) : ']
&ty Process.3. done sucessfully.
&s result = 3
&return
```

<makekey1.aml>

```
/* AML for making keyid-item from dxf-text

/* This program will create some new items.
/* The made items are 'san' 'bon' 'bu' 'jimok' 'error' 'keyid'
/* Usage :  &run makekey <coverage> {noadd}
```

```
/* If you aleady added above items you can use {noadd}_option.
/* It'll skip Process.3. which addes items to coverage.pat.

/* Before run this Aml, CHECK this points
/* Check point 1. Did you create the coverage?
/* Check point 2. Did you made the topology by clean or build command?
/* Check point 3. Did you join the coverage.pat with coverage.xcode?
/* Check point 4. Did you create the hcode1, hcode2 items and input values?

/* ==== program START!! ====
/* Warning Message : Don't Use the TAB_key for which is not aml command.


/*0. Main program
&severity &error &ignore
&args cover option
    &s error1 = 1
    &s error2 = 2
    &s error3 = 3

&call check_cov
&call check_prog
&if ^ %option% eq noadd &then
    &call add_item
&call set_cursor
&call divide_text
&call endding

&ty The whole process(6) done sucessfully!!
&ty Error_note : the error_item values indicate below message.
&ty 1: no bon,   2: no jimok,   3: no whole jibun
&return


/* 1. Check the coverage
&routine check_cov

&if [null %cover%] &then
    &return &inform Usage : makekey <coverage> {noadd}
&if ^ [exist %cover% -cover] &then
    &return &inform The %cover%_coverage does not exist.
&if ^ [exist %cover%.pat -info] &then
    &return &inform The %cover%.pat does not exist. Clean First!!
&ty Process.1. done sucessfully.
&return
```

```
/*2. Check the program
&routine check_prog

&if [show program] = ARCPLOT &then
              &ty The current program is ARCPOLT
&else
    &do
              &ty The current program is NOT ARCPLOT
          arcplot
          disp 9999 1
    &end
mape [quote %cover%]
&ty Process.2. done sucessfully.
&return


/*3. Add items to the coverage.pat file
&routine add_item

&if ^ [iteminfo %cover% -polygon dxf-text -exists] &then
    &return &inform There is Not dxf-text item. Joinitem(PAT with XCODE) First!

&do hcode &list hcode1 hcode2
    &if ^ [iteminfo %cover% -polygon %hcode% -exists] &then
     &return &inform There is Not %hcode% item. Create %hcode% and input value First!
&end

&do jbcell &list san bon bu jimok error keyid
    &if [iteminfo %cover% -polygon %jbcell% -exists] &then
    &return &inform Jibun_cell(%jbcell%) aleady exist!
&end

    &sys arc additem %cover%.pat %cover%.pat san 1 1 i
    &sys arc additem %cover%.pat %cover%.pat bon 4 4 i
    &sys arc additem %cover%.pat %cover%.pat bu 4 4 i
    &sys arc additem %cover%.pat %cover%.pat jimok 2 2 c
    &sys arc additem %cover%.pat %cover%.pat error 1 1 i
    &sys arc additem %cover%.pat %cover%.pat keyid 19 19 c

     resel %cover% poly area <> 0
     calc %cover% poly jimok = "
     calc %cover% poly keyid = "
&do jbcell &list san bon bu error
     calc %cover% poly %jbcell% = 0
&end
```

```
&ty Process.3. done sucessfully.
&return


/*4. Setting cursor
&routine set_cursor

&do cursor_name &list [show cursors]
    &if [locase %cursor_name%] = cs &then
        cursor cs remove
    &end
cursor cs declare %cover% poly rw
resel %cover% poly area <> 0
cursor cs open
&ty Process.4. done sucessfully.
&return


/*5. Divide dxf-text_item

&routine divide_text

&do &while %:cs.AML$NEXT%
/*      resel %cover% poly %cover%-id = [value :cs.%cover%-id]
    &s dxftext = [quote [show select %cover% poly 1 ITEM dxf-text]]
    &if %dxftext% = '' &then
            calc %cover% poly error = %error3%
    &else
            &do
                    &call rm_blank   /*5-1
                    &call dv_jimok   /*5-2
                    &call dv_san     /*5-3
                    &call dv_bon-bu  /*5-4
                    &call make_keyid /*5-5
            &end
     cursor cs next
&end
&ty Process.5. done sucessfully.
&return


/*5-1. Sub-Routine function of Process.5.

