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.

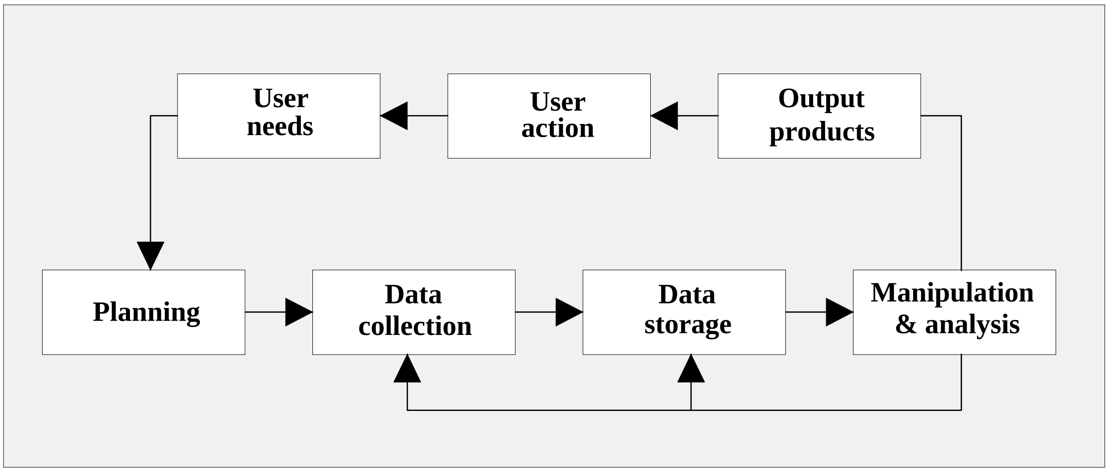


Figure 4.1 A simplified information system overview (after Star and Estes, 1990)

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)**.

LAND - RELATED or GEOGRAPHIC INFORMATION			
LAND INFORMATION			
ENVIRONMENTAL INFORMATION	INFRASTRUCTURE INFORMATION	CADASTRAL INFORMATION	SOCI-ECONOMIC INFORMATION
Soils Geology Watercourses Vegetation Wildlife	Utilities Buildings Transportation Communications	Land tenure Assessment Land use control	Health Welfare Population distribution

Emphasis on land Emphasis on people

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).

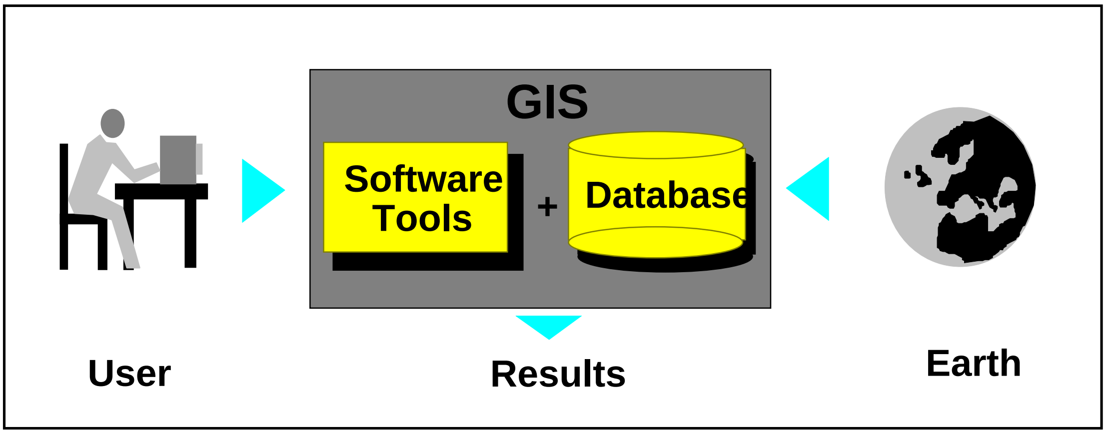


Figure 4.3 A simplified geographical information system (after ESRI, 1993)

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).

