Parcel-based Geo-Information System: Concepts and Guidelines

Arbind Man Tuladhar

Parcel-based Geo-Information System: Concepts and Guidelines

Proefschrift

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Preface

Topics on building and operating geo-information systems in an organisation environment have attracted me since the beginning of the 1970s. Late 1970 in the Republic of Yemen, I felt that there were real difficulties and challenges in organising and carrying out surveying and mapping tasks during my work in the Survey Department, especially with regard to land acquisition and registration. Yemeni society and the people stimulated me to manage the surveying tasks in line with their system thinking, enabling the jobs to be performed satisfactorily. At that time, I also thought that the jobs could be done effectively with the help of the computer. In 1991, when I was appointed assistant professor of multipurpose cadastre GIS at ITC, I met several people in the Netherlands, including the experts of Dutch Kadaster, who were really dedicated to the concepts of system thinking. Working closely with them stimulated me to choose my path towards system building for cadastral applications, using GIS techniques and software tools. In those days, Prof.mr.ir. J. L.G. Henssen used to discuss the registration of deeds and titles, as well as cadastral maps, with me, laying emphasis on automation and databases for cadastral information.

Later on, I began to supervise the MSc research projects of ITC students (from many developing countries) relating to geo-information systems for cadastral applications. During consulting activities in Asia, Africa and Latin America, I also experienced many difficulties and challenges related to the institutional, legal, financial and technical aspects of setting up cadastral information systems. These problems and our students' research outputs motivated me to go further in researching the development of parcel-based geo-information systems. The issues related to land tenure security and economic development are complex and are deeply rooted in society. The use of modern Geo-ICT tools in the developing countries further complicates the operations of cadastral information systems, because of the lack of infrastructure and resources. Prof.ir. R. Groot supported me in starting this research, and later on Prof.ir. P. van der Molen encouraged me to complete this piece of research work.

Completing the study took longer than intended. But my regular duties as director of studies, and such tasks as teaching, supervising students, consulting activities, writing papers and giving presentations at various conferences, contributed towards the success of this research. I hope the outcome will be useful to the land administration communities around the developing world, as well as to Nepal and Bhutan.

Arbind Man Tuladhar

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It is my great pleasure to express my sincere gratitude to my first supervisor, Prof.dr.ir. M. J. M. Bogaerts, who guided me in my research work by providing intellectual advice. His valuable comments have been most helpful in improving this thesis. I would also like to thank Prof.dr.ir. P. van Oosterom and Mr.dr.ir. J. A. Zevenbergen for providing their advice for the completion of this work.

I would like to express my sincere appreciation to Prof.ir. P. van der Molen, my second supervisor, for his intellectual and professional comments on my research work. His ocean of knowledge in this complex discipline, and close cooperation, allowed me to reach the ultimate goal of my research. Thanks also go to Prof.mr.ir. J. L. G. Henssen for his untiring inspiration, continuous encouragement, and sound advice during my research period.

My special thanks go to Dr. M. Radwan, who has provided me with continuous support and motivation, as well as the benefit of his intellectual knowledge. I would also like to thank C. Paresi, J. de Meijere, W. de Vries, B. Raid and C. Lemmen, who always helped me a lot during difficult periods, making time available from other duties. I would not like to forget Prof.ir. R. Groot, who actually provided the opportunity to get this research started during the time of the former Geoinformatics Management and Infrastructure (GMI) division. He personally helped me on many occasions, including the visits to the Department of Geodesy and Geomatics Engineering, University of New Brunswick, and the Geographic Information Corporation, New Brunswick, in Canada. I would like to acknowledge my deep appreciation to Prof.dr. J. McLaughlin for spending his valuable time discussing this research with me.

Thanks also go to all my colleagues at ITC and in the Department of Urban and Regional Planning and Geo-Information Management (PGM) for their kind support, and I want to express my sincere thanks to Prof.dr. W. van der Toorn and Prof. dr. D. Webster for their kind supports.

I would also like to extend my deepest appreciation to my colleagues in various departments of the Ministry of Land Reform and Management (MLRM) in Nepal, and the Survey of Bhutan in Thimphu. During my field studies, they warmly welcomed me and provided easy access to many documents and data within their departments; they also arranged meetings with many of the staff. With regard to Nepal, I would like to express my sincere gratitude to Mr. Y. Shah (former Secretary of MLRM), Mr. A. R.Pandey (Secretary of MLRM), Mr. B. R. Acharya (Director General of the Survey Department), Mr. B. N. Shrestha (former Director General of the Survey Department), Mr. P. P. Oli (former Director General of the Survey Department), Mr. T. B. Pradhananga (Head of the Topographical Branch), Mr. R. K. Sharma (Head of the Planning Division and Chief Surveyor), Mr. N. Ghimire (Director General, DoLIA), Mr. R. K. Shrestha (Director General of the Department of Land Reform and Management), Mr. N. R. Budhathoki (GIS specialist, DoLIA), and Mr. T. Pradhan (GIS Manager, Kathmandu Metropolitan City). With regard to Bhutan, I would also like to express my sincere gratitude to Mr. U. Tenzing (Deputy Surveyor General), Mr. D. Tshering (Head LIS), Mr. M. Sepi (GIS specialist) and Mr. T. Gyeltshen (GIS specialist) for their valuable support, and for material and data for the completion of this research.

Lastly, I cannot wait to express my sincerity and thanks to my loving wife, Selina, for her patience and total support in dedicating all her time to our family and home, while providing full encouragement and care and waiting for me to complete this research work. Finally, I want to give my love to my two sons, Anil and Ajin, for providing me with great inspiration.

Dedications

To my late mother and father
&
To my wife and sons

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Chapter 1

Research Background and Objectives

1.0 General Introduction

The development or improvement of land registration and cadastre systems requires a broad view of system concepts if it is to ensure that these systems operate efficiently for many purposes besides the basic tasks of providing legal security by titles or deeds and data for property taxation. The broad view of such system concepts concerns the integrated management perspective of tenure security, economic development and environmental control (Dale and McLaughlin, 1999). This requires understanding the behaviours of basic system objects in the given local situation and environment, and modelling their static and dynamic components, including their relationships. In this study, a static component usually refers to model structures of cadastral data; a dynamic component provides the flow of events that effect or change data in the system by interacting with users. This research deals with an approach that uses object technology for modelling cadastral systems, underlining their dynamic nature, considering their changing nature from the viewpoint of land tenure, and offering static descriptions. Within the scope of this research, the cases in Nepal and Bhutan were chosen in order to investigate their static and dynamic natures. At the end, this research provides guidelines on system reengineering, supporting the incremental approach to developing or improving a parcel-based geo-information system (PBGIS).

1.1 Background

A principal concern of any country in the world today is to define and better understand the interrelationships between population, environment, natural resources and economic development for the purpose of realising what is collectively known as “sustainable development” (WCED, 1987). Owing to excessive population growth in many countries, there has been increasing pressure on land and its resources for purposes of shelter, food, better living conditions and an improved market economy (Platteau, 1996). This pressure – which includes increasing informal occupation of land (particularly in developing countries) – has led not only to uncertainty as regards ownership or stewardship and the spatial boundaries of land parcels, but also to the excessive fragmentation of land. This in turn leads to diminishing land productivity, uncontrollable development and environmental degradation.

The concepts of sustainable development, which arise from the fears of overpopulation, pollution and the overexploitation of resources, reflect the view that land is a resource that must be preserved for future generations (Henssen and Williamson, 1990; Henssen, 1991). Land, being in one way or another the basic source of most material wealth and a commodity that is always affected by the forces of demand and supply, is of crucial importance and requires effective management. Land cannot be treated like other commodities because not only does it have economic value, it also has social, cultural and religious implications. Therefore, it is of the utmost importance that an adequate supply of land is available for all purposes at an affordable cost. For this reason, an integrated land management view has been seen as the means and tools for ensuring a balance between exploitation, utilisation and conservation, and thus achieving the sustainability of land. In the context of land management, the important tools (Henssen, 1996b) are physical or land use planning, land tenure, cadastre/land registration systems, land acquisition and delivery, valuation and taxation, information technology such as GIS/LIS or more specifically PBGIS, and finally institutional supports.

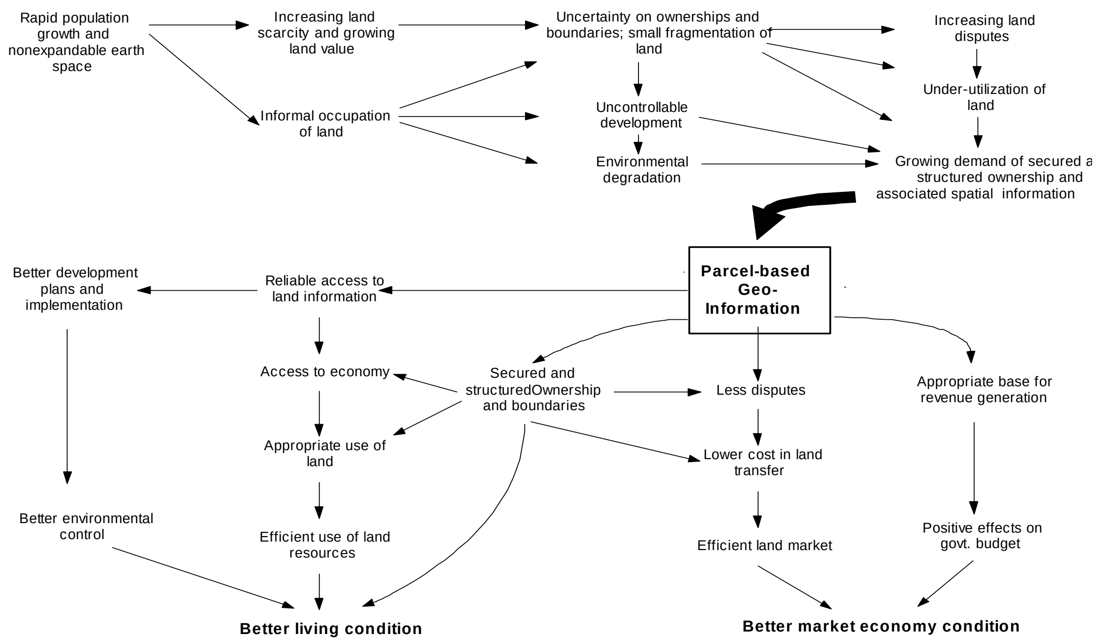

Figure 1.1: Need for parcel-based geo-information

Figure 1.1 shows the evolutionary need for parcel-based geo-information, with its environment. In the first instance, it indicates the growing need for secured land ownership, with its associated spatial information, and then the need for a system to support land administration and management from the environmental and economic perspectives. One such system is the parcel-based geo-information system (PBGIS), which maximises security of tenure, reduces investment risks, and facilitates, and lowers the cost of, land transactions. It is a basic requirement and infrastructure for modern economic development, just like water, road or utility infrastructures (CityNet, 1995). At the same time, it is essential to know how parcel information can contribute towards environmentally sustainable development. It is also recognised that developing, improving and managing a PBGIS offers an effective means of linking up with other land-related applications, and this would facilitate the improvement of shelter and land markets. It relates to such issues as property conveyancing (including decisions on mortgages and investment); property assessment and valuation; the development and management of utilities and services; the management of land resources such as forestry, soils and agriculture; the formation and implementation of land use policies; environmental impact assessments; and finally the monitoring of all land-based activities in as far as they affect the best use of land (see figure 1.2).


(a)


(b)

Figure 1.2: (a) Nepalese women harvesting on the fertile land, (b) urban suburb in the city of Thimphu

Land planning, management and control require comprehensive land-related information to ensure fair, orderly and intelligent decision making, and in this respect there is a growing demand for information concerning secured and structured ownership or stewardship, associated spatial descriptions, fair and reliable land values, and land use and resources. In this modern world, information technology has provided a dramatic new way of managing a geo-information system that delivers high-quality, efficient, customised and affordable products. For various cadastral information products (e.g. titles, deeds, parcel maps) and services (e.g. land registration and conveyancing, cadastral surveying, land or property valuation, land allocation), the reliable modular approach of a system such as a PBGIS would be desirable, and would eventually provide an appropriate contribution to environmentally sustainable living conditions and the creation of a healthier economy – provided such systems are designed and operated to satisfy the customers' needs. In a PBGIS, the data are organised around the cadastral parcel (Dale and McLaughlin, 1988). The cadastral parcel is a well-defined land unit based on a homogeneous interest with a unique identifier. All information is collected, stored, referenced and retrieved at the land parcel level. The basic component of a PBGIS is the cadastral/land registration system, which consists of descriptions of spatial and legal rights. It is also linked to land use, land allocation, valuation and taxation systems. It is therefore essential to place the PBGIS in the broad perspective for the efficient use of cadastral information. This broad view requires an understanding of the static and dynamic components of cadastral objects (e.g. land parcels, titles, deeds, public restrictions, persons, etc.), and their relationships and behaviour in a given environment. In this respect, the understanding and structuring of ownership or stewardship, supporting management activities, and institutional and legal frameworks (including land policies) are the basic, and initial, issues considered in this research, which aims to develop a reliable PBGIS under political, social, religious, cultural and economic circumstances (Bogaerts, 1995; de Soto, 1990).

1.2 Prior Works

This section is divided into two parts. The first part briefly addresses the current situation concerning cadastre and land registration so far, and what has been done within the research communities. The second part reviews some recent information technology, in terms of spatial modelling, database design and development, that could prove beneficial in accelerating the implementation of cadastral and land registration programmes in the developing countries.

(a) *Current Situation*

A lot of articles have been written by many researchers (see reference list and bibliography) about land information, cadastre/land registration, and related subjects such as land valuation, land allocation, land consolidation and taxation. Papers are presented at many congresses and seminars, for example, the Joint European Conference and Exhibition on Geographical Information (JEC) and those organised by the International Society for Photogrammetry and Remote Sensing (ISPRS), the International Federation of Surveyors (FIG), and the Urban and Regional Information Association (URISA). Much of this literature addresses aspects of implementation within organisations concerned with land tenure, the technical aspects of cadastre/land registration, and institutional, political, legal, economic and social issues. However, not enough attention has been paid to the adoption of new computer information technology for increasing the efficiency and effectiveness of the system in the broader context. Nowadays, information technology has changed the way the organisation and its users function; furthermore, it has changed the environment, owing to market demand for various kinds of digital and analogue products and services.

Some important works over the last two decades in the field of cadastral information are highlighted here. Henssen (1972, 1990, 1991, 1995 and 1996b) argued the need for land management for sustainable development, and in much of his literature he provided tools such as spatial planning, land tenure, land registration, land acquisition and delivery, land valuation and taxation, and dealt with the need for GIS/LIS and certain institutional aspects. He emphasised the need for modern information technology, such as using computers for the speedy delivery of reliable information at low cost. He discussed many legal, land use and institutional issues, including data security and protection, relating to the proper functioning of cadastral systems. Implementing improvements of existing cadastral systems should always be done on an incremental basis at low cost, with respect to the pace of development in the countries concerned.

Larsson (1971) extensively reviewed the cadastral and land registration systems in the developing countries, focusing especially on the situation in Asian and East African countries. These reviews described how the systems were running and the difficulties faced within organisations. Many systems were manual, and information was unreliable owing to the lack of legal and institutional support. Moreover, maintenance programmes were lacking in many cases. Many of them also lacked the strategic vision to support the efficient supply of information required by different levels of government, non-government agencies, and private individuals.

In his dissertation, McLaughlin (1975) closely examined an approach to modernising existing cadastral arrangements by developing and implementing multipurpose cadastre, with the focus on its nature and function. His intensive research was based on a holistic model, leading to the design criteria for system construction and implementation. His research was holistically based on the issues of cadastral and land registration problems in many developed and developing countries, and many researches since have focused on the basic ingredients of his work to support running a cadastral information system.

McLaughlin and Palmer (1996) argued that the formalisation of property is viewed as a fundamental requirement for economic development, and an example is presented of a successful formalisation approach in Peru. They also presented a reengineering of the registration functions in four sets of reforms, namely legal reforms, judicial reforms, administrative reforms and technical reforms. In addition, they highlighted the requirement for business models and presented three cases in the Canadian environment.

Platteau (1996) carried out an extensive and critical assessment of land rights and their consequences, as applied to sub-Saharan Africa. There are many other research reports and a body of literature has been produced by various concerned agencies such as the NRC (1980, 1983), UNCED (1992) and UNCHS Habitat (1990). They have set out the requirements and design criteria for improving land registration and land information in developing countries.

Some interesting work from recent PhD studies related to land administration can be cited: (a) Zevenbergen’s (2002) interesting study paid particular attention to the efficient functioning of land registration systems, focusing on the interrelationships between technical, legal and organisational aspects; (b) Mulolwa (2002), in his dissertation, studied integrated land delivery towards improving land administration and unifying customary and formal land rights, and discussed organisational consequences in Zambia; and (c) van Dijk (2003) dealt with Central European land fragmentation.

Some significant contributions can also be seen among published books: (a) *Land Information Management: An Introduction with Special Reference to Cadastral Problems in the Third World Countries* by Dale and McLaughlin (1988); (b) *Land Registration and Cadastral Systems: Tools for Land Information and Management* by Larsson (1991); (c) *Land Law and Registration* by Simpson (1976); and (d) *Land Administration* by Dale and McLaughlin (1999), which describes recent interesting advances in building formal property systems throughout the world, and examines the land administration infrastructure required to support such systems, with an extended discussion on the associated information management challenges.

The Global Strategy for Shelter for the Year 2000 emphasised the need to improve land management by creating an affordable land registration system, with a view to stimulating a supply of sufficient land to meet shelter and other development needs (UNCHS, 1990, 1991). More recently, the agenda of the Global Campaign for Secure Tenure of the Habitat identified the provision of secure tenure as essential to a sustainable shelter strategy, and as a vital element in promoting housing rights. It promotes the rights and interests of the poor, and recognises the role of women as being essential to a successful shelter policy (UNCHS, 2004).

(b) *Recent Information Technology*

The technological advances in computers, communication and GIS/LIS have changed the way in which information is structured, stored, managed, delivered and used. Consequently, there is a large amount of literature relating to the fields of GIS, metadata, databases (central, distributed and federated databases), spatial data standards, spatial data models and structures. Some important literature is mentioned in the reference section of this dissertation. Groot (1993) highlighted the problems when introducing environmental information system technology in developing countries and emphasised the need to create infrastructures that facilitate access to, and use of, geo-information, and which promote a culture of responsible information use. Spatial models and structures are an important technical aspect of GIS. Molenaar (1991, 1998) and other GIS experts have made a number of contributions to spatial modelling techniques in geo-information theory.

In the context of project implementation concerning cadastre/land registration systems, Angus-Leppan (1989) initiated a major project in Thailand, financed by the World Bank and the Australian Development Assistance Bureau, which aimed at upgrading cadastre and land titling procedures by adapting existing methods. In the Netherlands, the Dutch Cadastre has developed a nationwide operational, automated land information system. The Swedish land information system can be cited as a similar example.

The UN-FIG Bogor Declaration (FIG, 1996) indicated a number of issues related to PBGIS, concerning vision, needs, cadastral issues, the need for reengineering systems, administrative and technical options, and finally the role of the private sector and NGOs. In addition, the Bathurst Declaration in support of sustainable development encourages nations to tackle many issues. Most relevant are to recognise the interdependence of different aspects of land and property, and to improve access to data, as well as its collection, custody and updating, with an overall land information infrastructure as a national uniform service to promote sharing. It asks for security of tenure, access to land, and land administration systems to be improved through policy, institutional reforms and appropriate tools, with special attention being paid to gender, indigenous populations, the poor, and other disadvantaged groups. Good land administration can be achieved incrementally, using relatively simple, inexpensive, user-driven systems that deliver what is most needed for sustainable development. Whenever conflict arises, there must be inexpensive land dispute resolution mechanisms in place, which are readily accessible to all parties concerned. It also urges that the existing systems be reengineered to cope with the new requirements imposed by policy makers, new users and the market – including the changing Geo-ICT market.

1.3 Research Problems

Much literature of other disciplines, such as social studies, often states that land registration in many developing countries can create less, not more, security of tenure, and more, not less, conflict over the land rights (GTZ, 1998). This can be seen from the following points. First, the registration process starts with the adjudication phase, which recognises and records existing land rights according to the land law. For some categories of people, this reduces risks and transaction costs, but it has created additional uncertainty for others who depend on customary practices and rules to protect their land security. Such a situation is evident in Asia, Africa, Latin America, and many developing countries. Nepal and Bhutan are no exception. Because of these different practices, there are many lands that are not yet registered or are subject to dispute. Secondly, in many situations, existing data gathering, processing and storing methods are incomplete and inadequate, and do not comply with user requirements. Furthermore, an intelligent approach to data maintenance (changes in ownership and boundaries) is lacking. Consequently, the number of land disputes has not decreased and the quality of cadastral information is questionable as far as many groups of users are concerned.

The data gathering phase for cadastral information normally starts with (a) the registration of ownership and other rights (via the adjudication process in the first registration, or agreement in the case of conveyancing), which are commonly referred to as administrative data; and (b) the survey of cadastral parcel boundaries. For the first data category, an appropriate approach needs to be developed for gathering data of adequate quality. This is the most critical phase of the whole process for establishing and operationalising a reliable system, and could be the starting point for problems concerning disputes and misunderstandings regarding ownership, stewardship, laws, rules and regulations, especially in areas where customary or informal laws prevail. This also requires a comprehensive analysis of deed or title registration systems that are being, or are about to be, adopted. In the second data category, although it is a purely technological process, the concepts of general and fixed boundaries should be clearly understood, defined and adopted in light of legal requirements, land scarcity, rising land prices and the pace of development (Henssen, 1995).

Title deeds with secured ownership and boundaries can be used as collateral at financing agencies and give the landholders the incentive to invest in order to utilise land better. They also ensure a smooth land transaction process, with lower costs. Thus they contribute towards improving the market economy and support the speedy issuance of location and building permits by municipalities. These activities require institutionalisation with appropriate legal supports. Often there are no clear mandates for organisations (national or local government organisations) or departments within organisations. In addition, the appropriate exchange mechanism for information flows between national, provincial and municipal cadastres has yet to be devised in many countries.

Maintenance of land information is a complex issue, especially when well-designed approaches or processes do not exist within the responsible organisations. Therefore, it is often the case that initial land records soon become outdated – only a few years after the first registration.

Parcel-based geo-information is extensively used for property valuation and taxation purposes. The current approach for land and building valuation is rather subjective. Computer-assisted valuation technology allows the efficient storage of vast quantities of data and the sharing of such data by a multitude of users, as well as rapid retrieval and analysis, the efficient collection of particular spatial data, and the automation of complex analytical procedures. When used in property valuation, these characteristics allow the use of more complex models, bringing the advantages of objectivity, accuracy, efficiency, lower long-term costs, and utilisation by less-skilled personnel. Several researches have highlighted the fact that development of computer valuation models has several important controlling factors: the availability of sufficient relevant data of appropriate quality, the reliability and accuracy of the estimated values, and the social acceptance and feasibility of implementation.

New geo-information technology has greatly increased the potential of many users of land information to acquire the fast delivery of reliable products at lower cost. Land information systems, and specifically PBGIS, are an example that can be implemented and maintained effectively and efficiently. In this connection, FIG provides a formal definition of a land information system (LIS):

> *"It is a tool for legal, administrative and economic decision-making and aid for planning and development which consists on the one hand of a database 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 a LIS is a*

uniform spatial referencing system for the data in the system, which facilitates the linking of data within the system with other land-related data."

Of prime importance in building such effective, efficient and compatible systems are the availability of the common reference system, strategy in coordinating land-related functions, and standardisation of data and procedures. Traditional strategies have favoured the establishment of independent local, regional and national authorities to administrate data development, acquisition and storage programmes. The results have been programmes and activities that are redundant, inflexible, and ineffective with regard to cost recovery (Dale and McLaughlin, 1988).

The greatest problems in the existing rudimentary cadastre and land registration in developing countries (especially in Nepal and Bhutan) are inadequate techniques and methods in data acquisition, data storage, data maintenance, data access and finally data dissemination to users. Although technological impacts on these processes give us the opportunity to provide high-quality services at a reasonably affordable cost, Nepal and Bhutan now face a great challenge: How can this information be stored, managed, maintained and accessed so that all levels of user (government, local government, NGOs and private citizens) can use this information in a simple, secure, consistent and cost-effective way?

For the purpose of this research the following problems are considered:

(a) An initial problem in this research is to provide conceptual framework underlining the requirements for PBGIS, given the concepts and forms of land tenures and the role of PBGIS in supporting the needs of the users' environment.

(b) Understanding land tenure systems, land laws and rules in Nepalese and Bhutanese contexts are pertinent issues for clearly defining data and functional requirements, and there are always semantic gaps between the real-world users' environment and the database environment, which the system developer would have to take into account. In this problem we can identify two areas of study. First, there are problems with respect to fully understanding the laws and regulations, given the situation where there are different types of land tenure in the countries concerned. Secondly, the requirements have to be translated in order to model the environment.

(c) An automated system needs adequate business processes that operate within the system environment as well as the users' environment. Therefore, it is essential to define what the system model should contain, and what, how and when certain business processes should be carried out. These processes must obey land tenure systems, land laws, and land registration rules and regulations.

(d) A PBGIS requires appropriate cadastral information related to ownership/stewardship, the spatial structure of land parcel boundaries, land use, information concerning persons and relationship structure – and for some cadastres it may also include land value. Figure 1.3 shows the basic information structures and interrelationships of the cadastral system. Data about buildings or houses are also added to the above basic information if the PBGIS is connected to another system that serves the issuance of location and building permits or property valuation and taxation.

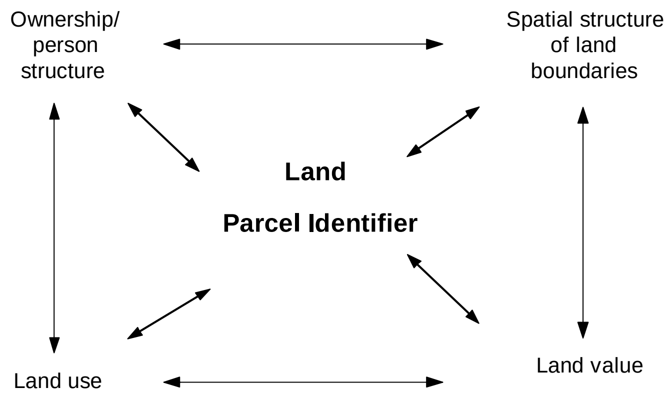

Figure 1.3: Interrelationships of cadastral information

Problems arise as to how these data should be modelled and structured in the computer environment so that data can be efficiently inserted, retrieved, updated, processed, analysed and accessed.

(e) The next problem is to define an information system environment (subsystems, system models, communication between subsystems and users) such that appropriate databases can be established, maintained and efficiently used in the organisational environment, given the situation that manual systems are to be replaced in a stepwise technique using modern GIS technologies. This requires methodology, finance and institutional supports.

(f) Then this research also provides organisational prototyping and quality parameters pertaining to system models and data, which affords the organisations in developing countries efficient use and a low-cost approach to modernising the cadastral systems in the given environment. Finally, this research discusses guidelines for improving land registration and cadastral systems by introducing PBGIS with critical success factors.

1.4 Research Objectives

The main objectives of this research are to carry out the comprehensive analysis and modelling of the dynamics of cadastral information, with an emphasis on Nepal and Bhutan, and to develop system models and guidelines for developing and implementing a reliable, effective and efficient PBGIS. With this in mind, the following specific objectives of the research work can be identified.

(a) To identify the components of a conceptual framework for developing and implementing PBGIS.

(b) To analyse land tenure and ownership structures as regards land and buildings, existing cadastre/land registration systems, and rules and regulations in Nepal and Bhutan in relation to land management and users' needs.

(c) To develop system models for PBGIS in terms of subsystems, objects, business and dynamic models (including products and services), in response to the real world in the spatial context and the users' environment in land administration and management.

(d) To evaluate system models (specific to cadastral services) in an organisational prototyping environment, and to develop quality parameters for system models and a concept of quality reviewing, including the testing of cadastral data.

(e) To define critical success factors and provide guidelines for developing and implementing PBGIS, with reference to Nepal and Bhutan.

1.5 Research Approach

To fulfil the above-mentioned objectives the following steps are proposed (figure 1.4).

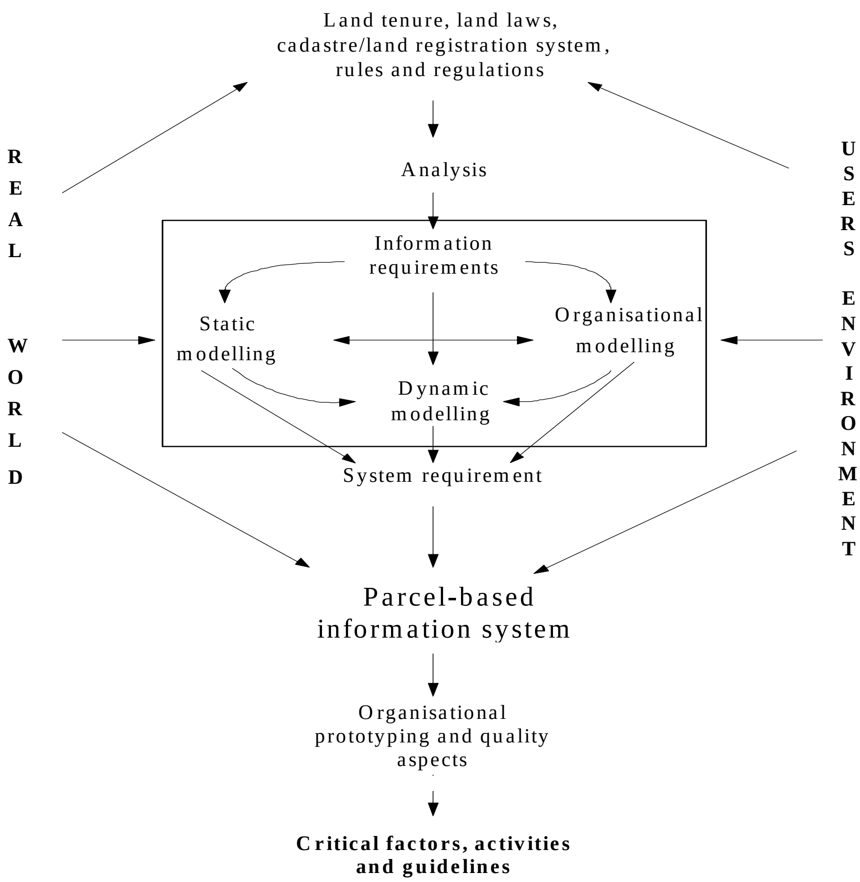

Figure 1.4: Research approach

(a) In order to follow the above research approach, a structured set of concepts as a conceptual framework is formulated using literature studies on land tenure, PBGIS concepts and the principle of reengineering.

(b) Studies on land policy, land tenure, land laws, cadastre/land registration systems, as far as theoretical knowledge is concerned, would be required to understand the ownership structures as regards land and buildings. The first phase would then be a formal understanding of land rights, ownership and stewardship, and their relationships with people (landholders). These issues will be studied in the context of political, social, cultural and religious settings. For this purpose, a number of publications concerning the land tenure systems and land registration systems of several developing countries have been collected.

(c) Then, detailed studies on the situation in Nepal and Bhutan are made through literature supported by field visits to these countries. The reasons for choosing these two countries are supported by the differences in society (cultural and religious, although within the same continent) and by the complicated landholding systems and difficult topography. Various workshops took place, as well as meetings and discussions with responsible officials of these countries.

In order to analyse the data and the functional aspects of the existing systems, the reverse engineering technique is applied as part of the system analysis. Reverse engineering consists of developing an abstract model of an existing business and its processes. This step also consists of gaining understanding of the objectives. Object orientation is an excellent way of clarifying the inner workings of organisations – its processes, products and services, resources – and how these depend on one another. Various conflicting problems with regard to institutional issues, land acts and other related acts (e.g. spatial planning, environmental, agricultural, forestry and municipality acts), and cooperation and coordination are also discussed. Some relevant acts and policies from the above two countries are researched and studied to identify these conflicting problems.

(d) The above analysis serves as a guide for modelling information requirements concerning the data and processes. For this purpose, organisational, static and dynamic models of cadastral information are identified using object-oriented techniques. Extensive literature on these models is also reviewed, as well as on spatial interests in land management activities such as land allocation, land consolidation, land control and land valuation. Object technology is most promising and is enjoying wide popularity in the domain of information system development (Taylor, 1992). Detailed data and functionality are identified and analysed using the unified modelling language (UML). An organisational model for data and process is developed using subsystems and the UML package. A static model (class diagram) is suitable for modelling data. The use-case-driven approach is suitable for the dynamic component, i.e. process design (Penker and Ericsson, 2000). A use case is nothing but a sequence of transactions in a system, whose task is to yield a result of measurable value to an individual actor of the system. Cadastral objects related to cadastral applications will be identified and organised in class hierarchies, showing properties, behaviours and constraints. Relationships will also be identified to describe the semantics of cadastral and land registration, forming adequate data models at the different levels of management and operational activity. These models are analysed against existing core models and are required to be compatible with land tenure, land registration and cadastral systems in the broader context of a PBGIS. This provides us with the system requirements for developing a PBGIS.

Detailed development of a PBGIS is then carried out using UML in the available software MS Visio. The subsystems are then discussed within the land administration environment. Cadastral data integrity, security and quality are studied within these proposed concepts.

(e) Organisational prototyping concepts are developed by reviewing literature and are tested for the efficiency and effectiveness of the cadastral business processes in the computer integrated network environment, using Oracle Designer. Experimental tests on cadastral map data are also conducted, using field measurement data, aerial photographs and IKONOS images.

(f) Finally, based on the above studies and experiments, critical success factors and guidelines are provided for developing and implementing a PBGIS.

1.6 Significance of Research Work

There is increasing recognition, especially in such organisations as the World Bank, that cadastral information has a very important role to play in the effective and efficient management of land. A cadastral system is not just a system that underpins security of rights or property taxation to raise land revenue, it has become the basis of much broader GIS/LIS in many developed and developing countries, in order to increase effectiveness in multipurpose applications. Thus, it is essential to view a cadastral system in the broad perspective during the development or improvement phases in order to use cadastral information effectively. In this context, investigations are necessary to identify what spatial information should be included and how it should be modelled in an information system in order to respond to changing interests in land measures. For this purpose, studies on spatial behaviour and relationships from the viewpoint of land tenure are required. Land tenure can be defined as the right or manner of holding a landed property. A study on the land tenure system should enable us to say what information, including spatial behaviour (concepts and relationships), is to be incorporated in an information system. Because of its dynamic nature, a cadastral system needs to be compatible with the interest of the existing land tenure, and simple and flexible enough to accommodate the changing nature of tenure. In many developing countries, there has been tremendous pressure to put land on the market. This is because of the rapid development programme and the wish to implement land reform activities under this programme. To undertake such land reform activities, it is extremely important to understand the existing land tenure.

Several reports and instances in literature indicate a lack of both relevant information and models that should be incorporated into the cadastral system for the appropriate spatial reasoning. Because the land tenure system varies from country to country, and even from region to region within a country, studies on spatial behaviour would also be required in order to build a comprehensive information system.

There are two broad classes of land information in a cadastral system, namely the geometrical part concerning locations in space and sizes of parcel, and the administrative part concerning rights, class and economic value of land, name of owner(s), address, etc. To model them properly requires an understanding of their behaviour in space with respect to socio-economic and cultural environments. There are several ways of modelling, such as entity relationship and object-oriented modelling. Here the question is: How can spatial objects and behaviours be modelled to respond to the changing interests of land measures? This requires an investigation into models that test them in an application environment.

It is the intention of this research to demonstrate system models in a PBGIS by studying the cadastral spatial data and other land-related data in Nepal and Bhutan, and to provide organisational prototype concepts and guidelines for implementing a PBGIS.

1.7 Structure of Thesis

This thesis is organised into seven chapters, and a description of each chapter is provided below.

Chapter 1 – Research Background and Objectives: This chapter first provides background information about land issue problems, prior work concerning the current situation and recent information technology. It then gives descriptions of the research problems, research objectives and research approach, and highlights the significance of this research work. Lastly, it outlines the structure of the thesis.

Chapter 2 – Conceptual Framework: In line with the purpose of this research, this chapter identifies a set of structured concepts as a conceptual framework for developing and implementing a PBGIS. Land tenure systems, PBGIS, reengineering and domain models are fundamental core concepts in this context, and these are discussed and presented in this chapter. At the end of the chapter, a brief summary and concluding remarks about the outcomes are presented.

Chapter 3 – Systems of Cadastre and Land Registration in Nepal and Bhutan: Using the concepts developed in Chapter 2, this chapter attempts to stimulate common thinking as systems by describing the land tenure systems, the legislative framework, and the forms and procedures of land registration and cadastre in Nepal and Bhutan. The objective of this chapter is to identify emerging issues and challenges that these countries are facing in adopting Geo-ICT in their organisations for developing and implementing PBGIS. The chapter consists of three main sections. It first describes the situation regarding land tenure, cadastre and land registration in Nepal. Secondly it covers the situation in Bhutan. Thirdly it analyses and discusses emerging issues and challenges in both countries. The results of a SWOT (strengths, weaknesses, opportunities and threats) analysis are presented here. Finally, a summary and concluding remarks bring the chapter to a close.

Chapter 4 – System Modelling Using Object Technology: Based on the results obtained in Chapters 2 and 3, system models are developed and discussed in the light of the requirements that are necessary for a PBGIS. This chapter first discusses modelling concepts based on object technology. Then a number of organisational, static and dynamic models of cadastral data are developed using the unified modelling language (UML). The outcomes are discussed in detail. At the end of this chapter, a summary and concluding remarks are given on the outcomes of the system models.

Chapter 5 – Organisational Prototyping and Quality Aspects: System models developed in Chapter 4 are evaluated in this chapter by using organisational prototyping. For purposes of this research, organisational prototyping means prototyping business processes within an organisational structure. This chapter consists of three main sections. The first section is concerned with a framework and the prototypes of services as business processes that are part of system models. These prototypes are developed and the results are presented. Secondly quality factors for system models (specifically data models) are identified, and a quality review procedure is presented. The next section deals with experiments on the quality of cadastral data. Finally, a summary and concluding remarks are given.

Chapter 6 – Guidelines for Implementation of Parcel-based Geo-Information System: This chapter provides guidelines, based on the outcomes of Chapters 2, 3, 4 and 5, for implementing a PBGIS in the Nepalese situation. It first identifies the critical success factors and relates them to activities required to achieve the goal of the PBGIS. It then discusses each activity in order to derive guidelines as outcomes of this research. Each outcome is then discussed and presented in this chapter. A brief summary and concluding remarks are given on the outcomes.

Chapter 7 – Conclusions and Recommendations: In this chapter, there are two sections. The first section deals with the final conclusions regarding the achievements or outcomes of this research for developing a PBGIS, with special emphasis on the situation of the cadastral and land registration systems in Nepal, and with some reference to Bhutan. Finally, the second section is devoted to recommendations for further research required in the field of PBGIS.

Chapter 2

Conceptual Framework

2.0 Introduction

In this research, a structured set of concepts is needed for developing models and guidelines for a parcel-based geo-information system (PBGIS) to support land administration functions. Figure 2.1 shows the conceptual framework of this research, in which land tenure systems, parcel-based geo-information systems, the principle of reengineering and the cadastral domain, existing cadastre and registration systems, and object technology are the main basis for developing system models for PBGIS. The new requirements normally originate from the fact that the existing systems are unable to cope with the changing requirements demanded by various users or stakeholders. The purpose of this chapter is to discuss the evolving nature of land tenure and the concept of PBGIS, and identify the principle of reengineering and the cadastral domain as a fundamental concept for system modelling.

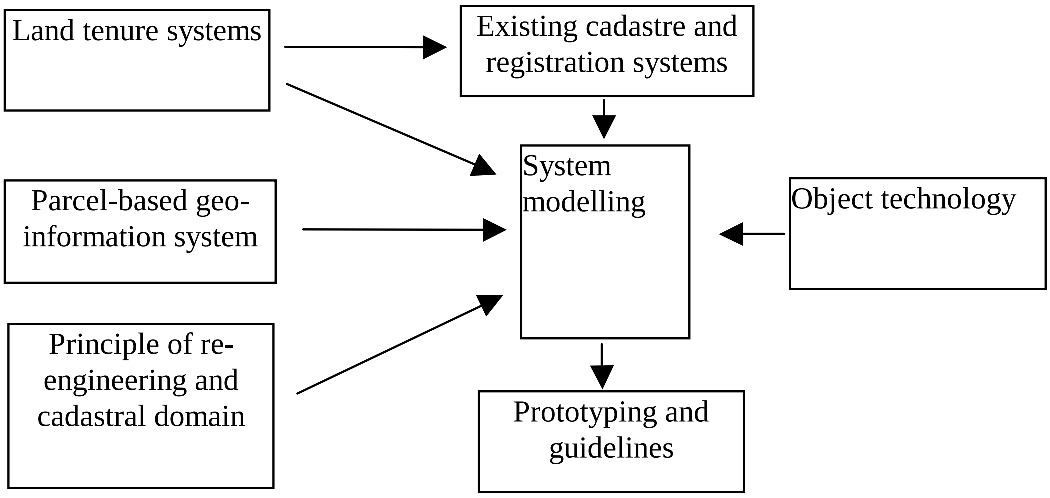

Figure 2.1: Conceptual framework

In this chapter, section 2.1 deals with a theoretical discussion on land tenure systems, with concepts and forms, and the changing characteristics in developing countries. Section 2.2 then describes the concept of PBGIS, with its components and the characteristics of the data contents. Section 2.3 describes the concepts behind the reengineering principle and the cadastral domain model. The other four elements are discussed in the subsequent chapters.

2.1 Land Tenure Systems

From the early days of history, man has always had a relationship with land in one form or another. For some, land was considered as wealth or as a source of Aborigines, “the land and the Aborigines were one and the same” (Hill, 1995). From a legal point of view, land may be considered as any portion of the earth’s surface over which land rights or stewardships could be exercised. These rights relate not only to the surface of the earth but also to every terrain object attached to it, above or below. Other issues relate, for example, to space, nature, the production factor, consumption good, situation, property capital, cultural heritage.

Different perceptions according to the various disciplines can have different land tenure arrangements through which man holds and uses land. Broadly speaking, we can see that these differences are due to three facts, which can be categorised as man-to-man relationships, man-to-land relationships, and land-to-land relationships (Barnes, 1993). History, political, cultural, religious and social systems, and economic situations have influenced these different arrangements (Agarwal, 1996). Thus, the situations of land tenure arrangements differ from one country to another, and even within a country it is possible that there are differences in land tenure arrangements. Basically, there are two categories of land tenure: those influenced by western law and those influenced by customary or traditional laws (Henssen, 1972, 1995, 1996a).

The term “tenure” implies that land can be held and used for economic and environmental benefits, and hence a relationship between an individual or a social group and a unit of land through a bundle of land rights is the most important part of land tenure and its administration. Land tenure can also be defined as the institutionalised relationship of people involved in the use of land and the distribution of its products (Luning, 1995).

Land tenure has several implications in our present-day society throughout the world. In all countries, the lack of well-organised tenure touches deep emotions and has been a main concern of every organised society, associating socio-economic with cultural structures (Henssen, 1996a, 1996b). Moreover, it can also be argued that insecure land tenure can prevent a large proportion of the population from realising the economic and non-economic benefits, such as greater investment incentive, transferability of land, improved credit market access, more sustainable management of the land resource, and independence of bureaucrats. Therefore, in a market-driven economy, when people own land they should have security of tenure. This means they can use ownership security as a form of collateral, and take out mortgages to raise loans for investment purposes, which can be economically stimulating.

2.1.1 Concepts and Forms of Land Tenure Systems

Figure 2.2 indicates two main categories of land tenure concepts, which owing to various economic and environmental pressure have led to the four basic property rights systems in this modern world:

- private property
- state property
- common property
- open access, i.e. systems with unrestricted (open) access to resources (GTZ, 1998)

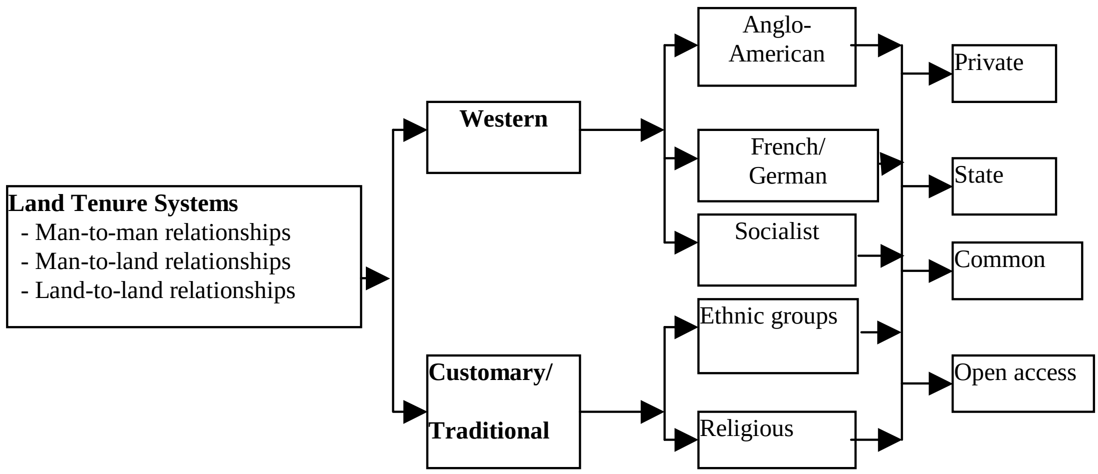

Figure 2.2: Taxonomy of land tenure and property rights

The first category of land tenure is very much influenced by the western law system. This system is derived mainly from either the Roman/German law adopted by France and Germany, or the common laws of Britain. In countries such as China, Russia, Romania, Bulgaria, Poland, Ethiopia, Tanzania and the former East Germany, tenure systems have been influenced by socialistic ideology (Henssen, 1996a). But the political changes and economic needs experienced by these countries have made the tenure system a central issue in the step towards a market economy. For example, the land tenure system in China combines private use rights with public ownership in order to provide economic incentives for farmer households without full land ownership and alienable rights. Under this arrangement, collectives and households share land rights. Collectives maintain formal ownership of farmlands and the collective body allocates land use rights to member households. The households' rights consist of rights to produce and dispose of crops – although rights vary according to the type of plot. There are five categories of land tenure (Lohmar and Somwaru , 2002): *responsibility land,* allocated to households in return for delivery of grain to state grain bureaus; *ration land,* allocated on a per capita basis to provide the household with food grain security; *private land,* allocated in small parcels for vegetables and other non-grain crops; *contract land,* contracted from a village land pool for expanding holdings; and *other land,* reclaimed wasteland allocated to households that participate in the reclamation effort. The current tendency in Chinese policies is to establish a land market based on private land ownership.

In Russia, state property was the predominant form of land tenure until the beginning of the 20th century. Following the 1917 revolution, private ownership was abolished, civil transactions involving land were forbidden, and land was assigned for the use of all who worked on it. However, by 1929 large-scale collectivisation was under way, resulting in the creation of so-called cooperative collective property. Under socialism, the buying and selling of land was never allowed (Limonov, 2002; Rolfes, 1996). In 1990, private ownership was introduced, permitting citizens to hold smallholdings for horticultural purposes, for constructing houses and for other personal uses, and the sale of land was also permitted.

Similarly, since the early 1990s there have been continuous efforts in the Central and Eastern European countries (CEEC) to change from a centrally planned economy to a market economy. This process has involved shifting ownership of land from the state and collectives to private persons.

In the second category fall the systems that are strongly influenced by customary or traditional laws. These have been established on the basis of (a) laws of ethics from the Afro-Asian countries, and (b) religious (Hindu, Islamic and Jewish) beliefs that established strong laws relating to the use of land (Larsson, 1971, 1991).

Management of these tenure systems has always been in the hands of central and local government organisations, in order to provide effective and efficient use of the finite and non-renewable resource that is land. The need for a sound land administration system, with appropriate PBGIS and coordination between various organisations at different levels of the hierarchical structure, is seen as critical for both the people and governments in order to ensure good security of tenure, fast and reliable land transactions, and support for various sectorial services by raising revenue from an equitable property tax structure; in order to maximise agricultural and mineral production to realise economic benefits; and in order to promote a more secure political system.

Forms of Land Tenure System

In the English concept (also applies to the French concept), property is considered as having a bundle of rights that can be exercised in many ways by the different parties. But the following appears to be most significant:

- non-formal (*de facto*) tenure
- private freehold and leasehold
- public freehold and leasehold
- communal ownership (tribal and neighbourhood)

Non-formal (de facto) tenure: This is the occupation and use of land without the permission of the real owner. It is sometimes known as “informal settlement” or “squatting”. It is prominent in and around major cities in many developing countries. Land law does not officially recognise such tenure, but under certain circumstances and conditions the tenure can be converted and become formal under the guiding principles of legislative and spatial planning frameworks. Such cases can be found in Peru (de Soto, 1990, 1994).

Private freehold and leasehold: Private freehold is the most familiar bundle of rights in land tenure. A private individual or corporation owns the land outright, and market forces dictate land use and disposition. There are exceptions in instances where the state reserves land for public use or control according to its land policies.

In private leasehold, a private owner (known as the lessor) leases (gives legal rights) land to a private individual or firm (known as the lessee) for a fixed term, possibly with restrictions on certain uses or activities on the land. It includes the so-called rental market value and can be applied to all categories of property, such as residential, commercial and industrial properties.

Public freehold and leasehold: Public freehold exists when the state or a government agency is the full owner of the land. It is normally applied to land for public use, such as parks, roadways, and sites for public building. When a public agency owns land and decides to lease it to a private firm or private individual for a specified period of time, this type of right so created is known as public leasehold. In rare cases, a public agency may also lease from a private firm or individual.

Communal ownership: In an area of land controlled by tribes, land is considered as the personal property of the tribe as a group or as a society and not of a family or firm. The tribal chief, being the guardian, allocates land to his people for various uses such as agricultural production and house building. The head of state, who is regarded as the “universal” landowner, gives the chief the power to allocate land. The head of state can grant specific rights to certain areas in exchange for certain duties. Although this attitude of communal ownership controls and keeps alive a sense of responsibility to both society and land as the common heritage to be preserved for future generations, it may also lead to land inequality because of the power of the head of state.

Neighbourhood communal ownership can be found in developing countries, where low-income neighbourhoods pool land, gaining control through the alienation of non-members and price control by some self-created neighbourhood organisations. This can act as a defence against land speculation, particularly by middle-income people who may wish to buy low-income areas, thus displacing the poor.

As we can now see, there are many forms of land tenure, but land tenure can never be considered as an independent variable. It is always part of the legislative and development policy framework and is always implemented following the land administration guidelines of any particular country. Land administration always includes the guiding principles and land management that regulate land rights and the uses of land.

2.1.2 Characteristics and Roles of Land Tenure Systems

In order to explain the characteristics and roles of land tenure systems, land tenures are termed “statutory” or “customary” for purposes of this research. This facilitates descriptions of how these systems play roles in supporting socio-economic development and environmental management.

Statutory Land Tenure

This system can be described as the right to, and the use of, the land supported by law (case law or statute law), which is brief, clear, easily accessible, knowable and in written form. In many countries, the historical source of law is custom, and thus the written law replaces custom. In developed countries, the written law came about as a result of the Napoleonic code based on the concepts of liberty, equality and fraternity (Platteau, 1996). In many developing countries, the written law was influenced by colonial administrations. Statutory land tenure is thus characterised by private freehold, private leasehold, public freehold and public leasehold, as described in section 2.1.

Statutory land tenure implies that written law guides all rights and use of land. In this respect, land registration and cadastre are vital instruments whereby real rights and associated spatial structures of land tenure are recorded. It should be understood that the registration of land does not imply changing the land tenure system. For example, registering land held under customary tenure does not necessarily mean changing the tenure system.

Assuming that the statutory land tenure system operates in a free market economy, its roles can be beneficial both to individuals and to the state. To an individual, it can provide legal security, enhancing the possibility of securing loans, and it acts as an incentive to land investment because of the documented evidence of ownership. Disputes usually decrease owing to increased legal security, and dealings in land become easier, faster and safer, improving accessibility to land. Government too can get benefits, such as less land speculation and the provision for land and property tax for development and infrastructure. Nevertheless, it is sometimes believed in the developing countries that the existence of statutory land tenure might lead to the abolition of custom and cultural practices.

Customary Land Tenure Systems

The characteristic of customary land tenure is that at the earliest beginnings all societies regarded land as belonging to the social group, whether it was a tribe, village, lineage or family. As a famous chief described it: "*I conceive that land belongs to a vast family of whom many are dead, a few are living and countless hosts are still unborn*" (Ollennu and Woodman, 1985). Customary laws are often based on the experience of the tribe elders, and are aimed at defending the interests of the tribe.

The advantages of this system are four-fold. First, the community itself controls and keeps alive the sense of responsibility to society and to land as the common heritage to be preserved for future generations. Hence it creates harmony and security in such a society and allows any member of the community access to some land within the community. In terms of land use, the system ensures that all land within the community is used, because unused land can be reassigned.

Traditionally, the customary system does not maintain the history and dealings regarding ownership of any piece of land within a clan. Thus, uncertainty over proprietary rights to any single piece of land leads to insecurity of tenure and conflicts concerning ownership or boundaries.

Some countries, such as Kenya and Malawi, have started recording and registering customary rights. This concept suggests that the registration of land can only be done on the basis of social groups headed by chiefs. Each member of the social group who has been allocated a piece of land for a certain purpose is identified and recorded as the owner by virtue of his birth. In Kenya and Malawi, this is implemented without altering the fact of community land control by registering the land in ownership of a customary group. The transfer of land is possible through the chief who approves it, and a legal form is given to the transferor. Similarly, in Zambia the local chief, the local planner and the registrar are the main actors involved during the initial registration and transaction relating to customary land. It is important that the indigenous methodology be developed for such registration of customary rights. Several low-cost approaches have been developed and can be tailored to existing conditions.

2.1.3 Land Tenure in Developing Countries

In many developing countries, the western laws of land tenure were introduced by colonial administrations. For example, the former British colonies in the Caribbean still operate on the basis of English common law. Socialist tenure systems in particular were introduced in those developing countries (such as Tanzania and Cuba) governed by socialist revolutionary ideas,.

In either case, the western system may have existed alongside a traditional tenure system, leading to a dual tenure system. Examples of dual land tenure systems exist in African countries that were formerly British colonies (South Africa, Zimbabwe, Zambia, etc.), where there was, or still is, Crown land or state land governed by English laws, as well as territorial reserves governed by ancient tribal customs. The customs are usually unwritten and ill-defined, and vary greatly from one tribe to another. English law applied to colonial settlements, ports, mines, etc., and tribal custom was applied to about 85% of the total area of such colonies (Podedworny, 1971).

Most of the European laws were influenced by the Roman law adopted from the Napoleonic code, which stated that a landholder had “the right of absolutely free enjoyment and disposal of object (land), provided that the rights are not in any way contrary to the laws or regulation”. In Francophone Africa, tribal concepts were sometimes modified by this code.

The French concept gives more power of control over land than does English law. Under English feudal law, all land was owned by the monarch, who granted estates[1] in land. The largest estate, i.e. the largest bundle of rights, was an estate in fee simple[2]. The Crown (monarch) determined which rights over land were included in the fee simple and which rights were served to the Crown. Once the Crown had decided the rights to be held and people began to hold land under those rules, the Crown could no longer step in and do what it wanted. However, the Crown, on behalf of government, could always take back rights in land by expropriation for the public use.

The system of collective ownership of land can be regarded as the result of socialist revolutions and collectivisation. It means that land rights are vested in the state (hence state ownership), with collective land use and division of labour. This system can be found in countries such as Ethiopia and Tanzania. Under this system, the state owns the means of production in the form of state property and collective cooperative property. Socialist ownership also embraces the property of trade unions and other public organisations, which the state requires to carry out its purposes under the socialist rules. No one has the right to use socialist property for personal gain or other selfish ends. The land, its minerals, waters and forests are the exclusive property of the state. Basic means of production and other assets are held by the state. The land held by the collective farms is secured for their free use in perpetuity.

Customary land tenure exists in most parts of Africa and Asia. It is the basis of holding and using land, giving a high measure of security to peoples with groups, clans, stools and tribes. Many research findings conclude that it does not readily allow changes in the customary living and working standards. It is believed that it becomes an impediment to the adjustment of tribal communities to the socio-economic advancement of the society as a whole. Some researchers still believe that this may not necessarily be true and attribute such thinking to little experience in the customary areas.

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[1] An estate is a bundle of rights over the land.

[2] Being the holder in fee simple meant having the right to exclusive use and possession of the land in perpetuity and the right to dispose of the land by sale, gift or will. It also meant having the right to further divide the rights in land and dispose of them separately.