    &routine rm_blank  /*Process.5-1.
            &s blankpo [search %dxftext% ' ']
/*          &ty The position of blank is : %blankpo%
```

```
            &do &while %blankpo% <> 0
                    &s dxftext [before %dxftext% ' '][after %dxftext% ' ']
                    &s blankpo [search [quote %dxftext%] ' ']
                    &ty %dxftext%
            &end
/*  &ty The blank in the dxftext removed.
    &return


    &routine dv_jimok  /*Process.5-2.
            &s length_dtext [length %dxftext%]
            &s :cs.jimok = [quote [substr %dxftext% %length_dtext% 1]]
            &do i = 0 &to 9 &by 1
                    &if %:cs.jimok% = [quote %i%] &then
                            &do
                                    &s :cs.error = %error2%
                                    &s :cs.jimok = ''
                                    &goto no_jimok
                                    /* &return &inform There is Not Jimok.
                            &end
            &end
            &s length_dtext = %length_dtext% - 1
            &s dxftext = [quote [substr %dxftext% 1 %length_dtext%]]
    &label no_jimok
/*  &ty The jimok was divided sucessfully.
    &return


    &routine dv_san  /*Process.5-3.
            &s length_dtext [length %dxftext%]
            &if [quote [substr %dxftext% 1 1]] = '산' &then
                    &do
                            &s :cs.san = 2
                            &s dxftext = [quote [substr %dxftext% 2 %length_dtext%]]
                    &end
            &else
                    &s :cs.san = 1
/*  &ty The san_code was divided sucessfully.
    &return


    &routine dv_bon-bu  /*Process.5-4.
            &s length_dtext [length %dxftext%]
            &if %dxftext% cn '-' &then
                    &do
                            &s :cs.bon = [before %dxftext% -]
```

```
                        &s :cs.bu = [after %dxftext% -]
                &end
        &else
                &s :cs.bon = [unquote %dxftext%]
/*  &ty The bon-bu was divided sucessfully.
    &return


    &routine make_keyid  /*Process.5-5.
        &s length_bon [length [quote %:cs.bon%]]
        &s length_bu [length [quote %:cs.bu%]]
        &select %length_bon%
                &when 1
                        &s :cs.bon = 000%:cs.bon%
                &when 2
                        &s :cs.bon = 00%:cs.bon%
                &when 3
                        &s :cs.bon = 0%:cs.bon%
                &when 4
                        &s :cs.bon = %:cs.bon%
                &otherwise
                  &do
                        &s :cs.error = %error1%
                        &s :cs.bon = 0000
                  &end
        &end
        &select %length_bu%
                &when 1
                        &s :cs.bu = 000%:cs.bu%
                &when 2
                        &s :cs.bu = 00%:cs.bu%
                &when 3
                        &s :cs.bu = 0%:cs.bu%
                &when 4
                        &s :cs.bu = %:cs.bu%
                &otherwise
                        &s :cs.bu = 0000
        &end
        &s :cs.keyid = %:cs.hcode1%%:cs.hcode2%%:cs.san%%:cs.bon%%:cs.bu%
/*&ty keyid = %:cs.keyid%
&ty Quote keyid = [quote %:cs.keyid%]
/*          calc %cover% poly keyid = [quote %:cs.keyid%]
/*
/*      &do jbcell &list san bon bu jimok error
/*          calc %cover% poly %jbcell% = [value :cs.%jbcell%]
/*      &end
```

```
/*  &ty The keyid was made sucessfully.
    &return


/*6. Endding
&routine endding

cursor cs close
clearselect
&ty Process.6. done sucessfully.
&return
```

Appendix 2

```
*-----------------------------------------*
*            Integration of Data                    *
*                91-98SET.SAS                         *
*-----------------------------------------*
;
DATA aa;
INFILE 'c:\data\d242591.dat';
 INPUT code $ 1-11 gm91 34-35 zn91 44-45 ls91 59-60;
proc sort; by code;

DATA bb;
INFILE 'c:\data\d242592.dat';
 INPUT code $ 1-11 gm92 34-35 zn92 44-45 ls92 59-60;
proc sort; by code;

DATA cc;
INFILE 'c:\data\d242593.dat';
 INPUT code $ 1-11 gm93 34-35 zn93 44-45 ls93 59-60;
proc sort; by code;