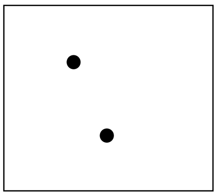
Outputs from a GIS may be a standard cartographic product such as a map sheet or a simple table of data entries, graphs, report etc. on printer and plotter. Alternatively, it may be the result of query or some analysis (Taylor, 1991). Modern technology produces computer-compatible materials: tapes and 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

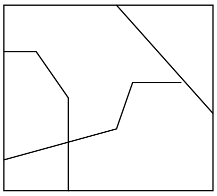
are zero-dimensional objects on a map which represent a single location on the earth. The location is recorded as an xy coordinate. Depending upon the scale and accuracy desired, a point can represent the location of a multi-dimensional feature (such as a bridge). Also known as nodes.



Examples: street intersections
water valves
parcel centroids
fire hydrants

LINES

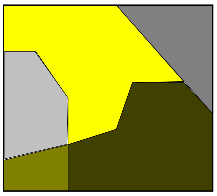
are one-dimensional objects on a map which represent a linear feature having a beginning point and an ending point. Depending upon the scale and accuracy desired, lines may be subdivided onto smaller units called arcs. (This is necessary in order to represent curved lines).



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).

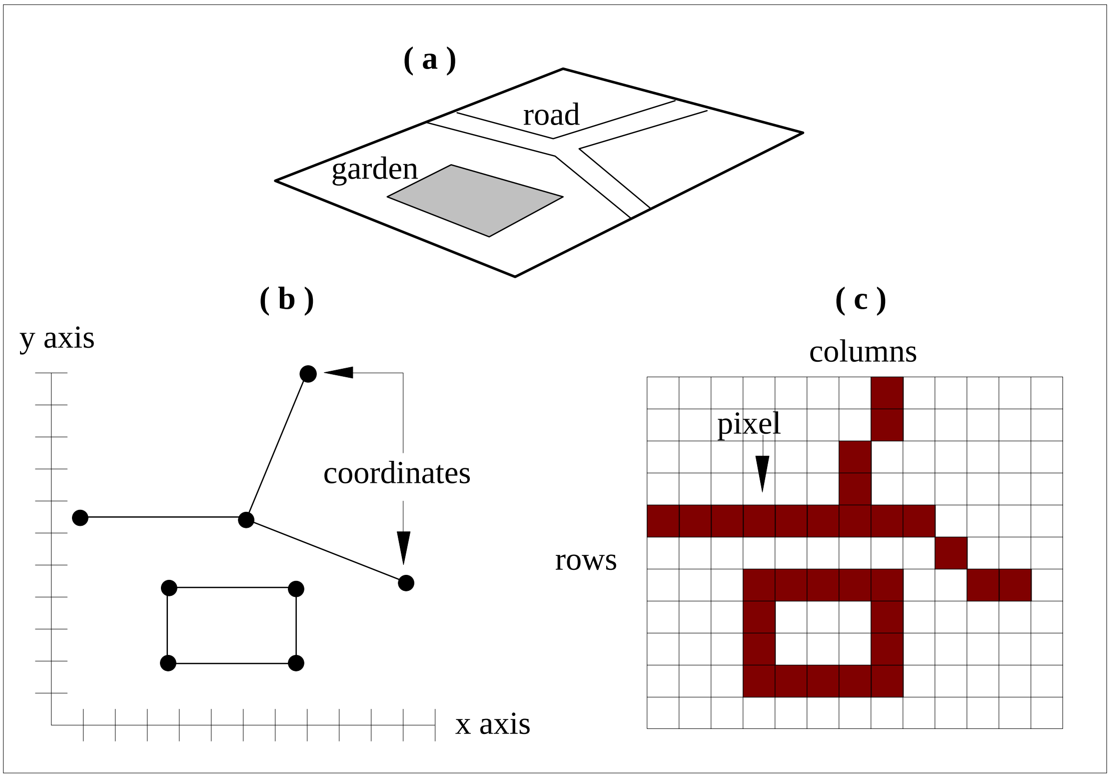


Figure 4.6 Vector and Raster data models. 4.6a. Analogue model of reality; 4.6b. Digital vector model; 4.6c. Digital raster model.

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.