In the Middle East and some parts of Africa and Asia influenced by Islam, land rights are defined by the concepts codified in the Ottoman Land Law of 1858. According to this law, the bundle of rights is categorised into *Mulk* (private), *Miri* (state), *Musha* (tribal and collective) and *Waqf* (charitable and religious).

2.1.4 Impacts on Land and Conflicts

It is often argued that land has dramatic impacts originating from political, economic and environmental aspects. These three aspects often conflict with one another, leading to various problems in communities and nations.

Political impacts: In most cases, the countries that moved to a socialistic form of administration amended the existing land laws to suit a particular need at a particular point in time in the country's political and economic metamorphosis. Tanzania is an example where, in early the 1970s, following the *ujamaa* (a type of socialism) reform, such an amendment took place. On the other hand, countries of the former communist bloc are changing from social property models to individual rights and private property, and consequently creating an open land market. In Hungary, for example, until the late 1980s there was only common and state land, but since the political changes of 1989 private ownership has become dominant.

Economic impacts: From the point of view of economics, land has a value that is capable of generating income. It is an immovable good that can be exchanged, rented, mortgaged, exploited and developed on the basis of the bundle of rights.

Resource management and conservation are key requirements for successful long-term economic growth. To combat increasingly serious problems in these areas, appropriate levels of management for land tenure must be applied to public and private lands.

In order to maximise economic development, tenure security must be established; people are more prepared to invest when they are given some form of legal protection. Land transactions are prompted through tenure security and so they increase the economic welfare. In an open land market society, the individual owners have better access to mortgages and so they can invest the money back into their land. As a result, land that is registered through a secure tenure system has higher market value.

Environmental impacts: Many of the developing countries are facing a population explosion in the urban areas. Expansion of the big cities has spiralled out of control; informal settlement is the most common result of this expansion. In most cases, squatters settle on public land at the edge of the cities, with no existing infrastructure, and they occupy the land *de facto.*

Informal settlement is a sensitive and rather complicated issue. There must be a clear policy in order to achieve uniformity in the way the land tenure is applied. What are the land rights and limitations that will apply to squatters? Should these rights be permanent or temporary?

Urban planning is a way of diminishing the effects of informal settlement, with the condition that the land parcels will be made available at an affordable price. Land registration and cadastre play a significant role, providing up-to-date cadastral information.

Managing conflicts: Many developing countries use either formal or informal institutions as a mechanism for resolving land conflicts. Formal institutions, for example central courts, district courts and local courts, follow governmental structures. These courts deal with not only land matters but also all kinds of conflicts/cases. The processes regarding land disputes are usually time-consuming and costly affairs. Furthermore, the number of lawyers and judges is not always sufficient to efficiently address the large number of conflicts.

Informal institutions are independent of the public authorities. They play a very significant role in the reconciliation of the disputing parties by acting as mediators (GTZ, 1998). These mediators, who can solve many land disputes, are either senior or distinguished members of a community, so the community respects their decisions. Moreover, mediators can be seen as “one of us” – the ones who are well aware of the needs, structures and generally accepted rules of the community – so they can relieve tensions. If the mediation does not succeed, the case can always be taken to court. In some villages in Nepal, for example, respected men are called in to mediate between conflicting groups. Sometimes, they even perform *Dharma*, a religious oath, to produce the truth.

Some developing countries try to solve the problem of urbanisation by reallocating land in underutilised areas. The lack of a financial budget means that planning and its implementation to provide adequate infrastructure for settlement are impossible. This creates unrestricted access to forest areas or areas with scare resources, and poses the threat of environmental catastrophe: deforestation, soil degradation and desertification, and biodiversity loss. Forests in the southern part of Nepal, particularly Tarai, were cut down and used for settlements for people migrating from the country’s mountain regions.

Property rights are one mechanism to control the use of natural resources, and experience shows that open access to land leads to its overuse. A sound land tenure system and its registration would stimulate the environmental protection of the land, since this would be in the owner's interest.

2.1.5 Gender Issues

In many developing countries, there is major concern about the issues of land or property rights for rural women and their families, as well as poor or underprivileged classes of people (Agarwal, 1996). The study indicates that traditional arrangements need to be changed and resolved at the family, community and national levels (Komjathy and Nichols, 2001). According to this publication, the factors that are applying pressure for change are (a) changing socio-economic conditions, such as increased population, new types of employment and growing cash economies; (b) urban and peri-urban migration, with the incorporation and/or replacement of traditional tribal and religious institutions by national and local government; (c) divorce and changes in inheritance patterns; and (d) the resulting role of women as sole household provider.

In developing reengineered models for parcel-based geo-information supporting land administration, special categories referring to individual, common, public or group ownership provide a better solution for women or groups of women to secure or extend their rights. Organisations must be active in providing services, and safeguarding and enforcing women's rights, which must be explicitly recognised by being documented in terms of land ownership certificates and deeds of agreement.

2.1.6 Land Uses and Institutional Options

In many countries, environmental land protection policies now impose restrictions on the use of land (GTZ, 1998; UN-ECE, 1996). In reserved forest areas, people can own land, but are not allowed to construct any buildings or houses on it. A particular type of activity with a certain buffer zone also protects archaeological sites. In some cases, in order to protect the flora it is forbidden to cut down specific types of trees. There have been many studies and considerable research that provide consistent methodologies to deal with such cases of land use restrictions. The following sections review some cases dealing with land used for purposes of religious and agricultural development, which are interesting issues for developing countries.

(a) *Land for agricultural purposes:* There are several types of land rights for agricultural purposes in the countries where there are no customary forms of land tenure. These are similar to those described in section 2.1.2, but are more specifically described as rights of ownership (similar to freeholds), leasehold rights, tenancy rights, and rights of usufruct. In many southern parts of Nepal, especially in the Tarai region where there are many large tracts of agricultural land, the tenants usually carry out the entire farm management with the agreement of the landlord (tenant relationships). In such a situation, even though they both earn a living from the same land, the landlord lacks incentives to invest in his land, while the tenant lacks both the incentive and the resource to invest. Similarly, sharecroppers have little or no incentive to improve and/or invest in the land. Even in these districts, which have fixed rents, there is little that a tenant can achieve. The level of rent is still high, and the tenant lacks access to credit and other inputs.

The mode of payment and the length of the tenancy usually influence the way in which the tenant maintains or improves the land. Short tenancies and high rents do not give tenants the incentive to adopt conservation measures. As a result, rights of tenancy in agricultural areas can lead to deterioration of the land.

The study shows that in many agriculture-dependent societies unequal distribution of land seems common, which causes (especially in the marginal areas):

- highly intensive cultivation, and sometimes over-cultivation, of the small parcels; this destroys the soil and results in eventual abandonment of the area.

- the small (generally poor) landholders to be dependent on the large (generally wealthy) landholders, since in agricultural societies wealth is usually proportional to the amount of land held. In extreme cases, this can lead to the exploitation of women and children as labourers on the larger farms.

(b) *Land for settlement and other purposes:* Land is needed for settlement, infrastructure (e.g. roads, utilities), industry, water, and other natural resources.

(c) *Land for religious purposes:* In many developing countries, some lands are often dedicated to religious purposes by virtue of performing social customs toward God. For example in Nepal, Bhutan, and many parts of

India there are tracts of land dedicated to Hindu and Buddhist temples. These lands can, however, be used for agricultural purposes. They are considered public lands, but no one has the right to construct private houses or buildings. Religious social groups exclusively enjoy the uses and economic profits of such land (*Guthi* land) for purposes of the community (Regmi, 1978).

In some Islamic countries in the Middle East and Africa, a type of religious land is *Waqf*. The term "waqf" comes from the phrase *mawful lilah,* which means "stopped" for God. The status and use of such land cannot be changed. Some research sees this as an impediment, especially to urban development or to major public projects such as highways and expansion, but it fulfils social functions within communities by providing for libraries, schools, and sometimes housing for poor Islamic families.

Christian cemeteries and land reserved for churches are often consecrated, preventing any type of activity other than religious.

Institutional Options

There are several options for taking measures to rectify this imbalance/inefficiency in production. One option is land consolidation, which is sometimes known as land pooling or land readjustment. It is the process of consolidating small economically unproductive fragmented parcels into larger, ecological and economic parcels that can be spatially distributed per landholder more efficiently. The land consolidation process requires sound planning procedures, land evaluation, land valuation and cadastral land information, as well as much dialogue between the landholders and land users concerned.

Land banking is the second option, and the goal is to regulate the land market. It involves the acquisition or reservation of land by the state in order to provide sufficient land in the future for specific target groups and specific public purposes, as well as to guide land use. In agricultural areas, the target group is usually the small landholders, and an example of specific purposes is infrastructure development (roads, irrigation channels, etc.).

A land ceiling is the third option and it has the effect of regulating the quantity of land that may be held by one owner. There may be a minimum ceiling, preventing farms from being too small to be economic and avoiding over-cultivation. There is also a maximum ceiling, restricting the total quantity of land to be held by one landowner. The maximum size depends on the particular farming system practised. Land in excess of the maximum limit can expropriated (taken) by the state, usually with compensation, and redistributed to others with less land, according to predetermined priorities. While this option has been reasonably successful in Indonesia with the enforcement of the Basic Agrarian Law 5/1960, it has been unsuccessful in Bolivia, Nigeria and India because of the weakness in their land laws. Similarly, this option has achieved little success in Nepal.

2.2 Systems for Parcel-based Geo-information

The PBGIS is an offshoot of the land information system. Figure 2.3 shows the taxonomy of information system growth leading to the origin and development of PBGIS. In this system, the most basic entities are the parcel units, land rights and persons.

As opposed to information on land rights and persons, the parcel unit is immovable, durable and can be precisely identified and surveyed in the terrain. It is also considered as an abstract thing that is manifest as a set of rights with responsibilities and restrictions to its use, with a value that can be traded (Dale and McLaughlin, 1988).

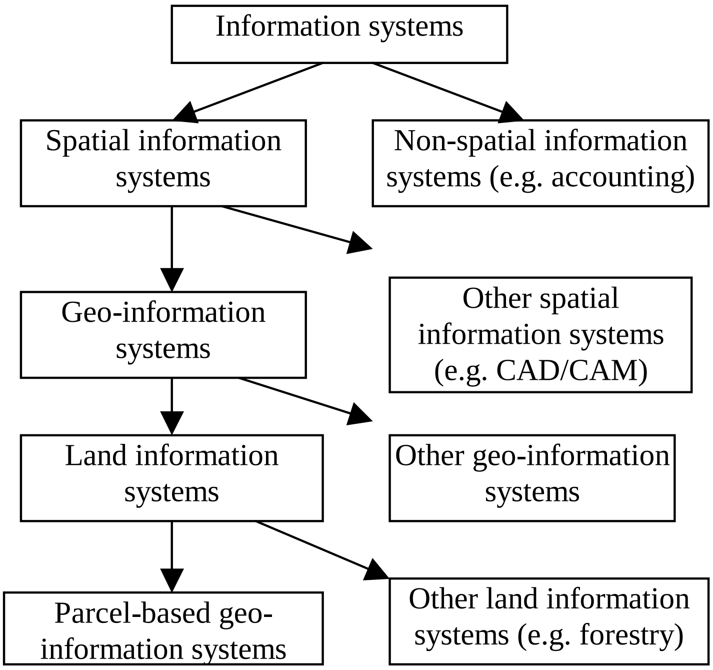


Figure 2.3: Taxonomy of information system (Dale and McLaughlin, 1988)

Such spatial units reflect homogeneous interests. These interests are ownership, responsibility or the restriction of uses, and will be linked to individual persons, local groups or communities, customary groups, or any other government or non-government organisations.

Hence a land parcel can be defined as being for land use, ecological or cadastral purposes, and as a continuous area of land within which unique and homogenous interests are recognised (Henssen, 1995). Thus a PBGIS can be defined as a kind of land information system whose basic spatial unit is the land parcel and in which land-related information is collected, stored, referenced, processed and retrieved basically at the parcel level.

Role of a PBGIS: The primary aim of a PBGIS is to support the administration of land, such as the alienation, transfer, valuation, development and utilisation of land (see figure 2.4). Geo-information can also be used and analysed for formulating, implementing and monitoring land policies, such as those concerning land redistribution, land consolidation, land acquisition, land allocation and land markets.

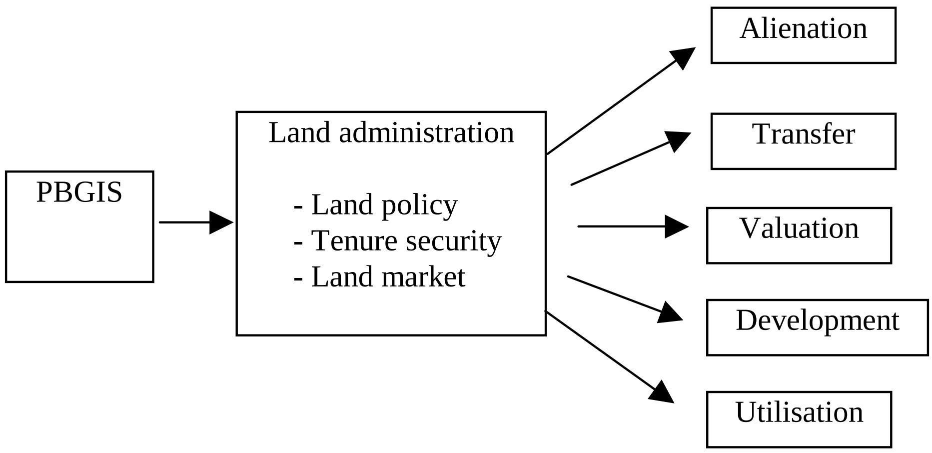


Figure 2.4: PBGIS and land administration (modified from Dale and McLaughlin, 1999)

The successful PBGIS should provide support for tenure security on land in formal and non-informal environments by supplying current and reliable information at the lowest possible cost. This facilitates mortgage-based investment financing for all, affords security to investors, and allows real estate to be traded in the market place.

The PBGIS enables the government to levy equitable taxes for the overall development of the country. For all the above activities, it is clear that the unique identification of land parcels, land rights (ownership, responsibilities and restrictions) and owners, as well as transparent mechanisms for transactions and for supplying information, are the prerequisites for developing land markets. They also help to eliminate or decrease litigation related to land.

Since many users or stakeholders (e.g. notaries, surveyors, developers, investors, tax authorities) use the data supplied by a PBGIS, it plays a significant role in providing standardised data and models, and significantly minimises problems encountered in sharing data among the users or stakeholders.

2.2.1 PBGIS Components

A PBGIS consists of the following components that enable it to function well within land administration:

- data sets (related to both spatial and non-spatial data)
- process or functions related to data acquisition, data processing and storage, data maintenance, data analysis and data dissemination
- hardware and software including communication networks
- well trained people

2.2.1.1 Data sets

Two categories of data set are generally stored in a PBGIS. The first category is basic cadastral data, which is directly connected with land ownership. The second category is supporting data, such as geodetic reference points, administrative boundaries and topography, which assure basic cadastral data (legal cadastral objects) of accurate referencing in relation to physical objects (especially topographical objects) and to the earth, as well as allowing integration with other types of spatial data.

(a) *Basic Cadastral Data*

There are three main cadastral data types (Dale and McLaughlin, 1988):

- cadastral land parcel
- cadastral records identifying land rights and persons who hold rights
- parcel identifier

Cadastral land parcel: A cadastral land parcel serves as a basic unit for a PBGIS. It is sometimes termed a lot or a plot. It is an area or, more strictly speaking, a volume of space recognised for land administration purposes. As a

3D division of earth, the parcel objects include superjacent and subjacent rights in addition to the surface rights. But in this research, only 2D land parcel objects are considered. In the broad sense, land parcels represent the locations of legally defined boundaries (e.g. district, village/municipality, informal or customary areas, subdivisions and lots, and individually owned parcel boundaries).

Difficulties in defining 2D land parcel objects of homogeneous interest in the terrain arise because of (a) differences in tenure and use, (b) delimiting various interests in a non-continuous form, (c) delimiting public land, and (d) changing natural features and administrative boundaries.

FIG Cadastre 2014 provides a concept that takes different tenure and use into account by delineating various object layers and structuring them in a layer structure similar to the GIS structure (Kaufmann and Steudler, 1998). Delimiting public land requires a proper identification procedure involving all parties concerned. Changes in natural features and administrative boundaries would have to be continuously monitored in the terrain.

Cadastral records: These generally describe three kinds of information concerning basic objects (land parcels, land rights and persons). However, to cope with the particular country requirements, formal or informal tenure and extended land objects of different types of land rights (e.g. group rights, individual ownership) must also be registered, including the rightful claimants, in the PBGIS. Copies of survey records, land ownership certificates and deeds should also be stored for future reference. The latest technique for archiving these documents is to scan them and store them in a database.

Parcel identifier: The objects with unique identifiers serve to link the cadastral records with many other records or information systems. In other words, they facilitate data sharing among different users of the information system. Even with a traditional system, it is necessary to have a parcel indicator or a unique parcel reference that identifies the parcel and allows cross-referencing within the register and other filing systems. Three important forms of identifier can be distinguished: name-related identifiers, abstract or alphanumeric identifiers, and location identifiers. The choice may depend on their uses. Dale and McLaughlin (1988) describe the various methods of referencing systems, such as (a) grantor/grantee index giving the names of the vendor and the purchaser; (b) title or certificate number allocated in sequential order; (c) volume and folio comprising the volume of the register and the page where the parcel details are given; (d) subdivision name and plot number, introducing some sense of spatial identity; (e) block and plot numbers, similar to the above but with blocks chosen for the convenience of registration and not necessarily coinciding with other administrative boundaries; (f) postal address, allowing identification of the land parcel in the street addressing system; and (g) grid coordinates or geo-code based on latitude and longitude or, more conveniently, on the national reference system. However, these system requirements need to be appropriately matched with the relevant objects of interest in the PBGIS in support of the land administration activities.

In a spatial context, the land parcel object possesses four major components (Al Taha and Barrera, 1994). The first is object identity, with a set of properties distinguishing and characterising the feature. Second comes spatial property, representing its geometry, topology and geographical location. The third component is the non-spatial properties, such as use, and the last component is the relationship to other spatial objects, such as the relationship of individual parcel objects to the higher objects of blocks or communities or cities or villages.

*Building:*In the traditional cadastral systems, the building objects are incorporated as physical objects, not as legal objects. In reality, however, building objects such as apartments are legal entities associated with rights, land parcels and owners. Data about building is also increasingly used for a variety of purposes. Therefore, the building objects are as important as land parcels in PBGIS.

(b) ***Additional Data***

In the context of the broader objective of the PBGIS, it is important to relate the following data in the system in addition to the basic cadastral data, as the users (municipalities, utilities, etc.) always expect topographical objects together with cadastral parcels for their multipurpose uses. These additional data as references provide quick and easy access to the area. In many situations, physical objects (e.g. walls, hedges, fences, ditches, forest boundaries, canals, riverbeds) are the evidence of legal boundaries. They protect against illegal or unknown boundary encroachments that create many boundary disputes. The Department of Survey in Nepal is responsible for surveying these objects and showing them in the cadastral maps; similarly the Survey of Bhutan is the body responsible for these objects in Bhutan.

National geodetic control points: These control points are essentially used for geo-referencing all kinds of spatial data in a uniform reference system. The global positioning system (GPS) is now seen as the most cost-effective means of establishing a national geodetic reference system, compared with the traditional approaches of triangulation, trilateration or traversing methods.

Topographical information: Administrative boundaries, transportation networks including roads and railways, cultural features, hydrographical features, utility lines, and digital elevation models are topographical objects. These physical objects provide extremely valuable supports for many applications in natural resource management and earth science applications, and form the basis for all kinds of boundaries, including land parcels and administrative boundaries.

Ortho-photos or images: Rectified and relief-displacement-corrected aerial photographs or high-resolution images (such as IRS, IKONOS or Quickbird) can be extremely effective as backdrops for the cadastral data, enhancing reliability for the users.

Socio-economic information: This includes population censuses, agricultural censuses and other environmental information.

Thematic (natural resource) information: This includes land use, vegetation, soil, geological and geophysical information.

Many of above datasets are usually produced by the various departments or agencies depending upon their tasks and responsibilities. With advancement of Geo-ICT technology, the data can be made accessible via Geo-spatial data infrastructure. Then a PBGIS as a multipurpose system provides various services and products to clients using these datasets (Tuladhar, 1992).

2.2.1.2 PBGIS Processes or Functions

Information from a PBGIS can be used for juridical, fiscal and many other purposes (McLaughlin, 1975; McLaughlin and Palmer, 1996). The juridical aspect mainly concerns property rights and the mechanisms for land transaction, and specifies the boundaries of homogeneous spatial units. It also describes the restrictions and claims on the property. The fiscal part deals mainly with the valuation and taxation of property, usually through mass valuation.

In the multi-use environment of land administration, the PBGIS is used for many purposes, such as land reform, land consolidation, land pooling, land-related statistical analysis, environment protection, utilities development and management, the analysis of changing land use, the schedule of maintenance activities, and the management of watersheds. In general, the multiple use of parcel-based information is afforded by the provision of services through which the dynamics of land parcels may be studied. Therefore, it can be seen as a coordinated framework, where institutional, financial, legal and technical aspects are considered to satisfy user requirements. PBGIS users can include all levels of government, mapping agencies, cadastral offices, land registration offices, land bureaus, academic institutions, landowners, utility companies, public works departments, agricultural companies, financial institutes and the general public. With this background, the PBGIS is based on the concepts of geospatial data infrastructure (GDI), emphasising reliable and easy access to information, and maximum data sharing with minimum duplication.

The juridical, fiscal and multi-use functions of the PBGIS can be realised by establishing and linking various databases through the functionalities of geo-information system (GIS) and database management system (DBMS) operations.

In the operational sense, the PBGIS contributes to land administration along the following lines (UN-ECE, 1996):

- *Certainty of ownership:* The compilation of land information will entail formal identification and recognition of ownership of land (adjudication). Land registration will show many ranges of land rights and this in turn will ensure social cohesion.

- *Security of tenure:* The documented evidence of these land parcels, rights and persons eliminate the risk of eviction. This alone induces the incentive to invest in the land.

- *Reduction in land disputes:* Boundary dispute settlements can be very expensive. Similarly, the properly documented evidence collected during adjudication and subsequent registration processes would reduce land dispute cases.

- *Improved conveyancing:* The cost and delays in property transfer can essentially be reduced through the operation of land registration.

- *Stimulation of land market:* Since the land registration system provides a facility for obtaining credit from the financial institutions, the resultant increase of players in the land market should see improvement in the operation of the land market.

- *Facilitation of land reform:* Because PBGIS can show the current legal status of every individual land parcel, it can therefore be used for land reallocation, land redistribution and consolidation.

- *Support for land taxation:* Historically, cadastre developed for merely fiscal purposes. After realising that land was the source of all material wealth, many countries saw it as the only unlimited source of revenue to support the running of their governments.

- *Improvement in physical planning:* Large projects have often been delayed because of lack of knowledge about existing land rights. With the development of PBGIS, governments can have information about the land parcels, land rights and owners of every piece of land. It can also be used as a tool to monitor/restrict developments that may cause pollution in certain areas.

- *Multifunctional system:* It offers itself to other instruments for public administration, and the availability of up-to-date information can lead to the creation to a multifunctional system that serves a variety of resource management activities.

2.2.1.3 Hardware and Software

The organisational functions, the applications and the data content usually drive the type of hardware and software needs in all information system development projects. The organisational functions normally determine the system configuration, ranging from a simple system to an advanced and networked system environment. The database content defines the size, source and update volumes of the data storage components. The applications define the software capabilities that are needed and it is the software that defines which types and mixture of hardware components must be installed, including network infrastructure.

Currently, the software capabilities are numerous, ranging from simple GIS functions to most advanced functions, including Web GIS in a client/server environment. There are now many advanced database management system software packages available in which spatial and non-spatial data are easily integrated, and they allow the easy exchange of data between systems with adequate levels of interoperability.

Once the data, processing and software needs have been determined, defining what hardware components are needed is a fairly uncomplicated task. By looking at the input and output needs of the applications for each user, the specific hardware requirements can be identified. Personal computers, servers, workstations, plotters, digitisers, printers and scanners are some examples that are easily available on the market.

2.2.1.4 People

The human resources needed to develop, implement and support the operations of a PBGIS are a critical component of the organisation, and eventually become the largest ongoing cost of the system. Success largely depends on an adequate number of dedicated and trained staff members. Careful selection, assignment, and management of the people responsible for the system are important activities in the development or improvement of the system in the organisation.

The mixture and number of staff required are dependent on the roles and responsibilities they have to perform, and on the size and complexity of the system and the stage of the project. Nevertheless, they can be categorised as committee members, project leaders or managers, domain experts, information analysts, GIS specialists, database administrators, system administrators, network managers, land surveyors, photogrammetrists (also handling remote sensing), planners, digitisers, cartographers, operators, among others.

2.2.2 Characteristics Desirable in a PBGIS

According to Aronoff (1989), *"a good information system is one that provides us with the necessary data relevantly organised so that we can make the right decision about the real world"*. The right decision is the one that best achieves the objectives of whomever the system is to serve – and to make the right decision requires the relevant data to be presented using the true criteria. Therefore the data in PBGIS must have a number of characteristics other than their relevance to land administration. These characteristics include:

- *Currency:* The users of PBGIS must have information about the currency of the data supplied before they use it in their applications. This means that information should be shown on how recently the data were collected. The data must be accessible in an up-to-date form within a time frame that meets the needs of the user.

- *Precision:* This measures the fitness of the scale used to describe the data. The data must therefore provide measurement information to the standard required.

- *Accuracy:* This measures how often, how much and how predictable the data will be. There must be little or no error in the information extracted from the data. For example, spatial data of cadastral boundaries from the cadastral surveys are usually documented in a field sketch prepared in agreement with owners and neighbours. Information stored in a database should not be different from the field measurements. If the spatial data in the database are adjusted, the users must know the accuracy of the adjusted data.

- *Reliability:* The user should be informed about the reliability of the data supplied to them. In boundary disputes, the users should be informed that the adjusted data are less reliable than the original measurements noted in the field sketches.

- *Verifiability:* Different users should be able to get the same answer to the same question.

- *Clarity:* The information must be free from ambiguity.

- *Quantifiability:* Where appropriate, numerical information should be obtainable.

- *Accessibility:* It should be possible to extract information quickly and easily.

- *Freedom from bias:* Data should not be altered or modified in order to influence those who receive them.

- *Comprehensiveness:* The data should be complete in spatial cover and content. Since data are costly to collect, the most cost-effective data should be collected, i.e. only those data that are needed.

- *Appropriateness:* The information derived from data should relate to the potential users' requirements.

The optimal quality that requires the minimum level of quality should be maintained in a PBGIS for the users' satisfaction. In a database environment, additional parameters that reflect quality are the structure of the data model, data acquisition methods, and the assigning of objects to, or storing of objects in, the correct classes (Tuladhar, 1996; Molenaar, 1998). More detailed discussion on quality review from the management perspective is given in Chapter 5.

2.3 Reengineering Concepts and Domain Models

In developing system models for a PBGIS, reengineering concepts is vital for reengineering the existing systems together with domain models.

In the context of PBGIS the following paragraphs provide aspects of reengineering.

The term "reengineering" is defined as: "*The fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance, such as cost, quality, service and speed*" (Hammer and Champy, 1993).

In this definition, the word "*fundamental*" means that during the reengineering of existing systems, we must ask basic questions about organisations and how they operate: Why do we do what we do? And why do we do it the way that we do? Analysing answers to these questions usually forces us to look at the tacit rules and assumptions that underlie the way we conduct the business. Often, these rules turn out to be obsolete, erroneous or inappropriate. In cadastre and land registration, it means that it is not just the adjudication, surveying and registration of land parcels; we have to ask ourselves if these processes are adequate to serve such purposes as handling customary rights and land rights on informal settlement for tenure security, for stimulating land markets, and for planning (Tuladhar, 2003).

The words "*radical redesign*" mean getting to the root of things: not making superficial changes or fiddling with what is already in place, but throwing away the old. Old systems may have to be redesigned completely to suit the new requirements, as explained above. A few improvements to the systems may not serve our purposes. For example, in customary or informal settlement areas, land parcel units can be spatial units referring to the groups of citizens or tribes, etc. This is a radically different registration perspective from that of individually owned parcels in the registration of deeds or titles. In Nepal, registration is based on the system of simplified deed registration. This system was designed for taxation purposes. Today's requirements within modern Nepalese society demand more security of tenure and easy access to land by stimulating the land market. The present system may have to be radically changed to suit the new requirements.

The word "*dramatic*" means there has to be a quantum leap in performance. It is not about making marginal or incremental improvements. This is highly desirable in order to improve the quality of land administration services and products.

Lastly, but most importantly comes *process*, which gives most organisational managers the greatest difficulty. *"A process may be defined as a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer"* (Hammer and Champy, 1993). This means that reengineering should focus on process not function and should use information technology for restructuring what was done and how it was done. The goal of reengineering should be to create a new way of doing things, where employees/workers are problem solvers and truly routine activities are automated. Such processes must be kept simple and low-cost to achieve quality and flexibility. The simplicity has enormous consequences for how processes are designed and how organisations are shaped.

2.3.1 Characteristics of Reengineering

In reengineering a process, several characteristics can be distinguished. First, it is possible that several jobs are combined into one job. This is the most basic and common feature of reengineered processes that do not require the assembly line as in traditional systems. In a traditional cadastre and land registration system, there are many steps that can be combined into one step. This can be easily achieved by using PBGIS. This means that many formerly distinct jobs or tasks are integrated into one task. Therefore, it is important to identify those steps that can be combined during reengineering.

Secondly, in a reengineered process employees undertake decision making. In traditional organisations such as cadastre, they often have to go to the higher level for decisions. This takes considerable time (spent waiting) without adding any value to the processes. Such a decision takes place horizontally and vertically in the hierarchy of the organisations. New systems must be able to eliminate these non-value activities by combining vertical as well as horizontal decision processes, and the benefits include fewer delays, lower overhead costs, better customer response, and greater empowerment for employees.

Thirdly, the steps in the process are performed in a natural order. In reengineered processes, work is sequenced regarding what needs to follow what. This makes a process transparent and clear to the customers.

Fourthly, a process has multiple versions. Traditional processes are intended to provide mass production for a mass market. All inputs are handled identically so organisations can produce uniform and consistent outputs. In a world of diverse and changing markets, that logic is obsolete. To meet the demands of today's environment, we need multiple versions of the same process, each one tuned to the requirements of different markets, situations or inputs. This is particularly important in the field of cadastre and land registration where the systems have to deal with multiple situations of the desired domain, such as fiscal, legal, market, planning and other systems. But these processes should have the same economies of scale that result from mass production.

Work is performed where it makes the most sense. This is most critical to cadastre and land registration systems. The processes are decentralised to the lowest possible units where customers are directly connected so that they do not need to travel to the head office in the capital city. In many developing countries, citizens have to travel long distances for registration, and this involves high costs. Because they cannot afford such time and costs, they do not even register their lands.

Checks and controls have to be reduced. The processes in the conventional cadastre and land registration are mostly replete with checking and control steps, which add no value but are included to ensure that people are not abusing the process. Reengineered processes use controls only to the extent that they make economic sense. Reconciliation should be minimised. The external contacts should be reduced to avoid the chance that inconsistent data requiring reconciliation will be received.

Lastly, a case manager provides a single point of contact. This mechanism proves useful when the steps are so complex or are dispersed in such a way that integrating them for a single person or even a small team is impossible. Acting as a buffer between the complex process and the customers, the case manager behaves with the customer as if he or she were responsible for performing the entire process, even though this is not really the case. This phenomenon can be seen in our traditional cadastre and land registration systems. The citizens who wish to survey and register their lands usually leave all kinds of arrangements to either their notaries or land surveyors, or even brokers. If a case manager is introduced in a PBGIS, then it is important to recognise him or her as professionally trained personnel, with an important role for market economy within institutional settings (particularly in the Nepal and Bhutan situations).

These characteristics suggest that many of the cadastre and land registration organisations would need major changes in the way they conduct their business, particularly in the developing countries.

2.3.2 Domain models

The concept of domain is to characterise the requirements of a system or, more specifically, to characterise the design that satisfies those requirements (Sullo, 1994). In a PBGIS, domain models focus towards the requirements (based on policy, legislation and users), strategic objectives, processes and data required for products and services.

Figure 2.5 shows the approach for developing cadastral domain models for a PBGIS. New requirements originating as a result of land policy, changes in legislation and users' needs are the main inputs to domain models, while strategic planning provides strategic objectives and action plans to new domain.

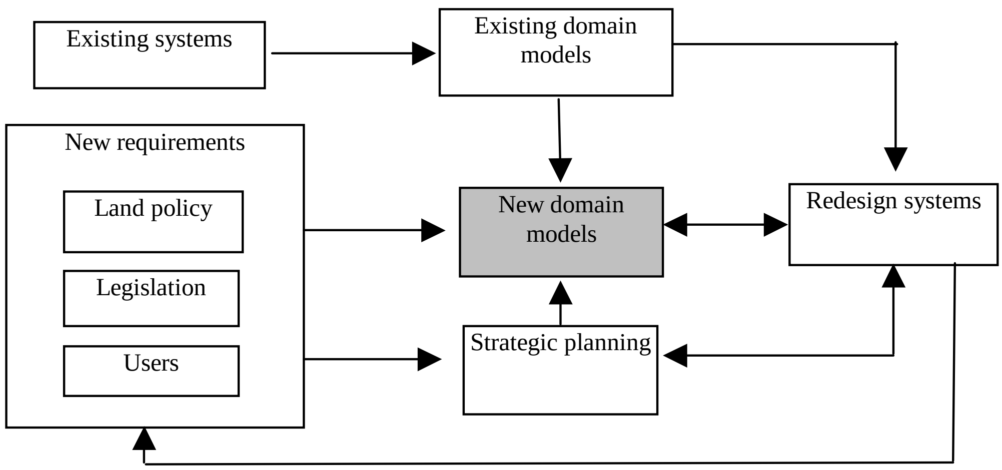


Figure 2.5: Approach for developing cadastral domain model (Tuladhar, 2003)

As a part of reengineering, the existing domains are also integrated in new domain models. Existing domain models are derived from the existing systems using a technique called "reverse engineering", which enables us to construct model of the business and the processes that we wish to improve.

It is argued that the true domain may be larger than the apparent domain represented by the design. Therefore, it is important that, as time goes by, an initially designed system is extended according to future users' requirements. This is particularly important initially, to limit the scope of the PBGIS domain to the extent that the national cadastral and mapping organisations are able to implement their mandates.

The concept of domain also allows a system (such as PBGIS) to be partitioned into several subsystems that reflect either the natural division of functions within a domain or the historical sequence in which the functions are automated.

2.3.3 Reengineering Activities

For developing a PBGIS as part of reengineering efforts in land administration, reengineering basically consists of three main activities that the organisation has to carry out. These are (a) developing vision, (b) engineering a newly redesigned system, and (c) installing the new system in the organisation including data conversion, operation and maintenance, as shown in figure 2.6. Three additional sub-activities (such as reverse engineering the existing system, developing domain models, and reorganising the agency) are necessary to support the main activities.

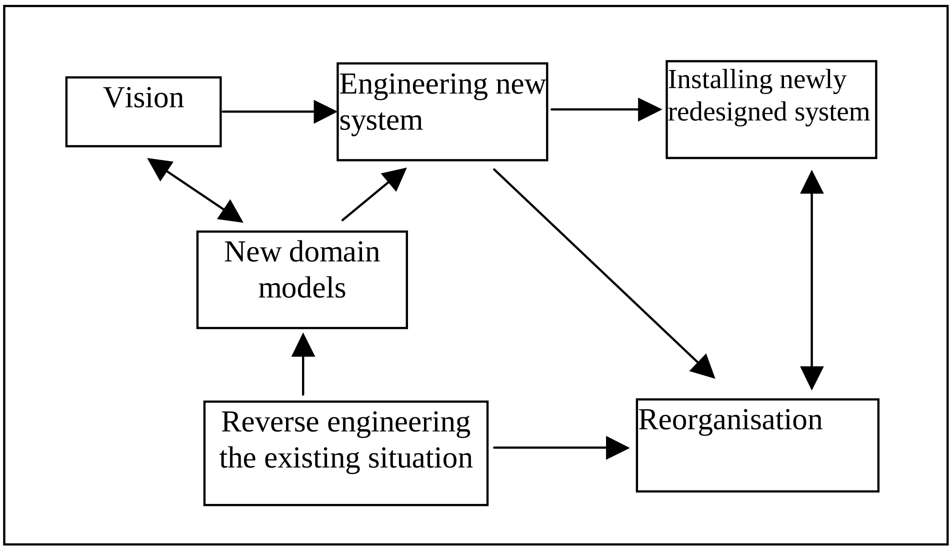


Figure 2.6: Reengineering activities for a PBGIS

In the activity concerned with developing a vision, the emphasis is on the business processes that the organisation needs to carry out to fulfil its strategic objectives in accordance with domain models. To achieve this, of course, we must know the organisational strategy and understand the existing business. We must at least understand the part that could be subject to reengineering.

The work of engineering a new system implies creating one or more new processes, designing them, developing a supporting information system, and prototyping them. The weight of the entire reengineering work rests on this activity, as it has to produce a workable system specification to satisfy the customer demands. The last activity normally includes installing the redesigned system, which is incisively implemented in the real organisation. This activity requires a reorganisation plan for the agencies.

2.4 Summary and Concluding Remarks

Land tenure systems exist in diverse forms. In many developing countries, there are hybrid systems (a mixture of statutory and customary tenure systems) that are tailored to suit the requirements of the particular country's socio-economic needs, religious views and customs. The land tenure for both urban and rural environments requires the development of a land policy that would guide the needs of citizens, while protecting and conserving the finite land resources. Such policies are effected via legislation, institutional structures (both formal and informal using a land mediator), and proper land administration using land information and communication systems.

The primary role of PBGIS is to support the land administration functions. To do so, it requires deep understanding of the land rights exercised on land by the local communities, landholders and users within the framework of land tenure in a particular country. Indigenous and customary rights on land cannot be ignored. In this context, land rights belong not only to individuals but to a wide range of community groups, customary tribes and families. They have, in many cases, territorial views rather than the view of individual rights. Thus, a PBGIS requires a variety of data, such as basic cadastral data, administrative data, topographical data, socio-economic data and thematic data, to serve a variety of products and services. It also requires concepts such spatial data infrastructure (SDI) for realising easy data access and sharing among the users.

To be able to develop a PBGIS, the domain model is an important part, specifically for applying the reengineering principle to redesign existing or traditional manual cadastre and land registration systems. In this activity, a domain model integrates the existing system and new requirements required by land policy, legislation and users, together with strategic plans.

Chapter 3

Systems of Cadastre and Land Registration in Nepal and Bhutan

3.0 Introduction

The purpose of this chapter is to identify emerging issues and challenges in the current systems of cadastre and land registration in the context of land tenure and its administration in Nepal and Bhutan.

This chapter also attempts to stimulate common thinking as regards systems by describing the land tenure systems, the legislative framework, and the forms and procedures of land registration and cadastre. Then the emerging issues and challenges are identified to justify the need for reengineering processes, where the dynamics of cadastral data are the main components to support security of tenure and the land market.

The chapter consists of three sections. Section 3.1 concentrates on the evolving nature of cadastre and land registration in Nepal, while section 3.2 discusses the situation in Bhutan. The last section, section 3.3, covers emerging issues and challenges that these countries are facing, and argues that there is a need to reengineer land administration.

3.1 Cadastre and Land Registration in Nepal

Nepalese society is based to a considerable extent on agricultural productivity, and it is estimated that 42% of the population is living below the poverty line (NPC, 2003). In such an agricultural society, where more than 80% of the total population depends on agriculture and natural resources for their subsistence and earned income, secure land rights are fundamental to society, including groups of people such as the poor, the landless and women. Although these groups work for most of their time on the land and feed their families, they are normally the least able to defend their land rights. Secure land rights are also crucial to providing the incentive for investment and the ability to transfer land at low cost to more efficient producers. In addition, secure land rights are essential for equity.

Geographical Location

Nepal is a landlocked country situated between China in the north and India in the south, east and west. It is bounded approximately by longitude 80° 04' to 88° 12' E and latitude 26° 22' to 30° 27' N. The surface area is about 147,181 sq km. Topographical elevations range from as low as 100 m amsl to Mount Everest (8848 m amsl), the highest peak in the world, which lies in the northern part of the country (CBS, 2001).

The country is divided administratively into five development regions and 75 districts. Village development committees (VDCs) and municipalities are the lowest local-level administrative units in each district. There are 3995 VDCs and 36 municipalities in the country.

Figure 3.1: Map of Nepal

The preliminary result of the 2001 census indicates that the total population of Nepal in 2001 was 23.6 million, and so only 25% of the total population holds land. Many of these people have difficulty in defending their rights, especially the rural poor and women. The female population accounts for 50% of the total population, and urban areas have 9.2% of the total population. Ecologically, Nepal can be categorised into three regions: mountain, hill and Tarai. More than 80% of the total labour force of the country is absorbed by the agricultural sector. Only 18% of the total land has been brought into operation for agriculture and 53% of these areas are mostly in the Tarai regions (CBS, 2001).

3.1.1 Land Management Practice

The land reform programme that was initiated in 1964 brought some simplification into the landholding system only in terms of *Raikar* (individual) and *Guthi* (trust) lands, breaking down the traditional land tenure system (Tuladhar, 1998). (This evolving nature of land rights is described in section 3.1.2.) But the simplified tenure rights, with constant struggles in the relationships between landowners and tenants, had no influence on securing land rights and therefore no far-reaching impact on capital formation in the agricultural sector. Despite the high-sounding objectives and policies, neither the landowner nor the tenant had any incentive to invest in improving land productivity. Tenants could not be evicted according to law, thus reducing landowner incentives. And the tenants did not have the ownership incentive to invest in the land. Also many of these land users/tenants were unable to gain adequate access to credit. Consequently, land reform did not adequately change the ownership incentive needed to improve agricultural outputs. Nor did the programme address issues of land taxation, which favours the rich and large landowners, who pay only nominal land tax.

The Land Resources Project Report clearly stated that land tenure was a major factor to be considered in the assessment of land utilisation. Land users or farmers would take the best care of land that they owned themselves, and would consider long-term investment to improve the productivity of such land (Carson, Nield, Amataya and Hildreth, 1986). On the other hand, if they have the rights of annual cropping via a landowner, they are uncertain of any rights as to reaping future benefits from any extra work they might do.

3.1.2 Land Tenure Systems

Land tenure can be defined as an arrangement of land holding, i.e. how land is held and used by individuals or institutions for economic opportunities (Henssen, 1995). Such arrangements are normally embedded in the ownership structures in the form of bundles of specific rights associated with the land, such that certain rights can be allocated for appropriate uses. Within the Nepalese context, however, the land tenure or ownership arrangement has evolved in many different forms, and the complexity arises from a lack of management capacity to implement such changes. Hence, traditional or customary land tenure in Nepal is often used in the remote areas. Let us now look at the land tenure forms of the past and present systems.

Historical Forms of Land Tenure System

Historically, state ownership has been the traditional form of land tenure in Nepal. The extensive use of the land by individuals acting in a private capacity and the emergence of intermediaries between state and the cultivators has obscured this basic character in recent forms of tenure system. This might be due to the fact that the state divests itself of ownership in favour of private individuals or institutions in a number of ways and under a wide variety of conditions (Regmi, 1978).

The administration of land dates back centuries. Geographical, political, cultural and economic constraints have always played major roles in the dynamics of land tenure. After the unification of Nepal in 1768, the political and cultural integration of people from different parts, with distinct feudal systems, was identified as a great task. Six basic historical forms can be seen as the major forms under which individuals or institutions could hold and use land in their capacity for economic opportunities (figure 3.2).

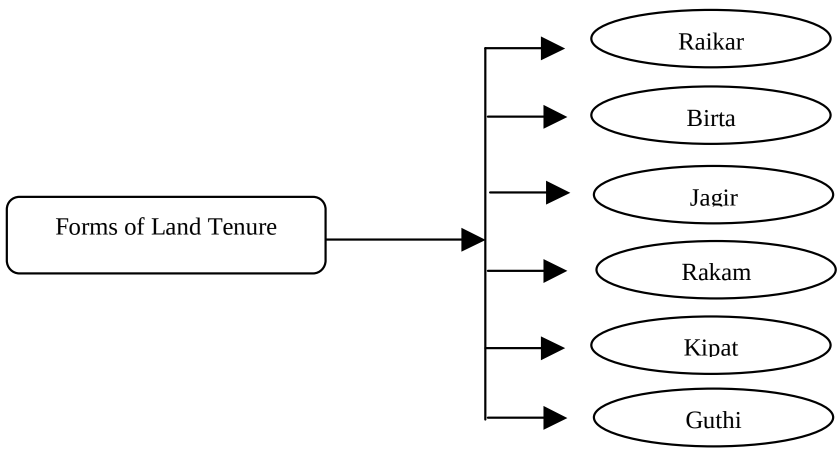


Figure 3.2: Historical forms of land tenure in Nepal

(a) *Raikar land:* The term *Raikar* is basically derived from the two words *Rajya* (state) and *kara* (tax). Raikar often refers to land that the state retains under its ownership while taxing the individuals who operate it. It also means the land on which taxes are payable by the landholders to the government representing the state, and such lands are registered in the official records (Regmi, 1978). Rights on such land are limited to occupancy rights vis-à-vis the state. After human labour and investment were incorporated in respect to land, occupancy rights emerged, with the result that land is inheritable and transferable. The rights on the land are recognised and secured for the purpose of utilisation so long as taxes are paid regularly. Raikar land transactions involve the transfer of occupancy rights, not of the land itself.

(b) *Birta land:* Divesture by the state of its ownership rights in favour of private individuals resulted in the emergence of the *Birta* system. Since a Birta comes into existence only after the state divests itself of ownership, private ownership of land is not an original right but the result of a specific grant by the state. Nevertheless, the law provides that if land has been used as Birta for a period exceeding 16 years on the basis of possession, it can be held even without the possession of documentary evidence. In this system, the state grants Birta lands to individuals to enable them to make a living through a financing transaction between the state and a private individual. Analysing this system, the Birta never carries absolute ownership rights because in many Birta grants restrictions are imposed on transfer or inheritance. The terms and conditions imposed in the Birta grants are so varied in character that it is difficult to see a systematic pattern. Although, in much literature, Birta landholders are not liable to pay tax, there have been indications that nominal tax was imposed in 1772. Later on, the Birta Abolition Act was introduced in 1959, indicating that the Birta system was to be terminated and all lands under this system were to be considered as Raikar lands.

(c) *Jagir land:* Until 1951 the state could alienate Raikar lands as emoluments of office to government employees. Such lands were called *Jagir* lands. In the past it was common policy for the government to pay the salaries of civil and military employees in the form of Jagir assignments as far as possible. Historical records show that such lands are found especially in Kathmandu Valley and the eastern and western hilly regions. After retirement or dismissal from the service, the land had to be returned to the state. This Jagir system led to many complications and was finally abolished in 1951.

(d) *Rakam land*: *Rakam* was similar to Jagir land but land was assigned as remuneration for the performance of a specific function, mostly manual in character. Right of use in such lands was held permanently and was inheritable provided the holder or heirs continued to perform the specific functions.

(e) *Kipat land: Kipat* was essentially a form of communal tenure in the eastern hills of the country. Only members of certain ethnic groups were permitted to hold land under this system. This was created to recognise and preserve traditional rights and privileges, with exemption from land taxation. A chief was the custodian of the land, but he would not be its owner.

(f) *Guthi land:* Land can be divested by the state to trust (*Guthi*) institutions for the purpose of charitable, religious and philanthropic activities. Raj Guthi can hold Guthi lands, which are always under state administration and are registered in the official records. Guthi lands are also owned by private Guthis for the performance of religious functions or family ceremonies, but they are not always registered in the official records. These Guthi lands can be assigned to the cultivators for generating income, which is used for the administration of Guthis.

Present Land Tenure System

Currently the pressure for suitable lands for various purposes is growing rapidly because of population growth, and the management of various land tenure forms has been challenged throughout the kingdom. Many legal efforts were made to convert the old systems into a uniform land tenure system during early 1950 and 1975. All lands were converted into Raikar land tenure, except Guthi land – for reasons of protecting cultural and religious traditions.

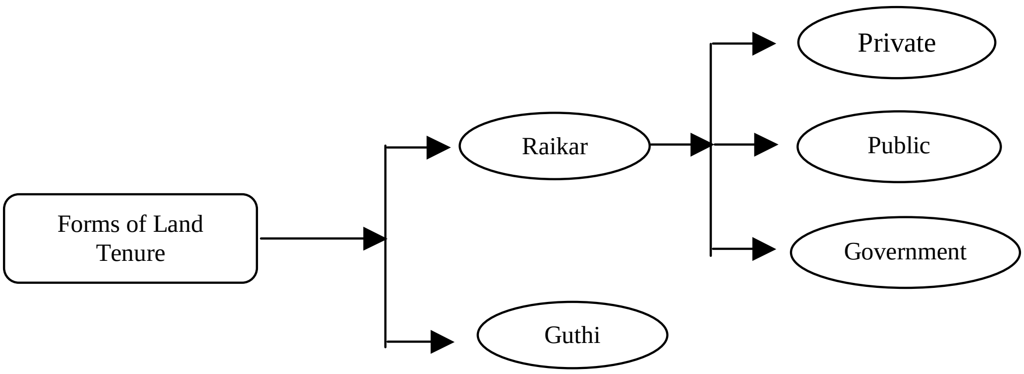


Figure 3.3: Present land tenure system

Figure 3.3 shows the present land tenure systems, which are governed by respective land acts within the framework of a land reform programme.

The basic understanding of Raikar is still state ownership. Nevertheless, the present Raikar tenure system allows distinct relationships between the landholders and the land through ownership providing a bundle of real rights, which can be held, used, inherited and enjoyed by landholders on the condition that they keep paying the tax fixed annually by the state. Raikar land can further be classified into private lands, public lands and government lands.

The rights on private lands can be held, enjoyed and used by individuals, private companies and institutions. The owner has the right of full enjoyment on the land, though in principle the relation between the state and owner is similar to the relation between a landlord and his tenant. Thus it is legally interpreted that individuals hold the ownership rights, which are granted by the state on the condition that they pay the tax fixed by the state, and can enjoy their land as absolute rights of freehold. The state can terminate an individual's legal rights on land under special circumstances:

- land for public purposes, but with due compensation
- non-payment of land tax
- convicted of murder by the court
- land above the ceiling
- if a dead person does not have any heir
- if mortgages are not paid back in the fixed period, land can be auctioned in public
- natural disasters causing diverse changes in the physical form of land

Until the year 1951, the rights of an individual over land were virtually non-existent. The landholder or occupier was considered as simply a tenant. The interim constitution promulgated in 1952 protected the citizens' full rights of using and occupying lands. Later, in the 1957 Land Act the term "tenant" was replaced by "owner".

Government lands are those lands used for roads, railways, government houses, offices, forests, rivers or streams and any uncultivated land to which the public have no claim or rights.

Public lands are those lands that not only one person and his family use but all persons use, on the basis of general consensus, for roads, playgrounds, lakes, and crematoria, or any such land where ponds, temples or public housing (where pilgrims and travellers are accommodated) are created, which is exempt from government land tax.

Trust institutions hold the ownership rights on Guthi lands, but the rights of use can be alienated to individuals under the conditions imposed by trust institutions. The conditions laid down in the contracts are such that the institutions can realise their charitable, religious and philanthropic purposes. Most such lands are agricultural lands. Therefore, such tenancy rights may be held and enjoyed by individuals /farmers who cultivate the land.

In Nepal, tenancy is the right to use land or property belonging to someone else and for which rent is paid. Regulation has placed clear obligations on the landowner to the benefit of the tenant. Landowners mostly leave the management of their estates to tenant farmers, who cultivate the land through their own or their families' hard work, and earn on the basis of an agreement with the owner of that land parcel.

In the early days in Nepal, land transactions usually took place among family members within their own communities (either by inheritance or gift). In such cases, information is rather symmetric. Those who hold transferable rights over lands can usually be identified by all members of the community/village. In city areas, with the advanced stage of development (more infrastructure and access) and the increased mobility of individuals, land transactions among individuals who are not members of the same community/village are now more frequent. As a result the scope for asymmetric information – and hence land disputes – increases. Despite the use of mediation techniques to resolve disputes, more than 40% of court cases can now be seen as land disputes.

The sample survey indicates that 0.3% of landowners are involved in annual transactions in remote and rural areas, while 21.8% are involved in transactions in (sub)urban areas of Kathmandu. These figures suggest that the extent of land transaction is very low in the remote areas, where few new individuals from other communities/villages go and purchase land. It is also possible that transactions in remote areas take place on an informal basis, without going to the district registry office, because people cannot afford the travelling and registration costs. But in Kathmandu Valley areas, the extent of transaction is high, owing to the growth in population and migration from the remote areas to the capital city. Here employment and other economic opportunities are high and people in the city can afford the transaction costs (Bhumichitra, 1996).

In recognition of the skewed distribution of land, inefficient agriculture products and the lack of credit, the critical issues that relate to fundamental property rights and the need for reinforcing the land reform programme are clearly set down in the Constitution of the Kingdom of Nepal 1990. This means that cadastre and land registration systems must function very well.

3.1.3 Institutional Framework

Various forms of institutions have existed for keeping land records and collecting land revenue at local level. Until 1964, His Majesty's Government (HMG) used the services of local agents such as *Mukhiyas, Talukdars, Zamindars* and *Patwaris* for registration, with the collection of taxes supervised by *Mal Addas* based at district headquarters. Later, with the introduction of the Land Revenue Act, the roles of such agents were discontinued because of the complex management problems in maintaining land records and tax records and of being unable to achieve the objective of land management.

Later on, in 1986, HMG established the Ministry of Land Reform and Management (MLRM), with a mandate to formulate and implement policies and programmes for land management and reform. Currently, there are four departments and one training centre at central level. The Department of Survey is responsible for the initial registration and cadastral surveying, while the Department of Land Reform and Management is responsible for maintaining land registry. Both the departments have further instituted offices in each district, with the aim of operationalising policies and programmes under the land acts, as discussed in section 3.1.4 below.

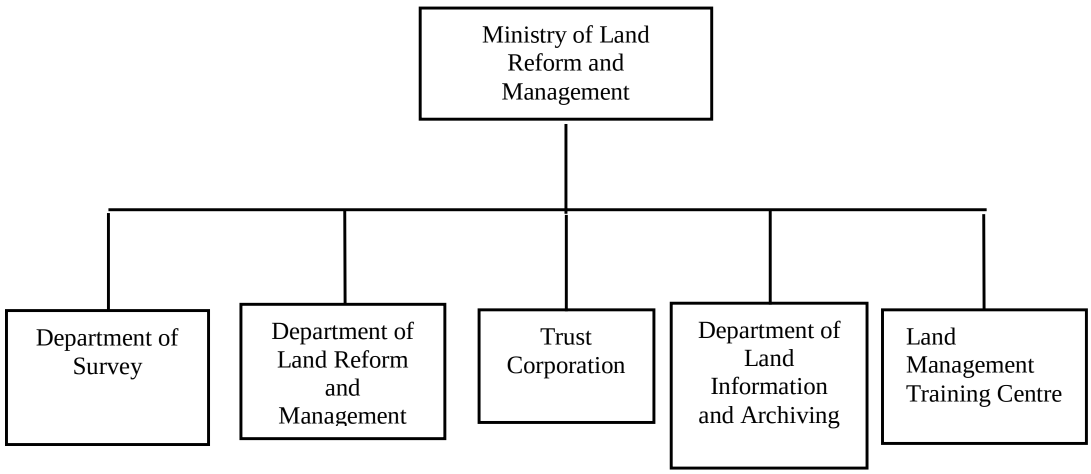


Figure 3.4: Organisations involved in land management in Nepal

The Department of Survey has three main branches: Cadastral Survey, Geodetic Survey and Topographical Survey (Survey Department, 1996). The duties of Cadastral Survey are to carry out adjudication of land ownership rights; identify and survey land parcels and owners; prepare cadastral maps; calculate areas of land parcels; classify land; prepare and issue the certificates of ownership through its district offices; and, finally, hand over the field books to the district office of the Department of Land Management and Reform for the maintenance of ownership information. As far as mapping is concerned, the District Survey Maintenance Office maintains the cadastral maps on a daily basis in conjunction with the district office of the Department of Land Management and Reform.

Geodetic Survey is responsible for establishing and maintaining geodetic control points throughout the kingdom. Topographical Survey is responsible for preparing and maintaining topographical mapping series at scales of 1:25,000, 1:50,000, 1:125,000, 1:250,000, etc., including an atlas of the whole country.

The Department of Land Management and Reform (formally the Land Revenue Office) is responsible for various kinds of land registration, regulated by the 1977 Land Revenue Act.

