A NOMINAL ASSET VALUE-BASED APPROACH FOR LAND READJUSTMENT AND ITS IMPLEMENTATION USING GEOGRAPHICAL INFORMATION SYSTEMS

by

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ABSTRACT

Land readjustment is a planning tool to assist in systematic urbanisation. The process aims to take rural or unplanned urban land, usually irregularly subdivided, and re-allocate it, in the required balance, for public and private use according to town planning requirements. It has great advantages in solving the land-use problem in urban areas but current land readjustment implementations are limited in many ways: for example, there are technical limitations in handling the wealth of data, economical limitations in compensation for acquire land, and social limitations in minimising the inconvenience and conceived injustices.

To maximise the benefits from land readjustment and to establish an ongoing land information system, a nominal asset value-based land readjustment model called LARES has been developed and implemented using ARC/ INFO GIS. This model specifically deals with the land valuation, decision-making, and information management issues of the current land readjustment applications.

While the objective of land valuation is to determine market value, in this approach, a *nominal asset value* is used to represent a land parcel's worth when compared to others. Many land valuation factors defining the economical, environment and spatial value of land parcels are analysed before and after the land readjustment project to ensure equality in land redistribution. Various equations and algorithms for land valuation and distribution analysis are investigated and implemented.

The model has been tested with a case study. Data for land valuation analysis are derived from property, land-use, thematic, and topographical maps, and from other related textual records. Using GIS functionality, spatial analysis is performed in order to determine land parcel asset values by the combination of mathematical analysis and subjective judgement.

The thesis describes the design, development and implementation of a nominal asset value-based approach to land readjustment for urban land development. It concludes that this approach improves the qualitative and quantitative ability of land readjustment process.

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CHAPTER 1

INTRODUCTION

> "In many Third World countries the greatest pressure on the land is in the urban fringe. Squatters move there from the rural areas in search of work and greater security, since the levels of starvation are often significantly less in urban than in rural communities. At the same time, the urban population is expanding because of the high birth rate. The solution to such problems requires new types of analysis based upon better information than has in the past been available."
>
> (Dale and McLaughlin, 1988)

1.1 Introduction

According to United Nations (1989) the annual population growth rate is 1.9 percent in the world. It has been estimated that over the next decade, there will be an enormous, unprecedented physical and population growth of cities in developing countries. Henssen (1990) observes that the population will be more or less stable in both urban and rural areas of the developed countries.

In the less developed countries, the population will be stable in the rural areas, but an alarming growth will be found in the cities and towns. This growth will result in a need for significant acquisition of urban land for public purposes such as roads, housing, schools, hospitals, parks, markets, and other public facilities.

Due to the availability of high living standards and profitable economic developments in urban areas, there have been huge migrations from rural to urban areas. Therefore, the land-use problems confronting urban areas are usually traced to rapid urbanisation and massive urban growth in the recent decades (Gilbert and Gugler, 1992).

As a result of these, rapid urbanisation has dramatically and continuously occurred in most major cities in the developing world. Thereby, these cities are faced with a lack of readily available land and this causes public services to fall further and further behind the demands of urbanisation (Doebele, 1982). In order to provide new services as rapidly as they are needed to support rapid urbanisation, local government authorities must contrive some efficient land acquisition strategies for new settlements and built-up areas.

Many methods, such as nationalisation of land, nationalisation of all development rights, government ownership of peripheral areas, special taxation on the benefits received by parcels from the installation of public services, and others, have been proposed to resolve these urbanisation problems (Doebele, 1982; Dunkerley, 1983; Kitay, 1985). Among the most interesting known devices in this field is *land readjustment*. This method has become an important tool for urban development in Germany, Japan, South Korea, Taiwan, Turkey, and the state of Western Australia (Seele, 1982; Doebele, 1982; Nakamura, 1986; Archer, 1992; Yomralioglu, 1992).

Land readjustment may be defined as an instrument used when developing land for modern urban use. The process aims to take rural or unplanned urban land, usually irregularly subdivided, and reallocate it, in the required balance, for public and private use according to town planning requirements (Yomralioglu and Parker, 1992). In other words, all land parcels within a project area are grouped together and a percentage of each parcel calculated to determine a contribution to public areas. This percentage depends on the size of the project area and the total size of required public-use areas. The remaining land is reallocated within the site blocks defined by the zoning plan (Muller, 1992).

In urban development, land readjustment helps to eliminate small parcels, irregular plots and land unsuitable for economic use. It creates usable site lots by consolidating, dividing and re-distributing land parcels back to the original land owners. During the land readjustment procedure, it also provides an opportunity to simply and inexpensively resurvey the land and demarcate new boundaries. Therefore, the practice of land readjustment can be considered as a method of strengthening the cadastre (Chou and Shen, 1982).

In helping to provide new built-up areas for urban development, land readjustment affects current land tenure and changes the existing parcel structure according to the detailed urban planning programs. However, land readjustment is a complex management tool with economic, physical, social and planning dimensions (Doebele, 1986).

Land readjustment has great advantages for solving the land-use problems in urban areas but current land readjustment implementations are still faced with some limitations. These included technical limitations in handling the wealth of data, economical limitations in compensation for acquiring land, and social limitations in minimising the inconvenience and perceived injustices.

However, the technical limitations, such as inequitable land distribution and inefficient land information management, affect the effective and efficient use of land readjustment applications in developing countries. For instance, land-value analysis has not been dynamically used in the process. Currently many substantial factors which affect a parcel's value are ignored during the project. Therefore, inequitable land distribution can occur to the original landholders affecting their benefits from the land readjustment project (Miyazawa, 1982; Doebele, 1982; Satoh, 1986).

Information management is another technical limitation that affects the performance of the process. Due to poor information management and the use of a manual process, to follow the entire procedure is time consuming and error prone (Chou and Shen, 1982). This causes some mismanagement and undesirable duplication in the project stages, so that the expenses of a project increase too much. In order to provide an equitable land parcel distribution, with a more effective decision-making process, there is also a need for an efficient information management procedure.

Considering overcoming of the present shortcomings of land readjustment applications, it has been conceived that land readjustment would be a most valuable and powerful urban land management tool to provide suitable land for public and private sector needs. It is also believed that, at the same time, land readjustment can help to establish a reference for the ongoing development of land information systems in developing countries.

Based on the above thoughts, this research has attempted to automate and improve the quantitative and qualitative capacities of the land readjustment technique, to maximise the benefits from the process.

1.2 Problem definition

Due to the widely varying conditions in the cities of the world, in cultural attitudes toward land, and in political and institutional structures, no single form of land readjustment can be universally applicable. While the main concept of land readjustment has been maintained in all applications, current land readjustment implementations are examined in different ways from country to country. Land readjustment still has however some common problems that most of the projects are faced with. As expressed by Satoh (1986), Seele (1982), Chou and Shen (1982), a land readjustment project can take up to ten years to complete as a result of some of social, political, economical, and technical requirements.

Considering the technical aspect of land readjustment, some of the common major problems with the present approaches to land readjustment may be classified as follows:

(1) Land Valuation

During the land readjustment projects, there is no dynamic land valuation analysis. Unit land value especially is not involved in the calculation of the percentages to be contributed by each landowner for public areas. In most cases, the only criterion is the parcel size, and the contribution factor is the public-use land area required in the zoning plan. This single coefficient is calculated and applied to all landholders in the project to derive their contribution to the public land. Redistributing land on an *area* rather than a *value* basis, does not provide an equitable approach for the landowners, because many other factors which affect a parcel value, are ignored. Such factors include, land-use, topography, shape, view, proximity to commercial areas, other public facilities, etc. However, during the project, each basic geographic unit of a land parcel should be characterised by a set of some economic, environmental, and spatial attributes.

(2) Decision Making

Land re-distribution is the most crucial part of the entire land readjustment process. In this stage, cadastral parcel boundary locations are changed and landholders are moved to new locations by the planner's judgement only. Due to a non-standardised land re-distribution process, the planners often have difficulty in making a decision about the new land parcel locations. The landowners are, therefore, at risk, because different approaches provide different land locations and benefits to them. Land re-distribution itself is a complex task which requires highly specialised expertise because there are many questions that should be analysed. In regard to the priorities of zoning plans, the questions are, for example, who will receive the new parcels; how will land be evaluated; what criteria and land characteristics should be considered; how will landholders be redistributed or be consolidated so that landowners will be satisfied, etc.

(3) Information Management

Analysing existing spatial information, searching legal land records and providing outputs for land readjustment applications are done with conventional manual methods which are time-consuming and error-prone. Sometimes, the information is not readily available for later use because of poor information management. Following the procedures in land readjustment calculations is a difficult task that requires great responsibility and accuracy. When any small mistake happens, whether technical or non-technical, it can mean repeating all the land readjustment processes. Sometimes unnecessary duplication can occur too. Therefore, information cannot be managed effectively and efficiently. In order to deal with all kinds of data within a considerable time period, a capable information management environment for land readjustment should be established with the aid of current spatial information analysis equipment, such as Geographical Information Systems (GIS) and Land Information Systems (LIS).

1.3 Research objectives

Considering the technical issues of land readjustment applications, a new approach to land readjustment has been developed in this study. The main objective of this research is to design and develop an automated urban land readjustment prototype model which will, specifically, deal with the land valuation, decision-making, and information management issues of the current land readjustment applications. In order to accomplish the objective of this research, the following specific tasks are considered.

(1) to define the land readjustment concept, and identify the current status of land readjustment structure and its role in a rural-to-urban land use change program;

(2) to classify the issues and requirements for better use of land readjustment, and investigate the potential use of land readjustment in the provision of land for public and private needs in urban areas;

(3) to establish a general framework for the development of a prototype model to increase the qualitative and quantitative capacities of land readjustment method;

(4) to design an algorithm which deals with the land valuation requirements and provides an equitable approach to land distribution process;

(5) to develop application software which deals with the prototype development requirements and provides a solution to entire land readjustment process in a single package;

(6) to introduce GIS/ LIS to the land readjustment model, to establish an effective information management environment for users and evaluate the capability of GIS/ LIS with land readjustment applications;

(7) to test and demonstrate the entire prototype model with a case study;

(8) to report the study results, and to make recommendations for further development.

1.4 Methodology

In order to achieve the thesis objectives, the outlined problems were individually examined. A solution to the combination of these problems was attempted in a single model. First, it was necessary to gain some background information on the concept of the land readjustment method, with its potential use, shortcomings, and requirements.

An approach for the land valuation problem is that each basic geographic unit would be characterised by a set of economic, environmental, and spatial attributes. To determine the value for land parcels, an understanding the land valuation concept was also needed. Usually the objective of land valuation is to determine *market value*. In this study, *value* is used as a *nominal asset value* which represents a land parcel's significance when compared to others. Hence, value is a numerical parameter for each land parcel, rather than a real market value. The nominal asset values are calculated from the combination of selected land valuation factors. A survey was carried out to classify land valuation criteria which can affect the total perceived value of a land parcel. Then, each land parcel is spatially analysed with regard to determined valuation criteria.

In addition, some terminology on computing technology matters were also reviewed, relating to spatial data processing demands. The concept of land-related information systems, and data organisation in such a system were also investigated. GIS and LIS are used to serve and support the entire model for data collection, storage, retrieval, and spatial analysis requirements.

Since every country has its own land policy system, documentation of the land readjustment procedures is not standardised world-wide. Therefore, land readjustment implementation depends on the land policy and the other land-related acts of the country. In this research, as a case study for a developing country, Turkey has been selected to examine the land readjustment procedures. The Turkish Land Readjustment Act, existing cadastral standards and zoning rules were considered during the case study. All required textual and non-textual data were obtained from Turkey.

1.5 Thesis outline

Chapter 1 gives some of the problems of the land readjustment process, the objectives of this research, and the study methodology.

Chapter 2 outlines the concept of land readjustment with its importance in the urban land development process. Land readjustment practices in some countries are also reviewed. Some examples of the land readjustment process are also included.

Chapter 3 proposes a new approach to land readjustment. A value-based land readjustment prototype model is detailed with its conceptual design and requirements.

Chapter 4 overviews the current land-related information systems. Particularly, terminology, definitions and components of GIS and LIS are described.

Chapter 5 includes the software design and algorithm development of the proposed model. Based on the combination of the ideas in Chapter 3 and Chapter 4, the proposed model is described using the data processing and spatial analysis functionality of GIS.

Chapter 6 describes and gives the details of the software components. The procedures, requirements, file management, spatial analysis, data input and output activities are explained.

Chapter 7 presents a case study and examines the results of this study. In order to implement the proposed prototype model, it has been tested using currently available data from Turkey. This gives a practical demonstration of data collection and integration using the developed software.

Chapter 8 outlines the conclusions of this work. Some suggestions are also included for future work that would extend the research already performed.

CHAPTER 2

LAND READJUSTMENT

> "Land readjustment as a different approach to financing urban development combines significant advantages with a number of technical complexities. It is no panacea for the staggering problems of furnishing infrastructure to a world likely to double its urban population in the next few decades. On the other hand, it is a device that deserves to be understood, and possibly experimented with, in many countries currently unaware of its existence and possibilities."
>
> (Doebele, 1982)

2.1 Introduction

In 1990, United Nations Centre for Human Settlements adopted a resolution that:

> "Under land readjustment programmes, undeveloped areas, usually an urban fringe, can be designated for improvement, including the rearrangement of plots, the grading of land, the construction of roads and the provision of infrastructure. Instead of paying a betterment levy, landholders must surrender part of their land to the local authority as payment for the improvements. The local authority can then resell this portion of land to recoup the improvement costs."
>
> (HABITAT, 1990)

Land readjustment is one of land management methods used in urban development or redevelopment processes. It is the process of bartering raw land for serviced land, and is therefore suited to countries where governments find it difficult to finance public infrastructure investment (Shoup, 1983).

In this chapter the concept of land readjustment method is outlined with its historical background, techniques, and the main characteristics. The potential use of land readjustment in urban land development is also explained with the advantages and disadvantages of the method.

2.2 Urban development

Modern urban areas are burdened with many problems such as: population concentration, deterioration of living environments, necessity for preventing fires and other disasters, traffic congestion, insufficient housing and housing sites, sprawl phenomena. To increase the supply of serviced land to accommodate rapid urbanisation, Grimes (1982) expressed that there are four major objectives of all that public authorities are trying to achieve in cities.

(1) There is first the need to identify or select locations where growth should be accommodated.

(2) These locations should be serviced in a cost-effective, rather than a high-cost manner.

(3) The financial burden on public bodies resulting from the infrastructure provision should be reasonable. Typically this means that costs should be recovered from the ultimate beneficiaries to the maximum feasible degree.

(4) There should be means of encouraging the right type of development on the land once it is serviced. Desirable land uses may be those that increase the access of poor families to housing and jobs; or that to do not result in large increases in land values; or in general that promote any policy objective that it is felt to be worth while.

2.3 Land use control mechanism

Governments in all countries have perceived the need to control the use of urban land in the general interest of the community. Land use in the community interest involves more than the recognition of spillover effects on contiguous land. One objective is to provide public amenities, such as open space. Another is to increase efficiency of land development or redevelopment for more desirable purposes. In land use, there are distributional aims such as making land available to all groups in the community and ensuring that the benefits of development go to the community as a whole. To achieve these aims, Courtney (1983) indicated that there are five common forms of land use controlling mechanism. These are;

(1) Zoning
(2) Subdivision
(3) Building regulations
(4) Approval by government agencies
(5) Urban planning

2.3.1 Zoning

Zoning is the demarcation of a city by ordinances and the establishment of regulations to govern the use of the zoned land (Courtney, 1983). It also includes general rules about location, bulk, height, and thus plot ratios, shape, use, and coverage structures within each zone. It is an attempt to organise and systematise the growth of urban areas by setting up categories, classes, or districts of land in the community. It also prescribes the uses to which buildings and land may be put, and applies uniform restrictions on the shape and placement of buildings. The main objectives of such regulations are to improve efficiency, to provide land for public good and services.

Zoning is also used to affect the distribution of benefits, especially the protection of the rights of existing owners, although it can be used more positively to release land for redistributional purposes such as low-income housing.

2.3.2 Subdivision

Subdivision regulations govern the development of raw land for residential or other purposes. They prescribe standards for lot sizes and layout, street improvements, procedures for dedicating private land to public purposes, and other requirements in far more detail than in the zoning plan. They also include procedures for filing maps and for receiving the approval of the public departments that grant permission. In the main, the objective of such detailed controls is to ensure that developments take account of the community's need for public goods and services, of minimum standard requirements.

The subdivision of land prior to development is one of the most important determinants of neighbourhood patterns. Once the size and shape of lots have been defined, the essential character of land uses, street patterns, and public utilities is determined. Lot size and shape also strongly affect the type, size, and quality of structures and the density of population.

The regulation and planning of subdivision on the outskirts of cities are widely accepted as essential to development. It has been practised in many developing countries for private development and the specification of public involvement. Subdivision is an effective way of controlling land-use, but current standards are often too high, too detailed and flexible, unrelated to local conditions and often even to the planning objectives of the community .

2.3.3 Building regulations

Building regulations limit or define the way new structures are to be built and the materials to be used. They may also be applied to the maintenance and improvements of existing buildings. They may prohibit the erection of any structure what so ever or restrict the style of architecture, the position of the building on the lot, or its distance from the street, its height or depth.

Building regulations are one of the oldest and most common methods of controlling land development. These are defined for a specific local, regional, or national area, depending on the size of the country, the political structure, the variations in climate, local standards, and other factors.

2.3.4 Approval by government agencies

Approval by government agencies is the main way in which controls over development rights, subdivision, and building are enforced. Generally, building permits are required to ensure compliance with the local by-laws and in some cases with the general city plan. A building permit is usually granted tentatively on the basis of schematic designs of the proposed building or group of buildings prepared in line with zoning, subdivision, and building regulations. The design is finally approved when the full set of contract documents is available.

2.3.5 Urban planning

In the broadest sense, planning is the allocation of scarce resources to achieve certain goals, and it therefore includes most functions of government. The common use of the term, however, refers to the process of making decisions about the physical environment and evaluating how changes in this environment affect people and the economy in relation to some specified objective. The plan is then put into operation with the use of the regulatory instruments.

Courtney (1983) also pointed out that the most commonly used planning processes are: comprehensive general planning, master planning, and action planning. Comprehensive and master planning tend to assume a static or slow-growing urban situation, quite manageable in terms of public investment decisions, and the long-range planning of major infrastructure projects. This assumption is usually close to reality in developed countries, where a prime objective of planning is to maintain the established order. Developing countries, however, are characterised by rapid growth, a major backlog of demand for infrastructure investment, and heavy competition for the limited financial resources. The pressing urgency of change with limited resources requires a more dynamic planning process.

Action planning highlights the critical issues, identifies the priority investments for infrastructure, and thereby establishes the areas in which growth and changes should occur. It is applied not only to the expansion of the city, but also to the renewal, upgrading or densification of older areas. Such planning does not require elaborate data gathering and can readily become an ongoing process involving selective action in key areas. It requires that priorities be established and that planning and decision-making be responsive to them. When the planning process is used to guide key investment decisions, it becomes an important positive tool in controlling and influencing the pattern of development and thereby encouraging efficiencies in public resource allocation over time and space.

2.4 Land management methods

Dunkerley (1983) stated that the unprecedented expansion of urban population in most of the developing world is causing an exceptionally rapid increase in the demand for urban land. Land location is specific, and existing urban plots cannot be reproduced. Thus the rising demand for urban land tends to be met primarily by converting rural land at the periphery of the existing built-up area. The subdivision of agricultural holdings and the provision of access roads is followed by the extension of other services.

In order to handle and manage these requirements, first it is necessary to make an appropriate and extensive plan. To realise this plan, it is crucial to take into consideration most important objectives to be accomplished and the conditions of the project area so that the most appropriate, concrete programme of urban development and land management may be selected. There are various urban development and land management methods and projects, which can be categorised in many ways (NCPB, 1982; Rhind and Hudson, 1980; Davis, 1976).

Table 2.1 attempts to categorise some land management methods so that they are contrasted with land readjustment.

2.5 Historical overview of land readjustment

The origin of land readjustment concept goes back to the German Lex Adickes' Law, which was adopted in Frankfurt-am-Main in 1903. Kuppers (1982) outlines an early form of land readjustment in Germany. As a result of its central position on the Rhine and Main rivers, the town of Frankfurt-am-Main in Germany entered a phase of rapid development as a centre of trade and industry after being annexed by Prussia in 1886. After the Industrial Revolution in Germany, building activities rapidly increased in Frankfurt-am-Main. In 1891, Franz Adickes was elected Lord Mayor of the city, giving priority to providing building sites. Intensive development of residential areas and shortage of building sites had caused property prices in Frankfurt-am-Main to soar despite political and administrative efforts being made to keep property taxes in line. One politician called for the value increase accrued by the conversion of farmland to building land to be confiscated by taxation. It was Adickes and Guastave Lube who were to initiate property reorganisation by voluntary regroupment contract.

Adickes' initial efforts at land regroupment were based on an exchange of property with private landowners in return for handing over suitable parcels for building streets and other facilities for the city. It was not always possible to reach agreement with those whose properties were to be affected. Therefore, most regroupment took place in areas where property owners were most agreeable to process, not necessarily where it was needed the most. It was also difficult to consider small property owners in new allocation schemes. They were not interested in exchanges, and many requested that the City to buy their properties outright. The City often refused, as prices demanded were too high.

In 1902, new Land Regroupment bills were submitted to the Prussian Diet with provisions stating that regroupment could take place by petition of one-half of the owners within the regroupment area. The head of local government would be responsible for project, and the new law would be applicable only to Frankfurt-am-Main. Its basic form was seen as giving maximum security to the rights of property owners. The "Act Concerning Regroupment of Property in Frankfurt-am-Main" became law on January 1, 1903. Contained in Article 13 of the Act was clause stating that monetary compensation was to be given to owners when land required for streets and other public facilities was more than 30% in excess of the amount of land surrendered by the owners.

In 1907, the level of expropriation without compensation was raised to 40% when regroupment was initiated by property owners, 35% when initiated by resolution of City Council. After the foundation of the Federal Republic of Germany, the German Bund passed the Federal Building Act in 1960. In this Act, articles 45-122 contain provisions on regroupment boundary regulation, expropriation and compensation (Kuppers, 1982).

In addition to German experience, land readjustment was also widely used in Japan, South Korea, Taiwan, Turkey and some cities in Australia and Canada (Archer, 1992; Yomralioglu, 1992). It has also been adopted in Indonesia and Nepal (Archer, 1986; Sjahrul 1987; Acharya 1988). The implementations of land readjustment in some of these countries are mentioned in section 2.13.

2.6 Definition of land readjustment

The term land readjustment has been used under different names in the literature. Such names are, *urban land readjustment* (Chou and Shen, 1982); *land readjustment* (Doebele, 1982; Minerbi *et.al*, 1986); *land pooling* (Archer, 1982); *land regroupment* (Kuppers, 1982); *land reform* (King, 1977); *land reordering* (Davis, 1976). Sometimes, the term land readjustment has been confused with the concept of *land consolidation*. Doebele (1982) has expressed that;

> "For uniformity, the term *land consolidation* has been reserved for descriptions of procedures that change the boundaries of rural or agricultural and forest land, while *land readjustment* has been used for projects in urban areas or that have as their objective the conversion of rural land to urban building sites or the redevelopment of existing urbanised areas. Since this mechanism has not yet been much discussed in English, it is hoped that *land readjustment* can become the commonly accepted term."

To contribute to the standardisation of a commonly accepted phrase, the term *land readjustment* has been preferred to use in this thesis.

There is no any international accepted definition of land readjustment. However, some authors have expressed some different definitions as follows:

> "Land readjustment/ pooling is a technique for managing the urban development of urban-fringe lands, whereby a group of separate land parcels are assembled for their unified planning, servicing and subdivision as a single estate, with the sale of some of the new building plots to recover the costs and the redistribution of the other plots back to the landowners."
>
> (Archer, 1992)

> "It is a technique by which public facilities in a certain area, such as roads, parks, and sewerage that are necessary for life, are created and/ or improved, and individual sites are made easier to use and their site utility is increased by dividing them into more regular shapes."
>
> (NCPB, 1982)

> "Land readjustment is an instrument for land organisation, which means both the provision of land needed for public purposes and the suitable formation of private land according to the rules of town planning."
>
> (Seele, 1982)

In a simple meaning, land readjustment can be defined as a land reformation process, because it changes the original location of land parcel and land-use within the project area. Conceptually, land readjustment aims to take rural or unplanned urban land, usually irregularly subdivided, and re-allocate it in the required balance for public and private use according to town planning requirements (Figure 2.1).

The concept is a simple one. When there is a need to develop a suburban area, first, a site plan is prepared by the municipality. Then the area is subdivided into an appropriate pattern of streets, parks, schools, and sites for other uses. Within site blocks formed by the streets, new lots are allocated for private development. Public use areas are then determined by measuring the square meters in the planned streets, parks, and so forth and comparing them to the total area of the project (Doebele, 1986). Each cadastral parcel is converted into building lots. After the project the city will be able to reorganise urban development, and at the same time, the private landholders will receive new lots which are as near to the same location as possible to their original land.

2.7 Objectives of land readjustment

Land readjustment aims to manage existing land structure when a systematic urban land development is required. The main objectives of a land readjustment project may be given as follows:

- Development of new urban sites
- Redevelopment of an already urbanised area
- Improvement and expansion of public facilities
- Disaster rehabilitation

2.8 Procedures in land readjustment

There are a number of steps to accomplish in a land readjustment project. Differences in the national land policies from one country to another mean that, to adopt the land readjustment procedures, slight changes will be expected. However, the steps in the process will be given here in a general context. A sequential order of land readjustment procedures is also given Table 2.2.

2.8.1 Decision of the authorities

To implement a land development project in a particular area, there must be a real land need for public and private requirements. For this purpose, a land readjustment project is designed and proposed to local authorities by the land planning branch. Then the city council discusses the alternative approaches and makes a decision about the project. If the project is approved by the council, all landowners in the project area, including corporate, communal, and association ownerships are informed. Land owners in the project area are asked to contribute an equitable portion of their land to build public facilities. The rest of the project steps are then carried out by municipality.

2.8.2 Land survey of project area

The basic land surveying works have to be completed before the project is began. All needed legal records and maps such as zoning plan, property map, and topographical maps are updated. Meanwhile, survey control densification is redesigned for further use. After updating the required documents, it has to be ensured that the property and topographical maps reflect the final layout of the project area. All kinds of boundaries such as cadastral parcel, project area, zoning details and site block outlines must be shown precisely in a base map. Using this map, site blocks are demarcated in the field and fixed block corners are re-surveyed and new point coordinates are calculated.

Table 2.2 Steps in urban land readjustment process

1. Determination of the project area
2. Approval of the project by the city council
3. Announcement of the project
4. Completion of detailed plans
5. Survey of the project area, boundaries
6. Owner identification
7. Determination of land characteristics
8. Drawing the implementation plan
9. Re-examination of land records
10. Calculation
11. Subdivision layout
12. Exchange, division, and consolidation of land
13. Land distribution
14. Compilation of records on distribution
15. Compilation of replotting plan
16. Submissions of reports to the authorities
17. Approval of the reports
18. Announcement of replotting plan
19. Hearing objections
20. Notification to landowners
21. Making final corrections
22. Demarcation of new boundaries
23. Drawing of cadastral map
24. Registration of new land rights
25. Distribution of new land titles
26. Final reports

2.8.3 Calculation

In a general term, the calculation process of land readjustment based on three steps (Figure 2.2). These steps are;

(1) All land parcels are put together to form a whole. This only happens in a mathematical way and does not appear in the land register.

(2) The public user areas such as roads, green bands, schools, hospitals are subtracted from this whole.

(3) The rest of the project area is subdivided into building land and redistributed to the original landowners.

In order to follow these steps, the project area is determined on the base map by drawing a precise project boundary. According to this boundary, all land parcels within the project area are determined by the registered legal parcel size. At the same time, basic property information such as parcel ID, location, registration number, owner names, addressees, and other interests are also extracted for further use.

Regarding the project boundary, if a land parcel is entirely involved in the project, the parcel's registered size is taken as an input area. Sometimes, a land parcel can be divided into two or more lots by the project boundary. In this case, only the area which is inside the project boundary is taken as an input area.

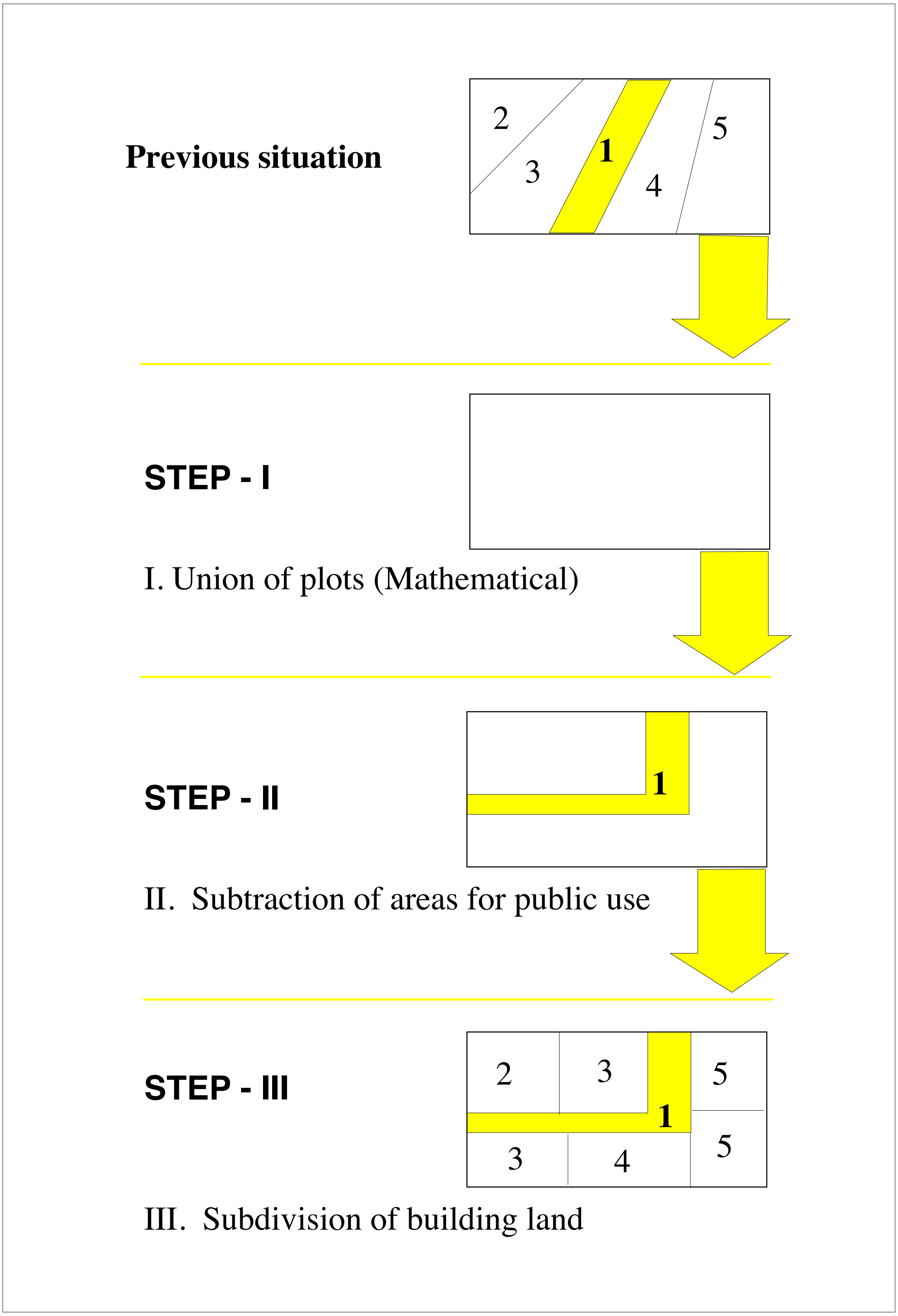


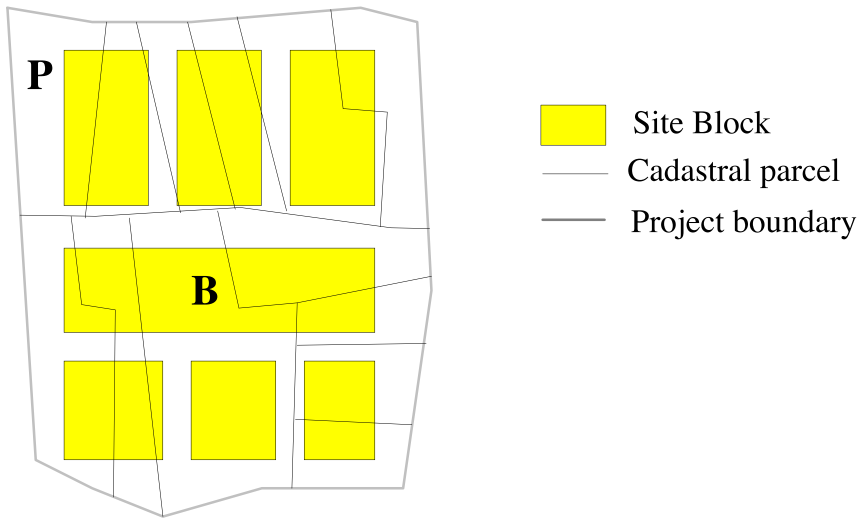
Figure 2.2 Calculation steps in land readjustment process

The determination of participating land parcels is followed by the calculation of site block areas. Using these variables, a single contribution coefficient is determined with the formula [2.1] in Figure 2.3. This coefficient represents the contribution percentages (**CP**) of each landowner by land portion. The **CP** is then applied to each of the land parcels to determine their individual contribution rates (**CR**).

In order to determine the contribution rate, two different calculation methods are practised in land readjustment. One of them is based on ***market value*** approach and the other based on ***areal*** approach. Some numerical examples based on these two methods are given in Appendix A.

2.8.4 Land redistribution

Land redistribution is the most important and complex step of the entire process. The main purpose of land redistribution is to create new building lots by zoning standards and then reallocate the cadastral parcels into the created lots. Within this framework land exchange between individuals and the community, and also among individuals is performed. Landholders receive new lots in a different size and location to their original land parcel. Often several pieces of fragmented lands parcels are consolidated into one parcel. The parcel sizes and minimum area of new lots are given by the zoning plan. The basic principle in the land distribution process is to keep land in its original location as much as possible, at least in the same block.



$$\mathbf{CP = 1 - ([B]/[P])} \qquad [2.1]$$

$$\mathbf{RP = 1 - CP} \qquad [2.2]$$

$$\mathbf{CR_{\mathit{i}} = CP * P_{\mathit{i}}} \qquad [2.3]$$

$$\mathbf{NP_{\mathit{i}} = P_{\mathit{i}} - CR_{\mathit{i}}} \qquad [2.4]$$

where:

CP	**=**	The contribution percentage within the project
[P]	**=**	Total area of the input land parcels
[B]	**=**	Total area of the site blocks
RP	**=**	The percentage of land given back to original landowners
$\mathbf{P}_i$	**=**	Land parcel area
$\mathbf{CR}_i$	**=**	The contribution area for a parcel
$\mathbf{NP}_i$	**=**	Land area given back to owner

i = 1,2,...,n (n = the total number of land parcels involved in the project)

Figure 2.3 The equations in land readjustment

2.8.5 Final registration

After the land distribution, a tentative subdivision layout is announced to the landowners. For a certain duration, landholders can object to the plan by writing their objections to the authorities. Landowners demands are considered by the planning committee and final decisions are made. After possible corrections, new cadastral maps are drawn and new lots are registered by the land title office. New land titles are prepared and distributed to the original landholders.

2.9 Characteristics of land readjustment

Land readjustment basically increases the site utilities when the urban infrastructure is comprehensively developed and improved. According to NCPB (1982) and Nakamura (1986), land readjustment can be characterised by the following features:

(1) **The infrastructure of the urban area can be comprehensively improved on an areal basis.**
A comprehensive project plan for the effective use of the land can be made, and the following improvements can be simultaneously carried out. Public facilities such as roads, parks, rivers and canals can be created and/ or developed; land for schools including nursery schools and kindergartens, and public office buildings can be secured. Supply or disposal facilities for utilities such as water, sewerage and gas can be developed effectively and economically. As a result, site utility is increased when the urban infrastructure is comprehensively developed and improved.

(2) **Landowners receive equitable development benefits.**
When the development project is limited to a road, a park or a river, cost defrayment benefits are often unfairly and partially shared. For

example, some individuals whose rights happen to fall within the project area lose them through purchase, while others may simply benefit because their land, previously located in the back, acquires road frontage. In land readjustment, the development cost and benefits are fairly shared through equitable contribution and replotting disposition.

(3) **Residents of the project area can maintain their normal life.**
Owners of land, leaseholders and other persons who have some rights within the project area can maintain their everyday life and business activities without interruption during the project period.

(4) **No waste in land use is created.**
Since lot shapes and land conditions are altered over the whole project area in a land readjustment project, there are no irregularly shaped and/or excessively small lots created as in the case of the land purchase method. Therefore, site utility does not decrease.

(5) **The project is usually limited to the infrastructure of the urban area, and does not include the direct improvement of buildings in the area.**
The project implementing body does not directly build or improve buildings within the project area. Often in practise, owners of buildings rebuild them or renew their functions when they are affected by replotting.

(6) **The project procedures are complex and it takes time for the landowners to understand them.**
The procedures of land readjustment are complex and require professional knowledge so that it takes time for the owners to understand the project itself. In addition, since many people's interests are involved, it is necessary to listen to their opinions fully, and adjust the project accordingly, which also requires much time.

(7) **Participation by all landowners is a necessary condition of a land readjustment project.**
Contribution is an important characteristic of land readjustment. Landowners within the project area are asked to contribute an equitable portion of their lands in order to accommodate public

facilities. Although landowners lose a small portion of land, they receive great benefit through the project's ability to maximise site utilisation by regularising shapes of lots.

(8) **Land rights are transferred after the replotting.**
Replotting is a unique characteristic of the process. It refers to the redistribution of pre-adjustment sites minus contribution lands for public facilities. All existing land rights and interests from previous sites are transferred to newly-replotted sites. This transfer of rights is called *replotting disposition*.

(9) **Development costs of a land readjustment project are lower than any other type of land development projects.**
In a land readjustment, both costs and benefits of development are shared by all landowners through equitable contributions and replotting disposition.

(10) **The land registration books, cadastral maps, street names and number can be arranged in an orderly manner, clarifying the boundaries of ownerships.**
During the land readjustment project land parcel boundaries are resurveyed and redemarcated according to the detailed urban planning programme. All related land records are reorganised. Therefore, the practice of land readjustment can be considered as a method of strengthening of the cadastre.

2.10 Advantages of land readjustment

Land readjustment is a crucial land management tool in urban planning when suitable reformation of private land is necessary for residential purposes. It is a method by which the city government, other designated public bodies, or even private associations can participate directly in the process of urbanisation and thereby share in its profits (Muller, 1992). Land readjustment projects provide an opportunity for simply and inexpensively resurveying the land and demarcating new and clear lines (Chou and Shen, 1982). Therefore, the practice of land readjustment can be considered a way of strengthening the reorganisation of cadastre. Minerbi (1986) pointed out that land readjustment;

- ***mobilises*** landowners in a temporary association for joint development of their fractionalised land parcels as a single planning unit,
- ***phases*** private structure development with public infrastructure provision,
- ***coordinates*** public planning with private development with a detailed administrative process,
- ***improves*** districts by providing infrastructures and facilities in appropriate locations according to a district design plan by reserving private land at no cost to the government,
- ***appreciates*** land values through public improvements and increased site utility,
- ***finances*** development by the sale of appreciated reserved land to new investors.

In addition, some of the advantages of land readjustment has been given by Doebele (1982) as follows;

- Land readjustment permits fragmented and scattered landholdings to be consolidated into a single unit for better planning, servicing, and subdivision,
- Land readjustment permits the public agency concerned to recover costs while private owners receive some of their land back, ready for building,

- A prerequisite and advantage is that it renew cadastral and land registration in those areas of a city under most pressure for development,
- Land readjustment permits an orderly and efficient method of obtaining sites for schools, parks, markets, and all other needed public buildings and facilities.

Besides the improving land utilisation for government, land readjustment is also a significant method for landowners to economically improves the use of their land. In essence, some benefits of land readjustment for both government and landowners may be given in Table 2.3:

2.11 Shortcomings of land readjustment

While land readjustment remains a strong urban development and redevelopment tool, a number of shortcomings of the method has been identified by Nishiyama (1980), Miyazawa (1982), and Satoh (1986).

A significant criticism is that land readjustment has succeeded in providing physical facilities, but that it neglected social aspects of urban life and failed to improve the community environment as a whole. An equally significant criticism is that the major beneficiaries are only large landowners. At the same time, landowners have protested at reduction of their land area without compensation through the readjustment process.

Table 2.3 The benefits of land readjustment for the government and landowners.

Land readjustment benefits for the government

- Compensation expenses for public-use land are greatly reduced so that the provision of public areas is captured in a more economical way,
- A zoning plan is realised in a short time, and urban land development projects are achieved rapidly,
- Tax revenue increases within project area. This provides an extra source to government,
- The land development programmes in urban fringe areas are systematically carried out,
- The existing cadastral records are updated, reorganised and cadastral administration is improved.