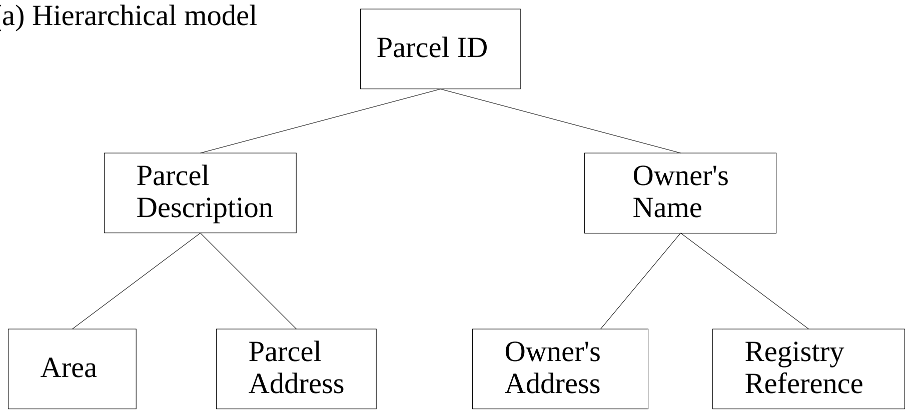
4.3.5 Database models

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.

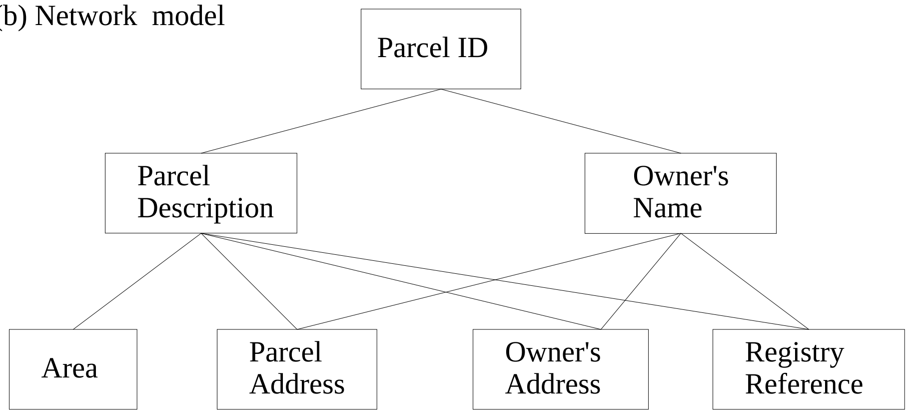
A Database Management Systems (DBMS) is comprised of a set of programs that manipulate and maintain the data in a data base. They were developed to manage the sharing of data in an orderly manner and to ensure that the integrity of data the data base is maintained (Elmasri and Navathe, 1989). A DBMS 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).

(a) Hierarchical model



(b) Network model



(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.