DATA dd;
INFILE 'c:\data\d242594.dat';
 INPUT code $ 1-11 gm94 34-35 zn94 44-45 ls94 59-60;
proc sort; by code;

DATA ee;
INFILE 'c:\data\d242595.dat';
 INPUT code $ 1-11 gm95 34-35 zn95 44-45 ls95 59-60;
proc sort; by code;

DATA ff;
INFILE 'c:\data\d242596.dat';
 INPUT code $ 1-11 gm96 34-35 zn96 44-45 ls96 59-60;
proc sort; by code;

DATA gg;
INFILE 'c:\data\d242597.dat';
 INPUT code $ 1-11 gm97 34-35 zn97 44-45 ls97 59-60;
proc sort; by code;

DATA hh;
INFILE 'c:\data\d242598.dat';
```

```
INPUT code $ 1-11 gm98 34-35 zn98 44-45 ls98 59-60;
proc sort; by code;

data all;
merge aa bb cc dd ee ff gg hh; by code;
data zz; set all;
FILE 'c:\data\d2425.dat';
PUT code $ 1-11 gm91 12-13 gm92 14-15 gm93 16-17 gm94 18-19 gm95 20-21 gm96 22-23 gm97
24-25 gm98 26-27 zn91 28-29 zn92 30-31 zn93 32-33 zn94 34-35 zn95 36-37 zn96 38-39 zn97 40-
41 zn98 42-43 ls91 44-45 ls92 46-47 ls93 48-49 ls94 50-51 ls95 52-53 ls96 54-55 ls97 56-57 ls98
58-59;
RUN;


*-----------------------------------------*
*            Integration of Data            *
*                91-98SET.SAS                 *
*-----------------------------------------*
;
data aa;
INFILE 'c:\data\d2425.dat';
INPUT code $ 1-11 gm91 12-13 gm92 14-15 gm93 16-17 gm94 18-19 gm95 20-21 gm96 22-23
gm97 24-25 gm98 26-27 zn91 28-29 zn92 30-31 zn93 32-33 zn94 34-35 zn95 36-37 zn96 38-39
zn97 40-41 zn98 42-43 ls91 44-45 ls92 46-47 ls93 48-49 ls94 50-51 ls95 52-53 ls96 54-55 ls97 56-
57 ls98 58-59;

data a1; set aa;
if zn98=21;
if gm91=gm92 and gm92=gm93 and gm93=gm94 and gm94=gm95 and gm95=gm96 and
gm96=gm97 and gm97=gm98 and ls91=ls92 and ls92=ls93 and ls93=ls94 and ls94=ls95 and
ls95=ls96 and ls96=ls97 and ls97=ls98 then delete;
FILE 'c:\data\dbjr.dat';
PUT code $ 1-11 gm91 12-13 gm92 14-15 gm93 16-17 gm94 18-19 gm95 20-21 gm96 22-23 gm97
24-25 gm98 26-27 zn91 28-29 zn92 30-31 zn93 32-33 zn94 34-35 zn95 36-37 zn96 38-39 zn97 40-
41 zn98 42-43 ls91 44-45 ls92 46-47 ls93 48-49 ls94 50-51 ls95 52-53 ls96 54-55 ls97 56-57 ls98
58-59;
RUN;

*-----------------------------------------*
*            Integration of Data            *
*                91-98SET.SAS                 *
*-----------------------------------------*
;
DATA aa;
INFILE 'c:\data\d242591.dat';
INPUT code $ 1-14 gm91 15-16 zn91 17-18 ls91 19-20;
proc sort; by code;
```

```
DATA bb;
INFILE 'c:\data\ d242592.dat';
 INPUT  code $ 1-14 gm92 15-16 zn92 17-18 ls92 19-20;
proc sort; by code;

DATA cc;
INFILE 'c:\data\ d242593.dat';
 INPUT  code $ 1-14 gm93 15-16 zn93 17-18 ls93 19-20;
proc sort; by code;

DATA dd;
INFILE 'c:\data\ d242594.dat';
 INPUT  code $ 1-14 gm94 15-16 zn94 17-18 ls94 19-20;
proc sort; by code;

DATA ee;
INFILE 'c:\data\ d242595.dat';
 INPUT  code $ 1-14 gm95 15-16 zn95 17-18 ls95 19-20;
proc sort; by code;