With respect to the Trust Corporation (*Guthi Sansthan*), the Ministry formulates policies and regulates the activities under the Trust Corporation (Guthi Sansthan) Act.

The Department of Land Information and Archiving is mandated to build and maintain a nationwide land information system (LIS) for the timely supply of reliable land information to all its users. Currently, the department is active in computerising land registration systems at district level. Lastly, the Land Management Training Centre has been established to build capacity in the land management programme throughout the country.

3.1.4 Legislative Framework

The following laws related to land ownership and tenancy currently govern the management of the present land tenure system:

- Mulki Ain (Common Law Codes)
- Birta Abolition Act, 1959
- Land (Survey) Act, 1962
- Land (Ownership and Tenancy) Act, 1967
- Land Administration Act, 1967
- Guthi Sansthan Act, 1967
- Land Revenue (Land Administration and Revenue) Act, 1977

Mulki Ain is equivalent to a common law and was widely applied before the Land Revenue Act for land administration was passed. After the passing of the Land Revenue Act, this law became ineffective. Because of the history of the Nepalese land system, the courts still refer to the law codes relating to the resolution of land disputes.

The main purpose of the Birta Abolition Act was to convert Birta land to Raikar land in order to promote the effective use of land, whereas the Land Act (relating to ownership and tenancy) was passed to implement the land reform programme and protect ownership and tenancy rights. The Guthi Sansthan (corporation) Act covers the administration and maintenance of Guthi land records.

Land (Survey and Measurement) Act 1962 was passed to enable systematic cadastral survey and maintenance in the country and to provide land information concerning land tenure to the various government and non-government agencies, as well as to individuals. These records of land information are authentic and replace any old existing information. They are also the basis for collecting land revenue in the country.

The purpose of the Land Revenue Act is to provide for reliable land transfer, by way of conveyancing, maintaining land records in accordance with the Land (Survey and Measurement) Act, collecting land revenues and resolving disputes (if any).

3.1.5 Financial Aspects

The daily operations of cadastral and land registration are fully financed by HMG of Nepal, at both the central and the district offices. Land revenue collected by the district offices goes to HMG Treasury. The Ministry of Finance allocates budgets yearly for running the various activities of departments within the MLRM. The financial sources for the current fiscal year comprise HMG Nepal, foreign aid grants and foreign loans. Currently, there is a foreign aid grant from the Government of Finland for the preparation of ortho-photos, and one from the European Union for several activities of the National Geographical Information Infrastructure Project (NGIIP) of the Survey Department. The Ministry of Finance manages the foreign grants and loans.

With regard to the procedures for financial decisions, the National Planning Commission determines, in line with government policy, the budget ceiling for the MLRM, based on the current fiscal year and with some increment in respect to inflation. The MLRM then notifies the departments concerned, with instructions to prepare the annual programme based on the allocated budget ceiling. Each department notifies its branch and project offices of the budget amount, with detailed instructions for preparing the annual programme. The draft programmes are then discussed and negotiated within the department, the MLRM and finally the National Planning Commission. If there are any differences in the policy and priorities of HMG programme, each department, branch and project office is instructed to make corrections accordingly. Finally, the Ministry of Finance looks after the budget for each budget section, negotiated as per their norms. This is, in most cases, the last stage, but sometimes, owing to the resources constraints of HMG, there may be deductions in the budget. A “Red Book” (i.e. budget book) is published after the budget announcement in parliament.

During execution of the programme, there is a chance that the allocated budgets may be exceeded or prove insufficient. If the budgets are not sufficient, the department takes action to reduce the number or content of programme items. This has to be approved by the National Planning Commission. The process begins from the branch or project office and moves up to the department, then to the Ministry, and finally to the National Planning Commission. If the budgets are exceeded, the excess is frozen at the end of the fiscal year.

3.1.6 Business Processes and Products

The rationale behind the cadastre and land registration is to introduce a uniform basis throughout the country for levying the land tax and implementing land reform policy (Shrestha, 1981). The systematic compulsory land recording has been done at district and local administrative levels. Almost all land parcels have already been covered by cadastral surveys with a simple survey by a plane table survey. Owing to its simplicity, it was possible to decentralise its operations to the district and local administrative levels. It is estimated that there are 81,223 maps at scales varying from 1:500 for urban areas to 1:2,500 for rural and large parcel areas. There are about 44,125 *moths* (land ownership registers). The cadastral survey method is purely a ground method, using a graphical technique with a telescopic alidade on a plane table and a metric staff. Not all maps are geo-referenced to the national geodetic framework system (Shrestha, 1999).

Initial cadastre and land registration is the responsibility of the Survey Department. The process steps are:

- Cabinet decision
- notification by means of newspaper, radio and television
- adjudication, demarcation, surveying, land classification and mapping
- preparation of cadastral maps and field books
- preparation of other registers and statistics
- issuance of initial landowner certificates
- supply of land registers to district land revenue office for levying tax and further land transactions
- establishment of district maintenance survey office for continuous maintenance of cadastral maps

The land register is composed of cadastral maps, cadastral records, tax registers and unregistered parcel records. Cadastral maps contain geodetic control points, parcel numbers, boundaries (parcel, ward, local village, district, zone, region and international), man-made objects (buildings, walls, fences, roads, telephone lines, power lines and water objects), vegetation (forests, orchards/nurseries, trees and plantations), water bodies (rivers, streams, lakes, canals, tube wells, natural water sources) and public services (parks, temples, mosques, post offices, police stations, hospitals and schools).

The cadastral record, called the field book, is a record of all the individual parcels of land contained in one map sheet. All land parcels are numbered consecutively. The landowners are identified by the tax receipt they produced as evidence of ownership. Their names, along with father's name (or husband's name), address and age, are recorded in the field book. No other evidence of legal rights is sought. If there are any tenants on any land parcel, their names and addresses are also written down. Parcel sizes and land use types are also recorded.

The tax register, popularly known as the "land ownership register", is kept in a loose-leaf binder, and is meant for collecting land tax. It contains all the land parcels of a village. The register is indexed by means of the parcel number.

Unregistered parcels are compiled from field books on loose sheets. Unregistered parcels are those parcels where the claimants remain absent and have not produced tax receipts and the village representative has not attested on their behalf. The records also include all government and communal land.

The District Land Reform and Management Department, in association with the District Survey Maintenance Office, handles further land transactions. Full transfer of land ownership can normally be done within a day if there are no subdivisions and no complications (such as mortgages, restrictions) regarding the land ownership certificate.

Once the field survey is completed, another book, called *Teris*, is prepared on the basis of the owner's name. A certificate of ownership (usually called *Lal Purja*) for each parcel is prepared and issued to each landowner, and a copy is also sent to the District Land Revenue Office (see appendix 3 showing a sample land ownership certificate).

Once the survey party completes their work in a district, the party moves to another district. All land records, such as the field book and Teris, are given to District Land Revenue Office, which maintains them using the ownership registry, called the *Shresta*. All cadastral maps are given to the District Survey Maintenance Section attached to the District Land Revenue Office. When parcels are to be subdivided, this survey section does the fieldwork and updates the cadastral maps, using a register called the plot register.

General Procedures for the Transfer of Ownership by Sale

A request to transfer ownership by sale should come with the duly filled-in deed, together with all the necessary documents, such as the land ownership certificate, tax payment receipt and copy of citizenship certificate. A sample deed/registration form translated to the English language is shown in appendix 2. The Land Revenue Office, where it is checked against a set of rules, receives the deeds. The office checks for the necessary information that needs to be supplied with the deed. In other words, the application is checked for its completeness. If it is found to be incomplete, the applicant is informed, giving reasons. A completed application is then checked to verify if the information mentioned in the deed complies with that in the ownership register. In other words, the deed is checked for its correctness. If verified and the restrictions are checked, a token is given to the applicant. If it involves parcel subdivision, the deed is sent to the Survey Office. The parcel is subdivided in the field and the geometry of the parcel is updated in the database of the Survey Office. The deed is then sent back to the Land Revenue Office, where the valuation of the parcel is done and the registration fee is collected from the applicant. The registration fee depends on the value of the parcel. Once both parties give their consent, the deed is finally approved. The deal is then recorded in the main register and the ownership register is updated. The ownership certificate is prepared and given to the new owner of the parcel. The deed is then archived and the whole process comes to an end. The general procedure is shown in figure 3.5 (drawn using the activity diagram of UML notations).

The following are the main characteristics of the improved deed registration system.

- Registration of transfer of ownership is compulsory by law, using standard forms as deeds, duly signed by all parties involved in the transaction. This also avoids the expensive involvement of notaries and lawyers.
- Connection between cadastral maps and land registers is established using the unique land parcel numbers maintained by the District Survey Maintenance Section.
- Land laws regulate land transactions.
- Restrictions and mortgages are checked before finalising the land transaction.
- Registration can be done in any district office.
- The ownership certificate is evidence for issuing citizenship and capital investments and credits.
- Land registers are open to the public.

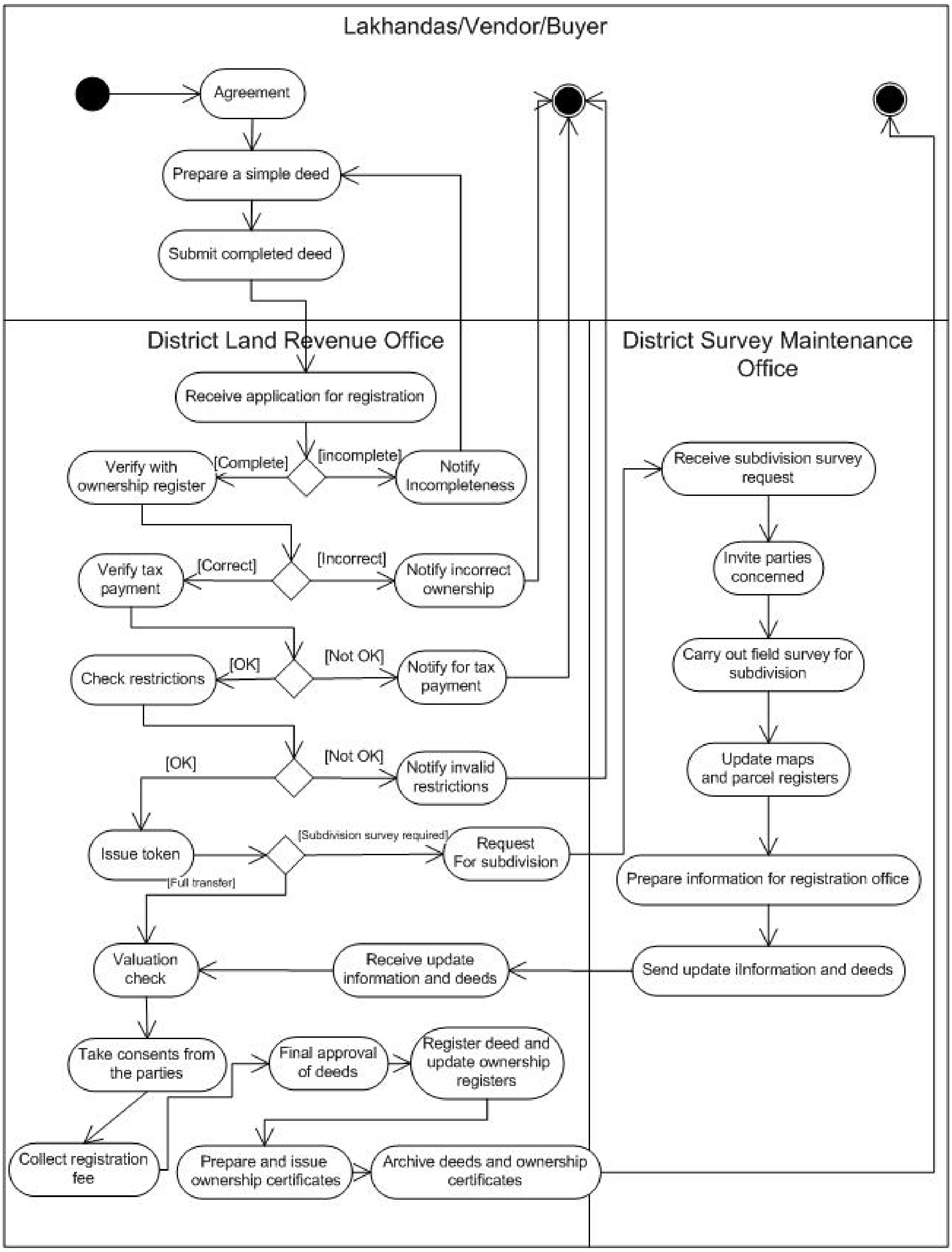


Figure 3.5: General procedure for transfer of ownership

Transaction Rules

According to Ghimire (1987), the rules for the transfer of ownership are:

(a) Deed must be duly filled in and contain the following information:

i. details of both parties, such as name, address, father's name, grandfather's name
ii. details of the parcel, such as parcel number, area, type of right to be transferred, neighbouring parcels
iii. area should be mentioned both numerically and alphabetically
iv. details of *Lekhandas* (person authorised to fill in a simple deed), such as name, address, professional registration number
v. Normally the buyer must pay money (in cash) to the seller for the price of land in front of land registrar and witness.

(b) The following documents should be attached:
i. land ownership certificate of the parcel to be sold
ii. copy of buyer's citizenship or land ownership certificate
iii. tax payment receipt
iv. details mentioned in the deed must comply with the content of ownership register (e.g. to ascertain that the seller corresponds to the real owner in the register (Shresta) or that the parcel really exists in the field)

(c) Parcel cannot be sold under any of the following conditions:
i. if the parcel has any restrictions; a restriction may have been imposed for many reasons (e.g. court order, or Cabinet decision)
ii. if the owner has more than a specified amount of land (i.e. more than ceiling)
iii. if it has a mortgage

Land Classification

Since the cadastre and land registration is mainly to raise land revenue, land valuation and taxation are based on land classification and the areas of land parcels in Nepal. Criteria for classifying land parcels are different for different sectors. Three sectors have been used for the whole country, namely the urban sector, the Tarai and valley sector, and the mountainous sector. In the urban sector, a committee comprising a survey officer, a tax officer and a representative of the municipality has the responsibility for land classification, while the Department of Survey is responsible for the other sectors. Details about land classification are provided in Appendix 1.

The land classification scheme is quite rigorous, and requires a lot of information on land parcels to decide on the land tax. Moreover, there is no adequate process for assigning the land classes that is carried out by the committee or the Department of Survey.

Land tax is based on flat rates on the basis of the above land classification. The government decides these rates. There is no official land valuation system in Nepal except ad hoc valuation for compensation during expropriation.

3.1.7 Computerisation of Land Records

In 1993, HMG started allocating its resources to introducing information and communication technology (ICT) in land administration in Nepal. A unit called the Central Integrated Land Information System was established within the Department of Land Revenue under the MLRM. The focus was to computerise the alphanumerical data on the cadastral parcels, and this was to be managed by the district land revenue offices. It continued until 1995, when the Council of Ministers set up a new project, the Integrated Land Information System (ILIS), directly under the MLRM. The intention of the change was to incorporate the spatial aspects of land administration data, which was, and still is, managed by district survey sections.

In 2000, the Council of Ministers decided to establish a new dedicated department called the Department of Land Information and Archiving (DoLIA).

Over the last decade, the MLRM has undertaken a number of initiatives/activities to modernise the land administration according to the needs of Nepalese society. In a broad sense, the progress of the PBGIS project based on ICT in Nepal is seen in three consecutive periods based on the national plans: the initial period (1993-1995), the intermediate period (1996-2000), and the post-period (2001 - 2002), after establishing DoLIA. Table 3.1compares twelve elements, which are considered to be the important factors in building a PBGIS.

Element	Period (1993-1995)	Period (1996-2000)	Period after establishing DoLIA (2001 - 2002)
Government policy	Eighth national plan (1992-1997) Envisions computerisation of land records	Ninth national plan (1997-2002) Computerises land records and maps with simplified procedure	Tenth national plan (2002-2007) Priority on the accessibility of services through computer-based system
Scope of the task	To computerise non-spatial aspects of cadastral parcels	To computerise both non-spatial and spatial aspects of cadastral parcels	Build PBGIS and develop the central archives of land records
Implementing agency	Department of Land Revenue of MLRM	Land Information System Project (LISP), within MLRM	DoLIA
Coordination	None	None	Council of Ministers (Cabinet) decision for steering committee under MLRM Minister's chairmanship
Human resource development	40 technical positions were created and people recruited	No recruitment but local training was organised, creating awareness at different levels	New department was established with 21 technical and 17 non-technical positions, including the director general.
Budget	Not known	US$ 0.565 million	US$ 0.535 million
Foreign assistance	None	Swedish's (1999-2002) support basically for the transfer of technology and experience	Swedish's support continued till March 2002
Research and studies	Computerisation of land recording system in Nepal by Spice Info Tech	- Detailed study report on developing an integrated land information system in Nepal - Design and development of District Land Information System (DLIS)	Swedish consultants in certain aspects of PBGIS. DoLIA staff together with the local consultants have carried out various studies
Software development	National Computer Centre developed application software for the non-spatial data	Developed District Land Information System (DLIS) software	Refined the DLIS software and developed customised application to handle the spatial aspects of LIS
Data capture	Started in few districts	Just continued	Use of private companies
Data sharing	None	Discussion started	Understanding with Kathmandu Metropolitan City
Awareness and understanding	Not that high as it was just the beginning	Increased level of awareness	Significant understanding about the complexities in building and operating PBGIS

Table 3.1: Overview of efforts towards building PBGIS

In the survey offices of the Survey Department, moderate resources have been deployed for the staff's hands-on practice in order to develop their skills. The task of data conversion has not really started, owing mainly to the lack of required human resources. There is also an activity to scan and store the cadastral maps for archiving purposes.

Thus, the efforts in building a PBGIS have not been as successful as expected. Over a period of about ten years, however, there have been certain encouraging developments and an increase in understanding regarding the underlying issues and complexities. The time has now come for an extensive review of the way the department has been managing the resources to build and operate LIS. It is realised that the past efforts have been ad hoc and have seriously lacked structured planning and clear strategies (Tuladhar, BC and Budhathoki, 2002).

3.1.8 Involvement of Private Enterprises

Recent amendments to land revenue and land survey acts allow private survey enterprises to carry out the cadastral survey work in the field. The Survey Department, as the national mapping agency, is beginning to adopt a new approach, involving licensed surveyors in survey and mapping work on a partnership basis. This is important, particularly owing to the lack of resources, communication, and the lack of a matrix organisation culture in the public sectors (Acharya and Chhatkuli, 2004). To deliver reliable services and products, the Survey Department is taking a leading role in the National Geographical Information Infrastructure Project in Nepal.

3.2 Bhutan Land Management and Registration

The Kingdom of Bhutan is located in the south-eastern Himalayas. It is a small landlocked country bordered by the Tibetan region of China and the Indian states Sikkim, West Bengal, Assam and Arunachal Pradesh. The area of the country is 46,500 sq km and its population was around 600,000 in 1996 (RGoB, 2000). Most of the people are Buddhists of Mongoloid origin, with a distinctive culture and language.

Topography ranges from an elevation of 200 m in the foothills (the southern part of the country) to an elevation of more than 7000 m. The country can be divided into three distinct zones. The southern sub-tropical zone lying along the foothills gets heavy monsoon rains and is covered by dense broad-leaved tropical vegetation. These areas extend up to a height of 1800 m and about 55% of the total population is settled here. The central mid-mountain areas (ranging from 1800 m to 3500 m) get moderate monsoon rain and are covered by coniferous vegetation. About 40% of the population is settled in this zone. The third zone is the alpine zone lying above 3500 m, which is composed of alpine grasslands, scrub, perpetual snow and glaciers. This is also the seasonal home of the nomadic yak and cattle herders (Ministry of Planning, 1996).

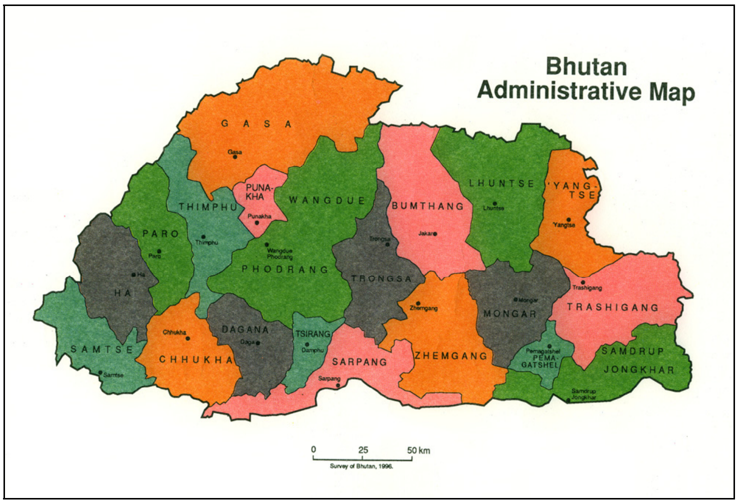


Figure 3.6: Map of Bhutan

Forests of fire, mixed coniferous, temperate and broadleaf species cover 72% of the country. As Bhutan’s flora have remained undisturbed, 26% of the country is considered to be nature parks and reserves, which form havens for a number of the world’s rare and endangered species.

In Bhutan, the area suitable for agricultural production is limited, mainly by the very steep terrain and by altitude. The river valleys and flatland in the southern foothills account for most of the fertile cultivable land, whereas the northern alpine belt below the snowline is suitable only for pasture. The most recent estimates suggest that 7.8% of the total land is used for agricultural production, including dry land and irrigated crop production and orchards. Most rural households also own livestock, which are grazed in the forest areas and on pastures.

Most Bhutanese live in villages in an extended family system or maintain strong links with their rural families. Thimphu in western Bhutan is the capital. About 90,000 people are estimated to live in the urban areas. The other main urban settlements are Gelephu, Phuntsholing and Samdrup Jongkar, all of them in the south. In Bhutan, there is no clear distinction between urban and rural settlements; 44 settlements are considered as urban.

Eighty-five percent of the population live in the rural areas and derive a living from agriculture and other traditional rural activities. In 1985, agriculture contributed 54.9% of the gross domestic product, while in 1995 this had declined to 38%. This low output may be attributed to the small size of fragmented farms, unsuitable agricultural practices, poor water management, shortage of arable land and the lack of an adequate land management programme. There is a wide range of agricultural land uses, owing to the climate and topographical variations (Ministry of Planning, 1996).

According to the land acts (Royal Government of Bhutan, 1991), the most important land use classes that are usually applied in cadastral and land registration are:

- *Chhuzhing* (wet land or paddy fields)
- *Kamzhing* (dry land)
- *Pangzhing* (land for shifting cultivation)
- *Sogshing* (forest land with right for collecting firewood and leaves for manure)
- *Tshamdo* (grazing land with grazing rights)
- Other types, such as orchard and cash crop

3.2.1 Institutional Framework

His Majesty King Jigme Singye Wangchuck, fourth in the Wangchuck Dynasty, is head of government. The National Assembly, the Royal Advisory Council, the judiciary, the Council of Ministers and the sectoral ministries are the organisations that play a crucial role in the governance of the Kingdom of Bhutan.

The kingdom is divided into 20 *Dzongkhags* (districts). Some large Dzongkhags are further subdivided into *Dungkhags* (sub-districts). The Dzongkhags or Dungkhags are further subdivided into 196 *Gewogs* (blocks), and each Gewog consists of towns and villages (Tshering, 1993).

The establishment in 1982 of the Dzongkhag Yargye Tshongchungs (DYTs) (district development committees), followed by further decentralisation to Gewog level with Gewog Yargye Tshongchungs (GYTs) (block development committees), ensures people's participation in the decision-making process. Dzonkhags are governed by *Dzongdags*, who function as the chairmen of the DYTs, and Dungkhags by *Dungpas*. The Gewogs are administrated by *Gups*, who are elected by the community and who also function as the chairmen of GYTs. The Gups assist the Dzongdags and Dungpas in collecting taxes, mobilising the workforce for community services and public construction, settling disputes, and dealing with many other local activities, including the implementation of the development programme (Ministry of Planning, 1996).

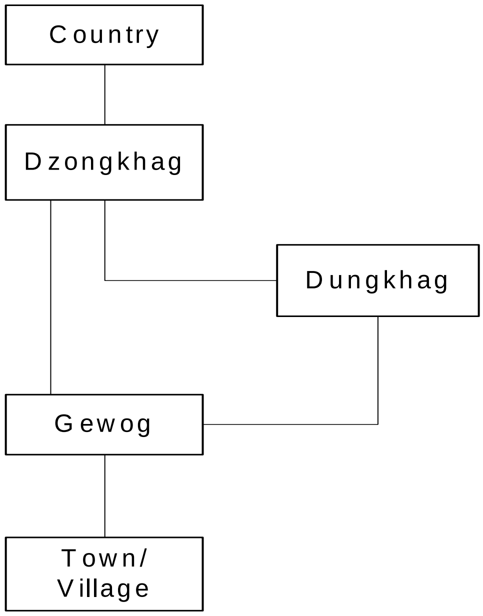


Figure 3.7: Administrative units of Bhutan

The central government consists of eight ministries and respective divisions, five commissions, the army, the police and several autonomous bodies. The ministry that deals with Dzongkhag administration, cadastre and land registration, besides other functions, is the Ministry of Home Affairs. It has five divisions: the home secretariat, planning and coordination, law and order, registration, and the Survey of Bhutan.

The Survey of Bhutan is responsible for geodetic control, topographical and photogrammetrical activities, cartography (including the printing of maps), cadastral surveys and the maintenance of land records.

3.2.2 Land Tenure Systems

Historically, the God King Shabdrung Ngawang Namgyel, who was the spiritual ruler of the 17th century, first established a formalised land tenure system after he conquered all the petty rulers. He brought all the land of the nation under a unified system. He set up a legal basis for land tenure, recording all land rights, known as *Marthram Chem* – a centrally maintained land record. During that period it was strictly for the purpose of land taxation.

The current legal system is still based on codes laid down by Shabdrung. Land rights are basically comparable to freehold rights. The owner can possess land and exercise his freedom of use, acquisition or sale of the land, with adherence to certain legal constraints. Various forms of trust land exist, where communities and religious institutions are given the right of use. Leasehold is also practised without registration at the land registry office. Land can be acquired in the following ways in Bhutan:

- sale/purchase of land
- exchange of land
- new allotment by the government
- inheritance
- gift of land

The legal basis for cadastre and land registration is the 1979 Land Act, which is an amendment to the 1957 Registration Act. All land owned by private individuals and communities is registered in the land register maintained centrally at the Office of Land Records in the capital Thimphu. Other land not registered is considered as state land and constitutes more than 80% of the country's total area (Royal Government of Bhutan, 1991).

3.2.3 Legislative Framework

All laws in Bhutan are codified. The 1979 Land Act, with some supplements, and the 1969 Forest Act of Bhutan form the basic legal framework for land registration. To possess and use land legally, individuals must have a registered *Thram*. A Thram is an inventory of individual land holdings owned by a single household. A household can hold only one Thram and a unique number (the Thram number) is assigned to the Thram. The Thram establishes ownership rights and has strong legal effects attached to it regarding how land can be utilised and under what conditions. The copy of the Thram, usually known as *Lagthram* or *Lagkhar*, is normally issued to the landowners by the Land Record Office under the authority of the Ministry of Home Affairs. The following land issues are dealt with in the Land Act:

- registration of land in the Thram
- validity of Thram and entitlement to land
- right of possession
- cost of land and taxation
- sale/purchase and exchange of land
- government land and procedure for allotment
- water channels, embankments and roads
- grazing land
- *Tsatong* and its allotment
- cultivation of land
- compensation for crops
- encroachment of land

- procedure for donating land for religious purposes

3.2.4 Registration Systems and Land Registers

In Bhutan, the registration of rural and urban lands is handled separately. For all rural lands, registration must be completed at the Land Record Office of the Survey of Bhutan through the offices of the Dungkhag and Dzongkhag. Urban lands are registered with the respective city corporation under the Department of Urban Development and Housing via the Ministry of Social Services, and should be registered through the respective offices of the Dungkhag and Dzongkhag.

To cover the whole country by cadastral maps and *Marthram*, the Government of Bhutan has three main processes: the initial registration process, the land transaction process and the new allotment process.

Initial Registration and Cadastral Process

This process systematically covers the country Dzongkhag by Dzongkhag by adjudicating ownership rights and rightful landholders, and by surveying individual private land parcel boundaries. All records are centrally stored in the Land Record Office of the Survey of Bhutan. These land records covering the whole country are known as Marthram. In this initial process, it appears that there are 14 activities carried out by three authoritative bodies, namely the Ministry of Home Affairs, the Survey of Bhutan and a committee (or adjudication body) representing the Ministry of Home Affairs, the Dzongkhag, the Dungkhag, the Gewog, the public (rightful landholders), the Survey of Bhutan and the Forest Office.

The main aims of this systematic registration and cadastral process are to ascertain land rights and rightful landholders, supported by cadastral maps with the correct areas, and to record them correctly in the Marthram. The detailed process activities are modelled in a UML activity diagram and shown in figure 3.8.

(a) The Ministry of Home Affairs identifies Dzongkhags and assigns them for initial registration and cadastral survey. It then gives the order to the Survey of Bhutan to carry out further activities.

(b) The Survey of Bhutan draws up an implementation plan and announces the activities in the relevant Dzongkhags on national radio and in the newspapers to ensure maximum cooperation from the citizens resident in the local villages during the investigation and survey work.

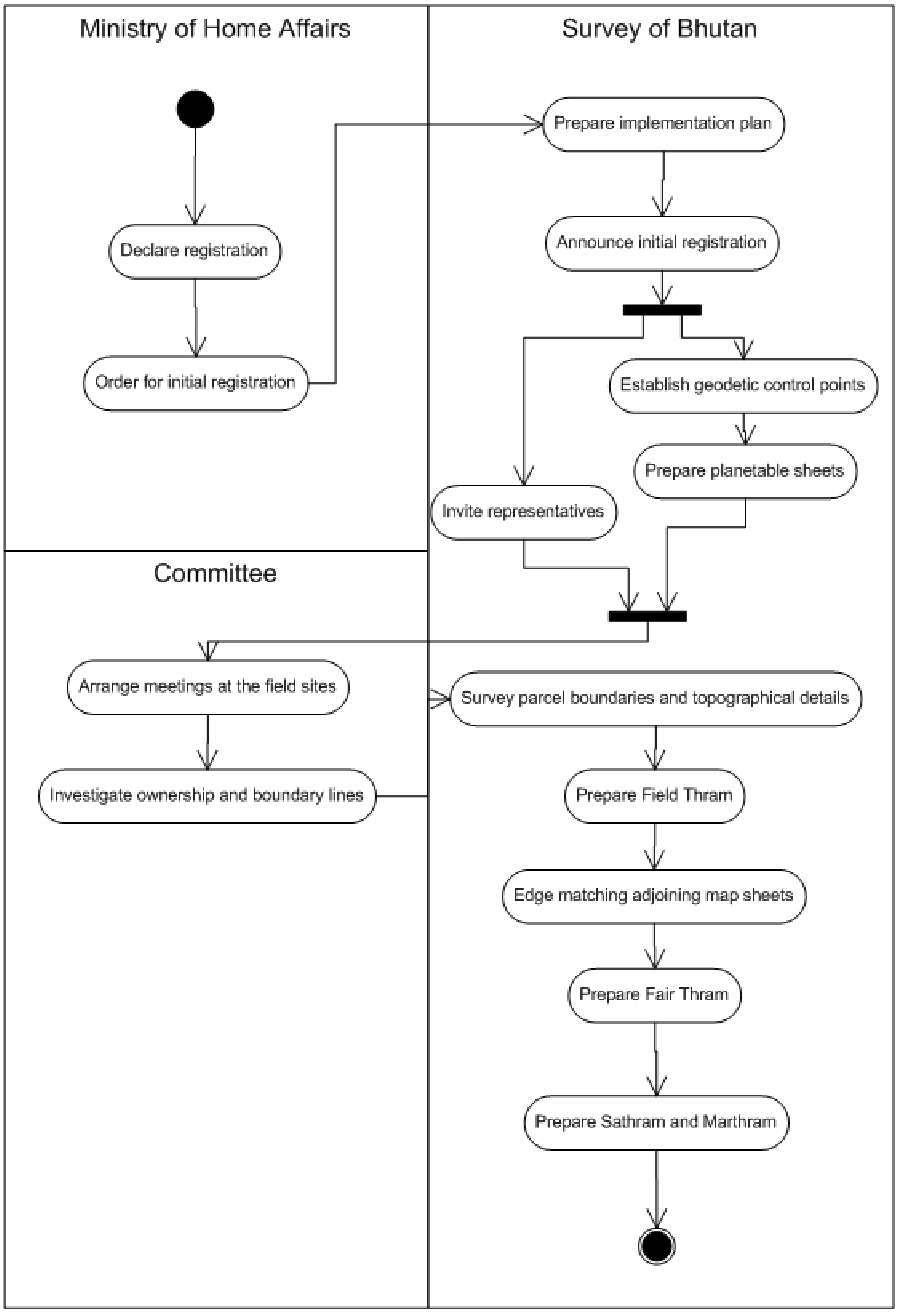


Figure 3.8: Activities in the initial registration and cadastral process

(c) The Survey of Bhutan establishes enough geodetic control points for each cadastral map sheet by using conventional triangulation and traversing methods. Control points are permanently marked and entrusted to local authorities for preservation and security for future reference. It then prepares white plane table sheets in the grid projection systems, and the ground control points (GCPs) are plotted on the sheets.

(d) The Survey of Bhutan invites the committee to the field sites. The committee consists of representatives from the Ministry of Home Affairs, the Dzongkhag, the Dungkhag, the Gewog, the public (rightful landholders), the Survey of Bhutan and the Forest Office.

(e) The committee investigates ownership by checking all documents: the certificate of ownership (*Lakher*), the national identity card, and other documents such as letter of grant, tax receipts, etc. The committee also decides on the land parcel boundaries in case of disputes.

(f) Surveyors from the Survey of Bhutan carry out survey work on all land parcel boundaries, using the plane tabling technique, and they compute the area of each landholding parcel. They are also responsible for verifying that there has been no encroachment on government land, and for seeing that there have been no illegal conversions. They also verify all the documents approved by the committee with their copy of the *Sathram*.

(g) The surveyors record the information in the Field Thram (basically field records). The information normally recorded is (i) the names of the Dzongkhag, Dungkhag, Gewog and village; (ii) Thram number, name of person, ID number and father's ID; (iii) map sheet number, plot number and areas of plots, and (iv) name of land, type of land, grade of land and number of bunds. The landowner approves all the above information by signing the Field Thram.

(h) In addition the surveyors survey some important topographical features, such as rivers, prominent natural water features, different classes of road, tracks, culverts and bridges, electricity lines, telephone lines, telegraph lines, buildings, temples and administrative boundaries.

(i) Edge matching between adjoining cadastral map sheets is carried out to make sure that there are no spatial inconsistencies in edge and attribute information.

(j) Then the Field Thrams are compiled by the surveyors to prepare a Fair Thram per Dzongkhag and this is checked by settlement officers of the Land Record Office and camp officers.

(k) Finally approved Fair Thrams are then established as the Sathram of each district. And the Marthram covering the whole country is established.

In the above process, apart from the individual Thrams, there are four other types of Thram. The Field Thrams and the Fair Thrams are the working land registers created during this process. The Field Thram is an inventory of individual land holdings that is compiled by surveyors per cadastral map sheet. The Fair Thram is an inventory compiled from the Field Thrams for a Dzongkhag. The Sathram is a Fair Thram attested by the Land Record Office and legal register. Copies of Sathrams are also kept at the Dungkhag and Dzongkhag offices. The Marthram is the master land record, which is the centrally located Sathram for the whole country at the Land Record Office in the Survey of Bhutan. Legally, any forms of land registration or land transfer must appear in the Sathram and Marthram, consistent with cadastral maps.

Land Transaction Process

According to the 1979 Land Act, all forms of registration, such as sale/purchase of land, inheritance, free gift, exchange of land, newly allocated lands by the government, must be registered in the individual Thram at the local court of the Dzongkhag/Dungkhag office. Then it must be registered at the Land Record Office, Survey of Bhutan, with the approval of the Ministry of Home Affairs.

(a) Sale/Purchase and Exchange of Land

Interested parties submit an application, with agreement for registration, to the local court of the Dzongkhag/Dungkhag. For 30 days, the local court investigates applications for legal ownerships, with an enquiry in writing to the local Gup. If there are no objections to legal ownership from the Gup, applications are then considered legal. The court then charges 5% of the cost of the land as sale tax; however, no tax is charged for the exchange of land.

Then the local court forwards the approved application to the Ministry of Home Affairs for registration at the Land Record Office, which updates the Sathram. After the Thram, Fair Thram, Sathram and Marthram have been updated, the relevant Gewog, Dungkhag and Dzongkhag are advised of the changes and consequently update their local Sathrams. Then a Lagthram is prepared and issued to the individual household owner.

Figure 3.9 shows an activity diagram. It suggests that there are at least 16 activities involved in the process of land transfer by sale/purchase and exchange. In this process, the 1979 Land Act indicates the following rules that must be observed by the concerned parties (seller and buyer) while executing a land transfer.

A member of a family possessing 25 acres of registered land, excluding pasture, *Sokshing* and orchards, cannot purchase any other land. If anybody buys more than the ceiling of 25 acres, the excess land is confiscated without payment and the amount equivalent to the cost of the land will be charged as a fine.

Nobody can purchase land from a family member possessing only five acres of land. If somebody buys this, the land has to be returned to the original owner and the money is returned to the buyer. Both seller and buyer must pay the government an amount equivalent to the cost of the land as a fine. Land donated to monasteries or state-owned land is not allowed to be sold or purchased in any situation. Once land has been purchased, all taxes will have to be paid by the buyer from the date of purchase.

If two or more families own a plot of land jointly and one family wants to sell its share of the land, it cannot do so without obtaining the consent of the joint owners. Unless separately registered in the Thram, a plot of land given as a share by a parent cannot be sold in part or in full without the permission of the parents as long as they live. In the case of a married couple living together with or without children, only a spouse who is in possession of land before the marriage, or has been given land by the parents or has inherited it from the family, has the right to sell the land. The spouse who does not possess the land cannot do so without the consent of the spouse who is the rightful owner.

(b) New Allotment of Land

According to the 1979 Land Act, there are two possible ways in which new land can be allotted: first by His Majesty the King, who can allot the type of land *Soilra* as a reward, and secondly by the government. In both cases, the citizens who receive the new lands must forward the original allotment letters to the local court (*Thrimkhag*) to be registered in their Thrams. Subsequently, they should be registered at the Land Record Office via the Ministry of Home Affairs.

(c) Inheritance

Land acquired through inheritance should be registered on the basis of an official agreement executed between the inheritor and the inheritee on a legal, stamped document. The agreement is then submitted to the local court for registration at the Land Record Office.

(d) Gift

When a piece of land is given as a gift, the one giving the land should draw up a document stating the facts, which should be attested by not less than two witnesses. After the legal stamps have been affixed, the document, with signature or thumb impression, should be submitted to the local court for registration.

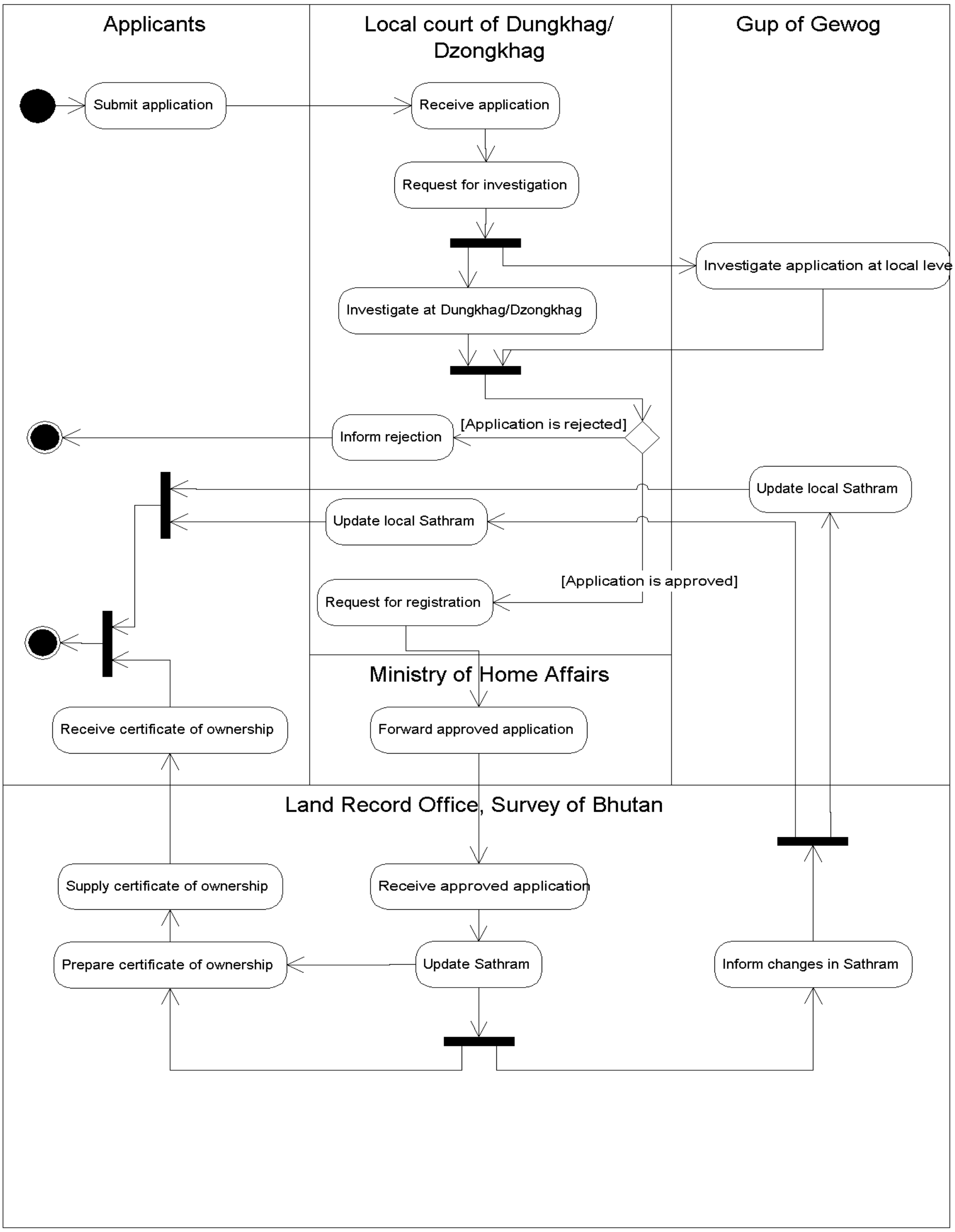


Figure 3.9: Registration regarding sale/purchase and exchange of land

Aged/Sick/Disabled Persons and Minors

If anyone is unable to come to the Dzongkhag office because of old age, sickness or disability, the agreement can be executed in the village under the guidance of the Gup of the Gewog and should be forwarded to the Dzongkhag/Dungkhag, along with a certificate from the person concerned stating they have no objection to the legalisation of the transaction.

Land cannot be registered in the name of minors (males under 18 years and females under 16 years). However, if it becomes imperative to register land, a legal document has to be prepared, giving details of the person to be registered. If a person has passed away leaving behind minors, then without any documents the land can be registered in the names of the minors.

Rules Regarding Use of Landed Property

For the benefit of landed properties, the 1979 Land Act allows the owners to construct new irrigation channels, embankments and roads on the existing alignment. Permission should be obtained for such renovation work from the local court, and the work should not obstruct the accessibility of other properties. Water from an irrigation channel should be shared based on mutual understanding or existing practice.

Grazing land is used for grazing and watering horses and cattle from a particular village. Such land, if not registered, should be registered in the Thram of the community of that village. Such land can be taken by the government for public use but cannot be allotted to any private individuals.

Tsatong is a special kind of land. If a person with land registered in the Sathram has passed away and all members of his family have also passed away and there is no claimant to the land from that family, such land is considered to be Tsatong. This is equally valid for a person leaving the country. The government must decide on a new allocation of such land.

Land acts set out very strict rules on agreements or contracts for cultivating land or share-cropping. Both parties must agree on the duration and conditions.

The procedure for donating land for religious purposes is as follows. Any rightful owners can offer their land for religious purposes within the country. Before making such an offer, complete documentation with the approval of family members must be submitted to the local court. Once it is donated, the responsibility for its use lies with the Dzongpen.

Land Valuation and Taxation

In principle, the Sathram is the basis for land valuation and taxation collected by the Dzongkhag. As such the Land Act does not provide any basis for valuation and taxation. In the case of expropriation, ad hoc valuation is usually carried out. The assessment is normally fixed on the basis of land use classes for those lands that have been classified. For others, the government fixes a nominal rate.

3.2.5 Surveying and Mapping

Cadastral surveying is based on ground survey techniques using a plane table and a telescopic alidade that allows the surveyors to apply slope correction on hilly terrain. Activities are similar to those shown in figure 3.8 for initial registration.

GCPs are established and measured by conventional triangulation and traversing methods. GCP coordinates are computed on the basis of the Lambert Conical Orthomorphic Projection system. These GCPs are plotted on stable material sheets (usually paper with cloth). These points are then used to locate the surveyor's strategic positions by resection. From these points, the boundaries are measured by reading the intercepts on a graduated metric staff through the telescopic alidade placed on the plane table. Using these readings and slope angles, the horizontal distances can be computed and plotted directly in front of the landowners.

Currently two survey scales are adopted: 1:5,000 and 1:2,500. The large-scale 1:2,500 is used in districts where the average plot areas are small, the value of land is high and in general the population is high. The plane table sheets are 3 km x 2 km for scale 1:5,000 and 1.5 km x 1 km for scale 1:2,500.

3.2.6 Computerisation of Land Records

The computerisation of land records started at the Land Record Office, Survey of Bhutan, in 1991, under the guidance of SwedSurvey experts. The main goals are to simplify the work as much as possible, to make services transparent to users, to minimise the amount of paperwork, and to retrieve various kinds of data (Dorje, 1999; Tshering, 1993).

In the process of computerisation, all cadastral maps, which are in analogue form, are digitised manually using a digitising tablet, and stored in databases of Autoka software. The textual data from Thrams are manually stored in a database of MS Access software. Both databases are linked through unique parcel numbers. The system can retrieve, update and maintain the databases. With the available functions it is possible to:

- digitise cadastral maps
- enter and update new ownership information from Thrams
- display and print certain Thrams and holdings
- display plots situated in certain cadastral map sheets
- print holdings less than five acres and greater than 25 acres
- make a land transfer
- enter land use conversion
- provide data security and access rights

A server linked to a number of PC-based workstations manages all data. Links to all Dzongkhag offices through the telephone system are also planned, so that these offices can have access to up-to-date information.

3.3 Deficiencies and Challenges of Systems

Analysis of the systems in Nepal and Bhutan has detected several deficiencies and challenges, and these are laid down in sections 3.3.1 and 3.3.2. SWOT analysis was the technique used to identify the deficiencies and challenges in the existing systems, as well as the real causes of ineffective systems. SWOT is an acronym that stands for strengths, weaknesses, opportunities and threats.

3.3.1 Deficiencies and Challenges in Nepal

As a part of the SWOT analysis, the environmental scanning of external and internal assessments for a nationwide PBGIS in Nepal was carried out (Tuladhar, BC and Budhathoki, 2002).

External Assessment

The external environment covers major driving forces, such as political/legal, economic, technological, socio-cultural and demographic forces. As indicated in table 3.2, useful opportunities come from changes in technology, changes in the market, changes in users' expectations, changes in government policy, etc. Threats are the external factors, such as the necessity for high investment, the lack of legal support for PBGIS, and increasing land disputes. These factors are in fact outside the MLRM, but they have significant impacts on the organisation and its mission.

Opportunities	Threats
Approval of IT Policy 2000 in October	Insecurity in the continuity of funding, commitment and project team
Capitalise on the demand for land information for multifaceted use and growing land market	Legislative framework has not yet been developed regarding the various LIS activities
With the increasing trend in ICT, there is an increased demand for digital land information	Building PBGIS to cover the entire country involves high initial investment
Private sectors have started focusing on GIS and therefore the skills are available in private sectors	Over-expectation of the stakeholders in terms of time and PBGIS functionalities
Contribution to good governance, environmental management and sustainable development	Computerisation attempt without analysing the current land administration system (especially data and processes)
The tenth five-year plan has given priority to modernising land administration	Lack of comprehensive land policy at the national level
Once PBGIS is fully operational, it will minimise the operating costs in land administration	DoLIA has been established without a clear definition of its mandate
Link to geospatial data infrastructure (GDI) at national level for meeting the demand from a wide variety of users. Network solution: central storage/decentralised services	Traditional mechanisms of producing and delivering the information/products/services are unsatisfactory
Creates increased awareness in policy/decision makers.	Lack of local capacity building

Table 3.2: Assessing the external factors of DoLIA

Internal Assessment

Various internal factors, such as organisation structure, culture, management, leadership, financial issues, operation issues and human resources, have been analysed to identify strengths and weaknesses, and its results are explained in table 3.3.

Strengths	Weakness
Department attracts all the stakeholders	Lack of both managerial and technical experience at all the levels
Continuous budget since its establishment	Lack of efficient and effective organisation, including knowledge field and ICT support
Increased awareness about PBGIS at all levels	Frequent change in leadership
Availability of knowledgeable, skilled and committed staff at MLRM	Resistance to change in the way the organisation needs to provide services and products
Extensive pilot experience regarding the underlying complexities in developing and operating PBGIS	Lack of rigorous planning to build, operate and maintain LIS
Study recently commenced to review situation and propose a more effective organisational structure for building, operating and maintaining PBGIS	Poor quality of the data sources (both administrative and the maps); poor methods of data capture, maintenance and storage
System to handle the non-spatial aspects of PBGIS has been built and is operational in pilot offices. Preliminary design of the system for spatial aspects of PBGIS is complete.	Severe shortage of human resource capacity
Government has decided to use private sector for data conversion. Currently, private houses are being used in two districts.	Poor communication, coordination, and participation of sister departments and stakeholders

Table 3.3: Assessing the internal factors of DoLIA

These observations suggest that the ineffectiveness is due mainly to the lack of an appropriate approach. The approach has to adopt appropriate solutions with regard to institutional, legal, financial and technical issues, and should include fully-fledged structured strategic planning, including the analysis of existing systems and user requirements.

Since the task is huge and complex, modern techniques such as Geo-ICT tools and active participation, including commitment on the part of all departments, play a determining role in the successful implementation of PBGIS.

3.3.2 Deficiencies and Challenges in Bhutan

Similarly, several deficiencies can be identified. The biggest challenge is that the current system does not have direct contact with the clients. The responsibilities are not clear. Although the districts or sub-districts execute the activities of land transaction, no land information is directly available at these offices from the Survey of Bhutan, where the cadastre and land registration systems are computerised. Mostly, communications are channelled through the hierarchies of the formal administrative bodies, which induces much error, duplication and inconsistency in the land records (Sathram). Other government organisations and agencies have no means of obtaining necessary land information. Although the system is meant for generating revenue, there are no agencies responsible for monitoring and valuing land. Thus the system is unable to determine whether it stimulates the land market or whether it promotes agricultural productivity in the rural areas.

There is no legislation with regard to mortgaging land. The field study also indicates that user requirements have never been identified, and there are no standards for data definition, quality, processes or data exchange. Lastly, local human capacity needs to be developed.

Legislative framework for any kind of land transaction, including registration, is guided by the Land Act and the Forest Act of Bhutan (Royal Government of Bhutan, 1991). According to the Land Act, any persons registered in the land records are legal owners and more or less guaranteed by the state. As such there is little or no legal provision for a third party to contest the ownership.

This field study shows that the processes of cadastral surveying and recording at the Survey of Bhutan are rather transparent. This has provided good opportunities to computerise them in short periods of time. But it is not clear how local courts and other administrative officials at various levels exercise their duties to register land transactions. This may be the reason why registration takes a long time, even a year in some situations. It is also not known how the registration system relates to the country’s other programmes of sustainable development and market economy.

3.4 Summary and Concluding Remarks

The above discussion and analysis suggest that the systems of cadastre and land registration in Nepal and Bhutan are fiscal in nature. Land valuation is mainly based on parcel areas and land classification. Since the land valuation approaches used are subjective, they are not transparent to the owners or taxpayers. There are no official property valuation systems based on scientific models in either country.

In Nepal, there is a good legal basis for a fiscal cadastre, including the role of land tenure. But the cadastral system does not provide a reflection of the need for securing land rights, and it does not provide a good basis for either agricultural development or the land market society. It provides products and services at the district offices. Registration services for transferring land ownership rights are fast, but the quality of both products and services is rather low. Cadastral surveying includes parcel boundaries and topographical objects. The updating cycle for topographical objects is not known, although it is claimed that during maintenance of cadastral boundaries, the topographical objects are also surveyed and mapped. There is no official valuation method except land classification. Field observation reveals a high volume of transactions in urban cities, supporting the land market. Many users are demanding timely access to reliable parcel-based geo-information. A new department has been established to handle the automation necessary to meet this demand.

In Bhutan, the system provides a good legal basis for private land rights transactions, but the registration services are slow. Cadastral surveying includes only privately owned parcel boundaries with major topographical objects (such as rivers and roads). The data are stored at central offices, and are not easily accessible owing to the institutional arrangement. Field observation reveals that the land market is not stimulated, as the registration services follow administrative procedures through many government departments. Many users are now demanding timely access to reliable parcel-based geo-information. System automation has already started to satisfy the demands for parcel-based geo-information.

The idea of domain models (as discussed in section 2.3 of Chapter 2) covering multifunctional applications does not yet exist in either country. In Nepal, the domain does not recognise the requirements of real land-related problems, as it focuses only on fiscal aspects. In Bhutan, reengineering is essential to ensure the availability of the system at the place where it is needed. There appears to be big gaps between citizen and cadastral system. Thus both systems require sound system models for automation, with sound goals and objectives for land administration.

Chapter 4

System Modelling Using Object Technology

4.0 Introduction

In Chapter 3, we argued that we need reliable cadastral data and services to influence increased tenure security, the land market, and sustainable land use development within the policy instruments in Nepal and Bhutan. Data and services are fulfilled by the PBGIS embedded in land administration to satisfy the demands of customers. However, traditional systems based on manual processes are inadequate to cope with such demands, because the data and processes in these traditional systems are unusable and unstructured. The PBGIS requires appropriate efforts to model them in a structured manner so that automated systems can be designed with proper attention to the customers or stakeholders and organisational mandates.

The purpose of this chapter is to develop system models for a PBGIS based on subsystems focusing on customers' needs, including tenure and land policy. Since there are already system development approaches available, such as soft system methodologies, structural system development methodologies, and object-oriented methods, a brief description of each approach is presented in section 4.1. Section 4.2 then provides a detailed discussion on modelling concepts based on object technology. A description of the unified modelling language (UML) is also presented here. Organisational, static and dynamic models for a PBGIS are developed and presented in section 4.3. All these models are developed using UML in Microsoft Visio 2000. Conclusions on these models are drawn in section 4.4.

4.1 System Development Approaches

Within the context of system development, a system development methodology consists of a collection or model of the information system, procedures, techniques, tools and documentation aids that guides us in implementing a new information system. It provides further knowledge on system behaviour and why certain systems do not function as desired by the users. It consists of several phases, and these help the designers in planning, managing, controlling and evaluating information system projects. Thus the methodology represents a systematic way of developing an information system (Avison and Fitzgerald, 1995). The sequence of systematic steps is known as the system development life cycle. The system life cycle is applied to organise the large number of phases needed to build a system.

During the last 20 or 30 years, computer programmers normally spearheaded system development. They are not necessarily now the best communicators, and best quality is critical in transforming the needs of clients into the appropriate systems to support their work processes. Cadastral Systems in developing countries were developed that were technologically excellent, but did not adequately meet the needs of the users and their environment (Fourie and Nino-Fluck, 2001). They were also very difficult to maintain owing to the lack of proper documentation. Over time user requirements and the need for procedures and proper documentation have been realised, leading to a wide variety of methodologies. The most popular categories now are soft systems methodologies, structured system methodologies and object-oriented system development methodologies.

4.1.1 Soft Systems Methodologies

The soft systems methodology (SSM) is based on the general systems theory that seeks to understand the nature of systems in their entirety. It concentrates on the actors understanding problem situations rather than on developing a solution. It structures the problems before applying the structured information systems development. SSM goes for a root definition of the relevant systems by defining precisely *who* (actor) is doing *what* (transformation) for *whom* (client); to whom are they *answerable* (owner); what *assumptions* (views) are made; and in what *environment* it is happening (Paresi, 1993). It develops a model relevant to the problem situation, and develops various models and a hypothesis. Feasibility of the recommendations is vital so as to come up with a proposal for actions to be taken. An example of the use of SSM is the development of a conceptual framework for a cadastral system in a South African situation based on strategic management theory and cadastral theory (Barry, 1999; Barry and Fourie, 2002).