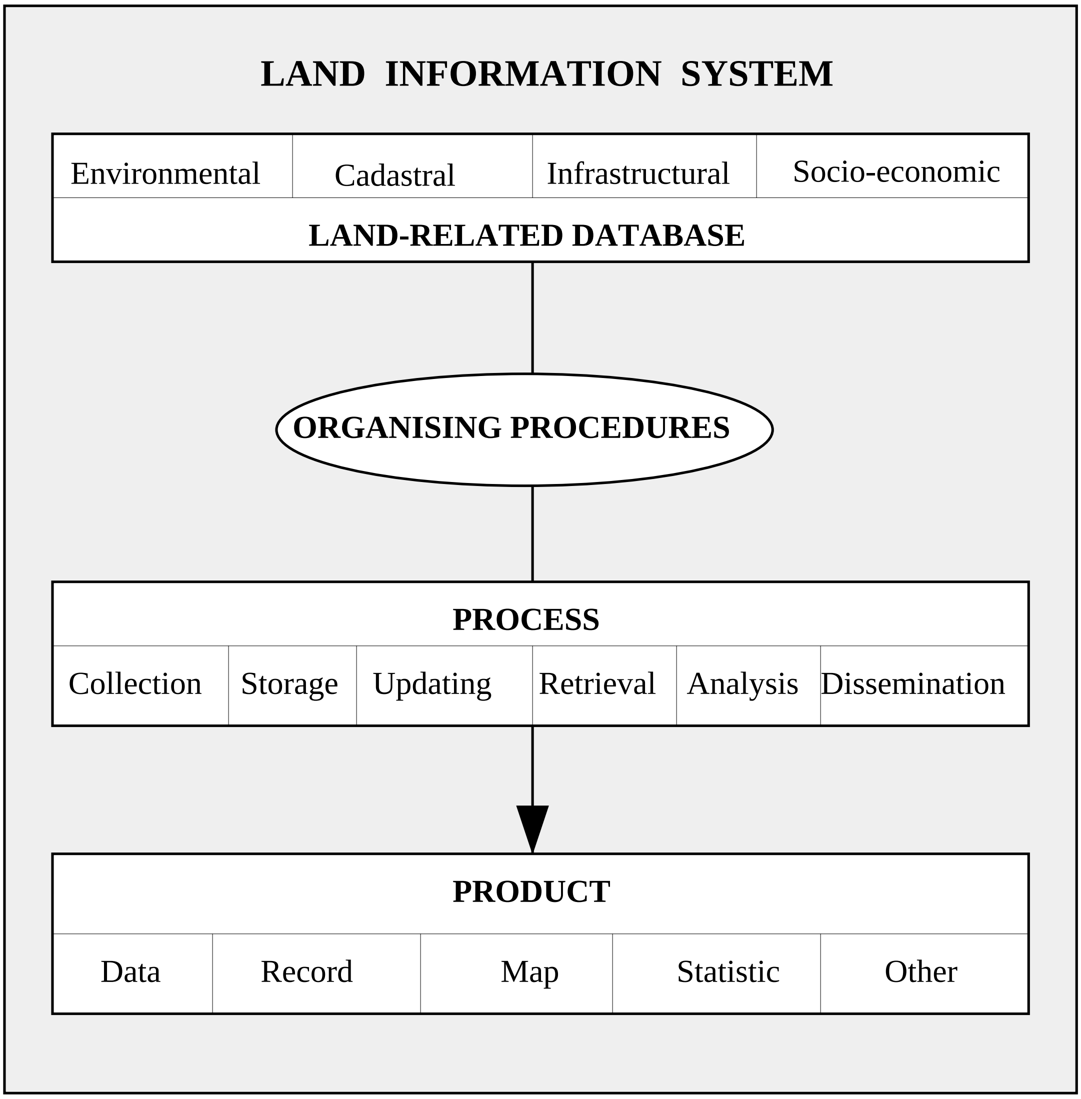


Figure 4.8 A simplified land information system (based on Larsson, 1991)

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).