DATA ff;
INFILE 'c:\data\ d242596.dat';
 INPUT  code $ 1-14 gm96 15-16 zn96 17-18 ls96 19-20;
proc sort; by code;

DATA gg;
INFILE 'c:\data\ d242597.dat';
 INPUT  code $ 1-14 gm97 15-16 zn97 17-18 ls97 19-20;
proc sort; by code;

DATA hh;
INFILE 'c:\data\ d242598.dat';
 INPUT  code $ 1-14 gm98 15-16 zn98 17-18 ls98 19-20;
proc sort; by code;


data all;
merge aa bb cc dd ee ff gg; hh, by code;
data cc; set all;
proc format;
  value zone 19='Quasi-urban' 20='Agri&Forest' 21='Quasi-agri&Forest';
  value gmok 1='Dry field' 2='Paddy field' 3='Forest' 4='Residential' 5='Factory' 6='Facilities';
  value luse 1='Residential' 2='Commercial' 3='Industrial' 4='Agricultural' 5='Forest' 6='Vacant'
        7='Public';

title '=== 91 - 98 Land Utilisation Character Surveys ===';
```

```
proc print;
var code gm91 zn91 ls91 gm92 zn92 ls92 gm93 zn93 ls93 gm94 zn94 ls94 gm95 zn95 ls95
   gm96 zn96 ls96 gm97 zn97 ls97 gm98 zn98 ls98;
format zn91 zone. gm91 gmok. ls91 luse. zn92 zone. gm92 gmok. ls92 luse.
     zn93 zone. gm93 gmok. ls93 luse. zn94 zone. gm94 gmok. ls94 luse.
     zn95 zone. gm95 gmok. ls95 luse. zn96 zone. gm96 gmok. ls96 luse.
     zn97 zone. gm97 gmok. ls97 luse. zn98 zone. gm98 gmok. ls98 luse;
RUN;

*-------------------------------------------*
*           Integration of Data              *
*                91-98SET.SAS                  *
*-------------------------------------------*
;
DATA aa;
INFILE 'c:\data\Yongin91.dat';
INPUT dong 11-15 bj $ 16-24 gmok 48-49 zone 61-62 nong 71 forst 74 luse 75-76;
if 33024<=dong<=33025;
if zone=19 or 21<=zone<=22 or zone=25 then zn91=19;
else if (zone=20 and nong=1) or (zone=23 and forst=1) then zn91=20;
else if (zone=20 and nong=2) or (zone=23 and forst=2) then zn91=21;
else if zone=24 or 26<=zone<=27 then zn91=22;
if 1<=gmok<=3 then gm91=1;
else if 4<=gmok<=5 then gm91=2;
else if 6<=gmok<=7 or 20<=gmok<=23 then gm91=3;
else if gmok=8 then gm91=4;
else if gmok=9 then gm91=5;
else if 10<=gmok<=19 then gm91=6;
else if gmok=24 then gm91=7;
if 1<=luse<=4 or luse=10 then ls91=1;
else if 5<=luse<=6 or luse=11 then ls91=2;
else if luse=7 then ls91=3;
else if luse=9 or luse=12 then ls91=4;
else if 13<=luse<=17 or luse=21 then ls91=5;
else if 18<=luse<=20 then ls91=6;
else if luse=8 or 22<=luse<=23 then ls91=7;
else if 25<=luse<=99 then ls91=8;
DATA a1; SET aa;
FILE 'c:\data\d242591.dat';
PUT dong 1-5 bj $ 6-14 gm91 15-16 zn91 17-18 ls91 19-20;
RUN;

DATA bb;
INFILE 'c:\data\Yongin92.dat';
INPUT dong 11-15 bj $ 16-24 gmok 42-43 zone 52-53 nong 62 forst 65 luse 66-67;
if 33024<=dong<=33025;
```