Land readjustment benefits for landowners

- After the project, land values increase very rapidly and land become more valuable for landowners,
- A cadastral parcel is re-shaped and transformed into a sufficient site lot that can be used more economically,
- Fragmented small parcels are consolidated into a new building parcel so that land use are maximised,
- Because of the effects of land readjustment project are same for every landowners, disputes about land planning injustices are reduced,
- At the end of the project, basic public services are supplied to new lots, therefore the new social services are brought into to the project area,
- There is no extra charge to landowners for the project expenses, except that they forfeit part of their land. In many case, all project expenses are met by the municipalities.

However, Doebele (1982) discusses that the theory of land readjustment is simple but its application can become complex. In fact, three different issues are involved:

(1) **Equity going into project.** Some owners will have flat, easy-to-develop land that already has high value for farming. Others will have hilly, rocky, or marshy land more costly to develop. Equity would seem to indicate that the former owners should receive better treatment in the calculations than the latter.

(2) **Equity during the project.** The actual construction of roads and other urban services can take years in a large project. Some land plots will be immediately impacted, particularly those falling in the beds of planned street, while other land will be much less affected. Equity indicates that some adjustment be made for those who have most difficulty and loss of income during the construction.

(3) **Equity after the project.** The new plan for the area may designate some areas for commercial uses, some for industrial or other productive uses, some for high-density residential development, some low-density residential use, and so forth. Each of these designations carries a different per square meter value. A lot near the centre of a large project and designated commercial may have many times the value per square meter of a low-density residential lot on the periphery of the project. An equitable system would adjust for these differences so that an owner whose land happens to be designated commercial, for example, does not receive a windfall compared to another whose land the plan has put to a less valuable use.

2.12 Requirements for land readjustment

According to Davis (1976) and Doebele(1982), some of the requirements for land readjustment may be given as follows:

(1) In most countries, major new national legislation will be required and, in some cases, constitutional amendment.

(2) The national, provincial, and municipal governments must support the idea. In particular, the key ministries that deal with public works should be thoroughly sympathetic to making it work.

(3) There must be real and generally recognised need. This is certainly so in a well-developed political democracy. Land readjustment is slow, complex, and expensive; realisable and commensurate benefits must be obtained from the process.

(4) There must be a reasonable stable and strong national economic situation. Public assistance of various kinds, usually including subsidy, is needed in substantial amount.

(5) The country must possess an efficient system of cadastration, title registration, and objective real-property appraisers.

(6) There must be, at the local level, an adequate level of technical and professional knowledge.

2.13 Selected land readjustment applications

Land readjustment has been widely practised by some countries around the world. Particularly, under the different names as stated in section 2.6, the land readjustment has been used in Germany, Japan, Taiwan, South Korea, Canada, Indonesia, Nepal, Australia, and Turkey as an effective urban land development tool. These countries have different land policies and land registration systems. Because every country has its own land readjustment legislation, there is not one single land readjustment model that has been standardised and used world-wide. Nevertheless, the main concept of land readjustment has been commonly recognised by these countries, even though implementation and procedures are slightly different. In order to understand how the process has been practised, some land readjustment applications in Australia, Taiwan, Japan, Germany, and Turkey are summarised in the following subsections.

2.13.1 Australia

Land readjustment is known in Australia as land pooling (Archer, 1992). It is a technique for the financing and management of the subdivision of privately owned land into well-planned serviced building sites. It is based on a scheme, or plan, prepared by a local municipal council, after consultation with the landowners involved. After proper adoption it constitutes a binding and compulsory partnership among the owners for design, servicing, and subdivision of their lands as a single estate, with both cost and returns being shared among them (Doebele, 1982).

Land pooling has been used only in the state of Western Australia, mostly in and near the state capital of Perth since 1951. The process has been carried out mainly on land not occupied by owners and usually has yielded substantial profits, often with fewer management problems than conventional development. For this reason it has generally not been resisted by landowners when they have been consulted in advance, even though after consultation it is compulsory. An important aspect of the Australian system is that detailed written statements of the costs and benefits are usually available to each landowner at the key stages of the project. While some aspects are compulsory for minority owners, every owner has enough information to act in his best interest as the project proceeds (Archer, 1982).

In the Australian system, the council prepares a scheme plan and text. The Valuer assesses the market value of each parcel (excluding any buildings) as it is at the time, and then as if the parcels had been subdivided into fully serviced building sites. The cost of subdividing and providing services are computed by the council, and the number of building sites needed to recover these cost (cost-equivalent land) is computed. These sites are tentatively identified, and the remaining sites are allocated among the participating landowners. These owners are informally notified of the allocation before the scheme is officially exhibited. After public exhibition, owners may file objections, which are reviewed by the town planning board in its report to the minister for urban development and town planning. After his review and approval, the scheme becomes legally binding.

The municipality then makes a formal land ex-change offer to each owner, who may accept or request arbitration if there is a disagreement about the values assigned. Meanwhile, the municipality takes out a short-term bank loan and, through the minister of public works, takes over the land and carries out the surveying and engineering works necessary to create finished building sites. At this point, any owners who want to get out of the project may claim cash compensation for the land taken. Most owners, however, find it much more profitable to stay in the project and receive back their share of building sites.

When the construction work is completed, roads, parks, and other public lands dedicated, and the subdivision registered, each landowner receives back his share of sites, with whatever cash adjustment may be necessary to maintain the same relative values as values of the land put into the project. The council sells its cost-equivalent lots at auction and uses the proceeds to pay off the bank loan. Any surplus is distributed among the participating owners.

An interesting feature of the Australian system is that lands are valued only when they go into the project. This establishes a percentage share for each owner. When the project is complete, the owner receives exactly the same percentage of the total value of all the lots created, less those taken as a cost-equivalent land. If the lots actually received back have less or more appraised value than the percentage share, a cash adjustment is made so that each share is kept equal (Archer, 1982).

2.13.2 Taiwan

For decades after the founding of the republic of China in 1912, wars and social commotions prevented the solution of land problems in the country. To solve China's land problems, Dr. Sun Yatsen called for equalising land rights, allotting land to farming, maximising returns from land, and assuring equal access to benefits from land. These ideals were incorporated in the republic's constitution, adopted in 1949. In those days, Taiwan reflected the situation in mainland China, the distribution of landownership was unequal; land tenancy was prevalent; rents were too high; tenant farmers had no reasonable rights; agricultural production was low; and the tenant's life was precarious (Lee, 1982).

When the government of the Republic of China moved to Taiwan in 1949, the government determined to make the island province a model for all of China. In Taiwan, agrarian land reform, which had been part of the philosophy of Sun Yatsen, but which could never be realised on the main land, was vigorously implemented in the early 1950s. However, this reform, which split up large estates into plots owned by the tillers, created new problems. The new plots were small, irregular, and sometimes in different locations. For efficient production, it was necessary to reunite them in a way that would permit common irrigation systems and use of machinery. Therefore, agrarian land consolidation was begun on a trial basis in 1958, and extended to a national program in 1962. From the agricultural productivity point of view, the results were quite successful (King, 1977; Doebele, 1982).

In spite of this success in rural areas, Taiwan has been slow to apply similar principles of land readjustment to urban development. In Kaohsiung, which is the second largest city of the country, urban population surged, primarily in the form of numerous squatter settlements of high density and very poor housing and sanitation conditions. Fragmented and tiny landholdings, plus the squatting, rendered the private market ineffective (Chou and Shen, 1982). To solve these problems, the municipal government had extremely limited financial resources. However, an active municipal administration in Kaohsiung has developed its own rules and procedures for urban applications.

The municipality had two alternatives to deal with these problems. First, large-scale expropriation of private lands, which would be cleared of existing irregular housing, were developed as a unified project with adequate public services, subdivided, and then resold to individual developers. Second alternative was the land readjustment, which would achieve the same ends, but by taking part of the land to finance the installation of services and returning the remainder to the original owners.

After considering the alternative advantages and disadvantages, the city chose land readjustment as its main vehicle for urban development. In Kaohsiung, the land office stated that the land for public uses, engineering expenses, and consolidation expenses should all be contributed by the benefited original landowners. Furthermore, such liability could be paid with land instead of cash. According to a resolution of the city council, the maximum contribution amount cannot exceed 40 percent of the total original area. Moreover, the land used as payment must be vacant land (Chou and Shen, 1982).

Appraisal of land value before and after readjustment is based on the Land Law. According to this law, the readjusted plots must be redistributed in compliance with the original land or price of the original plots; after the readjustment, landowners who suffer losses shall be compensated by those who enjoy the benefits. However, there is no criterion for determining the land price in this law. Generally, in assessing value, adjoining lands with similar prices are considered and their value is used as a standard for the appraisal of lands before the project. For appraisal of the land value after the project, it is necessary to estimate the likely development after readjustment, using for reference real-estate sales and purchases in neighbouring areas already developed to determine the value of land.

By the end of 1978, a total of 2,175 hectares in forty-nine areas have been completed under the land readjustment programme. Statistics on sixteen areas where urban land readjusted indicate that the increase in land values ranges between 560 and 163 percent. The government estimate that urbanised land will expand by 1996 to a total of 161 500 hectares, double the present area. In view of this, the readjustment of urban lands must be accelerated to forestall difficulties that might obstruct growth (Lee, 1982). The government is also working out incentives to encourage landowners to organise themselves for the purpose of introducing readjustment of their own lands.

2.13.3 Japan

As in Taiwan, land readjustment in Japan had its origins in agricultural land consolidation to increase the efficiency of production. In 1919, the first City Planning Act legitimised land readjustment for urban purposes. Land readjustment became so popular that it diverted energies from conventional city planning, and was of great importance in re-building, both after the great earthquake of 1923 and bombings of World War II, as well as in solving the land problems connected with the construction of the high-speed rail line from Tokyo to Osaka. In 1954, land readjustment legislation was enacted. Land readjustment has been one of the most important forces shaping Japanese urbanisation (Doebele, 1982). Of a total urban area of 5,600 square kilometres in Japan in 1965, about 27% either had been or were under land-readjustment procedures. From 1945 to 1965, some 900 square kilometres were affected, much of it around cities, often by private associations formed for this purpose (Miyazawa, 1982).

In Japan, five groups are legally allowed to execute a land readjustment project: private initiators, associations, local public bodies, administrative agencies, and public corporations. For each type of initiator there are slightly different procedures, but all involve public exhibition to comment and ultimate review by either the governor of the prefecture or the minister of construction.

In the land readjustment procedure, *equity* is the most important issue to success of the project. There are two levels. One is the economic effectiveness of the project: that is, the increase of private land values brought about by the project. The other important factor is equity between each landowner involved. The principle of replotting not only considers the equity of land value, but also the location, nature of the land, the area of lot, and other factors affecting each owner (Hayashi, 1982). In Japan, the replotting work is performed by the *evaluation method* of land value, or the *areal method*, or a combination of the two (Nakamura, 1986).

Evaluation is normally based on the street-value method, which has two-tier evaluation. One relates to streets, and the other individual lots. The street value normally uses index figures consisting of a *street coefficient* , an *accessibility coefficient*, and a *lot coefficient*. The street coefficient normally considers the condition of the street, its width, slope, existence of sidewalk, continuity, and so on. The accessibility coefficient deals with the proximity of railway stations, bus stops, schools, parks, and other amenity facilities. The lot coefficient deals with the environment condition of the land, or lot, such as density of the area, soil conditions etc. These three coefficients are aggregated to achieve the street value. This value must be adjusted according to land-market prices in the area, judged by sales or by such indexes as the property tax evaluation.

The areal method is based on the area itself. This method is adopted where land prices are similar or where a poor street pattern renders the street-value method inappropriate. The areal method is extensively used for perimeter development by private land readjustment associations, because it is more easily understood by the landowners. The contributory area is divided into two categories. One category is the cost -equivalent land and communal facility sites. The cost-equivalent land is sold to pay for infrastructure and other costs of the project. The other category comprises the individual contribution area mainly narrow street sites and the part adjacent to the lots of major streets. In other words, expanded street sites under eight meters are contributed by adjacent lots (NCPB, 1982).

The land readjustment process gives landowners and lessees the opportunity to express their objections to execution of the projects under the Administrative Appeals Law. In Japan, the largest number of complaints are concerned with replotting, followed by disputes about the amount of money for adjustment. Landowners often feel unfairly treated because of the reduction of land area without compensation through the process. Thus, opposition against land readjustment has become rather strong; a nation-wide organisation of opposing groups has been formed (Miyazawa, 1982).

However, the important role of land readjustment in planned urban development has been commonly recognised in Japan. The projects affect many fields, such as housing land supply, urban-sprawl prevention, reconstruction after disasters by war and fire, and redevelopment in commercial areas.

2.13.4 Germany

In Germany land readjustment has a tradition of about one hundred years (Muller, 1992). As in other countries, land readjustment in Germany began with the problem of consolidating agricultural land for greater productivity. With industrialisation, unrestrained urban development resulting from the haphazard marketing and development of small lots produced legislation to compel the consolidation of undeveloped land. If landowners are unwilling to voluntarily readjust and consolidate land into reasonable areas for development, municipalities may force orderly development by: compulsory readjustment; compulsory expropriation; or consolidation of farmlands or woodlands. In general, compulsory readjustment is used for peripheral areas; compulsory expropriation is used in areas for the promotion of urban development; and consolidation is used in agricultural areas.

All three systems make use of the highly developed German system of valuation boards, which since 1960 have been required to collect and analyse data on all real estate transactions. Land valuation boards receive copies of all contracts of purchase for real estate. Procedures for analysis are set forth in special federal legislation. Projects carried out by compulsory readjustment take about one to three years for reparcellisation, and about two years or less for the installation of services. Compulsory expropriation takes more time, and individual parcels are generally not on the market for about six years and may take more than a decade to complete (Seele, 1982).

Compulsory readjustment projects are always carried out by local government and do not require the consent of the owners. In the land readjustment process, market values are used in computing both the allocations of land before and after the project. The first value is representing the value of land without services, the latter value represents all the increments that result from ownership of a fully serviced lot. Indeed, even the zoning designation is considered as part of this latter value. However, no matter what the calculations, not more than 30 percent of the market value of land contributed to the project can be taken. In a typical compulsory land readjustment project, about 15 to 20 percent of the land would be contributed for use as roads and green areas, and the landowner would then be assessed in cash up to 5 to 10 percent of the market value of his input to pay for construction cost (Doebele, 1982; Seele, 1982). Thus, the German system basically differs from the others in that contributions to recover the costs of services are normally made in cash, not in the form of cost-equivalent land.

There are two different measures to redistribute the new land. The portion of redistribution the individual landowner is entitled to results from the relation either of *market value* or of *area*. In rural regions, *land readjustment by area* is more common. In urban regions and in redevelopment areas *land readjustment by value* is preferred. To decide on one of those two measures, there are different conditions and results to be taken into account.

Land readjustment by area can only be applied if the land values are quite homogeneous. In this case the land contribution for public-use cannot exceed 30 percent of the landowners individual area. Concerning land readjustment by value the whole redistribution area is divided among the landowners, except the areas needed for public facilities. Each landowner gets a plot corresponding to at least the same value he had before the project. The land value increase caused by the land readjustment project is compensated either by money or land. The municipality has to pay for administration costs. In generally, the municipality is able to refinance by selling the areas of land contribution which were not necessary for public facilities. The construction of sewerage, roads and green areas has to be paid by the landowners up to 90 percent of the cost as a infrastructure contribution (Muller, 1992).

The landowners can appeal against land readjustment when the measure is introduced and when it is completed. Judicial determination is by special courts of law and can only be made after objections to the authority responsible for the project. Protests against the land reallocation plan are mostly against the valuation of either the input or output in case of compulsory land readjustment by values or against the amount of land contribution in the case of compulsory land readjustment by area. At least 90 percent of all appeals are based on this (Seele, 1982).

2.13.5 Turkey

In Turkey, the limitation of financial, human, and technical resources restrict the urban land development process. Because of these limitations the government has difficulty in controlling rural-to-urban land-use change. There is a rapid immigration from rural areas to the cities and the appropriated land is not available in urban fringe to respond to immigration demands. This creates land allocation and settlement problems around the cities. As a result, many squatters have established patterns of land use rights that operate outside of the national cadastral system. The land allocated for public-use has been partly occupied by squatters (Dale and McLaughlin, 1988).

In order to provide land for both public and private sectors and to control urbanisation the government acquires land only in the cities and carries out all necessary tasks itself (Rivkin, 1983).

Most of the land developments are performed by local authorities using master plans and zoning regulations (Gurler, 1983). Basically, there are three different land development methods which are practised by the government. These are; Land compensation, Voluntary method, and Land readjustment.

Turkey has been discussed as a case study for this research. Therefore, details about these land development methods, particularly land readjustment applications in Turkey, are given in Chapter 7.

2.14 Chapter summary

This chapter has attempted to outline the concept of land readjustment. The definition of a land readjustment method was made. The current status of the method including its objectives, requirements, and its role to control the rural-to-urban land use changes have been presented. Some land readjustment applications from different countries were also reviewed.

Land readjustment is a powerful land management tool which provides great opportunities for local authorities when public and private land is needed for urbanisation. It is the process of exchanging raw land for serviced land, and therefore can easily be suited to countries where governments have difficulty to acquire land for public and private requirements.

Although land readjustment is a very effective land planning process in controlling urbanisation some technical issues limit the performance of land readjustment procedures. These issues including their possible solutions will be discussed in the following chapter.

CHAPTER 3

A NEW APPROACH TO LAND READJUSTMENT

3.1 Introduction

In the previous chapter, the land readjustment method was outlined with its characteristics, procedures, issues and potential use for urban land development. It is concluded that land readjustment is a powerful land management tool which provides great opportunities for local authorities when public and private land is needed for urbanisation.

In this chapter, considering the current status of land readjustment, issues and the solutions are specifically defined from the technical point of view. In order to improve the benefits obtained from a land readjustment process, a new approach is proposed and discussed. Based on the objectives of this research, a value-based urban land readjustment model was designed and developed.

The proposed model analyses each geographical unit of a land parcel with respect to some selected substantial and insubstantial land valuation factors. Each of these factors is mathematically expressed, and the *nominal asset values* for the parcels are determined with the combination of these factors. It has to be mentioned that, in this model, the term of *value* is used as a single unit figure which represents a land parcel's worth when compared with others. Therefore, the meaning of value is a numerical parameter of each land parcel rather than a real-market value. To determine this parameter, some land valuation factors which may affect the total perceived value of a land parcel are spatially examined. In order to accomplish the required analysis procedures, the spatial analysis capabilities of a GIS are used during the model development.

3.2 Requirements to improve land readjustment process

As pointed out by Doebele (1986), land readjustment is a complex management tool with economic, physical, social and planning dimensions. Not only the local government authorities but also private bodies are involved in a land readjustment project. Therefore, the interests in land readjustment are very broad. To clarify the research objectives, the requirements in the technical level are only considered during the study. Consequently, the study concentration was particularly focused on the following three requirements;

(1) Land valuation
(2) Decision making
(3) Information management

These requirements are examined individually. Then the solutions to them are tackled and provided within a single model.

3.2.1 Land valuation

The nature of land readjustment constrains the cadastral parcels to transform to new site lots. Hence, within a land readjustment project area, not only existing cadastral boundaries are changed but also the economic values of the parcels. From the economic point of view, these changes very much affect the landowners, land value profiles for the owners can be different before and after the project. Especially, after full implementation of the new plan, the land market-values increase greatly within the project region so that landowners can obtain new and different benefits from the project.

In general, the land valuation issue appears after the project. Most of the objections come from landowners about land valuation. They claim that equitable benefits are not obtained after the project. This is due in part to the fact that, during the project the planners have difficulty to estimate and distribute the benefits which a land-use plan may bring. Land market-values are usually used to evaluate these benefits.

However, in some countries, different approaches have been practised to deal with the land evaluation procedures. In Australia, for example, the land valuation board is established to determine the market value of the land parcels. After the project, a cash adjustment procedure is applied among the involved land owners. In Germany, annual real-market indexes are considered before and after the project. If the land values are quite homogenous in the project area then the values are ignored during the project. In the Japanese approach, land is evaluated in accordance with the site utilities. Land values are calculated using the index applying the same standard before and after the project. However, in Turkey, land evaluation is not considered during the any steps of the process.

In general, lack of information, funds, shortage of technical and administrative personnel delay implementation of the needed large scale land valuation activities. However, the determination of a land parcel value depends on a number of physical and economic characteristics which must be taken into consideration very carefully in a land valuation procedure. Some of these characteristics are intrinsic to the land, others are external or environmental factors. These factors can be determined in an objective way but there is always a certain degree of subjectivity that is difficult to measure in the valuation process.

In order to provide a more objective land evaluation approach to land readjustment, dynamic land valuation analysis is required. This analysis must deal with some tangible and intangible characteristics of a land parcel during the process. Criteria including location, view, shape, topography, available utilities, proximity to commercial areas etc. should be defined in a mathematical way and involved in the calculation process.

3.2.2 Decision making

Basically, in a land readjustment process, the site blocks which are given by zoning plan are subdivided into the new suitable lots according to the details of the plan. Then, the cadastral parcels are reallocated within these site blocks. During the land reallocation process, some small land parcels can be assembled within a new parcel. This means, a land parcel including its property rights can be shared between more than one landowner. On the other hand, a large cadastral parcel can be divided into more than one parcel. This can occur because new lot dimensions are given by the zoning plan that must be followed during the land subdivision.

Land reallocation is therefore the most complex part of the whole process which is carried out by planners after the land subdivision. Due to a non-standardised procedure, the planners have great responsibility to make decision about land reallocation, because the location of present cadastral parcels are changed, landowners are moved to new locations by the planner's judgement only. Thus, a more effective decision-making process is required to establish a standardised procedure which can be a guide for planners. In the decision making process, the land conditions before and after the project should be evaluated. To provide an equitable approach for landowners, considering the evaluation results and land ownership details, an optimal land distribution algorithm should be designed.

3.2.3 Information management

The examination of required cadastral records, basic calculations, and spatial data manipulation are important tasks during the land readjustment process. Currently used procedures for these requirements are done with conventional manual methods which are time-consuming and error-prone. In the land readjustment process, spatial data handling is a difficult task which requires great responsibility and accuracy, because when any small mistake occurs whether technical or non-technical, it may cause repetition of the whole process. This can also produce some unnecessary duplications in project stages so that the expense of the project increases. Hence, information management is the other issue that affects the performance of land readjustment.

However, a more effective information management process is needed to improve the qualitative and quantitative capabilities of land readjustment. The whole technical procedures and data flow can be automated for more efficient data use. This also establishes a reference for an information management system such as a land information system. To provide an effective information management system, the use of current information technology is essential.

3.3 Development of a value-based land readjustment model

Based on the technical requirements of the current land readjustment process, a new approach to land readjustment was proposed. In this section, the conceptual development of a value-based land readjustment model is discussed.

3.3.1 The aim

In order to accomplish the defined requirements in section 3.2, a new model which is a nominal asset value-based land readjustment was aimed to be developed using the currently available information technology. The main objective of this model is to determine the *nominal asset value* of a land parcel before and after the project with selected land valuation factors, then give back a new parcel to the landowner with the same value as that owned before. In other words, a parallel condition between the land parcel value profiles before and after the project must be provided so that all landowners who are involved in the project are affected in the same way from the land-use plan (Figure 3.1).

In this approach, due to the difficulty of collecting real-market value data, numerical parameters are intended to be calculated and used of for each land parcel rather than using the real-market value. In order to determine these numerical parameters, each geographical unit of a land parcel is analysed for selected land valuation factors. A land parcel value can then determined as a single unit figure which represents all factors effecting the land parcel as compared to others.

Figure 3.1 Land valuation profiles for landowners before and after project

The determination of a land parcel value with a selected valuation factors requires an effective computing environment which has the ability to make complex spatial analysis. Data collection, handling, manipulation, display and production of all necessary information should be done very quickly and accurately. Therefore, the use of some spatial analysis tools such as a GIS is essential.

3.3.2 Land valuation analysis

Land valuation is the process of assessing the characteristics of a given piece of land. The process may be described as a carefully considered estimate of the worth of landed property based on experience and judgement. However, the objective of land valuation is to determine value; a term generally prefaced by some description such as market value or benefit value (Dale and McLaughlin, 1988; Frizzel, 1979).

Land valuation is an essential process for the effective implementation of many development programmes and activities in a country. Land reform programmes, land and property taxation, land settlements and consolidation programmes, small and large land expropriations by governments and other public agencies, land use planning, land development projects, and private sales and purchases of land may be mentioned as fields and activities where land valuation may be needed (Henssen, 1990; Dale and McLaughlin, 1988; Walters, 1983). However, there are three generally recognised and widely used land valuation methods (Rees, 1988; Butler, 1987). These are:

(1) **The sales comparison method;** in which comparisons among recently sold properties are made. The procedure requires collection of all the available records of land sales in the area in recent years, making a scale by classifying them according to the characteristics of the land sold and comparing the land to be appraised with this scale.

(2) **The income capitalisation method;** that entails estimating the presents worth of future income expected from the land. This method takes into consideration the annual net income of the land. The estimated net income is capitalised, at an accepted interest rate, to give the capital value of the land.

(3) **The replacement cost method;** where the value of the land is first estimated separately, the current cost of constructing the buildings and other improvements is added, and then depreciation of the improvements is subtracted.

Selection of a land valuation method may not depend only on the availability or lack of the necessary data which are specially required for each method, but also on the purpose of valuation. With valuation for land reform purposes, market prices may not always be taken as a basis for evaluation because they may be inflated. Neither may capitalised value of potential income be a suitable method, either because the landowners will be better off than they were before or the new owners will be receiving over-priced land with this type of valuation. In this situation a combination of the three methods may be taken as a basis for valuation. More details about land valuation techniques can be found in Baum and Sams (1990), Dale and McLaughlin (1988), Rees (1988), Butler (1987).

The land valuation process plays an important role in the success of any land readjustment project. Yet, different approaches have been practised. In some countries, market value is used during the projects because of the data availability. Sometimes the data may not be available. In this case, depending on the valuation technique, the collection of data can delay the project. After the project, some objections may also arise from landowners questioning the determined value. They claim that the determined value does not represent the real worth of their land. Nevertheless, one of the difficulties is to estimate future values after the project. Due to the new developments, land speculations on market prices may occur during the project time and this also causes problems obtaining accurate market value data.

In reality, it is almost impossible to determine the exact value of a land parcel. However, a sufficient estimation can be done by analysing a certain amount of land characteristics in an objective way. In this research, rather than dealing with the real-market prices, the qualitative and quantitative characteristics of individual land parcels have been examined. To determine the value of a land parcel, some land valuation criteria are selected and formulated so that parcel values are assigned by the numerical parameters rather than real-market values. These parameters are derived from a combination of the selected land valuation factors which can be spatially analysed.

3.3.2.1 Classification of land valuation factors

In order to make an adequate value estimation for a land parcel, there are many tangible and intangible land valuation factors that should be taken into account during the valuation process. The determination and classification of these valuation factors is difficult, because the characteristics of these factors can be objective and subjective, changing according to a person's desires. Therefore, the number of land valuation factors cannot be limited but at least some of the land valuation factors are considered and analysed with respect to the past land readjustment implementations and the procedures of property appraisals.

Before the determination of specific factors, the global land valuation criteria for establishing the comparability of land parcels must be outlined.

3.3.2.1.1 Use of the land parcel

The most obvious land characteristic for purposes of comparison is its present use. Classification according to use is essential because the motives of buyer and seller of residential properties are different from those of investors in commercial, industrial and rural properties. In the case of a land readjustment, land-use is mainly considered for residential purposes. Especially, before the implementation of a land readjustment project, where different types of land use can exist but after the project most of the new land parcels are produced for residential use.

3.3.2.1.2 Characteristics of neighbourhood

The characteristics of a neighbourhood in which land parcels are situated is also important. A neighbourhood is a district of a municipality that serves a particular purpose. The type and size of a neighbourhood is largely determined by its location in relation to other districts in the municipality. The majority of land in a neighbourhood is subject to the same economic forces and most land values rise or fall together. Any neighbourhood, whether residential, commercial, industrial or rural can be analysed on the basis of three factors:

(i) Physical environment; Physical environment of a neighbourhood is the result of both natural conditions and human activities. The natural conditions most significant for neighbourhood development in urban areas are topography and load-bearing qualities of the soil. Human activities are also an important influence on the physical environment of a neighbourhood. The location of the neighbourhood in relation to the business, social and other forms of activity throughout the municipality is one of the most significant characteristics. The influence of human activity is also reflected by the type and architectural style of buildings, service, development, the adequacy of public facilities and the degree to which nuisances as well as health and safety hazards are present.

(ii) Government regulations: Municipal government is the most interested and most active of all levels of government in encouraging efficient development of neighbourhoods. In order to implement their development policies, municipal councils use legislation such as zoning and sanitary regulations, planning by-laws, and subdivision controls. If this legislation is carefully prepared, and efficiently administered, and reflects economic and environmental conditions as these are interpreted by residents and investors in the neighbourhood, development in that neighbourhood will be encouraged. On the other hand, if the legislation is poorly drafted or administered, or if it ignores underlying conditions, development can be seriously hindered.

(iii) Personal characteristics of the owners and residents: These considerations are essentially subjective as they relate to human attitudes, outlooks and prospects. The attitudes of neighbourhood residents towards law and order, towards maintaining their property, towards the future of the neighbourhood, as well as towards their neighbours can have important influence on neighbourhood development. These attitudes are not usually reflected directly in sales but they do impress would be investors and in that way influence development.

3.3.2.1.3 Location of the property

The importance of the various locational characteristics of a property is largely influenced by the use of the property, but there are other factors that apply to all land use. Access to transportation facilities, for example, is always an important influence on property values although the types of facilities that are important vary according to the use of the property. Quantity and quality of municipal services are also important. While every property requires at least a minimum level of municipal services, its use will determine the services required as well as what constitutes a minimum level.

Some location characteristics that affect the value of a residential land parcel may be given as follows:

- Access to major sources of employment,
- Access to major shopping and service areas,
- Access to neighbourhood shopping and service stores,
- Access to schools and religious places,
- Access to parks and recreational areas,
- Distance from sources of safety and health hazards,
- Distance from nuisances such as noise and smoke.

3.3.2.1.4 Site

With regard to urban land the most important site consideration is its suitability for its present use and its adaptability to some other use. The factors that may be examined when analysing the site are:

- Terrain, or topography of the site,
- Load-bearing qualities of the soil,
- Shape and dimensions,
- Landscaping,
- Street frontage,
- Size or area,
- Homogeneity with other sites in the neighbourhood.

3.3.2.2 Factor selection

The above classification gives a global view about the land valuation factors that may be considered during the valuation process. However, a better estimation of a land parcel's value requires more specific valuation factors. Some land valuation factors have been adopted to land-related works by many investigators (Nelson *et.al.*, 1992; Mackmin, 1989; Myhrberg; 1987; Chang, 1986; NRC, 1983). Based on this research and the global overview of value classification in section 3.3.2.1, some land valuation factors may be considered in a land readjustment process. These factors are listed in Table 3.1.

1. Topography	21. Access to railroad
2. Shape (narrow, large, etc.)	22. Access to waterway
3. Current usable area	23. Nearby nuisances
4. Size	24. Nearby healthy services
5. View	25. Noise
6. Landscaping	26. Smoke
7. Wind	27. Natural vegetation
8. Environment	28. Water use
9. Soil condition	29. Sewerage
10. Paid tax	30. Drainage
11. Current sale price	31. Available utilities
12. Distance to shopping areas	32. Basic municipal services
13. Distance to recreational areas	33. Building
14. Distance to play garden	34. Street frontage
15. Distance to parking facilities	35. Corner location
16. Distance to school	36. Location in a a site block
17. Distance to religious areas	37. Permitted number of floors
18. Distance to city centre	38. Permitted usable construction area
19. Access to street	39. Load-bearing utilities
20. Access to highway	40. Type of permitted building style

Table 3.1 Factors that may effect a land parcel value

In a land readjustment process, the main consideration in the selection of land valuation factors is based on the land itself. In other words, rather than assessing the buildings or other established constructions, the land parcel's surfaces are only considered. The current buildings are not considered because they are not subject to transfer to any location by the project. In Turkey, for example, the legal and physical positions of the existence buildings are maintained by the cadastral and land readjustment legislations. Only the cadastral parcel boundaries are replaced by the process. This means that the location of the land parcel is the only one that is subject to change. In this case, the current economical merits which depend on the parcel location are shifted and affected directly from the project. Therefore, in the selection of land valuation factors, a factor which would be affected by a change in location should be evaluated.

The required information about land valuation factors may be collected directly by a site survey or indirectly from external sources, but usually both methods are involved. Some of the sources of information include land registration offices (ownership documents), planning offices (building permits, zoning, services), and survey and mapping organisations (aerial photographs, topographic and other maps, survey plans). In this study, necessary information for a case study is mainly derived from cadastral, zoning and thematic maps.

3.3.2.3 Determination of a land parcel value

The number of land valuation factors is uncertain. Therefore, the precise value for a land unit cannot be determined easily. Consequently, the purpose of the land valuation process in a land readjustment is to estimate the nominal asset value with the combination of the selected valuation factors. To determine the significance of these factors for a land parcel, they need to be expressed mathematically so that the effect of each valuation factor can be determined for the complete land parcel.

To formulate the land valuation procedure for a land readjustment, the main aim of this approach can be expressed by the following equation [3.1].

$$\sum_{i=1}^{n} V_{(BEFORE)\,i} = \sum_{j=1}^{m} V_{(AFTER)\,j} \qquad [3.1]$$

where;

n = Total number of cadastral parcels
m = Total number of new parcels

According to the equation [3.1], total nominal asset values before and after must be equal so that all land owners within the project area are affected in the same way by the project. To provide the equation [3.1], the required value for both sides of the equation is then determined by the equation [3.2]. This formula represents the total value for a single land parcel. The variable (**f**) in this formula represents each individualy selected factor's value. These factors may affect the total value of a parcel in different ways. Therefore, each of these factors should be considered with some weights. The determination of weights is explained after the calculation of factor value, in section 3.3.2.3.3.

In this study, to determine the factor values, it was assumed that each factor value could have a maximum value of 100 for a fully developed land unit.

Thus, each selected factor is evaluated out of 100 percent (Figure 3.2). Consequently, the considered land valuation factors and formulation of theses factors are detailed in the following section.

$$V_i = AREA_i * \sum_{j=1}^{k} (f_{ji} * w_j) \qquad [3.2]$$

V : Total nominal asset value of a land parcel
Area : Land parcel size
f : Factor value
w : Factor weight

n: Total number of old parcels
m: Total number of new produced parcels
k: Total number of factors

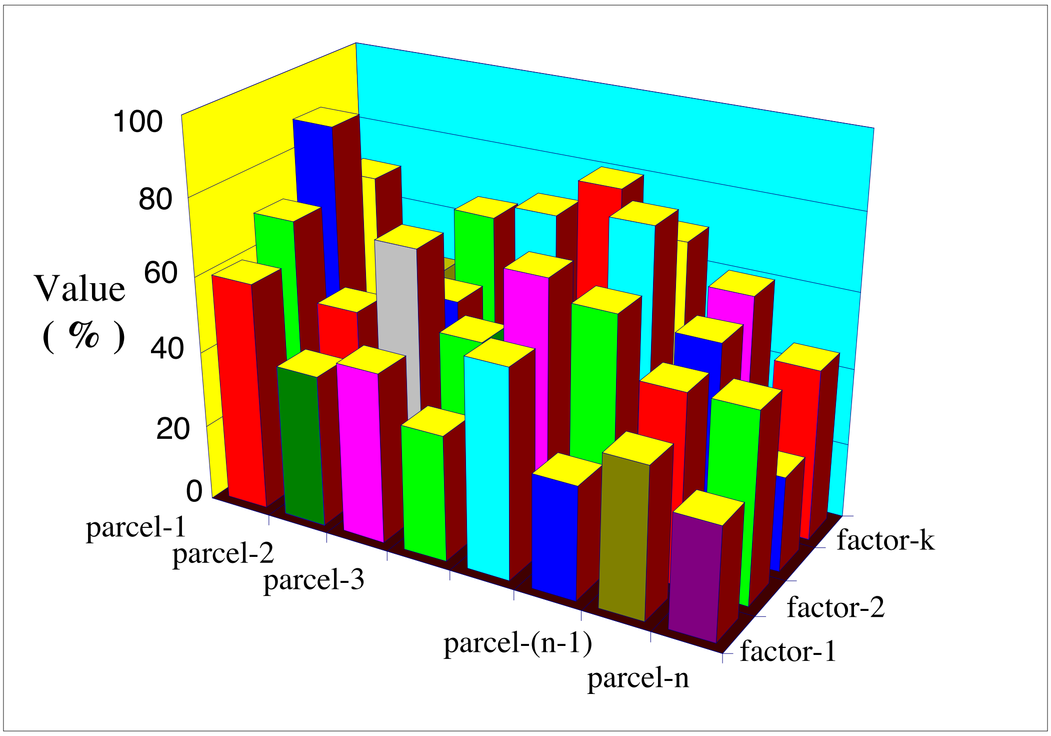


Figure 3.2 The conceptual view of land valuation factor assessment

3.3.2.3.1 Formulation of the land valuation factors

(a) <u>Topography</u>

Topography refers to natural contours of the land. As expressed by McRae and Burnham (1981); and Mackmin (1989), it is a significant element for the suitability of land, especially for residential purposes. Since the rough terrain may increase construction costs, flat or very nearly flat land is most desirable for more economical land use. Thus, it assumes that there is a reverse ratio between topographic value and slope level of the land. To determine the topographical factor value, the average slope of a land parcel is considered. However, the factor value for topography can be determined by the following formula:

$$\mathbf{v = 100 - S\%} \qquad [3.3]$$

where;
v = The factor value of a parcel's topography
S% = Average slope percentage of the parcel

(b) <u>Land parcel shape</u>

The shape factor recognises that the geometrical form of a land parcel influences the cost of construction per square meter of floor area. Therefore, a parcel with rectangular shape is advantageous for construction design. The position and the number of lot corners effects the homogeneity and use of a land parcel respectively broken lot sides create an irregular parcel shape.

In the real-market, a regular parcel shape has a significant value (Mackmin, 1989). Therefore, shape can be considered as a land valuation factor. To determine this factor value, the number of the lot corners is examined. In the calculation of the value of shape, it assumes that there is an inverse relationship between the number of lot corners and the value. In the calculation of the shape factor, it was accepted that a parcel with 4 corners reflects a regular parcel shape. The shape factor however may be formulated as follow:

$$v = \frac{4}{n} * 100 \qquad [3.4]$$

where;

v = Factor value for the shape of a land parcel

n = The sum of a parcel's corners { if n < 4 then n=4 }

If two corners of a parcel are very close to each other, one of them can be ignored because the lenght of the side may be insignificant on the parcel shape. Therefore, during the factor's value determination, a tolerance distance is considered and the corners within this given tolerance distance are ignored. Some examples for the lot corner are given in Figure 3.3.

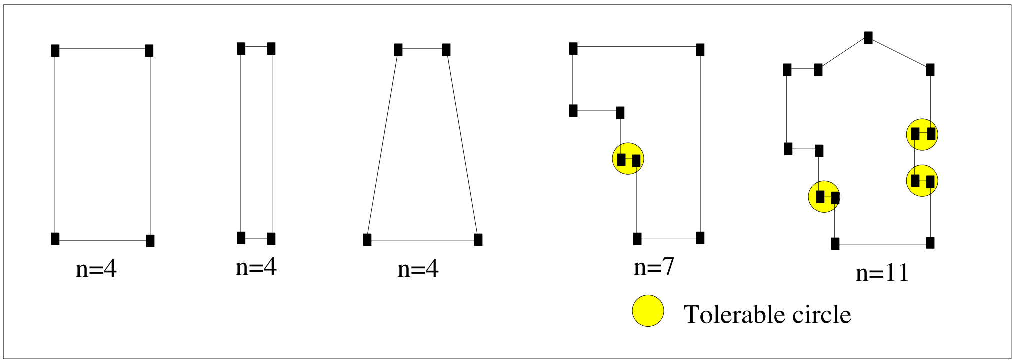


Figure 3.3 The examples for the different land parcel shapes

(c) Street frontage

Street frontage may be considered as the direct accessibility of a land parcel to a street. More accessibility provides more advantages for a parcel (Frizzel, 1979; Mackmin, 1989). Based on this, the parcel widths which face towards a street can be taken into consideration during the valuation process. To determine this factor's effect on the total value of a land parcel, the sum of the width of street frontages are compared with the total length of the parcel. The factor value can be expressed by the following equation:

$$v = \frac{\sum S}{\sum L} \qquad [3.5]$$

where;

v = Factor value of street frontage

ΣS = The sum of the length of street frontages of a parcel

ΣL = The total length of land parcel's perimeter

(d) Permitted number of floors:

In a parcel-based land development procedure, the zoning plan mostly regulates the construction dimensions, such as maximum construction area, maximum number of floors by given data, etc. In a land readjustment project area, these given dimensions may be different from parcel to parcel because of the planning design. For a new land parcel, these dimensions are important because they may directly affect the land usage. The permitted number of floors is however very significant for land holders. An extra floor for example provides more economical benefits to the parcel. Therefore, as a factor, the permitted number of floors should be considered during the land valuation process. The following equation can be used to determined the effect of this factor.

$$\mathbf{v = (F_{\mathit{i}} * 10)} \qquad [3.6]$$

where;

v = Factor value for the permitted number of floors

F = Permitted number of floor given for a parcel *i*

(In this equation, it assumes that the maximum floor number is 10)

(e) <u>Permitted construction areas</u>

Similar to the permitted number of floors, the construction area is another factor that comes with the zoning plan. Particularly, the permitted building dimensions on the ground are given by the plan. In generally, these dimensions are given as a percentage of the total parcel area that can be used by landowners. This factor can be expressed by the following equation:

$$\mathbf{v = C_{\mathit{i}} * 100} \qquad [3.7]$$

where;

v = The factor value for permitted construction area

C = The construction coefficient for parcel *i*

(f) <u>Location within site block</u>

The location within a site block is another important attribute for a land parcel. Due to their open face to different streets, corner lots are being more serviceable and valuable than the mid-block lots (Chang, 1986; Mackay, 1968). It assumes that when the parcel is far off from the block centre the factor value increases (Figure 3.4). Yet, to determine the significance of the location within the block, the distance from the block centre to the corner lot is considered. However, the factor value can be expressed by the following equation:

$$v = \frac{PD_i}{MD_j} * 100 \qquad [3.8]$$

where;

v = The factor value for the location within a block

PD = The distance from the centre of parcel *i* to the centre of a site block *j*

MD = The maximum distance from the centre of site block *j* to the centre of a corner lot in the same block

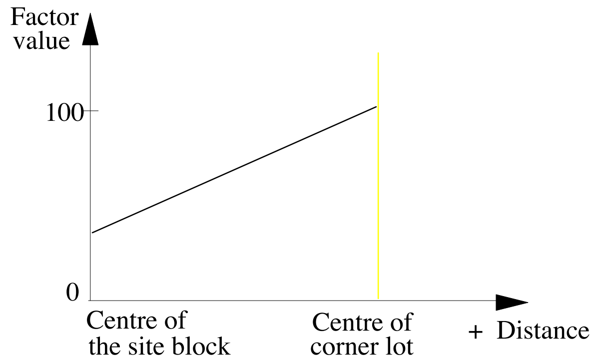


Figure 3.4 The relationship of factor value and a parcel location within a site block

(g) <u>Soil condition</u>

Soil condition is generally considered in the classification of agricultural land for farming purposes. In the case of land readjustment, the soil condition can be considered as a load-bearing characteristic of a site lot. The load-bearing quality of the soil is an important feature that the construction cost of the parcel is influenced. To determine the load-bearing quality of a land parcel, geological ground analysis is needed. Solid or marshy soil may increase the expense of any building plans (Baum and Sams, 1990). However, to represent the factor value, the following soil types and values can be considered during the valuation process.