4.1.2 Structured System Development Methodologies

The structured system development methodologies (SDM) are based on functional decomposition that breaks down complex problems into manageable units in a disciplined way (Hausen, G. and Hausen, J., 1991). They are function-oriented in the sense that the system is viewed from the standpoint of the functions it performs rather than the data on which it performs these functions.

Building an information system by using structured methodologies entails a number of steps and each consists of a set of iterative activities grouped in phases, as shown in figure 4.1. The fact that methodologies are function-oriented poses the drawback of neglecting the data, especially the structure of the data, and the functions that manipulate the data. Thus consideration is given only to those data immediately needed by the functions; as a result a system is developed that has short-term value at the expense of the long-term needs of the users. Since the functions have lower stability than the data as part of the system, the use of these methodologies is not popular, as system functions can change very fast (Hawryszkiewyz, 1994).

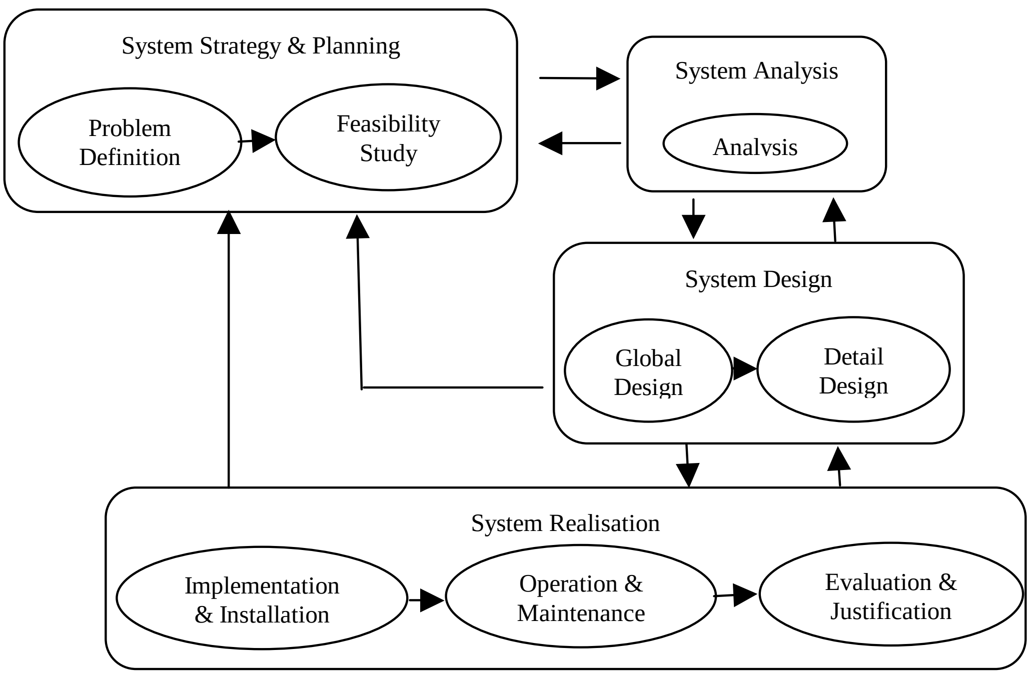


Figure 4.1: Major phases and life cycle of system development

4.1.3 Object-Oriented System Development Methodologies

The object-oriented system development methodology (OOSDM) uses the concepts of objects (referred to as object definition in section 4.2) as the building blocks of the systems. The objective is to remedy the division between process analysis and data analysis. Process analysis methods based around techniques such as data flow diagramming (DFD) and functional decomposition overemphasise the functional or dynamic side of the systems and underemphasise the structural side of the information systems. In contrast, data analysis methods based around such techniques as entity relationship (ER) diagramming and normalisation overemphasise data and underemphasise process. OOSDM combines both semantic data modelling and process modelling and totally avoids the gaps between them, overcoming the drawbacks of the classical waterfall model used in the SDM. OOSDM encourages an iterative fashion of system development; it seems like at every moment during the system development we are doing a little analysis, a little design, and a little coding and testing. That means it poses a life cycle as proposed by the Object Management Group (Yourdon, 1994; OMG, 2000). Throughout the development life cycle, the fundamental object-oriented (OO) concepts of abstraction, encapsulation, and inheritance are put into practice in order to identify, document, prototype and/or develop the objects. Figure 4.2 shows a typical example of the OOSDM life cycle in which (a) strategic planning, (b) analysis, design and implementation, (c) construction, and (d) delivery are the main phases.

The strategic planning phase deals with developing an organisational model in which the plans for individual systems within the organisation are developed according to the strategic objectives and their requirements to be delivered.

The second phase consists of three sub-phases, namely analysis, design and implementation. Analysis deals with identifying and documenting user requirement models for each specific system. Design focuses on specifying the external views with each view of a set of object types.

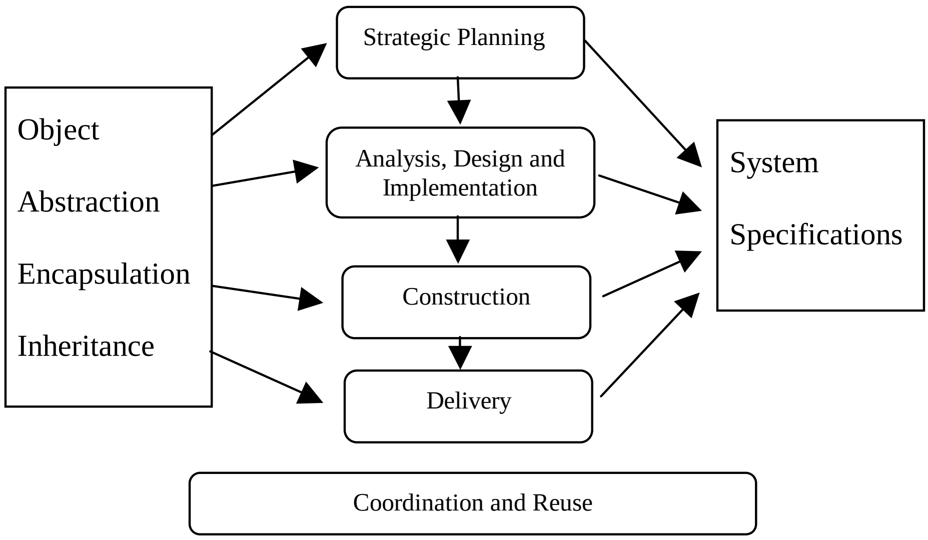


Figure 4.2: OO life cycle (Rutayuga, 1996)

Implementation concerns the distribution of objects across different hardware/software components in a client/server environment. It defines how objects and classes are distributed throughout various components of the operational hardware/software environment. The third phase deals with the actual construction of the system, with possibilities for prototyping, and the last phase consists of delivering the system for operations, and maintenance.

The OOSDM approach takes advantage of both top-down analysis and bottom-up design simultaneously (Henderson and Edwards, 1990). There are additional advantages to this approach, such as:

- extendibility, which presents object types and methods with easy modifications
- behavioural constraints, which allow the behaviour of each object to be predetermined with a fixed set of methods (encapsulation) and modelling power that is realised through various relational types
- inheritance of attributes and methods

With the above characteristics, the OOSDM is the well-known methodology for use in system development, and it plays crucial roles in the development or reengineering of systems.

4.2 Modelling Concepts

In the previous chapter, we saw that the PBGIS is considered a complex system, and consists of many subsystems with many sets of activities or processes and databases located at different geographical locations. It deals with the provision of products and services within its institutional, legal, economic and technical contexts. Therefore, we need a systematic modelling approach for system development to ensure consistency within and between all phases of the development cycle so that it avoids gaps and mismatches among the subsystems (Jacobson, 1992; Jacobson, Ericsson and Jacobson, 1995). The argument that the object-oriented (OO) paradigm is suited to complex applications such as land administration would be justified by the fact that OO models allow us to define the additional requirements of the complex relationships of the land unit objects; special data types for spatial data, such as raster and vector images; sophisticated operations; and multiple versions of data (Egenhofer and Frank, 1989). Given the complexities in PBGIS, OO modelling is an elegant choice for modelling cadastral data in PBGIS.

4.2.1 Object-Oriented (OO) Modelling Concepts

Conceptually *"a model is a simplification of reality"* (Booch, Rumbaugh and Jacobson, 1999*)*. Expressed differently, a model is a representation capturing the important aspects of a certain point of view of reality, simplifying or omitting the rest. Models are built to enable better understanding of a system as it is or of the system being developed. The larger and more complex the system is, the more important modelling becomes, as it provides a means of understanding an otherwise incomprehensible system.

Models are meant to capture and precisely state requirements and knowledge to enable stakeholders to understand and agree on them. Models enable us to think about the design of a system and also open up the possibility of exploring multiple solutions and mastering complex systems. Models consist of two major aspects vis-à-vis semantic information (semantics) and visual representation (notations). The semantic aspect captures the meaning of an application as a network of logical constructs that are translated to a database schema and programming languages, while the visual representation shows the semantic information in a form that can be seen, browsed and edited by humans (Rumbaugh, Jacobson and Booch 1999).

Object definition: An object is an abstraction of an entity in the real world; it reflects the information about the entity and methods for interacting with it (Martin and Odell, 1998). Objects encapsulate the complex structures of data with the behavioural component. The structural component of an object is described by means of attributes, or its characteristic features. The behavioural component of an object is represented as a set of methods (operations) that the object performs in appropriate situations. A class is a description of a set of objects describable with a uniform set of attributes and methods. A class therefore represents a generalisation of a set of objects with common properties and behaviour. Objects are instantiated (or generated) from this description (Hughes, 1991).

Object identification enables each object to be uniquely distinguished from all other objects in the database. An object identifier (OID) is generated by the system at the moment when the object is created, independent of the values of its attributes. An OID is dropped only if the object is destroyed; furthermore, it should be used only once in the database in order to be associated with just one real-world object (Martin and Odell, 1998).

Encapsulation is the principle that enables an object to hide its structure and/or behaviour from other objects. Internals of an object are accessible only via its interface, which is the operations known by the system.

Inheritance is a mechanism that allows new classes to be developed by inheriting the properties of an existing class and additionally adding their own properties. This is a mechanism that facilitates the reuse of existing class hierarchies. Inheritance defines generalisation and specialisation relationships between classes by developing abstractions or subtypes of classes. Multiple inheritances mean that a class may inherit attributes and methods from multiple superclasses. In this case, we have class lattices instead of class hierarchies.

Aggregation is the construct that enables objects of different types to be amalgamated into other objects. This concept facilitates modelling complex objects. Aggregation corresponds to the “a-part-of” relationship between two objects, where the component objects are also known as embedded objects. A complex object cannot exist without containing at least one aggregated object.

Association enables the relationships that exist between various objects in the database to be specified. Associations may be expressed explicitly in some OO models, while in others they are represented as reference attributes. In the latter case, the value of a reference attribute is the OID of the associated object. Additionally, some OO models have the construct of ordered association, which takes into account the order of associated objects.

Polymorphism is the mechanism that enables the operator to handle arguments of various types. It ensures that the appropriate version of the operator will be applied on supplied arguments.

Version control is needed in land administration, where different “versions” of the same object may be important. For example, the boundary of some spatial object changes in time, so information about the previous state (version) and the new state of the same object is required. Usually, versions are implemented as different objects, which mean that they will have different OIDs.

4.2.2 Model-Driven Architecture

In 2001, the Object Management Group (OMG) adopted a framework, the so-called model-driven architecture (MDA), that enables developers to separate the specification of the system (i.e. models) from details of the way that the system uses the capabilities of its platform. It is model-driven, because it provides a means of using models to direct the course of understanding, design, construction, deployment, operation, maintenance and modification (OMG, 2003a).

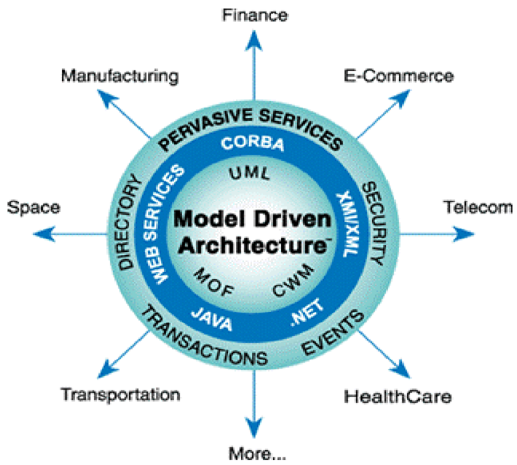


Figure 4.3: OMG’s model-driven architecture (Siegel and OMG staff, 2001)

The MDA concept specifies a system independent of the platform that supports it and has three major goals, i.e. portability, interoperability and reusability, through the architectural separation of concerns (Siegel and OMG staff, 2001). This means it provides common and platform-independent models of the pervasive services. Figure 4.3 shows the OMG’s MDA in relationship with the different technologies being incorporated (including UML) and the relationship with the different domain-specific models.

4.2.3 Why Modelling?

Conceptually, models are seen as “guiding templates” for developing or reengineering existing systems. Models for land administration are developed on the basis of user requirements in order to satisfy the demands created through the implementation of land policy. Hence, modelling plays a critical role for the implementing agencies that have the mandate to maintain systems for services and products (Tuladhar, 2002).

The modelling process starts by capturing the user requirements in the form of descriptions and sketches of the processes and data used, and ends with a formalised specification of data and operations, defining what has to be done in an organisation, and how and by whom it should be done under normal and abnormal operating conditions and constraints. Modelling can assist us in various ways.

(a) By examining *user requirements* or by abstracting what the users need, the models can represent business processes or services in a clear, concise way, thus providing insight into their structures, the dependencies between processes, the time scales on which they operate, etc. These are very important when the services or products need to be delivered in time.

(b) Understanding the existing business of the survey and land registry offices is essential for reengineering their functions and tasks. *Reverse engineering* (i.e. transforming actual codes into semantics and diagrams) allows us to bring these current business processes to models (Jacobson, Ericsson and Jacobson, 1995). We can *analyse* them to find the bottlenecks. Detailed analysis is made at all levels of the system under development. Sometimes it is classified as the documentation of the existing process and its sub-processes in terms of process attributes such as activities, resources, communication, roles, Geo-ICT and cost. This includes processes for data handling, data storing/archiving and data supply, such as issuing certificates or geo-information.

(c) Models help us in *redesigning* and evaluating the changes. Processes such as the manual editing and printing of cadastral maps, which may have no value or are not relevant to the organisation, can be replaced by another process using Geo-ICT, which can be verified using a modelling language. In this case, a new process is developed. This is accomplished by devising process design alternatives through brainstorming and creativity techniques. The new design should meet strategic objectives and fit with the human resource and Geo-ICT architectures. Documentation and prototyping of the new process is typically conducted and the design of new information systems to support the new process is completed.

(d) Models can be translated into a set of specifications such as business functions, data models for databases, user interface models, operating systems, hardware and software, networking and communication system during the development phase. The redesigning step provides us with the proposed system architecture and its detailed specifications.

(e) Since models consist mostly of a series of diagrams, they facilitate communication with the steering committee or members of the organisations about the business processes by creating a common frame of reference. Models are a means of communication that helps us to understand processes and document them.

For system modelling in this research, modelling activities are divided into the four most essential components or models for PBGIS (see figure 4.4 (Tuladhar, 2002)). The activities are related to the organisational, functional/process, static and dynamic aspects. In principle, they are not separated; they are different perspectives on one or more specific aspects of the system. The components when combined create a set of system models.

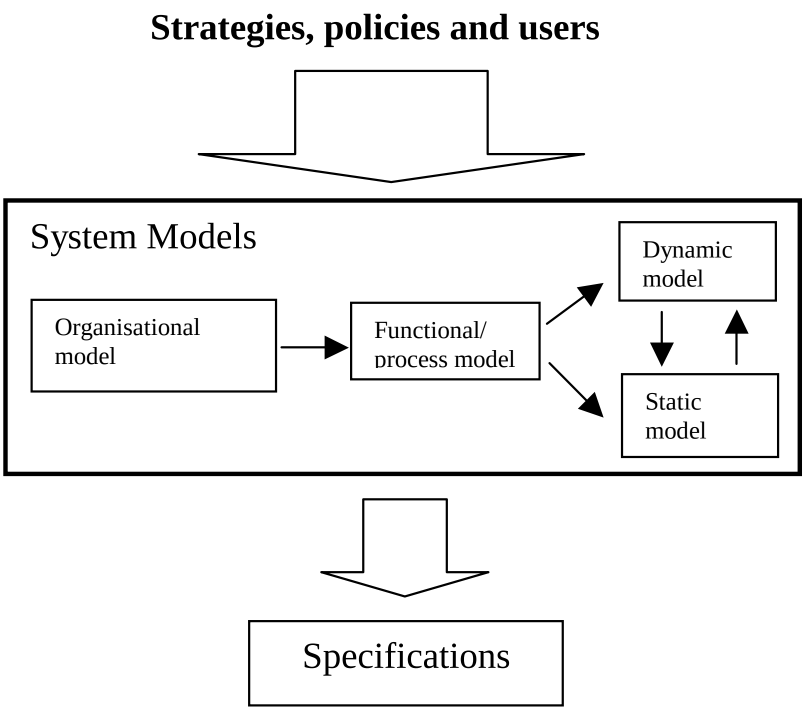


Figure 4.4: Components of PBGIS models

Organisational model: Its main purpose is to visualise the overall vision of the system organisation. It describes the goals and structure of the organisation and illustrates strategic plans and actions to achieve these goals. The system is divided into subsystems, which are manageable by the units or sections. It identifies information regarding the resources and responsibilities of the units to carry out the tasks. The most critical element in this model is the relations between the units, which help to improve the coordination and cooperation among departments and individuals. It has to deal with database sharing, which causes many obstacles to carrying out processes optimally within organisations.

Functional/process model: The term "function" is widely used in much literature on system development, but it hardly reflects the idea of user satisfaction. Here we have used this term to refer to system functionality having a number of business processes. Thus the functional/process model can also be replaced by the "business process model", and it represents the activities and value created in the business between the processes and resources to achieve the goal of each process. In other words, it illustrates the activities of the system, the transformation and the functionality, while concentrating on the interaction among the resources, goals and rules in the organisation (see figure 4.5). Basically it focuses on how the system is supposed to function, satisfying the users or stakeholders. This model consists of two important parts. The first part defines the processes that establish the relationships between users and the system. It defines the boundary of the system, which is very important, and the necessary conditions for fulfilling the strategic goals and objectives defined in the organisational model. The second part deals with how the processes have to be realised to deliver the products and services.

A business process model has the following characteristics (Eriksson and Penker, 1997).

- It captures the real business as truthfully and correctly as possible.
- It focuses on the key processes and structures of the business at an appropriate level of abstraction.
- It represents a consensus view among the people operating in the business.
- It adapts easily to change and extensions.
- It understands and fosters the communication among the different stakeholders in the business.

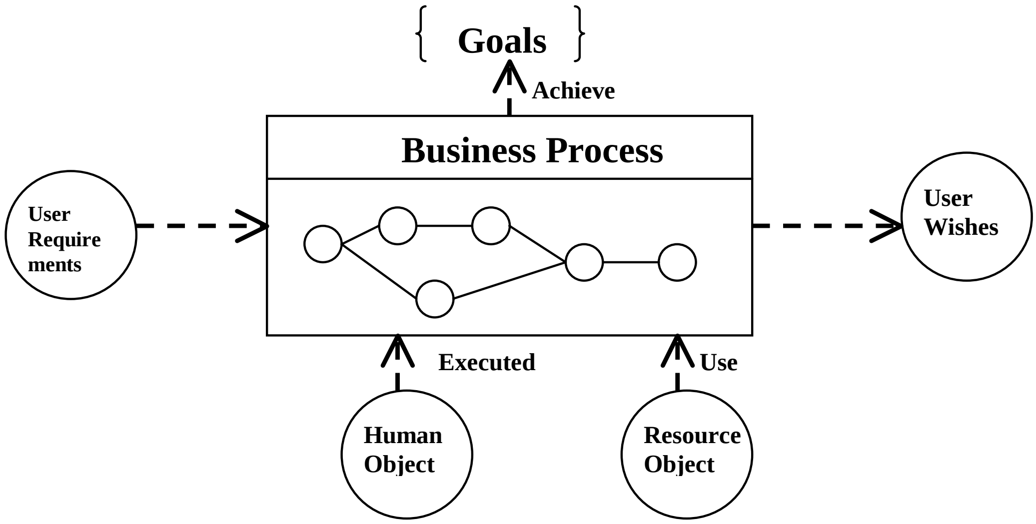


Figure 4.5: Business process concept

Static and Dynamic Models

In a PBGIS for land administration, it is important to distinguish the part of the system that is stable for the period of the system life cycle, and other parts that are not. The part that is stable during the life cycle is usually known as the "static" components. In cadastre and land registration, the structures of land registers and maps (as objects) do not change during their lifetime and are considered static components; only the values of their characteristics change. These changes occur because of their dynamic components. Services such as land transfers, land development, land reallocation, re-mapping, decision making on conflicts, and revaluation are examples of dynamic system components that cause changes in the characteristics of the objects. It is also possible that there are changes in the structures because of new user demands such as incorporating customary land objects and other objects, which reflect on the new processes or services.

Static model: This concerns the structuring of data for all kinds of information or resources used in the organisational business, and contains all information about the objects participating in the business. Such a model is usually called the static structure diagram in an OO system, where classes of interested objects are defined and relationships established. Such data models are usually static, because the entity types do not change during their life cycles. The changes relate only to the characteristics of the objects that belong to their respective classes.

Dynamic model: This describes the behaviour of the system containing each important resource, and interacts between several different resources. The behaviour concerns the evolution of objects in the system in terms of the changes they undergo in response to interaction with other objects inside and outside the system. Combining behaviours of different objects with a system produces a task or process that needs to be carried out to satisfy the users. The users/clients also have the responsibility to supply necessary data of the required quality, and the system needs to carry out the tasks required within the defined system boundary. Detailed elaboration will be given in the next section.

4.2.4 UML Modelling Language

For several decades, a number of modelling techniques, such as entity relational (ER) modelling, have been employed in the design and development of information systems (Chen, 1976). Now, we have reached the stage of worldwide acceptance of a standard modelling language: the unified modelling language (UML) based on OO concepts (Booch, Rumbaugh and Jacobson, 1999). It supports a rich set of graphical notations, describing classes, objects, activities, states, workflow, use cases, components, nodes, and the relationships among them. It provides significant benefits to system designers and the organisation by building rigorous, traceable and maintainable models supporting the development life cycle. It is used for modelling both the data aspect (structural) and the functional aspect (behavioural) of information systems, supporting both external and internal requirements. Thus, UML models can be used to describe and implement various components and their links with cadastre and land registration systems within the scope of a management framework for developing the information systems and their business processes (Tuladhar, 2002). In this, there are four main parts in UML: the use case diagram to capture external environments (user requirements and behaviours); the activity diagram to show how the use case can be realised; the object model (system behaviours) showing interaction between actors and entity objects; and the information model (commonly known as “class diagram”, which resembles the well-known entity-relationship diagrams). Subsystems and packages are the other diagrams that are useful for organising the system.

The UML seems at pains to point out that it is a *language* and not a *method*. This emphasis must be due to the background of the methods being associated with modelling languages. Fowler and Scott (1999) point out that most methods consist, at least in principle, of both a modelling language and a process, explaining that the *modelling language* is the notation that methods use to express designs, while the *process* is their advice on what steps to take in doing the design. According to Eriksson and Penker (1997), the goals stated by the UML designers are to:

- model systems ***(and not just software)*** using OO concepts
- establish an explicit coupling to conceptual as well as executable artefacts
- address the issues of scale inherent in the complex, mission-critical systems
- create a modelling language usable by both humans and machines

Since its introduction in November 1997, it has become the *de facto* standard modelling language for software development. The Object Management Group (OMG), an international consortium promoting the use of object-oriented information technology, is maintaining the UML standard.

Since the UML uses the same OO language in all phases of system development and operation, it allows the users, customers, developers and members of projects to communicate effectively and efficiently.

The UML has a number of predefined diagrams with rich and varied vocabulary. Depending on the problems and abstractions for which the system is to be built, we can organise them in the most suitable way. The following are brief descriptions of essential diagrams in UML.

Use Case Diagram

As the use case represents a task or process, it displays the dynamic part of the system. It shows the relationships among use cases within a system or other semantic entity, and their actors. A primary purpose is to describe how users and stakeholders (so-called actors) use the system. It is sometimes called an external view of the system. It describes the interaction between the system and external environments. It can be considered as the functionality/process of the system. The use case consists of three elements: actors, use cases and system boundary (Jacobson, 1992).

Figure 4.6 shows an example of use cases for the full transfer of ownership. The relationships among actors and use cases are organised using concepts such as generalisation, uses and extends. In uses relationships, the base use case explicitly incorporates the behaviour of another use case at a location specified in the base and avoids describing the same flow of events several times. The extends relationship between use cases means that the base use case implicitly incorporates the behaviour of another use case at a location specified by directly extending the use case. It is used to model the part of a use case that the user may see as optional system behaviour.

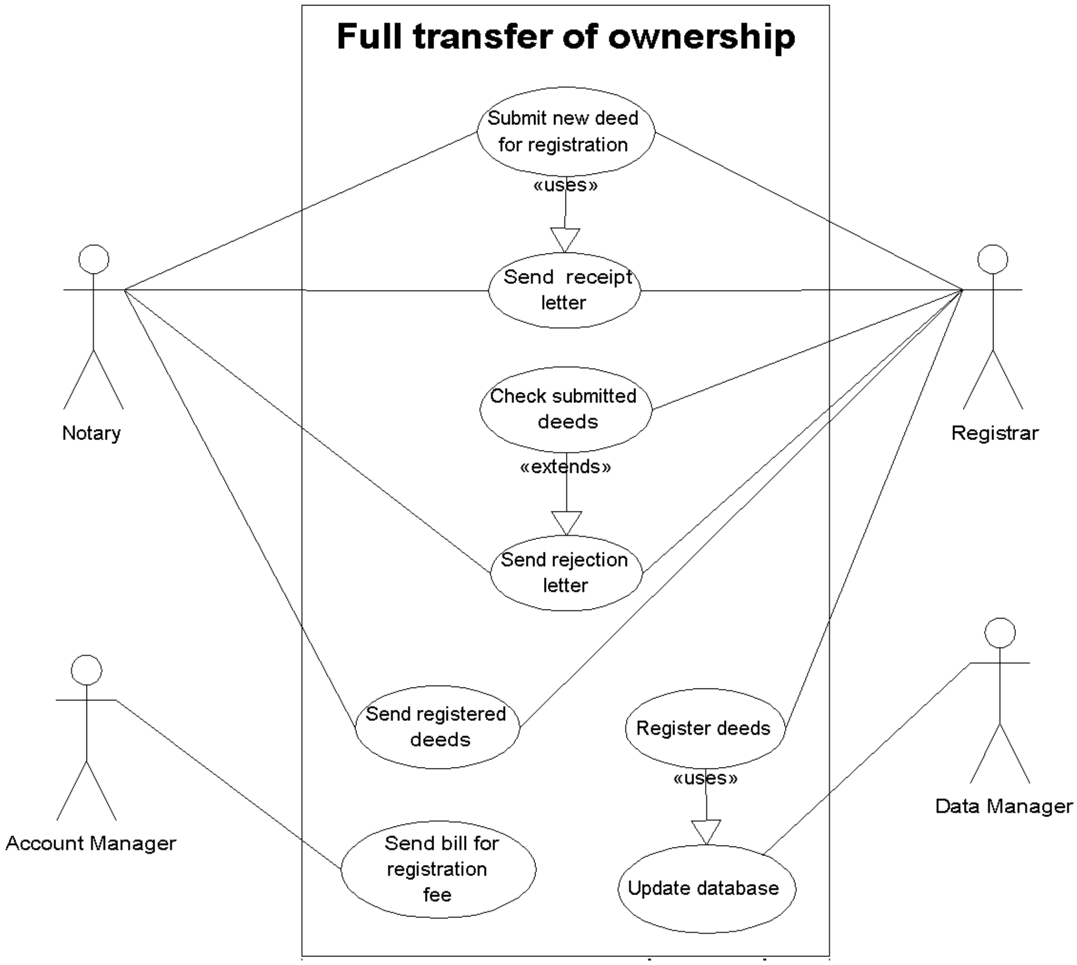


Figure 4.6: Example of use case model

To make sure that all actors are identified, the activity of identifying the actors is iterated while defining the use cases and describing the relationships between the use cases and the actors until all necessary actors and use cases have been identified and modelled. The example of a use case for transferring full ownership is illustrated in figure 4.6, where eight use cases are interacting with four actors.

The goal of the use case diagram is to define the expectations of users. The users may be people, systems or devices that need to interact with the system. Their interactions may be to provide input, to receive output, or to have dialogue with the system in order to cooperate in the completion of a task. All these interactions are focused through a set of specific system features called the use cases. Each use case defines specific goals that the system can achieve.

Another example of use cases for the cadastral subdivision process can be cited in connection with the framework of the COST Action G9 “Modelling Real Property Transactions” (Sumrada, 2002; Stubkjær, 2002).

Activity Diagram

Activity diagrams are used to explore and describe the activities or workflows in the organisation. They are basically the flow charts that are used to show the workflow of the system. Activity diagram provides a graphical way of documenting a business workflow in a simple and intuitive illustration of:

- what happens in a workflow
- what activities can be done in parallel, and whether there are alternative paths through a workflow.

The activity diagram also describes the roles and areas of responsibilities in the business, in other words who is responsible for doing what in the business. Roles and areas of responsibilities are documented as columns in the activity diagram. Swimlanes show which business workers participate in realising the workflow.

In the activity diagram, a task is represented as an activity drawn in a rounded rectangle containing a free-form text description of the task.

The transition from one activity to the next is indicated by an arrow, and a diamond symbol is used to model a decision. Each transition exiting the decision must be labelled with a guard condition and the conditions must be mutually exclusive. The diamond may be used to represent a merge point joining two alternative paths in the sequence. Guard conditions may also be used on transitions leaving an activity, where the result of the activities provides all information needed to meet one of the conditions. Concurrency allows multiple threads or processes to be executed simultaneously. The fork bar shows one transition initiating multiple transitions. The synchronisation bar shows multiple transitions coming to an end and one transition taking over. Figure 4.7 shows an example of an activity diagram for the registration of deeds.

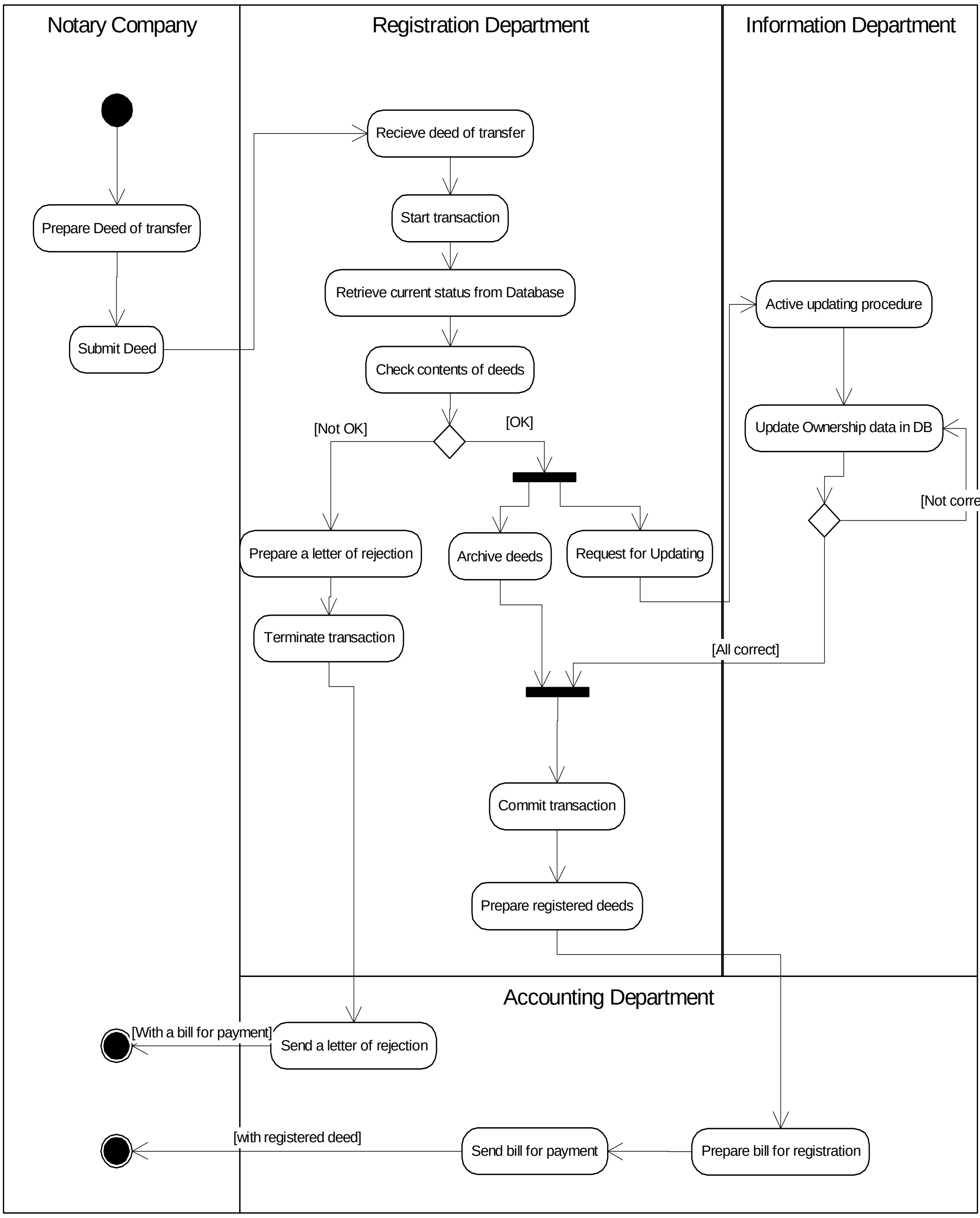


Figure 4.7: Example of activity diagram for the registration of deeds

Class Diagram

A class is a description of a set of objects that share the same attributes, operations, relationships and semantics. The static structures are built from the classes and relationships. The classes can represent and structure information, products, documents or organisations. The purpose of a class diagram is to document the relationships between workers (who deal with entities) and entities. It provides a way of visualising who interacts with whom and who is responsible for what. The class diagram is used for two main purposes:

- to show how workers and entities are collaborating to implement a business process
- to show static structure and relationships among entities

Generalisation is a relationship between a general thing (called the superclass or parent) and a more specific kind of that thing (called the subclass or child). It is also known as the “is-a-kind-of” relationship. In this type of relationship, the properties and behaviours are inherited by the subclasses. There are two types of inheritance, namely single inheritance and multiple inheritances.

Association is a structural relationship that specifies that objects of one class are connected to objects of another class. When a class participates in an association, it plays a specific role in that relationship. The term “multiplicity” or “cardinality” is used to indicate the degree of object participation in the classes in the cardinality relationship, such as exactly one (1), zero or one (0..1), zero or more (0..*), one or more (1..*), and numerically specified (m..n).

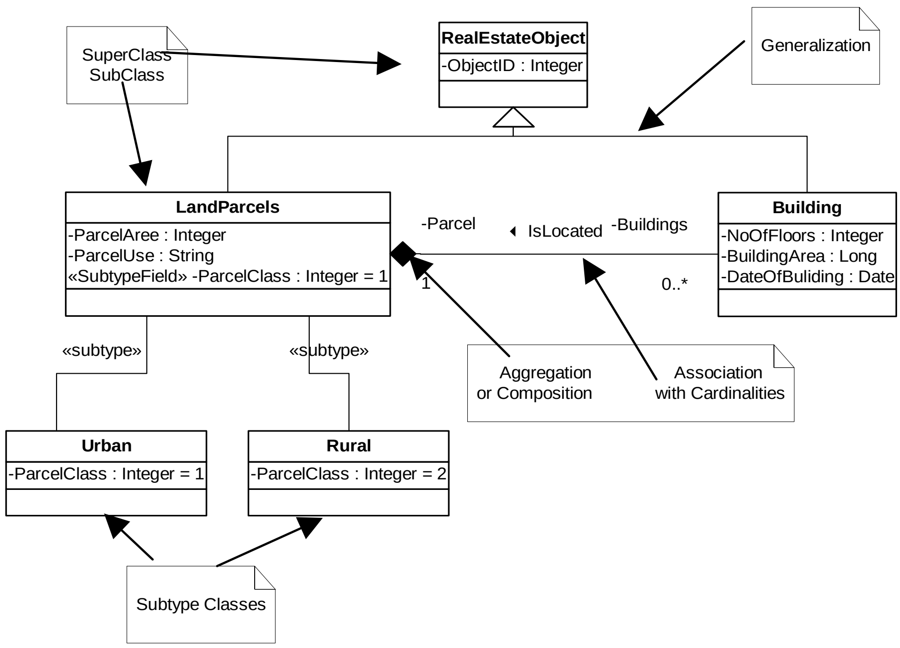


Figure 4.8: Class diagram

Aggregation is a special kind of association and is also known as the “whole/part” relationship. One class represents a larger thing (the whole), which consists of smaller things (the parts) and “has-a” relationship.

Figure 4.8 shows class diagram with the concepts of generalisation (identifying superclass and subclass), associations between two classes (participating role as composition or aggregation).

In generalisation, subclasses can also be subtypes of superclass.

Object Diagram

The object diagram is the part of the static models that describes specific entities, whereas the class diagram models the rules for types of entities. Objects are real things, such as parcels and persons. An object diagram would represent, for example, the fact that a person owns a parcel. In contrast, a class diagram would describe the rule that a person can own parcels. Therefore objects are instances of a class.

Interaction Diagram

The interaction diagram is the part of the dynamic model that describes how groups of objects collaborate in some behaviours. An interaction diagram captures the behaviour of a single use case. The diagram shows a number of objects and the messages that are passed between these objects within the use case. The interaction diagram comes in two forms based on the same underlying information, specified as collaboration and communication. The two forms are the *sequence diagram* and the *collaboration diagram*.

A sequence diagram shows the explicit sequence of communications and is better for complex scenarios. It presents an interaction, which is a set of messages between objects in the use case. It has two dimensions: (a) the vertical dimension represents time, and (b) the horizontal dimension represents different objects. On the horizontal axis are objects represented by rectangles, with the respective object and/or class name underlined. On the vertical axis are dashed lines extending downwards from each object. These lines are referred to as the object's *lifelines*. Along each lifeline is a narrow rectangle called an *activation*, representing the execution of an operation that the object carries out. The length of the rectangle indicates the activation's duration (see figure 4.9).

For the sake of clarity a use case may have several interaction diagrams, each of which shows one flow of events in a use case. A use case is more precisely described or explained by showing the interaction between the participating objects in the use case. The interaction diagram is based on a use case model and an information model. Feedback from the interaction diagram goes back to the use case model and the information model. This iterative procedure continues until the whole model is completed.

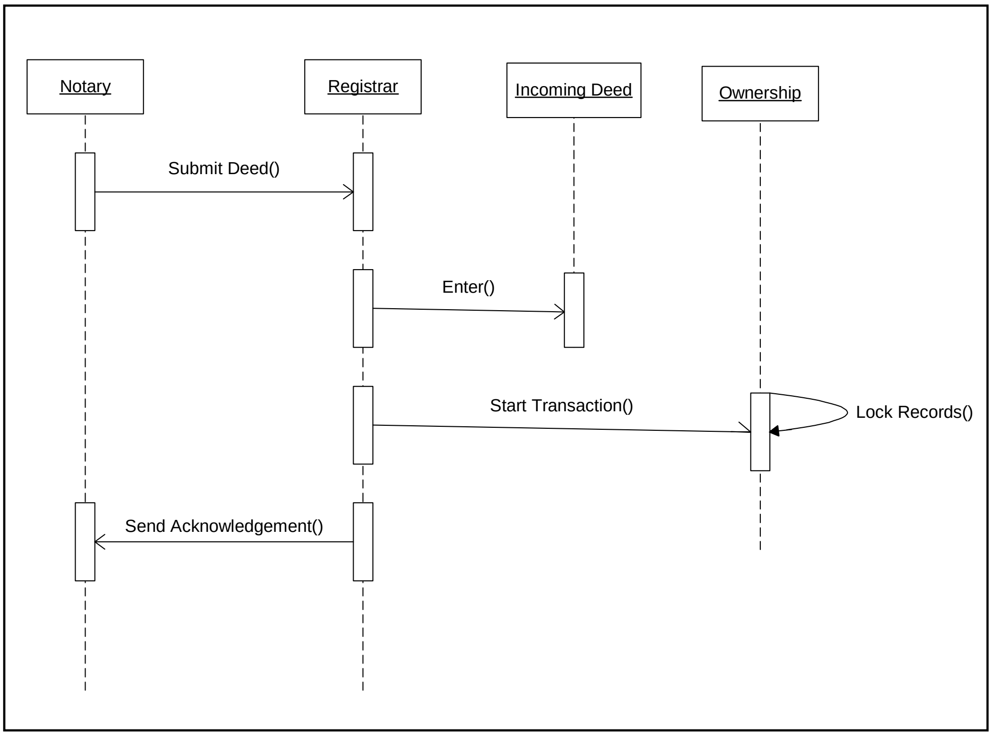


Figure 4.9: Sequence diagram for submitting deeds to registration office (Tuladhar, 2002)

A collaboration diagram shows an interaction organised around the roles in the interaction and their relationships. It does not show time as a separate dimension, so the sequence of communications and the concurrent threads must be determined using sequence numbers. It models the *objects* and the *links* that are meaningful within an interaction. The objects and the links are only meaningful in the context provided by the interaction. A *classifier role* describes an object and an *association role* describes a link within the collaboration. A collaboration diagram shows the roles in the interaction as a geometrical arrangement (or spatial layout). One use of the collaboration diagram is to show the implementation of an operation.

Collaboration diagrams are drawn in the same way as classes, but their names are underlined. The links are shown with lines, which look like associations. A message can be attached to the link, defining among other things, a sequence number for the message (see figure 4.10).

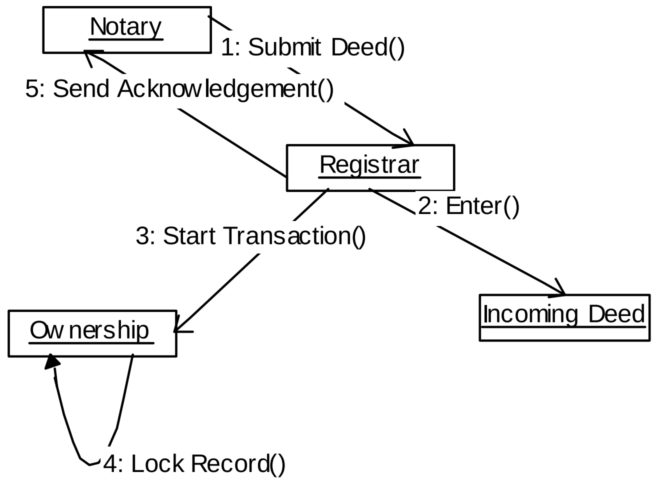


Figure 4.10: Collaboration diagram for submitting deeds to registration office

Both sequence diagrams and collaboration diagrams show the interactions, but they emphasise different aspects. A sequence diagram shows the *time sequence* as a geometrical dimension, but the relationships among roles are implicit (implied or understood though not directly expressed). A collaboration diagram shows the *relationships among roles* geometrically (i.e. in space) and relates the messages to the relationships, but the time sequences are less clear because they are implied by the sequence numbers. Each diagram should be used when its main aspect is the focus of attention.

State Diagram

The state diagram captures the dynamic behaviour of an individual object, which undergoes changes to various states. It expresses the possible states of a class. It is very useful for a real-time system. In PBGIS, for example, a parcel undergoes many stages, from an unidentified parcel through parcel under investigation, unresolved parcel, resolved parcel and finally to surveyed parcel. Such changes can be modelled using a state diagram for a class. In this way, we would be able to identify which operations may be applied at a certain stage of a class. However, it is important to note that not all classes need to be modelled, because some classes may have obvious behaviour that does not need to be displayed through a state diagram.

The state diagram may also be applied in a system (or subsystem) as an object to capture the dynamic behaviour of system.

There are two additional diagrams, mainly used for the implementation of the system, namely component and deployment diagrams.

Component Diagram

The component diagram describes components within a system – specifically the software units from which the application is constructed – as well as the dependencies among components so that the impact of a proposed change can be assessed. It also models the assignment of classes and other model components.

Deployment Diagram

The deployment diagram is used to describe hardware within a software system. It represents the arrangement of run-time component instances on node instances. A node is a run-time resource, such as a computer, device or memory. This view permits the consequences of distribution and resource allocation to be assessed.

Extensibility Construct

The UML includes three main extensibility constructs that enhance semantic of the above diagrams: *constraints, stereotypes,* and *tagged values.*

A constraint is a textual statement of a semantic relationship expressed in some formal language or in natural language. Constraints are useful for making statements that can be expressed in formal text language. Recently the object constraint language (OCL) has been developed within the UML constructs (see section 4.2.5 for details).

A stereotype is a new kind of model element devised by the modeller and based on an existing kind of model element.

A tagged value is a named piece of information attached to any model element. Text values are especially useful for project management information and for code generation parameters. Most tagged values would be stored as pop-up information within an editing tool and would not usually be displayed on printed pictures.

4.2.5 Object Constraint Language (OCL)

In general terms, the UML diagrams are very good for identifying the system requirements, but they may not be sufficient for a precise and unambiguous definition of a model. The information conveyed by such diagrams has a tendency to be incomplete, informal, imprecise, and sometimes even inconsistent.

The OCL is a language that describes precise meaning in the forms of expressions and constraints in UML models. It is a formal language similar to structured English to express side-effect-free constraints within UML models (Warner and Kleppe, 2003). Therefore, we can define precisely the business rules, technical requirements, or constraints, using the OCL. The OCL is a standard language, which is part of the UML set by the Object Management Group (OMG) as a standard for object-oriented analysis and design. A recent version of UML 2.0 OCL is available as the final adopted specification published by the OMG (OMG, 2003b).

The OCL is used for a wide variety of purposes using expressions and constraints. An expression is an indication or specification of a value. A constraint is a restriction on one or more values of (part of) a model or system (Klasse Objecten, 2004). There are the four types of constraint:

- An *invariant* is a constraint that states a condition that must always be met by all instances of the class, type or interface. An invariant is described using an expression that evaluates as true if the invariant is met. Invariants must be true all the time.

- A *precondition* to an operation is a restriction that must be true at the moment that the operation is going to be executed. The obligations are specified by postconditions.

- A *postcondition* to an operation is a restriction that must be true at the moment that execution of the operation has just ended.
- A *guard* is a constraint that must be true before a state transition fires.

Figure 4.11 shows an example of a simple class diagram in a mortgage system, where three classes, namely House, Person and Mortgage, and their relationships are defined. In this example, note that a person must an owner, if (s)he mortgages a house.

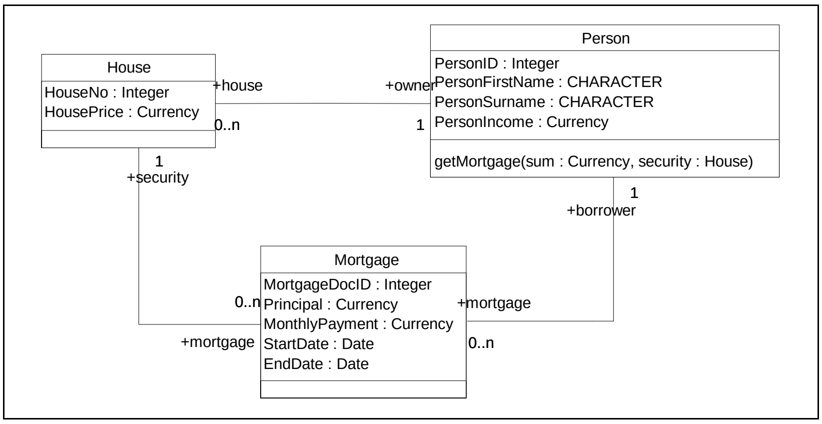


Figure 4.11: Sample class diagram of a mortgage system

To be able to understand this class diagram, a number of rules are formulated as shown below:

- person identification of all persons must be unique
- a person may have a mortgage on a house only if he or she owns that house
- starting date of any mortgage must be before the end date
- a new mortgage will be allowed only if person's income is sufficient
- a new mortgage will be allowed only if house price is sufficient

These rules are formulated in OCL, as shown in figure 4.12.

```
package Mortgage_system

context Person
inv: Person::allInstances->isUnique(PersonID)

context Mortgage
inv: security.owner = borrower

context Mortgage
inv: startDate < endDate

context Person::getMortgage(sum : Currency, security : House)
pre: self.mortgages.monthlyPayment->sum( ) <=
self.PersonIncome * 0.30

context Person::getMortgage(sum : Currency, security : House)
pre: security.HousePrice >= security.mortgage.principal->sum( )

endpackage
```

Figure 4.12: The rules in OCL

4.3 Models in Parcel-based Geo-information System

The above sections described the methodology and modelling techniques for describing a system. The following sections provide the models for a PBGIS concerned with the organisation, function/process, static and dynamic aspects of the systems, with specific cases in Nepal.

All models shown in this chapter are developed using UML in Microsoft Visio 2000 software (Microsoft, 2000). In this software, many functions are available, including checking consistencies in UML diagrams.

Overall inputs to the modelling activities are the overall vision of the system and organisation, and the goals and structure of the organisations. They illustrate the strategic plans and actions as to how these goals defined in the defined domains are reached within the organisations. The most critical element is coordination and cooperation among departments and individuals. It has to deal with database sharing, which causes many obstacles to carrying out processes optimally within organisations.

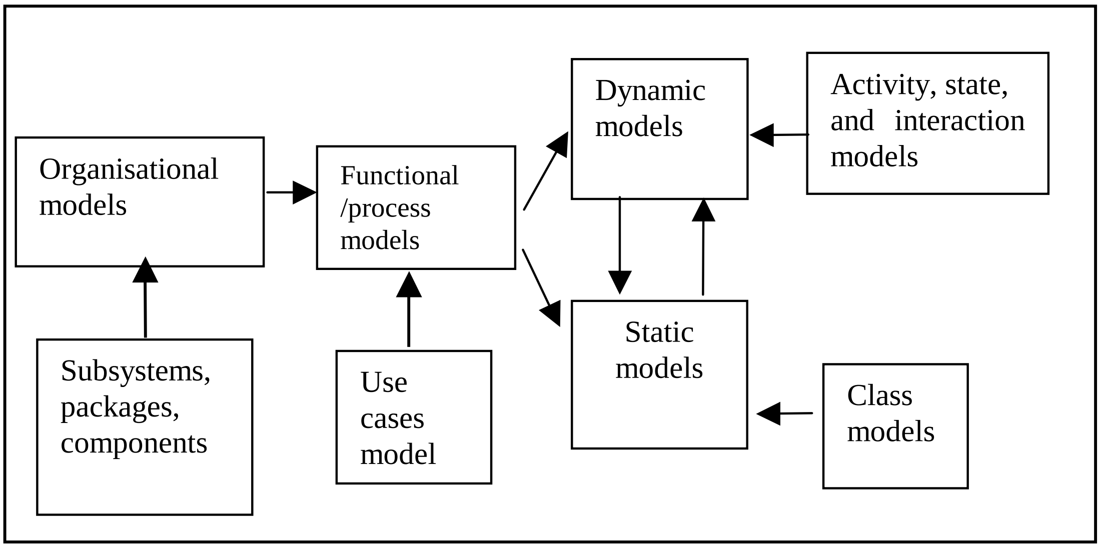


Figure 4.13: System models in a PBGIS and supporting UML diagrams

Figure 4.13 illustrates the components of the system models and the corresponding UML diagrams.

Organisational model: The core of this model is to organise system models in terms of subsystems for PBGIS. The best way is to use packages, subsystems and the component diagram of the UML.

Functional/process model: This represents the activities and value created in the business between the processes and resources to achieve the goal of each process. In other words, it illustrates the activities of the systems, the transformation and the functionality, while concentrating on the interaction among the resources, goals and rules in the organisation. Basically it focuses on how the system is supposed to function, satisfying the users or stakeholders. These functions or processes are also described as a part of the organisational models, within the subsystems (see sections 4.3.1 to 4.3.5). Since function/process is part of the dynamic model, the behaviour of each function/process is described using use cases in the dynamic models within the users' environment.

Static model: This concerns the structuring of databases for all kinds of information or resources used in the organisational business, and contains all information about the objects participating in the business. Data models are usually static, because the entity types do not change during their life cycles. The changes are only objects that belong to their respective classes. Therefore the class diagram (or information model) describes static models (see section 4.3.6).

Dynamic model: This describes the behaviour of the system containing each important resource and interacts between several different resources. The behaviour concerns the evolution of objects in the system in terms of the changes they undergo in response to interaction with other objects inside and outside the system. As discussed before, dynamic models are mainly described by state diagrams. Nevertheless, the realisation of use cases (i.e. functionalities) is modelled by activity and interaction models, which can be considered as part of dynamic models. Sample models are presented in section 4.3.7.

4.3.1 Subsystems in PBGIS in the Cadastral Domain

As mentioned in section 2.3.1 of chapter 2, a domain is generally larger than any one system, and therefore the design is partitioned into several systems that reflect either a natural division of business within a domain or the historical sequence in which the processes are automated. The concept of domain allows a large system to be organised into a number of subsystems. Since a PBGIS is large and complex in nature, by using the domain concept it may be subdivided into a number of small subsystems, each having its own domain of subjects in the effort towards tenure security, an open land market for multifunctional applications:

- cadastral surveying subsystem

- land registry subsystem
- property valuation subsystem
- dissemination subsystem

The PBGIS, through a network of these subsystems and others, increases the ability (performance and customer satisfaction) to provide the users or stakeholders with high-value intelligent information to fulfil the requirements for tenure security, for stimulating land markets, and for sustainable development. Figure 4.14 shows UML static structure diagram with interdependent four subsystems in the total PBGIS system. Arrow shows the direction of dependency.

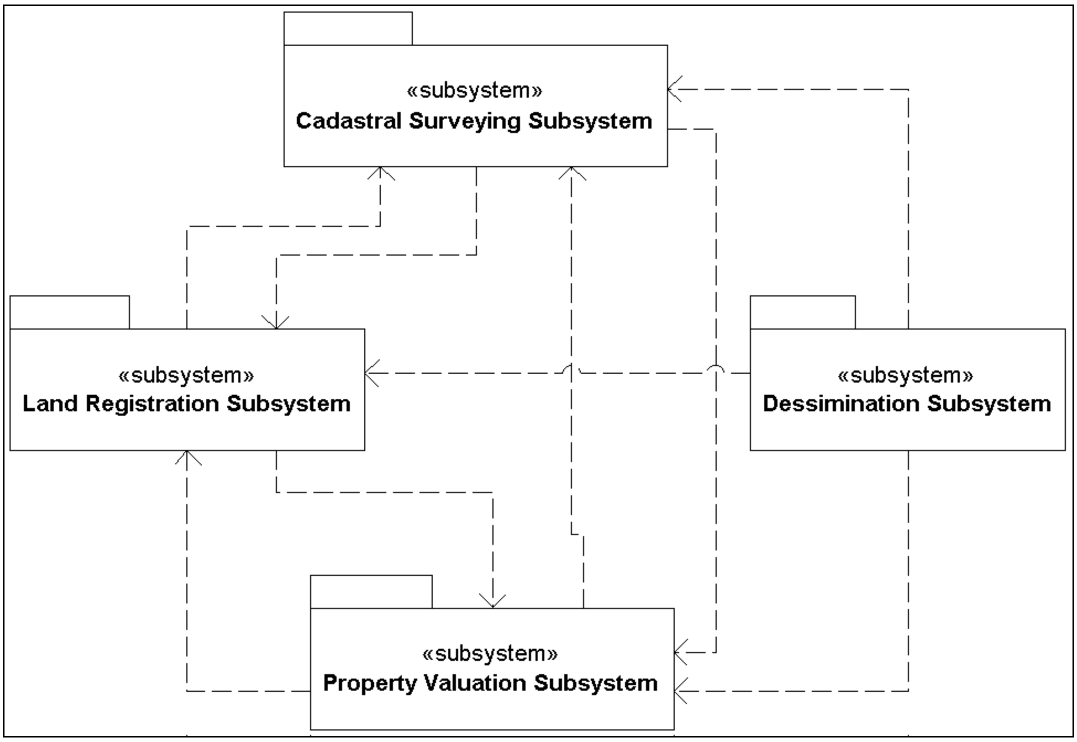


Figure 4.14: Subsystems of PBGIS domain

In this PGBIS, there are two critical issues to be tackled. First, data must be maintained and shared among the individual subsystems inside and outside organisations to minimise data duplication. Secondly, a one-stop shop is recommended, to provide services and disseminate land information to all users, including the general public and other stakeholders. To a certain extent, the dissemination subsystem is considered to be a one-stop shop.