```
if zone=19 or 21<=zone<=22 or zone=25 then zn92=19;
else if (zone=20 and nong=1) or (zone=23 and forst=1) then zn92=20;
else if (zone=20 and nong=2) or (zone=23 and forst=2) then zn92=21;
else if zone=24 or 26<=zone<=27 then zn92=22;
if 1<=gmok<=3 then gm92=1;
else if 4<=gmok<=5 then gm92=2;
else if 6<=gmok<=7 or 20<=gmok<=23 then gm92=3;
else if gmok=8 then gm92=4;
else if gmok=9 then gm92=5;
else if 10<=gmok<=19 then gm92=6;
else if gmok=24 then gm92=7;
if 1<=luse<=4 or luse=10 then ls92=1;
else if 5<=luse<=6 or luse=11 then ls92=2;
else if luse=7 then ls92=3;
else if luse=9 or luse=12 then ls92=4;
else if 13<=luse<=17 or luse=21 then ls92=5;
else if 18<=luse<=20 then ls92=6;
else if luse=8 or 22<=luse<=23 then ls92=7;
else if 25<=luse<=99 then ls92=8;
DATA b1; SET bb;
FILE 'c:\data\d242592.dat';
 PUT  dong 1-5 bj $ 6-14 gm92 15-16 zn92 17-18 ls92 19-20;
RUN;

DATA cc;
INFILE 'c:\data\Yongin93.dat';
 INPUT  dong 11-15 bj $ 16-24 gmok 42-43 zone 52-53 nong 62 forst 65 luse 66-67;
if 33024<=dong<=33025;
if zone=19 or 21<=zone<=22 or zone=25 then zn93=19;
else if (zone=20 and nong=1) or (zone=23 and forst=1) then zn93=20;
else if (zone=20 and nong=2) or (zone=23 and forst=2) then zn93=21;
else if zone=24 or 26<=zone<=27 then zn93=22;
if 1<=gmok<=3 then gm93=1;
else if 4<=gmok<=5 then gm93=2;
else if 6<=gmok<=7 or 20<=gmok<=23 then gm93=3;
else if gmok=8 then gm93=4;
else if gmok=9 then gm93=5;
else if 10<=gmok<=19 then gm93=6;
else if gmok=24 then gm93=7;
if 1<=luse<=4 or luse=10 then ls93=1;
else if 5<=luse<=6 or luse=11 then ls93=2;
else if luse=7 then ls93=3;
else if luse=9 or luse=12 then ls93=4;
else if 13<=luse<=17 or luse=21 then ls93=5;
else if 18<=luse<=20 then ls93=6;
else if luse=8 or 22<=luse<=23 then ls93=7;
```

```
else if 25<=luse<=99 then ls93=8;
DATA c1; SET cc;
FILE 'c:\data\d242593.dat';
 PUT  dong 1-5 bj $ 6-14 gm93 15-16 zn93 17-18 ls93 19-20;
RUN;

DATA dd;
INFILE 'c:\data\Yongin94.dat';
 INPUT  dong 11-15 bj $ 16-24 gmok 41-42 zn94 51-52 luse 65-66;
if 33024<=dong<=33025;
if 1<=gmok<=3 then gm94=1;
else if 4<=gmok<=5 then gm94=2;
else if 6<=gmok<=7 or 20<=gmok<=23 then gm94=3;
else if gmok=8 then gm94=4;
else if gmok=9 then gm94=5;
else if 10<=gmok<=19 then gm94=6;
else if gmok=24 then gm94=7;
if 10<=luse<=19 then ls94=1;
else if 20<=luse<=29 then ls94=2;
else if 30<=luse<=39 then ls94=3;
else if 40<=luse<=49 then ls94=4;
else if 50<=luse<=69 then ls94=5;
else if 70<=luse<=79 then ls94=6;
else if 81<=luse<=83 or 86<=luse<=88 then ls94=7;
else if 84<=luse<=85 or luse=89 then ls94=8;
DATA d1; SET dd;
FILE 'c:\data\d242594.dat';
 PUT  dong 1-5 bj $ 6-14 gm94 15-16 zn94 17-18 ls94 19-20;
RUN;

DATA ee;
INFILE 'c:\data\Yongin95.dat';
 INPUT  dong 11-15 bj $ 16-24 gmok 41-42 zn95 51-52 luse 65-66;
if 33024<=dong<=33025;
if 1<=gmok<=3 then gm95=1;
else if 4<=gmok<=5 then gm95=2;
else if 6<=gmok<=7 or 20<=gmok<=23 then gm95=3;
else if gmok=8 then gm95=4;
else if gmok=9 then gm95=5;
else if 10<=gmok<=19 then gm95=6;
else if gmok=24 then gm95=7;
if 10<=luse<=19 then ls95=1;
else if 20<=luse<=29 then ls95=2;
else if 30<=luse<=39 then ls95=3;
else if 40<=luse<=49 then ls95=4;
else if 50<=luse<=69 then ls95=5;
```