<u>Ground type</u> <u>Value</u>

Rocky	10
Gravel	25
Mud	50
Clay	75
Loam	100

(h) Current usable area

The factor of current usable area may be considered as a physical characteristics of the land itself on the ground rather than the planning aspect of it. With respect to the physical attributes of the land, there may be some natural restrictions that limit the appropriate use of individual parcels. These natural restrictions such as rocky, marshy, downfall areas are considered as a disservicable areas of a land parcel. It is presumed that more usable areas may have a positive influence on the value. Yet, the factor value can be determined by the following equation.

$$v = (1 - \frac{NU_i}{PA_i}) * 100 \qquad [3.9]$$

where;
v = The factor value for current usable area
NU = The total non-usable area of land parcel *i*
PA = The total area of land parcel *i*

(i) Supplied municipal services

Whilst some land parcels have the basic services the others may not have. Therefore, the served parcels have advantages over the unserved parcels. At the same time, a land parcel may not be fully supplied. Hence, currently supplied services should be considered individually for each land parcel. The existence of the basic services such as sewerage, electricity, water supply, telephone, gas, cable may be examined to determine the factor value. The following equation can represent the factor value.

$$v = \frac{S}{N} * 100 \qquad [3.10]$$

where;

v = The factor value for the supplied basic services

S = The total number of services which a land parcel has

N = The maximum number of considerable services

In this study, the below items were taken into account as the basic services. According to the list N is 6 in the equation [3.10].

Services
(1) Electricity
(2) Sewerage
(3) Telephone
(4) Water supply
(5) Gas
(6) Cable

(j) Available utilities

A land parcel may have some intrinsic utilities that affect the parcel value. Such utilities are wall, water foundation, existing plants, vegetation etc. The availability of these utilities provides a tangible economical value for the parcel. However, the assessment of these utilities requires a careful examination. In this study, such utilities are individually assessed out of 100 with respect to their qualitative and quantitative characteristics. The following equation then can be used to represent the factor value.

$$\mathbf{v = \frac{1}{n} \sum_{j=1}^{n} G_j} \qquad [3.11]$$

where;

v = The factor value for available utilities

G = The assessment value of the utility *j* out of 100

n = The maximum number of considered utilities

Some of the availability utilities which were considered during the study are given as follows. According to the list *n=6* in the equation [3.11].

(1) Tree
(2) Pool
(3) Private road
(4) Garage
(5) Water foundation
(6) Current plants

(k) Environment

Research (Li and Brown, 1980; Nelson *et.al.*, 1992) routinely finds that environmental features can increase land value if they are viewed as attractive or desirable, and they can reduce land value if they are viewed undesirable.

The determination of an environmental effect on a land parcel value is a very complex task. Because many subjective and objective criteria are involved which are very difficult to classify. Both the physical and social conditions influence the landowners feelings and developments (Mackmin, 1989). To determine the factor value, the environmental features may be examined by considering the present living standards and paid-tax prices.

Some known regions within the project area or other developed parts of the city may also be considered as a reference for the environmental assessment. Based on this, an assessment map is prepared and the regions with different attributes are evaluated out of 100 (Figure 3.5). For the factor analysis, a land parcel is overlaid on the assessment map and corresponding value is determined by the following equation.

$$v = \frac{\sum_{k=1}^{m} (a_k * p)}{A} \qquad [3.12]$$

where;

v = The factor value for environment

A = The total area of the land parcel

a = The corresponded parcel area of a particular environmental region

m = The number of parcel portions which are divided by environmental regions when overlaid on the land parcel

p = The value of an environmental polygon which corresponds to the parcel

$\{ \sum_{k=1}^{m} a_k = A = \text{The parcel area} \}$

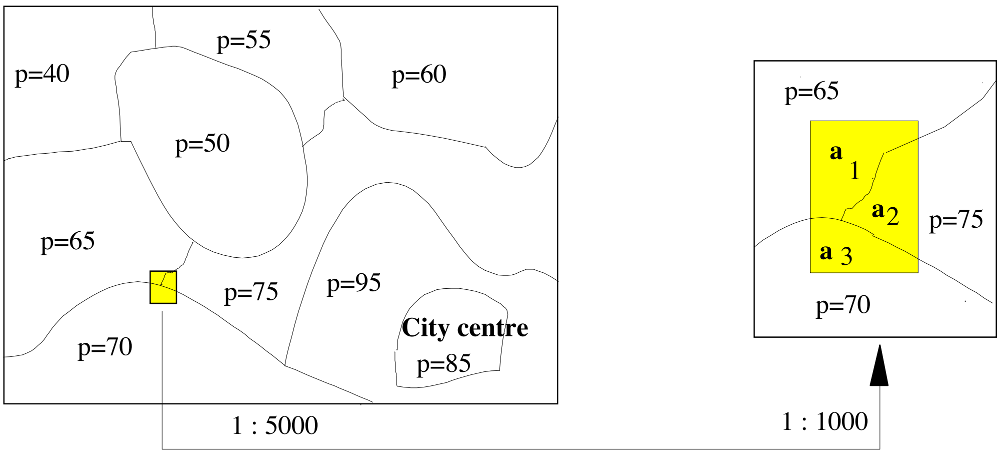
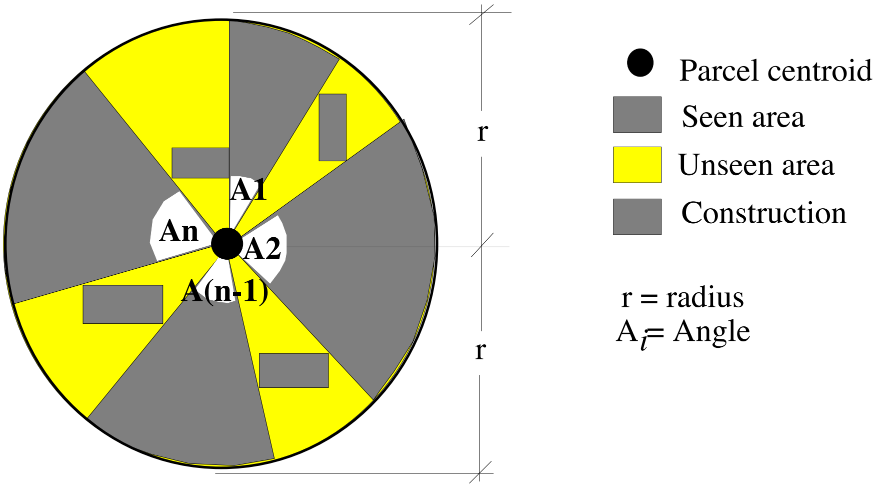


Figure 3.5 An environment assessment of land parcel

(I) View

When a land parcel is surrounded by some trees, buildings, or any other tall construction, the view from the parcel may not be possible. This can be considered as a disadvantage for the parcel because landscape benefits may not be enjoyed. A view of the landscape has always been an attractive characteristics for a parcel. Hence, the view has to be taken into account during the land assessment (Price, 1978; Mackmin, 1989). To determine the factor value, the sighting from parcel to around is analysed (Figure 3.6).



$$\text{Factor value} = \frac{\text{Total area of unseen areas}}{\square\, r^2} * 100$$

Figure 3.6 The view analysis for a land parcel

(m) <u>Access to street</u>

Sometimes a land parcel is fully surrounded by the other land parcels and the directly connecting road is closed. In another words, a land parcel cannot directly link to any public road. This condition particularly appears for undeveloped cadastral parcels, and the only connection to street can be provided through the other parcels. A lack of direct access to a street may have a negative influence on the total value of a land parcel. Therefore, access to streets needs to be examined as well. In the factor valuation process, if a land parcel has direct access to a street, the factor value can be considered as 100, otherwise it is null (Figure 3.7).

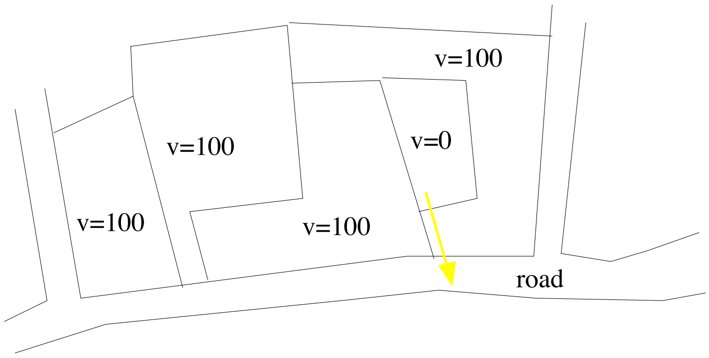


Figure 3.7 A land parcel access to street

v = 0 { if there is not a direct access to street }
v = 100 { if there is a direct access to street }

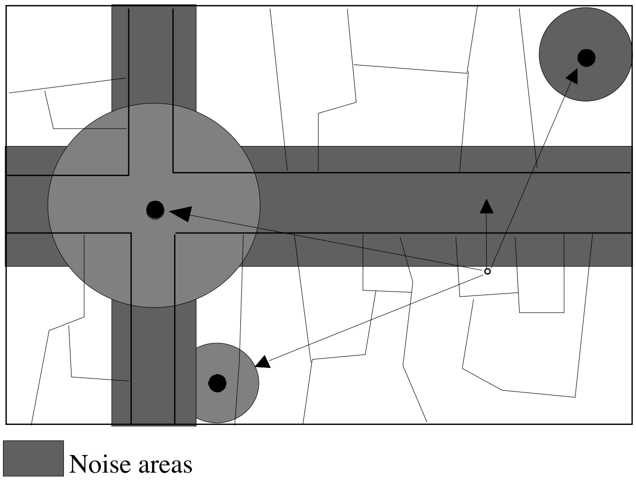
(n) <u>Proximity to noise</u>

The effects of noise on land prices have been studied by Walters (1975) and Nelson, *et.al*., (1992). These studies showed that any noise from commercial or industrial activities have an adverse effect upon the values of a residential parcel. Hence, there is a inverse ratio between the value and the amount of noise.

There is a natural quantitative measure of noise used by physicists. It is the energy content of a noise emission (Walters, 1975). But such a measure is very difficult to incorporate in the case of a land valuation process. However, the proximity of a land parcel to noise areas, such as entertainment places, main roads, road junctions, airport, railroads, can be examined. To do this, some buffer zones of a specified radius can be created around the noise resources then the parcel distance to the zones considered (Figure 3.8).

(o) <u>Proximity to nuisance</u>

The distance to nuisance places is also important. As in the noise factor, it assumes that there is a inverse ratio between the value and proximity to nuisance areas. So, the examination of nuisance factor may be considered as the determination of the noise factor. In the calculation of the factor value, first, the nuisance areas should be decided on a map. Then, the determination of value is carried out like the noise analysis.



Distance (meter)	Value
000-024	1
025-049	5
050-074	10
075-099	20
100-124	30
125-149	40
150-174	50
175-199	60
200-249	70
250-299	80
300-400	90
400->	100

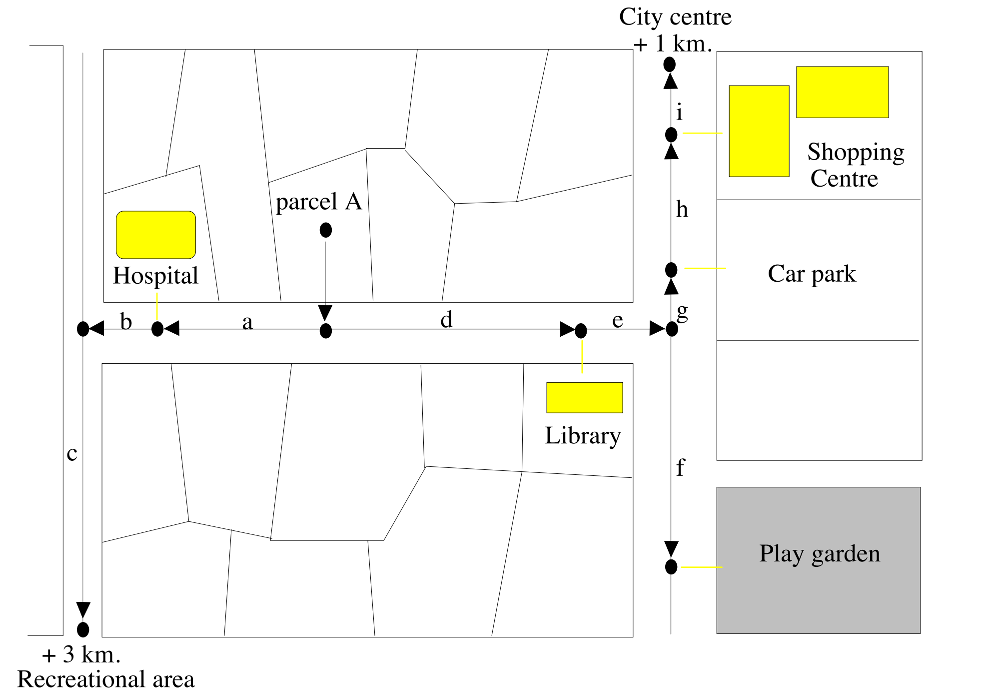
Figure 3.8 Noise and nuisance analysis

(p) <u>Distance to shopping area, health services, educational places, play gardens, recreational areas, religious places, city centre, car parking, fire and police stations</u>

These are some other important criteria that may effect a land parcel value. But, proximity to one or other may give rise to higher or lower relative values depending upon desirability or otherwise of being close to such a feature. So, as expressed Ravenscroft (1992) and Mackmin (1989), it is really difficult to decide of what type of feature may have advantages or disadvantages on a land parcel value.

However, in this study, it presumed that when the distance from a land parcel to the mentioned places increases then the land value decreases. Hence, there is an inverse relationship between value and distance from the above places.

These factors are examined individually and the factor value is determined by particular proximity ranges (Figure 3.9).



Distance (meter)	Value
000-024	100
025-049	90
050-074	80
075-099	70
100-124	60
125-149	50
150-174	40
175-199	30
200-249	20
250-299	10
300-400	5
400->	1

The distance of parcel A to hospital = a
The distance of parcel A to recreational area = a + b + c + 3 km.
The distance of parcel A to car park = d + e + g
The distance of parcel A to city centre = d + e + g + h + i + 1 km.

Figure 3. 9 Determination of proximity factors

For the calculation of the factor value, first, a street network is created. This network represents the road connections of land parcels and public areas or other public buildings. Street axes and lengths from the centre of land parcels to the street axis are considered as linkage routes to the selected places. Then, the shortest path from parcel to the sites are calculated with respect to road segments.

(q) <u>Access to highway, railroad and waterway</u>

The distance from parcel to the entrance of highways, railroads and waterway points are also significant features for a land parcel. It is assumed that there is a regular ratio between the land nominal asset value and the distance from parcel to the connection nodes of main transportation networks. For the value determination, access to highway, railroad and waterway are examined individually as three separate factors. To do this, network analysis is required along the main streets. The shortest paths from parcel to main junctions are considered. A factor value is determined similar in Figure 3.9.

3.3.2.3.2 Calculation of the value parameters

Following the land valuation factor analysis, the total value of a parcel is determined using equation [3.2]. This equation applies to all land parcels within the project area. These are the current cadastral parcels and the produced site lots. In a land readjustment process, there are two main distinction stages that must be realised while performing the land valuation analysis. These stages are;

(1) Pre-project stage (Before) which represents the current land parcels and land-use condition. The land parcels are the cadastral or old parcels which are subject to land development process. These are the only parcels that are totally affected by the project. They are also considered as the original input parcels of a land readjustment project (Figure 3.10). In this stage, all land parcels are evaluated and classified by their existing suitability without referring to the urban land scheme.

(2) Post-project stage (After) which represents the new site lots. These lots are created according to the detailed urban planning programme. The zoning plans which have been designed by the town planners are used as a base map (Figure 3.11). These maps basically provide the planned roads, streets, residential areas and other public and private places. The creation of new land parcels within the given site blocks are left for land surveyors. The lot dimensions such as minimum construction area, depth, street-frontage are given by the plan to perform the land subdivision. It is important that these given data should be followed during the creation of new land parcels. Therefore, in the post project stage, based on the zoning data all given site blocks are carefully subdivided into the new suitable lots. These created new lots are considered as the output parcels of the project. After the completion of the project, these new lots are demarcated in the field and legally registered. However, in the post-project stage of land readjustment, the new lots are created evaluated with respect to the planning details as if these lots were fully developed.

The land valuation process is carried out differently in both these stages. Considering the suitable land valuation factors, first, the parcel values are calculated. Then, using the equation [3.2], the total value of the project area is determined for the both stages by following equations;

$$\Sigma \mathbf{V}_{\text{(before)}} = \mathbf{V}_1 + \mathbf{V}_2 + \ldots\ldots + \mathbf{V}_n \qquad [3.13]$$

$$\Sigma \mathbf{V}_{\text{(after)}} = \mathbf{V}_1 + \mathbf{V}_2 + \mathbf{V}_3 + \ldots\ldots + \mathbf{V}_m \qquad [3.14]$$

where; n = The total number of cadastral parcels (input parcels)
m = The total number of produced site lots (output parcel)

Figure 3.10 A sample of cadastral map

Figure 3.11 A sample of zoning map

It has to be noticed here that, except for a very extreme condition, the results of these two equations mathematically will not be same, because the total number of land parcels before and after is different, as will be the number of their selected factors too. However, to prove the main equation [3.1], a scale coefficient is required to be applied the individual parcels. This coefficient can be determined as follows:

$$z = \frac{\sum V_{before}}{\sum V_{after}} \qquad [3.15]$$

The scale coefficient [3.15] is multiplied by the new parcel's parameters to determine the final valuation parameters. Then, these determined parameters are considered during the land distribution. As a result, the total value of land parcels will be exactly the same before and after while the total number of the parcels is different. In another words, land valuation profiles before the project will be same after the project.

3.3.2.3.3 Determination of the weights

The weight determination for the land valuation factors is important in a value-based land readjustment process, because each land valuation factor does not have the same effect on the total perceived value of a land parcel. For example, proximity to city centre may have a different effect to the topography. Sometimes, a valuation factor such as the permitted number of floors may not be significant before the project, but it may be very significant after the project. Hence, during the factor selection, the project stages should also be considered.

To give a priority to the factors in accordance with their importance, the selected valuation factors should be assigned usimg some weight parameters. However, the determination of these weights is complicated and difficult because they are changeable from person to person. For the implementation of the proposed model, it was thought that a number of land valuation factors could be evaluated with the aid of a survey study. Based on the list in Table 3.1, the possible land valuation factors that may be subject to change when a land readjustment project is applied, were considered.

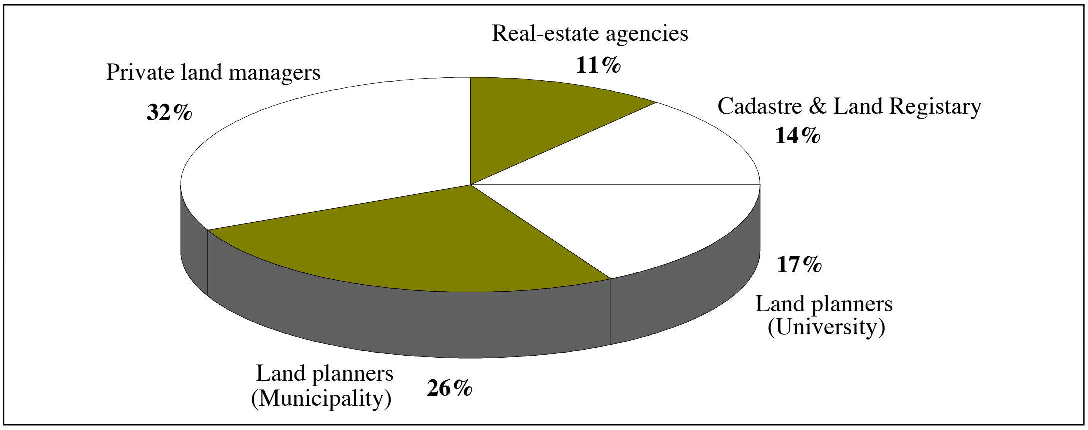


Figure 3.12 The distribution of the responded questionnaire forms

(a) The survey study

For the evaluation of the selected land valuation factors, a survey was carried out in Turkey. The main aim of this survey was to find out the mean values of the given factors then use these mean values as the factor weights in the equation [3.2]. For this purpose, a questionnaire form was prepared and sent to 302 people in Turkey (Table 3.2). But only 202 questionnaire forms have been responded. For this survey, the professional people who are from the government branches, universities and private sectors which are actively involved in land management processes were selected (Figure 3.12). Landowners were not involved in the survey because it was thought that they would consider only their own individual land position, so that they may not make an objective evaluation.

Table 3.2 The questionnaire form

The purpose of this Questionnaire is to determine and give priority to the selected land valuation factors and their effects on total land parcel value.

"Because of a land position, every land parcel has some tangible and intangible criteria which affect the total perceived value of a land parcel."

Suppose that you are looking for a land parcel on which to build a new house. Please assess the following factors in accordance to their importance to parcel value. Each of these factors should, individually, be marked out of 100%
(100 = very high, 1 = very low, 0 = No idea).

Grade(%)	**Selected Land Valuation Factors**
1________	ENVIRONMENT [living conditions within the parcel district]
2________	SUPPLIED BASIC SERVICES [electricity, water, telephone, cable, sewer, bus stop, etc.]
3________	LANDSCAPE, VIEW [parcel position determines amount and quality of view]
4________	DISTANCE FROM NUISANCES
5________	LAND PARCEL SHAPE [number of corners, long, narrow, large, regular or irregular conditions]
6________	DISTANCE FROM NOISE (from heavy traffic, airport, plants, entertainment area etc.]
7________	AVAILABLE UTILITIES [currently available capital resources such as timber, garage, wall, fence etc.]
8________	PERMITTED BUILDING CONSTRUCTION SIZE [in accordance with zoning plan limitations]
9________	ACCESS TO STREET
10________	CURRENTLY USABLE AREA
11________	STREET FRONTAGE [number of sides which are facing street]
12________	PERMITTED NUMBER OF FLOORS [in accordance with zoning plan limitations]
13________	DISTANCE TO CITY CENTRE
14________	SOIL CONDITION [the characteristic of soil that allows to economical load-bearing]
15________	DISTANCE TO SHOPPING CENTRE
16________	DISTANCE TO HEALTH SERVICES
17________	PARCEL LOCATION WITHIN SITE BLOCK [parcel located on corner or centre of the site block]
18________	TOPOGRAPHY [slope percentages, flat or rough surface]
19________	DISTANCE TO EDUCATIONAL CENTRES [school, library]
20________	ACCESS TO HIGHWAY
21________	DISTANCE TO RECREATIONAL AREA
22________	DISTANCE TO CAR PARKING AREA
23________	DISTANCE TO POLICE STATION
24________	DISTANCE TO PLAY GARDEN
25________	DISTANCE TO FIRE STATION
26________	DISTANCE TO RELIGIOUS PLACE
27________	ACCESS TO RAILWAY
28________	ACCESS TO WATERWAY

(b) Analysis of the survey data

The survey data were analysed for statistical significance. For this purpose the *RELIABILITY* analysis was applied to the data which are given in Appendix B. Winer (1962) indicates that the *reliability* of the results is conceived of as that part which is due to permanent systematic effects, and therefore persists from sample to sample, as distinct from error effects which vary from one sample to another.

Using the SPSS-X statistical package, the reliability test was applied to the survey data. The reliability coefficient of the test was found as $\boldsymbol{\alpha=0.9398}$. This figure provides a significance value that the survey data are reliable to 94%. The interpretation of the reliability test can be given as follow:

> If the survey were to be repeated with the other people, but the same land valuation factors, the correlation between the mean rating obtained from the data sets on the same land valuation factors would be approximately 0.94.

The test results including statistical description of the data and frequency tables are given in Appendix B. However, Table 3.3 illustrates the mean values and the standard deviation of the land valuation factors. According to the survey results, the factors; *supplied municipal services, permitted number of floors, permitted construction area, view, environment, location within site block, and access to street* have been found as the most important factors on the total perceived value of a land parcel. On the other hand, the factors; *distance to fire station, police station, religious places, access to waterway, and railway* have been found as less important factors. The graph in Figure 3.13 however shows the mean value distributions for the land valuation factors.

Table 3.3 The basic statistical results of the survey data

ID	VARIABLE	MEAN	STD DEV	CASES
001	ENVIRON	75.2772	21.8266	202.0
002	MUNICIP	81.7277	20.0109	202.0
003	VIEWLCP	74.8713	24.4994	202.0
004	NUISANC	63.9307	29.3014	202.0
005	SHAPEFO	65.4505	27.7779	202.0
006	NOISEDI	61.5941	27.5331	202.0
007	UTILITI	54.4851	26.9712	202.0
008	PERMTAR	78.2673	19.5272	202.0
009	ACCSTRE	72.4901	27.3949	202.0
010	USABLEA	62.8218	29.5060	202.0
011	FRONTAG	69.0495	24.5137	202.0
012	PFLOORS	76.7079	23.5986	202.0
013	CITYCNT	67.7624	22.9855	202.0
014	SOILCON	56.6188	28.4313	202.0
015	SHOOPIN	58.9109	25.1636	202.0
016	HEALTHS	60.0347	25.0540	202.0
017	LOCATIO	72.8713	23.0990	202.0
018	TOPOGRH	56.8911	23.5836	202.0
019	SCHOOLD	61.4604	23.8196	202.0
020	HIGHWAY	57.3812	27.0906	202.0
021	RECREAT	56.1188	24.3712	202.0
022	PARKING	50.4109	24.8489	202.0
023	POLICED	39.7178	26.2168	202.0
024	PLAYGRD	50.3564	25.2939	202.0
025	FIRESTS	39.1089	26.6351	202.0
026	RELIGIO	44.5842	31.3219	202.0
027	RAILWAY	38.6683	26.4397	202.0
028	WATERWY	35.5446	27.6490	202.0

As mentioned above, the main aim of this survey was to obtain some figures that can be used as a factor's weight in the equation [3.2]. Based on the questionnaire results, the *weighted* mean values were used as the factor weights. The *weighted* mean values were determined because in this way the effects of the "*0*" values on the mean values can be ignored. For this, each data item was considered as its own weight. Finally, Table 3.4 illustrates the land valuation factors and their weights in a sequence form. These factors and the assigned weights were then used in the implementation part of this study, particularly in the land valuation analysis and the calculation of a parcel nominal asset value.

Figure 3.13 The graph of mean value..

Table 3.4 Land valuation factors and their weights

No	CODE	LAND VALUATION FACTOR	WEIGHT
1)	002	SUPPLIED BASIC SERVICES	86.60
2)	012	PERMITTED NUMBER OF FLOORS	83.93
3)	008	PERMITTED CONSTRUCTION AREA	83.12
4)	003	LANDSCAPE, VIEW	82.85
5)	009	ACCESS TO STREET	82.79
6)	001	ENVIRONMENT	81.57
7)	017	PARCEL LOCATION WITHIN BLOCK	80.16
8)	011	STREET FRONTAGE	77.71
9)	004	DISTANCE FROM NUISANCES	77.29
10)	005	LAND PARCEL SHAPE	77.18
11)	010	CURRENTLY USABLE AREA	76.61
12)	013	DISTANCE TO CITY CENTRE	75.52
13)	006	DISTANCE FROM NOISE	73.84
14)	014	SOIL CONDITION	70.82
15)	019	DISTANCE TO EDUCATIONAL CENTRES	70.65
16)	016	DISTANCE TO HEALTH SERVICES	70.44
17)	020	ACCESS TO HIGHWAY	70.11
18)	015	DISTANCE TO SHOPPING CENTRE	69.61
19)	007	AVAILABLE UTILITIES	67.77
20)	021	DISTANCE TO RECREATIONAL AREAS	66.65
21)	018	TOPOGRAPHY	66.62
22)	026	DISTANCE TO RELIGIOUS PLACE	66.48
23)	024	DISTANCE TO PLAY GARDEN	63.00
24)	022	DISTANCE TO CAR PARKING AREA	62.60
25)	025	DISTANCE TO FIRE STATION	57.16
26)	028	ACCESS TO WATERWAY	56.95
27)	023	DISTANCE TO POLICE STATION	56.94
28)	027	ACCESS TO RAILWAY	56.66

3.3.3 The process of decision making

Land distribution can be considered as a crucial phase of the entire land readjustment process. In this phase, the location and the boundaries of land parcels are changed and landowners are moved to the new locations. From the cadastral point of view, this is very important because current land rights are legally affected and exchanged by individuals.

The main purpose of this stage is to maintain the current property rights while reallocating the land parcels in the new locations. This may partly be achieved by giving back a new parcel in the same location, at least within the same block. Although the parcel location is maintained, the planning benefits may not be fully provided for a parcel with respect to the nominal asset value of land before and after the project. Therefore, not only the locational characteristics but the planning effects must be taken into account.

By the analysis of land valuation factors, the nominal asset values of parcels are determined both before and after the project. Based on these nominal asset values, the old and new conditions of a land parcel can be compared and the possible best location is decided for the parcel. So, land valuation analysis gives more objective criteria which greatly helps planners during land reallocation.

3.3.3.1 Land subdivision

In a land readjustment process, the existing cadastral parcels are considered as the input parcels. On the other hand, the zoning plan exists. This plan only shows the designed planning details such as main roads, street patterns, public-user areas, site blocks with the zoning codes. More importantly, the detailed subdivision layout scheme is not given by the plan. Thus, land subdivisions are fulfilled during the implementation with respect to site blocks and zoning codes. The main objective of land subdivision is however to produce new land parcels that will be used for land development.

In order to compare the land parcel conditions before and after, first site blocks are subdivided into suitable lots. These site lots must be created according to the zoning details. The created lots are considered as the developed land parcels. These parcels are mostly in a rectangular form that allow for more economical use of the land. After the project, these lots are legally registered so that they become the new cadastral parcels.

To estimate the land nominal asset values after the project, the availability of new site lots are very important to accomplish the land valuation analysis. Therefore, the land subdivision can be considered as the first requirement of the process. This process is followed by the land valuation analysis, so that land parcel values before and after are determined. Finally, land distribution is performed with respect to the results of the land valuation analysis.

3.3.3.2 Land distribution

Land distribution may be considered as the final stage of the land readjustment process. In this stage, the old cadastral parcels are reallocated into the new site lots. Based on the calculated land valuation parameters, land distribution is carried out and the old parcels are replaced with the new site lots. Due to the different lot sizes after the project, a cadastral parcel may be reallocated within various site lots. On the other hand, small cadastral parcels may be assembled within a site lot as well.

However, during the land distribution process there are two main cases that should be carefully examined in order to provide an optimum land distribution to landholders. These are;

Case 1: **If a cadastral parcel is larger than a new lot:**
In this case, the cadastral parcel is distributed to more then one parcel. But the distributed land portions may fit a few new lots, then the rest of it may not fit any new lot. As a result of this, the remaining land should be shared with other parcel or parcels (Figure 3.14).

Case 2: **If a cadastral parcel is smaller than a new lot:**
In this case, small size cadastral parcels are consolidated in a new lot. In accordance with their participant percentages, the new lot is shared by the landowners (Figure 3.14).

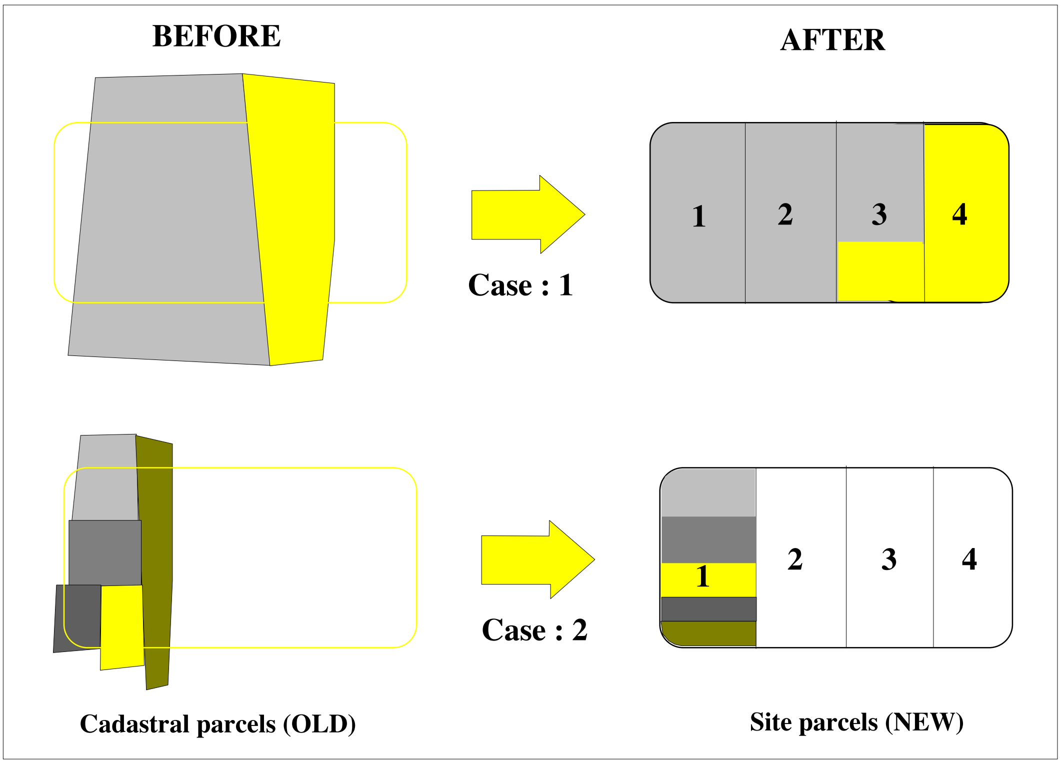


Figure 3.14 Two cases which occur during the land distribution

During the land distribution process, the original location of a cadastral parcel should be maintained as much as possible. This is very important for the landowners because they may not be happy when moved to other locations.

3.3.4 The procedure of information management

A value-based land readjustment process requires highly complex spatial analysis with textual and non-textual data. Following the entire process also requires effective information management in order to control the data input, output, manipulation and analysis. Therefore, the value-based land readjustment model would be a very complicated process if computing technology is not involved.

Today, some information technology such as a GIS or LIS provides a great opportunity to deal with such complex spatial data analysis requirement. However, to determine the ability of a GIS/ LIS and integration with a value-based land readjustment process, the concept and terminology of GIS and LIS are summarised in Chapter 4.

Nevertheless, there are three main information management processes for the value-based land readjustment process. These are data input, data analysis and data output.

3.3.4.1 Data input

All required spatial data are basically derived from the property, land-use, thematic and topographical maps. On the other hand textual data such as landowners names, shares, addresses, parcel ID's, details of property rights are obtained from the registration documents or other related texts. The zoning codes are also considered as textual data. Table 3.5 illustrates some this necessary textual and non-textual information.

Using information technology, the graphical data are first digitised from the existing maps. Following the digitising process, the graphical data and related descriptive information is linked via a database system. All data can then be stored in suitable formats for later use.

3.3.4.2 Data analysis

The land subdivision process is the first step of data analysis. Considering the digitised zoning plan and related zoning codes, a subdivision layout plan is produced. Basically, the site blocks are automatically subdivided into the new lots in the required dimensions.

Following the land subdivision, land valuation analysis is performed. This is the most complicated part which requires to deal with many spatial objects dealing within a geographical unit. With respect to the selected land valuation factors, some spatial analysis such as map overlaying, buffering, street network analysis, surface analysis, extraction of information for other use is essential.

After the analysis of land valuation factors, the land parcel values are determined individually for both before and after the project. These values are actually in numerical form and represent the total perceived value of a land parcel when compared to the others. The determined parameters are then used in the land distribution.

Table 3.5 The initial textual and non-textual information for land readjustment

	TEXTUAL DATA	**GRAPHICAL DATA**
Cadastral	Land parcel IDs	Cadastral parcel boundaries
	Block IDs	The boundary of project area
	Legal parcel size	The outlines of site blocks
	Owner(s) name	Buildings
	Parcel address	Play gardens
	Volume no.	Green areas
	Title number	Planned buildings
	Plan no	Elevation contours
	Registration date	Main roads
	Landowners shares	Streets
	Map sheet no	Railways
	City name	Streams
	District name	Soil type
	Paid tax	Sewers
	Mortgages	Car parking
		Nuisance areas
Zoning	The plan no	Public buildings
	Date of issued	Recreational areas
	Type of land -use	
	Site block ID	
	Permitted floors	
	Permitted area	
	The width of streets	
Surveying	List of coordinates	
	Surveying plan no.	
	Date of surveying	
	Map ID	

Land distribution performs the reallocation of the cadastral parcels within the site lots. An algorithm should be designed to provide an optimal solution to consolidate, divide, and redistribute the land parcels to minimise the number of shares within a single site lot.

3.3.4.3 Data output

Data output and presentation relates to the way the data should be displayed. The results of valuation analysis should also be reported to the users. However, all results both graphical and non-graphical, including land valuation maps with the 3-D visualisations, street networks, ownership records, land distribution tables are presented as both hard and soft copies for further use. An interactive environment can be created for more sophisticated query requirements as well.

3.4 Chapter summary

The technical issues of land readjustment process were defined and a new approach to solve these issues was discussed in this chapter. Three different issues have been classified. These are land valuation, decision making, and information management.

Land valuation is an important issue because during the implementation, some land valuation factors which may effect the total perceived value of a land parcel are ignored. Due to non-standardised procedures, the planners often have difficulty in making decisions about the land parcel locations. The landowners are at risk because different approaches provide different land locations to them. Therefore, inequitable land distribution can occur to the original landowners affecting their benefits from the project. Information management is another issue that affects the performance of land readjustment process. The process has not been integrated with the current information technology in sufficiently. Hence, the technological benefits have not been enjoyed.

In order to solve these issues a value-based approach to land readjustment was proposed. The main idea of this approach was to determine a land parcel value before and after the project with considerable land valuation factors, then give back a new parcel to each landowner with the same value as that owned before. To accomplish the idea, first the requirements for this approach were explained. Then, the possible land valuation factors were defined with their formulas and land valuation analysis was involved in the entire process.

In this approach, the term of *value* was used as a single numerical parameter which represents a land parcels nominal asset values when compared the others. A land parcel value has been determined mathematically with the combination of different land valuation factors. The land distribution process was based on the calculated unit parcel value. So, rather than using parcel area, the determined nominal asset values are distributed to landowners.

The value-based land readjustment process requires highly complex spatial analysis. An effective information management procedures are also required to control the data input, output, and manipulation.

Therefore, the use of information technology is essential. In order to understand the capability of information technology, some land-related information systems such as a GIS and LIS have to be examined. However, GIS and LIS are reviewed in the following chapter.