Within each of these subsystems, a server (such as cadastral server in cadastral surveying subsystem) is introduced and its task is to allow reliable and secured communication between production databases and application services. It also communicates between subsystems for accessing required data.

4.3.2 Cadastral Surveying Subsystem

Figure 4.15 illustrates a component diagram with various components of a cadastral surveying subsystem using subsystem and package in UML constructs. This subsystem provides users with the various services required for securing tenure, specifically with regard to identification, boundary investigation, and surveying land parcel boundaries in the terrain. The products of this system may be cadastral maps, field sketches with boundary measurements, and calculations of the areas of land parcels.

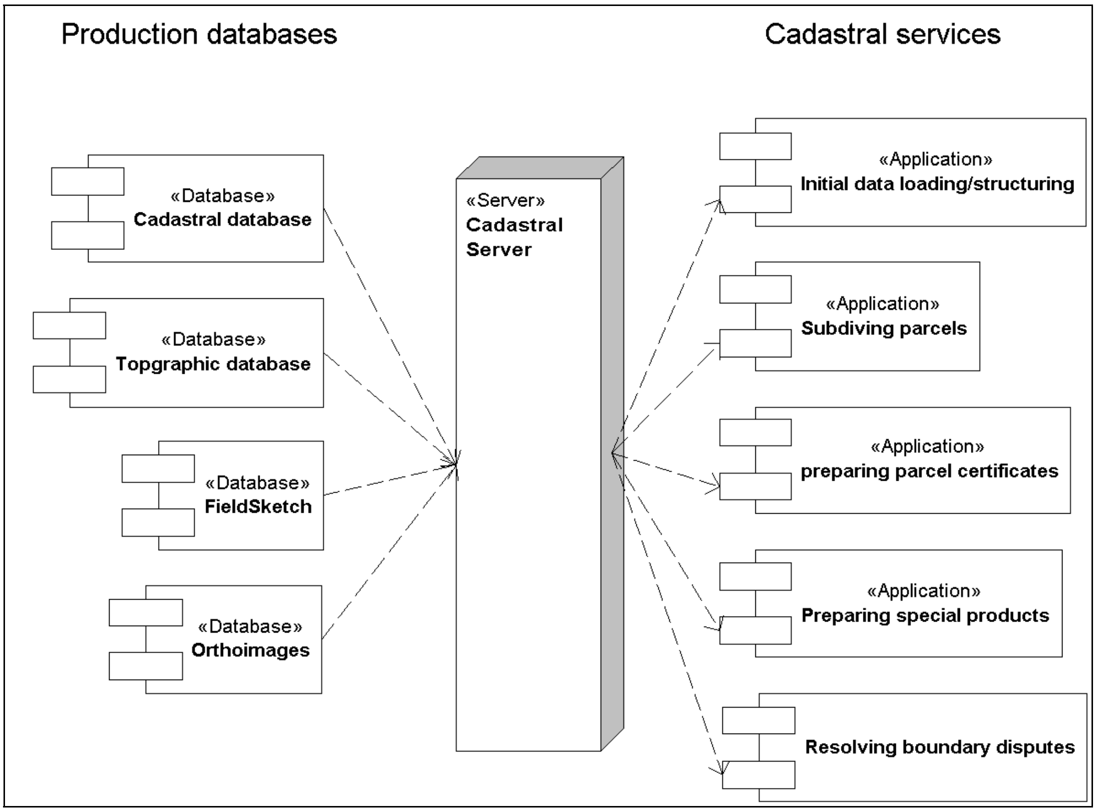


Figure 4.15: Components of cadastral surveying subsystem

The five services are identified as applications: a) Initial data loading/structuring for populating digitised existing maps and documents into databases, b) subdividing land parcels and updating spatial databases (this also includes merging of land parcels and area computation for registration, c) preparing parcel certificates, d) preparing special products such as cadastral display with ortho-images and topographic features in perspective views, and e) resolving boundary disputes and update databases, if necessary. This subsystem interacts with land registry subsystem. The first service is one time investment during initial system operation phase, while other above services and products are required continuously for system operation and maintenance specifically in business service in the transfer of properties involving the subdividing and merging of the parcels.

In this subsystem, distinctions may be made if general boundary or fixed boundary concepts are followed. The general boundary concept is recommended in rural areas, while the fixed boundary concept would be required in urban areas for minimising boundary disputes because of the high land prices. Here, the field sketches with detail field measurements are scanned, stored in a database and used for relocating any boundaries in future.

The subsystem also classifies land parcels into different classes based on criteria defined by the land acts (refer to Chapter 3). Any changes in land class and use occurring during the subsequent registration process should be incorporated by updating geo-databases.

This subsystem also identifies other levels of spatial land object higher than individual land objects. Such higher-level spatial land objects concern areas such as ward or block areas, village or city areas, customary areas for registering customary land rights, land units of specific interest for resource management, land units of local development areas and administrative areas. Identifying and registering these higher levels of spatial land unit provides information to those responsible for monitoring and advising on land development within these areas. These spatial units are often used in various administrative applications such as population census.

This subsystem also deals with the maintenance of large-scale topographical data, such as rivers, streams, lakes, ponds, roads, buildings, temples, churches, mosques and elevations. Modern cadastral systems also include ortho-images, so products such as parcel certificates can be delivered with an image as background. These data are useful for many purposes within land administration systems. Sample static models are presented in the section 4.3.6.

4.3.3 Land Registry Subsystem

Figure 4.16 illustrates the subsystem that supports tenure security by registration and change of ownership, mortgages, restrictions, etc. The functions of this subsystem are to provide services for registering ownership (including tenancy), mortgages, restrictions, and so on to all users.

The services provided by this subsystem are as follows:

- Initial loading of ownership data including all other data such as mortgage, tenancy, easement, restrictions, etc.
- Transfer of land ownership
- Registration/release of mortgages, leases, restrictions, tenancy, easement and higher level objects
- Preparing ownership certificates as result of transfers of ownership
- Resolving ownership disputes

Initial loading of ownership data: It is time consuming process and one-time for data conversion phase of system. It involves manual entry of data into the databases (ownership, mortgages, restrictions and others) and interactive editing using appropriate application programme. In some cases, it involves scanning of documents and stored them in the document database.

Transfer of land ownership: This is one of the most common services in land administration. This service may involve the transfer of full or partial ownership of the land. If the transfer is a full ownership transfer, the geometry of the parcel is not altered, whereas in the case of a partial ownership transfer, the old parcel is divided into two or more new parcels, and the old parcel stays as a historical parcel. In Nepal, registration of transfer of ownership is not possible without subdividing land parcels in the field and updating spatial database. Therefore this subsystem has strong relationship with cadastral surveying subsystem.

The transfer of land ownership may be the result of:
- sale
- inheritance
- gift
- other

The transfer of ownership depends on the type of land registration, i.e. whether the deed registration or title registration system is in operation. In both cases, the notary prepares the agreement between the buyer and seller.

The agreement is then lodged with the land registration office. The application is checked against the set of rules. If the application meets all the requirements, the old owner is deleted from the registry and the new owner is recorded as the owner of the land. If the transfer is not a full transfer, i.e. only a portion of the land is being transferred, the land registration office sends the request to the cadastral surveying subsystem to subdivide the land. After completing the subdivision, this subsystem updates its database (automated registry) and gives the ownership certificate to the new landowner. Thus the whole process of ownership transfer is completed.

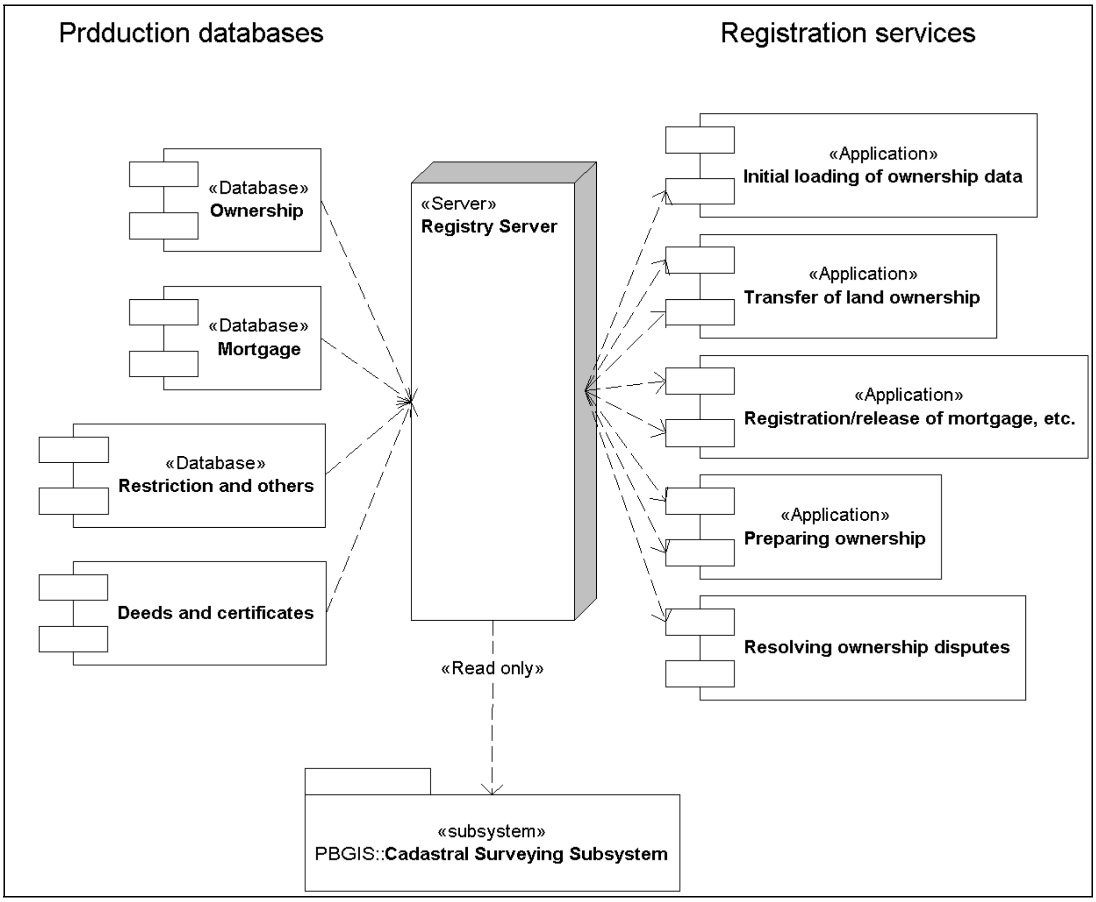


Figure 4.16: Components of Land registry subsystem

The third service "*Registration/release of mortgage, etc.*" in this subsystem relates to a number of sub-services. They are described below:

Registration of mortgage: This is another type of land administration service to support tenure security both for individuals and for financial institutions such as banks that provide mortgages with land parcels as collateral.

Registration of leases: The long leases are usually registered in the registration office.

Registration of tenancy and easement: These are registered to know who has access to land for certain purposes.

Registration of restrictions: There are many reasons for restrictions on land. Court instructions and government decisions are among the main reasons.

Registration of higher-level objects: The higher levels of spatial object such as provide responsibilities to the concerned agencies for development activities for stimulating land market activities, and aggregated information on the rate of transactions, dispute cases, and the maximum, minimum and average ownership areas. Even the heads of these areas may be involved in resolving disputes on land ownership and boundaries, as these heads are elected democratically. Registration of these names is required.

There are other two services namely “preparing ownership certificate” and “resolving ownership disputes”.

4.3.4 Property Valuation Subsystem

As discussed in the chapter 3, there is no official property valuation system based on market price in either Nepal or Bhutan. It is important that they acquire property valuation systems as part of their land policy. A land market is the most appropriate mechanism for guaranteeing both fair and equitable access to land and for maximising the efficiency and productivity of land. It is recognised that land value greatly enables land markets to work and land to be used in economic transactions. In this framework, those seeking land and those owning or controlling land are brought into transactions in order to affect access to land by land seekers.

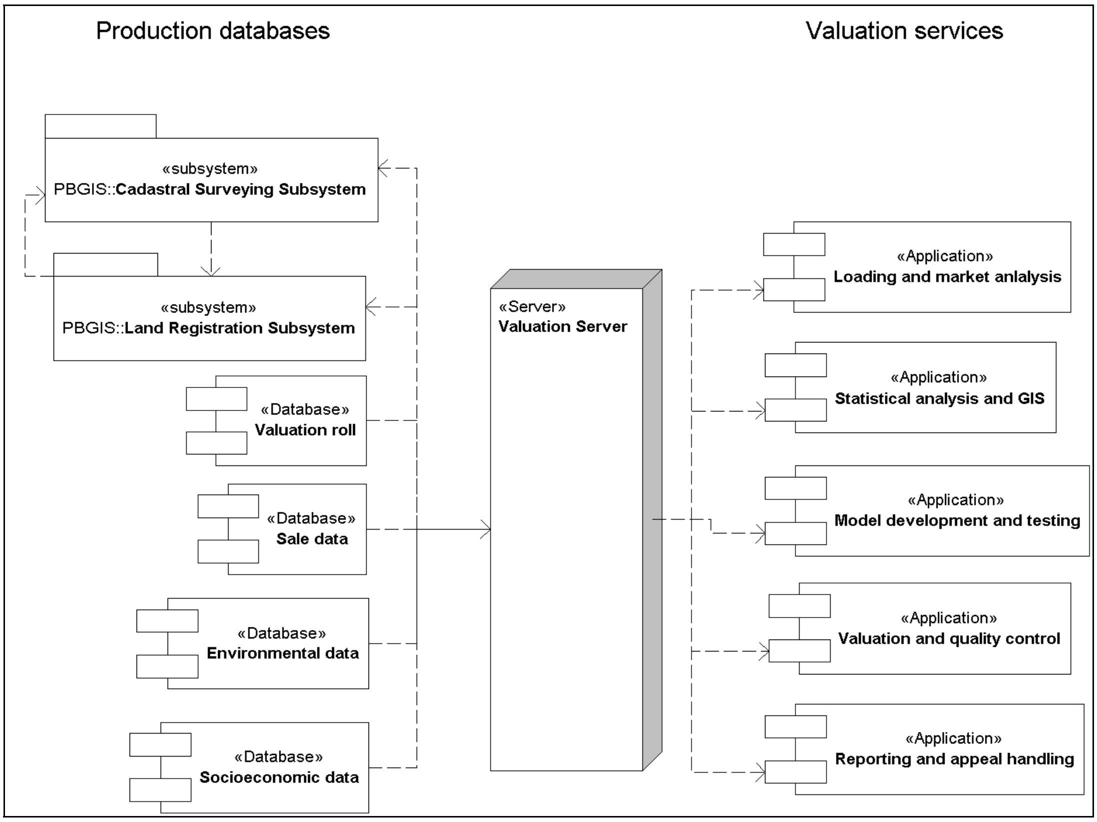


Figure 4.17: Components of valuation subsystem

When the land policy recognises that land has value and its values are taken into consideration in all transactions involving land, market-based valuation decisions will also play an even greater role than has been the case in Nepal and Bhutan.

Therefore, an official valuation system is necessary to establish the use of professionally determined standards. Figure 4.17 shows the possible system configuration in UML components for a valuation subsystem.

Data that are used for property valuation depend on approach and method. Primary data are, however, property size and location, market prices, social data regarding status, economic data such as interest rates, environmental data concerning pollution, infrastructure data and topographical data. Several approaches for land valuation have been developed: the sales comparison approach, the cost approach, the income approach and the residual approach. The sales comparison approach is the preferred method when there are adequate and accurate sales data. This condition is necessary for satisfying the principle of substitution, which states that a buyer will consider the costs of all reasonable alternative land parcels before deciding to bid on a particular land parcel. It compares the subject parcels (parcels being appraised) with similar parcels that have been sold recently (comparable parcels) or for which offers to purchase have been made. The selection of parcels is based on similarity with the subject parcel, and sale prices are adjusted according to differences from the subject. A market value for the subject is estimated from the adjusted sale prices of the comparable parcels.

In this subsystem, five application services are identified as follows:

- Loading and market analysis: This service involves collection of market sale data about the properties sold on the market. Prices indicated in deeds are normally collected and stored in sale database. The data about various factors that affect the value of properties (such as area, location, neighbourhood, environmental pollution, population, land uses, economic indicators, etc.) are collected and stored in environmental and socioeconomic databases. These data are analysed to sort out the data that look most reliable for valuation purposes.

- Statistical analysis and GIS: This service is required to analyse the data that are most affecting properties values using regression analysis and GIS analysis tools. Statistical tools such as MS Excel or SPSS software would be required for market analysis and for calibrating and updating the property value model. Tools such as correlation coefficient, T-test, F-test and regression analysis are common for checking and verifying purposes

- Model development and testing: This service is used to develop valuation models using mass appraisal for taxation purposes. Different approaches for models are available as discussed above. The appropriate model is applied to relevant data to estimate property value.

- Valuation and quality control: This actually estimates property values using models and comparing with comparable sale data of properties with vicinity of the properties being valued. Quality control for defining valuation standards and ensuring that they are adhered to, as well as for identifying weaknesses in the model and proposing appropriate refinements. This also applies to the review of values by local valuers – with field visits if required and the values updated where necessary.

- Reporting and appeal handling: This is last service but considerably important to get reliable information. Property owners must be informed of the property values in time, and enough time must be given for appeal in case the owner does not agree with the estimated value. Extreme care must be exercised at the correct time to sort out an appeal on value. A proper appeal procedure must be developed and followed to avoid any delays. Valuation roll is prepared and the report on property valuation is sent out to the owners for verification. In case, the complaints are launched, this subsystem should justify the property values on the basis of factors the system used. If necessary, the values should then be corrected. If disputes cannot be resolved, then the matters will be taken to the court.

This subsystem has several production databases. Database management provides functionalities for data entry, verification, storing, updating, querying and sharing.

Four databases (valuation roll, sale price, socio-economic and environmental databases) are maintained. Property sales data are shared via the land registry subsystem, for which the parties in a transaction submit a sale declaration stating the sales price, details about the payment, and the nature of the transfer (open market sale, inheritance, family transfer, auction). It is important to investigate whether the sale prices declared in the deeds are correct. Only correct sale prices can be registered in the sale prices database.

The valuation roll database contains the cadastral parcel number and land area of each parcel; these are supplied by the cadastral authority. It further includes all results of each valuation based on the model and is used for collecting property tax. It also contains information about each building (e.g. floor size, number of floors, number of rooms, condition, age). This information is normally shared with municipalities or local authorities, where continuous updating of these data takes place.

Other databases containing information on socio-economics (e.g. social status, population, economic indicators) and the environment (e.g. noise, pollution, zoning plan) are also needed for developing models. These data are maintained regularly and accessed via spatial data infrastructure from other data producing organisations.

4.3.5 Dissemination Subsystem

In transparent land administration, the geo-information should be made available to the public. This is important for many purposes in society. For the general public, it provides confidence in the legal security of land. This may enhance the proper use of land, as well as the use of land in economic activities in society. For institutions, it serves many purposes. Planning bodies are interested in the aggregated information on land. Financial institutions use information for investment purposes. This information is also important for researchers. In the PBGIS concept, the separate dissemination subsystem is proposed to serve these purposes.

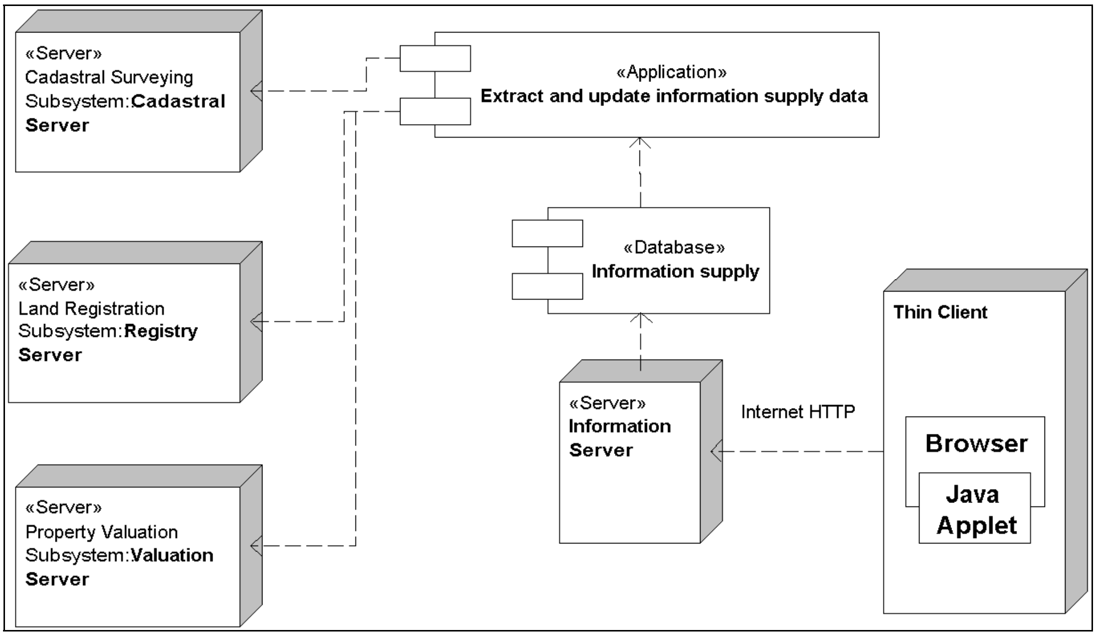


Figure 4.18: Dissemination subsystem and its relationships

This subsystem will extract all land objects at the level the users require from the information supply database populated by other subsystems (as shown in figure 4.18) and disseminate them via intranet or Internet, following the principles of geospatial data infrastructure. The data must be available at the place where needed. For example, the data are stored at the central headquarters in the capital of the country; then the data are disseminated through the dissemination subsystem to all offices of the users/stakeholders at central, district and local offices through the telecommunication network infrastructure.

The data model of the dissemination subsystem plays a critical role in sharing data among the subsystems, and among other systems belonging to other organisations if necessary. Such a data model may be termed as a "core data model" and serves as the standard for exchanging cadastral data. In principle, the content of the core data model should be matched with the data models of other subsystems in such a way that by extending the content of the core data model we should be able to derive the data models of the other subsystems.

In this subsystem, information supply database is introduced to separate it from the production databases of other subsystems for data protecting and securing against illegal access by unknown users. Information supply database is regularly maintained by application service "Extract and update Information supply data". Only essential data are stored in this database.

4.3.6 Static Models in PBGIS

The most important objects that are needed for tenure security are land objects, rights and responsibilities, and persons. These are the core objects of any cadastre and land registration around the world. The extensions to these objects are needed to suit the policies and requirements of individual countries. Since these objects are collected, stored and maintained in different subsystems (as discussed in sections 4.3.1 to 4.3.5), which usually fall under different organisations, the relationships between them must be maintained through unique land parcel object identifiers. The responsibility for assigning the unique identifier is mostly given to the cadastral surveying subsystem, because it involves the identification of objects in the real world through field surveying or imaging systems (e.g. remote sensing or digital photography).

The above four subsystems contain data of three domains, i.e. cadastral surveying, land registration and property valuation, which have both spatial and non-spatial dimensions. In this research, we concentrate on the cadastral surveying and land registry subsystems. Before we discuss the static models for these two subsystems, a brief introduction to the core cadastral data model is presented below.

Core Cadastral Domain Model

The concept was first introduced by Oosterom and Lemmen during the FIG Congress in Washington DC, USA, in 2002. Since this model can be seen as a standard template that can easily be adjusted to local situations for the development of cadastral databases, there are continuing efforts to standardise this core model in association with ISO TC211 and ESRI within working group 7.3 of FIG commission 7 (van Oosterom, P., Lemmen, C., and van der Molen, P., 2003; van Oosterom, Grise and Lemmen, 2003).

The cadastral core data model is based on the principle of relationships between basic entities of the cadastral system, i.e. real-estate object, right or restriction, person, and their relationships, as shown in figure 4.19 of the UML class diagram. It shows that RightOrRestriction is an association class between the classes Person and RealEstateObject (Lemmen, van der Molen, van Oosterom, Ploeger, Quak, Stoter and Zevenbergen, 2003; van Oosterom, Lemmen and van der Molen, 2003).

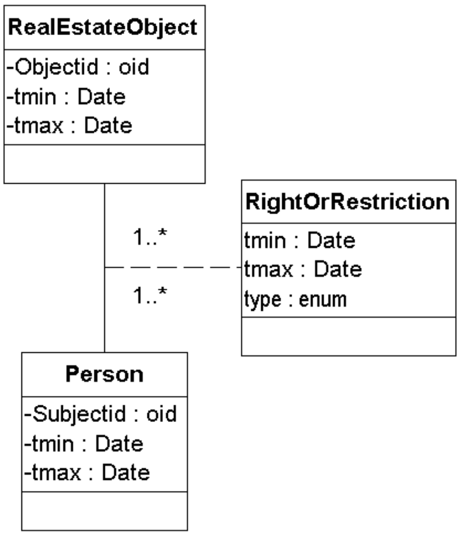


Figure 4.19: Basic entities of the cadastral data model (Lemmen, van der Molen, van Oosterom, Ploeger, Quak, Stoter and Zevenbergen, 2003)

Detailed information on the further specialisation of real-estate object classes, surveying classes, geometry and topology (imported OpenGIS classes), land administrative classes and 3D aspects can be found in the paper written by Lemmen, van der Molen, van Oosterom, Ploeger, Quak, Stoter and Zevenbergen (2003). The general characteristics of a cadastral core data model appear to be as follows:

- It contains the basic needs of the cadastral systems, such as data about subject, right and real-estate object.
- It establishes relationships between the person and real-estate object by association class RightOrRestriction by n-m relations (represented as 1..* in UML class diagram) at both ends of the association.
- It is based on the titles or deeds (or both) with legal rights and survey documents.
- It defines spatial-temporal aspects of basic entities.
- It supports 3D aspects of cadastre.
- It defines the scope of the system as a domain with respect to real-estate objects and land rights supporting land transactions and the land market.
- It serves as a reference model for the national reference system, where access to data about three entities through common identifiers such as parcel identifiers, addresses or common coordinates are known to all users.

In Chapters 2 and 3, it is argued that the requirements of a system always depend on local circumstances in a particular country. Owing to the institutional setting (specifically land tenure and policy) in a country, the relationship between people and land differs in the sense that land is not only a tradable commodity but also a resource for living. With this in mind, the following static models are developed and discussed.

Static Models for Cadastral Surveying Subsystem

Given the situation in Nepal as described in Chapter 3, five categories of land objects are laid down for the cadastral surveying subsystem, as shown in figure 4.20. These categories are as follows:

- geometry object class
- land administrative units
- land resource object class
- legal (real-estate) object class
- topographical object class

The first category consists of geometrical and topological aspects concerning the objects (or features) defined in the other four categories. Other categories are modelled in a separate UML package as a "feature data set" using stereotypes.

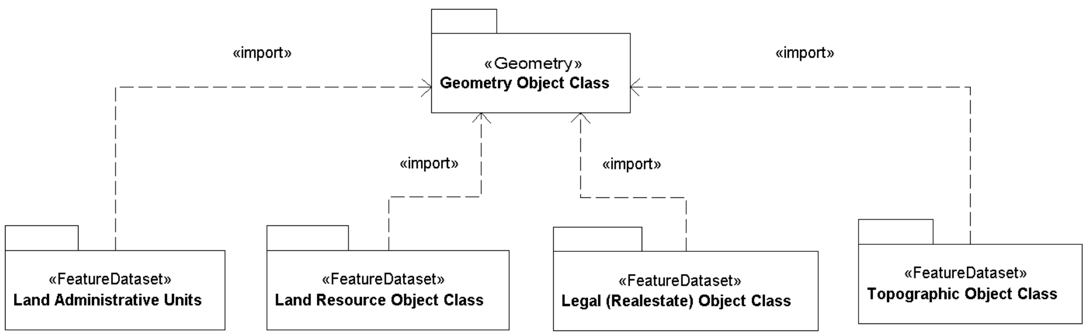


Figure 4.20: Categories of land object classes

(a) *Geometry object class:* The geometry object class package contains three basic primitives with topology, namely polygon, line and point. But accepted standards on geometry and topology have already been published by ISO and OGC (ISO, 1999a, 1999b; Open GIS Consortium, 1998, 2001). A simple way to use these standards is that, if the geometry of a point is based on survey point measurement (converted to the national coordinate system), its geometry is then associated with classes of tp_node (topological node) and tp_edge (topological edge) (Lemmen, van der Molen, van Oosterom, Ploeger, Quak, Stoter and Zevenberger, 2003). In general, it is possible to have any feature combined with the geometry and topology. This is similar to the solution provided by Molenaar (1998), where each feature is assigned a point, line or polygon in which the topology is defined. Further discussion on these issues is beyond the scope of this research, and it is assumed that other feature data sets are assigned appropriate spatial data types according to the ISO and OGC standards.

(b) *Land administrative units:* These land objects are, in general, large in spatial extent, and serve to support security by assigning the responsibilities of the formal or non-formal authorities. Within a country, four subclasses can be identified, namely, Customary Areas, Districts, City/Village and Blocks/Wards, as drawn in the UML class diagram shown in figure 4.21. Country is also assigned as a class for the sake of clarity.

Customary areas can be clan/family land or community land – for example, if customary areas are identified, surveyed and registered, and the chiefs/headmen can further exercise their responsibilities to manage and develop these areas under the guidance of district planners. This concept is not only beneficial to the Nepalese and Bhutanese societies, it is also important in many parts of African countries (e.g. Zambia, Ghana, Namibia), where many areas of land are under customary rules and still have not been surveyed and registered.

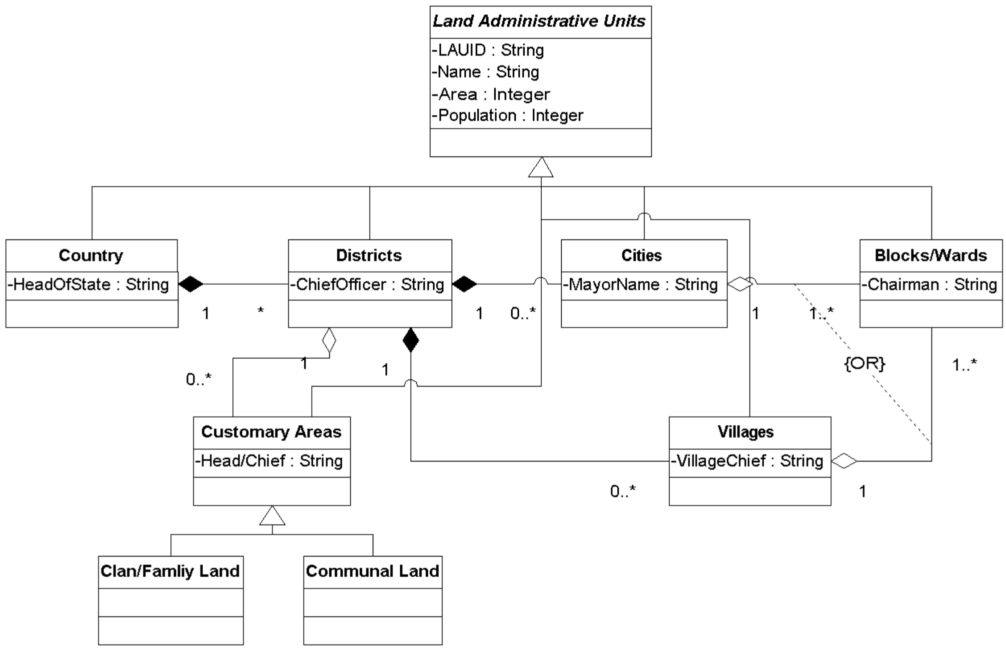


Figure 4.21: Class hierarchy for land administrative objects

In principle, the chief district officers (CDOs) of Nepal or the Dzongdags of Bhutan are responsible for seeing that development plans are implemented in their districts in accordance with their plans and market needs. These activities can be implemented only if proper attention is paid to land tenure and market orientation. For their information needs, the district class containing district objects with information about district name, total land parcel, number of disputed parcels, yearly transaction, and minimum, maximum and average market prices of land parcels is essential in our model.

The Cities, Villages and Blocks/Wards are other essential subclasses of land administrative objects for supplying information to the concerned municipality or ward offices for decision-making purposes. They are responsible for the development and maintenance of urban services and infrastructure in their cities and wards. Blocks/Wards belong to either the City or the Village. The {OR} constraint is used in such cases.

In principle, these land administrative objects are surveyed in the field or identified in aerial photographs or satellite images. Later on, we need to digitise the boundaries in a correct national coordinate system. As regards the spatial data types, all these objects get *polygon geometry with face topology*.

(c) *Land resource areas class:* In PBGIS in Nepal, it is important to identify the boundaries of land objects that are used for various resource management purposes (such as forest management, watershed management, hazard management), and record them in the register database at the cadastre to show the bodies responsible for their management. Being a developing country, there are many projects taking place around the country for managing resources. For local people, it is important to know how these projects affect their rights on land for their own benefit. Therefore, an example of such a static model is shown in figure 4.22. Here we have four subclasses for land resource areas: forest reserved areas, watershed areas, hazard areas, and others. More subclasses can be easily added, if necessary.

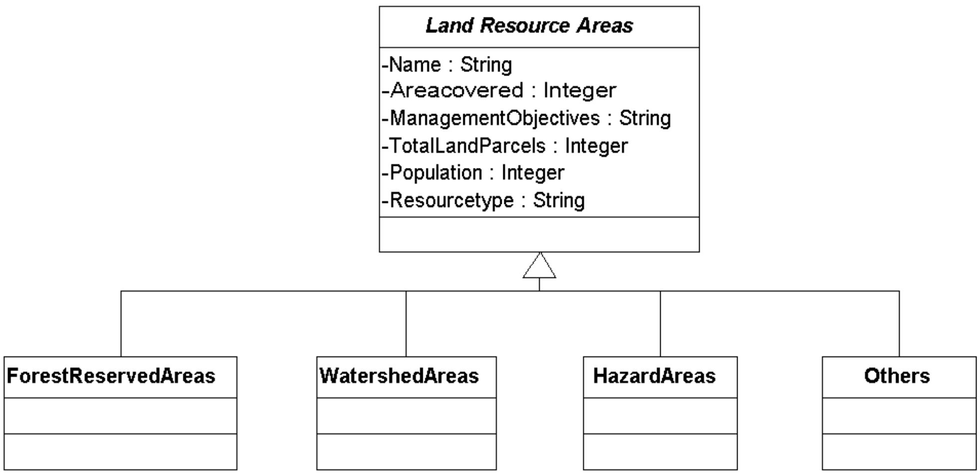


Figure 4.22: Class and subclasses for land resource areas

The essential characteristics of such land resource areas would be the names of the responsible bodies, area covered, management objectives, the total land parcels, population and resource types. In some subclasses, additional characteristics would be average land market price and transaction rate, etc.

Data about their boundaries can easily be collected from the relevant agencies via SDI, and stored under separate themes. Since these are of the area type, polygon geometry with face topology is assigned.

(d) *Legal (real-estate) object class:* Traditionally, the land parcels with limited characteristics related to tax rates have been the main interest for generating revenue by levying land and property taxes. Since, by their very nature, land parcels are considered as commodities on open markets and resources for the management of wellbeing, land parcel objects could very well be modelled as shown in figure 4.23. In this model, the focal object is the individual land parcel class, which is the basic unit for individual rights or responsibilities and for levying land taxes. In the diagram, it is linked with the Building object through association relationships, and this Building class may consist of an Apartment object class. In the case of Nepal, the land parcel objects can be located in Urban, Tarai Valley, or Mountain. These distinctions are modelled through the generalisation/specialisation concept in UML. Another interesting remark is that land parcels can lie either in the blocks/wards or customary areas, which are management units. In this way the responsible officers know the person who owns the land and where it is located within the management units.

Since the boundaries of land parcels within customary areas are very flexible and it is impossible to demarcate them, building point objects are used to locate the place where the indigenous people live. This concept is important to protect the rights of indigenous people within the customary area, in case they are displaced by land acquisition for public purposes or any other events occurring in the areas.

Land Parcel objects lay either inside a Block/Ward or Customary Areas. Note that constraint {OR} is indicated in the diagram. Both these classes belong to the package called Land Administrative Units, but they are dragged into this model.

The classes such as Mapsheet and DistrictLandRecord are legally essential in Nepal, and hence they must appear in the model. Land parcel objects must be recorded in DistrictLandRecord and must appear in the map sheet. Similarly House and Apartment are modelled using association. An apartment cannot exist without a house, therefore there is a strict composite relationship. Note that Parcel class and Apartment class are subclasses of Real-Estate Object, and so they are considered as commodities which can be sold, purchased, mortgaged, leased and inherited. A single house is always a part of a parcel, while an apartment only shares a parcel.

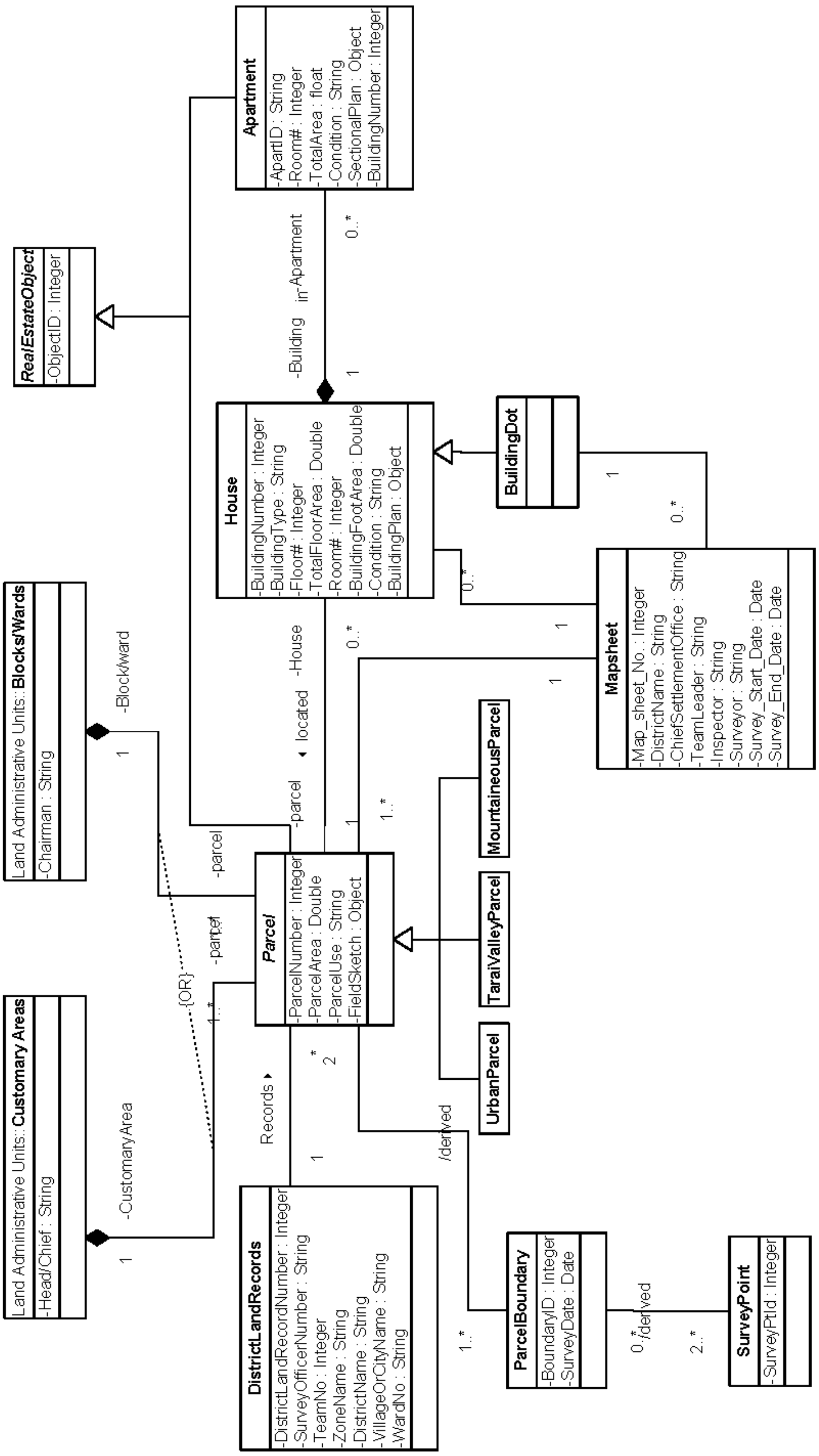


Figure 4.23: Static model for legal (real-estate) objects

In figure 4.23, there are several classes that require spatial and non-spatial data types. Since we consider only 2D objects, spatial data types are assigned as follows:

- Parcel class is derived from parcel boundaries. Face topology is needed here.
  - Parcel boundaries are constructed from survey points with edge topology.
  - Survey points are concerned with node topology.
- House and Mapsheet classes are assigned with polygon geometry and face topology.
- BuildDot class is assigned with point geometry and node topology.

There are other classes (e.g. District Land Record and Apartment), which are purely non-spatial.

One last remark on this model, there is no class such as “part-of-a-parcel” in Nepal, because the parcel must be constructed in the field by a subdividing or merging process before registration can take place in the land registry office.

For the maintenance of object history, the object versioning technique is promising. Implementation details are given by Kim (1990) and Zeiler (1999), but these details are not considered for the modelling stage in this research work.

(e) *Topographical object class:* There are many reasons why we need topographical features together with other land objects. In Nepal and Bhutan, the cadastral surveying is currently performed using a plane table and an alidade, which measures distances with the application of slope corrections in the field. Field boundaries are very much of the general boundary nature and exact boundaries are never surveyed. In such a situation, it is important that land parcel boundaries are near to reality on the ground. If there were reliable topographical objects in the digital databases (vector or images), this would always provide owners with more confidence in their boundaries.

Figure 4.24 shows an example of a topographical class diagram. There are seven main subclasses of the Topographic Object class, namely Geodetic Control Points, Roads, Water Features, Cultural Objects, Electricity, Telephone, and Digital Elevation Model (DEM). These subclasses inherit the properties and behaviours of the Topographic Object class. Since we consider that all data are of the 2D type, there is an attribute called elevation that allows heights for every point and line of objects in all subclasses to be stored. In topographical survey, it is normal practice to record elevation for every object.

Geodetic Control Points (GCPs) are linked to Mapsheet, which belongs to the Legal (Real-Estate) Object class. This is necessary; a minimum number of three GCPs are required in a map sheet when plane table surveying takes place for cadastral surveying. There are many types GCPs, such as first-, second-, third- and fourth-order triangulation points or traverse points, in Nepal. Most of these survey points are established as monuments and surveyed accurately in the field. They are documented with locational sketches, showing the location and how to reach them. These sketches can be scanned and attached to each GCP object as an object attribute. There are also global positional system (GPS) points.

Roads are classified into Highway, Main Road, Secondary Road, City Road and Footpath. In large-scale mapping, these objects are mostly polygons in geometry with face topology. Since these roads are often too large to be digitised as polygons, it is normal practice to partition them, digitise them as lines, and then build the topology as polygons.

Water Features are classified into River, Stream, Lake, Pond, Well and Dam. Here all objects are polygons with face topology, although if a well is too small it can be a point, depending on the standard adopted for large-scale mapping.

The Cultural Objects (mostly religious objects) are classified into Temple (its type may be Hindu or Buddhist), Church and Mosque. In most cases, these objects have polygon geometry.

The Electricity objects are classified into Electricity Line, Electricity Pole and Power Station, while Telephone objects are divided into Telephone (above surface or underground) and Telephone Pole (either normal or mobile). Here objects are based on either lines or points, with the exception of Power Station, which is a polygon.

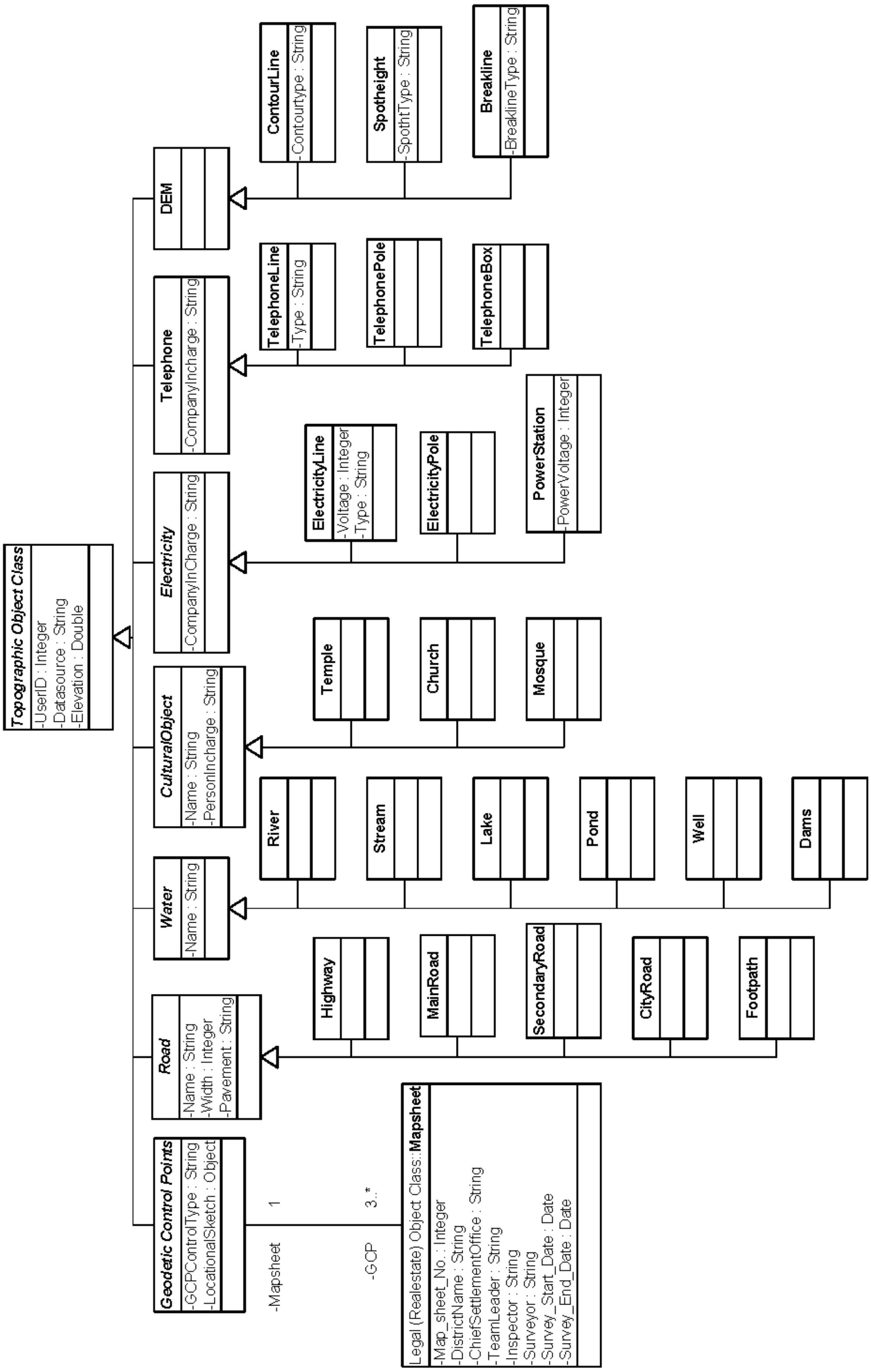


Figure 4.24: Static model for topography

> Normally, the DEM is not given on the cadastral maps, but with the PBGIS in mind it is necessary for various GIS applications, and is classified into Contour Lines, Spotheights (pits, peaks, saddles), and Breaklines (ridge lines, streams, banks, etc.). Regular grid points as points can be added as a subclass. Slope, aspect, and the triangular irregular network (TIN) are normally derived from the above data and stored as theme. Here contour lines and breaklines are line objects, while regular grid and spot heights are points.

In Nepal, the responsibility for producing, maintaining and disseminating large-scale topographical objects is still with the Cadastral Survey branch, and a plane tabling technique is used to capture these objects. In a paper-based system, such an arrangement is acceptable, but in a digital environment, a separate department and technical skills different from cadastral surveys are needed to maintain these spatial data. Digital photogrammetry is often used for capturing and updating these data sets. Data are then made accessible via SDI.

Static Models for Land Registration Subsystem

Since there are many field books and records in Nepal and Bhutan at the district offices, it is important that district land records are input into databases. In Chapter 3, it was indicated that recordings kept at the districts are unable to cope with the search requirements of the customers. Thus, all individual land parcels must be linked to land records, which are then used for conveyancing and taxation purposes.

Two models are developed for the Nepalese case. The first is for the person only and is presented in figure 4.25. The second refers to the ownership, tenancy, mortgage and restrictions relating to the Real-Estate Object subclass of the Legal (Real-Estate) Object class and Person class. This is presented in figure 4.26.

(a) Model for Person

In figure 4.25 showing the model for person, there are two subclasses of the abstract class Person (i.e. Natural Person and Non-Natural Person). They are modelled using generalisation/specialisation.

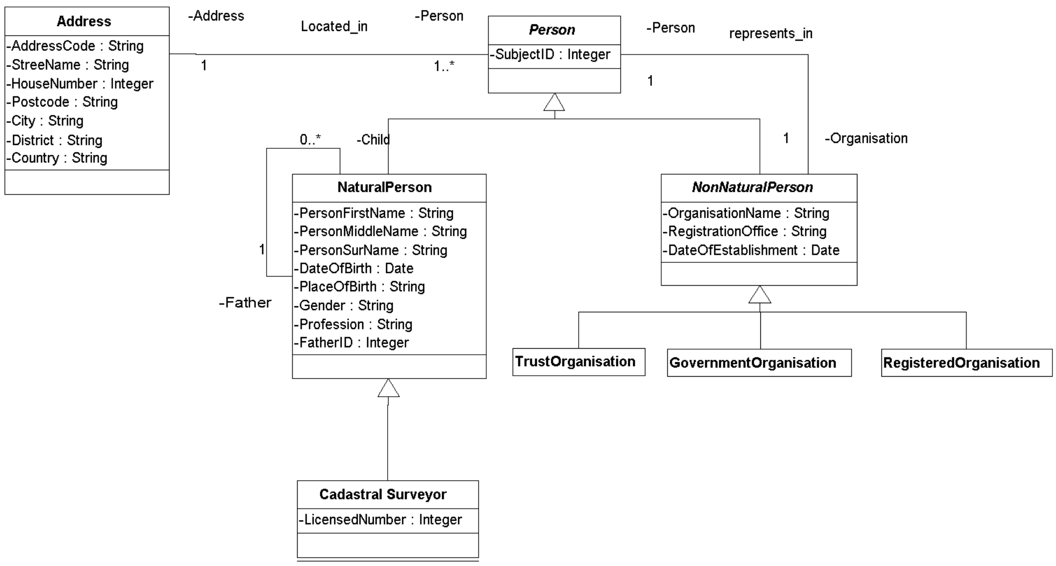


Figure 4.25: Static model for person in Nepalese cadastre

The class Non-Natural Person is further specialised into trust organisations, government organisations or registered organisations. Registered organisations may be private or non-government. Financing agencies or banks are considered in this subclass. There is an association link between Person class and Non-Natural Person class to show that a person participates as a representative on behalf of that organisation. There is also another association link between Person class and Address class with a 1-to-1..* relationship. This also means that a person cannot be registered with an address.

With Person class, there is an association link showing that a person (as father) may have zero or more children. In Nepal, this is important for inheriting properties, and similarly a relationship between husband and wife can be defined in Person class. For the purpose of clarity, this is not shown in the above figure.

(b) Static Model for Ownership, Tenancy, Mortgage and Restrictions

Figure 4.26 illustrates a static model for ownership, tenancy, mortgage and restrictions. Since there are relationships with Person class and Real-Estate Object class, there is a similarity with the core cadastral data model shown in figure 4.19.

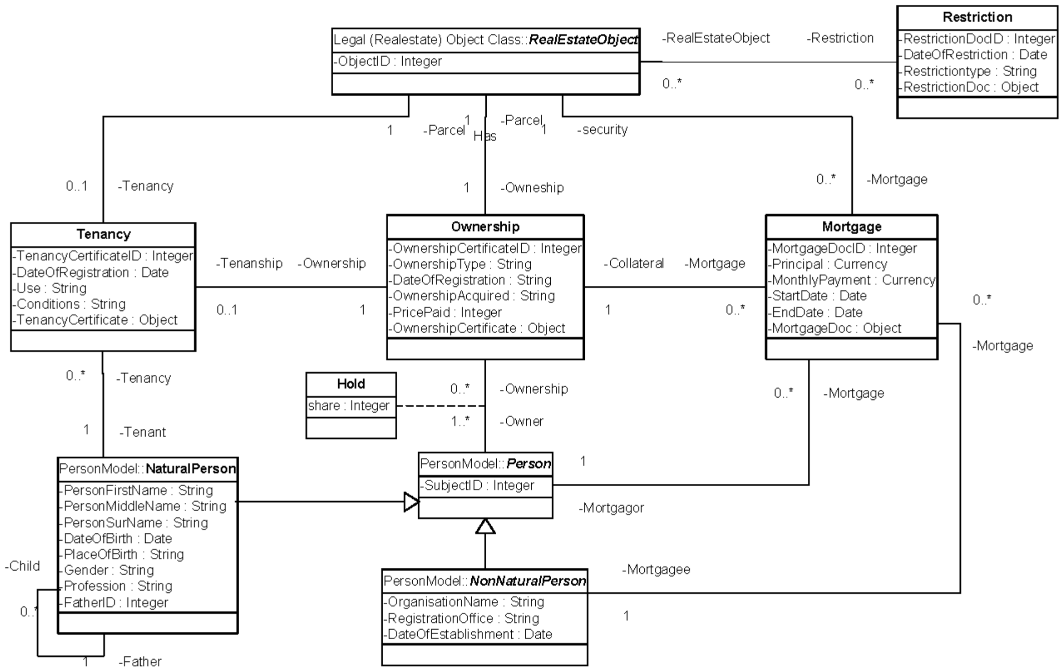


Figure 4.26: Static model for ownership, tenancy, mortgage and restrictions

Looking at the land tenure arrangement in Nepal described in Chapter 3, it reveals that the land rights relationship tends to focus on the fact that ownership (or raiker) is strongly related to real-estate objects, which cannot exist without ownership. That is why there is a 1-to-1 relationship between them, as shown in figure 4.26. Then a person as owner holds an ownership certificate through an association class called Hold, in which share is defined as an attribute. This means that one or more persons as owners can hold ownership to the same real-estate objects with a share.

In the case of tenancy rights, the relationships are different. A natural person acting as tenant can only hold zero or more tenancy rights, while the real-estate object may contain zero or one only tenancy right. Note that it is not Person class that has the link with tenancy rights.

In the case of mortgage, Person class (as mortgagor/borrower) is related to Mortgage class by an association link (as 1 to 0..*). In Nepal, a non-natural person is the only one who provides a loan as mortgagee. Hence Non-Natural Person class is related to Mortgage class by an association link (as 1 to 0..*). Then the real-estate object is used as security for the mortgage, and the mortgagor/borrower is owner of that real-estate object.

In the case of restrictions on real-estate objects, the relationship is an association link (as 0..* to 0..*). Usually non-natural persons impose restrictions only.

4.3.7 Dynamic Models for PBGIS

As discussed previously, the changes that occurred in the characteristics of the objects, as defined in the above sections, can be modelled using a UML diagram, such as use case, activity, state transition and interaction diagrams (sequence and collaboration diagrams).

The changes in the systems are usually triggered by the external environment of the PBGIS, using the services of subsystems. This is a dynamic aspect of the external environment, where users are involved in carrying out these services. Use cases are very well suited to modelling such user interactions and can exhibit the responsibilities of the users/customers (or actors in UML). Such a use case model allows us to see if the users/customers are satisfied with the services and products within defined scope and boundary of a system. Therefore, it gives us a sense of the behavioural aspects of users/customers, and of how the system and users should interact with each other. This is important particularly to execute a process in defined rules.

A use case can be realised through a series of activities, which are modelled internally within the system by the activity diagram. Behaviour aspects of such individual activities can be modelled using state diagrams. Normally the state diagram models the states of an object. Thus internal dynamic aspects show us the activities necessary to accomplish a certain use case, displaying the state of an object. In the modelling stage, an interaction diagram such as a sequence diagram or collaboration diagram helps to show how a use case can be accomplished. In this research, some dynamic models are shown, because others can be developed in a similar way.

In the following sections we firstly discuss two dynamic models for a PBGIS in users' environment by use cases for parcel subdivision and dissemination of cadastral information. Secondly dynamic models using activity diagram (for editing topographical database) and state diagram in internal system environment (Deeds) are developed and discussed.