```
else if 70<=luse<=79 then ls95=6;
else if 80<=luse<=89 then ls95=7;
else if 90<=luse<=99 then ls95=8;
DATA e1; SET ee;
FILE 'c:\data\d242595.dat';
 PUT  dong 1-5 bj $ 6-14 gm95 15-16 zn95 17-18 ls95 19-20;
RUN;

DATA ff;
INFILE 'c:\data\Yongin96.dat';
 INPUT  dong 6-10 bj $ 11-19 gmok 33-34 zn96 43-44 luse 57-58;
if 33024<=dong<=33025;
if 1<=gmok<=3 then gm96=1;
else if 4<=gmok<=5 then gm96=2;
else if 6<=gmok<=7 or 20<=gmok<=23 then gm96=3;
else if gmok=8 then gm96=4;
else if gmok=9 then gm96=5;
else if 10<=gmok<=19 then gm96=6;
else if gmok=24 then gm96=7;
if 10<=luse<=19 then ls96=1;
else if 20<=luse<=29 then ls96=2;
else if 30<=luse<=39 then ls96=3;
else if 40<=luse<=49 then ls96=4;
else if 50<=luse<=69 then ls96=5;
else if 70<=luse<=79 then ls96=6;
else if 80<=luse<=89 then ls96=7;
else if 90<=luse<=99 then ls96=8;
DATA f1; SET ff;
FILE 'c:\data\d242596.dat';
 PUT  dong 1-5 bj $ 6-14 gm96 15-16 zn96 17-18 ls96 19-20;
RUN;

DATA gg;
INFILE 'c:\data\Yongin97.dat';
 INPUT  dong 6-10 bj $ 11-19 gmok 33-34 zn97 43-44 luse 58-59;
if 33024<=dong<=33025;
if 1<=gmok<=3 then gm97=1;
else if 4<=gmok<=5 then gm97=2;
else if 6<=gmok<=7 or 20<=gmok<=23 then gm97=3;
else if gmok=8 then gm97=4;
else if gmok=9 then gm97=5;
else if 10<=gmok<=19 then gm97=6;
else if gmok=24 then gm97=7;
if 10<=luse<=19 then ls97=1;
else if 20<=luse<=29 then ls97=2;
else if 30<=luse<=39 then ls97=3;
```

```
else if 40<=luse<=49 then ls97=4;
else if 50<=luse<=69 then ls97=5;
else if 70<=luse<=79 then ls97=6;
else if 80<=luse<=89 then ls97=7;
else if 90<=luse<=99 then ls97=8;
DATA g1; SET gg;
FILE 'c:\data\d242597.dat';
 PUT  dong 1-5 bj $ 6-14 gm97 15-16 zn97 17-18 ls97 19-20;
RUN;

DATA hh;
INFILE 'c:\data\Yongin98.dat';
 INPUT  dong 6-10 bj $ 11-19 gmok 33-34 zn98 43-44 luse 58-59;
if 33024<=dong<=33025;
if 1<=gmok<=3 then gm98=1;
else if 4<=gmok<=5 then gm98=2;
else if 6<=gmok<=7 or 20<=gmok<=23 then gm98=3;
else if gmok=8 then gm98=4;
else if gmok=9 then gm98=5;
else if 10<=gmok<=19 then gm98=6;
else if gmok=24 then gm98=7;
if 10<=luse<=19 then ls98=1;
else if 20<=luse<=29 then ls98=2;
else if 30<=luse<=39 then ls98=3;
else if 40<=luse<=49 then ls98=4;
else if 50<=luse<=69 then ls98=5;
else if 70<=luse<=79 then ls98=6;
else if 80<=luse<=89 then ls98=7;
else if 90<=luse<=99 then ls98=8;
DATA g1; SET hh;
FILE 'c:\data\d242598.dat';
 PUT  dong 1-5 bj $ 6-14 gm98 15-16 zn98 17-18 ls98 19-20;
RUN;
```

Appendix 3

```
'*** Export the neighbor matrix to a .txt file

theProject = av.GetProject
theView = av.GetActiveDoc
theTheme = theView.GetactiveThemes.Get(0)
theFTab = theTheme.GetFTab

'Get the name for neighbor file to export
theFN = FileDialog.Put("neighbor.txt".AsFileName, "*.txt",
"Name An Adjacency File To Write")