CHAPTER 4

AN OVERVIEW OF LAND-RELATED INFORMATION SYSTEMS

> " Computing technology provides a means to carry out routine tasks with a speed, precision, and flexibility that is often not easy for the lay person to grasp. Though the range of applications is diverse, from scientific analysis to graphic art, from the automated factory to satellite TV, the role of the technology is quite basic, namely to process 'bits' of information according to certain instructions. There is thus a set of fundamental relationships between information concepts and computing concepts."
>
> (Bracken and Webster, 1990)

4.1 Introduction

Information related to the spatial characteristics of resources has been very difficult to incorporate in decisions on land planning and management. The collection and compilation of spatial data and producing a printed map have been error-prone, costly and time-consuming in land planning activities. Because of urban planners and cadastral agencies deal with a large and complex spatial data sets, they need detailed and accurate information about the distribution of land and resources in town and cities.

The key to the efficient use of such data sets depends on the existence of powerful systems which are capable of acquiring data from a variety of sources; changing data into a variety of useful formats; storing the data;

retrieving and manipulating the data for analysis; and then generating the outputs required by a user. Performing these basic functions on large volumes of spatially addressed data are therefore of critical importance. Thus, today's information technology has a great ability in providing these functions.

In order to design and implementation of an effective urban land readjustment system, the nature of current land related information systems should be understood. However, this chapter overviews some aspects of land-related information systems, which are commonly known as, ***Geographical Information Systems***, and ***Land Information Systems***.

4.2 Classification of information systems

Information itself may be defined as an intelligence resulting from the assembly, analysis or summary of data into a meaningful form. However, an ***information system*** is a mechanism which provides the means of storing, generating and distributing information for the purpose of supporting the operations and management functions of an organisation (AGI, 1991). Such systems may be manual or, more commonly they represent an integration of manual and computer assisted components. The main function of an information system is to improve a user's ability to make decisions in research, planning and management (Martin and Powell, 1992). As illustrated in Figure 4.1, an information system involves a chain of steps from the observation and collection of data through their analysis to their use in some decision making process.

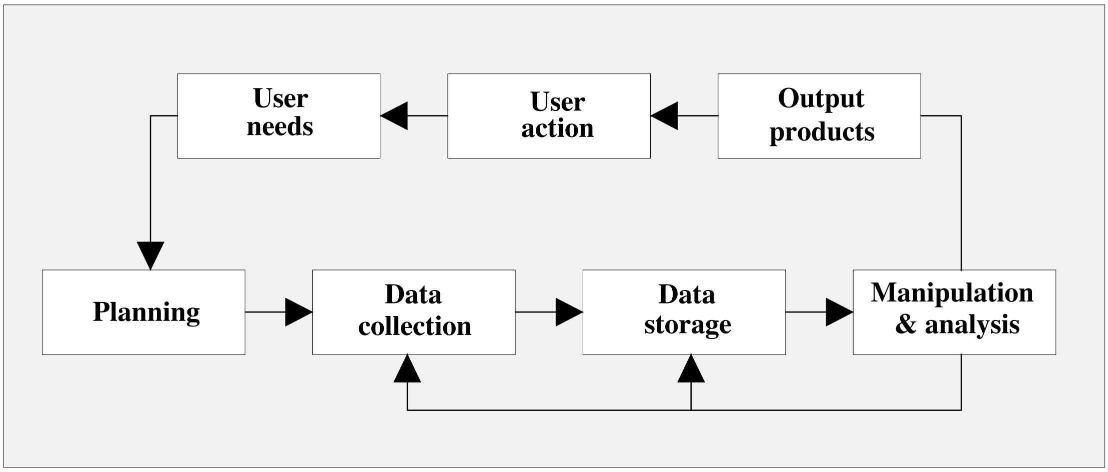


Figure 4.1 A simplified information system overview (after Star and Estes, 1990)

The application approach divides information systems on basis of the problems they seek to address. Therefore, several different categories of land-related information systems have been classified by many authors (Williamson, 1986; Dale and McLaughlin, 1988; Bracken and Webster, 1990; Huxhold, 1991; Maguire, 1991). Figure 4.2 represents one of a variety of classification schemes that may be derived for a land-related information system. In this context, land-related information may be environmental, infrastructure, cadastral, socio-economic, derived from measurements, scientific principles, or judicial decisions.

Today, the use of computer technology for the capture and organisation of spatial data and the use of computer-based analytical modelling techniques offer the only opportunity whereby the present and future demands and expectations regarding land based planning, engineering, and management activities can be met. Over the last two decades the computing technology has provided an exciting potential for geographic information to be used more systematically and by a greater diversity of disciplines than ever before (Aronoff, 1989). The technological umbrella for data management systems that capture, organise, and use spatial data utilising the computer is generally referred to as ***Geographical Information Systems*** **(GIS)**.

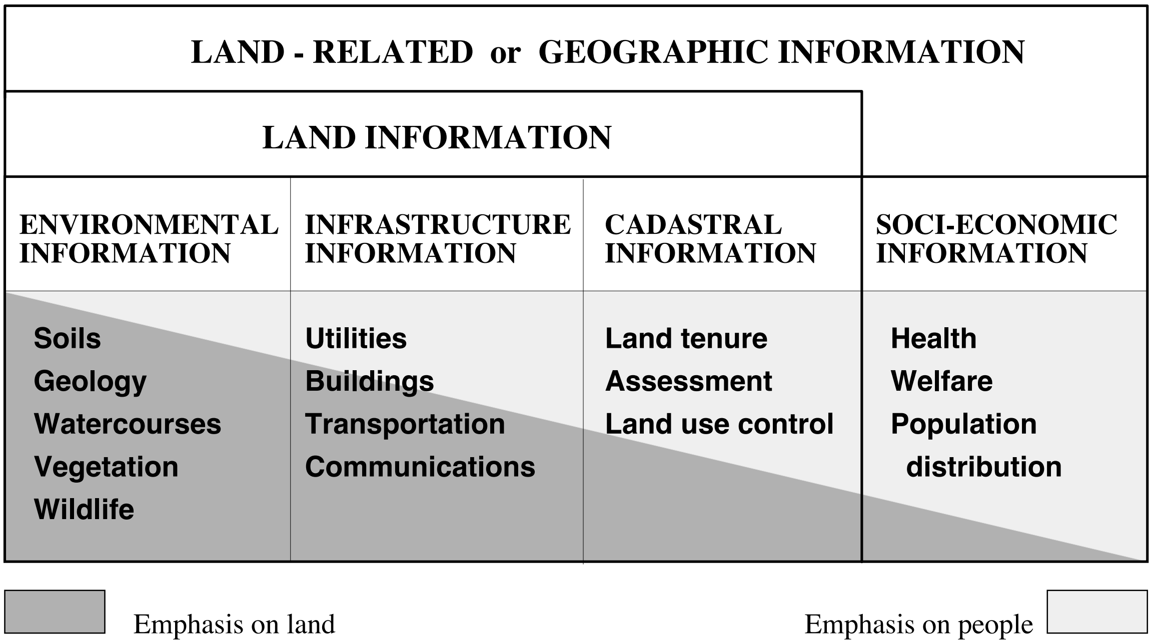


Figure 4.2 Land-related information (based on Dale and McLaughlin, 1988)

4.3 Geographical information systems

The primary goal of GIS is to take raw data and transform it, via overlays and other analytical operations, into new information which can support the decision making process. GIS are integrating systems which bring together ideas developed in many areas including the fields of agriculture, botany, computing, economics, mathematics, surveying, photogrammetry, zoology and geology. However, GIS themselves may also be subdivided on application basis as shown in Table 4.1.

Table 4.1 Examples types of GIS classified according to the application area addressed.

It is also possible to consider these as alternative names of GIS (from Maguire, 1991)

Cadastral information system
Image based information system
Land data system
Land information system
Geographically referenced information system
Natural resource management information system
Market analysis information system
Multipurpose cadastre
Planning information system
Property information system
Spatial information system
Spatial decision information system
Urban information system

4.3.1 Definition of GIS

As pointed out by Maguire (1991);

> " GIS have been generating massive interest world wide. Their comparative recency, rapid rate of development, commercial orientation and diversity have not assisted in producing a clear and unambiguous definition of GIS "

Yet, many different definitions of "Geographical Information Systems (GIS)" have been developed by the investigators. Such definitions are :

> "GIS is a set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes."
>
> (Burrough, 1986)

> "GIS is a tool for storing and manipulating geographical information in a computer."
>
> (ESRI, 1987)

> "...an information system that is designed to work with data referenced by spatial or geographical coordinates. In the other words, a GIS is both a database system with specific capabilities for spatially-referenced data, as well a set of operations for working with data."
>
> (Star and Estes, 1990)

> "...a system for capturing, storing, checking, manipulating, analysing and displaying data which are spatially referenced to the Earth. This is normally considered to involve a spatial referenced computer database and appropriate applications software."
>
> (AGI, 1991)

Consequently, GIS may be concerned as a tool which handles and analyses spatial data that result from observation or measurement of earth phenomena" (Figure 4.3).

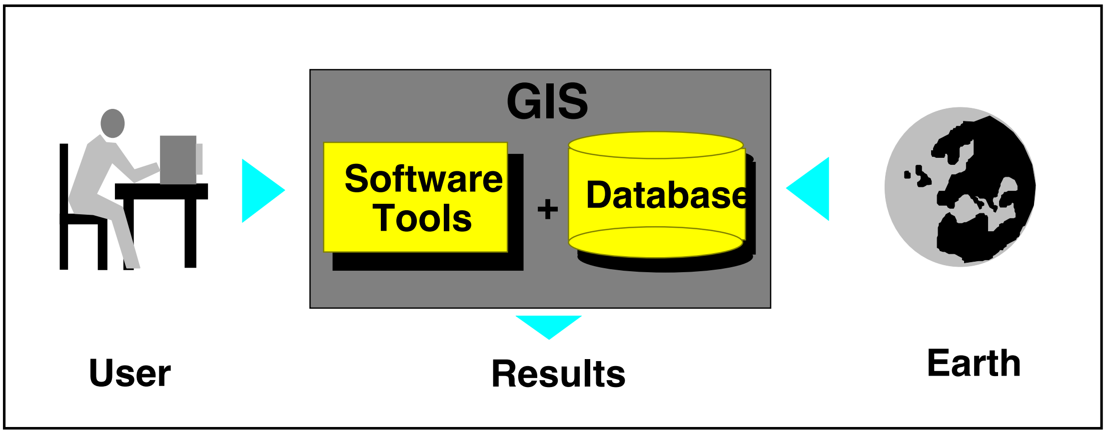


Figure 4.3 A simplified geographical information system (after ESRI, 1993)

4.3.2 Characteristics of GIS

Some of the established characteristics of GIS may be summarised as following (DOE, 1987):

- Data integration of the available information systems with future data sets can easily be done,
- The system is modular, i.e only those parts required need to be used,
- It has a flexible growth path whereby any user may identify and construct their own information system,
- It has standard facilities where any user may construct their own information system,
- Information can be extracted through names, locations, reference numbers etc.,
- Information can be made available through a geographic interface and query master interface,
- Users may add and change information and arrange it in a way that suits their application.

4.3.3 The functional elements of GIS

GIS deal with the geographic data which describe objects from the real world in terms of their;

(1) position within a known coordinate system;
(2) spatial relationships with one another;
(3) attributes.

It has also ability to answer a broad range of questions about these data. As illustrated in Figure 4.4, GIS are designed to manage data gathered by widely disparate methods, integrate it, provide analysis, and map the result (Maguire and Dangermond, 1991; Shepherd, 1991).

According to Knapp (1978), a computer-based GIS may be itself be viewed as having five component sub-systems, including:

(1) data acquisition;
(2) data management;
(3) data retrieval;
(4) data manipulation and analysis;
(5) data display.

4.3.3.1 Data acquisition

Data acquisition is the process of identifying and gathering the data required for a spatial procedure. Data for input to a GIS are typically acquired in a variety of formats, including graphic data and non-graphic data (i.e. attribute data or descriptive and textual data) from both printed and digital files.

4.3.3.2 Data management

Data management allows a data base to be used through a combination of hardware and software facilities and operations. Basically, it provides consistent methods for data entry, update, deletion, and retrieval information when necessary.

According to Smith *et.al.*, (1987), a GIS should include integrated data base management software designed to provide:

- the ability of the system to support multiple users and multiple data bases;
- efficient data storage, retrieval, and update;
- non-redundancy of data;
- data independence, security and integrity.

4.3.3.3 Data retrieval

In the conception of a data base, access procedures should be established to provide for retrieval of both spatial and non-spatial data. This clearly affects the user's ability to obtain the information behind the data (graphical or non-graphical types) and to structure the information to solve a particular problem.

Efficient data retrieval operations are largely dependent upon the volume of data stored, the method of data encoding and the file structure design. Searching for spatial features or sets of features often involves procedures of considerable complexity with data searching, additions, deletion and changes. Data retrieval may locate any of the following:

- a single feature;
- a set of defined features;
- an undefined feature or set of features;
- features based on defined relationships within data set;
- a set of features where the criteria are within another data set; and
- all features in a given class.

4.3.3.4 Data manipulation and analysis

The analytical functions required to operate on the spatial and non-spatial elements of geographical data range from those that retrieve simple subsets of information for display to those that use spatial relationships and topological overlay to create new objects. However, Knapp (1978) categorised data analysis procedures as follows:

(a) ***Spatial analysis*****,** including procedures such as polygon overlay; cell overlay (arithmetic, weighted average, comparison, multiple map dependent reassignment, correlation functions); connectivitiy (proximity functions, optimum route selection, intervisibility); and neighbourhood statistics (slope, aspects, profile, clustering);

(b) ***Measurement of line and arc lengths*****;** of point-to-point distances; of perimeters, areas and volumes; of polygons in grid and x,y-coordinate format;

(c) ***Statistical analysis*****,** including histograms or frequency counts; regression, correlation and cross-tabulation;

(d) ***Report generation***, including the ability to provide labels for reports; to save text files as part of the data base; and to alter the standard default format.

4.3.3.5 Data display

A GIS includes software for the display of maps, graphs and tabular information in a variety of output media. Software should exist for the production of maps which depict the spatial or areal distribution of various objects. Display media include both hard copy (durable since they are printed on paper and film) and soft copy (transient images on television-like computer display).

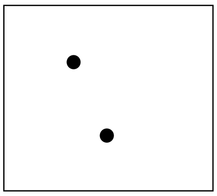
Outputs from a GIS may be a standard cartographic product such as a map sheet or a simple table of data entries, graphs, report etc. on printer and plotter. Alternatively, it may be the result of query or some analysis (Taylor, 1991). Modern technology produces computer-compatible materials: tapes and disks in standard formats for storage in an archive or for transmission to another system in future use.

4.3.4 Spatial data models in GIS

Within the context of a GIS, each spatial data type or theme is referred to as a spatial data layer or data plane. Each of these spatial data layers has three possible types of geographic entities: *points*, *lines*, and *polygons* (Figure 4.5). In a spatial data layer, spatial objects are basically encoded employing one of two basic data models. These are referred as vector and raster models (Figure 4.6).

POINTS

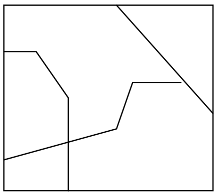
are zero-dimensional objects on a map which represent a single location on the earth. The location is recorded as an xy coordinate. Depending upon the scale and accuracy desired, a point can represent the location of a multi-dimensional feature (such as a bridge). Also known as nodes.



Examples: street intersections
water valves
parcel centroids
fire hydrants

LINES

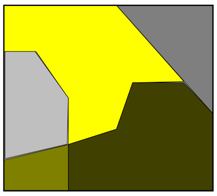
are one-dimensional objects on a map which represent a linear feature having a beginning point and an ending point. Depending upon the scale and accuracy desired, lines may be subdivided onto smaller units called arcs. (This is necessary in order to represent curved lines).



Examples: street centerlines
lot lines
rivers
water mains
sewer mains

POLYGONS

are two-dimensional objects on a map which represent shapes which have area. When the lines which form their boundaries are defined as polygon boundaries, the polygons become distinct objects which can be manipulated and displayed as a single entities.



Examples: blocks
census tracts
parcels
zoning disrticts
political districts

Figure 4.5 Geographic elements (points, lines, and polygons) used for defining topological data structures (taken from Huxhold, 1991).

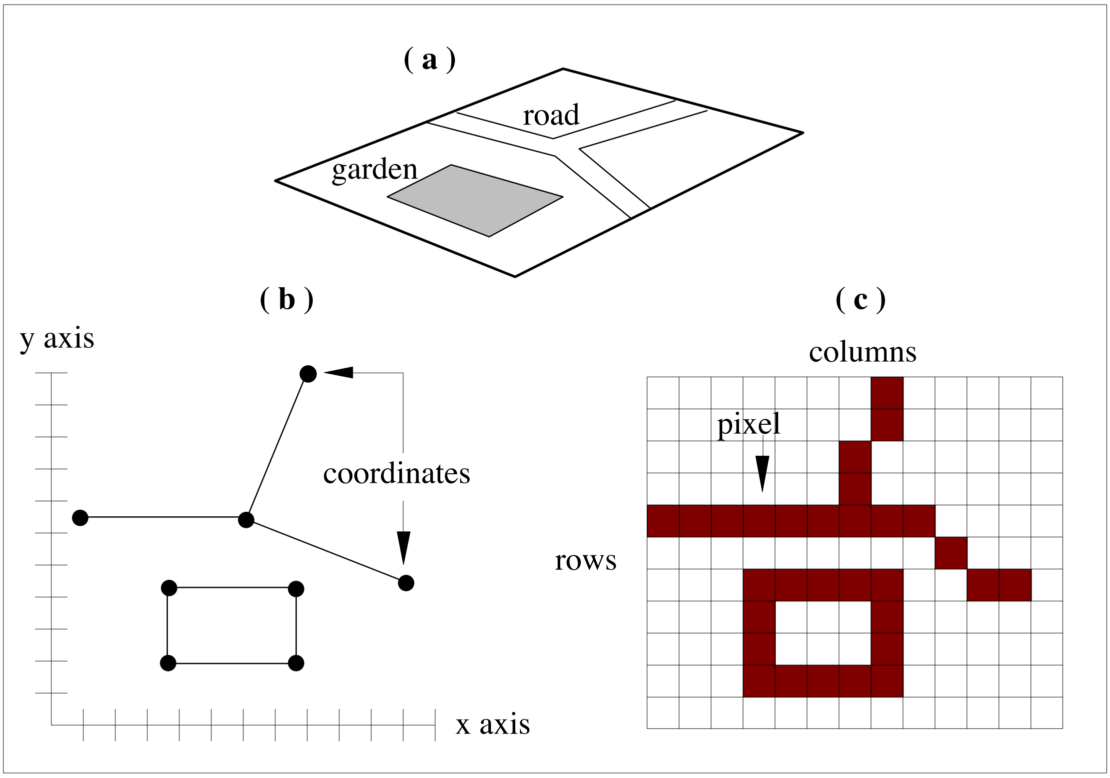


Figure 4.6 Vector and Raster data models. 4.6a. Analogue model of reality; 4.6b. Digital vector model; 4.6c. Digital raster model.

4.3.4.1 Vector spatial data

The basic logical unit in a vector model is the line, used to encode the locational description of an object, and represented as a string of coordinates of points along the line. Closed areas, modelled as polygons, are represented by the set of lines that constitute their boundaries. Vector data model may be classified as ***spaghetti*** or ***topological***.

The simplest form of vector representation has been termed the ***spaghetti model***. In this model each map entity is enclosed separately in a vector form without referencing any of its neighbouring entities. The intersection point of two links is not recorded. Points common to two links (end points) are recorded twice. Data is usually stored sequentially in no particular order.

Searching for a particular coordinate point is achieved by examining each one in turn, a slow process (Taylor, 1991).

Alternatively, in the ***topological model***, the network of lines partitioning a map is represented as a planar graphs. Line segments correspond to arcs in the graph and their endpoints to nodes. A topological model for spatial data contains information about the connectivitiy, adjacency and hierarchy of features. Additional information such as which polygons, links and nodes are contained within a given polygon and which polygons are adjacent are built into the model. This model provides the basis for powerful analytical techniques such as polygon overlay and intersection (Burrough, 1986).

4.3.4.2 Raster spatial data

In a raster model, entities may be generalised and stored using grid cells as a polygonal units of space in a matrix. The units are usually regular squares referred to as pixels. The raster is easily traversed in both the *x* and the *y* directions in the uncompacted state. Run length encoding in the *x* direction is frequently used to achieve data compression. The raster model, however, often results in some loss of geographic specificity.

4.3.4.3 Raster versus vector

Raster and vector approaches to data storage are distinctly different; however they are both representing spatial information and translatable from one to another. Raster representations have come about because of efficient collection by means of scanning devices, such as are on Landsat satellites, and because of the pixel representation of graphic devices, whereas vector representation is preferred because of accurate feature representation and point definition as required in surveying applications. For the practical work of this project the vector spatial data format is used. Table 4.2 gives a comparison of vector and raster models.

Table 4.2 Comparison of vector and raster data methods (from Burrough, 1986).

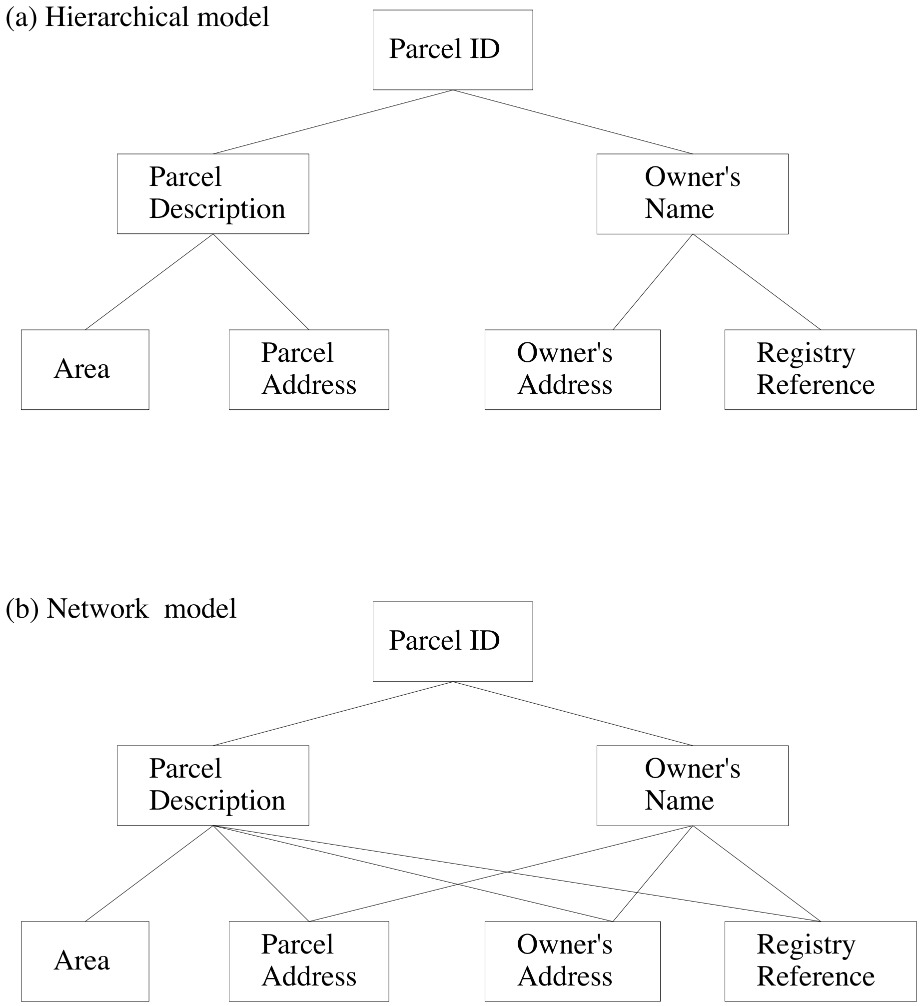
	ADVANTAGES	DISADVANTAGES
Vector methods	• Good presentation of phenomenological data structure. • Compact data structure. • Topology can be completely described with network linkage. • Accurate graphics. • Retrieval, updating and generalisation of graphics and attributes are possible.	• Complex data structures. • Combination of several vector polygon maps or polygons and raster maps through overlay creates difficulties. • Simulation is difficult because each unit has a different topological form. • Display and plotting can be expensive, particularly for high quality, colour and cross-hatching. • The technology is expensive, particularly for the more sophisticated software and hardware. • Spatial analysis and filtering within polygons are impossible.
Raster methods	• Simple data structures. • The overlay and combination of mapped data with remotely sensed data is easy. • Various kinds of spatial analysis are easy. • Simulation is easy because each spatial unit has the same size and shape. • The technology is cheap and is being energetically developed.	• Volumes of graphic data. • The use of large cells to reduce data volumes means that phenomenologically recognisable structures can be lost and there can be a serious loss of information. • Crude raster maps are considerably less beautiful than maps drawn with fine lines. • Network linkages are difficult to establish. • Projection transformation are time consuming unless special algorithms or hardware are used.

4.3.5 Database models

A database is a collection of information about things and their relationships to each other. The objective in collecting and maintaining information in a database is to relate facts and situations that were previously separate. This may simply require the retrieval of facts in the data base, such as the retrieval of an address associated with a person's name. Or it may require extensive data processing in which multiple relationships are evaluated, such as the analysis of a housing development.

A Database Management Systems (DBMS) is comprised of a set of programs that manipulate and maintain the data in a data base. They were developed to manage the sharing of data in an orderly manner and to ensure that the integrity of data the data base is maintained (Elmasri and Navathe, 1989). A DBMS acts as a central control over all interactions between the data base and the application programs, which in turn interact with the user. Typical functions of a DBMS include the logical and physical linkage of related data elements, the retrieval and verification of data values, and other data management functions such as security, archiving, and updating (Healey, 1991).

The conceptual organisation of a database is termed the *data model*. It can be thought of as the style of describing and manipulating the data in a database. There are three classic data models that are used to organise databases: hierarchical, network, and relational models (Figure 4.7).



(c) Relational model

Parcel ID	Area	Parcel Description	Parcel Address	Owner's Name	Owner's Address	Registry Reference

Figure 4.7 Database models

4.3.5.1 Hierarchical data model

In the hierarchical data model, the data are organised in a tree structure. The top of the hierarchy is termed the *root*. It is comprised of one entity. The root may be represented by a record containing a single data field, or by a record containing many fields. Except for the root, every element has one higher level element related to it, termed its *parent*, and one or more subordinate elements, termed *children*. An element can have only one parent but can have multiple children. Access to a record is made first through its parent record. The hierarchical model provides a "one-to-many" relationships.

4.3.5.2 Network data model

The network data model overcomes some of the inflexibility of the hierarchical model. Network models tend to have less redundant data storage than the corresponding hierarchical model. In the network model, an entity can have multiple parent as well as multiple child relations and no root is required. As a result, data records can be directly searched without traversing the entire hierarchy above that record. A network model provides "many-to-many" relationships.

4.3.5.3 Relational data model

Unlike the other two models, the relational database comprises *flat files* or tables. Each file or table is referred to as a *relation* as it contains logically related information. The data are stored as a collection of values in the form of simple records, termed *tuples*. Each tuple represents a fact, i.e. a set of permanently related values. The tuples are grouped together in two-dimensional tables, with each table usually stored as a separate file. The table as a whole represents the relationships among all the attributes it contains, and so it is often termed a *relation*. Using the relational model, a search can be made of any single table using any of the attribute fields, singly or together. Searches of related attributes that are stored in different tables can be done by linking two or more tables using any attribute they share in common. This procedure is termed a *join* operation.

All the models have advantages and disadvantages. The access paths defined by pointers in the hierarchical model provide relatively high performance for routine queries. However, because the pointers have to be defined before the model is constructed, it is inflexible. The network model provides more access paths, but they still have to be predefined. The relational model is extremely flexible, on the other hand, as it has the ability to process ad hoc queries. However, because access paths are not predefined, relational databases have to be searched exhaustively to satisfy a query.

4.3.6 GIS applications

GIS has great ability to deal with such large volumes of data that are not efficiently handled using manual methods. These data may exist as maps, tables of data, or even as lists of names and addresses. When those data have been input to a GIS, they can be easily manipulated and analysed in ways that would be too costly, too time-consuming, or practically impossible to do using manual methods. The applications are diverse, for example:

- finding the coincidence of factors, such as the areas with a certain combination of soil type and vegetation, or the areas in a city with a high crime rate and low income level;

- updating geographic information, such as forest cover maps to show recent logging, or updating land use maps to show recent conversion of rural land to residential development;
- managing municipal services, such as scheduling maintenance activities, notifying local residents of re-zoning applications, or assigning police patrol areas.

The number and type of applications and analyses that can be performed by a GIS are as large and diverse as the available of geographical data sets. A government report which is Handling Geographical Information Report (DOE, 1987), gives a broad and detailed analysis of the use made geographical information. According to this report geographical data may be categorised as follows:

(1) Land and property
(2) Socio-economic
(3) Land-use, rural resources and environmental
(4) Infrastructure data
(5) Sea and air

To date, a wide variety of GIS has been developed and used, primarily for land use planning and natural resource management at the urban, regional, state and national levels of government, but also for applications by public utilities and private corporations. Most of these systems rely on data from existing maps or on data that can be readily processed to provide the locational information required. The areas of GIS applications are extensive. Examples are:

- Planning and management of public services
- Defence and security systems
- Land use and resource management
- Environmental monitoring
- Epidemiology
- Utility network management
- Transport network management
- Property development and investment
- Marketing and business location
- Civil engineering
- Mineral exploitation
- Teaching and education

Urban land planning applications require a systematic collection, updating, processing, and distribution of land-related data. The capability to handle land survey data is also a common requirement of these activities. Especially, municipalities use GIS for legal, administrative, and economic decision-making, as well as for various planning activities.

The term *Land Information System* is frequently used to refer to GIS that have been specialised for these applications (Aronoff, 1989). While GIS deals with geographical data, land information system emphasises parcel level data, the level of geographical aggregation where people's rights and interests are defined (Epstein, 1991). However, land information systems will be reviewed in the next section.

4.4 Land information systems

Since there are increasing population pressures and a great need for environmental controls, the optimal use of land resources is important. The misuse of land resources, weak or non-existent planning, poor management and insufficient land regulations cause problems in land development activities which require improved land management. To improve land management depends on the acquisition, and effective use of accurate data on land. Land Information Systems (LIS) deal with both the nature and extent of land interests.

4.4.1 Definition of LIS

Several formal definitions of LIS have been proposed. Best known is the one adopted by the Federation of Internationale des Geometres (FIG):

> "A **LIS** is a tool for legal, administrative and economic decision-making and an aid for planning and development which consist on the one hand of data base containing spatially referenced land-related data for a defined area, and on the other hand, of procedures and techniques for the systematic collection, updating, processing and distribution of the data. The base of LIS is a uniform spatial reference system for the data in the system, which also facilities the linking of data in the system with other land-related data."
>
> (Hamilton and Williamson, 1984)

Some other definitions of LIS may be given as follow:

> "LIS is a combination of human and technical resources, together with a set of organising procedures, which produces information for some managerial requirement."
>
> (Dale and McLaughlin, 1988)

> "LIS is a system for capturing, storing, checking, integrating, manipulating, analysing and displaying data about land and its use, ownership, development, etc.."
>
> (AGI, 1991).

Considering the above definitions, LIS may be illustrated as in Figure 4.8.

4.4.2 Management objectives of LIS

LIS may be designed to serve one primary function, or they may be multifunctional. It is directed at the effective use of information to achieve an objective or set of objectives. These objectives have been given by Dale and McLaughlin (1988) as following:

(1) determining the requirements for land-related information;

(2) examining how the information is actually used in the decision making process, how information flows from one producer or user to another, and what constraints there are upon that flow;

(3) developing policies for determining priorities, allocating the necessary resources, assigning

responsibilities for action, and setting standards of performance and methods for monitoring them;

(4) improving existing land information systems or introducing new ones;

(5) assessing and designing new tools and techniques.

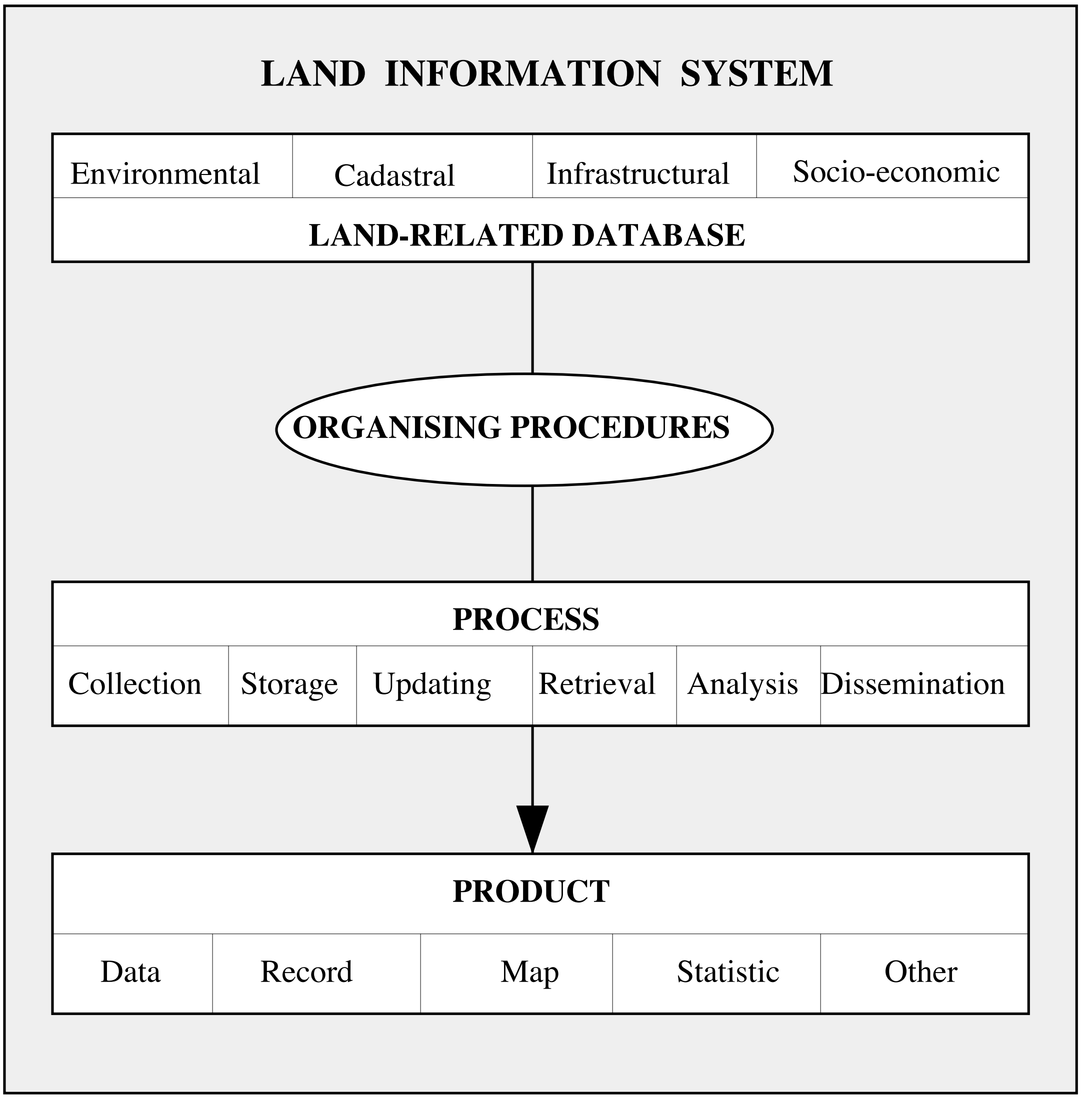


Figure 4.8 A simplified land information system (based on Larsson, 1991)

While LIS provide both the information infrastructure necessary for land allocation and settlement, a land parcel is especially used as the basic spatial unit. In this case, LIS are considered as a ***parcel-based LIS*** or ***cadastre***.

4.4.3 Parcel-based LIS: The Cadastre

The cadastre is concerned with land, law and people. A cadastre is a general, systematic and up-to-date register containing information about land parcels including details of their area, value and ownerships (Dale, 1976).

The cadastre or a parcel-based LIS is referred as a subset of LIS that has been defined as:

> "...a record of interests in land, encompassing both the nature and extent of these interests. An interest in land (or property right) may be narrowly construed as a legal right capable of ownership or more broadly interpreted to include any uniquely recognised relationship among people with regard to acquisition and management of land."
>
> (NRC, 1980)

In a simple form, the cadastre may be defined as:

> "..an official record of information about land parcels, including details of their bounds, ownership, tenure, use, and value."
>
> (McLaughlin and Nichols, 1989)

The cadastre is a public record in which complete, up-to-date information for all parcels within a given geographical region is maintained. The information in a cadastre is collected, stored, referenced, and retrieved essentially at the land parcel level. Other referencing systems, such as coordinates, may then be added to facilitate data manipulation and the exchange of information with other systems.

4.4.3.1 Components of the cadastre

According to McLaughlin and Nichols (1989), a cadastre has three basic components,

1) ***The cadastral parcel*****;** which is a continues area of land in which unique, homogeneous interests or property rights are recognised. As a three dimensional division of earth, the parcel may be include superadjacent and subadjacent rights in addition to surface rights, as shown in Figure 4.9 Importantly, in a parcel-based LIS, the data are organised around the cadastral parcel.

2) ***The cadastral records;*** which consist of a cadastral map (or property map) and text (legal descriptions). These records contain graphical and alphanumeric information concerning the delimitation of a cadastral parcel and the nature of the tenure interests (including land rights, duties prescribed, duration, etc.)

3) ***A parcel identifier (PID)*****;** which links each land parcel with related cadastral records. A PID is a unique code that may contain geographical information (e.g., centroid coordinates, lot and block number, municipal street address) or may be unrelated to location (e.g., a numerical code).

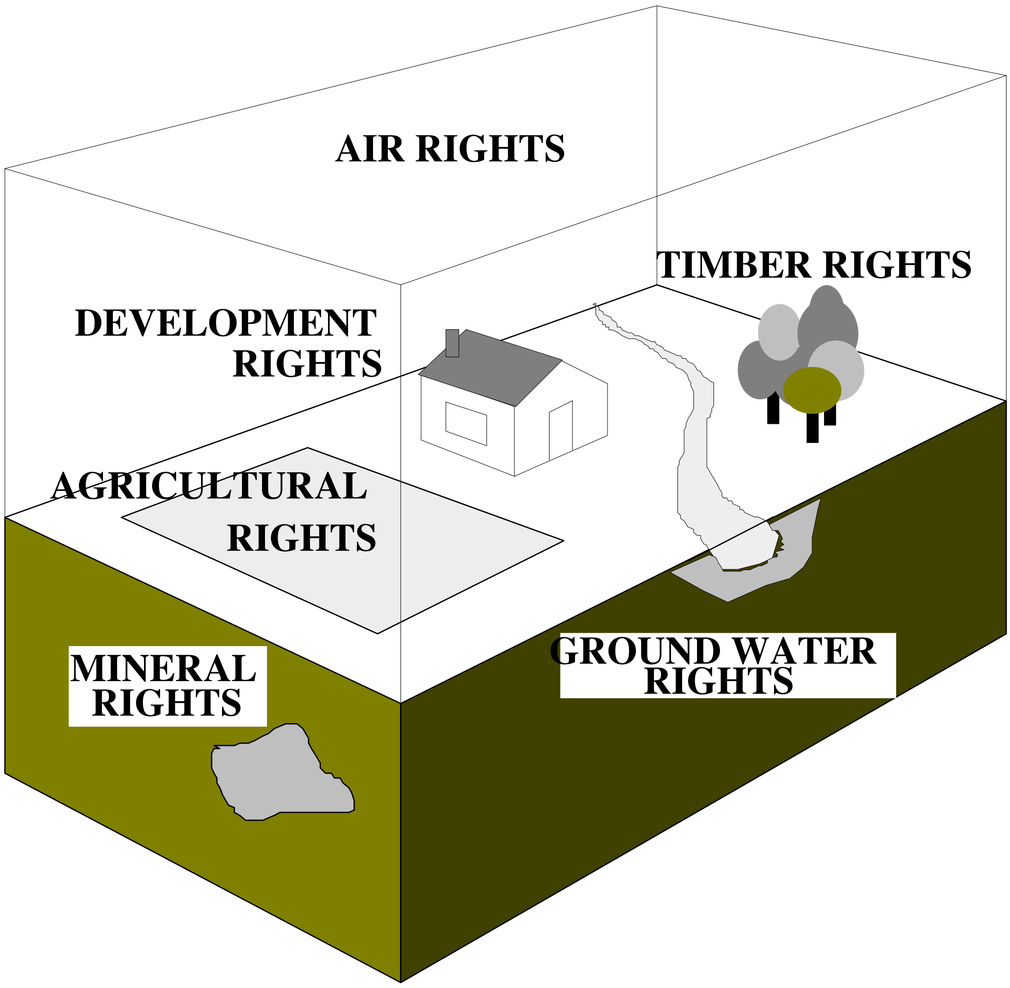


Figure 4.9 The land Parcel (after Dale and McLaughlin, 1988)

Many types of land data can be linked in a cadastral system by the cadastral components. The attribute information contained in the textual records and the spatial data of the graphical records may interrelated through reference to a PID which serves as a primary indexing, access, and linkage mechanism. An example of potential linkages to other land-related information and the primary components of a cadastre are given in Figure 4.10.