(a) Models in Users' Environment

This model explains what the system must do by means of use cases and who uses the system by means of users/actors. Identifying users/actors and use cases is usually the first step in modelling the system. An actor represents a role that someone or something in the external environment can play in relation to the business process (Jacobson, 1992). These users are classified into actors in terms of the roles they play in relation to the system. A use case represents a business process. Every actor and use case should have at least one association with each other.

The first model, as an example of the cadastral parcel subdivision process in the cadastral subsystem, is shown in figure 4.27. There are four actors in this process:

- Land registrar: requests, on the behalf of sellers and buyers in a transaction, the subsystem to subdivide the land parcels and to provide parcel certificates.
- Owners: identify the boundaries at the site in front of the land surveyor and other concerned parties at the appointed date.
- Land surveyor: prepares field survey plan, makes appointment for survey, carries out survey and checks computation, and finally passes all documents to the database manager.
- Database manager (DB): updates spatial database, builds topology and prepares parcel certificates.

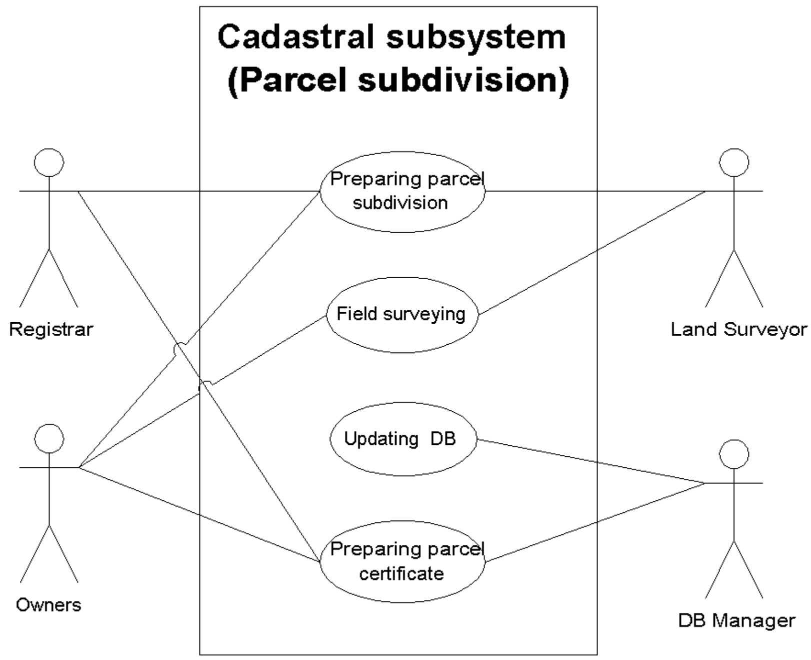


Figure 4.27: Use case model for subdivision process

The subdivision process may have four use cases:

- Preparing parcel subdivision work: In the event of a request, this use case organises the work plan in combination with other instances of requests. Necessary data are retrieved from the databases and appointments are made with owners and other concerned parties. This use case takes the longest period and delays fieldwork execution.
- Field surveying: This use case produces a field sketch and all field measurement documents.
- Updating databases: This use case subdivides parcels in the databases and produces topologically correct parcels.
- Preparing parcel certificates: This use case prepares parcel certificates with correct areas and sends copies to the land registrar and owners.

The second model, as an example of the dissemination subsystem, is given in figure 4.28.

- Contractor: represents private individual to whom national mapping agencies supply products and services by making a contract.
- Mandated client: represents public authority to which national mapping agencies supply products and services through the legislation.
- General customer: represents individual who orders standard products or user-specific products.
- Internet user: represents individual who accesses national mapping agencies, and orders and receives products through the Internet.

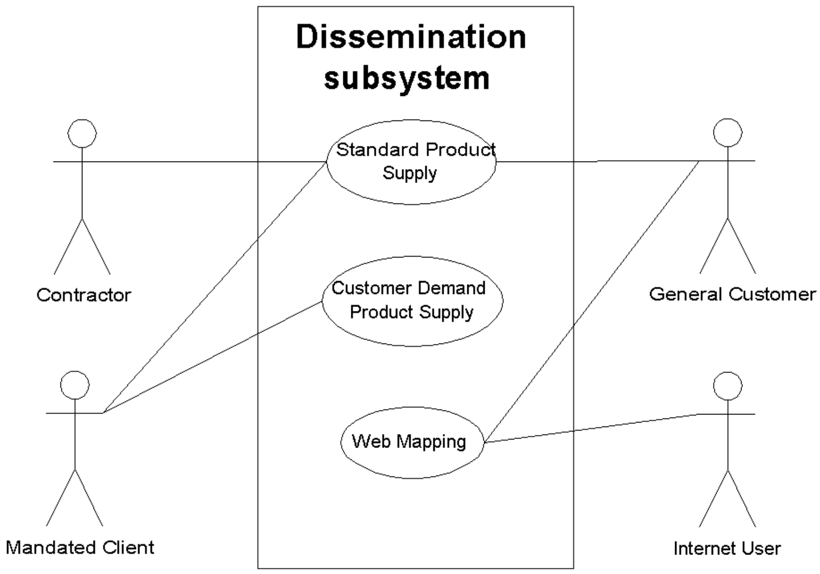


Figure 4.28: Use case model for dissemination subsystem

The use case description can be given as follows:

Standard product supply: provides products to the contractors and mandated clients through contracts or the legislation. Input to this use case is the distribution plan; output is standard products supply.

Customer-demand product supply: handles customers who are mandated clients. Customers initiate this use case by submitting an application. This use case is extended by the hardcopy map production use case and various digital products production processes in the case where new products are needed. Inputs to this use case are user's application, a standard product list, and metadata; output is user-defined products supply.

Web mapping: handles Internet user by publishing spatial information on the website. Inputs to this use case are information supply database and metadata; outputs are products and services to the Internet users.

(b) Models in Internal System Environments

As shown in the first case above, the actors through the use cases trigger the changes that occur in the objects. The realisation of use cases (or activities), such as the establishment of geodetic reference systems, the editing of topographical data, demarcation, the field surveying of parcel boundaries, and land transaction (by sale, inheritance or gift) can be accomplished by carrying out activities. Figure 4.28 gives an example of the activity model for editing topographical data. But the activities must be realised by ensuring correct interaction among objects of various classes. Correct interaction also means that the object of the precise stage should be known to the activities. Such precise modelling can be done through a state diagram.

Activity model for editing topographical data

The activity model in figure 4.29 displays the basic flow of events and alternatives, showing the conditions under which the activity can be accomplished.

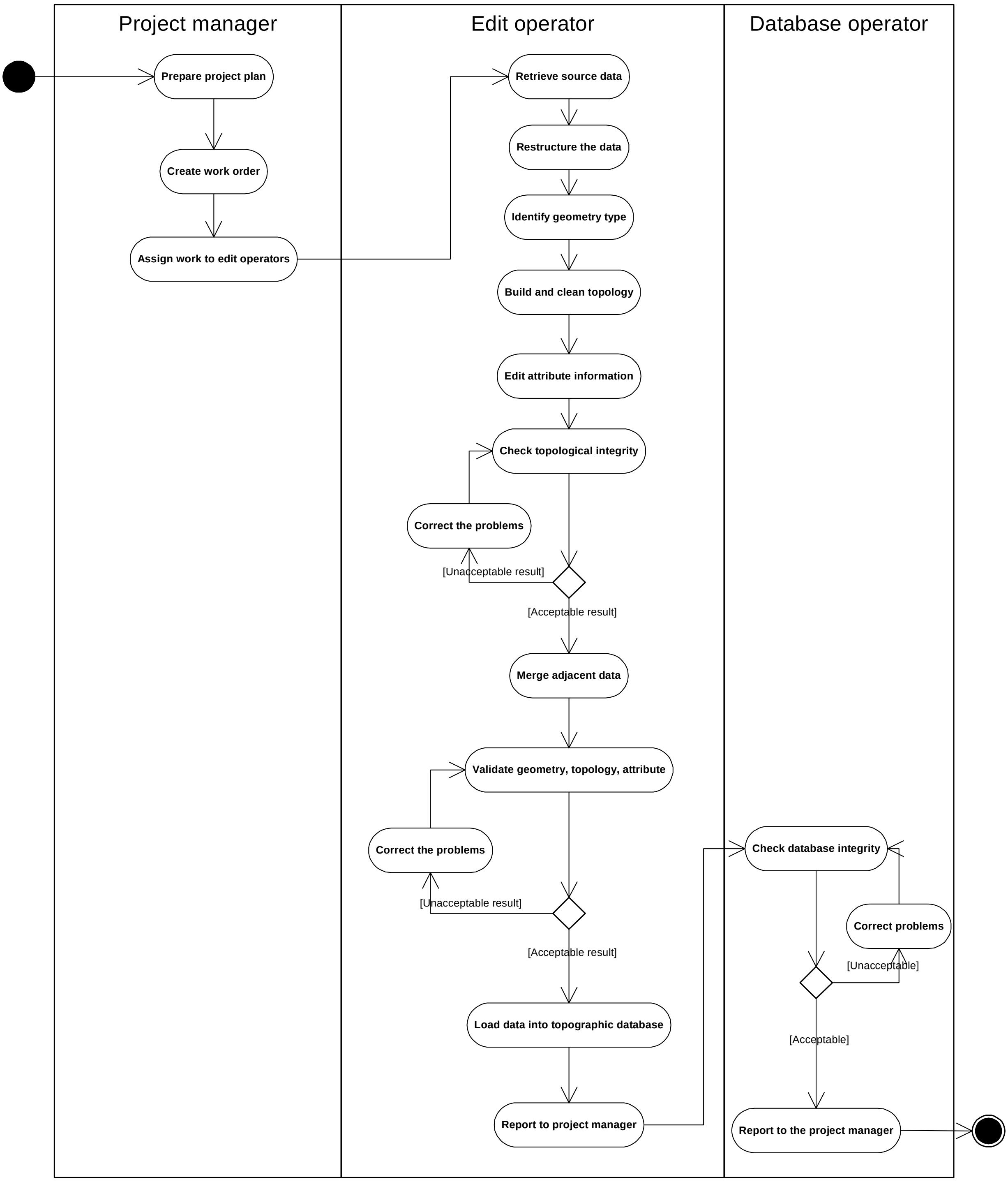


Figure 4.29: Activity model for editing topographical data

Scenario (basic flow of events)

Step 1	Project manager prepares project plan
Step 2	Project manager assigns work orders to each operator
Step 3	Edit operator retrieves digitised data from source data archive
Step 4	Edit operator restructures the digitised data into different themes
Step 5	Edit operator identifies and defines geometry type and attributes for each feature according to database specification
Step 6	Edit operator builds and cleans topology between features
Step 7	Edit operator edits attribute data
Step 8	Edit operator checks topological integrity within and between layers
Step 9	Edit operator merges adjacent area
Step 10	Edit operator validates geometrical, topological and attribute integrity
Step 11	Edit operator loads spatial data into the topographical database
Step 12	Edit operator reports to project manager
Step 13	Database operator checks topographical database integrity
Step 14	Database operator reports to project manager

Conditions may be applied a number of times in the above activity model. For example, step 4 is repeated a number of times until the database is restructured in a defined number of thematic layers. Similarly steps 8, 10 and 13 are repeated until the result is acceptable.

State diagram of a deed

A state diagram is highly suitable for identifying the possible states of a deed while lodging a deed with the land registry office. Figure 4.30 shows such a state diagram for a deed, illustrating the eleven possible operations that can be applied to a deed, resulting in the six possible stages of that deed.

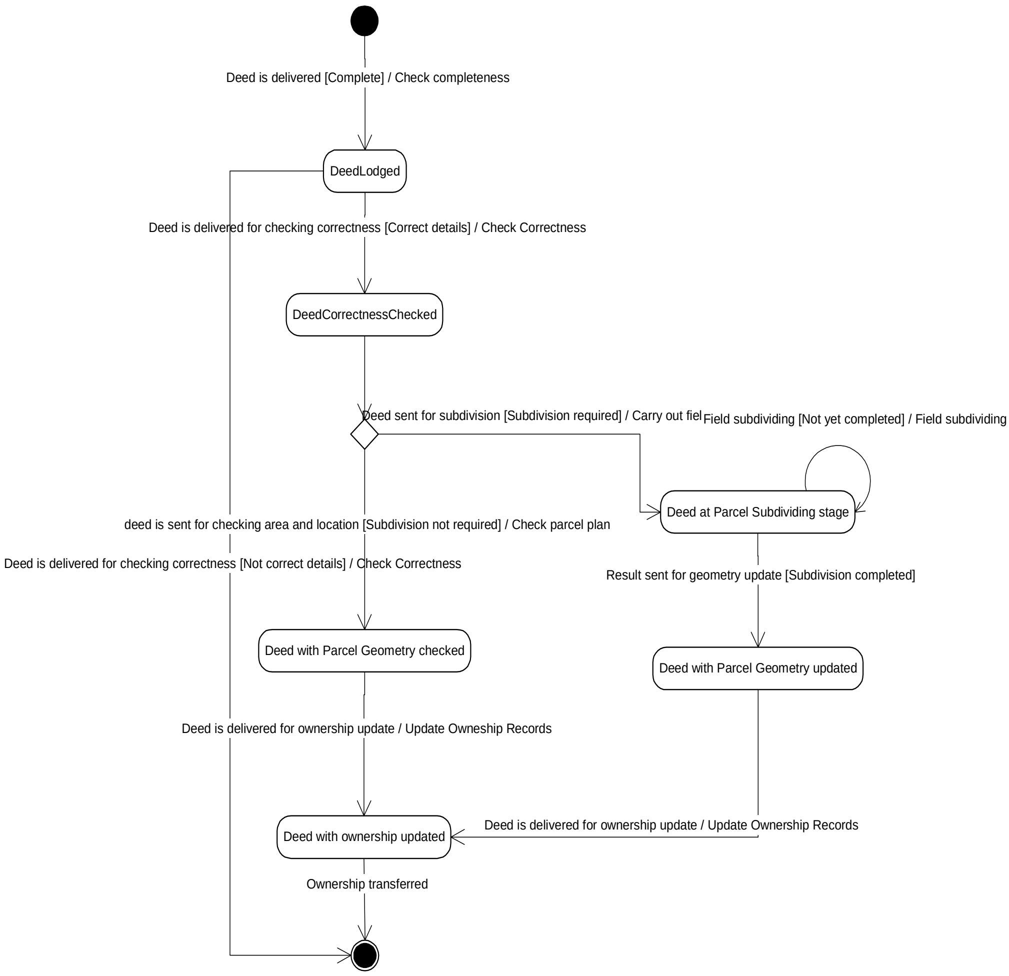


Figure 4.30: State diagram for a deed

These operations will then appear in the deed class structure so that the deed object responds to its behaviour to change from one stage to another.

When a deed is delivered, it is checked for its completeness. First stage of state is “Deed lodged”. Then it is checked if all written items are correct or not. If correct, next stage of state is “DeedCorrectnessChecked”.

If subdivision is required, the request is sent to the cadastral surveyor. This state is called “Deed Parcel subdividing stage”. When subdivision is complete and updated, the next stage is “Deed with parcel Geometry updated”. Then deed is delivered for updating ownership records.

If subdivision is not required, deed is directly delivered for updating ownership. The last state of deed is called “Deed with ownership update”. This is stage where ownership is actually transferred.

4.4 Summary and Concluding Remarks

The objective of this chapter is to develop system models for a PBGIS using object technology. To achieve this, this chapter looked briefly at the existing methodologies of system development (e.g. soft systems methodologies, structured system development and object-oriented methodology). All these methodologies emphasise the need for models. The object technology using the UML is described as a flexible approach for a system. The models presented in the above section are not complete, but they are a representation of cases in order to understand an approach for developing system models in PBGIS.

Four subsystems are presented within a PBGIS for Nepal. These subsystems are highly interrelated to carry out tasks and services within the defined domain. Each subsystem contains application services and production databases. In this way, the responsibilities of each subsystem are clearly known, as well as with whom they have to communicate to ensure the success of services. The data and services are shared among themselves.

The starting point for static models in the cadastral surveying subsystem and land registry subsystem is the (FIG) core data model, in which the emphasis is on registering real-estate objects (parcels and apartments) and persons through rights or restrictions as the main cadastral domain. In the PBGIS of this research, a domain is very large, as it not only has real-estate objects but also contains four kinds of land object class, containing land administrative unit objects, land resource objects, legal (real-estate) objects and topographical objects. The first two object classes are basically responsible for the administration and management of land. The Administrative Unit Object class also includes customary areas in which chiefs/heads are assigned as responsible persons. The role of land resource objects is maintaining information about the benefits and responsibilities of all land users and owners.

There are two kinds of legal (real-estate) objects in Nepal similar to the FIG core data model. The basic unit for registration is the parcel (not boundary), and the parcel must be surveyed before registration, but the structure of a parcel is similar to the (FIG) core data model in terms of topology. For urban areas, accurate surveying field sketches for each parcel are recommended and archived for future use. Since the concept of general boundary is followed in Nepal, topographical objects are an essential part of cadastral surveying and mapping. In a 2D situation, apartments need to be registered with their sectional plans. For houses in customary areas, nodes are proposed for locating houses, as they are likely to move.

With regard to Person class, two main subclasses, namely Natural Person and Non-Natural Person, are identified. But Non-Natural Person is subclassified into trust organisations, government organisations and registered organisations.

The relationships between persons and legal (real-estate) objects depend on the type of land rights. In general, they are holding rights. In the case of ownership, there are slight differences owing to the local land tenure situation in Nepal. A person holds ownership and ownership applies to a parcel. In the case of tenancy rights, only a natural person can be a tenant. In the case of a mortgage, a non-natural person provides a mortgage, while a natural person must be an owner who gets a loan. Real-estate objects are used as security. Restrictions are related to real-estate objects and ownership, and non-natural persons impose restrictions.

In general, land objects, persons and their land right relationships depend on the local land tenure situation and the domain defined within a PBGIS. In conclusion, Real-Estate Object class alone is not sufficient for a PBGIS in Nepal. Other kinds of land objects are needed to assign responsibilities. Therefore, there are basically two kinds of object – non-real-estate object and real-estate object – as core objects. Non-real-estate objects are land administrative units and land resource areas. In addition to the Right Or Restriction class, the Responsibility class is necessary and is linked to Non-Real-Rstate Object class. Thus the Right Or Restriction and Responsibility classes are then considered as core objects. Under the Non-Natural Person class, additional subclasses (e.g. customary (trust) organisation) are added. Therefore, a core cadastral data model for Nepal contains classes for land object (i.e. Non-Real-Estate Object class and Real-Estate Object class), right or restriction, responsibility, and person. Their relationships are not always Association class; they rather depend on the type of land rights defined by the land tenure system, as shown in figure 4.26.

The use case models of the subdivision process and dissemination of information show that the use cases are excellent for capturing users' requirements as they have direct contact with users. The examples of the activity diagram and state diagram are promising for realising services by the organisation. These diagrams are very well synchronised within packages and subsystems for a PBGIS.

Finally, this chapter shows an approach for developing system models in a PBGIS, using subsystems and the function/process, static and dynamic aspects of data.

Chapter 5

Organisational Prototyping and Quality Aspects

5.0 Introduction

In Chapter 4, we discussed the modelling approach and models for cadastral services and data in a parcel-based geo-information system (PBGIS), using a universally standard modelling language (i.e. UML).

The purpose of this chapter is to prototype services and analyse them in an organisational environment, and to discuss data quality issues concerning a PBGIS. Thus it deals with two main components in relation to prototyping a PBGIS.

The first component (in section 5.1) is related to organisational prototyping for aligning organisations (or departments) with respect to their business service, so that appropriate responsibilities are identified within the context of organisational strategies and goals. This is called “organisational prototyping” for the purpose of this research. Discussion and results are presented in section 5.2.

The second component concerns quality aspects of the system models and data. The quality factors and reviewing approach at system model level are proposed and discussed in section 5.2. Data quality is investigated using real data sets. And the results are presented in section 5.3

In this research, these components are considered essential for organisations, as well as for satisfying market demands and changes in customer behaviour and for developing PBGIS, since directly executing cadastral processes without full tests against the resources of the organisation are risky and expensive. The choice of these components is based on the fact that some processes could be long overdue for improvement. Although everyone knows they are inefficient, the staff dislike them, and the organisation is losing money because of them, no one has investigated deeply enough to find out why all this is happening. In other cases, the introduction of a brand new process in the organisation would bring a new line of business as part of the strategies that the organisations want to adopt. This is an ideal candidate for prototyping, because it helps the organisations to eliminate risks or potential inefficiencies from the start.

5.1 Organisational Prototyping for PBGIS

If the existing organisation is already matched with the analogue cadastral systems, organisational restructuring and process reengineering of the existing systems becomes necessary with the introduction of new Geo-ICT components. Many of the available restructuring approaches focus on the modelling and documenting of business processes as a basis for the redesign of these processes, while other approaches concern the modelling of human behaviour in organisations where norms, values and belief are key elements in organisations (Krumbholz and Maiden, 2001). So far, none of these approaches concern the prototyping of organisational structures and their logical evaluation.

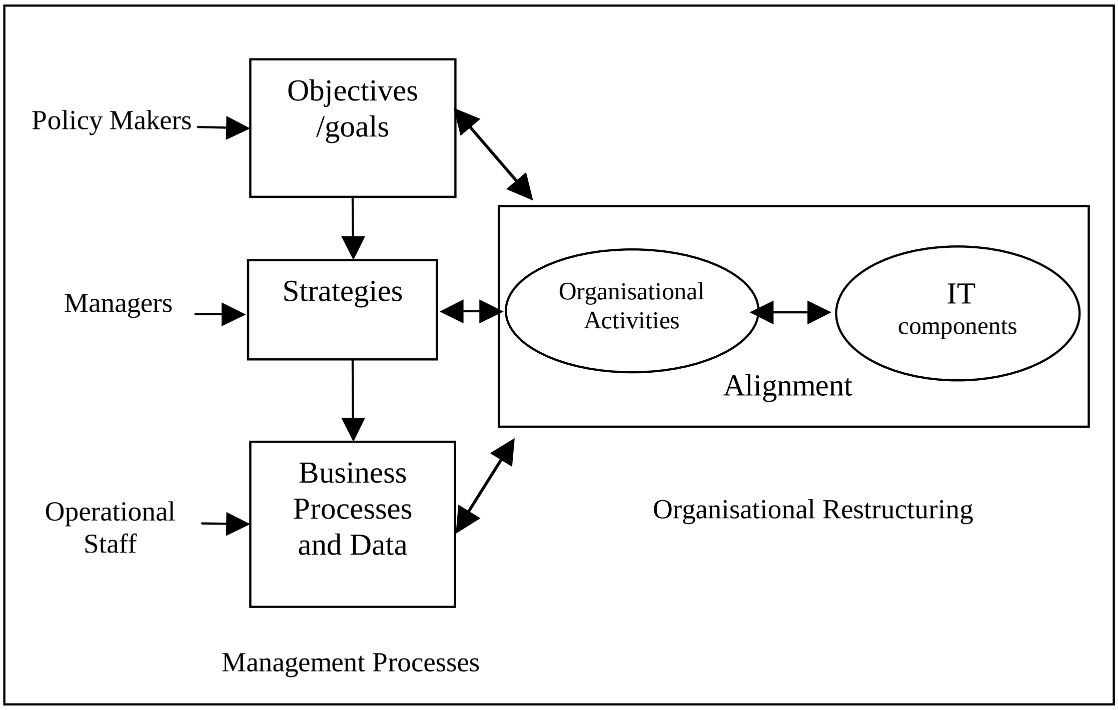


Figure 5.1: Framework for organisational prototyping

In terms of processes, it may be possible that old processes have to be completely dismantled and new processes have to be installed. In this case, it is essential to know the responsibilities of new organisational units in terms of managing the execution of business processes and managing the corresponding databases according to the specifications. Prototyping the organisation, processes and databases is also very useful for improving the existing situation, and when using the prototypes the employees of the organisation, as well as external stakeholders, can provide feedback before implementation. For the purpose of this research work, such prototyping is called as “organisational prototyping”.

Figure 5.1 shows a possible framework for organisational prototyping. There are three main elements that are essential for prototyping. The first is the objectives or goals of the system, which are usually defined by the policy makers. As discussed in Chapters 3 and 4, the definition of objectives for PBGIS is based on the external and internal environments of the organisational systems, such as history, legal security, social structure, culture and equity in socio-economic terms. The second element concerns strategies, which are laid down on the basis of the targets, institutional and organisational arrangements, cooperation and communication between organisations and involvement of any other private parties. The strategies for the targets are aligned with the objectives or goals of the system.

The third element, at the operational level, consists of business processes and databases, where the data models play a key role in satisfying customers and stakeholders.

From the viewpoint of good practice, a number of issues are elaborated at the policy, management and operational levels for the PBGIS (Masser, 2003). These issues form a solid base for the organisational prototype of an efficient and effective production process within the goal and strategies of the organisations.

5.1.1 Organisational Prototype of Cadastral Business Processes

In Chapter 4, the number of cadastral services and data models was identified. Within the cadastral surveying subsystem, there are five major cadastral services at the district level that are considered to be bottlenecks in terms of delivery time, cost and resources used in the organisations, especially in Nepal. They are *initial data loading/structuring and, subdividing parcels, preparing parcel certificate* and *preparing special products and resolving boundary disputes*. Each of these major processes is made up of a number of lower-level processes or activities. For purposes of illustrating the approach, the first two services and a service “full transfer of ownership” of land registry subsystem will be discussed here in detail.

While prototyping, cadastral and registration services are organised as a business process in a hierarchical arrangement, with major processes at the top, each being composed of a number of sub-processes. The process has well-defined start and end points, each of which is associated with a customer.

5.1.1.1 Prototyping Tool

Oracle 9i Designer 2000 is used for the organisational prototyping in this research. It has the ability to model business processes, and decompose activities in an organisation unit (Lulushi, 1998). It also defines what information a system must manage and process, and provides details about how information is used by business activities. It allows a designer to allocate the organisational resources (such as personnel, cost and time) needed to carry out functions in accordance with the strategic goals or objectives to be quickly discovered. The process-driven approach is used in Oracle 9i Designer 2000 to analyse the requirements and to model business processes. The advantage of this tool is that Oracle databases and application user interfaces in Oracle forms are iteratively generated. Thus the development can be controlled stepwise before implementation.

Oracle 9i Designer 2000 uses UML class diagram for databases. There is no UML diagram for process modelling. Instead process diagrams are used. Therefore, all processes presented (in figure 5.2, 5.5 and 5.7) in the following sections are developed in Oracle 9i Designer 2000.

For second part of experimental testing for data quality, there is other two software. ESRI ArcGIS is employed for construction and manipulating of cadastral databases using ArcCatalogue and ArcMap. ERDAS Imagine software is used for processing digital images (aerial photographs and IKONOS images).

5.1.1.2 Cases Used in Prototyping

The following three cases are prototyped:

- initial database structuring and loading: for clarity reason, this title is given here instead of *initial data loading/structuring*
- parcel subdivision: similarly this title replaces *subdividing parcels*
- full transfer of ownership: This is only a part of *transfer of ownership*

(a) Initial Database Structuring and Loading

This process does not interact with the actual customers, but it is the most fundamental process in building up a PBGIS that consists of both spatial cadastral and ownership data in the organisations. In the prototype, three main departments are involved in carrying out the activities of this process in the Nepalese context. Setting up and managing databases is the responsibility of the Department of Land Information and its information management section; spatial data loading into the database is the task of the district cadastral office under the Department of Survey; and entering data about ownership, mortgages and restrictions is the responsibility of the district registration office under the Department of Land Reform and Management. The topographical survey branch supplies only topographical data or ortho-images for the districts. In this prototype, preparing large-scale foundation data is not included. It requires more resources and time and can be considered as a separate business process of the topographical survey branch, and it is possible that the funding mechanism may be different for this process because there are more users who are interested in topographical or ortho-image data.

There are 16 activities or sub-processes in the business process of initial database creation and population, which run across the different organisational units, as shown in figure 5.2. Two main production databases (namely spatial databases and land ownership databases) are identified and maintained at the district offices by information management sections (IMS).

At departmental level, the Department of Land Information and Archiving (DoLIA) has three major sub-processes, e.g. decision making for automation, defining requirements for the information system and IT infrastructure, and acquiring IT hardware and software. The IMS has three sub-processes, namely installing and testing IT infrastructure (including networks), establishing databases (spatial databases and land record databases), and developing user interfaces in accordance with specifications for data entry, loading, editing, etc.

The district cadastral survey office has five sub-processes, namely collecting cadastral maps for conversion, scanning them, on-screen digitising together with integrating topographical data (or ortho-images), topological editing, and loading cadastral parcel data into the district spatial databases. Three sub-processes could be computer-based, while the other two processes of collection and archiving can be manual without computer support.

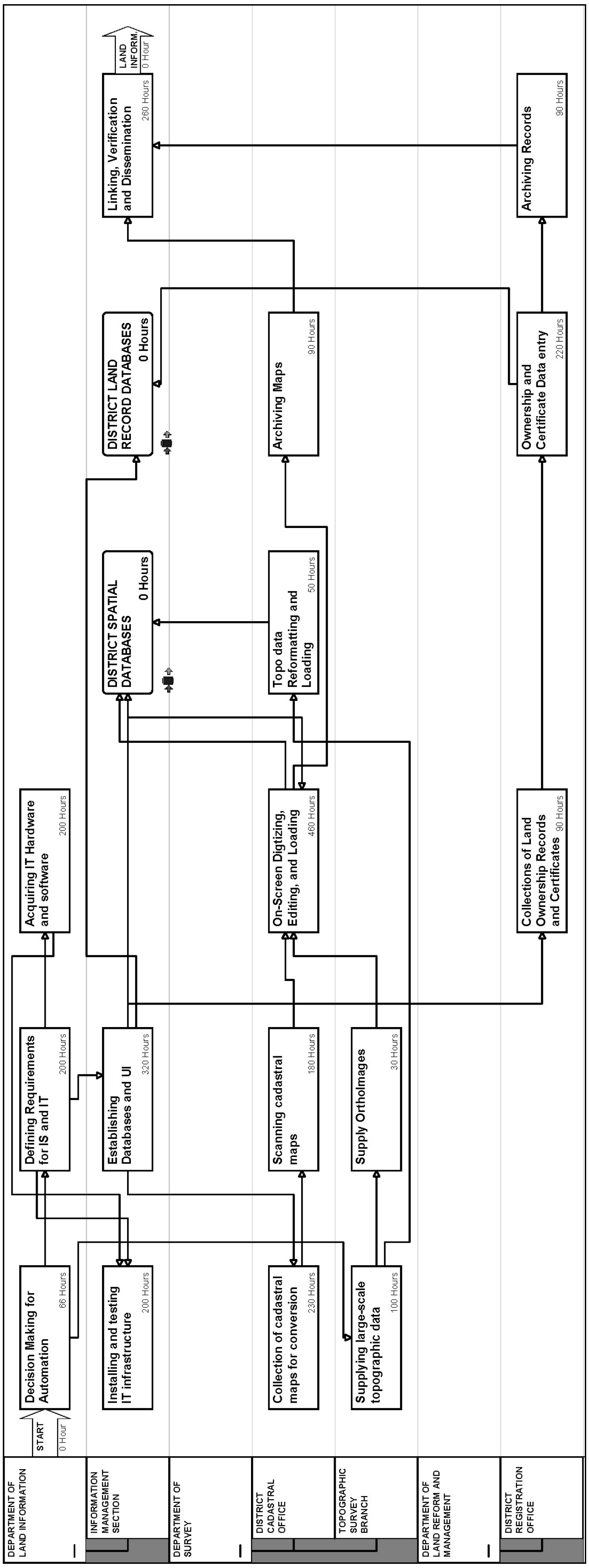


Figure 5.2: Initial database structuring and loading process

Similarly, the district registration office has three sub-processes, of which the sub-process data entry on ownership (including mortgage and restriction) and certificates is computer-based, while the other two sub-processes of collection and archiving records are purely analogue-based.

With respect to data collection about duration (including elapsed time), cost and salary for sub-processes, they are collected from experienced and senior officials from various departments. These data are then entered in designed process models. Some data (i.e. topographic data reformatting and scanning, archiving), however, are estimated, because they have limited experienced.

Total estimated duration is around 2.5 years (without holidays) for about 500,000 parcels with working 6 hours in a day.

Figure 5.3 suggests that the most time-consuming sub-process is the on-screen digitisation of cadastral maps, followed by the establishment of databases and user interfaces, and then the collection of cadastral maps.

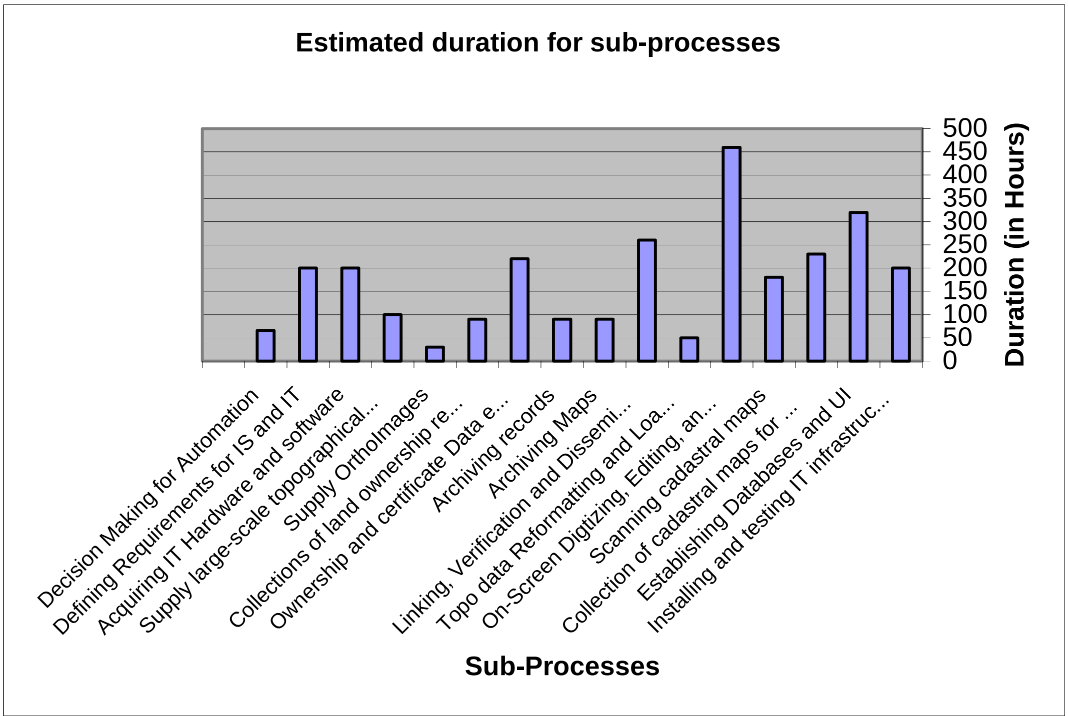


Figure 5.3: Estimated duration for initial database creation and population

The argument for the considerable time taken in collecting cadastral maps is the poor storage situation in the district cadastral offices and the considerable of indexing them.

Again, for the resource in term of workload, figure 5.4 shows that the DoLIA contributes 42% of the effort by setting up the databases and making sure that the data are correct and logically consistent, and the district cadastral office similarly contributes 41% with data conversion, loading and assuring quality by comparing with either topographical data or ortho-images.

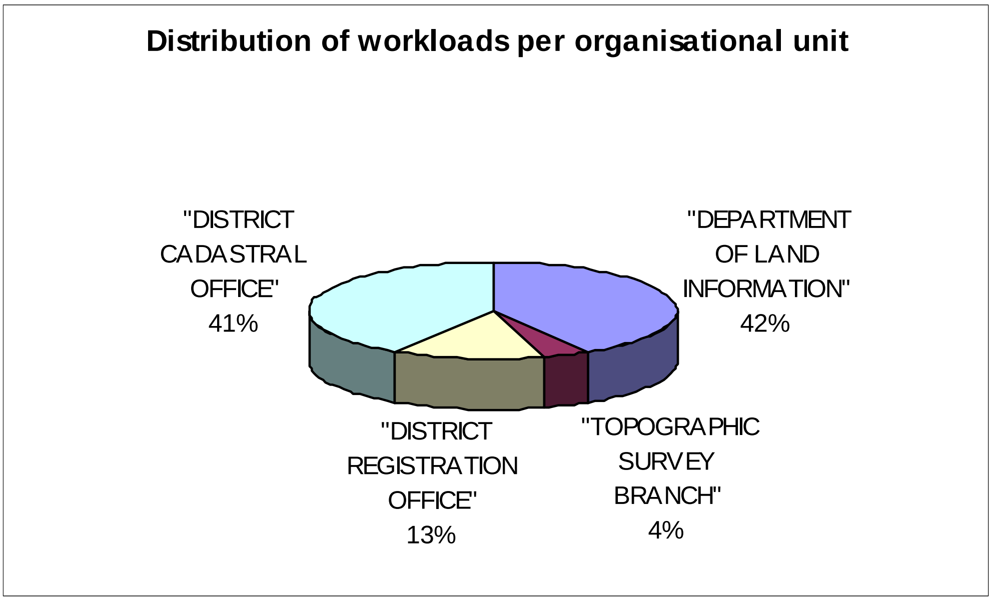


Figure 5.4: Distribution of workload per organisational units

While the district registration office contributes 13% of the effort by entering ownership, mortgage and restriction data into the databases, the topographical survey contributes only 4% by supplying topographical data or ortho-images. In terms of departmental contributions, the above figures suggest a high contribution of about 45% by the Department of Survey.

These figures were validated by key officers in the Department of Survey for a district. These key officers indicate that they have a very limited experience of officers on the establishment of databases including ortho-photo production. So far their experience is restricted to only non-spatial data. The total estimated cost is likely to be around €350,000.

Similarly, the results were compared with data obtained from the Survey of Bhutan. In Bhutan, it is the only organisation involved in establishing and implementing a land information system with foreign assistance. Their estimated figures suggest a tremendously low cost and short time for completing this process for 500,000 parcels. The total estimated cost is about €100,000 for one year. In this estimation, the process does not include topographical data or ortho-photographs. It includes only a simple table digitisation process. Moreover, the cadastral maps in Bhutan include only private parcels, with few details such as rivers and roads. There is no complete coverage of land, which means that the public and government land parcels are not surveyed or registered.

(b) Parcel Subdivision

Assuming that private practices in surveying are allowed, two main clients (landowners and surveyors) are involved in this business process. Private surveyors are involved in interacting with landowners and district survey offices (see figure 5.5). There are thirteen sub-processes and they are designed in Oracle 9i designer. The result is presented in figure 5.5. Based on the author's experiences, the data about time, cost and resource required are estimated for subdividing a parcel into two parcels. Cost per hour is estimated for each sub-process on the basis of the salary and daily allowance for a surveyor and two survey assistants. It also includes running costs such as renting vehicle, surveying equipments and other materials. On the basis the author's field experience, estimated time is entered for each sub-process

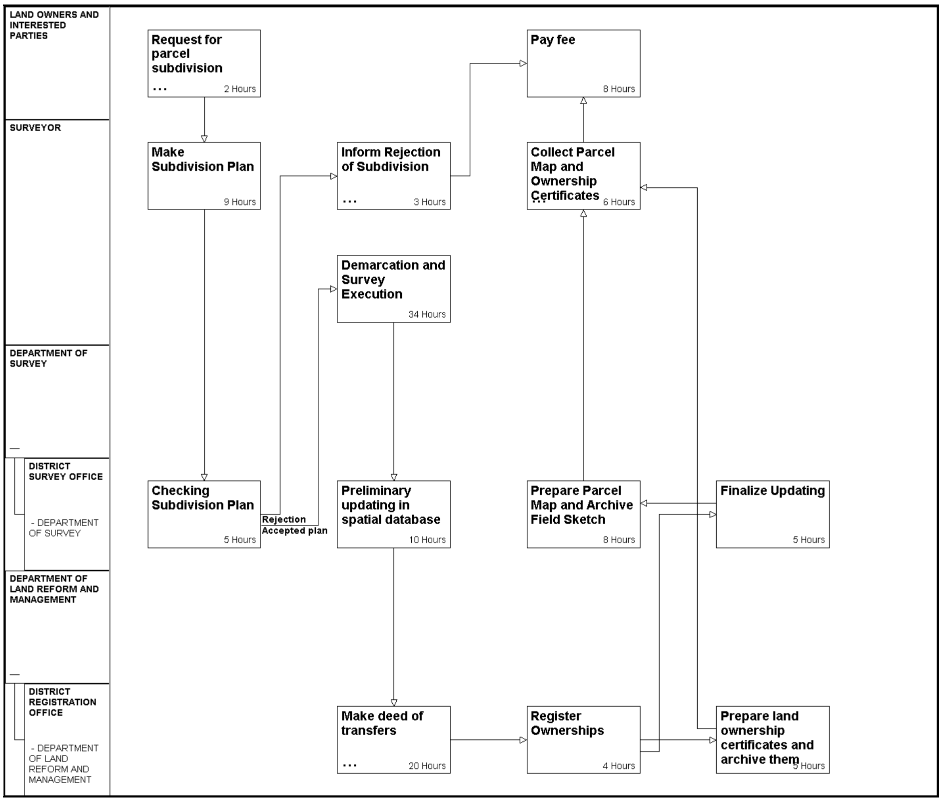


Figure 5.5: Sub-processes for land parcel subdivision

Internally, the district registration office is involved in making deeds and updating ownership, mortgages and restrictions. Figure 5.6 shows that the most time-consuming sub-process is demarcation and survey execution, followed by the sub-process of making deeds of transfer.

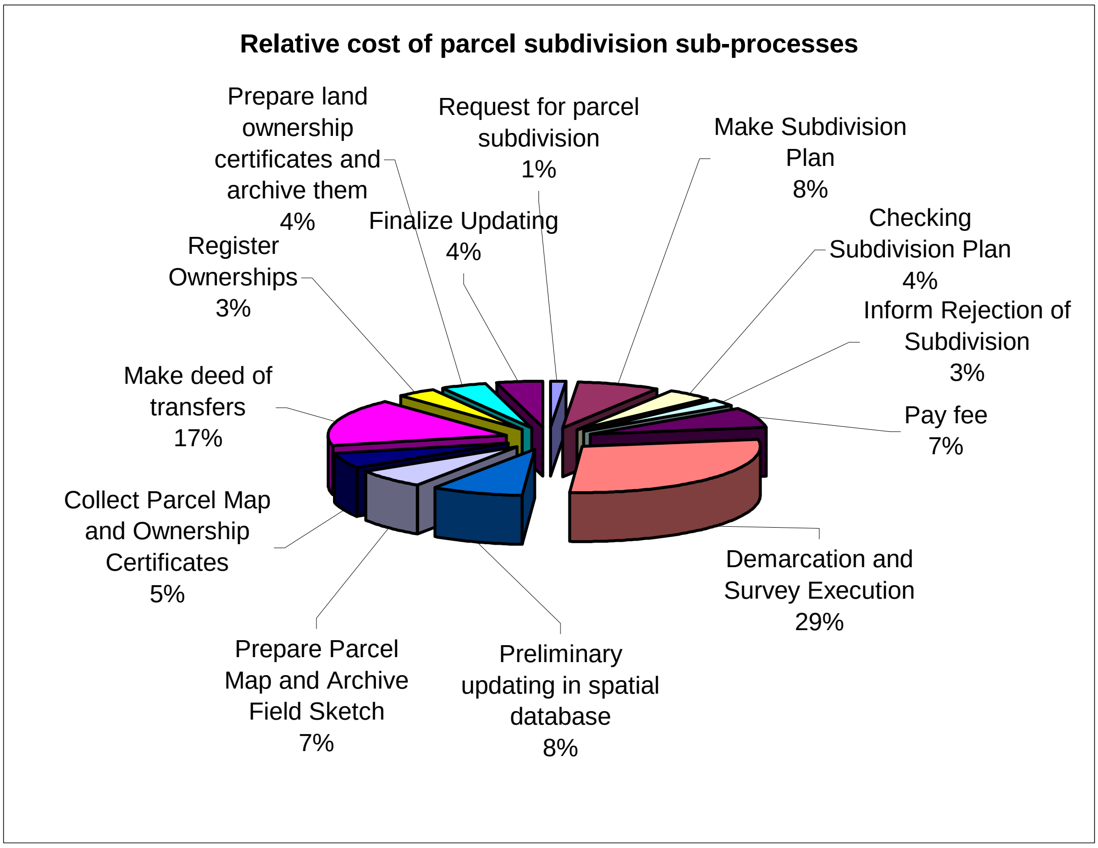


Figure 5.6: Relative cost of parcel subdivision

Total estimated duration to subdivide a parcel into two parcels is about 15 days in an area where there is easy access by road. To optimise time and cost spent on this process, it is common to wait for other subdivision requests and carry out demarcation and survey execution in one time.

(c) Full Transfer of Ownership

In this process, most of the activities take place at the district registration office, and lekhandas (i.e. 'writer' in Nepal) or notaries initiate the process by preparing preliminary agreements and making sure that process steps are correctly executed. Lekhandas also makes sure that products (e.g. new certificates and parcel maps) are delivered against payment of fees.

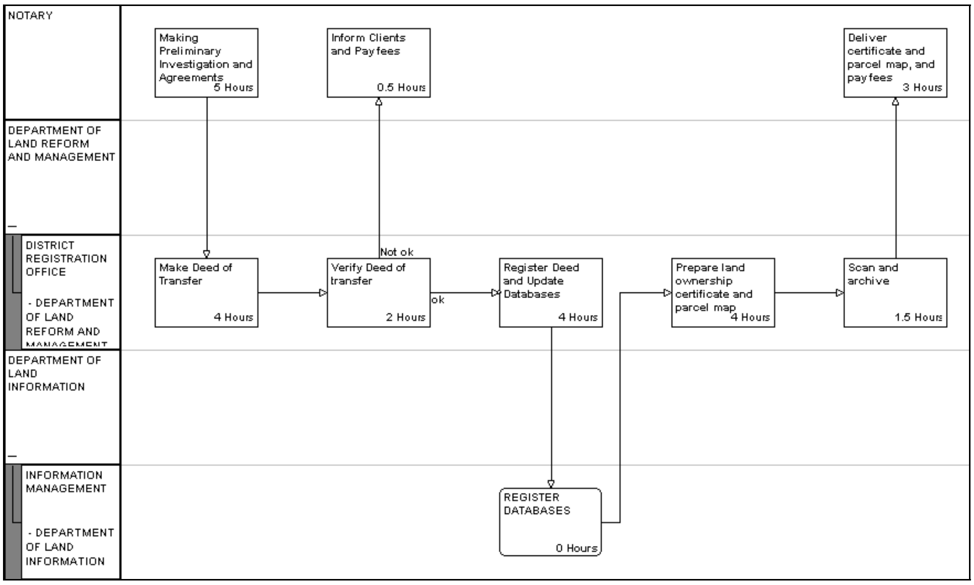


Figure 5.7: Process steps for full transfer of ownership

Duration for registration is about 24 hours. Figure 5.8 shows that preliminary investigation and preparation of agreements takes about five hours, followed by drawing up deeds, registration, preparing the certificates, etc.

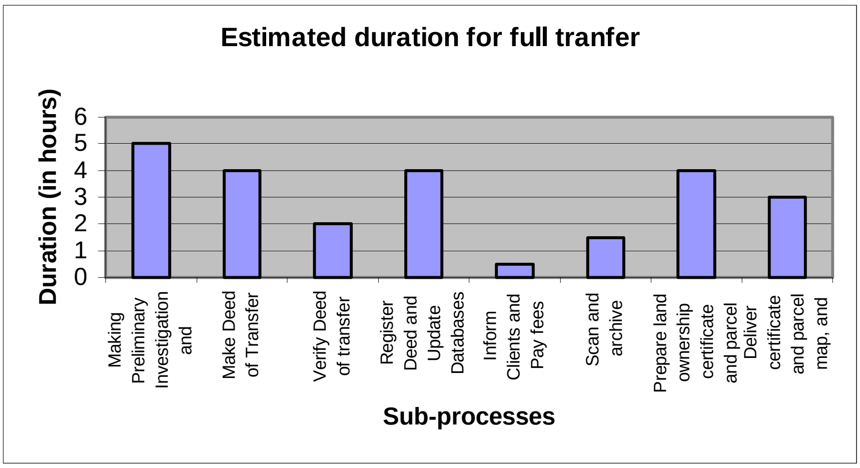


Figure 5.8: Estimated duration for full transfer of ownership

In terms of resource requirements, figure 5.9 indicates that the most expensive process steps are filling up improved deeds of transfer, registering deeds and updating databases, and preparing land ownership certificates and maps.

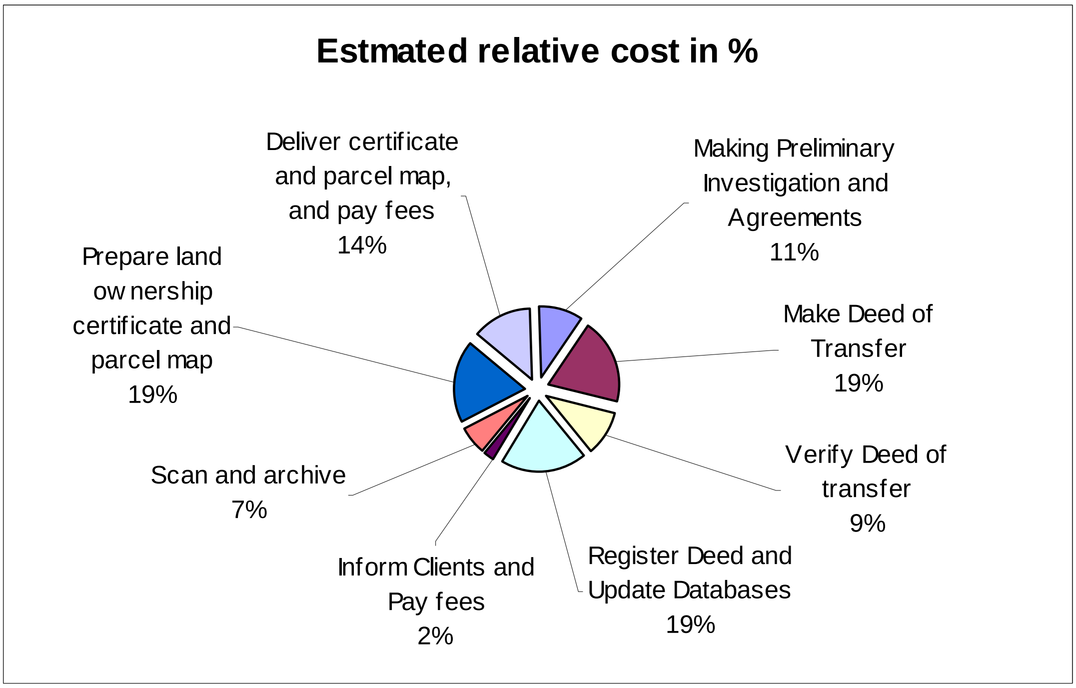


Figure 5.9: Relative cost for full transfer of ownership

In order to optimise the process steps, a notary can combine the investigation and the drawing up of deeds and verifying them, but access to a reliable database is a precondition. Hence the business process *disseminating the parcel information and ownership* is required. Cost and time are estimated as explained in the previous.

5.1.2 Implications of business process

From the above, a number of implications for the organisational structures can be analysed at the policy, management and operation levels.

At the policy level, the business processes must match the well-defined objectives of the organisation – in view of societal needs, ensuring equal access to services by all people regardless of race, group or caste – and the system must be economically viable.

At the management level, the organisational structure for the system management and the operations are clearly defined, useful for reaching and satisfying objectives. Each service and its sub-processes require appropriate allocation of resources regarding finance, human, hardware and software. From the point of view from system management, the objectives of each business service are aligned with Geo-ICT components.

At the operational level, the process steps are appropriately assigned to the organisational units as part of workflows to complete a business process, and the organisational unit is given the responsibility for sub-processes as part of strategies and objectives. Customers and stakeholders are properly informed and supplied with the products and services as required. The prototypes suggest careful consideration of critical parameters on restructuring the organisation with regard to the redistribution of resources and activities, because each process or activity requires time and finance to complete, as well as resources such as hardware, software and trained manpower. Critical parameters concern orientation towards customer, product, process, task and task ordering (Tuladhar, 2004).

Customer-orientation: The organisation aligns business processes towards the customers according to the demands of a specific customer or customer type. The main advantage lies in the relationships with individual customers and the reduced reaction times to their demands and, as a result, a higher customer satisfaction level. In the case of business processes on parcel subdivision and full transfer of ownership, the cadastral agencies must satisfy the needs of individual owners, notaries and surveyors in order to ensure timely delivery of products and services at affordable cost. Otherwise the cost of establishing and populating a PBGIS in other districts (subsequent phases), requiring huge investment, cannot be justified at the policy decision level.

Product orientation: With product orientation, different departments of the organisation are assigned according to the different types of products or product groups, with the aim of achieving synergy and training effects. This is one of the fundamental reasons why two or more organisational departments or units are normally installed within organisations such as the Ministry of Land Reform and Management (MLRM) in Nepal to deliver the different types of products.

Process orientation: Its main goal is to optimise the workflow through structuring along similar production procedures. With the assignment of personnel along the workflow, departmental boundaries can be evaded.

Task orientation: Similar to product orientation, its aim within the organisational units is to focus on technical competence and human-related productivity by combining similar tasks or functions in the same organisational unit. The repetition of similar tasks may allow a certain specialisation of the assigned personnel and may lead to a reduction in process times.

Order orientation: Similar to task orientation, this allows the organisation to assign similar orders; the assignment of order-specific activities can be made to specialised personnel, while keeping the range of assigned activities at a higher level.

The combination of the different parameters may benefit from the advantages of the individual parameters. Thus, the above parameters can be used for restructuring the organisation based on the process characteristics.

5.2 Incorporating Quality Process

Quality is an important element in system development process. This study is restricted to some relevant issues as awareness to managers in organisations. Detailed study is beyond scope of this research. The section 5.3 presents quality factors and its review procedure for system model in order to support system development. The section 5.4 provides the results of experimental tests on cadastral data using aerial photographs and IKONOS image. Although these two are quite independent, but later is one that most system users (outside organisation) are most concerned.

According to Dale and McLaughlin (1999), *Total Quality Management (TQM) is a way of improving the quality of what is delivered by encouraging the total commitment and participation of a workforce.* It focuses all services and products within an organisation from input through processing to the final delivery of services and products so that each and every customer are satisfied. Within the context of TQM, two distinctive approaches are available in the system development.

First, product quality focuses on the characteristics of the system products. Several quality criteria are used to carry out inspections of the finished product and detect and correct defects. This is the traditional approach to quality assurance.

The second approach is to focus on process quality, where the emphasis is on defect *prevention* rather than *detection*, and its main aim is to reduce reliance on mass inspections as a way of achieving quality.

From the system modelling point of view, product quality is concerned with evaluating and improving the quality of data models (such as class and object models) and products (such as deeds, certificates, parcel maps), whereas process quality is concerned with improving analysis and the design process for the entire system life cycle.

Product quality is important to ensure that the data model is free of defects and has correct structure so that a database can be built and the final products meet user requirements. Nonetheless, process quality is more important in the wider organisational context, in order to improve the organisation's ability to efficiently deliver high-quality PBGIS services and products.