'Get the list of fields in FTab

numeric_fields = {} 'Numeric fields in the VTab
field_aliases = {} 'List of field aliases
all_fields = theFTab.GetFields

'Build list of numeric fields from all fields.
'Also list of field aliases to display to user.
for each f in all_fields
if (f.IsTypeNumber) then
numeric_fields.Add(f)
field_aliases.Add(f.GetAlias)
end
end

fname = MsgBox.ListAsString(field_aliases,
"Select the variable for identification:",
"Export Neighbor Matrix to a TEXT File")

if (fname <> nil) then
'Match the alias to the actual field object
theField = numeric_fields.Get(field_aliases.FindByValue(fname))
else
exit
end

' Set modified flag, clear any previous selection

av.GetProject.SetModified(true)
theFTab.GetSelection.ClearAll
theFTab.UpdateSelection
```

```
' find the total number of records

theCount = theFTab.GetNumRecords

' define an output file for storing adjacency relationship

outFile = LineFile.Make(theFN, #FILE_PERM_WRITE)

' Find out adjacent polygons for each individual polygon

theBitMap = theFTab.GetSelection

for each rec in theFTab
theIndex = theFTab.ReturnValueNumber(theField, rec)
theRecord = rec.Clone
theFTab.GetSelection.Set(theRecord)
theFTab.UpdateSelection
theFTab.SelectByFTab(theFTab, #FTAB_RELTYPE_ISWITHINDISTANCEOF,
0, #VTAB_SELTYPE_NEW)

selBitMap = theFTab.GetSelection
theString = theIndex.AsString
for each rec in selBitMap
recVal = theFTab.ReturnValue(theField, rec)
if (recval <> theIndex) then
theString = theString++recVal.AsString
end
end

' Write results to file and clear the selection

outFile.WriteElt(theString)
theFTab.GetSelection.ClearAll

end
outFile.Close
```

Appendix 4-1

Module1 - 1

```
Sub count()
Dim nbr(1 To 7) As Double
Open "LU_AV_result_91.prn" For Input As #3
Open "LU_AV_result_94.prn" For Input As #1
Open "Adj9194.dat" For Output As #2
Input #1, lnuse$
Input #3, lnuse2$

For l = 1 To 3994

Input #3, lnuse2$
i = 0
Do
 i = i + 1
 code = 0
 If Mid$(lnuse2$, i, 1) = "D" Then code = 1
 If Mid$(lnuse2$, i, 1) = "P" Then code = 2
 If Mid$(lnuse2$, i, 1) = "F" Then code = 3
 If Mid$(lnuse2$, i, 1) = "R" Then code = 4
 If Mid$(lnuse2$, i, 1) = "I" Then code = 5
 If Mid$(lnuse2$, i, 1) = "U" Then code = 6
 If Mid$(lnuse2$, i, 1) = "N" Then code = 7
Loop Until code > 0
nextcode = code

first = 0
For i = 1 To 7
  nbr(i) = 0
Next i

Input #1, lnuse$
For i = 1 To Len(lnuse$)
  code = 0
  If Mid$(lnuse$, i, 1) = "D" Then code = 1
  If Mid$(lnuse$, i, 1) = "P" Then code = 2
  If Mid$(lnuse$, i, 1) = "F" Then code = 3
  If Mid$(lnuse$, i, 1) = "R" Then code = 4
  If Mid$(lnuse$, i, 1) = "I" Then code = 5
  If Mid$(lnuse$, i, 1) = "U" Then code = 6
  If Mid$(lnuse$, i, 1) = "N" Then code = 7
  If code > 0 Then
```

```
    If first = 0 Then
      current = code
      first = 1
    Else
      nbr(code) = nbr(code) + 1
    End If
  End If

 Next i
nbrs = nbr(1) + nbr(2) + nbr(3) + nbr(4) + nbr(5) + nbr(6) + nbr(7)
Valid = nbrs > 0
If Valid Then
  For i = 1 To 7
    nbr(i) = nbr(i) / nbrs
  Next i
  Print #2, nextcode, current, nbrs, nbr(1), nbr(2), nbr(3), nbr(4), nbr(5), nbr(6), nbr(7)
End If
Next l