4.4.3.2 Classification of parcel-based LIS

Parcel-based LIS may be classified according to the information contained in the system or the primary purpose of the system. Three categories of cadastre, as identified by McLaughlin (1975) are:

4.4.3.2.1 Legal cadastre

A legal cadastre is an official legal record for a jurisdiction, state or country showing legal ownership, tenure, rights, ownership of interests, the area of land, a description, all in terms of the legal parcel. The record may consist of some or all of the following components:

(a) documentary records of ownership in the form of register of certificates of land title or register of deeds,
(b) maps and survey plans of the land, the subject of the documentary registers, and
(c) indexes linking the documentary records and maps.

4.4.3.2.2 Fiscal cadastre

Fiscal cadastre is developed primarily for property valuation and taxation. It is an up-to-date official record for a jurisdiction showing the taxable and/or rateable owner, the address of such an owner, a legal description of the parcel concerned and the address of parcel, the valuation of land and improvements together with the associated date of valuation, land use and planned land use. Valuation mapping is usually available; such maps resemble cadastral maps though the parcels shown may be the rating or valuation parcel rather than the legal parcel.

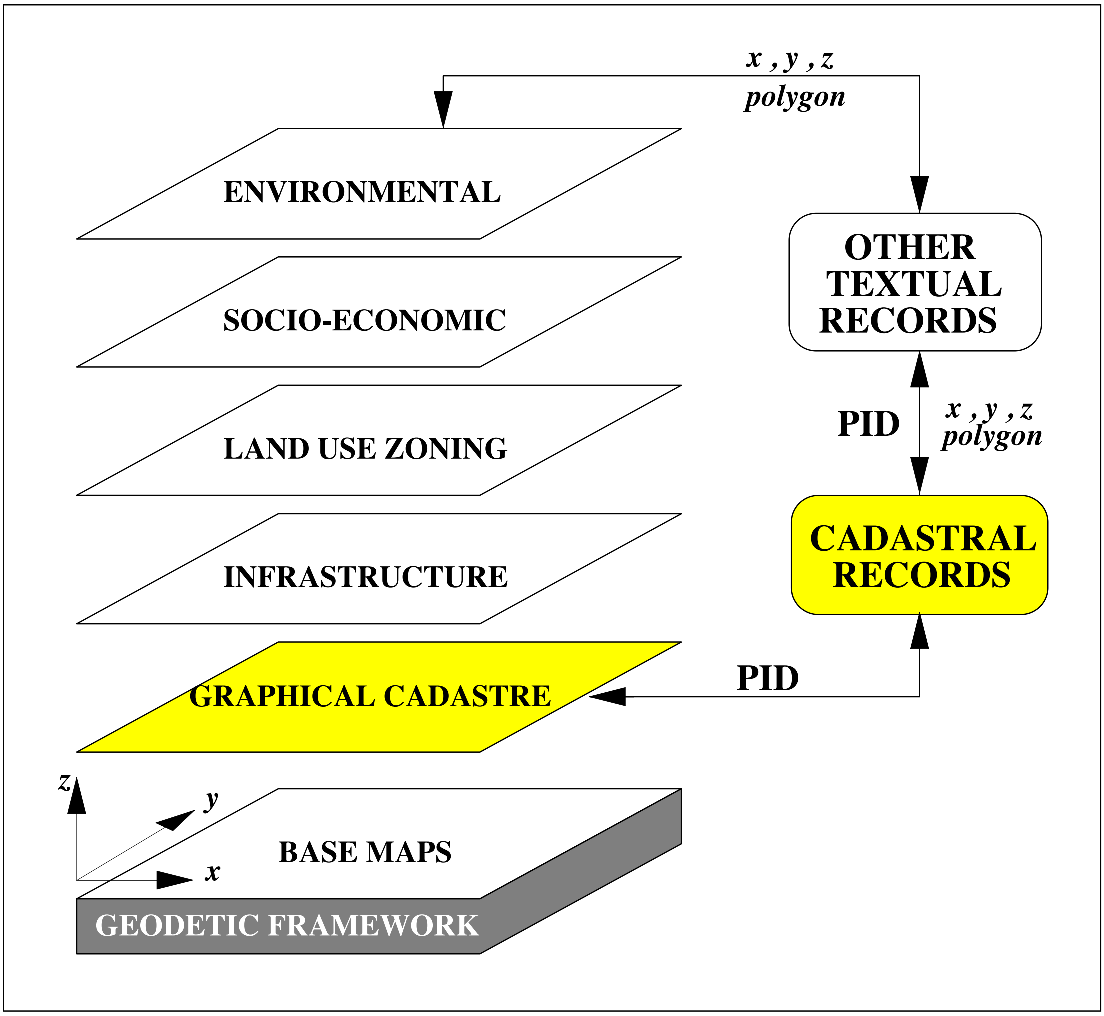


Figure 4.10 Primary components of a cadastre and examples of potential linkages to other land-related information
(taken from McLaughlin and Nichols, 1987)

4.4.3.2.3 Multipurpose cadastre

Multipurpose cadastre can encompass both fiscal and judical cadastre and contain a variety of other parcel-related land information. A large recording and analysis system, community-oriented LIS designed to serve both public and private agencies, and individual citizens by:

(a) employing a proprietary land unit (the cadastral parcel) as the fundamental unit of spatial organisation,

(b) relating a series of up-to-date (maintained) land information records (ownership, tenure, value, land use) to the parcel, and

(c) providing a ready and efficient means of access, analysis, linking, integration and display of records held.

Whereas the parcel structures for juridical and multipurpose cadastral systems are generally based on parcel definitions in legal documents (including survey plans), parcels in fiscal cadastre are sometimes related to unit of land use.

4.4.3.3 Role of the cadastre

Considering the role of cadastre within a nation for both the individual citizen and society as a whole, a comparison of the merits and impediments of the cadastre can be observed.

4.4.3.3.1 Merits of the cadastre

Henssen (1990) describes that the merits of having a cadastral system can be related to the individual or government on the other.

Merits to the individual or citizen

(1) The documented evidence of land ownership, which a cadastre provides, supplies security, reduces or eliminates the risk of eviction and thus enhances the incentive to invest in the land or property.

(2) This legal security effects the availability of resources for financial investment. The supply of credit, especially from institutional or formal resources, depends usually on the borrower's ability to provide cadastre-documented evidence of ownership.

(3) Dealings in land become easier, cheaper, faster and safer. Access to land is consequently improved. Conveyancing of unregistered land is often expensive, unsafe and takes a long time.

(4) Increased legal security results in a decrease of title and boundary disputes and related litigation, which saves costs for both government and citizens and promotes good relations between neighbours.

Figure 4.11 shows the influence of these four effects of cadastre on investments, which in turn give higher output or benefit from the land or property. This again results in higher income, higher value and ultimately results in improvement of the economy, expressed in growth of the gross national product.

Merits to the government or society

(1) A cadastral system enables the government to establish an efficient and equitable system for levying land or property taxes. Levying this tax -based on value, income or revenue- requires information on location, size and ownership of the land or property. This information can be supplied by a cadastre to ensure that the tax is levied on the correct persons and organisations and justified amounts.

(2) For land development through reforms, consolidation or readjustment, the data from the cadastral system provide an inventory of the existing land use to be used in determining the desired future situation and its implementation and management.

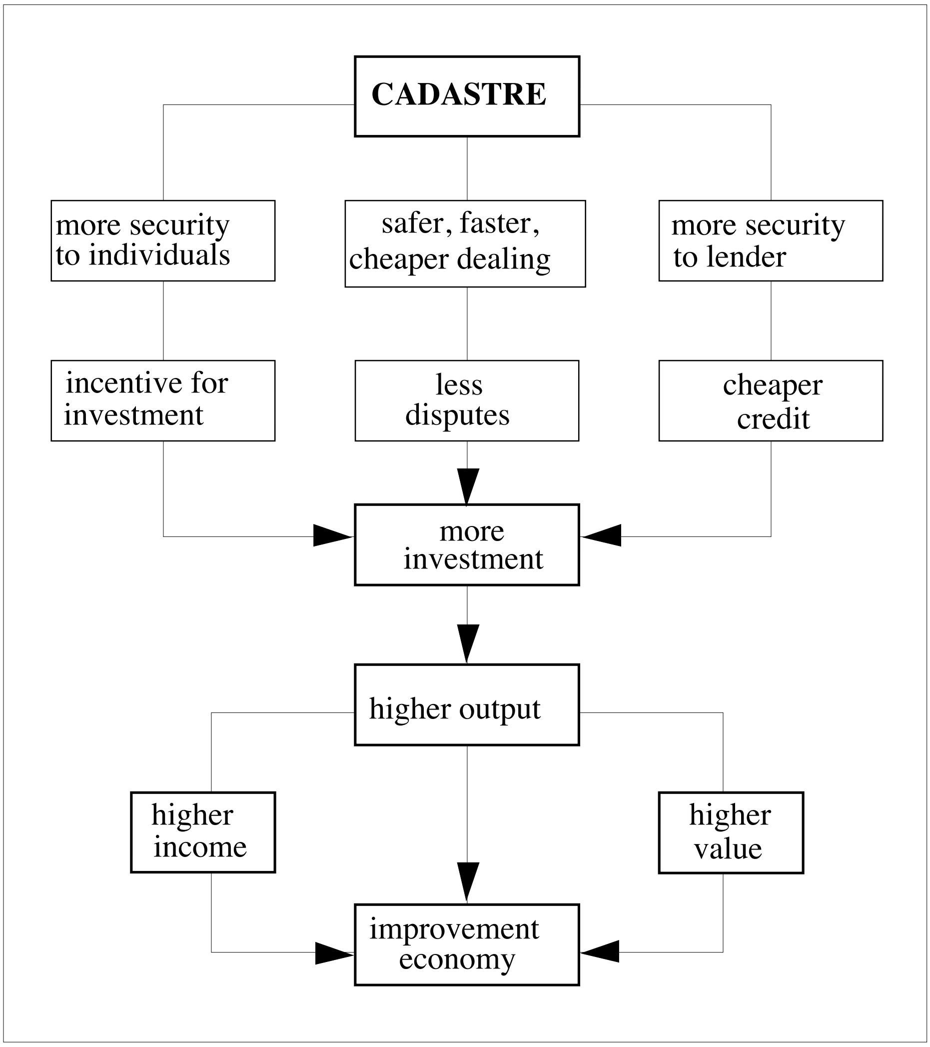


Figure 4.11 Positive effects for individuals (after Henssen, 1990)

(3) A mechanism becomes available to the government to assure that transactions meet the requirements of planning, spatial management, the allowed maximum amount of land per owner, maximum sales price or restrictions of land ownerships by foreigners. A countrywide recording system makes it possible for a government to determine the amounts of private, communal and state land.

(4) A useful tool is also created for the execution of a multitude of other governmental tasks. On a parcel level, data relevant for the environment can be processed and represented on maps or in lists. It is

thus also possible to determine the sources of pollution and the liable organisations or persons.

(5) The collected basic data of the cadastral map can also be serve as a basis for other large-scale maps, which will in long term result in considerable savings of time and costs.

(6) A cadastral system can provide the basis for geographic or land information systems. In such a system the parcel identifier can serve as a key for integrating and coupling several kinds of land data systems.

4.4.3.3.2 Impediments of the cadastre

Henssen (1990) remarks that, in some developing countries, it is sometimes feared that introduction of a cadastral system may lead to abolition of customary land tenure, applicable in a given area or for a given family, clan or tribe. It is also sometimes regarded as excessive government interference in private life and in the special family or tribal ties to the land.

Another impediment sometimes originates from influential citizens or families in their capacity as large landowners or landlords. They sometimes, together, own more of the total area of the country. If this situation is made visible to the ordinary citizen through the medium of a cadastre, it may well lead to political unrest.

Obstruction or opposition to the introduction of a cadastre sometimes comes from those who earn their money from the lack of such a system (title insurance companies, solicitors, lawyers), as well as from those whose interests do not lie in a just levying of land tax, or those who fear losing land to government-sponsored development projects.

More details about the cadastre and cadastral systems, can be found in Dale (1976), McLaughlin and Nichols (1987), Dale and McLaughlin (1988), Henssen (1990), Larsson (1991).

4.5 Chapter summary

In order to develop the proposed land readjustment model discussed in the previous chapter, the use of information technology is essential. Due to poor information management data cannot be used more effectively in the present land readjustment applications. There is a need to integrate land readjustment with currently available information systems. However, to understand the nature of these systems some land-related information systems were reviewed in this chapter.

GIS and LIS were particularly described with their definitions, objectives, general principles, and applications. GIS is one of the most effective land-related information systems which have been widely used in land development applications. There is not a single definition for GIS. But it is basically defined as a tool for collecting, storing, manipulating, and displaying spatial data. LIS is also defined as a spatial information tool for legal, administrative and economic decision making. However, it deals with both the nature and extent of land interests on a land parcel base.

CHAPTER 5

SOFTWARE DEVELOPMENT :
The development of LARES (LAnd REadjustment System)

5.1 Introduction

As outlined in Chapter 3, the value-based approach to land readjustment is a complex process which requires spatial data analysis. Especially, when many land valuation factors are involved in the process, it is almost impossible to analyse these factors by conventional manual methods. While dealing with a large amount of information, to fulfil all necessary calculations, land distribution is difficult to perform manually. Therefore, current computing technology should be introduced to the land readjustment process in order to increase the speed of data and to manage information effectively.

In this chapter, the automation of the proposed model is described. A prototype land readjustment model which is to be referred as **LARES** (**LA**nd **RE**adjustment **S**ystem) was designed and developed using GIS. The development stages of the model are outlined, including the used GIS package and its associated modules. As a GIS tool, the functionality of ARC/INFO was used during the prototype development. A menu-driven system which is easy to use for the user has been created. Arc Macro Language (AML) and FORTRAN77 programming languages were used for the programming requirements.

5.2 Integration of land readjustment with GIS

A value-based land readjustment approach certainly requires an effective information management system in order to accomplish the whole process in a successful way. Land valuation analysis, for example, deals with many land valuation factors which should be spatially examined in a defined geographical unit. In addition, data input, basic calculations, data extraction, manipulation and providing all necessary information should be done precisely in a short period of time. Querying and display of any graphical or textual information is also an important for user requirements. Therefore, the integration of the value-based land readjustment with a spatial information system such as a GIS is essential.

However, as explained in Chapter 4, GIS is a system to collect, store, manipulate, use and analyse spatial information. It has the capabilities to handle all required graphical and textual data within a computer system so that any desired new information can be reached and derived from that which exists. GIS also provides great functionality to deal with complex spatial data analysis that the value-based land readjustment requires.

Due to its great functionality, the use of GIS is vital to develop a value-based land readjustment prototype model. Using the capability of GIS, the main analysis requirements of the proposed model were developed. Based on Figure 5.1, some main algorithms such as land subdivision, land valuation factor analysis, and land distribution were designed and performed. The following sections however give more details about the development of these algorithms, including the GIS tool used and the other data procedures throughout the prototype LARES.

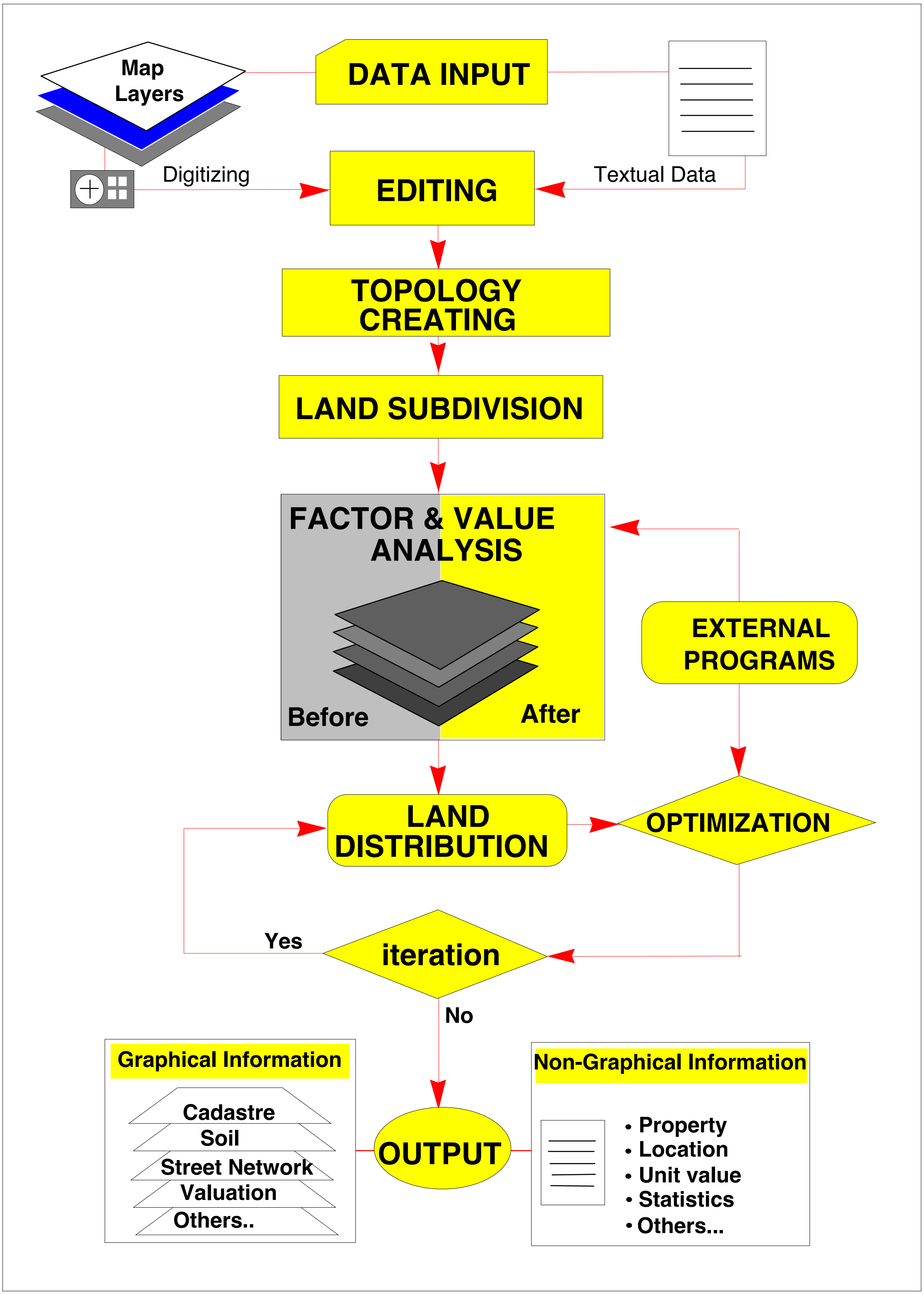


Figure 5.1 An overview of LARES

5.3 Choice of a GIS tool

To execute the required spatial data analysis for the value-based land readjustment model, the use of a GIS system is essential. Therefore, the GIS systems which would perform the requirements of the proposed model were examined. The details about different GIS tools are reviewed by Parker (1990), Taylor (1991), Bakker and Toppen (1993).

Due to its availability in the Surveying Department, ARC/ INFO GIS software was selected and used for the development of the proposed model. ARC/ INFO was selected because it is a world-wide used vector based GIS system which is suitable for the large scale applications. It has a number of vector process modules that the value-based land readjustment model requires. Such processes include polygon overlay, buffering, 3-D views and network analysis. ARC/INFO also has its own programming language which allows the user to develop independent algorithms and user interface environments for a particular application. The linkage with other external files is also possible with ARC/ INFO. However, more details on ARC/ INFO GIS system is given in Appendix G.

5.4 Software organisation

In order to design and develop the prototype model LARES, the following considerations were taken into account during the software development;

- the prototype LARES should be designed as a single model which deals with all data processing within that model,

- the required spatial data analysis should be performed by the designed model,
- an interactive user environment should be created for data extracting, editing, and displaying requirements,
- the main applications such as land subdivision, land valuation, and land distribution algorithms should be designed as different modules,
- when the query of information is required both graphical and non-graphical data should be provided quickly,
- a user friendly menu-driven interface should be designed,
- the model should allow the modification of a land valuation factor including the adding of a new valuation factor,
- all kinds of data should be stored in suitable formats for further use.

Using ARC/ INFO GIS system, the above considerations were accomplished. One of the main advantages of ARC/ INFO is to communicate to external programs via AML. AML enables users to define sets of ARC/ INFO command sequences and to be stored in files for both interactive and non-interactive use. It also provides various functions and directives for accessing ASCII data files and executing user-defined external programs. Therefore, AML and FORTRAN77 programming languages were used for the algorithm requirements.

5.4.1 Data processing

The main tasks of the software are illustrated in Figure 5.2. According to Figure 5.2, firstly, the required data is derived from the property, zoning, thematic, topographical maps, and from the other related textual records. These maps are considered as the input coverages.

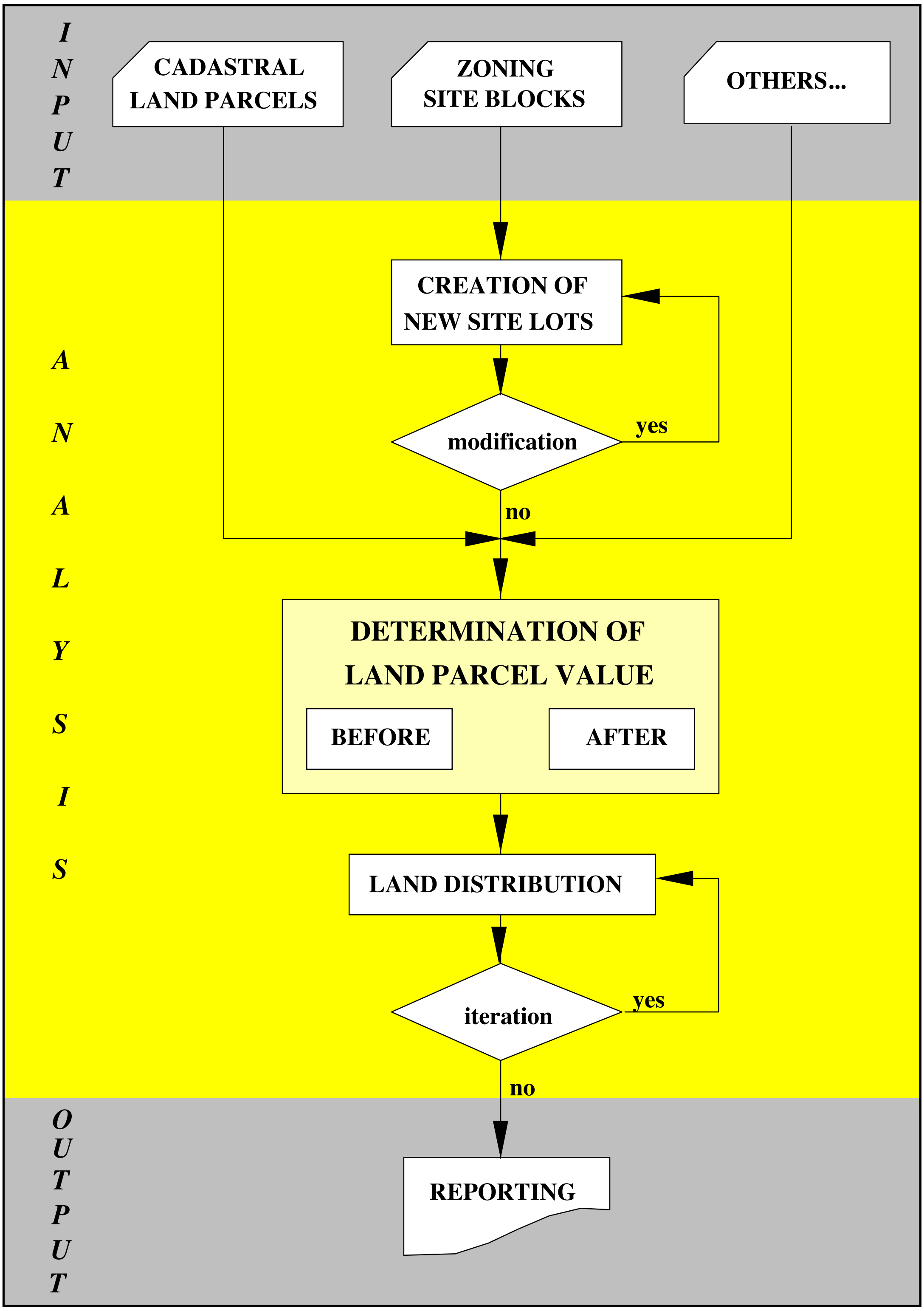


Figure 5.2 The main tasks which undertaken during the software development

Then, site blocks on zoning plans are subdivided into new land parcels with respect to detailed zoning codes. Following the subdivision process, cadastral and newly created land parcels are individually analysed by the selected land valuation factors. Using the required equations, each land parcel value is determined before and after. Land distribution is then performed. Based on the calculated valuation figures, each cadastral land parcel is finally reallocated within the new lots.

In order to carry out these operations, a number of algorithms were developed. The main operations such as land subdivision, land valuation analysis, land distribution, and query of information were designed as individual modules. The development of these modules is detailed in the following sections including data storage.

5.4.2 Customisation

Throughout the data processing, many tasks are performed by different commands. Most of them are the ARC/ INFO commands which are executed very often. To avoid repeating of these commands, data processing is automated and simplified for frequently performed actions by AML macros and menus. However, the AML macros were used to organise a sequence of ARC/ INFO commands into easily performed, sophisticated data processing operations. The menus were used to develop menu-driven user interfaces to meet the needs of particular applications. The menu system of the prototype model is explained in Chapter 6.

5.4.3 Storage of data

There are two types of data to input. These are graphical and non-graphical data. The graphical data was digitised and stored as a series of coordinates which identify the locations of the digitised entities. In ARC/ INFO, this locational data is used to build topology which identifies points, arcs and polygons, so that map features are represented by sets of arcs and label points and topological relationships between connected lines and points. This spatial data is linked by common feature numbers to the non-graphical data in a relational DBMS by Arc Attribute Tables (AAT) and Polygon Attribute Tables (PAT).

Area features such as land parcels, and zoning blocks, are defined by polygons which are outlined by a list of arcs. Arcs are stored as an ordered series of *x,y* coordinates. They have unique user-IDs and all the arcs in a coverage are sequentially numbered. An arc consists of two nodes. These nodes are also sequentially numbered in ARC/ INFO. The internal arc number and the related node numbers with from- and to-node are stored in AAT.

Non-graphical data is stored in feature attribute tables. A relational database structure is used to store numerical and alpha-numerical data. Using AAT and PAT tables, the feature attribute tables are also linked to graphical data tables. The relational DBMS which forms the second half of ARC/INFO allows the user to associate and interrelate information from several files by matching selected codes which are common to each file. As illustrated in Figure 5.3, a lot-ID can be associated with each land parcel, it can be then be related to a file containing information on ownership, zoning etc. of the parcel.

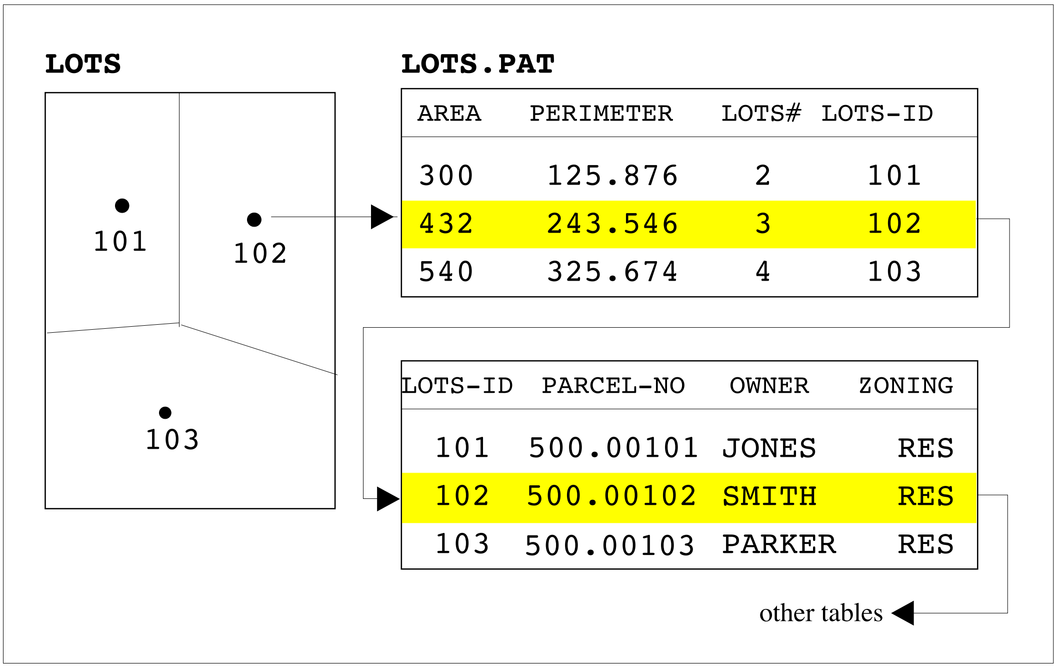


Figure 5.3 Graphic and tabular integration

5.4.4 Data check and correction

Due to digitising errors the input data must be checked before implementation. In order to make spatial analysis, the input data should be free of errors and topologically correct. This is accomplished by establishing the existing spatial relationships, identifying errors, correcting them, and reconstructing the topology. Some of the common errors that topology construction can identify are;

- Arcs that do not connect to other arcs
- Polygons that are not closed
- Polygons that have no label point or too many label points

Once data are put in ARC/INFO, the system provides two commands to create topology automatically. These commands are `BUILD` and `CLEAN`.

Although both are used to construct topology and create feature attribute tables, they differ somewhat. BUILD processes points, lines and polygons, whereas CLEANprocesses only lines and polygons. However, when these commands are issued, digitising errors can be listed and display. Using the ARCEDIT environment, these errors are edited and corrected. Then, topology is reconstructed. This process is repeated until the spatial relationships are satisfied within a given tolerances (Figure 5.4).

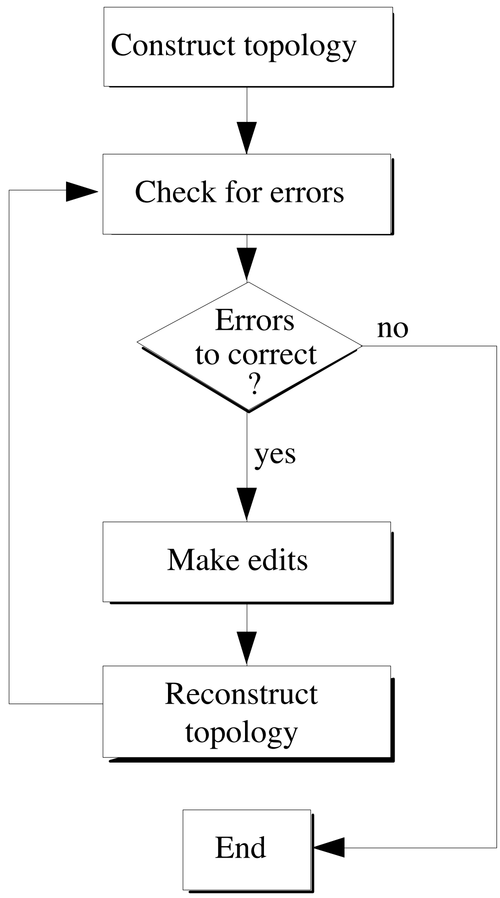


Figure 5.4 Reconstruction of topology

5.4.5 The sequence of polygon segments

In a land readjustment process, the polygons such as land parcel and site blocks are mostly dealt with as a geometrical feature. A polygon is digitised corner by corner rather than as a continuous line. In this case, several digitised arcs make a polygon. As illustrated in Figure 5.5, an arc can also consist of several line segments as vertex between two nodes.

In ARC/ INFO, line segments are stored in accordance with the digitising direction of an arc. Therefore, line segments can be stored in non-sequence form (Figure 5.6.a). This creates a problem when there is a need to know what particular parcel side follows the which one. On the other hand, the verteces are not considered as an arc in AAT tables. The verteces are represented with pseudo-nodes. However, in the cadastral process each broken line should be identified with its real-nodes and considered as a single geometrical feature.

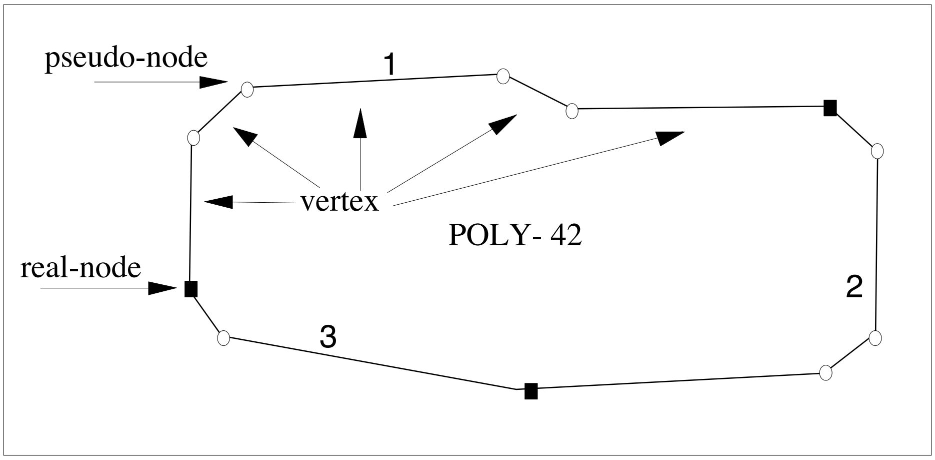


Figure 5.5 A polygon digitised with three arcs

In order to solve this problem, all pseudo-nodes were converted to real nodes and the new line segments are re-stored in a sequence form for a polygon. As a result, all corners of a land parcel were identified and the following parcel sided were re-arranged in the same direction with respect to from-to-node numbers (Figure 5.6.b).

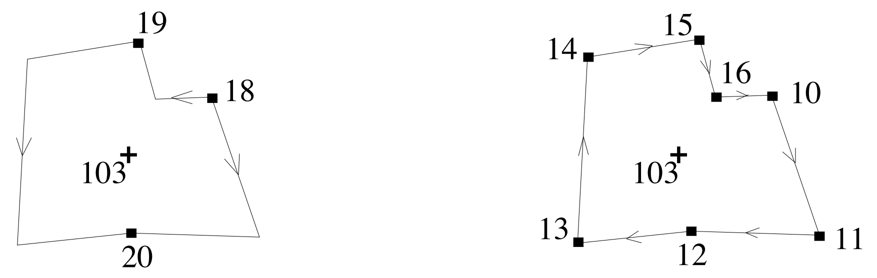


Figure 5.6.a
The initial nodes before

Figure 5.6.b
Node arrangement after

Figure 5.6 Node re-arrangement

5.5 The modular design of LARES

The single modules which perform particular tasks for the requirement of the proposed land readjustment process are explained in the following sections.

5.5.1 Land subdivision: The creation of new lots

In a land readjustment project there are two main input coverages. These are cadastral parcels and zoning site blocks. The property map which consists of cadastral parcels represents the current land-use condition in the project area. On the other hand, zoning plans represent the newly designed land patterns that aim to be applied to the land. In this plan, rather than individual new lots, only the site blocks are given, with the necessary zoning codes. So, before the project site lots do not exist on the zoning plan. The land subdivision process is usually carried out by land surveyors during the plan implementation stage.

In the proposed model, to compare the land parcels before and after, the new lots should be created with respect to zoning details. For this purpose an algorithm was written and linked with the ARC/ INFO environment. The flowchart of this and subdivision algorithm is given in Figure 5.7.

The land subdivision programme, first, reads the AAT and PAT tables of the input zoning coverages. In the AAT table, there is the re-organised line segments with their internal node numbers and coordinates of these nodes. On the other hand, PAT tables hold the attribute records of the zoning plan with the associated zoning codes. Following the data reading, site lots are created block by block.

Once a site block is taken, the algorithm determines the corner positions of the block then finds out two reference points on the long sides of the block. These are called upper and lower points (Figure 5.8.a). Based on both these reference points and minimum street frontage, the top corner of the new lot is positioned (Figure 5.8.b). Then, the other corner of the new lot is positioned with the aim to create a lot with a square shape (Figure 5.8.c). When a lot is created its area is calculated and compared with the given minimum area. If the created lot area is smaller than given area, the previous street frontage is increased and process is repeated. When a new lots is successful with the given zoning area, then the other lots are created using the same procedure.

If a site block has a very complex geometrical shape, after a certain number of iterations of the process, the subdivision program stops subdividing that block and gives a warning message to the user that editing is needed. Therefore, after the execution of the land subdivision program, some editing would be required.

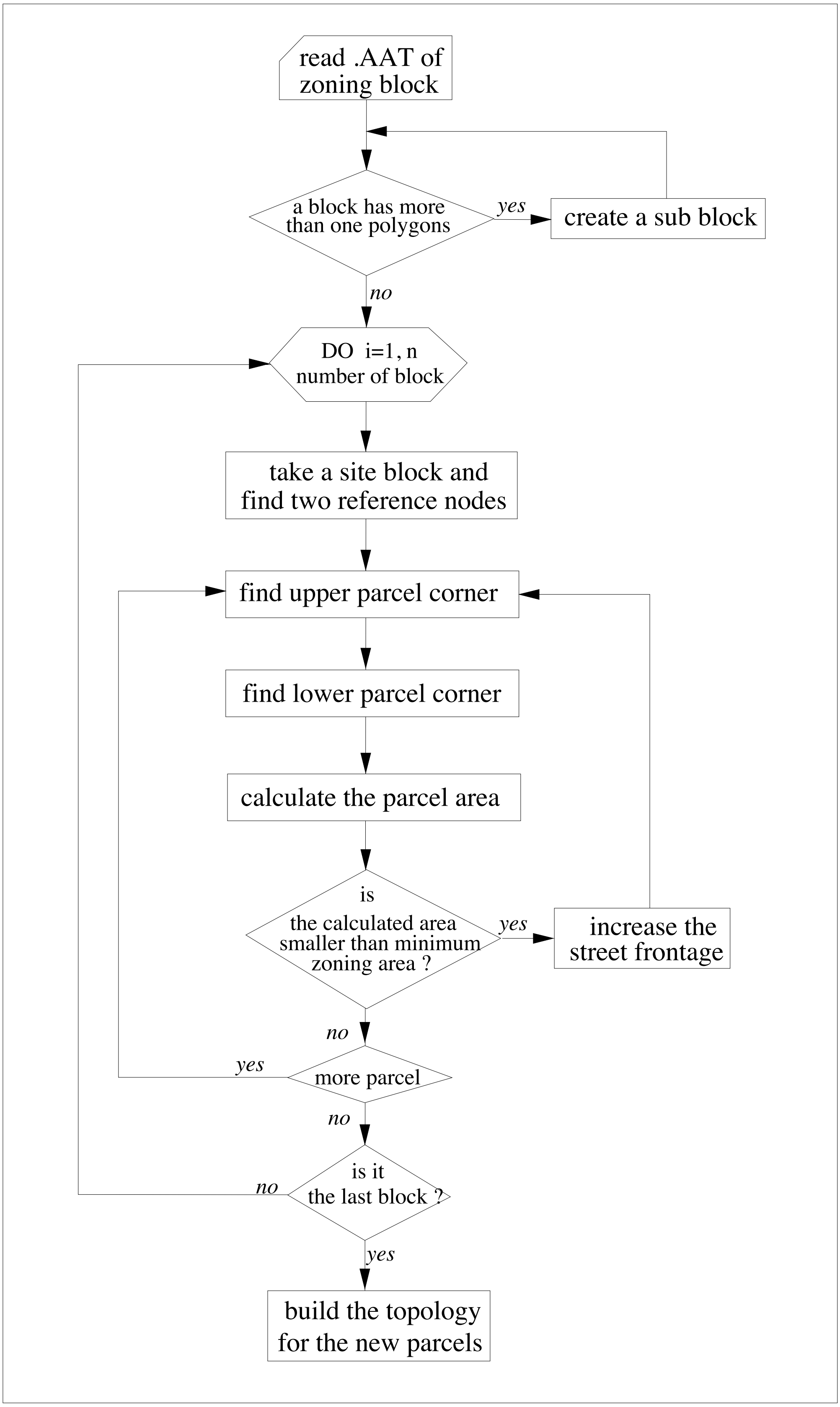


Figure 5.7 The flowchart of land subdivision algorithm

A user may also wish to change a produced lot shape. In these cases, the ARCEDIT environment is used to complete the subdivision process. When the subdivision of the site block is fully completed, then the final check is done automatically regarding the zoning requirements. The topology of new lots are then created for further use.