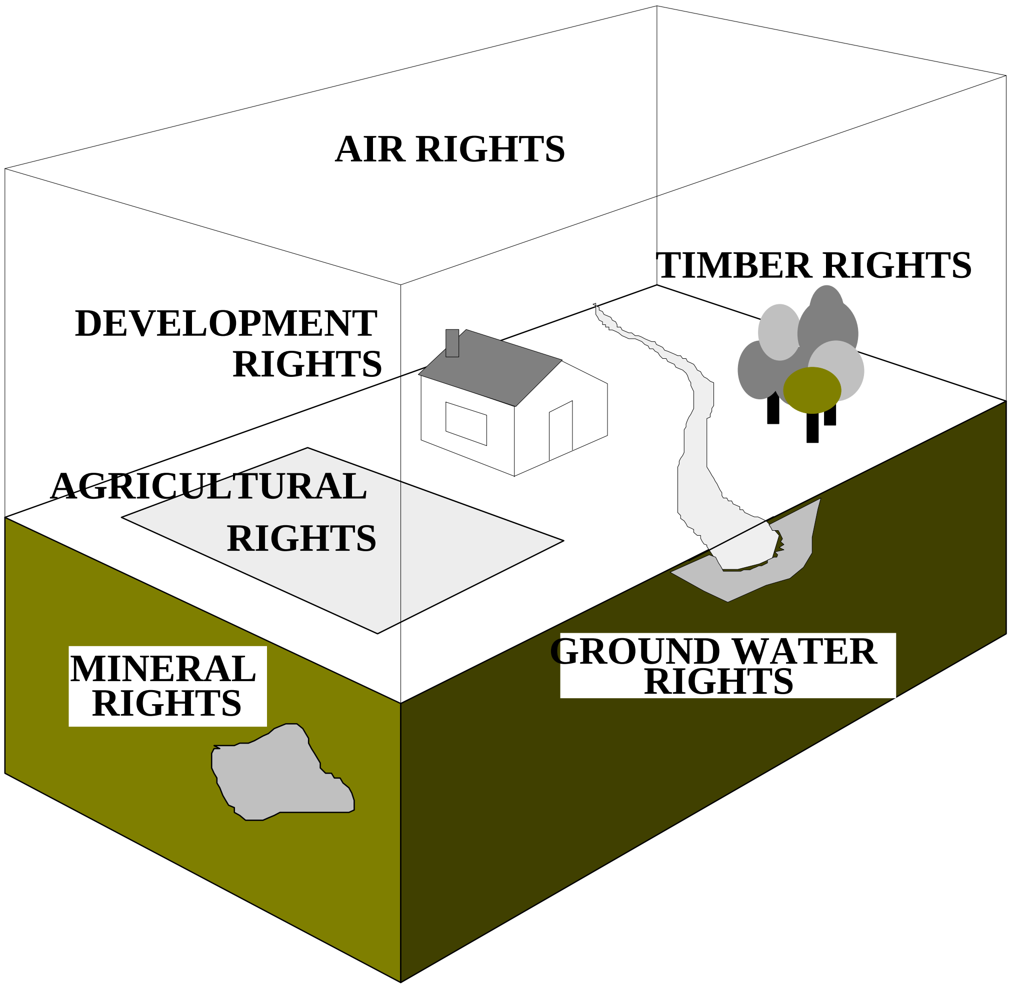


Figure 4.9 The land Parcel (after Dale and McLaughlin, 1988)

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.