Close #1
Close #2
Close #3

End Sub
```

Appendix 4-2

```
Sub count()
Dim nbr(1 To 7) As Double
Open "LU_AV_result_94.prn" For Input As #3
Open "LU_AV_result_98.prn" For Input As #1
Open "Adj9498.dat" For Output As #2
Input #1, lnuse$
Input #3, lnuse2$

For l = 1 To 3994

Input #3, lnuse2$
i = 0
Do
 i = i + 1
 code = 0
 If Mid$(lnuse2$, i, 1) = "D" Then code = 1
 If Mid$(lnuse2$, i, 1) = "P" Then code = 2
 If Mid$(lnuse2$, i, 1) = "F" Then code = 3
 If Mid$(lnuse2$, i, 1) = "R" Then code = 4
 If Mid$(lnuse2$, i, 1) = "I" Then code = 5
 If Mid$(lnuse2$, i, 1) = "U" Then code = 6
 If Mid$(lnuse2$, i, 1) = "N" Then code = 7
Loop Until code > 0
nextcode = code

first = 0
For i = 1 To 7
 nbr(i) = 0
Next i

Input #1, lnuse$
For i = 1 To Len(lnuse$)
 code = 0
 If Mid$(lnuse$, i, 1) = "D" Then code = 1
 If Mid$(lnuse$, i, 1) = "P" Then code = 2
 If Mid$(lnuse$, i, 1) = "F" Then code = 3
 If Mid$(lnuse$, i, 1) = "R" Then code = 4
 If Mid$(lnuse$, i, 1) = "I" Then code = 5
 If Mid$(lnuse$, i, 1) = "U" Then code = 6
 If Mid$(lnuse$, i, 1) = "N" Then code = 7
 If code > 0 Then
  If first = 0 Then
```

```
      current = code
      first = 1
    Else
      nbr(code) = nbr(code) + 1
    End If
  End If

 Next i
nbrs = nbr(1) + nbr(2) + nbr(3) + nbr(4) + nbr(5) + nbr(6) + nbr(7)
Valid = nbrs > 0
If Valid Then
  For i = 1 To 7
    nbr(i) = nbr(i) / nbrs
  Next i
  Print #2, nextcode, current, nbrs, nbr(1), nbr(2), nbr(3), nbr(4), nbr(5), nbr(6), nbr(7)
End If
Next l

Close #1
Close #2
Close #3

End Sub
```

Appendix 5

List of variables

Name	Measurement/ Value	Label
Cng9498	C	Land Use Change from 1994 to 98
Cng9194	C	Land Use Change from 1991 to 94
	0	No Change
	1	Change
LndCtg98	C	Land Category in 1998
LndCtg94	C	Land Category in 1994
LndCtg91	C	Land Category in 1991
	1	Dry Field
	2	Paddy Field
	3	Forest Land
	4	Building site
	5	Factory site
	6	Public Facilities
LnUsSt98	C	State of Land use in 1998
LnUsSt94	C	State of Land use in 1994
LnUsSt91	C	State of Land use in 1991
	1	Residential use
	2	Commercial use
	3	Industrial use
	4	Agricultural use
	5	Forest use
	6	Vacant use
	7	Public Facilities
UbUs9194	S	% of Neighbours used for urban use from 1991 to 1994
UbUs9498	S	% of Neighbours used for urban use from 1994 to 1998
Zone98	C	Zoning; Special land use areas in 1998
Zone94	C	Zoning; Special land use areas in 1994
	19	Quasi-urban areas
	20	Agricultural and Forest Areas
	21	Quasi-Agricultural and Forest Areas
Size	S	Size of land

Forest	C	Forest Land
	1	Preserved forest land
	2	Quasi-preserved forest land
Heit	C	Height of land
	1	Lowlands
	2	Flatlands
	3	Gentle grade
	4	Steep grade
	5	Highlands
Drec	C	Direction
	1	South Facing
	2	Southeast Facing
	3	Southwest Facing
	4	East Facing
	5	West Facing
	6	North Facing
	7	Northeast Facing
	8	Northwest Facing
Road	C	Accessibility to main road
	1	Adjacent Areas
	3	Within 50m
	4	Within 100m
	5	Within 500m
	1	Over 500m
LndPrc98	S	Land Price in 1998
LndPrc94	S	Land Price in 1994
LndPrc91	S	Land Price in 1991

C: Categorical ; Nominal and Ordinal are both treated as categorical.
S: Scale ; numerical data on an interval or ratio scale