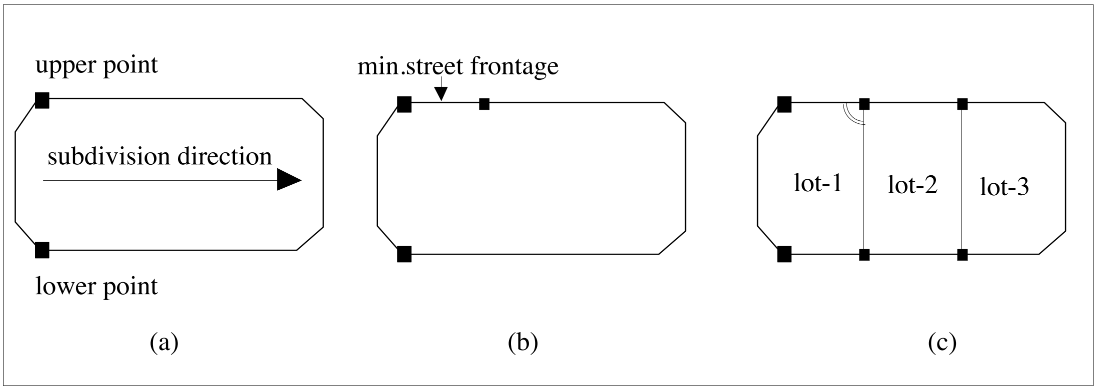


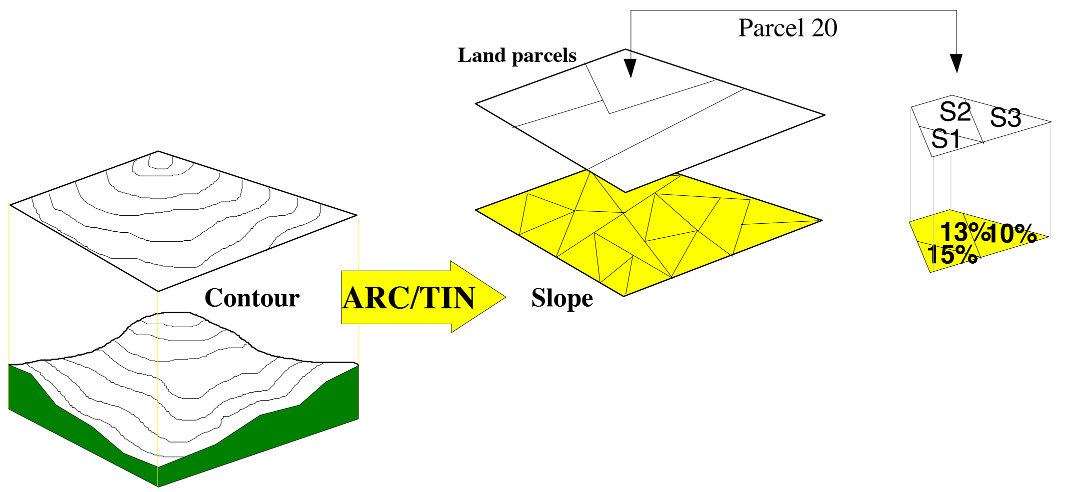
Figure 5.8 Parcel creation

5.5.2 Land valuation factor analysis

Following the land subdivision process, land valuation factor analysis is carried out for both cadastral parcels and the produced new lots. In this stage, land valuation factors are individually selected and related factor formulas applied. To determine a land parcel value, the algorithms were designed for each land valuation factor. The design and development of these algorithms is discussed in the following sections:

(a) <u>Determination of topographic factor value</u>:

Formula [3.3] is used to calculate this factor value. According to this formula, the corresponding slope values of a land parcel should be examined. Therefore, the input coverage which contains the contours was considered. Using the contour lines with their attached heights, a slope coverage was created by the `TIN` module of ARC/INFO. This coverage represents the slope polygons which includes the slope percentages. This slope coverage was then overlaid on the cadastral and lot coverages. The slope values of the corresponding areas were considered to determine the total value of a land parcel. In the determination, the surface area of a land parcel is used rather than its flat area. Figure 5.9 illustrates the calculation of topographic factor value of a land parcel.



Topographical factor value = 100 - Average slope %

F1=100-15=85 S1=230 m2

F2=100-13=87 S2=280 m2

F3=100-10=90 S3=150 m2

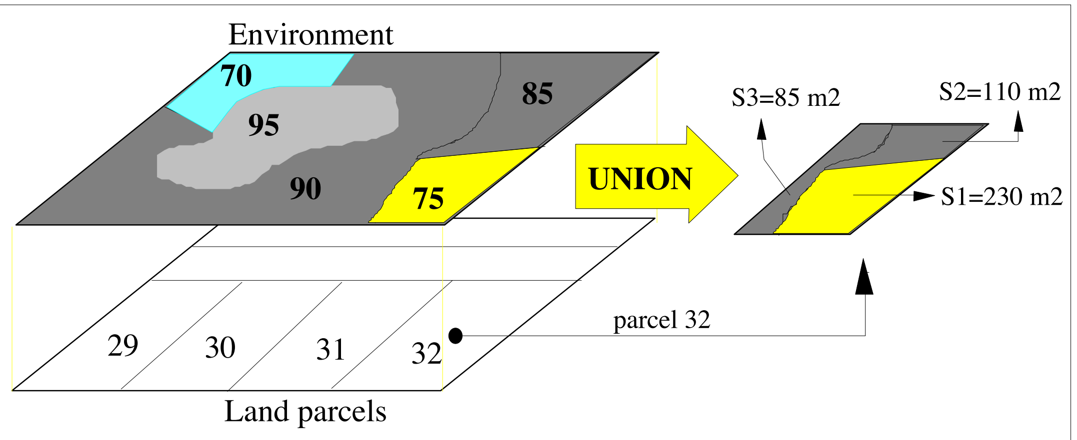
Surface Area [S] = S1+S2+S3 = 660 m2

The Factor Value for the parcel 20 = [S1*85+S2*87+S3*90] / [S] = 87 units

Figure 5.9 Topographic factor value analysis

(b) Determination of factor value for environment, soil condition and usable area:

Due to their similar formulation these three factors are calculated in the same way. The related map coverage is overlaid with the land parcel's coverage. Then, based on the combination of these coverages, the factor value is determined. Basically, this overlaying process is done through `UNION` command of ARC/INFO. The process is illustrated in Figure 5.10.



Surface area of the parcel 32 = S = S1 + S2 + S3 = 230 + 110 + 85 = 425 m2

$$\text{The factor value} = \frac{75*230 + 85*110 + 90*85}{425} = 80.59 \text{ unit}$$

Figure 5.10 Environmental factor value analysis

(c) Noise and nuisances:

To determine the noise and nuisance effects, the road coverage is basically examined with the land parcels. The roads are considered as the main noise resources due to traffic movement. Besides, a coverage which includes some other noise and nuisance places such as airport, entertainment places, are also combined with the road coverage and a new layer is created. On this new coverage, buffer zones are created around the roads and the noise places. The roads are classified in accordance with their width. The direct distances from the centroid point of parcel to the closest point of noise or nuisance buffer zones are calculated. Then, based on the illustration in the Figure 3.8, these factor values are determined for a land parcel.

(d) Shape:

The shape factor is determined by examining the number of parcel corners and distance between these corners. The coordinates of parcel corner are read from the input coverages and based on the formula [3.4], the shape factor is calculated. An algorithm which calculates the shape factor value is illustrated in Figure 5.11.

(e) Street frontage and access to street:

For the street frontage, land parcel coverage is overlaid on a coverage which contains the block outlines only. When a block outline and a parcel boundary share the same arc then the total length of these shared arcs or line segments are taken into account in the value calculation. An example for the calculation of street frontage value is illustrated in Figure 5.12. During this operation, if a parcel shares any boundary with a block outline, then the parcel is considered as an accessible parcel from the road and assigned with 100 value. Otherwise it is considered as non-accessible parcel and assigned with 0 value.

(f) Location within site block:

A site block and related land parcels are examined. Within the same block, the distance from the centroid point of a block to the centroid points of land parcels are calculated. The most far off parcel from the block centre is taken as the most valuable parcel inside the block. Then, using the formula [3.8], factor values is determined for the other parcels within the block.

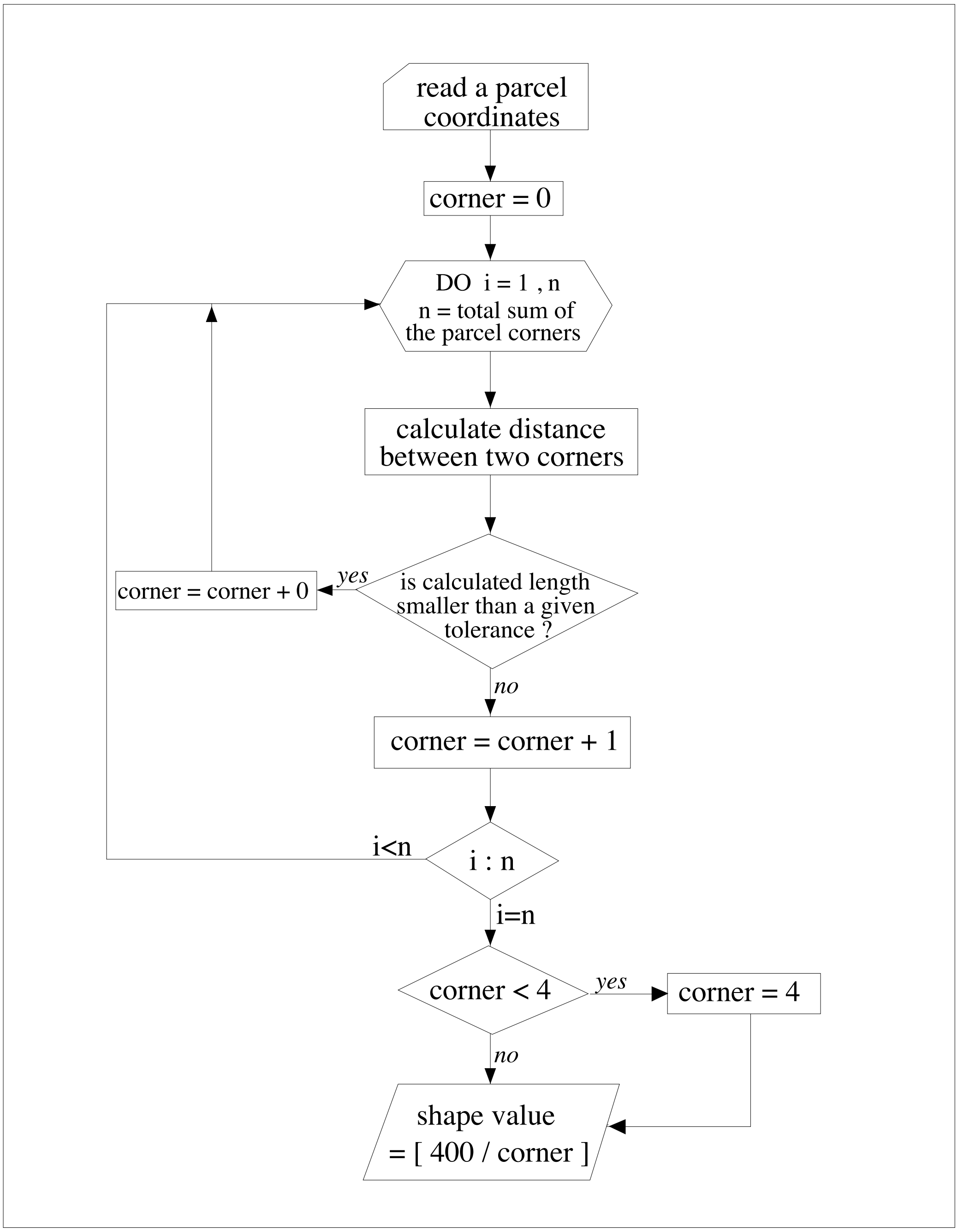
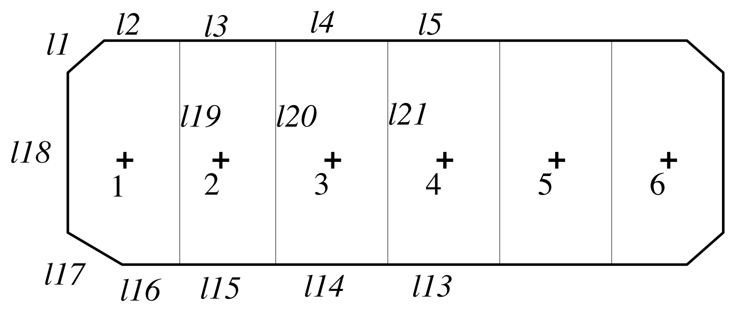


Figure 5.11 The flowchart of parcel's shape calculation

(g) <u>Permitted number of floors, construction areas:</u>

These factors are only considered for the new site lots because of the new zoning requirements. The factors are determined by the aid of zoning feature attribute tables and the required formulas. Information about these factors are included in the zoning PAT table as descriptive data. This PAT table is linked with the new lots and the corresponding data is examined for a lot.



$$\text{Street frontage value for parcel 1} = \frac{l1 + l2 + l16 + l17 + l18}{l1 + l2 + l19 + l16 + l17 + l18}$$

$$\text{Street frontage value for parcel 2} = \frac{l3 + l15}{l3 + l20 + l15 + l19}$$

Figure 5.12 Analysis of the street frontage factor value

(h) <u>Supplied services and available utilities:</u>

These factors are also given as the input data and stored in PAT tables. Using these tables, both cadastral and new site parcels are examined with respect to the related formulas.

(i) <u>Proximity to shopping areas, health services, educational places, play gardens, recreational areas, religious places, city centre, car park, fire station, police station, access to highway, railway and waterways:</u>

For the proximity analysis, first, a street network coverage is created. The parcel coverages and road coverages are combined together to build an input coverage for this process. On this new coverage, the parcel centroid points are linked to road axes. In the linkage process, a parcel centroid point is connected to the closest street frontage segment. So, a node is marked on the frontage segment. Then, this node is linked to the closest road segment. Finally, the shortest path from the centroid point of parcel to road segment is defined and road-parcel connection is accomplished. This connection process also applies for the target points. The target points can be considered such as library, hospital, shops, metro station, city centre. The connection of an hospital building to the closest road segment is geometrically identified. At the end of the road-parcel and road-target linkage process, a new line coverage which represents the street network is created for both the cadastral and the new land parcels (Figure 5.13).

Using the created network coverage, the shortest paths from a parcel to a target point is calculated and factor value is determined. Along the path, the 3-D surface is considered. Therefore, surface distance is used for the length unit, rather than planimetric distance.

In the street network coverage, ARC/ INFO `TIN` modules were first used to determine the surface length along the line segments. Then, to find out the shortest path between the given two nodes, these lengths and from-to nodes were loaded into the `ROUTE`modules of ARC/INFO.

Sometimes more than one factor target may exist. For example, in a project area, a few shopping centres, schools etc. could be located. The algorithm also examines these conditions and takes the closest target point for the land parcel.

Figure 5.13 The street networks for old and new land parcels

(j) View:

On a topographic surface, two points are defined as inter-visible if it is possible to connect the two points with a straight line segment without intersecting any part of the surface. For the analyses of visibility between land parcels first a TIN model is created. Then, a visibility region is determined by a circle. Using ARC/ INFO `visibility` function, land parcels are examined individually. `Visibility` uses a lattice file to determine visibility by calculating the number of times an area is seen from viewpoint. If the two points are inter-visible view value is taken as, $V = 1$. If the two points are not inter-visible $V = 0$. (Figure 5.14). During the visibility analysis, instead of using the ground elevations of viewpoints, new elevations are defined for the land parcels with respect to building's heights.

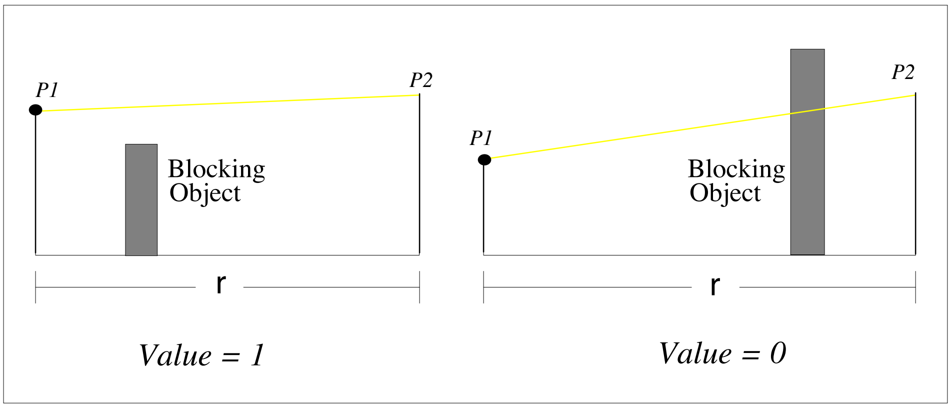


Figure 5.14 Inter-visibility and blocking object

5.5.3 Calculation of parcel values

Following the determination of each factor value, the parcel values are calculated by the equation [3.2]. This equation is applied to both the old and new land parcels. Then, the individual land parcel valuation results are used in the determination of the total values of the project area, before and after. As explained in section 3.3.2.3, these total values should be equal in the value-based land readjustment model. This is provided by equation [3.15]. At the end of all the calculation procedures, the final land parcel values which are subject to reallocation are stored for the land distribution process.

5.5.4 Parcel distribution

Land distribution is carried out block by block. First, the cadastral and new parcel coverages are combined. Then, the cadastral parcels which match a zoning block are grouped and reallocated within the same block in accordance with their old location and the input value. In this process, the total value of the grouped cadastral parcels are compared with the total value of the new lots within the block. If the total value of the cadastral parcels is not sufficient for the zoning block, than the closest parcel or parcels to the block are included in the cadastral parcel's group. The main idea here is to fill a zoning block with the corresponding cadastral parcels regarding the value and their original location. When sufficient value is provided for the block, then land distribution is accomplished in that parcel base. A simple example for the distribution process is basically illustrated in Figure 5.15.

Figure 5.15 An example for land distribution

After land distribution, some of the new land parcels can be shared between more than one cadastral parcel. This occurs because the limits of a new parcel size are given by the zoning plan that must be followed. However, the number of shared parcels can be decreased by giving a tolerance value. This tolerance is considered during the comparison of old and new parcel values. When the new parcel needs more value to fill it up, then the required value is compared with the given tolerance. If the needed value is less than the given tolerance, the required value can be ignored for the new parcel. The determination of the tolerance value depends on the value accuracy which the user is expected to provide. So, the involvement of tolerance value for the process is optional.

5.5.5 Outputs

After the whole calculations and spatial analysis, all results, input and output information both graphical and textual, including land valuation maps with 3D visualisations, street networks, ownership records, and land distribution tables are stored for the display at user's request. Using the ARCPLOT facilities, a query modules which provides the above information was designed for LARES. More details on the data presentation and query modules are given in Chapter 6 under section 6.4.5 and 6.5.

5.6 Modification of LARES

The modification of the prototype model allows for further development of LARES. When some changes are required on the existing modules, the user should follow the AML and FORTRAN files to do these changes. Modification may be needed for the following procedures.

5.6.1 Valuation factors

In the LARES, each land valuation factor has a single algorithm which was developed in accordance with its own valuation formula. Each of these valuation factors was also assigned a unique factor code. These codes are used to link a valuation factor with its related written algorithms. When a user wants to modify a valuation algorithm, the valuation codes should be considered (Figure 5.16). These codes are also assigned with some of the other files which are related. For example, for a land valuation factor, a coverage file and its input and output files are represented with the same factor ID. Although each land valuation factor is designed separately, the modification of factor does not affect the other valuation factors. On the other hand, a new valuation factor would also be attached to the model by following the same procedures.

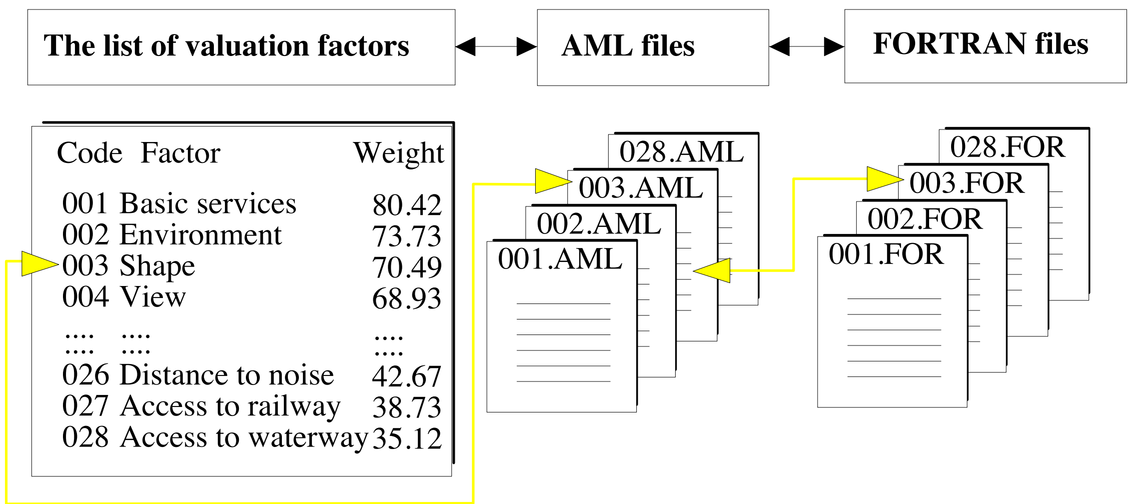


Figure 5.16 The linkage of valuation factor, AML and FORTRAN files

5.6.2 Factor weights

If a weight change is required for a particular land valuation factor, this can be done in the factor valuation file. Within the weight column of the file, only the factor weight data is changed. As illustrated in Figure 5.16, the data format should be same as before.

5.6.3 Menu changes

The whole process is customised by AML. Using the functionality of ARC/ INFO AML, a menu-driven system has been established. This menu system provides an easy-to-use interface employing a mouse to select desired menu choices. The menu system consists of some main menus such as *valuation* and sub-menus such as *factor-selection* under the *valuation* menu (Figure 5.17). A user can perform the ARC/ INFO commands without leaving the menu-driven system. A particular application can also be included in the main menu and run through it. In order to improve the functionality of the LARES menu, the menu design can be modified in a various ways. Based on the user's requirements, these changes are done via *.MENU files.

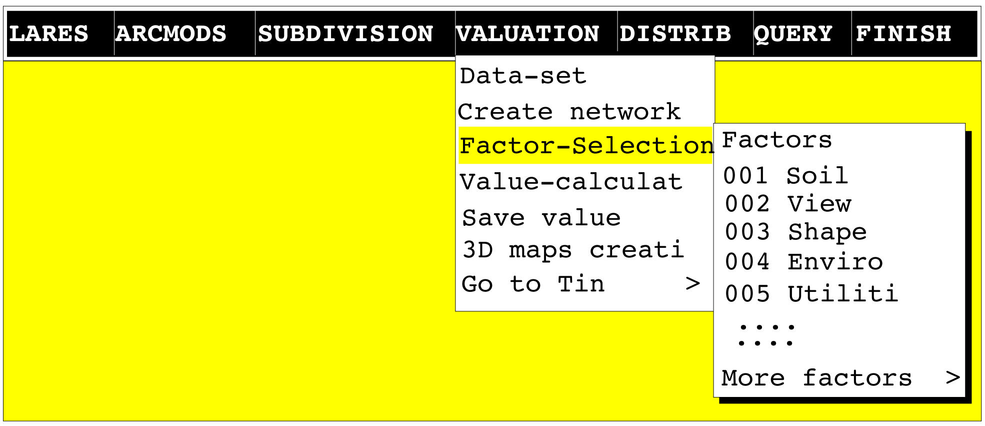


Figure 5.17 The view of land valuation menus

5.7 Chapter summary

In this chapter the software design and development for a value-based land readjustment model were described. The integration of land readjustment with GIS was followed by the development of a prototype model. This prototype model which has been referred as LARES was designed to perform all computing requests of the value-based land readjustment process in a single computing environment.

ARC/ INFO software has been used as a GIS tool for the spatial analysis and data management requirements. Using the functionality of ARC/ INFO, the algorithms which deal with the land valuation factors were developed. The main operations such as land subdivision, land valuation analysis, and the distribution of land parcels were designed and developed as different modules. However, LARES was designed to combine all these operations within a single model to manage the data process effectively. To perform any required task easily, menu-driven system was also created for the user. This menu system including the modules of LARES will be described in the following chapter.

CHAPTER 6

DESCRIPTION OF LARES

6.1 Introduction

The software design for the proposed land readjustment model was explained in the previous chapter. The main algorithms and their approaches were particularly discussed on the problem solving level. Based on the combinations of these algorithms a software suite which called LARES has been developed.

LARES is a menu-driven prototype software which performs the all requirements of a value-based urban land readjustment process. Its development procedures are mainly based on ARC/ INFO GIS system. This chapter overviews the prototype LARES. In order to fulfil the value-based land readjustment procedures, the requirements and functionality of LARES is described in detail. The file management procedures for data input, output, storage and spatial analysis functions are explained. The menu system of LARES is also illustrated with some examples.

6.2 Design criteria

LARES was basically designed to perform the needs of a value-based land readjustment process within an interactive environment which is user friendly. Using ARC/ INFO AML, a user interface was created. During the design of this interface a number of criteria were considered to provide an effective user environment. These design criteria are given in the following sections.

6.2.1 Hardware

Hardware is the term used to describe the actual computer machinery itself including all of the attendant peripheral devices such as keyboard, printers, screens, digitiser, plotter, disks drivers etc. The choice of hardware for a GIS is optional (Dangermond, 1991). A typical standalone computer suitable for many GIS application would be a graphical workstation with about 16 megabytes of RAM and 600 MB of harddisk. Such hardware platforms include SUN, HP, IBM etc. Figure 6.1 shows a UNIX based SUN workstation which was used concurrently for this research.

6.2.2 Software

The functioning of the computer is controlled by specific coded instructions capable of performing a variety of tasks. These instructions are generally referred to as software. There are two categories of software which enable the computer hardware to perform. These are ;

(a) Operating system ; makes the computer do what is required. These, together with executive programs, supervisors and monitor systems, control the running of the computer. The common operating systems are MS-DOS and UNIX. Based on these operating systems, the latest technology has provided the Graphical User Interface (GUI) systems such as MOTIF and OPEN LOOK that can easily be used by the user in program execution and file organisation requirements.

b) Application software ; is used by analyst and programmer to solve particular problems. GIS packages are part of the application software. Presently, there are many GIS packages in the market that perform various spatial analysis. They include ARC/INFO, INTERGRAPH, SLIMPAC, Smallword, System 9, etc.

In this study, the UNIX operating system and ARC/INFO GIS application software were used for the software requirements.

Figure 6.1 The view of hardware used for this study

6.2.3 Digitising

Digitising is one of the methods used for converting analogue or hard copy documents into computer readable format. By digitising a paper map becomes in digital form. A digitising table equipped with a precise cursor is commonly used as a device to operate the GIS. The digitising table electronically encodes the position of the pointing device with a precision of fractions of a millimetre. The most common table digitiser uses a fine grid of wires embedded in the table.

Other methods like scanning exist but manual digitising is the most commonly used method which was used in this study. In manual digitising the map is affixed to a digitising table and a pointing devices used to trace the map features. As the map elements are traced, the coordinate data are generated from the digitising table are either processed immediately by the GIS or are stored for later processing.

In a GIS implementation, the principal aim of the digitiser is to input quickly and accurately the coordinates of points and bounding lines. To do this, first, the map is secured is secured to the digitiser surface with tape. The scale of map must then be entered to the computer, followed by two digitises at the extreme corners (X_{min},Y_{min}) and (X_{max},Y_{max}) to define the area being used. Lines can be digitised in two ways, known respectively as stream and point digitising (Burrough, 1986). For a vector based process, the point digitising method is more preferable.

Thus, in this study, the point digitising method was used to digitise the required data layers such as cadastral and zoning maps. During the digitising of these maps, cadastral parcel boundaries, site blocks, roads, land use, buildings, public areas, contours are particularly considered. As illustrated in Figure 6.2, the other data layers such as environment, streams, soil condition, planned public buildings, and the other thematic data should also be digitised. On the other hand, the related attribute data were entered by keyboard in ARC/INFO.

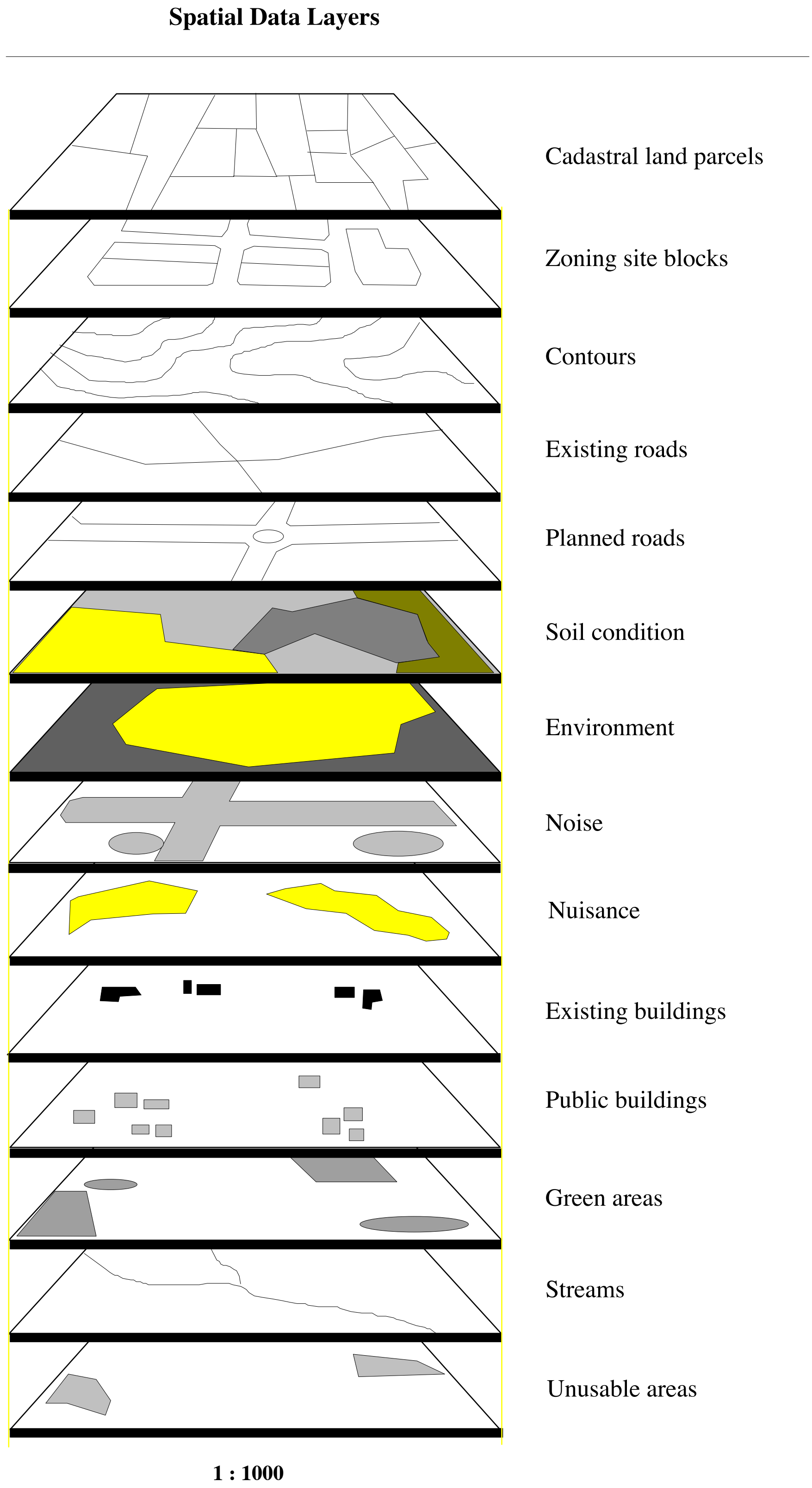


Figure 6.2 The digitised spatial data layers

6.2.4 Organising attribute data

Following the digitising procedure, additional information need to be specified before the analysis can be done. For example, zoning codes such as permitted number of floors, construction areas for the site blocks should be linked to the corresponding digitised polygons. To do this, the descriptive data need to be added to the zoning coverage.

picture of zoning.lut table..

Figure 6.3 A view of standard feature attribute tables

However, when topology is created for a coverage the corresponding feature attribute table is automatically created by ARC/INFO. This is a tabular data file storing standard attributes about the feature (Figure 6.3). To add a new attribute or item to a feature table, the following procedures are performed in the INFO subsystem in ARC/INFO. Then the item values are added by typing them directly into the feature table.

```
Arc  : tables
Info : additem <input_info> <out_info> <item_name> .
```

Many feature attribute tables can be created for different purposes. These type of tables are created to hold a specific data such as soil type, land use and zoning codes. These tables are called Look Up Tables (LUT). Importantly, at least two attribute tables must have a common item as a key to link these two tables. An example of how these INFO tables were used to create an attribute table for a zoning coverage is given in Appendix C.

6.2.5 User interface

LARES has a menu-driven system for user interaction. This menu system provides access to implement the all requirements for the value-based land readjustment process, including the basic ARC/ INFO modules. Primarily, the main menu has some sub-menus which performs the individual procedures, such as subdivision, valuation. Figure 6.4 views the LARES menu. However, the components of the menu system is presented under section 6.4. The AML file that starts the process can be reached by following path.

```
>home/.../gis/lares.aml
```

To run LARES, the following commands are performed.

```
>login
>home/...
home/... > cd gis
home/.../gis >  arc
Arc  :  &r lares
...{ LARES menu appears }
```

Figure 6.4 A view of LARES interface

6.3 File organisation in LARES

To provide a more effective file management procedure, the data and other system files were organised for a particular land readjustment project. So, several sub-directories were created under a root directory which titled with a project name. When LARES is started then user is asked for the project name. Then the workspace is setup for this particular project. The file management process is presented below.

6.3.1 Directory structure

Directory organisation was based on a tree structure in the LARES. First, there is a parent directory which handles the starting up execution file an a subdirectory which holds AML and FORTRAN source codes and the other execution files. Under this parent directory, there are also some other sub-directories which include particular project data such as coverages. These sub-directories were called project directories. The path for a project may be given as follow;

```
>home/.../gis/project1
```

The main objective of this directory organisation was to provide a manageable and accessible file processing environment. During the land readjustment analysis, many files are created under different names. Therefore, to reach these files may become very complicated for the user. To reduce this file complexity, a directory organisation was considered.

The fully directory structure of LARES is illustrated in Figure 6.5. However, more details on these directories including their particular files are given in Appendix D.

6.3.2 Data file management

Within a project directory there are three other main sub-directories which hold the input and output data files. These are;

```
>home/.../gis/project1/LR_COV
>home/.../gis/project1/LR_INF
>home/.../gis/project1/LR_RES
```

Figure 6.5 The directory structure of LARES

LR_COV directory holds the input coverages in ARC/INFO interchange formats. Before the entire process, the input coverages which topologically corrected by ARC/INFO are exported as interchange files. An interchange file contains all data source information in a fixed length ASCII format. These files are then stored in LR_COV directory for further use.

LR_INF directory holds the information files such as selected valuation factors, (*x,y*) coordinate lists, angle and distance measurements of land parcel boundaries. These files are created during the spatial analysis. Using some existing data, the new one is created for specific calculations and later use. Consequently, the information files contain the land surveying data that would be used by surveyors.

LR_RES directory holds the result files such as land distribution tables, old and new land valuation parameters, input data to created land valuation relief. After the land valuation analysis all results for each individual factor are stored within this directory. These files are named with related factor codes. The result files are then used as input data for land distribution process.

6.3.3 AML files

AML files provide the customisation for the model. The ARC/INFO commands were coded to execute some particular spatial applications such as topographical and network analysis. The AML files also provide the communication process to run a UNIX benchfile or to compile a FORTRAN program in the system. Data retrieval, storage and the other file management procedures are also accomplished by these AML files. Within the main directory tree, all the AML files were kept together and located in the following directory.

```
>home/.../gis/lares/lr_aml
```

6.3.4 Menu files

The menu files which were written in AML provide a menu-driven interface for the user. The menu files were also located with the AML files. The main tasks such as the selection of land valuation factors and information query are operated by specific menus. Within the main LARES menu, there are seven titles. These titles are illustrated in Figure 6.6. The file which creates the main LARES menu is presented in Appendix D.

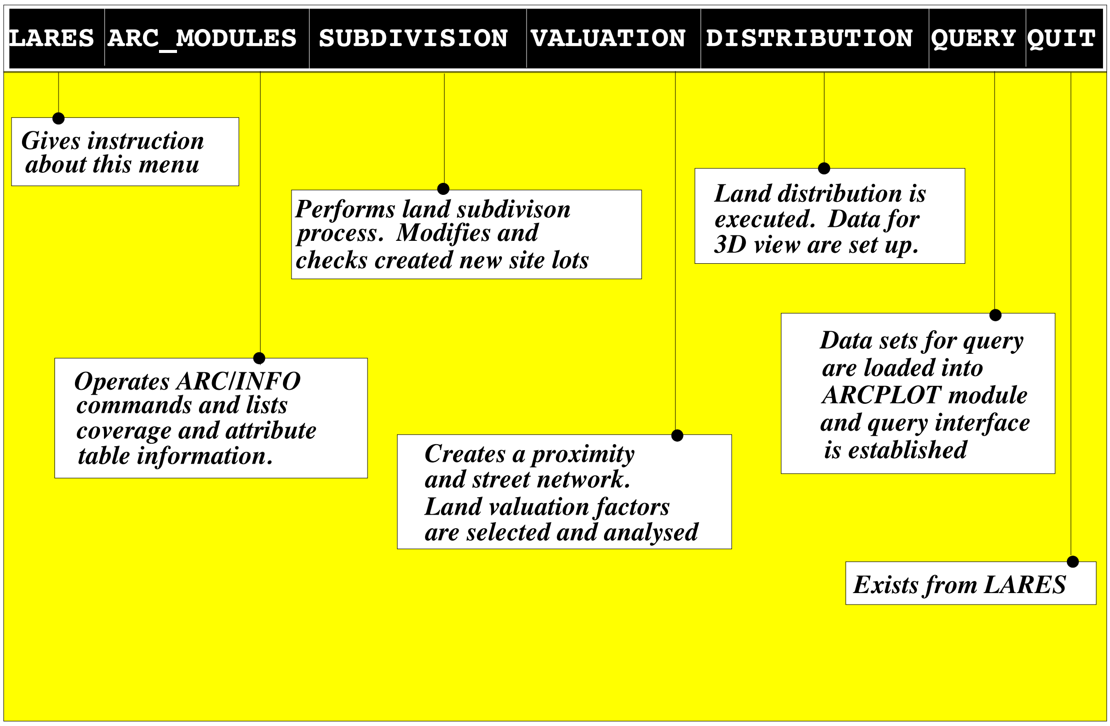


Figure 6.6 The menu titles of LARES

6.3.5 Execution files

During the entire analysis, some calculations are performed by external programs which were written in FORTRAN. When the AML was insufficient to execute a process, these external files were used. However, once a FORTRAN coded external program is compiled, an execution file is created and used for a specific task. Data input and output procedures during these execution files are provided by AML files. Therefore, AML provides the linkage mechanism between external files and ARC/INFO. The main advantage of using the execution files is to increase the speed of job execution. On the other hand, they need a permanent large space in the memory. The execution files were stored in the following directory;

```
>home/.../gis/lares/LR_EXE
```

However, the external files with FORTRAN source codes are kept in the following path;

```
>home/.../gis/lares/LR_F77
```

6.4 The components of LARES

The LARES menu has five basic components to complete the entire procedure of value-based land readjustment. These components are considered as the main modules of the model. The components of LARES are described in the following sections.

6.4.1 Arc modules

This module provides some functionality of ARC/ INFO including ARCEDIT, ARCPLOT utilities. Basically, file management, data input, editing, displaying data, and topology building are performed here. The other functions of ARC/ INFO are also executed without leaving the main menu. The menu title of arc-module is illustrated in Figure 6.7.

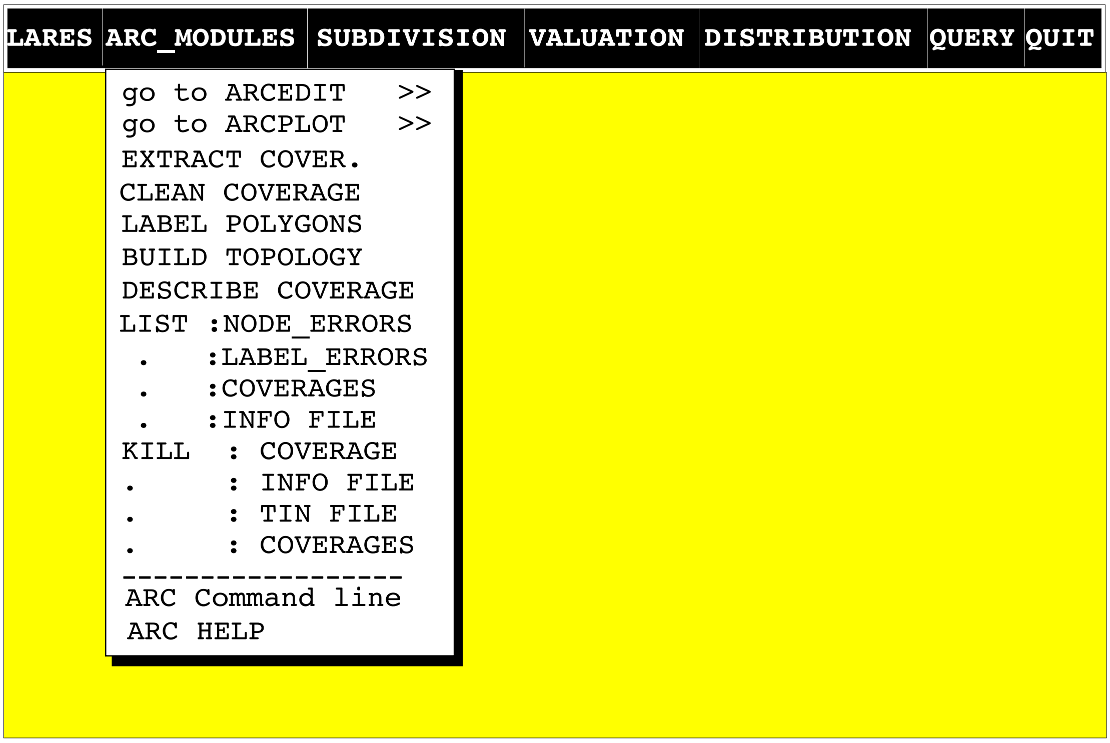


Figure 6.7 The view of ARC-MODULE menu

6.4.2 Subdivision

This module performs the land subdivision process. The required data are loaded into working workspace. Then, the site blocks on zoning coverage are automatically subdivided into the new patterns according to land-use planning details. In this case, *zoning.LUT* tables are used to retrieve the planning codes. Following the subdivision, some modifications may be required in the created layout plan. Especially, the subdivision of some geometrically complicated site blocks could be ignored during the process. In this case, the program lists the warning messages after the execution. The modification procedure can be done interactively through the LARES menu. ARCEDIT environment is however automatically set up with related coverages and attribute tables. The subdivision menu is illustrated in Figure 6.8.