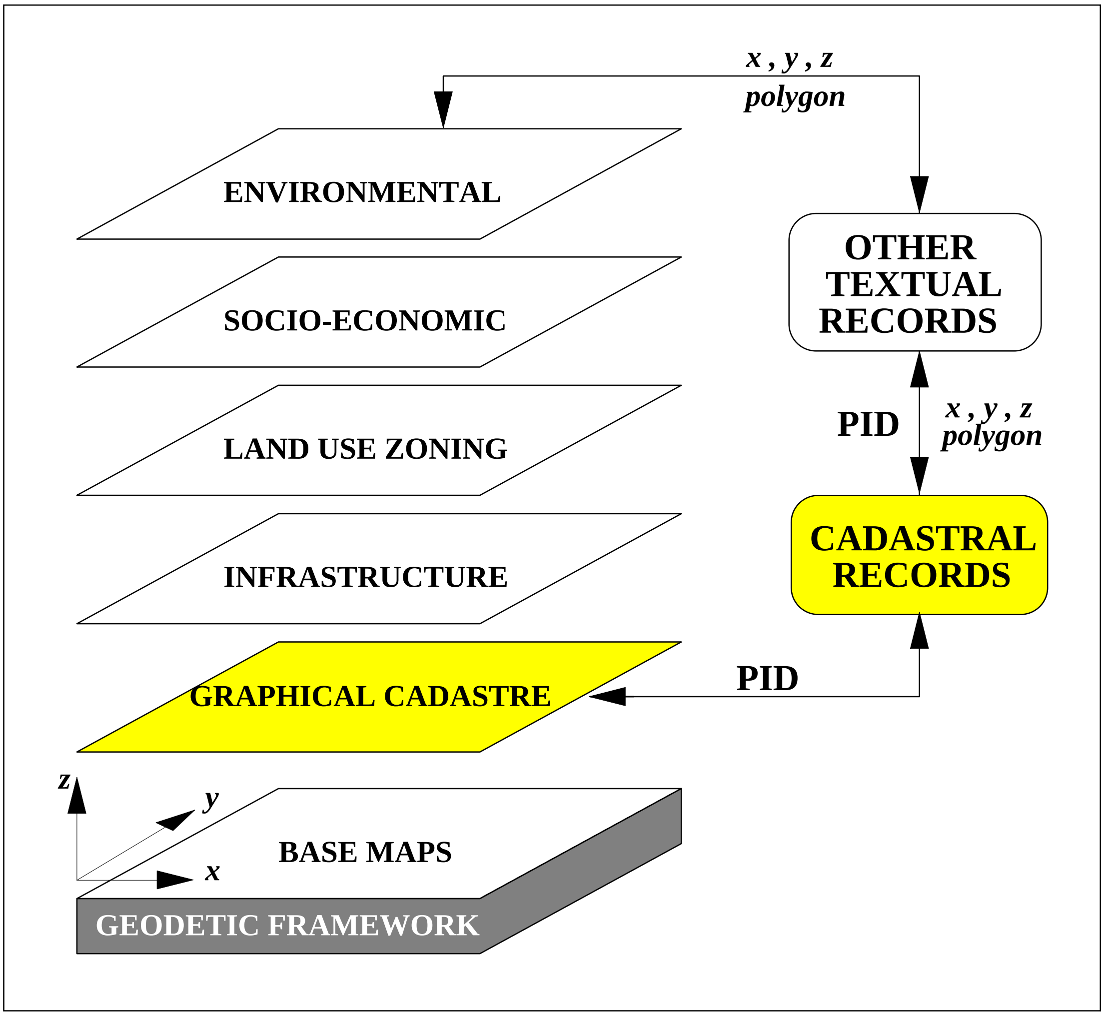


Figure 4.10 Primary components of a cadastre and examples of potential linkages to other land-related information (taken from McLaughlin and Nichols, 1987)

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.

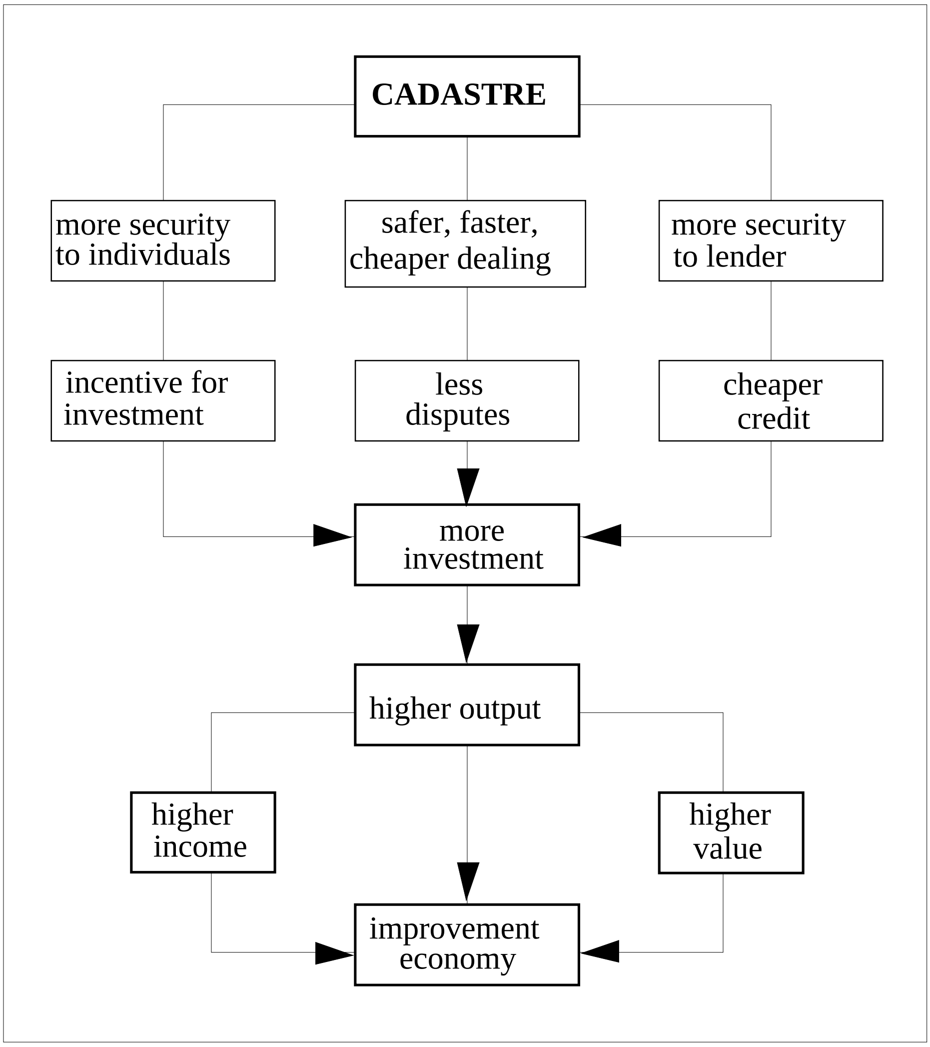


Figure 4.11 Positive effects for individuals (after Henssen, 1990)

(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.