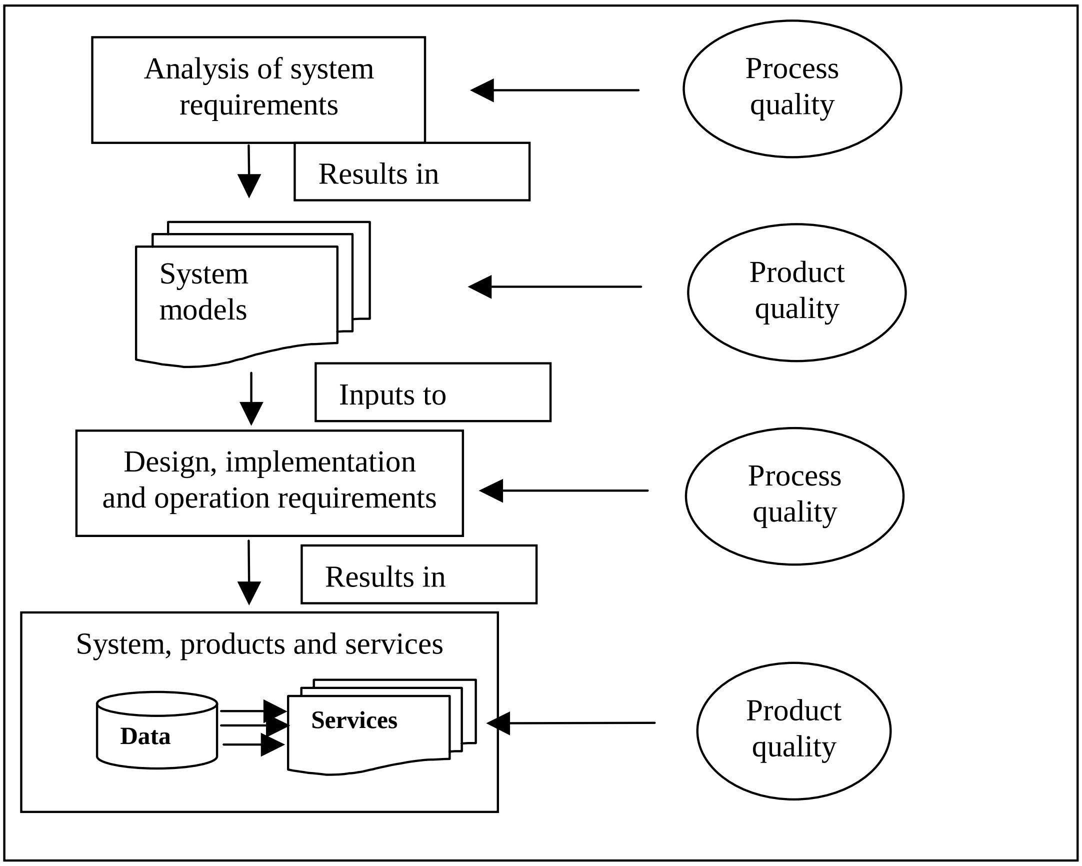


Figure 5.10: Integration of process and product qualities in PBGIS system development

The choice of a correct and appropriate representation of a system model for PBGIS is one of the most crucial tasks in the system development process. Although data modelling represents a small proportion of the total system development effort, its impact on the quality of the final system is greater than any other phase. Thus it is a major determinant of system development costs, system flexibility, integration with other systems, and the ability of the system to meet user requirements.

Figure 5.10 shows the integration of process and product qualities in the system development phases.

Although the scope of this research is limited, it argues that, if the organisations do not take care to remove a defect discovered during the requirement phase, it would probably cost much more. This research suggests that much effort should be spent during the early development phases to catch defects when they occur, or to prevent them from occurring altogether.

5.3 Quality Factors for System Model

The quality factors for PBGIS models are strongly influenced by the interested stakeholders. This includes both upstream participants (people who provide inputs to the modelling process) and downstream participants (people who use the models). The main stakeholders in the data modelling process may be categorised as follows:

- business users, whose information requirements are supposed to be represented in the system model
- system analysts, who are responsible for developing the system model
- system administrators, who are responsible for ensuring that the data model is consistent with the rest of the organisation's data
- application developers, who are responsible for the applications based on data model

From the perspective of business users, eight factors contribute to the quality of the data model, as shown in Figure 5.11:

- Completeness: This refers to whether the data model contains all the requirements. Two situations may occur in the process. The first is obviously missing requirements. Correcting these errors can lead to indirect cost saving, as the cost of adding these requirements later on in the life cycle would be much higher. For example in PBGIS, if some necessary data elements such as land tenants along with landowners are missing and not collected during fieldwork or the adjudication process, collecting them at a later stage would cost the organisation much more. Secondly, if unnecessary requirements are found in the data model, unnecessary money would be spent on the development of the system. To detect if model is complete or not, system models are compared with the requirements of PBGIS domain.

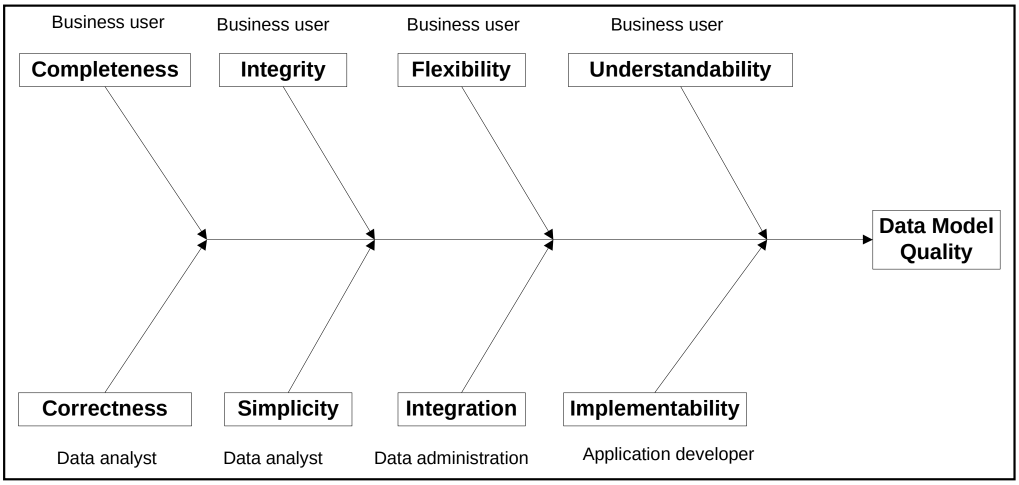


Figure 5.11: Quality factors related to the PBGIS data model

- Integrity: Definition of business rules (integrity constraints) is an important part of the organisation to guarantee data integrity and enforce policies. Rules incorporated in data models are formulated in tabular forms so that they can be verified against the requirement of PBGIS domain. The verifications are normally done by business users (including stakeholders) by asking them to answer questions related to system model. The relationships of entities between and within subsystems are also verified in this way.

- Flexibility: This is defined as the ease with which the data model can cope with business and/or regulatory change. Too many constraints in data model decrease its flexibility. Basic constraints, that are least affected by regulatory change, are introduced at database model. Other constraints that are affected by policies or business rules are normally placed at business application model.

- Understandability: This is defined as the ease with which the concepts and structures in the system model can be understood. For this, metadata is essential and is communicated to all stakeholders. Continuous evaluation is required.

- Correctness and simplicity: From the perspective of the system analysts, we need to consider the correctness and simplicity of the system model. Correctness has to deal with the precise definition of data elements so that the data can be collected, stored, maintained and disseminated at the required accuracy levels. Simplicity means having the minimum number of entities and relationships in a data model so that the data can be collected and stored at the minimum cost.

- Integration: For the system administrators, the data must be consistent with the rest of the organisation’s data for integration purposes. During development of system models, all stakeholders are involved. Data standards are formulated for each class with subsystems. Any discrepancies are communicated among users. All users follow same standards.

- Implementability: Lastly, implementability of the system is important for the application developers, and it is defined as the ease with which the system model can be implemented within the time, budget and technology constraints.

5.3.1 Quality Evaluation: Approach Using Kiviat Diagram

One of the problems often faced by the system developing team is to visualise, evaluate and communicate the quality aspects of data models (specifically models such as data models). In this research, a kiviat diagram is considered as a suitable candidate from the management perspective.

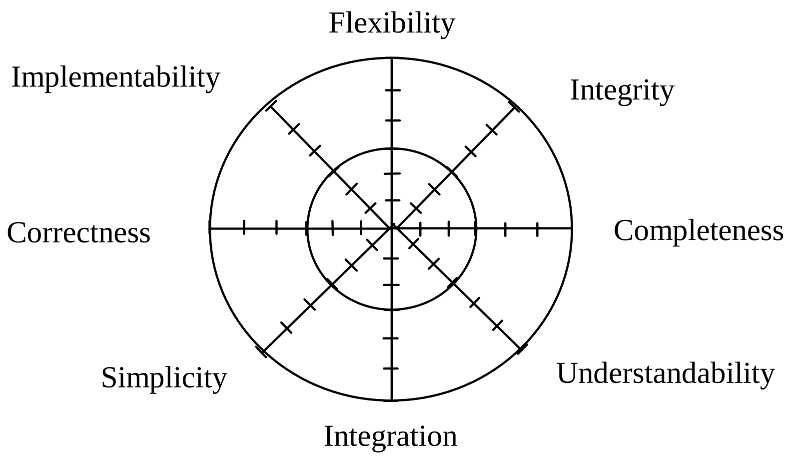


Figure 5.12: Kiviat diagram showing quality parameters of data model

This diagram is simple to construct and easily understandable, presenting graphically the qualities of each parameter (figure 5.12). Each axis represents one quality parameter. On each axis the point is marked that represents the ranking according to the quality report. A point on the innermost ring means the model supports this parameter the least, while a point on the outermost ring means the model provides better support.

In order to conduct the quality review of the data model, the following steps are needed.

- Identify the detailed issues (quality process) of each quality parameter described above. All information required for interview starting from objectives of system model with its components to each object class of interest are produced from software tool such as Microsoft Visio, which has UML diagram.

- Tabulate them and translate them into forms of questions for interview. Questions are formulated in detail enough so that all stakeholders can answer them.

- Conduct interview based on these questions. Quality points for each parameter are assigned in ranking order by stakeholders. Each quality factor is rated on a scale of 1 to 5:
  5 = excellent
  4 = very good
  3 = good
  2 = poor
  1 = very poor

  The ranking is rather subjective, but this is provided only as sample. Further study is necessary on this issue.

- Develop a kiviat diagram.

  A sample kiviat chart is presented here to demonstrate the usefulness of this approach for a data model. Figure 5.13 shows such an example how the results of the review are presented in the form of a kiviat chart. It shows that the model is technically sound (correctness) but has major deficiencies in simplicity, integrity and implementability.

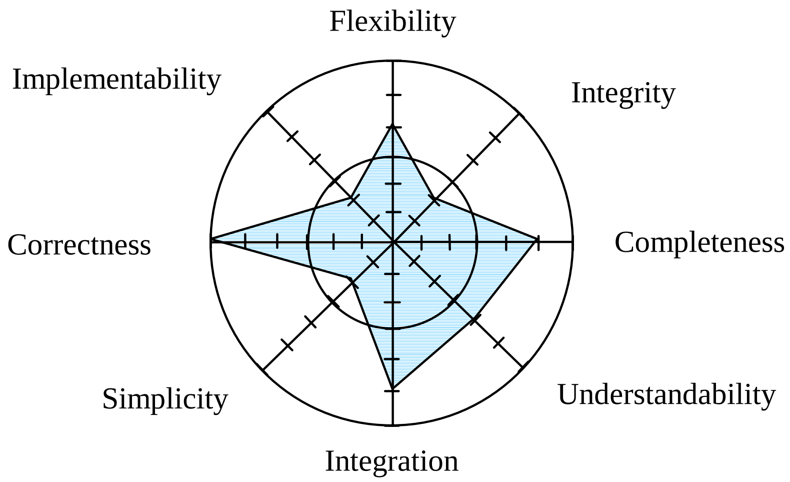


Figure 5.13: Possible results of quality review

5.4 Experimental Results on Quality of Cadastral Data

As discussed before, the quality of cadastral data is important for land owners and other users. This section is limited to the experiments concentrating on the accuracy of the spatial data collected from the existing system in Nepal. The results are presented on the geometry quality of the existing cadastral maps, its comparative quality with orthophoto of aerial photographs and IKONOS images.

5.4.1 Testing Geometrical Quality of the Existing Cadastral Maps

This test was conducted in the northern part of Kathmandu city by comparing the areas and perimeters of the existing cadastral map data and newly collected data in the field using theodolites and measuring steel tapes. The test area is more or less flat, and is located in the suburban area of Kathmandu.

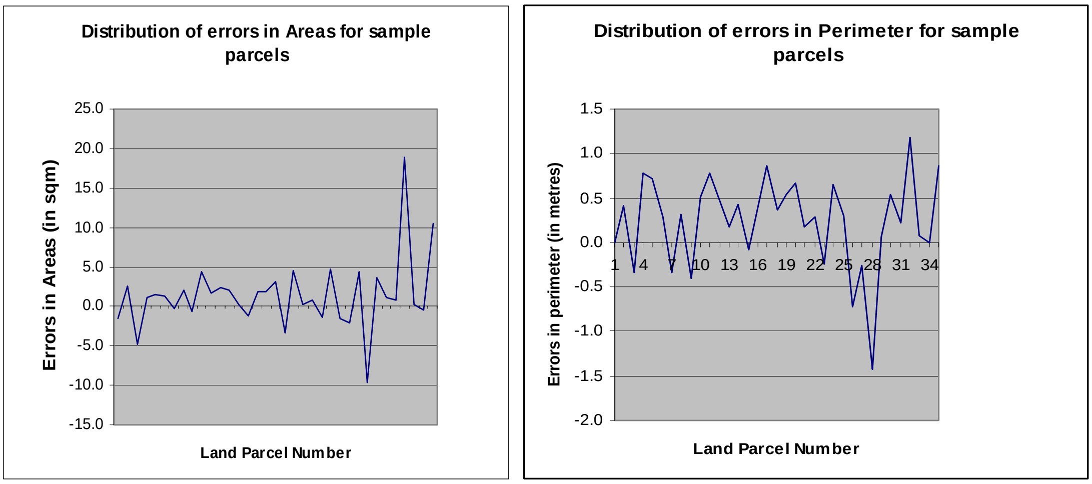
The hardcopies of the existing cadastral maps and district field books (including ownership information) were collected from the Kathmandu district survey office of the Department of Survey in Nepal. Then these maps were digitised on a high-quality digitising table available at ITC, Enschede, using the coordinates of the ground control points and grid corners of the maps. The digitised digital data were converted into coverages in the ESRI Arc/Info format. The areas and perimeters of each parcel are automatically computed while building the topological structure in Arc/Info software.

During fieldwork, the owners and their neighbours showed the boundaries to the survey team. The survey team checked the boundaries against the existing maps, but measured only the boundaries shown by the owners and their neighbours. The survey team of three assistant surveyors for measuring, recording, identifying and checking boundaries was led by a senior surveyor from the cadastral office of the Department of Survey. All data (parcel numbers, bearings and distances) were recorded in the standard format.

These recorded data were inserted into another layer in ESRI Arc/Info, using the COGO functions. It is designed primarily for converting field survey data, traverse data entry, adjustment, and the construction of new objects. Many of its operations can be used in applications requiring accurate coordinate geometry for data entry and manipulation.

Once accurate coverage is obtained, areas and perimeters can be computed while building topology. These areas and perimeters are considered as a reference for comparative purposes. For this experiment, we had only 35 land parcels as a sample of sheet no. 102 98 416 (map scale 1:500) of Kathmandu city.

After comparison, the average size of land parcel area is 157 sq m, while the maximum and minimum sizes are 1575 sq m and 9 sq m respectively. The average size of perimeter is 46 m, while the maximum and minimum sizes are 213 m and 9 m respectively.



(a) (b)

Figure 5.14: Distribution of errors in (a) areas and (b) perimeters

The comparison shows that maximum errors and minimum errors in areas are 19 sq m and 0.2 sq m, and maximum errors and minimum errors in perimeters are 1.4 m and 0 m respectively. The analysis in figure 5.14 shows that the larger the area, the larger the errors that seem to occur in that area. However, the overall errors of ±1.2 sq m in area and ±0.2 m in perimeter are quite justifiable, because the technique used in cadastral mapping in the existing system in Nepal is manual, using the plane table technique with measuring staff and telescopic alidade for observing distance and slope. In this system, errors are more easily accumulated in the large and hilly parcel areas than in the small and flat areas.

5.4.2 Testing with Ortho-images of Aerial Photographs

There are two methods that use the digital images of the stereo-aerial photographs for testing cadastral parcel data.

The first method uses the digital photogrammetric stations where the stereo models are constructed, using digital stereo-aerial photographs (at least 25micron of pixel size) with 60% forward overlap and 25% side overlap and sufficient control points (mainly from aerial triangulation). In such stations, GIS software is integrated to facilitate collecting data and merging digital data and images in 3D stereo-models. Thus, old cadastral and topographical databases can be accessed by such a system, where recent images are oriented absolutely and displayed on the screen in the correct coordinate and projection system. By analysing integrated images and other data, old existing data can be either evaluated or updated in line with new images.

The second method relies on the production of digital ortho-photographs and the use of digital elevation models. Many GIS software packages, such as ERDAS Imagine and ILWIS, can efficiently produce ortho-photos, correcting the geometry of photographs and terrain relief with the help of ground control points and digital elevation models. If the area is flat, even ESRI ArcGIS can be used for the simple rectification of images.

Once ortho-images are produced and they are stored in an image database. The existing cadastral data and ortho-images are visualised in simple GIS desktop software (such as ESRI ArcView and ESRI ArcExplorer).

For this test, second method is used. A pair of available stereo-aerial photographs was collected from the Department of Survey, Nepal. These aerial photographs were taken during the months of August and September 1990, at the nominal scale of 1:10,000, with a Carl Zeiss camera with a wide-angle lens (150 mm focal length). The camera calibration certificate was not available.

The diapositives were scanned at the resolution of 500 dpi at ITC. The ortho-photo of the left photograph was then produced for the northern part of Kathmandu city, using ERDAS Imagine software.

The overall planimetric accuracy of the ortho-photo was found to be ±2 m when compared with the ground control points used for the cadastral survey. Such low accuracy is caused mainly by the low quality of low diapositives, difficulties in identifying ground control points accurately in the images, and the non-availability of camera calibration certificates. The accuracy of ground control points is only ± 1 m in planimetry. Since the cadastral maps are just ordinary paper maps that are used for manual digitising, the quality of these maps is found as low as ± 2 m in planimetry. Affine transformation is applied for adjustment to improve their quality.

Both the cadastral parcel data and the digital ortho-images of aerial photographs were merged in the national geodetic coordinate systems, using ESRI ArcGIS software. Figure 5.15 shows the merged images made as part of the test.

Forty-two parcel boundary points were selected, covering six cadastral map sheets and seven points in each sheet. These points were interactively identified in the maps, as well as in the image, and the discrepancies between them were measured using the ArcGIS measuring tool. These points are cadastral boundary points that are visible in the image. The overall discrepancy over this area was found to be ± 1.8 m. The high discrepancy, maximum 6 m, was found in the west part of the area. This is primarily due to the forest coverage and mountainous terrain, and it is difficult to identify boundary points correctly in such areas. This can also be attributed to the low quality of digital elevation in the forest areas. Low discrepancy, as low as zero, is also found in the flat areas, where boundaries are clearly visible in the images. The overall matching of cadastral parcel boundaries with natural boundaries such as walls and ditches is quite acceptable.

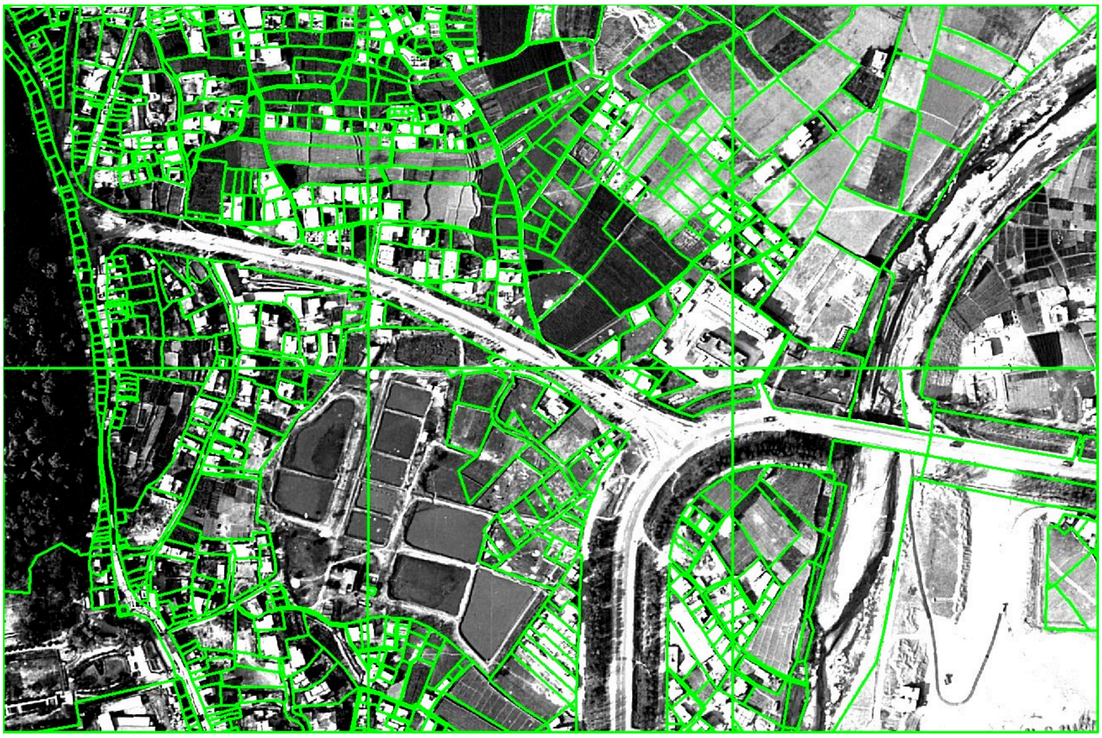


Figure 5.15: Merging cadastral parcel data (in green) and ortho-images (b/w aerial photographs)

Looking at the merged image in GIS, it is observed that in the many parts of areas some local shifts of cadastral boundaries seem to occur in the existing cadastral maps. By employing local spatial adjustment methods available in the GIS tools, systematic shifts and local adjustments can easily be made. This reconciliation process can improve the spatial data, to achieve uniform accuracy throughout the areas.

5.4.3 Testing with IKONOS Images

The advantage of using IKONOS images over stereo-aerial photographs is that first they cover a larger area than aerial photographs. Since the images are continuously captured every 14 days, new data can be quickly processed and loaded into the databases for maintenance. Ground resolutions of IKONOS images are 1 m for the black-and-white (panchromatic) band and 4 m for multispectral bands. The geometrical accuracies of the raw data, orbit-corrected data, the geo-corrected data on the basis of ground control, and stereo-imagery for Carterra IKONOS 2 products are stated as ±12 m, ±6 m, ±3 m and ±1 m respectively (Konecny, 2002).

IKONOS images of panchromatic and multispectral bands of September 2001 were purchased from Space Imaging by the Nepal Department of Survey for the Kathmandu Valley mapping. These images were already resampled to 1 m resolution of the standard geometrically corrected in the UTM projection system with WGS84 ellipsoid, using projective transformation and cubic convolution of the interpolation method. So these images are assumed to be accurate within ±3 m in geometry.

The overall visual interpretation shows that it is difficult to guess boundary lines on the images, especially if the image is zoomed in. This is due to two reasons. First reason is pixel size which is only 1 m. When image is zoomed in, pixels become visible, making difficult for interpretation. Second reason is quality of image itself which is caused by the weather conditions in the valley. But figure 5.16 suggests that the general matching of the boundaries with image boundaries is still satisfactory, even in the mountain area covered by tree in left edge of the image.

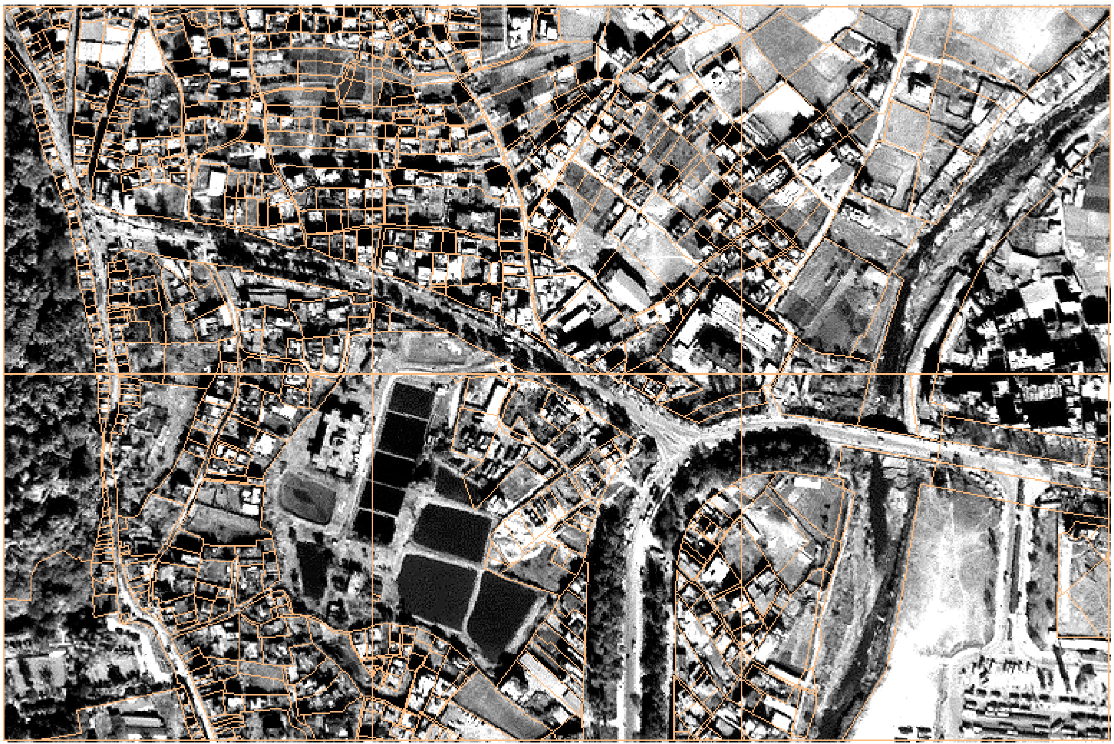


Figure 5.16: Merging cadastral parcel data (in orange) and IKONOS image (pan)

There are many boundary changes in some places in the upper and lower right portions of the area, and hence it is difficult to identify the boundary points with certainty. Thirty-six boundary points are identified on both map and images. The discrepancies are measured using the ArcGIS measuring functions. Surprisingly, the overall discrepancies are estimated to be ±3 m, and the maximum and minimum values are respectively ±5 m and ±1.1 m.

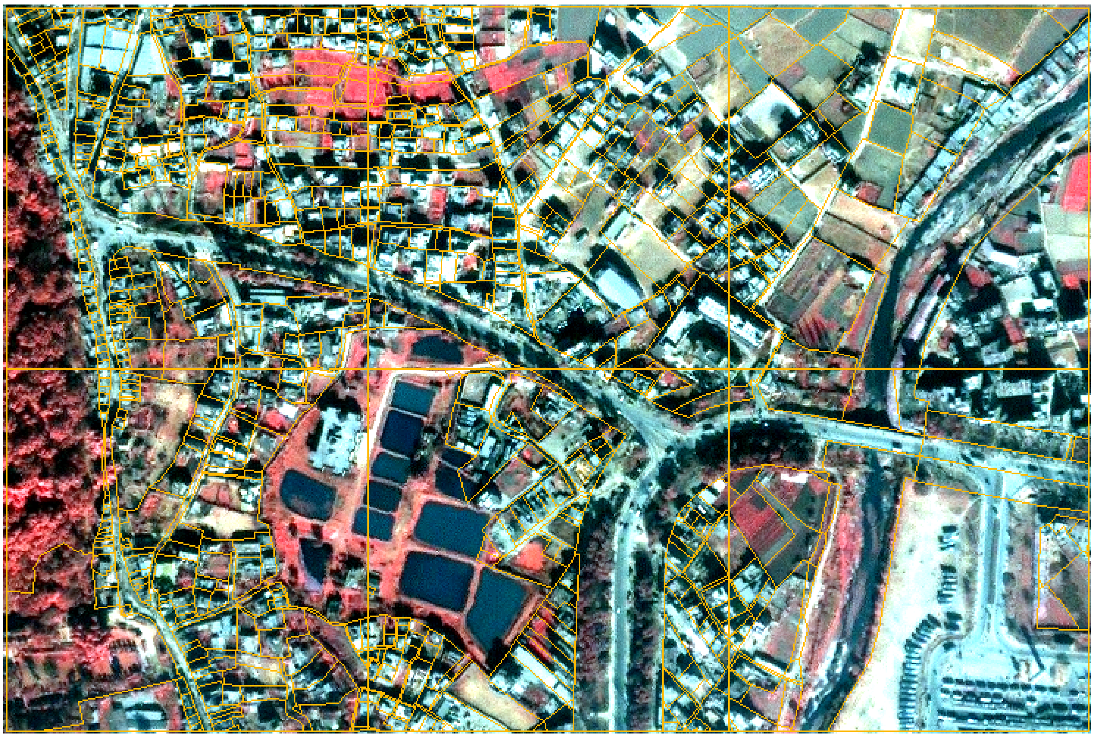


Figure 5.17: Merging cadastral parcel data (in orange) and colour composite of IKONOS images (MS bands)

Figure 5.17 shows the IKONOS image (MS band), together with cadastral parcel boundaries in orange. Visually, this is much better for identifying hard objects such as buildings and roads. Interpretability for parcel boundaries is still comparable to the IKONOS image of the panchromatic band.

The changes are better interpretable in the IKONOS image (MS bands) than in that of the panchromatic band. The cadastral maps are 20 years old, while the images date from September 2001. Along the riversides, there is much development. By combining these images with topographical features, new features such as buildings, changes in minor roads, and changes in river course are easily detectable.

Figure 4.18 shows a perspective view of the areas created by combining IKONOS images, cadastral parcel boundaries and topographical objects. Cadastral boundaries and Topographical objects such as road, river, lake, ponds, contour lines (DEM), and building are created in oracle database. The perspective image is then created and displayed in ArcGIS software using the data stored in the Oracle database, and IKONOS image.

The analysis of the above tests suggests that the quality of cadastral parcel boundaries can be upgraded by using interactive editing functions of simple GIS software by integrating cadastral data with IKONOS images and/or topographical data.

Hence, such an integration process is necessary as a process step for creating and populating databases using digitised existing maps. This allows operators to check and verify the cadastral boundaries with actual walls and ditches, which are considered as cadastral boundaries in most cases in Nepal. The field-checking method should verify major discrepancies.

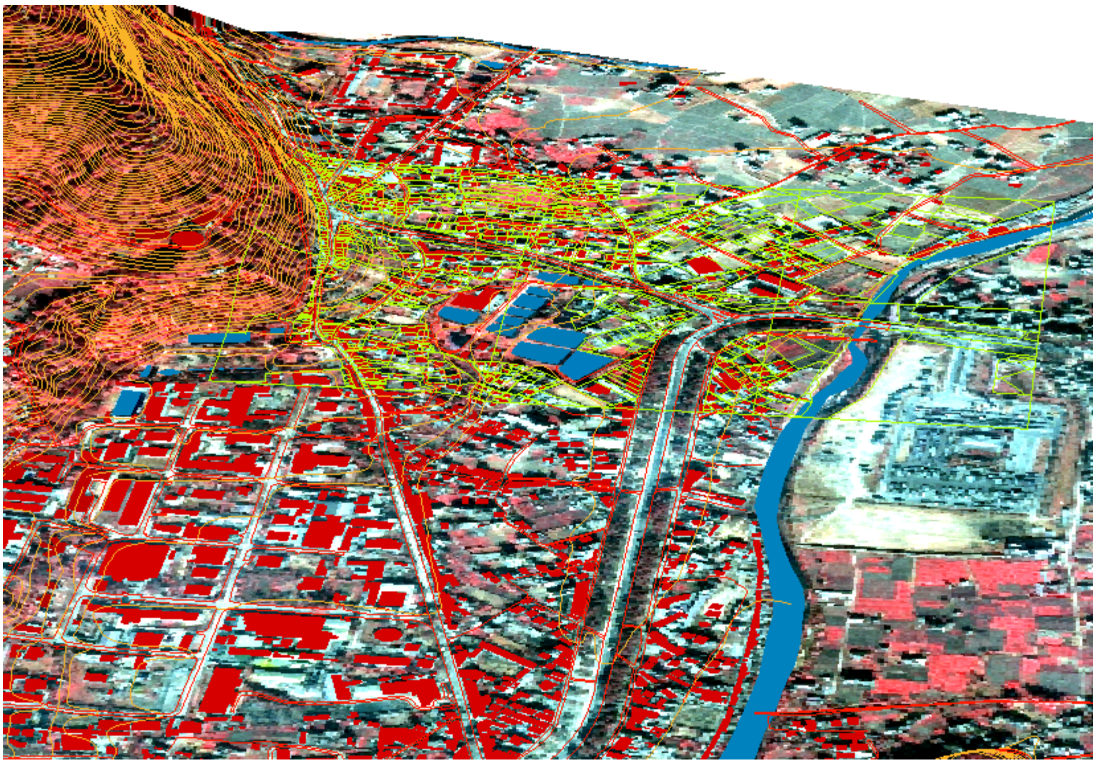


Figure 5.18: Perspective view: cadastral parcel data and topographical data with IKONOS image (MS bands)

5.5 Summary and Concluding Remarks

This chapter has clearly identified three components that emphasise the prototypes and quality aspects of business processes in the context of PBGIS.

The first component is the prototyping of three business services, which shows that there is a direct link between the business services (including the lower-level process steps) and resources (such as people, hardware and software), including time and cost. They are guided by policy objectives at strategic, management and operational levels. The success of the service “initial database structuring and loading” is dependent on the cooperation, coordination and financial arrangement of three departments in Nepal. The most expensive part of this service is data conversion, followed by setting up databases. The topographical database needs to be separated from the cadastral database, as it requires financial and technical resources different from cadastral activities. Up-to-date data are always needed for parcel subdivision and full transfer of ownership. The data are accessible via SDI.

The second part of this chapter concerns the quality aspects of data models. In order to achieve best quality, it is emphasised that the concept of process and product quality, similar to the concept of total quality management, is applied as part of the system development. The chapter identifies eight major quality parameters that affect data models. These parameters are completeness, correctness, flexibility, integrity, simplicity, integration, understandability and implementability. In order to review the system model as a PBGIS, this chapter recommends a simple approach using a kiviat chart, whereby the manager can decide which parts of the system have to be revised as a result of the quality review. The classification or ranking of quality factors in the review procedure is subjective. More research is needed.

Lastly, the experimental tests indicate that integrating the existing digital cadastral data with aerial photographs or IKONOS images improves the quality of existing cadastral data.

In Nepal, the cadastral data contain all kinds of parcels, covering entire areas, and topographical details that include roads, buildings, rivers and temples. Buildings should be part of cadastral data as they are vital to property value, which includes building value too.

Although no experimentation has been carried out using the data from Bhutan, it has been observed that the cadastral data contain only private cadastral parcels, with some features such as rivers and roads (see the cadastral maps in Appendix 6). Looking at Chapter 3, where the cadastral system in Bhutan is explained, the cadastral parcels belong to communities, religious bodies, the public and government. They need to be surveyed and registered in the cadastral databases, as in Nepal. All topographical features are also needed in a separate database.

Chapter 6

Guidelines for Implementation of Parcel-based Geo-Information System

6.0 Introduction

The previous chapters show that there are many complicated processes in implementing a PBGIS for delivering full benefits to society, and these processes relate to land tenure, cadastral and land registration systems, property valuation, system models, Geo-ICT and organisation. This chapter presents the essential elements as part of the guidelines for PBGIS development and implementation. These elements relate to factors and activities that strongly influence the development and implementation of PBGIS to achieve the system goals.

This chapter consists of four sections. Section 6.1 highlights critical success factors that contribute towards the goals of PBGIS. Section 6.2 discusses goals and activities in the specific cases of Nepal and Bhutan, addressing critical success factors as guidelines. Section 6.3 proposes guidelines within the organisational context of Nepal and Bhutan.

According to Bogaerts (1994, 1995, 1999a), the most critical success factors for cadastral systems are legislation, organisation, financing, data and its quality, technologies used and human resources. Among these, organisation and management are most critical in the context of the Phare Countries (Bogaerts, 1999b). Along these lines, there are two documents available as guidelines for land administration. First, the UN-ECE (1996) provides a series of guidelines covering the broad understanding of land issues and the role of land administration, while the UNCHS (1990) elaborates guidelines for the improvement of land registration and land information systems in developing countries (with special reference to English-speaking countries in Eastern, Central and Southern Africa). The study shows that these guidelines do not focus in detail on the system development process issues (users' needs, data and process models, system architecture, etc.). The implications of evolving Geo-ICT in the implementing organisations are too many. Hardware and software are changing quickly, and are costly to purchase and maintain. Communication networks and human resources are both limited. But requirements are changing owing to changes in governmental policies. Therefore, the organisations in the developing countries are unable to cope with the changing requirements of users and the evolving nature of Geo-ICT technologies in data collecting, processing, maintaining, storing and disseminating land information. The organisations are unable to absorb these new technologies into their functions or business processes owing to a lack of financial and organisational capacity. Secondly, there are no mechanisms embedded in the organisations to understand and monitor the changing requirements of users and stakeholders.

6.1 Critical Success Factors: An Approach for Guidelines

Critical success factors (CSFs) are those factors that determine the achievements (e.g. success or failure) of implementing PBGIS. The CSFs are strategically based on the definition of the goals and the activities required to satisfy the goals. Since the market-driven quality of PBGIS depends on the critical factors as defined by Bogaerts (Bogaerts, 1995, 1999a) for the development of secured land tenure, reliable land markets and sound environment protection, the use of CSFs is considered to be crucial, as well as a means of providing guidelines for developing and implementing PBGIS in developing countries such as Nepal and Bhutan.

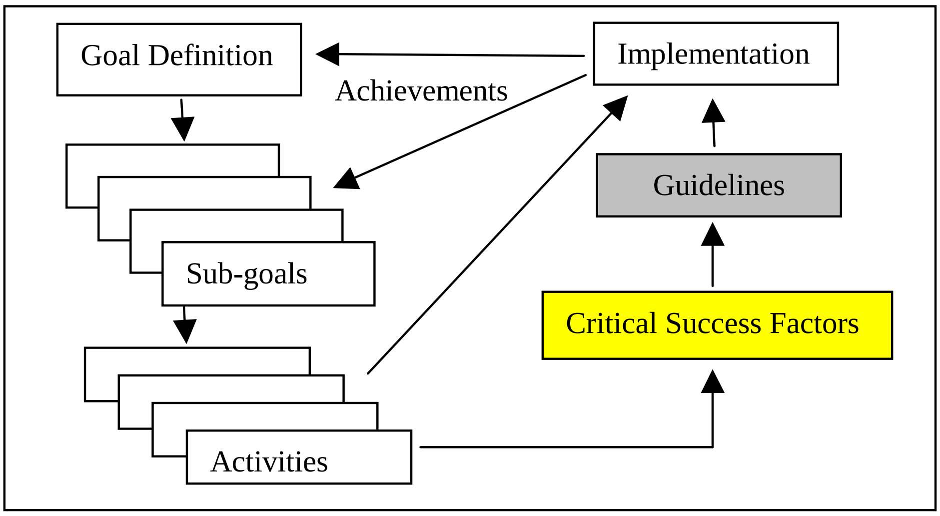


Figure 6.1: CSF approach for devising guidelines

The CSF approach involves the definition of the goal that the PBGIS is to achieve. The main goal is then decomposed into sub-goals, and a series of necessary activities are carefully identified to accomplish these sub-goals. The activities are then implemented as a means of achieving the goals of the system. Figure 6.1 shows the approach for devising guidelines for implementing PBGIS in Nepal and Bhutan.

Based on the above-mentioned literature, the following CSFs are relevant to the development and implementation of PBGIS:

- institutional support, including political support
- legal
- financial
- organisation, including coordination and cooperation
- management, including market orientation and information requirements
- technical, including system development, system installation and infrastructure establishment and maintenance
- standards
- quality management

The CSFs are discussed in the following sections within the scope of the goals and activities for PGBIS implementation.

6.2 Goals and Activities

From the management perspective, the goals can be categorised into main goal (long term) and sub-goals (short term) for Nepal and Bhutan. The main goal of PBGIS is generally derived from the mandate (or land laws/land policy).

For this research, it is defined as "*Provide reliable & up-to-date land information at a lowest possible cost to the decision/policy-makers, governments, non-government organisations, communities and individuals to support tenure security, economic growth, social development, agricultural productivity and environmental conservation*" (Tuladhar, BC and Budhathoki, 2002).

From the analysis of existing systems, models and organisational prototyping (as discussed in the previous chapters), the main goal is further divided into a number of sub-goals, such as:

- revise land policies/acts, including copyright laws and pricing policy
- restructure existing organisations
- develop human resources
- develop and implement a nationwide PBGIS
- build document archiving system

- provide services and products of land information, using PBGIS

Each of these sub-goals is discussed below, with formulation of the activities by careful analysis specific to Nepal and Bhutan.

6.2.1 Revise Land Policies/Acts

Legislation for implementing PBGIS is considered more as a guiding principle in the performance of an obligation than an instrument of enforcement. It plays an important role in defining functions, assigning responsibility and establishing processes or procedures. Thus possible conflicts may be avoided between two or more agencies that operate in the same area in pursuit of a common goal but have different interests and points of view. However, almost all the existing land and related laws or acts of the country have simply failed in their purpose to implement PBGIS in Nepal and Bhutan because they are inconsistent and there is no mention of land information for the management of land as such. In Nepal, the analysis indicates that cadastre and land registration systems mainly focus on revenue generation (i.e. collection of land tax), while in Bhutan the system focuses on providing statutory security rights. A legal framework for business-like organisations is therefore paramount, not only to guide all users or stakeholders of the new PBGIS but at the same time to enforce rules and regulations for the management of land and land information in terms of tenure security (ownership, tenancy, customary or indigenous rights), economy (rents, leases, taxes) and environment (urban and rural planning and development control). Thus, in the Nepalese situation, this research argues for extending the land acts towards tenure security in order to protect ownership rights for both land and apartments, including customary and indigenous rights. Concerning property valuation, in neither country is the purpose of valuation and the responsibility of the organisation clear. New property law has to be introduced in both countries for property valuation and taxation. The following activities for revising and introducing laws are proposed:

- Revising land acts: This applies to existing acts, with a view to including laws regarding customary areas and laws related to apartments.
- Introducing specific acts on land parcel boundaries for urban and rural areas.
- Introducing land acts for property valuation, focusing on market values and equitable property taxation.

Legislation facilitates the distribution and use of land information. Land information acts require attention to copyright/intellectual property rights, liability, privacy, data protection and access/commercialisation (Masser and Burrough, 1998).

- *Introducing copyright laws in land information:* Copyright is generally divided into two types. One type is labelled as moral rights, which denote the rights of the original producers. The other category of rights is the economic or exploitation right, also referred to as the exclusive right to reproduce and publish or disseminate the work. These are the rights that make it possible to exploit the information products, and they are of utmost relevance in the geographical information sector (Masser and Burrough, 1998). Copyright law also allows implementing organisations to protect their investment. Under such legislation, copying means reproducing work in any material form (Dale and McLaughlin, 1999). Given the pressure of cost recovery on organisations, the copyright law is a means of protecting their investment to cover the huge cost of PBGIS and its sustainability. It encompasses the exclusive right to reproduce a work and to publish or disseminate it. The copyright law also encourages the expression of ideas in tangible form so that the ideas become accessible to, and can benefit, the community at large for social or commercial gain (Masser and Burrough, 1998). Liability can be part of copyright laws and it plays a crucial role when data are integrated from different sources and used for operational purposes. However, liability is not only important for the producers of the information but also for intermediaries, since the latter depend on producers so far as the reliability of information is concerned (Groot and McLaughlin, 2000).

- *Introducing data protection and privacy laws:* Land information products such as paper maps and plans or digital databases are often used by the courts in various countries, including Nepal and Bhutan, and thus need to be protected by copyright laws. The period of protection would run from the moment that a record of fact was created. Data need to be protected physically from disasters such as fire, earthquake and theft (Henssen, 1995). Archiving the complete and original databases in a separate place is a prerequisite in the development of PBGIS. Under privacy law, individuals also have the right to know what data are held about them in the PBGIS. The definition of personal data and addresses that belong to individuals, and their use, must be declared at the time the data are collected. The use of data must be registered and the individual must be informed about how the information will be used (Dale and McLaughlin, 1999). In this context, the access of land information data is very much related to such questions as "Who may access it?" In principle, PBGIS data belong in the public domain. Therefore, everyone should have open access, but in a regulated manner. For example, under the Data Protection

Directive of the European Union, member states are required to bring their national legislation in line with the directive. This directive applies to any operation or set of operations that is performed on personal data by computers. It also deals with the protection of privacy in telecommunication, and member states must guarantee confidentiality through national legislation (EU Directive 95/46/EC, 1995).

6.2.2 Restructure Existing Organisations

Chapter 5 indicates that the structure of the existing organisations within the Ministry of Land Reform and Management (particularly in Nepal) is highly ineffective in responding to the efficient operations of cadastral processes because each process passes through three or more organisations. The same situation also exists in Bhutanese cadastral systems: it runs through several organisations. The goal includes restructuring organisations by establishing, or restructuring existing, high-level committees at political, organisation and technical levels to ensure greater efficiency and effectiveness in the development and implementation of PBGIS. The following activities might be useful in achieving the goal:

- Establishing high-level political and technical committees involving representatives of responsible ministries or departments, non-government organisations, private organisations, and communities that deal with land issues in the country.
- Restructuring the executing organisations, involving users focusing on business processes and Geo-IT strategies.
- Establishing Geo-ICT departments to manage PBGIS and Geo-ICT in both countries (Nepal and Bhutan).
- Organising the activities within one district office (including surveying, registration and valuation) at the district level. This merger would allow efficient and effective service delivery to the clients.
- Seeking external funding mechanisms to avoid constraints. Since the government needs to invest huge amounts of money in building and maintaining the system, the government expects partnerships with the users (internal and external). Internally, the different departments involved pool their funds to realise the implementation of the system. Cooperation and coordination are vital to this joint effort. The external agencies could also contribute to this funding effort. In the long term, the agencies delivering the services could expect return on the maintenance through the fees charged. Charging fees depends on the existing regulations, policies and practices for the recovery of costs, as well as user-pay principles, freedom of information policies, and uses to which the data will be put (Dale and McLaughlin,

1999). In the market-based environment, the customers or users usually make decisions to purchase the information products considering the perceived price, which might be just the cost of producing the product. But this does not necessarily reflect the reality. The actual price may be calculated as the sum of the total cost of production, the minimum profit, and the price range. From the organisational point of view, it is possible to set a minimum price ceiling and still earn acceptable profits for maintaining various organisational resources (Tuladhar and van der Molen, 2003).

6.2.3 Human Resource Development

The Bathurst Declaration (FIG, 1999; UN-FIG, 1999) called for a global commitment towards investing in land administration infrastructure and equal access for men and women to land-related opportunities. So land administration involves various actors as its infrastructure requirements (Groot and van der Molen, 2000). As part of capacity building in land administration, the purpose of the human resource development (HRD) goal is to re-educate and re-train the managers and operational staff (of the departments and ministries) to take advantage of the opportunities offered by Geo-ICT to satisfy the changing requirements imposed by the users. Such a programme improves the skills and capability of existing staff to develop, maintain and implement the PBGIS. It should be carried out on the ongoing basis of workshops or training programmes by specialised institutes or universities, focusing on information management and technological aspects as human resource development. Activities would be:

- Developing and conducting awareness programmes or workshops focusing on the changing requirements and the latest enabling Geo-ICT, and improving relationships between organisations and other partners.

- Developing and conducting internal departmental training programmes on management and the impact of technology on organisation, in order to improve the efficiency/quality of staff at various levels. Departmental training would also focus on marketing skills.

- Developing and conducting academic programmes in geo-information management, focusing on the management of land tenure, cadastre, registration processes, geo-information organisations, and geoinformatics.

- Seeking foreign advisers to improve technical and management skills of senior/middle-level managers.

6.2.4 Developing and Implementing a Nation-wide PBGIS

This sub-goal aims to develop and implement the PBGIS by creating databases that will be maintained and accessed by the automated processes related to cadastral survey, land registration and land valuation, in order to provide efficient land administration service delivery to the general public. Priorities in implementing PBGIS services at district offices should be based on the land management needs and land market needs. The following can be laid down as the activities needed to achieve this goal:

- Developing an information architecture that supports nationwide maintenance, access and distribution of parcel-based geo-information. Countries such as Nepal and Bhutan are not so big; it would be economical to establish two main databases: production and supply databases at headquarters, where enough resources and knowledge are available for maintenance, protecting privacy, access, and the security of valuable information. A simple and low-cost desktop GIS at the district or users' offices could be utilised to access and maintain land information by network links to these central databases.

- Developing PBGIS models based on system architecture, using the incremental system development approach focusing on business objectives and user requirements. This research supports the use of the unified modelling language (UML), as it is the universally accepted standard language in software system development. It allows forward and reverse engineering. As discussed in Chapter 5, the development process of models is based on the concept of both product quality and process quality right from the beginning – from requirement analysis, to design to implementation. This reduces the risk of failure in system implementation and operation.

- Installing physical infrastructure and computer facilities at headquarters and in district offices. Initially, communication and links with the main databases at headquarters may be done via the telephone network system. As the system becomes operational, more sophisticated network infrastructure may be installed. The purchase and installation of hardware and software are normally done stepwise. During the initial starting phases, the most important items will have to be purchased and used for the modelling and testing phases to produce the first release of the system. For the second release, more hardware and software can be purchased and installed as per requirements, and so on. Budgets and the acquisition of hardware and software therefore depend on the system life cycle, including maintenance.

- Developing standard procedures for data collection, maintenance and distributing information. These standards should be based on new system and client requirements. A standard is required for digitising cadastral maps. On-screen digitising will be most suitable for this purpose. Currently, plane table techniques are used for making cadastral maps based on geodetic control points. In an area capital and other big cities where there are high demands for land transactions and high land prices, more sophisticated data collection methods such as the global positioning system and total station system can be employed. Then standard procedures should be built up for maintaining databases. Similarly, standards for distributing information can be developed. These standards must be developed in compliance with PBGIS models.

- Converting land registry data and cadastral maps into a digital database. Because of the complicated processes in handling cadastral map data, it is important to start with the registry data, which are in the form of registry books. After getting enough experience, cadastral maps should then be converted.

- Developing a valuation model to estimate market values. Various approaches (such as sale comparison, cost, and income approach) are available for developing such a model.

6.2.5 Building Reliable Archiving System

This is one of most important goals for the PBGIS and aims at archiving documents such as land records, cadastral maps and field sketches to keep them secure from disasters such as fire, earthquake, theft and from other factors. This is also important for maintaining history, if deed registration system is adopted. The following activities are laid down to achieve this sub-goal:

- Developing the central archiving system. This activity is most important for archiving valuable documents such as agreements, land ownership certificates, court orders, field sketches and cadastral maps for historical purposes. They are necessary in case of land disputes and of being required by the district courts.

- Developing procedures for scanning and archiving all documents. They are scanned and stored into a database management system managed by the central office. Later on, access to these documents can be gained via intranet or Internet at all district offices.

6.2.6 Providing Services and Products using PBGIS

Services and products are mostly delivered at district offices. There are also some services that are needed to deliver from central office.

- Operating PBGIS services at the district offices. Cadastral, land registry and valuation services and products are delivered at these offices. Workflows should be developed on the basis of standards. The flows must be supervised so that there is always very good communication between operators. Scheduling must be followed so that more resources can be allocated depending on the number of land transactions. These services require services such as updating or access to central databases from central office. The products are delivered to customers only after updating takes place in central databases.

- Operating PBGIS services at the central office: Data are disseminated from one central office. This is required to deliver the same information at all time. Internet/web technology is used for this purpose. Updating services are made available so that every district makes use of the same procedure and standards.

6.2.7 Interrelationships of Activities with CSFs

In 1973, the United Nations Ad hoc Group of Experts identified that *"Institutional problems are among the most difficult to resolve in the establishment and maintenance of a cadastre, and the lack of recognition and adequate resolution of such problems are most common causes for the ineffective functioning of a cadastre. The effective implementation of a cadastre is a complex operation involving the establishing of a function system of relationships among the several institutions for the establishment, maintenance, use and future refinements of the cadastre. No part of the system is entirely independent of the others; and if one part fails to work, the system breaks downs."*

On the basis of this statement, a table 6.1 is constructed to identify interrelation of activities and CSFs. Table 6.1 suggests that many activities are dependent on the factors related to organisation and management, while there are four activities, namely seeking external funding, developing information infrastructure, PBGIS models and installing infrastructure, which are influenced by all the factors. The complex relationships between several subsystems under several organisations, as well as other factors, also equally contribute to success.

Factors / Activities	Institutional, Legal, Financial	Organisation, Management	Technical, Standards, Quality management
1. Revise land acts	x		
2. Introduce new property laws	x		
3. Introduce copyright laws	x		
4. Data protection and privacy laws	x		
5. Establish a high-level committees	x	x	
6. Restructure executing organisations		x	
7. Establish Geo-ICT department		x	
8. Organise the local activities under single office at district		x	
9. Seek external funding	x	x	
10. Develop and conduct awareness programme		x	x
11. Develop and conduct inter-departmental training programme		x	x
12. Develop and conduct academic programme		x	x
13. Seek foreign advisors	x	x	x
14. Develop information architecture	x	x	x
15. Develop PBGIS models	x	x	x
16. Install infrastructure	x	x	x
17. Develop standards			x
18. Convert analogue data to digital DB		x	x
19. Develop valuation model		x	x
20. Operation at district offices and central office		x	x
21. Develop and implement central archiving system		x	x

Table 6.1: Matrix for factors and activities

According to Groot and McLaughlin (2000), the implementing organisations should be supported by political commitment over effective data access, use, maintenance and operation. Experience has shown that politicians in Nepal influence the system development process in organisation and management, including financing aspects. Therefore, it is of paramount importance that there is political stability, in order to ensure sustained political commitment. This allows the related organisations to cooperate and be part of system development and implementation. Organisations not involved in the initial system development can also be called in later, and the model modified to accommodate their requirements. This brings increased benefit on the part of the organisational change process in accommodating better use of the latest Geo-ICT tools and creating an effective environment to share, exchange and manage land-related data, and distribute up-to-date land information among the organisations.

Another important factor often addressed in the access and use of geographical information is the cultural habits of the society. de Man (2003) finds that culture and institutions guide individual actions and behaviour in solving spatial problems where both access and use of geographical information and technologies are embedded in the culture and the institutional arrangements of the society. Four main dimensions of culture influence the acceptance of information technology (Hofstede, 1997; Groot and McLaughlin, 2000). These are:

- power distance: society's way of accommodating human inequality
- uncertainty avoidance: society's way of accommodating uncertainty
- masculinity versus femininity: society's way of accommodating masculine and feminine values
- individualism versus collectivism: society's way of accommodating the individual and the group

Cultural conditions determine the propensity to socially accept information technologies such as GIS, i.e. cultural conditions primarily determine the desirability. Cultural desirability relates specifically to the functionality of GIS: communication and information sharing, strategic planning, operational planning and management, and monitoring and evaluation.

6.3 Guidelines for Implementing PBGIS

Where section 6.2 has addressed issues and CSFs as guidelines, this section primarily identifies items as guidelines or activities needed for system development for PBGIS within the organisational context in Nepal and Bhutan. There are fourteen items that need utmost attention for development of the PBGIS. These items are given below:

- Establish a system development team
- Decompose the PBGIS system into subsystems
- Follow system development life cycle
- Use standard modeling language for analysis and design
- Develop information architecture
- Develop system architecture

- Develop system models
- Develop prototypes as continuous
- Use commercially available hardware and software
- Develop data and process models as standards
- Develop standard user interface using internet technology
- Develop standard procedures for data conversion and integration
- Use large scale topographic data or ortho-images as a base
- Follow total quality management concept

Each element is further discussed in detail below.

6.3.1 Establish a System Development Team

A system development team should consist of members with expert knowledge in:

- system development (all phases, including implementation and maintenance of land registration and cadastral aspects)
- land issues (land tenure, legislation, land market and environment)
- modern data acquisition, processing, spatial databases and dissemination of land information
- networking, hardware and GIS and DBMS software
- organisational management, financing and marketing
- communication and cooperation skills

These members are recruited from various government and non-government organisations, including academic institutions, and the team should be led by a top LIS expert, who is also a member of the national coordinating committee, giving political backup.

6.3.2 Decompose the PBGIS System into Subsystems

Section 4 shows that there is a considerable increase in complexity when developing a large-scale system like PBGIS. In this case, not only does it require a complex set of modelling entities, but we are also introducing a large set of resources, which is difficult to manage both for development and implementation purposes. One possible approach for PBGIS is to think of a system in broad terms, which includes managing land registration, cadastral mapping, topographical mapping and fiscal components. This superordinate system is decomposed into subsystems. This concept is used in Chapter 4. The relationships between these subsystems are made clear. There are several advantages:

- The subsystems can be managed separately during all life-cycle activities.
- It is easy to use a subsystem to implement other subsystems by just plugging it into other systems of interconnected systems.
- Normally, we do not know whether we have to build a single system or a system of interconnected systems.
- It allows internal changes to the subsystems without developing a new version of the system.

6.3.3 Follow System Development Life Cycle

In order to manage the development as a continuous effort on reengineering, four major steps are recommended, as described in section 4.1.3 within the management framework (Tuladhar, 2002). These steps are strategic planning, the modelling phase, the construction phase and finally the delivery phase, which includes deployment and maintenance. In these phases, the life cycle of each subsystem is required to maintain dependencies among other interrelated subsystems.