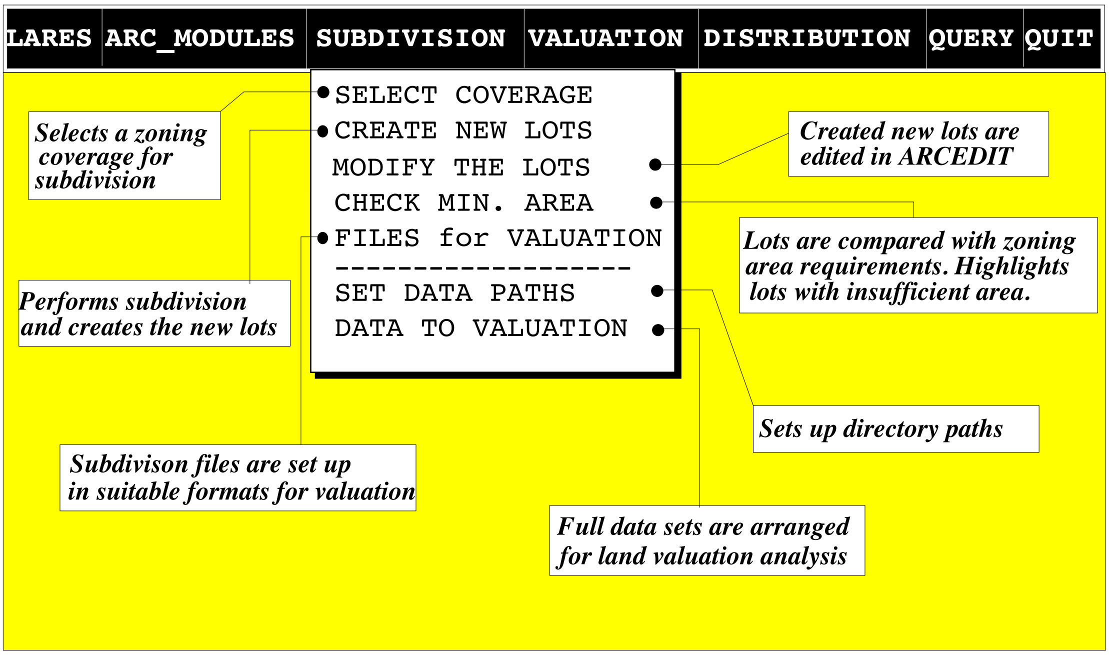


Figure 6.8 The view and functions of SUBDIVISION menu

6.4.3 Valuation

This module analyses the land parcels with selected land valuation factors. Before the factor selection, a street network is created. Then, using the factor selection sub-menu, land valuation factors are determined to analyse. Each selected factor is evaluated individually in both stages, before and after. When the valuation analysis is completed for the selected factors, then the process returns to the main menu. The final land valuation parameters are then calculated for cadastral and new site land parcels. All required information is stored in suitable formats for other uses, especially for land distribution. The valuation menu title with its sub-menus is illustrated in Figure 6.9.

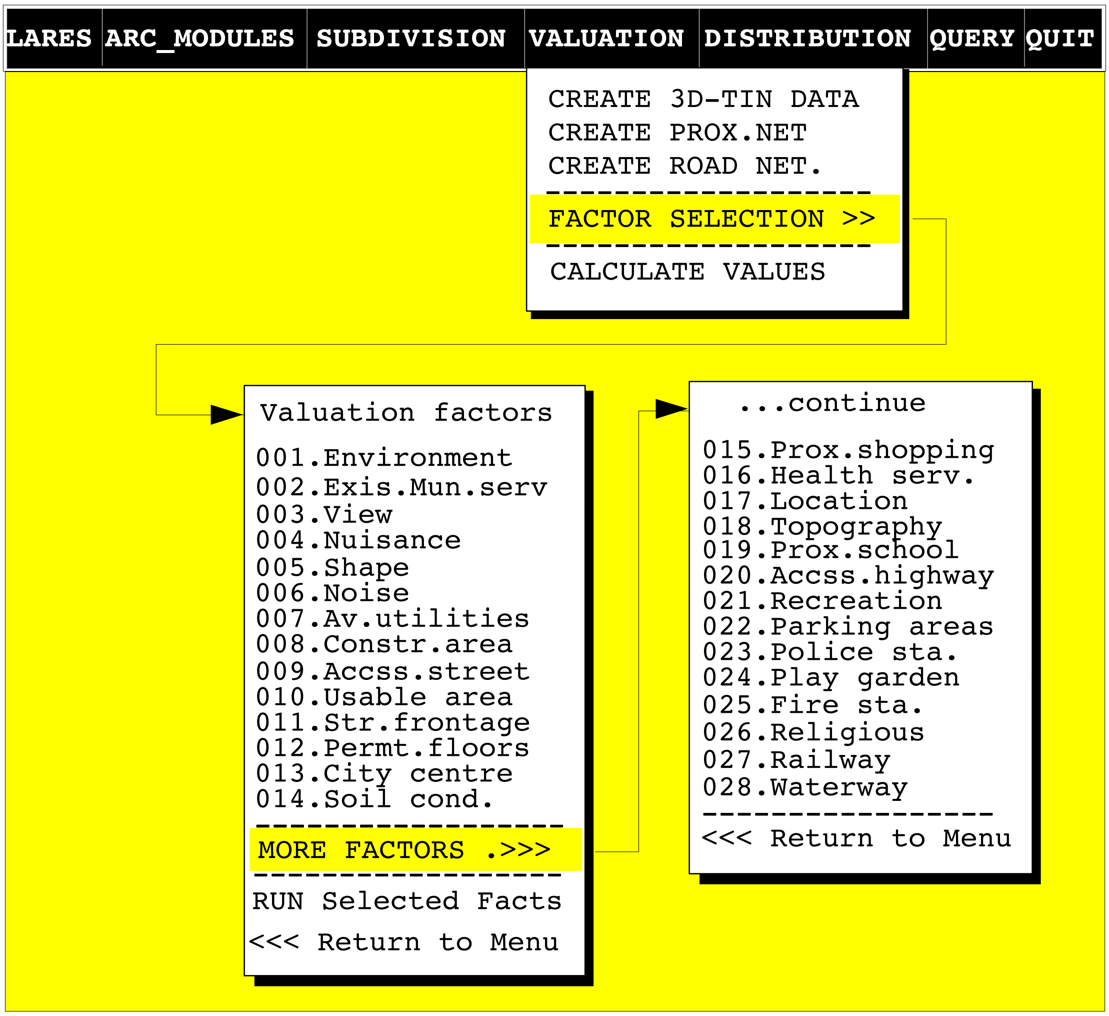


Figure 6.9 The view of VALUATION menu

6.4.4 Distribution

This module performs the land redistribution using the results of land valuation analysis. All the cadastral land parcels are reallocated within the new site lots with respect to their determined parcel values. Since the valuation parameters are the main components for land reallocation, the original location of cadastral parcels are also considered during the distribution. So, an optimal solution is provided to consolidate, divide, and redistribute the land parcels to minimise the number of shares within a single land parcel. All these steps are carried out by the distribution algorithm. However, Figure 6.10 illustrates the distribution menu title.

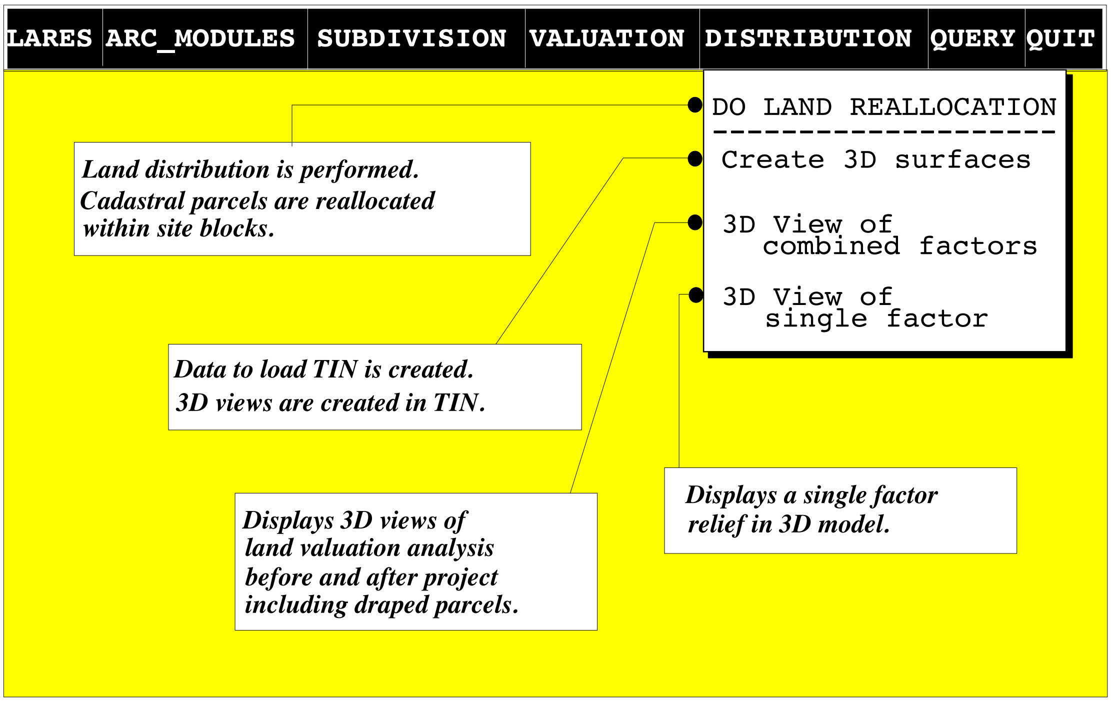


Figure 6.10 The view of DISTRIBUTION menu

6.4.5 Query

This module utilises the display of results for user's requirements. The ARCPLOT is basically set up for the query requirements. All process results both graphical and textual, including land valuation maps with 3D visualisations, street networks, ownership records, and land-distribution tables are loaded to ARCPLOT environment to display and query. Any information about a land parcel can be easily queried. More details on the query procedures are presented in the next section.

6.5 Attribute query

Query functions retrieve records in attribute data base according to conditions specified by the operator. The query of information is done either graphical or non-graphical or with the combination of both. Depending on the requirement, query can be very simple such as finding the class assigned to a selected polygon. However, complex queries involve selective searches of all the attributes for one or more data layers and the generation of a report that tabulates the results.

In LARES, the graphical data is displayed in ARCPLOT which allows the user to zoom in and display an enlarged part of the database. Textual information can also be displayed with these graphical data. However, to query more specific information may be required. Such information is land parcel identification, the relationship between old and new parcel, value and share distribution of land parcel. More details on the information query is given in following sections with some examples.

6.5.1 Coverage information

Using the arc-modules in the LARES menu, the coverages and their attribute tables can be displayed. These are the textual information that user may interest. Especially, PAT and LUT tables are listed to see the details on feature attributes of a coverage. Using INFO facilities, more specific data can be selected and listed. Figure 6.11 illustrates an example for this. In this example, the cadastral parcels which have value greater than 20,000 and less than 70,000 units are highlighted.

6.5.2 Query of two-dimensional information

The land parcels and the other factor coverages are basically displayed with their attribute data. Using ARCPLOT, a single or the combination of different map layers can be visualised (Figure 6.12). A particular land parcel and its related information can also be displayed by pointing on it (Figure 6.13). However, a specific query menu was designed for often information requirements. These are used to query the land valuation results for both cadastral and new land parcels. This query procedure was attached to ARCPLOT menu. Some tasks which perform by this query menu are;

picture of cadastral attr. table.

Figure 6.11 A list of cadastral parcels with selected value attributes

picture....

Figure 6.12 A view of layer combination

picture....

Figure 6.13 A view of cadastral parcel and its attached information

(a) Displaying land distribution information for cadastral parcels:

The cadastral parcels are displayed with their assigned new lots. Basically, the old and new parcel connection is presented. When a cadastral parcel is picked up by pointing on it, the new site lots that belong to this cadastral parcel is highlighted. So, the reallocation of cadastral parcel is shown. The distribution table with the valuation figures are also displayed. An example for the reallocation of a cadastral parcel is illustrated in Figure 6.14.

(b) Displaying land distribution information for the new site lots

This option presents the above option in a reverse way. This time, the new lots are displayed. Then, a lot is selected and the cadastral parcels which were assigned with this lot is highlighted. Figure 6.15 illustrates an example for this option.

(c) Land owner sharing situation

The zoning limitations on new lot creation may cause the sharing of a new lot by more than one landowner. The sharing information in both old and new parcels can be queried by user. The parcels are basically highlighted with the number of landowners. Figure 6.16 illustrates an example for the sharing condition of new site lots after land distribution.

(d) Querying land parcel values

Land values in a given interval range are highlighted. This query option helps to user to find land parcels with a certain value. The maximum and minimum values are always listed. The user asked to enter desired interval ranges for value display. The valuation query can be done both old and new land parcels. An example for new parcels is given in Figure 6.17.

picture....

Figure 6.14 A cadastral parcel with its new site lots after land distribution

picture....

Figure 6.15 A new site lot with its related cadastral parcels after land distribution

picture....

Figure 6.16 Share distribution of new site lots after land reallocation

picture....

Figure 6.17 A view of new land parcel values
between 50,000 and 60,000 units

6.5.3 Displaying three-dimensional views

A three-dimensional model of surface is generated from a TIN or a lattice file. Both models are based on point data which associates a *z* value item with an *x,y* location. Although surface elevation is commonly used, alternative *z* values can be used to produce any three-dimensional models (Raper and Kelk, 1991). Using ARC/ INFO TIN module in LARES, these values were used to represent the value measurements of land parcels. The valuation reliefs of project area for old and new land parcels are viewed in a three-dimensional model. Optionally the land parcel coverages are also draped on valuation surface. Figure 6.18 and Figure 6.19 show the examples of three-dimensional valuation models before and after project. As illustrated in Figure 6.20 and 6.21, any single land valuation factor can also be viewed.

Data for three-dimension visualisation are loaded from the LR_RES directory. The data file contains the x,y coordinates of a land parcel centroid and corner points and corresponding parcel value as *z* variables. To put this data file in ARC/ INFO TIN module, there is a need for data conversion procedure. To accomplish this requirement a data conversion algorithm is developed. This algorithm is given in Appendix E.

When the data are put in TIN environment, the other utilities of the module can also be used for information query. Once a three-dimension surface is generated by **VIEW** command, it can be used for interactive calculation of value for a particular location. Using the **SPOT** command to select any point on the surface will return an interpolated value of that point's x,y and z location. If these points are saved after they have been selected, their value parameters are recorded as an INFO data item. A valuation profile graph can also be generated interactively using **PROFILE** command.

picture....

Figure 6.18 A three-dimensional view of land valuation relief with cadastral parcels before project.

picture....

Figure 6.19 A three-dimensional view of land valuation relief with site lots after project.

picture....

Figure 6.20 A three-dimensional view of available utilitiy land valuation factor relief with cadastral parcels.

picture....

Figure 6.21 A three-dimensional view of permitted number of floor land valuation factor relief with site lots.

6.6 Chapter summary

In order to perform the spatial analysis and display requirements of value-based land readjustment process, a prototype model called LARES has been developed. This chapter has described the main functions of LARES with illustrated examples. The development of LARES was mainly based on ARC/ INFO GIS system. Using ARC/ INFO functions, a menu-driven system was designed to provide a friendly user environment.

LARES has five main modules to perform the certain tasks. *ARC* module, for example, provides all functionality of ARC/ INFO including Arcedit, Arcplot, Tin and Network utilities. *SUBDIVISION* module performs the land subdivision process. The site blocks are automatically subdivided into the new patterns according to land-use planning details. *VALUATION* module analyses the land parcels with selected land valuation factors in property map and subdivision layout. Each selected factor is evaluated individually in both stages, before and after. All required information is stored in suitable formats for other uses, especially for land distribution. *DISTRIBUTION* module performs land redistribution using the results of land valuation analysis. Finally, *QUERY* module utilises the display of results for user's requirements. All process results both graphical and textual, including land valuation maps with 3D visualisations, street networks, ownership records, and land-distribution tables are stored for further use.

CHAPTER 7

A Case Study: IMPLEMENTATION AND TESTING OF LARES

7.1 Introduction

As expressed by Taylor (1991), the correctness of a program when applied to its implementation is not a two-step process, and incorrect program does not suddenly become correct. The reliable implementation of a program, relatively a model, is achieved through a number of stages. According to Taylor (1991), these stages are:

- correct algorithm design,
- successful compilation and execution,
- production of correct results from valid test input data,
- correct behaviour from invalid input data,
- correct results from every possible combination of data,
- acceptance by end users.

For these, the entire functions of LARES were implemented and tested with a case study. Data processing throughout the LARES was illustrated with the examples of large scale maps. However, this chapter describes the qualification of the developed prototype model with a case study.

As a case study, a developing country which practices a land readjustment process was considered. Due to its rapid urbanisation and the present issues with the land readjustment system, Turkey was selected. Following the outline of Turkish land readjustment system, a pilot project area was described. The value-based model was applied to this project area. Finally, the results are discussed.

7.2 Implementation concerns

In chapter 2, the concept of land readjustment method was outlined with some of its present applications. Then, based on the technical matters of the method, a new value-based land readjustment model was described in chapter 3. In order to see the effects of such a model, it is so obvious that to implement the entire process is essential. Therefore, the developed prototype model was applied to a pilot project area. The description of the project area is given under section 7.4.

Following the required data installation, the prototype model was implemented for the selected project area. During the implementation, the LARES menu was redesigned and possible algorithms redefined. The linkages of execution files were tested. The testing of programs or procedures that directly manipulate spatial or textual data is achieved by using carefully selected test data sets, and checking results.

Another implementation concern is to show the applicability of the model for the developing countries. As explained by Doebele (1982), financial and technical limitations badly affect the urban land developments in these countries. However, as mentioned in the earlier chapters, the land readjustment method has many advantages to deal with the urban developments. On the other hand, land readjustment would also provide an opportunity for the establishment of a LIS in these countries, because with the method, the existing land tenure system can be changed and a new designed scheme is applied. During this process, a large amount of land-related information is newly created in a cadastral parcel base.

To see these possibilities, the Turkish land readjustment system is discussed with respect to a selected pilot project area. Among the developing countries, Turkey is selected because of the practice of the compulsory cadastral system and land readjustment process. Therefore, a previous land readjustment project which was carried out with conventional methods was examined. The developed model was applied to the same project area then the results were compared.

7.3 An overview of Turkish land registration system

7.3.1 General

Turkey is a country between Europe and Asia with 57.2 million population and 779,452 square kilometres. Population density is 73 persons for per square kilometres. Almost 61% of the people are living in urban area. (The Economist, 1992). According to 1988 figures, annual population growth is 2.1% in Turkey (EC, 1991).

Turkey has a republic system. The president, as head of state, is elected by parliament for seven years. The cabinet, headed by the prime minister, is appointed by the president. The one chamber Meclis (Grand National Assembly) has 450 members directly elected for five years. The local governments are also elected for five years, including city councils.

7.3.2 The cadastral system in Turkey

The root of the Turkish land registration system goes back to the age of Ottoman Empire. According to the archives which are kept by the cadastral head office, first land registration book is compiled in 1534, during the time of Magnificent Suleyman (Uzel, 1982). As in all other fields, the new changes were made in the system with the foundation of the Republic of Turkey in 1923. The Swiss Civil Code was primarily adopted in 1926. Based on the Swiss Cadastral System, the first regulation of land registration was acted in 1932. With this regulation, the modern cadastral system was adopted and the land registration became compulsory. In 1987, the regulations for the land title registration were enacted with respect to new developments.

Since the first cadastral law was legislated, almost 57% of the entire territory was registered by the cadastral offices. Cadastral maps at 1/ 1000 and 1/ 5000 are produced by using both the Geodetic and Photogrammetric methods. However, 86% of urban areas was completed and cadastral maps were produced at scales 1/ 1000 and 1/ 2000. The standard Topographical maps at 1/ 5000 scale is produced by both organisation General Commands of Map and General Directorate of Land Registration and Cadastre (Unal, 1990).

The land registration procedures are carried out by the Directory General of Land Registration and Cadastre under the related law and regulations. There are two main components for the cadastration. These are land registration book and cadastral map. Each surveyed land parcel is demarcated on the ground and mapped. Then, the land rights and ownership information are recorded on the registration book with a unique parcel ID. This ID provides the linkage between the registration book and cadastral map. After the registration of a land parcel, landowners receive a land title and use its property rights under the protection of the constitution.

In Turkey, the cadastral surveys are carried out by the public sector only. In recent years, the involvement of the private sector is being examined with the pilot project studies. The land registration process is done and updated manually. The use of computer aided surveying and drafting systems for the production of digital maps was started in 1986. In the province of Izmir, the computerisation of the land registration processes has began under a pilot project. It is expecting to extend this project to other provinces to establish a base for the national land information system.

7.3.3 Land acquisition methods and issues

As a result of rural-to-urban migration, urbanisation problems are created by rapid population growth in Turkey. Like many other developing countries, these problems have exerted a negative influence in the fields of human settlement and regular urban development. To provide these, land is acquired and developed with respect to master plans in a five year period.

Since the cadastral parcels were registered with their existing layouts, the implementation of zoning plans has became difficult in technical, economical and social senses. It is technical because most of the parcels were irregularly shaped. It is economical because of the budget limitations for land expropriation and developments. On the other hand, social issues have arisen when private landowner is compensated by the government. Landowners claim that this impairs the property rights of private land which are under the protection of the law.

The limitation of financial, human, and technical resources mostly restricts land development options. The government therefore has difficulty in controlling rural-to-urban land-use change to provide the appropriate land for both public and private sector requirements (Biyik and Uzun, 1990). Thus, as expressed by Dale and McLaughlin (1988), many squatters have established patterns of land use rights that operate outside of the national cadastral system. The land allocated for public-use has been partly occupied by squatters.

In order to provide urban land needs, some land acquisition methods are practised by the government. The objectives of these methods include the provision of basic public services and other aspects of infrastructure to urban areas undergoing development. However, most of the land-related developments are carried out by municipalities using master schemes and zoning regulations (Gurler, 1983).

The rapid urbanisation requires readily built-up areas in suburban areas. Hence, the provision of sufficient new lots, streets, roads, green areas, play gardens and parks are the main objectives of local land planning authorities. Controlling these urban land developments, three different land acquisition methods are basically performed by specific acts (Akyol and Tudes, 1987). These methods are;

(1) Land compensation method
(2) Voluntary method
(3) Land readjustment method

7.3.3.1 Land compensation

When the government urgently needs the land for public constructions, such as building a new highway, hospital, school, opening new green spaces, the compensation method is basically applied. All compensation procedures including land valuation are done in accordance with The Compensation Act, which was enacted in 1983 (Yildiz, 1987).

The compensation method can be practised by any government department. As long as they prove that land is needed for public use, they can make any compensation decisions. These decisions must be approved by the city council. Landowners who have any property in designated areas are then informed about the compensation decision. These procedures are followed by other steps which include land survey, assessment, payment and registration. At the end of the process, the determined value is directly deposited in the landowner's bank account. However, in many cases, landowners object to the amount of compensation that in offered. They always argue that the determined value does not reflect the real value of their property. This has always resulted in prolonged litigation in courts of law (Akyol, 1987).

From the government perspective, the compensation method provides a practical solution to land acquisition, because it is a short-cut method that is easy to implement by the force of the act. Although the compensation method has great advantages for government, there are also some disadvantages with the method. Table 7.1 illustrates some of the advantages and disadvantages of the method.

Advantages • Land compensation is a rapid land acquisition method for government in urgent land provision, • The government has great power making decisions by the Act. This accelerates the land-acquisition process and project time positively, • The method is more efficient in small land development projects.
Disadvantages • Compensation is an expensive method for the government, • A readily available budget is always required, • It is a mandatory land-acquisition process which uses legal force. In many cases, landholders are not happy with the decision about the compensation for their land, • The process causes land valuation disputes between government and landowners. This delays the implementation of project, • Land speculation occurs in project areas.

Table 7.1 Advantages and disadvantages of land compensation

7.3.3.2 Voluntary Method

The voluntary land acquisition method is usually applied when a landowner wishes to obtain a construction permit, for example he wants to build an house. The basic principle with the method is to re-demarcate existing cadastral parcel boundaries according to the rules of zoning plans. In regard to zoning requirements, the suitability of a cadastral parcel is examined by the municipalities. If the checked land parcel does not provide the requirements, then the landowner should find out some alternative solutions to provide zoning requirements. In this case, there are a few options that can be followed by landowners in order to obtain have a construction permit. These options are as follows:

i) Private subdivision: If an existing cadastral parcel is adequately large, a special subdivision can be performed with respect to zoning requirements. A cadastral parcel is subdivided into two or more suitable new lots. During the subdivision, land which covers the public use area is contributed to public use. Subdivision procedures are carried out by a private surveyor. In order to register the new site lots, subdivision plans and all other related documents must be checked and approved by both the cadastral office and the municipality.

ii) Consolidation: When land parcels do not have sufficient area for the plan objectives, land holders can consolidate their parcels with adjoining land parcels. Before the consolidation of these parcels, an agreement between the interested landowners is required. It may not always be necessary to consolidate all the adjoined parcels entirely because some portion of land may be satisfactory for the zoning requirements. It should also be considered that after the consolidation, the rest of the consolidated parcels should certainly allow for further development.

iii) Boundary Exchanging: If an existing land parcel has an irregular shape, adjoined cadastral parcel boundaries can be re-demarcated or some land portions can be exchanged between landowners. The boundary demarcation and land exchange are done by the agreement of interested landholders only. Adjacent landowners make an agreement that their land parcel shapes can be modified, in order to give a regular shape to land parcels. If the agreement is satisfactory, then technical procedures are carried out only by the cadastral office, with no fee.

The voluntary method has also some advantages and disadvantages for land development process. These are given in Table 7.2.

Advantages • Voluntary method is inexpensive land-acquisition way for government, • Instead of the government, individual landowners are more actively involved in the land development process, • New site lots for housing purposes are produced, • A cadastral parcel is transferred to a site lot so that the legal position of the parcel changes. This increases tax revenue, • The government obtains land required for public use freely, without any compensation.
Disadvantages • It is a time-consuming approach to the land development process for a large project area, • The method works when a landowner needs a construction permit only, • Landowners are under an obligation that if the existing parcel covers a public-use area, the covered portion of land should be dedicated to public use. This results to lost of revenue to landowners, • Land exchanges between the owner require a legal agreement.

Table 7.2 Advantages and disadvantages of voluntary method

7.3.3.3 Land readjustment

Land readjustment is another land acquisition method that has more advantages when compared with the other land-acquisition methods. Due to the implementation difficulties with the other methods the government tried to set a more powerful and practical solution to the land development process by an act. In 1985, therefore, the Land Readjustment Act was passed in Turkey. It was the hope that, with this Act, the implementation of the zoning plans will be operated more effectively in the expanding project areas.

7.3.4 Land readjustment system

The first Land Readjustment Act was adopted in 1963. Then, in 1985, it was enacted with some new technical and administrative arrangements. The basic principle of the Act is that the local government has complete authority to apply the zoning plans within their district without the consent of owners. The main title of the Act which is no.18 states that landowners who have any parcel in the project area have to give up 35% of the total area of their land for public use. This percentage depends on the size of public area required including new roads, streets, green areas, play ground, religious places, parks and building area within the project area (IK,1985).

The Land Readjustment Act and related technical regulations guide the implementations. Before the beginning of such a project, all cadastral works and zoning plans should be completed in the project area. The city council then makes the implementation decisions on the project. The final project area is determined and voted by the council members. If the project is approved, the decision is announced publicly. The cadastral office is also informed about the project, so that any interested people are notified about the project during the cadastral transactions. No construction can take place within the project area until the rules have been fulfilled.

After the council decision, all required technical and non-technical procedures are carried out by the municipality. Following the land surveying, the basic calculations are made to determine the final distribution figures for the parcels. Then, land subdivision and reallocation are performed. The new layout plan and distribution tables are publicised for a month. During this period, landowners can make their objections. Following the consideration of the objections, the planning committee makes their final decisions. The new plan is then approved and the new parcels are registered by the cadastral office. The new land titles are prepared and posted to original landowners. Finally, the municipality begins the construction of the basic infrastructures in public areas.

According to a survey (KTU,1990), since 1985, area with 10,800 hectares has been developed by land readjustment process in Turkey. Figure 7.1 illustrates these project areas in the country. On the other hand, since the first land readjustment programme was enacted, some projects were found to be unsatisfactory or were not completed on schedule. The limitation of budget, poor land information management, and lack of public support have prevented some projects from achieving their objectives. Significantly, there have been many objections from landowners about the reallocation process. Particularly, the reduction of original land size and the changing of location have been the main issues in the project areas (Akyol, 1987). Some of these issues can be outlined as follows:

(a) Issues for landowners

In many cases, most landowners do not support the land readjustment project. They are aware of the fact that some parts of their land will be forfeited for public use without any compensation. However, some of landowners whose land is already fragmented and more or less useless do support land readjustment to gain from the project benefits.

(b) Issues for the municipalities

The municipalities have the greatest responsibilities throughout a land readjustment project. However, because the city council has power to allow the land readjustment applications, some projects can be delayed or cancelled for political reasons. Because the large number of people who are living in a project area can affect the local election results, therefore, the elected council members may not be positive about the implementation of the project. For this reason, the land readjustment projects fail very often, especially in small and non-powerful municipalities.

A part from the political reasons, the municipalities have also some technical issues with the project. In most cases, available municipal resources such as technical persons, budget, and equipment are not sufficient to carry out such a project. Due to the complexity with process, the availability of professional people is very important.

(c) Technical issues

Land value does not play a role in the calculation of the percentages to be contributed by each landowner for public areas. The only criterion is the parcel size, and the contribution factor is the public-use land area required in the zoning plan. This single coefficient is calculated and applied to all landholders in the project to derive their contribution to the public land. There is no parcel appraisal, before or after the project. The area method, instead of valuation, does not provide an equitable approach for the landowners, because many other factors which affect a parcel value, are ignored.

Analysing the cadastral information, searching needed records and providing necessary outputs are done with conventional manual methods. Sometimes, the information is not readily available for later use because of poor information management. Thus, following the procedures is a complicated task which requires great talent. The use of computers has not been introduced to the entire process yet.

Particularly, the land reallocation procedure has not been standardised. Therefore, the planners often have difficulty in making a decision about the new parcel locations. The parcel boundaries are changed and landholders are moved to new locations by the planner's judgement only, so that the planners make their own decision upon land distribution, as if they are the only ones responsible for the land reallocation and distribution. This also affects the landowners because different approaches provide different land locations and benefits to them.

As a conclusion, land readjustment is a powerful and economical way to acquire urban land in Turkey. But still some problems exist. To deal with these problems, a careful analysis of spatial characteristics of the land, notably economic, social, and planning aspects is required. With respect to these aspects, a new approach to land readjustment, which particularly deals with the land valuation process, would improve the functionality of the method.

7.4 The study area

Although land readjustment is a popular device for local governments for subdividing raw land in Turkey, small cities frequently do not implement many land readjustment projects, since demand for land is not very high.

Large metropolitan areas implement the process more frequently in the urban-fringe. The sample area was however selected from one of these urban-fringe areas. Ideally, the selection of several cities would have been preferred. But it has been limited to evidence in one project area because of a limited budget and time.

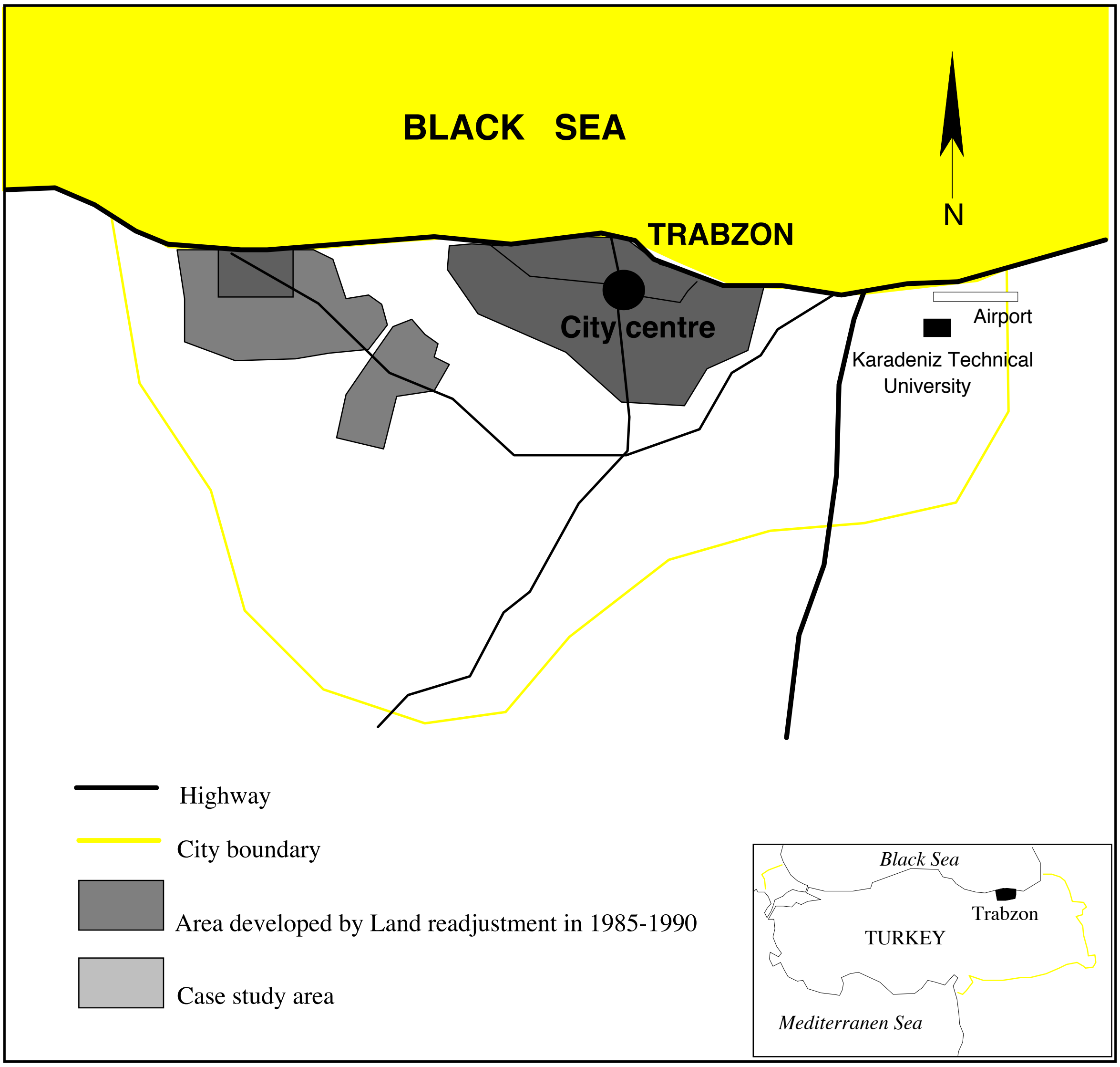


Figure 7.2 City of Trabzon

The sample study area selected for this study is in the city of Trabzon which is located on the Black Sea coast. It is an harbour city which provides the import and export requirements of the north-east part of Turkey. The city has a population of 100,000 and rough topographical characteristic. Since 1985 almost 500 hectares area has been developed by land readjustment process (KTU, 1990). The particular project site which illustrated in Figure 7.2 is an area with 700x700 meters in the west part of the city. Urban expansion occurs from the city centre to the western side because of topographical limitations in the other parts of the city.

7.5 Data gathering

The type of information which could be useful for the study was collected in Turkey. The present zoning and cadastral maps and other relevant information to this study area were collected from the municipality of Trabzon. Data sources were available in 1:1000 scale. However, some required data were not available. Such maps soil, environment, available utilities etc. were created during this study.

The cadastral map shows the legal position of current land parcels, buildings, parcel IDs, and existing roads. The zoning maps on the other hand represent the combination of several maps such as topography, land-use, thematic map. The new land development plan is also drawn on the zoning maps. Basically, new site block patterns with designed roads, green areas, and public buildings are shown in the zoning map. The zoning codes are also given on the map.

7.5.1 Digitising of required map layers

Since geoprocessing requires information to be in digital format, existing maps were converted into digital format using the process of hand digitising. Since digitising facilities were not available for ARC/ INFO, AutoCAD was used to capture the data in digital form.

In Turkey, digital data are not available. Therefore, the map sheets were collected as blueprint copies. So, all required data layers were stored as vector data. Land parcels, site blocks, buildings and other polygonal areas were represented with closed chains of straight line segments. Linear features such as roads, contours, streams were recorded as *x,y* coordinate pairs of pivot points linking short straight line segments.

7.5.2 Data transfer from AutoCAD to ARC/INFO

Using AutoCAD, the required data on a map sheet were digitised under different map layers but saved as a single file. To use this data file in ARC/ INFO, first the AutoCAD file was converted into DXF format. The conversion of the AutoCAD file into DXF format was performed as follow:

```
Command: DXFOUT <file_name>
```

Following this command a DXF formatted file with **file_name.dxf** is created. Then this file is loaded into a project directory. Using ARC/ INFO, **DXFINFO** command is performed. This command reads any DXF formatted interchange file and displays information about the file. It lists all the layers in the file, the kinds of features contained in each layer, and length of character strings that may be converted into attributes or text strings of annotation. Then, **DXFARC** command is performed to convert an AutoCAD map layer to ARC/ INFO map coverage. When this command is issued, a dialogue is initiated and the layer names are entered interactively. However, it has be noticed that if a single layer wants to be converted to a single coverage, **DXFARC**command must issued for that layer only. Otherwise, all AutoCAD layers are combined in a ARC/INFO coverage.

A sample example use of **DXFARC** where the conversion parameters are specified through interactive dialogue is given below.

```
Arc :  DXFARC  CADASTRE.DXF CADASTRE.COV

Enter the layer names and options (type END or $REST when done) :
==============================================================
Enter the 1st layer and options: PARCELS
Enter the 2nd layer and options: END

Do you want to use the above layers and options (Y/N)? Y

Processing <SUPPORT>AI50>DXF>CADASTRE ...
Externalling BND and TIC...
      426  Arcs written.
       58  Labels written.
        0  Annotation written.
        0  Annotation levels.

Arc :
```

7.5.3 Topology creation

Before the spatial analysis, a correct topology must be provided for the available coverages. To create the topology, **CLEAN** command is issued in ARC/ INFO. This command builds polygon and arc-node topology by performing a geometric analysis on the coverage arcs and label points to identify coverage nodes and polygons. During **CLEAN**, two or more arc coordinates within the fuzzy tolerance of each other are snapped together and becomes the same coordinate point. The choice of a fuzzy tolerance is important because it affects the resolution of the output coverage. For this study, the fuzzy tolerances were determined according to the resolutions of the input coverages. The following **CLEAN** command was issued for a cadastral coverage to correct the topology.

```
Arc : CLEAN CADASTRE CADASTRE 0.02 0.02 LINE
Arc : CLEAN CADASTRE CADASTRE 0.02 0.02 POLY
```

The coordinate precision of output coverage is determined by the current processing rule as set by the **PRECISION** command. If the processing rule has not yet been established using **PRECISION** during current ARC/INFO section, then the processing rule will be HIGHEST. This means that **CLEAN** will create an output coverage in the same precision as the input coverage.

7.5.4 The correction of topology errors

To check out the topology whether it was built correctly or not, **NODEERRORS** and **LABELERRORS** commands are issued. **NODEERRORS** detects and lists all nodes of a coverage that represent potential errors. This command lists the information on type of node error, node number, and its *(x,y)* coordinate location. If a coverage being evaluated has no node errors, the following report must be received.

```
Total number of Dangling Nodes:  0
Arc :
```

On the other hand, **LABELERRORS** is used to identify label point errors for polygons. This command lists all polygons which have either no label points or more than one label point. If more than one label point is found in a polygon, the `User-ID` of each label point is listed. If a coverage being evaluated has no label errors, the following report must be received.

```
Polygon 1 has 0 label points
Arc :
```

If any errors are detected, both label and node errors are corrected by using editing facilities in ARCEDIT. After editing, the coverage topology is recreated. These editing and topology recreation procedures are repeated until node and label errors are provided in correctly.

7.5.5 Input of descriptive data

Besides the graphical information, additional information need to be specified for the special analysis. For example, the zoning codes such as permitted construction area, minimum street frontage, permitted number of floors for the site blocks should be represented with the coverage.

When topology is constructed for a coverage the corresponding feature attribute table is automatically created. This is a tabular data file storing standard attributes about the features such as area, perimeter, coverage-ID. It is also possible to add any additional information to a tabular data file by joining with different data sets. To add new attributes for each feature the following procedures were followed:

(1) Creating a new INFO data file to hold the attributes,

(2) Adding attribute values to the INFO data file,

(3) Joining the INFO data file to the feature attribute table for the coverage.

To add additional attributes to the feature attribute, another INFO data files were created to hold the new attribute values. These INFO files were named with corresponding coverages and LUT extension, such as *ZONING.LUT*. To create such a table, first an INFO file should be defined including its item names and formats. Then, the attribute values were added to the newly created INFO data file by typing them directly into the file. Appendix C shows an example of how the *ZONING.LUT* was created. The other LUT tables which were used in this study are also given in Appendix C.

The newly added attribute values to the INFO data file were attached to the feature attribute table for the coverages using common item. This is a joining process of two different tabular data files that is performed as follow:

```
Arc :  JOINITEM <in_file> <join_file> <out_file>
         <relate_item> <start_item>
```

7.5.6 Formulation of land parcel IDs

In Turkey, land parcels are coded with unique parcel IDs during the land registration. The ID coding for a parcel is based on the following procedures:

Parcel ID = *Name of city + Name of district + Block no + Parcel no*

An example of parcel coding system is illustrated in Figure 7.3 In this case study, a new type parcel coding system was used rather than using the current parcel IDs.

After the topology creation unique coverage-IDs are created for each land parcel. Based on these IDs and the block numbers, the new land parcel numbers were determined automatically by the system with following commands:

```
Arc : ADDITEM CADASTRE.LUT CADASTRE.LUT O-PARCEL-ID 15 15 N 5
Arc : TABLES
Tables :  SELECT CADASTRE.LUT
Tables :  CALCULATE  O-PARCEL-ID = (( BLOCK-ID * 100000 ) +
CADASTRE-ID) / 100000
Tables :  Q STOP
Arc:
```

End of this calculation, for example, a land parcel is represented with following form:

```
O-PARCEL-ID =  502.00018
```

In this representation, the first three digits represent the block number and rest of it represents the sequence number of parcel within the coverage.

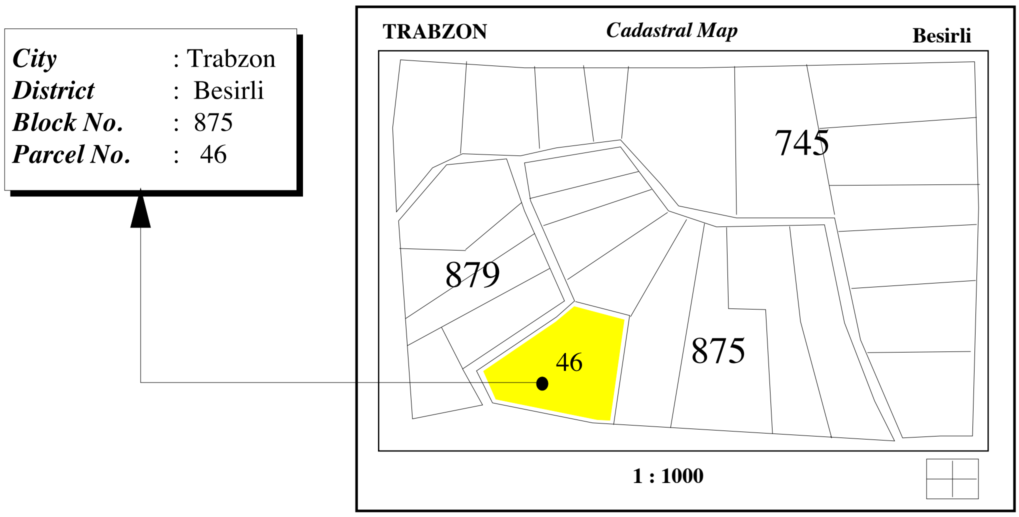


Figure 7.3 A land parcel identification

7.5.7 Exporting of input coverages

Before running LARES, the workspace should be emptied. Therefore all input coverages with their attribute tables were exported and stored under different file names in LR_COV directory. This is one of the requirement of LARES in order to control data flow during the process. So, after the topology creation and descriptive data input, the following commands were issued before the full process of LARES.

```
Arc :  EXPORT COVER ZONING CASE1.ZON
Arc :  EXPORT COVER CADASTRE CASE1.CAD
Arc :  .......
Arc :  EXPORT COVER CONTOURS CASE1.CON
Arc :  &system mv case1.*.E00  ~/gis/project1/LR_COV
Arc :  KILL ZONING ALL
Arc :  KILL CADASTRE ALL
Arc :  .......
Arc :  KILL CONTOURS ALL
```

7.6 Data Processing

Using LARES, the value-based land readjustment process was implemented for 185 cadastral parcels with 430,834 square meters (Figure 7.4). These parcels were reallocated within 68 site blocks. During the implementation some other new coverages such as slope, view, old and new network were derived from the input coverages. More importantly, the performance of LARES was tested and land related information was resulted. The entire procedures of this case study are presented in Appendix F. All related information such as input coverages, data, land subdivision, valuation analysis and outputs are also included to Appendix F. However, following sections give summary information related to the main modules of LARES.

7.6.1 Creation of new site lots

Based on the zoning coverage and its related attribute tables, the new subdivision coverage was created. After the first implementation of land subdivision program, some land parcels were edited to satisfied the zoning requirements. The main idea during the land subdivision was to produce the maximum number of new land parcels with respect to zoning restrictions. The new land parcel-IDs were also created similar to cadastral parcel-ID creation process which explained in section 7.5.6.

Figure 7.5 shows the input zoning coverage for land subdivision. Figure 7.6 represents the output coverage after the implementation of land subdivision process. The output coverage were considered as the final layout of the project area. This coverage which names as CASE1.LOT coverage was used as input coverage for land valuation analysis.

7.6.2 Land valuation analysis

Land valuation analysis was implemented for both cadastral and lot parcels. Different number of land valuation factors were selected to analyse. The results which named with the corresponding factor code IDs were stored under the LR_RES directory. These results represents the each selected land factor values for the land parcels. These factors were evaluated out of 100 with respect to their formulas. The factor weights were also considered during the calculation.

Figure 7.4 Cadastral coverage

Figure 7.5 Zoning coverage

Figure 7.6 Subdivision coverage

7.6.3 Determination of parcel values

For the implementation of the model, only 17 land valuation factors were examined because of computer memory limitations. The 15 of these factors were used for the evaluation of the old cadastral parcels and another combination with 15 factors were also used for the evaluation of the new lots. These different factor groups are given as follows;

No	CODE	USED VALUATION FACTORS	BEFORE	AFTER
1	001	ENVIRONMENT	*	*
2	002	SUPPLIED BASIC SERVICES	*	*
3	003	LANDSCAPE, VIEW	*	*
4	004	DISTANCE FROM NUISANCES	*	*
5	005	LAND PARCEL SHAPE	*	*
6	006	DISTANCE FROM NOISE	*	*
7	007	AVAILABLE UTILITIES	*	*
8	008	PERMITTED CONSTRUCTION AREA		*
9	009	ACCESS TO STREET	*	*
10	010	CURRENTLY USABLE AREA	*	*
11	011	STREET FRONTAGE	*	*
12	012	PERMITTED NUMBER OF FLOORS		*
13	013	DISTANCE TO CITY CENTRE	*	
14	014	SOIL CONDITION	*	*
15	015	DISTANCE TO SHOPPING CENTRE	*	
16	017	PARCEL LOCATION WITHIN BLOCK	*	*
17	018	TOPOGRAPHY	*	*

Using the results of these factor values, the nominal asset values of the land parcels were determined by equation [3.2]. Then, the final value figures were calculated as explained in section 5.5.3. The initial implementation outputs for the project area are presented below.

```
Total value before the project =  28,496,489  units
Total value after the project  =  31,041,087  units
The readjustment coefficient (z) =  0.918025
```

7.6.4 Distribution of new land parcels

Following the determination of parcel value, the cadastral land parcels were distributed with respect to their calculated nominal values. As explained in section 5.5.4, the value of old and new land parcels were compared in order to reallocate the cadastral parcels within the new lots. The general information about input and output parcels are given below.

```
===============================================
Input parcels  = 185
Output parcels = 506

382 parcels ; with  1  owner(s)    ( 75.5 % )
 83 parcels ; with  2  owner(s)    ( 16.4 % )
 29 parcels ; with  3  owner(s)    (  5.7 % )
  8 parcels ; with  4  owner(s)    (  1.6 % )
  2 parcels ; with  5  owner(s)    (  0.4 % )
  1 parcels ; with  6  owner(s)    (  0.2 % )
  1 parcels ; with  7  owner(s)    (  0.2 % )
===============================================
```

7.6.5 Final reports

At the end of the full implementation, the distribution results were reported as the final outputs. These outputs contain the information about the parcels including their old and new land parcel-IDs, assigned values, share percentages, etc. Some of the results of this case study are presented in Appendix F. However, an example for the land parcels in the site block no.111 is illustrated in Figure 7.7.

7.7 Assessment of the implementation

To test the performance of LARES a land readjustment project area of 430,834 square meters with by 185 land parcels was examined. Data processing was began with digitising of the property map, the land-use plan, topographical maps and other required map layers. Land ownership records were also included in the database. Then, 68 site blocks were subdivided into 506 land parcels according to the plan's rules. The total area of the new land parcels is 247,400 square meters. Because of the nature of the land readjustment concept, the total area of old land parcels was reduced to 247,400 square meters with the process. In another words, 183,434 square meters of public-use areas were gained by the contribution of the landowners and reserved for public-use after the project. The rest of the land was then redistributed among the involved landowners.

The total value for the project area was estimated as 28,496,489 units by 15 land valuation factors in the post-project phase. These units were distributed to the landowners with respect to the their calculated old nominal asset values.

In Figure 7.7, for example, the land parcel no.14 within the block no.103, had a total of 306,635 units value before the distribution as a single parcel. With the process this total value was reallocated within five new site lots. These lots are no.36-41 within block no.111, and lot no.87-90-118 within block no.248. It must to be noted that after land distribution some new lots such as no.41 in the block no.111 can be shared by more than one landowner. This occurs because the limits of a new parcel size are given by the zoning plan that must be followed.

Figure 7.7 Land distribution for a site block

103.00014	*5*	*111.00036*	*111.00041*	*248.00087*	*248.00090*	*248.00118*
306634.98	*v*	*75214.16*	*29068.04*	*56723.69*	*45772.65*	*99856.43*
% OLD -->	*%*	*24.53*	*9.48*	*18.50*	*14.93*	*32.57*
% NEW -->	*%*	*100.00*	*38.66*	*100.00*	*100.00*	*100.00*
111.00036	1	103.00014	0.00000	0.00000	0.00000	0.00000
75214.16	v	75214.16	0.00	0.00	0.00	0.00
0.00	%	100.00	0.00	0.00	0.00	0.00
111.00041	3	103.00014	103.00019	106.00171	0.00000	0.00000
75183.24	v	29068.04	6805.69	39309.51	0.00	0.00
0.00	%	38.66	9.05	52.28	0.00	0.00
111.00045	1	103.00017	0.00000	0.00000	0.00000	0.00000
74910.19	v	74910.19	0.00	0.00	0.00	0.00
0.00	%	100.00	0.00	0.00	0.00	0.00
111.00049	2	103.00018	107.00170	0.00000	0.00000	0.00000
79439.51	v	34589.98	44849.53	0.00	0.00	0.00
0.00	%	43.54	56.46	0.00	0.00	0.00

7.7.1 The selection and implementation of different factors

The selection of land valuation factor is optional in LARES. When a different number of land valuation factors is selected, the parcel nominal asset values are subject to change after the project. In order to see the effects of the selection of different factors on the land distribution process, three different factor groups were applied to the same land parcels in the case study area. Table 7.3 shows the selected factor groups and related distribution results. As an example, the results of 10 land parcels are given in Table 7.4. The results shows that nominal asset values are different after the project. Figure 7.8 and Figure 7.9 illustrate the nominal asset value graphs before and after the project in accordance to the selected factor groups.

The selection of different numbers of the factors also affects the total land parcel area which a landowner will obtain after the project. Table 7.5. shows some of the land parcel sizes with the selected factor groups. The graph in Figure 7.10, indicates that there are significant differences (in square meter level) between the re-distributed land parcel sizes.

Table 7.3 The results of land distribution with three different factor groups

```
Total number of NEW parcels =   506
Total number of OLD parcels =   185


GROUP 1:

USED FACTOR ID's :  001 - 002 - 003
TOTAL of USED OLD VALUE  =     5922283.40
Initial NEW VALUE        =     7409981.71
z = 0.7992

Share Distribution...
--------------------------------------------------
    383 parcels ; with  1  owner(s)   < 75.6 % >
     85 parcels ; with  2  owner(s)   < 16.8 % >
     21 parcels ; with  3  owner(s)   <  4.2 % >
     13 parcels ; with  4  owner(s)   <  2.6 % >
      2 parcels ; with  5  owner(s)   <  0.4 % >
      2 parcels ; with  6  owner(s)   <  0.4 % >


GROUP 2:

USED FACTOR ID's :   001 - 002 - 003
                     004 - 005 - 006 - 007
TOTAL of USED OLD VALUE  =    10547366.14
Initial NEW VALUE        =    12744805.01
z = 0.8276

Share Distribution...
--------------------------------------------------
    381 parcels ; with  1  owner(s)   < 75.3 % >
     83 parcels ; with  2  owner(s)   < 16.4 % >
     34 parcels ; with  3  owner(s)   <  6.7 % >
      5 parcels ; with  4  owner(s)   <  1.0 % >
      1 parcels ; with  5  owner(s)   <  0.2 % >
      1 parcels ; with  7  owner(s)   <  0.2 % >
      1 parcels ; with  9  owner(s)   <  0.2 % >


GROUP 3:

USED FACTOR ID's :  009 - 010 - 011
TOTAL of USED OLD VALUE  =     7218810.73
Initial NEW VALUE        =     8140748.95
z = 0.8867

Share Distribution...
--------------------------------------------------
    383 parcels ; with  1  owner(s)   < 75.7 % >
     84 parcels ; with  2  owner(s)   < 16.6 % >
     24 parcels ; with  3  owner(s)   <  4.7 % >
      8 parcels ; with  4  owner(s)   <  1.6 % >
      7 parcels ; with  5  owner(s)   <  1.4 % >
```

Table 7.4 The calculated parcel unit values for the selected factor groups

Table 7.5 The land parcel sizes which landowners obtain after the project

7.7.2 Statistical analysis of the case study results

To examine the developed model itself, the case study results have been statistically analysed using SPSS-X. Basically, the following questions have been investigated.

(1) Is there correlation between the selected land valuation factor's value? If so, how are these factors are correlated to each other?
(2) When a parcel nominal asset value is determined, are there any significant differences between the selected factors?
(3) What factor or factors have most effect on the estimation of an individual land parcel's nominal asset value?
(4) What is the achievement validity of the developed model if different land parcel groups are implemented?

To answer the first question, the factor correlation matrix has been created and examined. For the second and third questions the *one-way* variance analysis has been applied to case study results. The final question was also investigated with *one-way* analysis by creating different number of data sets. The statistical analysis has been applied to the land parcels with 15 land valuation factors in both project stages, before and after. The following sections discuss the statistical analysis.

7.7.2.1 Correlation between the factor values

In order to see the relationships between the land valuation factors the correlation matrix of the estimated factor values can be examined. Based on the case study results, a correlation matrix was created with the correlation coefficients (see Appendix. H). The correlation coefficients can provide a quick way of indicating whether or not two land valuation factors are related at all in the given data and the numerical size of coefficient value reflects the amount of scatter in the data. A correlation near +1 means high values of *y* mostly occur with high values of *x*, and low with low. A correlation near *0* implies little or no special tendency for high *y* to occur with high *x*. A negative correlation arises when high *y* tend to go with low *x* and vice versa. A general limitation of the correlation coefficient is that it does not say what the relationship actually is. i.e. how *y* varies *x*. It only indicates the relative amount of scatter.

Table 7.6 represents the correlation matrix of the calculated nominal asset values before the project (n=185). According to this correlation matrix, the following land valuation factors are highly correlated (*r: correlation coefficient*);

Environment and distance to nuisance (r=0.78)
Environment and distance to noise (r=-0.53)
Environment and soil condition (r=0.77)
Environment and distance to shopping centre (r=0.58)
Distance to noise and distance to nuisance (r=-0.57)
Distance to noise and soil condition (r=0.76)
Access to street and distance to noise (r=-0.60)
Access to street and street-frontage (r=0.52)
Distance to shopping centre and distance to city centre (r=0.89)

On the other hand, according to the correlation matrix, it has been found that there is no correlation between the following factors (r<0.009):

Distance to city centre and distance to nuisance
Distance to noise and land parcel shape
Available utilities and soil condition
Access to street and soil condition
Location within the site block and topography

correlation matrix

7.7.2.2 Test of the significance on asset value

It can also be analysed whether each land valuation factor contributed significantly to the determined land parcel nominal asset value. To examine this, one-way of variance analysis was used. One-way can analyse several independent variables (in this case independent variables are land valuation factors) by one dependent variable (in this case dependent variable is the parcel nominal asset value) with one specification of the procedure.

One-way analysis, first, produces a table which shows how the selected land valuation factors are significantly different at the selected confidential level. In our example, 15 land valuation factors which have been used for the old cadastral parcels in the case study were tested at the 99% and 95% statistical confidence levels. In Table 7.7, the test result shows that most of the land valuation factors are significantly different at the 0.01 (99%) level (the '*' mark in the table indicates that there is a significant between the cross-variables).

Referring to this table, it is possible to say more about the significance of a factor. For example, there is a significant variance between the factor *street frontage* and the factors *utilities*, *noise* at 0.01 level, in favour of the factor *street frontage*. It indicates that the factor *street frontage* has had significantly higher effect on the parcel nominal asset value than the factor *utilities* and *noise*. Similarly, it can also be said that there is no significant variance between the factor *topography* and *soil condition*. This indicates that both factors have had same effect on the parcel nominal asset value.

Table 7.7 One-way test for the selected factors (before)

```
     MEAN    GROUP   FACTOR NAME               FACTOR-ID

     .3419    007  UTILITIES                   007
     .6646    006  NOISE                       006
    1.7216    011  STREETFRONTAGE              011
    2.7928    003  VIEW                        003
    4.2467    005  PARCEL SHAPE                005
    4.3292    002  MUNICIP.SERVICES            002
    4.4158    017  LOCATION IN BLOCK           017
    4.9069    015  DISTANCE TO SHOOP           015
    5.0101    013  DISTANCE TO CITY CNT        013
    5.4318    014  SOIL CONDITION              014
    5.5005    018  TOPOGRAPHY                  018
    6.5520    004  NUISANCE                    004
    6.7135    009  ACCESS TO STREET            009
    6.9463    001  ENVIRONMENT                 001
    7.3773    010  USABLE AREA                 010



THE RANGES ABOVE ARE TABLE RANGES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
        0.9814 * RANGE * DSQRT(1/N(I) + 1/N(J))


                          0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
                          0 0 1 0 0 0 1 1 1 1 1 0 0 0 1
                          7 6 1 3 5 2 7 5 3 4 8 4 9 1 0
     Mean     Factor ID's

      .3419       007
      .6646       006     .
     1.7216       011     * *
     2.7928       003     * * *
     4.2467       005     * * * *
     4.3292       002     * * * * .
     4.4158       017     * * * * . .
     4.9069       015     * * * * . . .
     5.0101       013     * * * * . . . .
     5.4318       014     * * * * * * * . .
     5.5005       018     * * * * * * * . . .
     6.5520       004     * * * * * * * * * * *
     6.7135       009     * * * * * * * * * * * .
     6.9463       001     * * * * * * * * * * * . .
     7.3773       010     * * * * * * * * * * * * . .


(*) DENOTES PAIRS OF GROUPS SIGNIFICANTLY DIFFERENT AT THE 0.010
LEVEL

(.) DENOTES PAIRS OF GROUPS SIGNIFICANTLY NOT DIFFERENT AT THE 0.010
LEVEL
```

One-way test also gives information on the variable groups. The analysis produces homogeneous subsets from the given variables (see Table 7.8). Each subset consist of some variables which have similar effect on the independent value. In our example, we can group the land valuation factors in accordance with their effect on the land unit value.

Based on the Table 7.8, it can be said that the *subset 7* has had the highest effect on the land unit value. In other words, the factors *access to street*, *environment*, and *usable area* have had the highest effects on the land unit value than the other land valuation factors. On the hand, the *subset 1* indicates that the factors *utilities* and *distance to noise* have had the lowest effect on the land unit value.

Table 7.8 Homogeneous subsets (before)

```
(SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS
DO NOT DIFFER BY MORE THAN THE SHORTEST
SIGNIFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET  1
GROUP       007           006
MEAN        0.3419        0.6646
- - - - - - - - - - - - - - - - - -
SUBSET  2
GROUP       011
MEAN        1.7216
- - - - - - - - - - -
SUBSET  3
GROUP       003
MEAN        2.7928
- - - - - - - - - - -
SUBSET  4
GROUP  005           002           017           015           013
MEAN   4.2467        4.3292        4.4158        4.9069        5.0101
- - - - - -- - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
SUBSET  5
GROUP       015           013           014           018
MEAN        4.9069        5.0101        5.4318        5.5005
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
SUBSET  6
GROUP       004           009           001
MEAN        6.5520        6.7135        6.9463
- - - - - - - - - - - - - - - - - - - - - - - - - -
SUBSET  7
GROUP       009           001           010
MEAN        6.7135        6.9463        7.3773
```

The same test also applied to the new land parcels. Table 7.9 shows the factor significance for the nominal asset values of the new land parcels. Homogeneous subsets for the new parcels are also given in Table 7.10. According to the Table 7.10, the *subset 10* which consists of the factor *usable area* and *street frontage* has had the highest effect on the land unit value. The *subset 1* indicates that the factors *utilities*, *distance to noise*, and *construction area* have had the lowest effect on the estimation of new land parcel nominal asset value.

Table 7.9 One-way test for the selected factors (after)

MEAN	FACTOR ID'S	FACTOR	FACTOR-ID
.5885	008	CONSTRUCTION AREA	008
.6281	007	UTILITIES	007
1.0848	006	NOISE	006
3.2983	012	PERMITTED FLOORS	012
4.4498	003	VIEW	003
5.9431	005	LAND PARCEL SHAPE	005
7.5500	002	MUNICIP. SERVICES	002
7.8207	018	TOPOGRAPHY	018
8.4241	014	SOIL CONDITION	014
9.1704	017	LOCATION IN BLOCK	017
9.4361	009	ACCESS TO STREET	009
11.3502	004	NUISANCE	004
11.9060	001	ENVIRONMENT	001
12.7370	010	USABLE AREA	010
12.9740	011	STREET FRONTAGE	011

Mean	Factor IDs	008	007	006	012	003	005	002	018	014	017	009	004	001	010	011
.5885	008															
.6281	007	.														
1.0848	006	.	.													
3.2983	012	*	*	*												
4.4498	003	*	*	*	*											
5.9431	005	*	*	*	*	*										
7.5500	002	*	*	*	*	*	*									
7.8207	018	*	*	*	*	*	*	.								
8.4241	014	*	*	*	*	*	*	*	*							
9.1704	017	*	*	*	*	*	*	*	*	*						
9.4361	009	*	*	*	*	*	*	*	*	*	.					
11.3502	004	*	*	*	*	*	*	*	*	*	*	*				
11.9060	001	*	*	*	*	*	*	*	*	*	*	*	*			
12.7370	010	*	*	*	*	*	*	*	*	*	*	*	*	*		
12.9740	011	*	*	*	*	*	*	*	*	*	*	*	*	*	.	

(*) DENOTES PAIRS OF GROUPS SIGNIFICANTLY DIFFERENT AT THE 0.010 LEVEL

```
(.) DENOTES PAIRS OF GROUPS SIGNIFICANTLY NOT DIFFERENT AT THE 0.010
LEVEL
```

Table 7.10 Homogeneous subsets (after)

(SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN THE SHORTEST SIGNIFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1			
GROUP	008	007	006
MEAN	0.5885	0.6281	1.0848
SUBSET 2			
GROUP	012		
MEAN	3.2983		
SUBSET 3			
GROUP	003		
MEAN	4.4498		
SUBSET 4			
GROUP	005		
MEAN	5.9431		
SUBSET 5			
GROUP	002	018	
MEAN	7.5500	7.8207	
SUBSET 6			
GROUP	014		
MEAN	8.4241		
SUBSET 7			
GROUP	017	009	
MEAN	9.1704	9.4361	
SUBSET 8			
GROUP	004		
MEAN	11.3502		
SUBSET 9			
GROUP	001		
MEAN	11.9060		
SUBSET 10			
GROUP	010	011	
MEAN	12.7370	12.9740	

7.7.2.3 Testing the validity of the developed model

To test the developed model the best way is to use real-world data which produced the use of similar land valuation factors. But such data were not available during this study. Another option is to use real-market data but this cannot provide the efficiency of the model because it has not been intended that the model fit the calculated unit value to the market value.

Table 7.11 Testing the model (Rank of the 15 factors at 0.05 level)

(old)				(new)			
set-1 n=185	**set-2 n=60**	**set-3 n=65**	**set-4 n=60**	**set-1 n=506**	**set-2 n=247**	**set-3 n=259**	**set-4 n=188**
007	006	007	007	008	008	007	007
006	007	006	006	007	007	008	008
011	011	011	011	006	006	006	006
003	003	003	003	012	012	012	012
005	005	017	005	003	003	003	003
002	002	002	015	005	005	005	005
017	017	005	013	002	002	002	002
015	014	015	002	018	018	014	018
013	015	013	017	014	014	018	014
014	018	018	014	017	017	017	017
018	013	014	018	009	009	009	009
004	004	009	004	004	004	004	004
009	010	004	001	001	001	001	001
001	001	001	009	010	010	010	010
010	009	010	010	011	011	011	011

However, the validity of the model with 15 factors can be tested using a different number of land parcels. For this purpose, four different data sets were considered with respect to different number of parcel groups. The first data set represents the factor values for whole cadastral land parcels. The last three data sets were randomly picked from the whole data set. By applying the one-way analysis on these four data sets, the mean values of the land valuation factors and the rank of these factors between the selected data sets were examined. Table 7.11 shows the test results with the selected land valution factor ID's. It has been found that the rank of the land valuation factors remain almost the same for each data sets. In other words, the variance of land valuation factors on the land unit values are the same when different numbers of land parcels are considered. The data sets were tested at the 0.05 level. So, the test result indicates that when the model (with 15 factors) apply to other land parcel sets, 95% of the results will be the same.

This gives an evidence that the developed model is adequate. The details about the statistical tests are given in Appendix H.

7.8 Chapter summary

In this chapter, a case study was examined in order to implement and test the developed prototype LARES. A land readjustment project area in Turkey has been considered as a case study. First, land registration system and land readjustment applications in Turkey have been outlined. Then, using data from Turkey, the value-based land readjustment process was carried out. Following the land subdivision, land valuation analysis was performed and tested with different numbers of land valuation factors.

The results of land valuation analysis showed that the nominal asset values of the land parcels are relatively different before and after the project. Based on the calculated land valuation figures, land distribution was then performed. The distribution tables, all attached textual information and land valuation maps were produced as final outputs.

Finally, the case study results have been statistically tested. The correlation between the determined factor values and the significance of the selected factors have been examined. The developed model itself has also been tested with the different land parcel groups. The discussion about these tests have been given in this chapter. However, the test results are presented in Appendix H.

CHAPTER 8

CONCLUSIONS

> " The land is man's most valuable resource. It is indeed much more than this: it is the means of life without which he could never have existed and on which his continued existence and progress depend."
>
> (Binns, 1953)

8.1 Introduction

This research was undertaken because it was felt that the current implementations of land readjustment have not been used totally effectively for improved land management. The benefits of land readjustment therefore cannot be shared sufficiently by both government and landowners. The controlling of the rural-to-urban land use change requires careful analysis of spatial characteristics of the land; particularly economical, social, and planning dimensions. It was also considered that the existing information technology has not been introduced to land readjustment adequately, so the benefits of the technology cannot be enjoyed.

Based on the objectives of this thesis, a new approach to land readjustment has been investigated. A land readjustment prototype model which deals with *land valuation*, *decision-making*, and *information management* issues of current land readjustment procedures has been designed, developed and implemented using GIS. This chapter, first, summaries the research and discusses the developed model itself. Then, following specific conclusions, some suggestions for further works are included.

8.2 Research summary

The work began with a review of related literature and the problem definition. The research objectives and methodology were defined in Chapter 1. In chapter 2 the land readjustment method was described with its potential use for urban land management. The current status of the method with its objectives, characteristics, and its role to monitor a rural-to-urban land use change have been outlined.

In Chapter 3 the important issues of current land readjustment applications were categorised. These issues were subdivided under the heading of *land valuation*, *decision-making*, and *information management*. The solutions for these issues were analysed and a new approach to land readjustment proposed. This new method has been designed to increase the qualitative and quantitative ability of the land readjustment process. The conceptual design of this proposed model was also set out in Chapter 3 along with its development requirements.

To implement the designed model a prototype, called LARES, has been developed using the currently available land-related information technology. In Chapter 4, to integrate the land readjustment process with the land-related information systems, GIS and LIS have been reviewed with their potential use.

In Chapter 5 the software development has been explained with particular algorithms such as land subdivision, land evaluation and the distribution of new land parcels. During the software development the functionality of Arc/ Info was used as a GIS tool for the spatial analysis, data manipulation, storage and display. Some external programs were also used to support the computing environment. A menu-driven system was developed to perform the process in an interactive way so that the main tasks of the prototype LARES were executed from the series of pull-down menus. The menu system including data flow, file structure and particular modules of LARES are described in Chapter 6.

Finally, a case study was carried out to test an implementation of the developed prototype model. For this purpose Turkey, which practices land readjustment, has been considered and a review of land readjustment in this country was made in Chapter 7. Using data from Turkey, the prototype model was tested on a particular project area. The case study results were statistically analysed in order to understand the relationship between the used land valuation factors and implementation validity of the model.

8.3 General discussion

Land readjustment is one of the land management techniques used in urban development. The main objective of land readjustment is to transform undeveloped land parcels, usually irregularly subdivided cadastral parcels, into appropriate forms according to the zoning planning requirements. For this, all cadastral parcels within a project area are grouped together and a percentage of each land parcel calculated to determine a contribution to public areas. This percentage depends on the size of the project area and the total size of required public-use areas. The remaining land is then reallocated within the site blocks defined by the zoning plan

As given in section 2.10, land readjustment has some valuable advantages in solving land-use problems in urban areas but current implementations are still faced with some problems. These included technical problems in handling the wealth of data, economical problems in funding compensation for acquiring land, and social problems in minimising the inconvenience and conceived injustices. These problems were discussed in sections, 1.2, 2.11, and 3.2.

It was considered that there was a need for a better land evaluation process because in many cases the most significant criterion by which land is redistributed is the parcel size. Based on the parcel size and the public-use land area required in the zoning plan, a single coefficient is calculated and applied to all landholders to reallocate their land and derive their contribution for the public areas. From the economical point of view, this process cannot guarantee fairness for landowners because it assumes that land unit values are the same within the project area and they do not change after the project. Thus, in current land readjustment applications, especially in Japan and Turkey, many objections arise from landowners. They claim that an equitable land distribution is not provided after a project, because many other economical and environmental factors which affect a parcel value are ignored.

Land valuation is therefore important in land readjustment. Using the market unit values, it is possible to implement such a project. But difficulty is to estimate the parcel values before and after the project. The conventional way to estimate the value is to use real-market data. If such data are available, this can only be used for the present cadastral parcels. The real-market data for the new land parcels are also needed but to collect such data requires the completion of the project which may take a long time. In Germany and Japan, for example, the assessment of the new land parcels takes more than five years to complete so that the projects are delayed (see sections 1.2, 2.13.4).

To convince landowners that fair land distribution has taken place, the asset value profiles among the landowners before the project should be the same after the project. To achieve this, based on a wide range of significant criteria, the nominal asset values of land parcels can be derived before and after the project. Then, the land distribution is performed with respect to the derived asset values. In this case, regardless of the new land size and location, a landowner would obtain the land with its derived value that was the same before the project. So, based on this idea a new model has been designed and developed.

In this research, rather than dealing with the real-market data, the qualitative and quantitative characteristics of individual land parcels have been examined before and after the project. To estimate the parcel nominal asset value, 28 land valuation factors were selected and formulated (see section 3.3.2.3.1). In the assessment of importance of these factors, it was assumed that each factor value could have a maximum value of 100 for a fully developed land unit. In other words, each factor was evaluated out 100% (see section 3.3.2.3). Then, a land parcel value was determined with the combination of these factors. In here, as mentioned in section 1.4, the term *value* was used as a *nominal asset value* which represents a land parcel's worth when compared to others.

As mentioned above, there is a need to estimate the parcel values in both project stages, before and after. The cadastral parcels are available in the pre-project stage but the new land parcels are not. For the post-project phase the only available document is the zoning plan which represents the designed roads, public areas, and the bounds of site blocks. Therefore, first, the zoning site blocks need subdivision. During the subdivision process the new land parcels are created according to the given zoning data only. The subdivision process was discussed in section 5.5.1.

Following the land subdivision, both the old and new land parcels are analysed to determine the nominal asset values. Using these determined values, the total value before and after the project is calculated. The case study demonstrated that overall asset value in the post-project phase is greater than that in the pre-project because of upgrade in the whole area by applying the new plan (see section 7.6.3). But in order to achieve the equation [3.1] in section 3.3.2.3, the total asset value *after* was scaled down to match total asset value *before* (see section 3.3.2.3.2).

After the determination of the land unit values, land distribution is carried out block by block. As explained in section 5.5.4, first, the cadastral and new parcel are overlaid. The cadastral parcels which overlapped in a common zoning block are reallocated within the same block in accordance with their original location and the determined asset value. The main idea here is to fill a zoning block with the corresponding cadastral parcels with regard to their asset value and original location. This land distribution process was automated.

Land valuation analysis and the land distribution require an effective computing environment. Land valuation analysis, for example, deals with some land valuation factors which should be spatially examined in a defined geographical unit. In addition, data input, basic calculations, data extraction, manipulation and provision of all necessary information should be done precisely in a short period of time. Querying and display of any graphical or textual information are also important user requirements. To provide these, a GIS was used.

Using GIS technology, the designed model was computerised and a prototype called LARES developed. GIS provided a great advantage in the land valuation analysis. Some algorithms which perform particular tasks such as land subdivision, land distribution, the proximity analysis were also possible with GIS. More importantly, a user friendly computing environment was created for land readjustment application (see Chapter 6).

The functions of the developed model were implemented and tested with a case study. While the linkage of execution files were being tested, the model was modified. Finally, the case study results were statistically analysed and some remarks on the implementation validity of the model have been made in section 7.7.2.

Using 15 land valuation factors, the test result shows that most of the land valuation factors are significantly different at the 0.01 statistical level (see sections 7.7.2.1, 7.7.2.2). It was found that the factors *access to street*, *environment*, and *usable area* have higher effects on the asset land value than the other land valuation factors. On the other hand, the factors *utilities* and *distance to noise* have the lowest effect on the asset value. In addition, the validity of the model were tested with different land parcel groups. The test results indicate that when the model is applied to other land parcel groups, 95% of the results will be the same (see section 7.7.2.3).

Due to the time and financial limitations it was not possible to implement this land readjustment model on a current project. For a better assessment of the nominal asset value-based land readjustment model, some pilot projects are necessary. Such projects would help the evaluation and modification of the developed model. However, some suggestions for further work have been given in section 8.5.

8.4 Results and conclusions

The following conclusions can be drawn from this research project:

1. ***A new approach to land readjustment was proposed, designed and developed.*** To maximise the benefits from the land readjustment process the current land readjustment applications were evaluated (see chapter 2, section 3.2) and a new approach for the process was designed and developed (see sections 3.3, 5.2, 5.5).

2. ***A land valuation analysis was involved in land distribution***. To provide a fair land distribution process for landowners, the significant tangible and intangible land valuation factors were spatially analysed and the nominal asset values of land parcels were determined with the combination of these factors (see section 3.3.2.3.2). Then, based on the calculated land valuation parameters, land distribution was achieved so that while the original location of a cadastral parcel is changing, its asset value is maintained after the project (see sections 5.5.4, and 7.7). In this way, all landowners are treated in similar fashion.

3. ***A survey was carried out to give priority to the selected land valuation factors with respect to their effects on the total perceived value of a land parcel***. The survey results with 202 responses showed that the factors;

supplied municipal services, permitted number of floors, permitted construction area, view, environment, location within site block, and access to street are more important on the total perceived value of a land parcel than the factors; *distance to fire station, police station, religious places, access to waterway, and railway* (see section 3.3.2.3.3. a, b and Appendix B).

4. ***It has been demonstrated that it is possible to implement the land readjustment model using GIS techniques.*** It was only conceivable to handle such a large quantity of spatial data using GIS. During the development of the model, the map overlaying, buffering, data extraction were made possible by GIS (see section 5.5.2). To automate the model a menu-driven module called LARES was developed using the GIS tool Arc/ Info (see chapter 6). This provides a user interface for data input, storage, manipulation, and output. Querying land readjustment results, particularly the relationship between the old and new land parcels, was also provided by pointing to the required land parcel (see section 6.5.2).

5. ***An algorithm for the automation of land subdivision process was developed.*** A site block was automatically subdivided with the given zoning codes such as minimum street frontage and area (see section 5.5.1). To modify the created land parcels a *subdivision* module was developed with the aid of ARCEDIT (see section 6.4.2).

6. ***An algorithm automating the connection of land parcels to roads was developed.*** The linkage of a land parcel to road is essential for the proximity analysis within the land valuation analysis (see section 3.3.2.3.1.p). To create and extend a street network, the new line segments from the parcel's centroid points to the closest road points were

automatically created. This provided a geometrical and topological connection between land parcels and the road network (sec section 5.5.2.i)

7. ***The developed model has been tested with a case study.*** The value-based land readjustment procedures have been implemented with a case study to examine the effects of the process. The results showed that individual land parcel values are relatively different and the total asset value of the project area increases after the project (see section 7.6.3). When the unit value is concerned, even a small land parcel can be more valuable than a large one (see section 7.7.1).

8.5 Suggestions for further investigations

The previous section in this chapter has summarised the main results and conclusions from this work. There are however more analyses and development work that could be carried out in this area. This section will summarise some suggestions for further work:

1. ***Evaluation of the value-based land readjustment model.*** To evaluate the developed model more implementations are required. For this, the model would apply to a project area where land readjustment has been already implemented. Then, the land distribution results can be compared in terms of parcel size and value. However, it could be difficult to compare the estimated land parcel values with the real-market value because different valuation criteria may be taken into account to determine the parcel value. However, it should be considered that even the real-market value does not reflect the exact value because it is also an estimation process. Nevertheless, the developed model and

real-market value profiles among the land parcels can be examined. To provide a trusty value profile for real-market data, some long term observations on the market would be needed. Thus, it may possible to compare the current cadastral land parcel values. But the assessment of the created new site lots is difficult in a short time because it requires to observe the situation, at least, after the initial land developments in the project area. So, the evaluation of the developed model, with respect to real-world, requires some long term iterative investigations with the pilot projects.

2. ***An effective land valuation analysis***. The analysis of land valuation factors is the most important part of the value-based land readjustment process. Land parcel asset values are determined with the combination of some objective and subjective valuation criteria. However definition and representation of these factors is unclear because these are the tangible and intangible factors that depend on the project type, location, and the desire of landowners. Better formulation for the individual valuation factors and weights for these factors would be achieved with a more organised and iterative survey methods such as *Delphi Method*.

3. ***Investigating and collecting of different types of data for land valuation procedure.*** Data sources are different for a value-based land readjustment process. Considering the selected land valuation factors, different types of data with different quality are required from different organisations. Field survey may also be required for a particular land valuation factor. Therefore, a procedure for data collection and distribution of the produced information can be investigated. This would increase the efficient use of the land-related information.

4. ***Full automation for land subdivision.*** Land subdivision process works with more regular geometrical figures. The subdivision of a polygon which can fit in a rectangle is done easily. But the polygons with more complex shapes are difficult to subdivide. Thus, the subdivision algorithm stops if the polygon is not subdivided after an iteration process. The full automation of land subdivision can be achieved by the examination of the different geometrical figures. The positions of the polygon line segments with arcs, node, and angle should be analysed.

5. ***The use of expert system in land readjustment***. Information technology is changing very rapidly. Today artificial information systems are used in the decision-making procedures. To provide an optimisation procedure in land distribution process, an expert system could be introduced to land readjustment. The expert system rules which concern how to distribute or consolidate landowners shares and how to find the suitable locations for the new site parcels can be written.

8.6 Concluding remarks

The initial aims of this research have been achieved. A new prototype model which provides a nominal asset value-based approach to land readjustment has been designed and developed. GIS was used to capture, manipulate, analyse and display spatially referenced data during the development. The prototype model specifically deals with the land valuation, decision-making, and information management issues of the current land readjustment applications. It is hoped that the developed model not only improves the qualitative and quantitative ability of current land readjustment applications but also increases the speed of urban land planning activities in developing countries.

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