Countries such as Nepal and Bhutan require a learning model (consisting of prototype, evolving and measuring) for developing a system. It is best to start small and allow for evolution based on work experience. By paying attention to the goal right from the start, it is possible to measure the results against expected objectives and improve the system in incremental steps.

6.3.4 Use Standard Modelling Language for Analysis and Design

There are many computer-assisted software engineering (CASE) tools available in today's ICT market. They can be efficiently used to develop system models, as discussed in Chapters 4 and 5. Some tools are more sophisticated than others, offering functions that range from simple flow diagramming to modelling the organisation, business processes, and data models, and even generating programming codes for databases and user interfaces.

It is also important to use a standard modelling language such as UML, because it can be easily connected to standards such as ISO/TC2111 and OGC for GIS. The CASE tools can provide good consistent checks.

Rational Rose, System Architect, MS Visio and Oracle designer running on desktop computers are just a few examples of such CASE tools that provide a flexible approach for system analysis and design. Some of them have the ability to model business processes and decompose activities under the organisation units. They define what information (data model) a system must manage and process, and provide details on how information is used by business activities. They allow quick prototyping of the organisational management, data and interfaces needed to carry out functions according to the strategic goals or objectives provided at policy level.

6.3.5 Develop Information System Architecture

As a part of strategic planning, it is important to know how the information requirements are satisfied. For this, a business plan is necessary for organisations. Within this plan, the information system architecture is presented in order to align business and Geo-ICT strategies. It also includes how the information system at central level is linked to district information systems where actual new information is collected and processed. Information flow and communication protocols are then established.

6.3.6 Develop System Architecture Perspective

During the design phase, system architecture is an important system component. It is possible that different data sets are stored and used using different hardware and software systems in different databases located at different places. It is important to know how the communication and cooperation are maintained among them. In principle, a wide area network (WAN) at inter-organisational level or a local area network (LAN) within an organisation can achieve access to information flows and databases located at different places. In both cases, WAN and LAN, there are different computers, different hardware configurations, and different operating systems that have to communicate with each other. Standards such as ISO/OSI or TCP/IP are needed to make that communication possible.

System architecture contains diagrams showing system configuration with communication and access protocols, including the access method and privileges for the various users of PBGIS. Basically, it is broad picture of technical and infrastructure specifications for PBGIS.

Client server architecture has two important basic features of system architecture: open systems architecture and interoperability. Open systems co-operate with each other using standards for accessibility, processing, and transfer of data, and are not hindered by system-specific structures.

6.3.7 Develop System Models

The purpose of analysis and design is to achieve a robust system architecture. Models of various system components are developed as part of the requirement analysis. As discussed in Chapter 4, an organisational model, a functional model, a dynamic model and a static model are necessary for designing the system. The development team ensures their quality in terms of completeness, correctness, extendibility, flexibility, etc., as well as their implications for the organisation and the financial aspect.

6.3.8 Develop Prototypes as Continuous Process

Throughout the continuous processes of system design and implementation, the development team ensures that the users are satisfied with the system being developed. For this purpose, various components are prototyped and the users then validate them. It is important to note that not all parts are prototyped at once: prototyping and measuring processes are carried out in incrementally, applying a “piecemeal concept”.

6.3.9 Use Commercially Available Hardware and Software

A PBGIS consists of a collection of users, data, software and hardware, whose purpose is to meet defined functional objectives. In order to implement such a system, the physical network, hardware system and application software are required. The choice of software seems more critical than the choice of hardware in today’s market. Hardware systems are becoming cheaper and are easy to use and install in organisations. It is software that makes our life difficult. The team needs to understand interoperability between the various systems or components of a system in order to provide information sharing and cooperative inter-application process control.

While choosing software, the programme should be able to develop friendly user interfaces for interaction between system and users. This is where the users measure the value of information systems. In order to realise client server architecture, standard software such as ESRI ArcGIS, Oracle Database, Ingres, Informix, Geomedia, MapInfo and CARIS can easily be adopted and used. There are many other software products that work in a client/server environment.

Organisations must have maintenance contracts with the hardware and software vendors for repairs and new versions. Normally, when we purchase software, yearly licence fees have to be paid to use them. This allows the organisations to automatically obtain new versions of the software as part of the maintenance programme.

6.3.10 Develop Data and Process Models as Standards

A common concern of PBGIS users is the terminology and definitions used. After analysing a land ownership certificate, it was found that the terms used are often not clear. Terms and definitions are explained neither in the land acts nor in the rules and regulations of land registration in Nepal. Developing data models as standards for collecting data as input to databases, processing databases, and disseminating outputs as products would help the users and implementing organisations to increase the availability, accessibility, integration and sharing of geographical information.

If these models lead to (inter)national standards, these will create an environment for improving the quality of data documentation, reducing information loss in data exchange, and avoiding duplication of data acquisition and information generation, and they will finally ease the establishment of geospatial data infrastructure at local, regional and global levels (http://www.opengis.org).

In the spatial component of PBGIS, standardisation typically involves the national coordinate system and projection system, including a unique identification system for land parcels, buildings, subjects, ownership (including mortgages), restrictions, easements and other indigenous rights. Standard forms with explanation are necessary for transferring ownership, mortgaging land, etc. All legal documents must be identified with a unique numbering system.

Furthermore, data standards include standards for topographical objects and quality parameters, including lineage information, as well as for place names (standard and official names of places) as well as metadata.

A process model serves two purposes. First, it provides information about the required input data, the process steps, and the output products. It has direct influence on the requirements and business objectives. Secondly, it provides organisations with information about the resources required to complete that process.

Developing metadata and metaprocesses would help organisations in many ways in providing information about an organisation's data holdings to data catalogues, clearing houses and brokerages, and in processing and interpreting data received through a transfer from an external source.

6.3.11 Develop Standard User Interfaces Using Internet/Web Technology

There are many users around the country, ranging from surveyors, lawyers, real- estate brokers, municipalities, district offices, tax offices, banks to ministries. To query information from PBGIS, we need user interfaces that display the same information in the same fashion on their computer screens.

Since Internet technology is reasonably cheap and platform independent, and we can even use existing telecommunication systems to access PBGIS by using the MS Internet explorer or Netscape, it is advisable to implement web-based browsers to access and display parcel-based information in a decent way.

Sophisticated user interfaces are developed for more detailed information and for transaction processes. At every district office, a GIS system and appropriate user interfaces supporting the processes are installed. For exchanging bulk data between organisations, appropriate media such as CDs may be employed.

6.3.12 Develop Standard Procedures for Data Conversion and Integration

Since there are many maps and registers, it is essential to develop standard procedures for data conversion for digital databases. These procedures can be used for digitising maps and land registers.

A standard keyboard with appropriate user interface is normally used to enter data from land registers into the database. Checking the land ownership and tenancy certificates or Thrams ensures good quality control. Cataloguing land registers and certificates is an important part of the preparation, as they are required for continuous manual transaction processes, which can be costly.

Scanning technology is normally more cost-effective than using digitising tables, because scanners cost much less and are very easy to use when equipped with commercial scanning software. The scanned map data can then be used in a simple GIS desktop computer for on-screen digitising to create vector data in digital form, including topological structure.

Here integration means linking between registration databases and spatial databases. A careful procedure must be developed to link them through correct unique identifiers. Consistency as preserved in the data models must be maintained. A checking procedure is required at the central as well as district offices.

6.3.13 Use Large-scale Topographical Data or Ortho-images as a Base

During data conversion, uniform cadastral data quality has to be ensured throughout the country. This can be achieved by integrating cadastral data with large-scale topographical data or large-scale ortho-images. By displaying both types of data with cadastral data in a separate layer, interactive editing can be applied to the cadastral parcel data. Topographical data are usually accessed via SDI.

The large-scale topographical data or ortho-images are usually derived using digital photogrammetric processes, from either stereo-aerial photographs of normally 1:5000 scale or images such as IKONOS or Quickbird. The experiments show that both are equally useful. However, the use of IKONOS or Quickbird can be less time-consuming in acquiring these images, and the benefits are greater as they contain more image spectral ranges for interpretation than the normal aerial photographs.

6.3.14 Follow Total Quality Management (TQM) Concept

Lastly, the system development team must follow the TQM concept, focusing on both process quality (of development phases) and product quality in data models, process models, standards and procedures, input data, intermediate products, and products and services that go to the clients.

During the development phases, all items (related to strategic planning, analysis and design, construction, deployment and maintenance) must be documented for a number of reasons. The people inside the organisation must have access to this documentation to ensure continuous future improvement.

6.4 Summary and Concluding Remarks

The critical success factors relevant to the implementation of PBGIS are the institutional, legal, financial, organisational, management and technical aspects, and standards and quality management. A CSF approach is formulated and it relates to defining goals, sub-goals and activities concerned with the implementation. Implementation depends on guidelines that are influenced by CSFs.

Once the goals and sub-goals have been defined, activities related to these sub-goals are identified. There are six sub-goals, namely, revise land policies/acts, including copyright laws and pricing policy, restructure existing organisations, develop human resources, develop and implement a nationwide PBGIS, build a document archiving system, and lastly provide services and products. The interrelationships between CSFs and activities are tabulated, and the result indicates that organisation and management are the most critical factors, followed by technical aspects, standards, and quality management. Institutional, legal and financial aspects are equally important in Nepal. System models including processes affect organisation and management.

The fourteen guidelines given below need the utmost attention in the development of a PBGIS:

- Establish a system development team
- Decompose the PBGIS system into subsystems
- Follow system development life cycle
- Use standard modelling language for analysis and design
- Develop information architecture
- Develop system architecture
- Develop system models
- Develop prototypes as a continuous process
- Use commercially available hardware and software
- Develop data and process models as standards
- Develop standard user interface using Internet technology
- Develop standard procedures for data conversion and integration
- Use large-scale topographical data or ortho-images as a base
- Follow total quality management concept

With regard to funding mechanisms for development and implementation, the joint funding of the implementing organisations is to be employed. The same is valid for the other resources.

Finally, because system development and implementation is a costly affair that requires the utmost care if no mistakes are to be made, the use of a learning model concept (prototype, evolving and measuring) is highly recommended. And one further recommendation, within the ministries in Nepal and Bhutan a system development team should be formed that has direct relationships with users, technologists, managers and a high-level steering committee.

Chapter 7

Conclusions and Recommendations

7.0 Introduction

In this chapter, conclusions are drawn as to the achievements or outcomes of this research regarding land tenure, system models, prototyping and guidelines for developing a parcel-based geo-information system (PBGIS), with special emphasis on the situation of the cadastral and land registration systems in Nepal and Bhutan. These are presented in section 7.1. Then recommendations for further research are presented in section 7.2.

7.1 Conclusions

The motivation behind this research basically relates to the fact that the existing systems of cadastral and land registration are unable to meet the needs of present societies in Nepal and Bhutan. Thus, this research has focused primarily on land tenure issues, analysis of existing systems, developing system models, organisational implications, quality issues and implementation guidelines, based on the needs of users and their requirements.

Conceptual framework

To carry out this research, a structured set of concepts for developing or improving existing systems is developed as a conceptual framework in the chapter 2. The essential components as the main outcomes in this conceptual framework are:

- land tenure systems
- PBGIS
- the principles of the reengineering approach
- domain model

These elements play the dominant roles in reengineering the existing systems and developing system models in PBGIS.

Land tenure systems: Land issues feature prominently on the agenda in many countries. Different forms of land tenure system exist around the world. While they are very much influenced by western land laws, there are continuous changes occurring in the developing countries in a shift towards a market-based economy. Customary lands in the rural areas and informal settlements in the urban areas, which often involve gender issues, are under constant debate, with land access for the poor high on the government political agenda. Different forms of land rights exist to enabling access to land. Not only individual rights exist but also there are customary rights, informal rights or community rights. Moreover, indigenous persons in customary areas look at their land more as territorial rights than individual rights. The relationship between person and land vary from country to country depending upon political system, social system, culture and tradition, and lastly economical situation.

Land is allocated for agriculture, settlement, religious purposes, infrastructure, industry, water and other natural resources. Land use rights are always part of the land use policy. Institutional options such as land consolidation, land banking and land ceilings play important roles. Cadastral and land registration systems are important tools.

PBGIS: The primary aim of PBGIS is to support the land administration processes by acquiring, storing, maintaining and disseminating land information for the functions of land alienation, transfer, valuation, taxation, development and utilisation. Basic data in such a system are cadastral parcels, cadastral records of land rights and persons who hold rights, and unique identifiers for these objects. Building data is important, and is considered as legal objects that relate to land market. National geodetic reference systems, geographical name (including postal addresses) topographical information, ortho-photographs or images, socio-economic information and thematic information are extended and the foundation data for PBGIS. Production, maintenance and dissemination of these foundations are normally mandated to the national agencies different from cadastral and land registration offices. Here spatial data infrastructure (SDI) plays an important role for sharing these data. Then the PBGIS acts as an integrating multifunction platform for delivering products and services.

Principles of the reengineering approach: In order to improve the existing systems, the general principles of reengineering are laid down as applied to PBGIS, emphasising the combination of tasks, decision making, the natural order of performing tasks, making a single point of contact, reducing checks and controls, and minimising reconciliation. Finally, the use of a case manager for the business services provided to users is supported. Analysis of the situation in Nepal and Bhutan in the light of these principles reveals that the present systems are poor and have inadequate capacity for acquiring, processing, maintaining and supplying cadastral information.

Domain model: The concept of domain model is to characterise the requirements of a system or, more specifically, to characterise the design that satisfies those requirements. In traditional cadastral and land registration systems, domain is rather narrowly defined and focuses only on registration of individual parcels. In a PBGIS, domain models focus towards the requirements (based on policy, legislation and users), strategic objectives, processes and data required for products and services. So it is a broad-based concept, which includes registration of land objects including responsibilities of stakeholders on land. In order to develop a new domain model, principles of reengineering is a part of incorporating existing domains and new requirements (derived from land laws, land policies, and users' requirements).

Analysis of existing systems in Nepal and Bhutan

With specific regard to the *Nepalese* context, the following conclusions as outcomes of this research are drawn:

(a) Historically, Nepal has had at least six forms of land tenure, but now has only two forms, which are currently operating under the Ministry of Land Reform and Management (MLRM). This transformation was due mainly to the pressure for suitable land for various purposes and to the difficulty in managing all forms of land tenure.

(b) The land is protected and managed under land laws and acts, as described in Chapter 3. Under these acts, the initial registration process, including adjudication, demarcation, surveying, recording, and issuing certificates, is conducted by the Department of Survey. When a district is completed, all records except cadastral maps are given to the District Land Revenue Office for maintenance. The district office using the "improved deed registration system" handles the transfer of land by sale, gift or inheritance, while the district survey office maintains the surveying and mapping.

(c) Land classification is done mainly for the purpose of land taxation and is approved by a special committee. The system is complex, and there is no official valuation system except for expropriation. Thus land tax system is not reliable.

(d) In the early 1990s, the computerisation of land records started, partly supported by the SwedSurvey experts and private companies. A new department called the Department of Land Information and Archiving (DoLIA) was established in 2000. The awareness of Geo-ICT tools and the need for cadastral information are recognised. Recent amendments to land surveying acts were made to introduce private survey enterprises for carrying out cadastral surveying.

(e) Based on the SWOT analysis of cadastral and land registration systems in Nepal, the most critical challenges are the political support, leadership, responsibilities and cooperation; the lack of institutionalised information and archiving systems; increasing land disputes; inappropriate organisational structure and culture; and inappropriate business processes, management capacity, and financial mechanisms.

With specific regard to the Bhutanese context, the following conclusions as outcomes of this research are drawn:

(a) The land management and registration system in Bhutan focuses mainly on fiscal purposes, although there are very strict rules and regulations under the 1979 Land Act for the transfer of land.

(b) The Survey of Bhutan is responsible for the initial registration and cadastral processes and collaborates with the Ministry of Home Affairs, Dzongkhag, Gewog, forest office and the public.

(c) The process to transfer land is initiated by the local court of the Dzongkhag office and must be registered at the Land Record Office of the Survey of Bhutan in Thimphu.

(d) There are also six main types of land use for land taxation. There is no official land valuation model for taxation, except for expropriation as in Nepal.

(e) In 1991, the computerisation of land records started under the guidance of SwedSurvey experts. The system does not have direct contact with the clients or allow them to access information. Communication is strictly based on the administrative hierarchy. The responsibilities at the district offices are not clear to the working staff. There is no adequate legislative framework for mortgaging land or for ownership of apartments.

System modelling

With respect to the system modelling, the following conclusions as outcomes of this are given:

(a) The modelling phase consists of analysis and design and is identified as part of the object-oriented system development life cycle, as shown in Chapter 4. The use of standard language such as the unified modelling language (UML) is orchestrated, as it supports the incremental approach and reuse of components. This is particularly important for adopting changing needs identified by a PBGIS domain. The applicability of use case, activity, class, and sequence and state diagrams is demonstrated in the cadastral domain. Organisational, functional, dynamic and static models give a complete view of the system models, and provide an approach for systematic development of system specification using the UML.

(b) The subsystems (cadastral surveying, land registry, property valuation, and dissemination) of the PBGIS are presented with detailed descriptions of static and dynamic models, including the services and products. Starting point in the static models is FIG core data model, in which real-estate object, right or restriction and person are core classes for the cadastral domain. This domain model focuses on transactions of real-estate objects within individual rights or restriction supporting stimulation of land markets. In this research, because PBGIS domain is a broad-based, Static model for land objects are extended to land administrative objects, land resource objects, legal (real-estate) objects and topographical objects, and are developed using the UML package and class diagram. Geometry and topology are linked to ISO TC211 and OGC standards. Static model for person is further specialised to natural person and non-natural person (which is further classified into trust, government and registered organisations. Relationship between person and land objects depends on the way a person holds and uses rights or restriction on land, and takes the responsibility on the use of land. Hence, a (FIG) core model can be extended firstly from real-estate objects to non real-estate objects (containing land administrative objects, land resource objects, and topographical objects) and legal (real-estate) objects. Secondly it can be extended from the right or restriction to responsibility.

In order to capture the dynamic aspects of the systems, the use case models for the parcel subdivision process and the dissemination subsystem are presented to capture the needs of external environment including users of the PBGIS. The activity and state diagrams are used to capture internal views of the PBGIS showing how a certain use case (or combination of use cases) is realised to deliver reliable products and services. Thus system modelling presented in this research has added values, such as synchronising external requirements (users) and internal requirements (static and dynamic components) to realise the functional aspects of the system at the modelling stage.

Prototyping business process and quality aspects

To link the system models specifically with organisations, the framework for organisational prototyping of business processes is proposed. Secondly quality factors are identified for system models and continuous quality review is proposed. Lastly experimental tests on the real cadastral data sets are performed and compared with ortho-photo and IKONOS images, as most users are always concerned about the quality of data delivered from PBGIS.

(a) Business process: The framework consists of objectives/goals, strategies and business process, and data. These are the inputs to the organisational restructuring, where activities and the Geo-ICT component are major parts. A prototype for initial database structuring and loading suggests that coordination and cooperation are vital to the successful implementation of PBGIS, because there is not just one department (DoLIA) but three departments (in Nepal) responsible, both financially and technically, for creating such a PBGIS. This is equally valid for parcel subdivision. If production database is centrally located at the central office, access to information must be available and reliable for delivering PBGIS products and services at the district office and is normally done via SDI.

(b) Quality aspects of system Models: It is also argued that removing defects discovered in the analysis phase would cost much less than fixing them in the post-delivery phase. So, emphasis in removing defects must be given to the system modelling and testing phases.

Product quality and process quality are combined as part of the system development phase. The quality factors specific to system models are completeness, correctness, flexibility, integrity, simplicity, integration, understandability and implementability. In order to review these factors of the system model, this research identifies a simple approach using a kiviat chart, whereby a project manager can decide which parts of the system have to be revised as a result of the quality review. But classification of ranking for quality factors in review procedure is still subjective.

(c) Experimental tests: There are three experimental tests. The first test is on the accuracy of parcel areas on cadastral map compared with field measurement data in Kathmandu area. The comparison shows that maximum errors and minimum errors in parcel areas are 19 sq m and 0.2 sq m, and maximum errors and minimum errors in perimeters are 1.4 m and 0 m respectively. The overall error in parcel area is ±1.2 sq m and that in parcel perimeter is ±0.2 m.

Second test is to compare adjusted cadastral parcel boundary points with orthophoto of aerial photograph. The overall discrepancy of boundary points over this area was found to be ± 1.8 m. The high discrepancy, maximum 6 m, was found in the west part of the area. This is primarily due to the forest coverage and mountainous terrain, and it is difficult to identify boundary points correctly in such areas. This can also be attributed to the low quality of digital elevation in the forest areas. Low discrepancy, as low as zero, is also found in the flat areas, where boundaries are clearly visible in the images. The overall matching of cadastral parcel boundaries with natural boundaries such as walls and ditches is quite acceptable.

Third test concerns with comparison test of cadastral parcel boundary points with the points visible on IKONOS images. Surprisingly, the overall discrepancies are estimated to be ±3 m, and the maximum and minimum values are respectively ±5 m and ±1.1 m. For visual interpretation, IKONOS image (Multispectral) provides better performance than IKONOS image (Pan)

Using above techniques the reliability of the existing cadastral data can be improved and the accuracy is brought to a uniform level. Thus overall results show that the quality of the existing cadastral data can be improved by integration with digital ortho-photographs or IKONOS images in a GIS desktop computer.

Guidelines for implementing PBGIS

The last item of this research is to present some essential issues as guidelines for the implementation of PBGIS. The conclusions are drawn as outcomes.

(a) <u>Critical success factors (CSFs)</u>: CSFs are used as the starting point of the approach for devising guidelines. This approach consists of (i) definition of goal and sub-goals of the system, (ii) definition of activities, and (iii) their implementation. The most critical factors related to PBGIS are institutional support (including political support), legal, finance, organisation (including coordination and cooperation), management (including market orientation and information requirements), technical issues (including system development, system installation, and infrastructure), standards and quality management. Six sub-goals are presented and discussed in the section 6.2 of the chapter 5. These sub-goals are related to the CSFs including changing needs of the markets. The activities are formulated from these six goals, and interrelated with the CSFs. Most influencing CSFs for a PBGIS are found to be organisation and management (including domain models of information requirement) followed by technical parts (system development, system installation, infrastructure), standards and quality management.

(b) Guidelines for implementation: The guidelines are formulated from a set of the activities. There are fourteen items as guidelines that needs utmost attention for development of the PBGIS. These items are given below:

- Establish a system development team
- Decompose the PBGIS system into subsystems
- Follow system development life cycle
- Use standard modeling language for analysis and design
- Develop information architecture
- Develop system architecture
- Develop system models
- Develop prototypes as continuous
- Use commercially available hardware and software
- Develop data and process models as standards
- Develop standard user interface using internet technology
- Develop standard procedures for data conversion and integration
- Use large scale topographic data or ortho-images as a base
- Follow total quality management concept

At the end, to cope with the changing requirements occurred both from land policy and Geo-ICT perspectives, the use of a learning model (i.e. prototype, evolve and measure) is motivated both for the organizations and PBGIS system development.

7.2 Recommendations

Several issues are identified below as recommendations for further research and development in the context of PBGIS.

(a) With regard to land tenure systems, research on defining and integrating spatial units, rights, and responsibilities of customary land with PBGIS is strongly recommended to suit to the local circumstances. In Nepal, land belonging to the trust (Guthi) organisation is seen as a burden, not as a way to manage sustainable agricultural development. Research is needed to investigate issues regarding Guthi land.

(b) In Bhutan, the current system covers only private land. It is not known how public, government and community land are managed. The existing system does not register these lands. Further research on the administration of public, government and community lands is therefore recommended. These different types of land should be brought under a single cadastral and land registration system.

(c) Both countries lack official valuation methods for taxation purposes. Therefore, it is recommended that research into land valuation systems, including building, be conducted. This is required as a base not only for equitable taxation but also for effective evaluation of the land market as an input to the gross domestic product of the national economy.

(d) Thorough research is carried out to identify gaps and overlaps in land laws. These investigations should include apartments, water rights in lakes and rivers, underground objects, mining and other 3D objects (including 3D objects on and inside the mountains). Even streams run inside caves inside the mountains. Additional research is required to model them.

(e) Since this research focuses only on the system modelling approach and guidelines, it is recommended that further research be carried out on information infrastructure architecture, focusing on a wide range of users within the context of geospatial data infrastructure (GDI) at local, regional and national levels.

(f) This research did not mention electronic conveyancing. The speedy delivery (from notary to land registrar) and registration of deed documents is vital from the client perspective. Research on the feasibility of such electronic conveyancing for countries such as Nepal and Bhutan is recommended.

(g) This research assumes that field survey documents are scanned and stored in a separate field sketch database. Further research is necessary to integrate field survey measurements with a cadastral database.

(h) This research work indicates an approach for aligning processes and organisational structure in an organisational prototyping concept. Therefore, further research related to organisation restructuring is needed within the context of Nepalese and Bhutan societies.

(i) Since the organisations are already using some kinds of Geo-ICT components, they do have some experience. This research further recommends investigation into the Geo-ICT process maturity levels.

(j) Further investigation on the standards concerning cadastral data in these countries is required. But such standards should be based on ISO and OGC standards, in order to be interoperable between various systems using the GDI network.

(k) In countries such as Nepal and Bhutan, the communication infrastructure is still poor. Research is needed to find an efficient approach for disseminating land information via telephone lines and Internet technology without the loss of information.

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Appendices

Appendix 1: Land Classification in Nepal

Land classification in Nepal is divided into three sectors, details of which are given below.

Urban sector: All municipalities fall under this sector, and land is usually classified into six classes.

- Class A (Ka): parcels with all town facilities, main shopping centre, and parcels connected to main road
- Class B (Kha): parcels connected to parcel class 1 or near class 1 but connected to secondary road
- Class C (Ga): parcels connected to parcel class 2 or connected to branch road
- Class D (Gha): parcels connected to parcel class 3 or connected to the street
- Class E (Ang): parcels connected to parcel class 4
- Class F (Cha): parcels not connected within parcel classes 1 to 5 or parcels without town facilities

Tarai and Valley sector: This sector consists of all regions of Tarai (southern part) and the lands of the Kathmandu, Pokhara and Dang valleys that are not part of municipalities. Land parcels in these sectors can be classified based on agricultural crops.

(a) Classification of land parcels having paddy, based on soil type:
  - Class 1 (Abal): good soil that can produce two or more crops, irrigated through the year
  - Class 2 (Doyam): soil irrigated by rainfall only, good-quality soil that can yield two crops in a year
  - Class 3 (Sim): soil irrigated by rainfall, only one crop can be harvested in a year
  - Class 4 (Chahar): sandy and dry soil, irrigation not possible, water holding capacity very poor, can yield only one crop; or land flooded with water and can yield one crop at intervals of some years

(b) Classification of land parcels having wheat, maize, and other crops, based on soil type:
  - Class 5 (Abal): good quality of soil, can yield wheat or maize easily
  - Class 6 (Doyam): some sand mixed in soil, can yield only maize and mustard

- Class 7 (Sim): sandy soil, can yield maize and mustard at intervals of one or two years
- Class 8 (Chahar): not plain land, sandy soil
- Class 9: none of above classes applicable

Mountainous sector: Mountainous land parcels are classified on the basis of land use and elevation.

(a) Classification of land parcels of paddy:
- Class 1 (Abal): good soil, up to height 3000 ft (915 m)
- Class 2 (Doyam): soil irrigated for up to six months, or in the rainy season soil has enough water holding capacity, up to height 3000 ft (915 m); or irrigation facility and good soil, height between 3000 ft (915 m) and 4000 ft (1220 m)
- Class 3 (Sim): irrigation for only two months, some sand mixed with soil, within height 3000 ft (915 m); or good soil with water holding capacity for more than two months, or soil with some sand and stone mixed, not good water holding capacity but water facility for more than two months, between height 2000 ft (610 m) and 4000 ft (1220 m); or good soil, irrigation facility for more than five months, between height 4000 ft (1220 m) and 5000 ft (1524 m)
- Class 4 (Chahar): sandy soil, no water holding capacity, can yield paddy at intervals of some years, or more slope, ploughing impossible, up to height 3000 ft (915 m)

(b) Classification of land parcels having wheat, maize and other crops:
- Class 5 (Abal): good soil, up to 2000 ft (610 m), or gradient is not steep so ploughing is possible, and the temperature can rise to a level at which crops can ripen in three months if arrangements are made for irrigation, up to 2000 ft (610 m)
- Class 6 (Doyam): soil not so good, ploughing possible, height up to 2000 ft (610 m); or crop produced in more than three months, height between 2000 ft (610 m) and 4000 ft (1220 m)
- Class 7 (Sim): sandy soil or good soil, cultivation only possible with barriers up to 2000 ft (610 m) due to slope; or soil in shadow, height 2000 ft to 4000 ft (1220 m); or good soil, height 4000 ft (1220 m) to 6000 ft (1830 m)
- Class 8 (Chahar): sandy soil, cultivation only by spade and hoe up to 4000 ft (1220 m); or soil not so good, height 4000 ft to 6000 ft; or cultivated land, height 6000 ft to 8000 ft; or apple and cardamon can be produced on land
- Class 9 (Pakho fifth): cultivated land above 8000 ft

Appendix 2: A sample registration form (translated to the English language)

HMG / NEPAL

MINISTRY OF LAND REFORM & MANAGEMENT

REVENUE OFFICE

REGESTRATION NO

SUBJECT :-

REGISTERED THE DOCUMENT OF RS ... ... AFTER BEING AGREED BY BOTH THE PARTIES WHEN READ OUT TO THEM

OFFICER

ACCOUNTANT

CLARK

DATE

APPLICATION DATE

SIGNATURE

SIGNATURE GIVEN IN OFFICE

VENDORS: RIGHT / LEFT

PURCHASER: SIGNATURE

WITNESS TO STATE THAT BOTH THE PARTIES ARE NEPALIES AND THE NAME & ADDRESS ARE CORRECT

GUARDIAN IF NECESSARY NAME CAST & RELATION

SIGNTURE :-

PERSON PREPARING THE DOCUMENT

I/We hearby authorise to enjoy right of my/our immovable property not transferred to any other person of any of its right or interest by any document(private or official) of coneyance for the sum of Rs.... In case this document is proved defictive, I/We have no objection to collect this aforesaid sum with interest out of any other property (land, building or any other) by way of legal proceeding. This document will be officeally processed withen time limit specified by the provisions of legal code.

	VENDOR	PURCHASER	PURCHASER DECLARATION	VENDORS DECLARATION
AGE, NAME & CASTE			I declare that lands in my and my family names do not exceed ceiling	I declare that lands including this do not exceed ceiling.
ADDRESS				
FATHER				
GRAND FATHER				

WITNESS

DESCRIPTION OF THE IMMOVABLE PROPERTY (RELINQUISHED):-

DISTRICT	PANCHAYAT	CELTION NO	PARCEL	CLASSIFICATION	LOCATION	AREA	VALUE OF EACH PLOT	STATEMENT ABOUT THE RIGHT	TENANT'S NAME & ADDRESS	PARCEL	AREA	REMARK

PRESENT NEW PARCEL NO.

SIGNATURE OF THE SURVEYER

SIGNATURE OF THE CERTIFIER

VENDOR'S SIGN IN WRITING

THOUMB PRINT: RIGHT / LEFT

RECEIVED A COPY OF THIS DOCUMENT OFFICIALLY

COPIES OF RELIVANT DOCUMENTS

1. REVENUE RECEIPT OF YEAR ... ...
2. LAND OWNERS CERTIFICATE

OTHER DOCUMENTS OF RIGHT

DATE YEAR MONTH DATE

CLERK TO CHECK IMPEDIMENT

CLERK TO VARIFY TAXRECORD ....

RECEIVED REGISTRATION FEE RS.......

SIGNATURE ....

RECEIPT NO.......

Appendix 3: A sample land ownership certificate (translated to the English language)

Ka

Land Ownership Certificate

Cover page (Red colour)

Price : Rs. 15/-

His Majesty's Government
Ministry of Land Reform & Management
Land Revenue Department
.... Office

Land Ownership No.......

photo

Signature of the photo attestor

Thumbs Print	
Right	Left

Land Ownership's Name & Caste ....
Address............ Zone .... District .... Location........
...............................Municipality/V.D.C. Ward No. ....
Land Ownership's Father's/Husband's Name & Caste ....
Land Ownership's Grandfather's Name & Caste.....................
Citizenship No. & Date ....
Office Issuing Citizenship Certificate......................................
Land Owner's Signature ....
Office Issuing Land Ownership Certificate ....

(Office Seal)

Inner page 1

His Majesty's Government
Ministry of Land Reform & Management
Land Revenue Department
Land Owner's Name:............
Land Ownership Certificate

District	Municipality VDC	Reference	Ward No. & Plan	Plot No.	Description	Ownership-Right	Tenant's Name Caste & Address	Classification	Area	Tax Registration No. Page No.	Remarks	Attestor's Signature

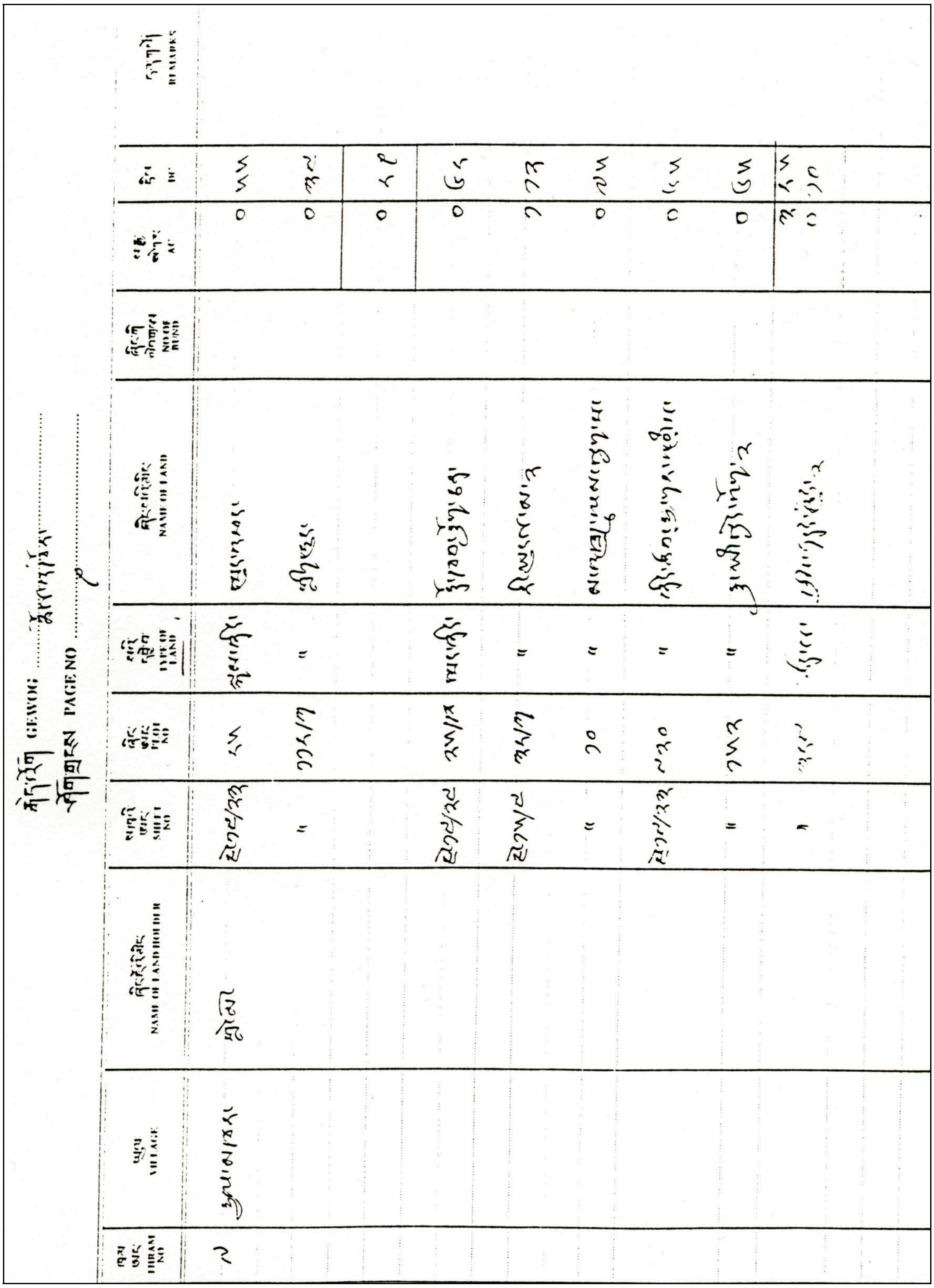
44

Plate 7.2 – Land Ownership Certificate, Inside Pages

Appendix 4: A sample scanned cadastral map in Kathmandu, Nepal

(Prepared by using plane-tabling technique)

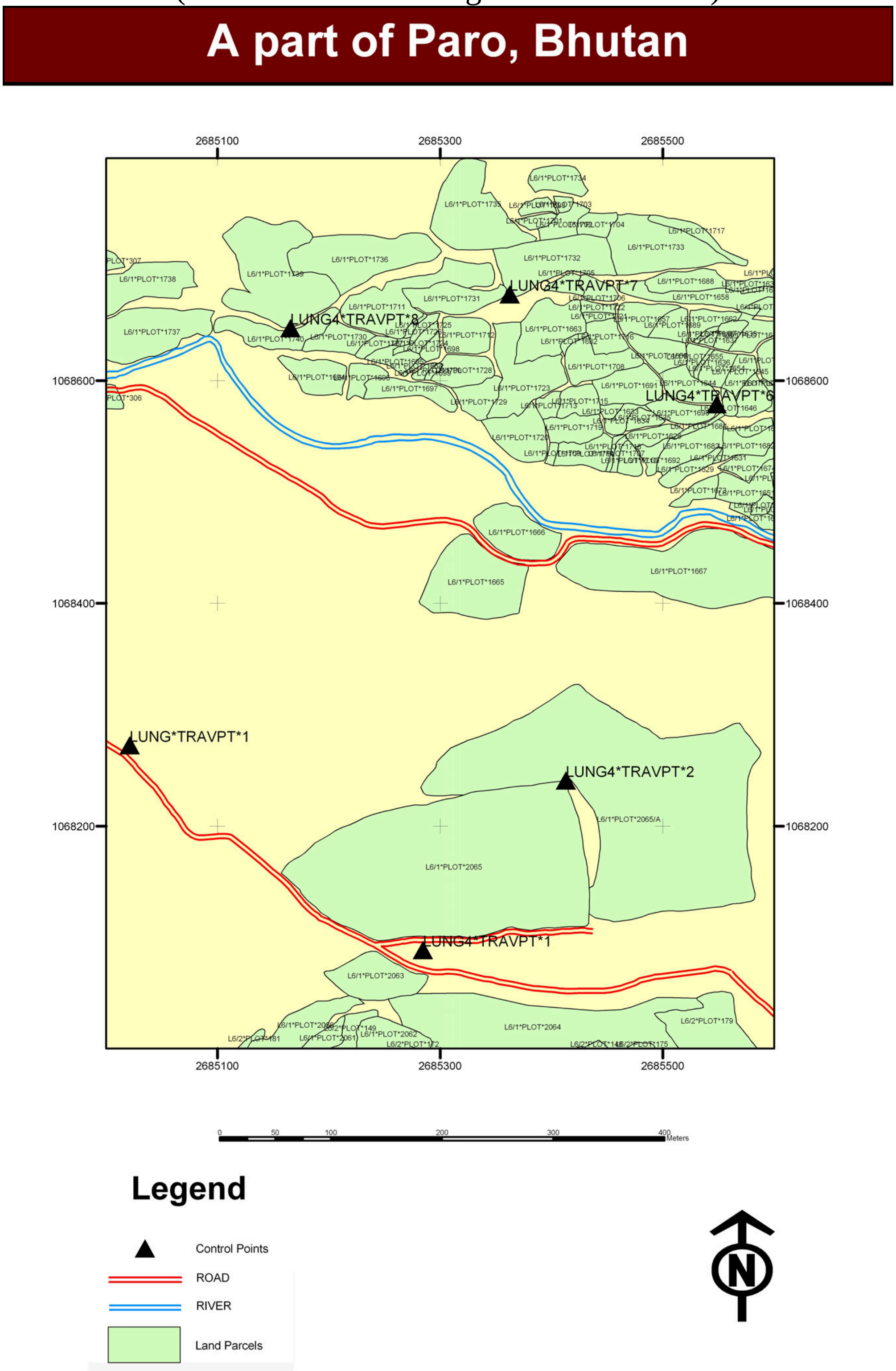
Appendix 5: A sample extracted land records (Sathram) in Bhutan


GEWOG
PAGE NO

THRAM NO	VILLAGE	NAME OF LANDHOLDER	SHEET NO	PLOT NO	TYPE OF LAND	NAME OF LAND	NO OF RUND	AC	DC	REMARKS

Appendix 6: A sample cadastral map in Bhutan

(Extracted from the digital cadastral data)



Appendix 7: Glossary for Nepalese and Bhutanese words

Abbal	First grade land
Birta	Type of rights acquired by means of Gratuity
Chahar	Fourth grade land
Chhuzhing	Wet land or paddy field
Doyam	Second grade land
Dungkhag	Sub-district
Dungpa	Head of a sub-district
Dzongkhag	District
Dzongkhag Yargye Tshongchung	District Development Committee
Dzongdag	Chairman of District Development Committee
Fair Thram	Compilation of Field Thram
Field Thram	Field records collected by Land Surveyors
Gewog	Block
Gewog Yargye Tshongchung	Block Development Committee
Gup	Elected leader of a block
Guthi Sansthan	Trust Corporation
Jagir	Type of land rights provided as emolument
Kamzhing	Dry land
Kipat	Communal tenure right
Lagthram	A copy of a Thram issued to the Land Owners
Lal Purja	Ownership certificate
Lekhandas	Writer of deed form
Mal Adda	Land revenue office before enactment of land revenue act
Marthram Chem	Master Land record for the whole Country
Moth	Ownership registers
Mukhiya	Head man
Mulki Ain	Civil code
Pakho	Cultivated land in High Mountain
Pangzhing	Land for shifting cultivation
Patwari	Land recorder
Raiker Land	Land owned by individuals
Rakam	Type of land right assigned for specific use

Sarthram	Land record for each district
Shresta	Land registers
Sim	Third grade land
Sogshing	Forest land with right for collecting firewood and leaves for manure
Soilra	Land allocated by King as reward
Talukdar	Revenue agent
Teris	Statistics of parcel for each owner
Thram	An inventory of individual land holdings owned by a single household
Thrimkhag	Local court
Tsatong	Unclaimed land
Tshamdo	Grazing land with grazing rights
Zamindar	Land-lord

Summary

In many developing countries, there is increased need for efficient and effective delivery of geo-information concerning tenure security, and the value and use of individual land parcels. The existing systems of cadastre and land registration in these countries are old and paper-based, and they are unable to provide reliable and up-to-date information products and services to the current society. Typical cases of cadastral and land registration systems in Nepal and Bhutan are presented in this research work.

The goal of this research is to provide modelling concepts and guidelines for developing or reengineering a parcel-based geo-information system (PBGIS) that provides efficient and effective delivery of parcel-based geo-information products and services. In this context, this research underlines a number of components that are required for a PBGIS. They are related to land tenure systems, existing cadastral and land registration systems, modelling the dynamics of cadastral data, organisational alignment with the Geo-ICT environment, including quality aspects, and finally guidelines for the implementation of PBGIS.

To be able to combine the above components, this research first identifies and analyses a set of structured concepts as a conceptual framework. The framework defines four important concepts (i.e. land tenure systems, the PBGIS concept, the principle of reengineering and the cadastral domain) as the basic essential elements for developing system models in PBGIS, as they affect the behaviour of PBGIS.

This research study reveals that around the world land tenure and its dynamic nature consists of a variety of land rights exercised by individuals, groups of individuals, communities, customary groups or the state. Significant forms of land tenure are non-formal tenure (i.e. customary tenure and informal settlement), private freehold and leasehold, public freehold and leasehold, and communal ownership. In addition to land survey and registry, this research also recognises institutional options such as land allocation, land consolidation, land banking and land ceiling for both rural and urban land as important tools in allocating land rights for agriculture, settlement, religious purposes, infrastructure, industry, water and other natural resources. It also indicates that land tenure systems in developing countries evolve due to the changes in policies concerning tenure security, economy and environment.

The primary role of PBGIS is to support the land administration functions that require various kinds of spatial data on land objects, and the rights and responsibilities held by the state, communities, family groups and individuals. In developing countries, the indigenous groups think not only about individual rights but also about communal and group rights. Thus, a PBGIS requires (a) basic cadastral data, including building and apartment data, land administrative boundary data, topographical data, socio-economic data and thematic data; (b) land rights and responsibilities according to local land tenure; and (c) a variety of person data.

To be able to develop such a PBGIS, a domain model is identified as an essential part, specifically for applying the reengineering principle to redesign existing digital or analogue cadastre and land registration systems. In this activity, the domain model integrates the existing system and new requirements demanded by land policy, legislation and users, together with strategic plans. Reengineering existing processes requires the basis of a cadastral domain model that defines the scope of a PBGIS.

The second part of this research concerns the analysis of the systems in Nepal and Bhutan in order to understand both the present situation and stimulate the challenges to implement PBGIS using computerised GIS systems.

This research reveals that Nepal has had at least six forms of land tenure in the past, but these have now been reduced to two. It further indicates that these changes have occurred owing to the difficulty in managing all the forms of land tenure for the various purposes. The lands are protected and managed under various land laws and acts. These laws provide a mandate to the Survey Department to carry out the initial registration process, including adjudication, demarcation, surveying, recording and issuing certificates. When the initial registration of a district has been completed, all records except cadastral maps are given to the District Land Revenue Office (DLRO) for maintenance. The DLRO provides continuous services regarding the transfer of land by sale, gift and inheritance, using the “improved deed registration system”, while the District Survey Office (DSO) of the Survey Department maintains the surveying and mapping components. Computerisation of land records started in the early 1990s and was partly supported by private companies. The result of the SWOT (strengths, weaknesses, opportunities and threats) analysis of cadastral and land registration systems in Nepal shows that the most critical challenges are political support, leadership, responsibilities and cooperation, institutionalising business processes, information and archiving systems, and management capacity, including the financial mechanism for system automation.

In Bhutan, the land management and registration systems are mainly for fiscal purposes, although the 1978 Land Act lays down very strict rules and regulations governing the transfer of land. The Survey of Bhutan is responsible for the initial registration and cadastral processes, in collaboration with the Ministry of Home Affairs, districts (i.e. Dzongkhag), blocks (i.e. Gewog), the forest office and citizens. The process for transferring land is initiated by the local court of the Dzongkhag office and is registered at the Land Record Office of the Survey of Bhutan in Thimphu. Computerisation of land records was introduced in 1991 and the analysis suggests that the registration system has no direct contact with the clients that allows them to access information, as communication is based strictly on the administrative hierarchy. There is no adequate legislative framework for mortgaging land or for the ownership of apartments.

The third part of this research concerns system modelling using object technology. The unified modelling language (UML) is used for modelling the PBGIS, as it supports the incremental approach and the reuse of existing system components. The subsystem, package, use case, activity, class, sequence and state diagrams are the core concepts of the system models in the PBGIS. Four subsystems are identified within the PBGIS as part of the organisational models. They are the cadastral surveying, land registry, property valuation and dissemination subsystems. The functions or processes, and data are discussed within these subsystems.

Static models for the cadastral surveying subsystem are developed. By comparing these models with (FIG) core data model, in addition to the legal (real-estate) object class, this research identifies additional classes such as land administrative units, land resource object classes, and topographical object classes in Nepal. The land registry subsystem consists of land rights and person objects. Land rights are represented by classes themselves, not always by the association class, because the relationship between persons and land rights are strongly dependent on the land tenure arrangement in a country. In order to capture the dynamic aspects, models (in the form of use cases, and activity and state diagrams) for the parcel subdivision and information dissemination processes are presented.

The fourth part of this research is about organisational prototyping to test the business processes that run through various departments. Three cases, namely initial database structuring and loading, parcel subdivision, and full transfer of ownership, suggest that coordination, cooperation, and the appropriate distribution of activities are vital to the successful implementation of the

PBGIS, because one or more departments are involved in deploying resources in both financing and technical work. Analysis of the results shows that we need to lay emphasis on customer orientation, products, processes, tasks and order. The quality factors regarding the data models are completeness, correctness, flexibility, integrity, simplicity, integration, understandability and implementability. These factors can be taken into account in the system models by combining product quality and process quality during the development phase. A continuous quality review during the operational phase is suggested.

Several experiments are carried out on the geometrical quality of the cadastral data at the database level. Test databases for the outskirts of Kathmandu city are constructed using ESRI ArcGIS software. The first test relates to the accuracy of the areas and perimeters of land parcels derived from old cadastral data (digitised from cadastral maps) as compared with the field boundaries. The results show that the overall errors are ± 1.2 sq m in area and ± 0.2 m in perimeter for an average land parcel size of 157 sq m. The second experiment tests the quality of existing cadastral data against a digital ortho-photograph derived from the aerial stereo-photographs taken at a 1:10,000 nominal scale. The overall accuracy is ± 1.8 m in planimetry, depending on the quality of the digital terrain model, terrain type and land coverage. The overall accuracy is ± 3.0 m with IKONOS images, both for panchromatic and multispectral bands. The analysis reveals that the overall quality of old cadastral maps can be improved by the interactive editing functions of the GIS software, integrating cadastral data with either ortho-photos or IKONOS images.

The last part of this research provides guidelines for developing a PBGIS, and critical success factors are identified. The most critical factors are organisation and management, followed by technical and quality aspects, and then institutional, legal and financial aspects. Fourteen items, needing the utmost attention, form the guidelines for developing the PBGIS:

- Establish a system development team
- Decompose the PBGIS system into subsystems
- Follow system development life cycle
- Use standard modelling language for analysis and design
- Develop information architecture
- Develop system architecture
- Develop system models
- Develop prototypes as a continuous process
- Use commercially available hardware and software
- Develop data and process models as standards
- Develop standard user interface using Internet technology

- Develop standard procedures for data conversion and integration
- Use large-scale topographical data or ortho-images as a base
- Follow total quality management concept

At the end, the use of a learning model (i.e. prototype, evolve and measure) is motivated for both the organisations and PBGIS system development.

Samenvatting

In veel ontwikkelingslanden bestaat een toenemende behoefte aan de levering van doelmatige en doeltreffende geo-informatie met betrekking tot de juridische status, waarde en gebruik van percelen. De bestaande systemen voor grondregistratie[1] in deze landen zijn oud, meestal analoog en niet in staat de huidige samenleving van betrouwbare en actuele informatie producten en diensten te voorzien. Dit typeert ook de grondregistratie in Nepal en Bhutan, die in dit onderzoek aan de orde komen.

Het doel van dit onderzoek is met bruikbare concepten en richtlijnen te komen voor het ontwikkelen en/of herontwerpen van Perceels-gebaseerd Geo-Informatie Systemen ('PBGIS'). Zulke systemen dienen te voorzien in een doelmatige en doeltreffende levering van geoinformatie produkten en diensten. Het onderzoek benadrukt een aantal essentiële componenten die te maken hebben met de ontwikkeling van dit soort systemen, namelijk de regeling van het 'grondbezit'[2], de relatie tot bestaande grondregistratie systemen en het modelleren van de dynamiek van de betrokken gegevens in een organisatorisch verband. Aspecten van Geo-ICT management, kwaliteit alsmede richtlijnen voor de implementatie van een PBGIS komen eveneens aan de orde.

Dit onderzoek richt zich allereerst op het conceptuele kader In dit kader worden vier belangrijke componenten gedefinieerd, namelijk 'grondbezit'-systemen, PBGIS zelf, de principes van herontwerp van systemen en ten laatste de modellering van het zogenoemde kadastrale domein. Dit blijken essentiële elementen te zijn voor de ontwikkeling van systeemmodellen voor een PBGIS omdat deze het gedrag ervan beïnvloeden.

De studie toont aan dat 'grondbezit' een dynamisch karakter heeft. Wereldwijd bestaat 'grondbezit' uit een variëteit aan rechten op grond die worden uitgeoefend door individuen, groepen, gemeenschappen of de Staat. Belangrijke vormen van 'grondbezit' zijn private eigendom en private huur/pacht, publieke eigendom en publieke huur/pacht, vormen van groepseigendom en ten laatste het informeel bezit, dat buiten de formele regelingen om wordt uitgeoefend. In aanvulling op de behandeling van technische aspecten van landmeten en registratie welke van belang zijn voor de registratie van 'grondbezit' in

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[1] 'Grondregistraties' worden ook wel genoemd 'kadastrale systemen': de registers en kaarten die de relevante informatie weergeven.

[2] Als vertaling van het Engelse woord 'land tenure' is in deze samenvatting het woord 'grondbezit' gebruikt

registers en op kaarten, komen in dit onderzoek ook institutionele aspecten aan de orde. Het gaat om belangrijke instrumenten voor de allocatie van rechten op grond zoals landinrichting, grondbank of de regulering van de onroerend goed markt door bijv. het stellen van plafonds aan perceelsgroottes in zowel ruraal als urbaan gebied. Bij de allocatie van rechten op land moet rekening worden gehouden met de diverse soorten huidig en toekomstig gebruik zoals landbouw, huisvesting, godsdienst, infrastructuur, industrie, en met het benutten van water en andere natuurlijke hulpbronnen.

De belangrijkste rol van een PBGIS zoals het in dit onderzoek wordt gezien, is het ondersteunen van de procedures voor grondregistratie. De gegevens die daarvoor nodig zijn betreffen ruimtelijke gegevens betreffende percelen, rechten, belangen van de Staat, en gegevens over rechthebbenden zoals gemeenschappen, familiegroepen en individuen. In ontwikkelingslanden is in hoge mate sprake van zowel individuele als groepsrechten (bijv. familie, stam, dorp). Een PBGIS heeft een scala aan gegevens nodig: omtrent rechtsgrenzen (inclusief gebouwen en appartementen), administratieve grenzen, topografie, socio-economische en thematische gegevens, gegevens betreffende rechten en verplichtingen ten aanzien van grond, grondgebruik, en gegevens omtrent rechthebbenden.

Om een PBGIS te kunnen ontwikkelen is een domeinmodel essentieel, vooral om het beginsel van herontwerp (‘re-engineeing’) van bestaande digitale of analoge grondregistratiesystemen te kunnen toepassen. Een domeinmodel integreert het bestaande gegevensmodel met de nieuwe eisen die voortkomen uit nieuw grondbeleid, gewijzigde wetgeving, wensen van gebruikersgroepen en strategische plannen van betrokken organisaties. Een succesvol herontwerp van bestaande processen vereist een goede basis in de vorm van een kadastraal domeinmodel. Het bereik van PBGIS wordt daarmede gedefinieerd.

Het tweede deel van dit onderzoek betreft de analyse van de grondregistratiesystemen in Nepal en Bhutan met de bedoeling om de bestaande situatie in kaart te brengen, en om de autoriteiten in Nepal aan te moedigen de uitdaging van een PBGIS te begrijpen en aan te gaan.

Het onderzoek toont aan dat in Nepal in het verleden tenminste zes vormen van grondbezit voorkwamen. Thans is dit teruggebracht tot twee. Het onderzoek laat zien dat deze verandering optrad als gevolg van de moeilijkheden in het management van allerlei vormen van grondbezit voor verschillende doeleinden. Grondbezit wordt thans geregeld in verschillende onroerend goed wetten. Deze wetgeving mandateert het Departement Landmeten van het Ministerie van ‘Land Reform and Management’ om het initiële registratieproces uit te voeren, inclusief aanwijzing, afpaling, meting, vastlegging (registratie) en uitgifte van eigendomscertificaten. Zodra de registratie van een district is afgerond worden alle documenten, behalve de originele kadastrale kaarten, overgedragen aan de District Grondbelastingdienst voor verdere bijhouding. Hier wordt voorzien in continue dienstverlening bij overdracht van onroerende zaken zoals door verkoop, schenking en vererving, ondersteund door een registratie van akten, waarbij de Districtsafdeling van het Departement Landmeten de metingen en kaartering bijhoudt. Begin jaren negentig is een aanvang gemaakt met het digitaliseren (A/D conversie) van de grondregistratie met ondersteuning van het bedrijfsleven. Het resultaat van een sterkte/zwakte analyse van het grondregistratie systeem voor Nepal wijst uit dat de meest kritische factoren zijn: politieke steun, leiderschap, verantwoordelijkheden en samenwerking, het institutionaliseren van bedrijfsprocessen, informatie- en archiefsystemen met bijbehorende managementcapaciteit en de financiering van de automatisering.

In Bhutan is het grondregistratiesysteem opgezet met name voor fiscale doeleinden. De overdracht van onroerende zaken is strikt gereguleerd onder de Onroerend Goed Wet van 1979. De Survey of Bhutan (Topografische en Kadastrale Dienst) is verantwoordelijk voor de initiële registratie en de kadastrale processen, in samenwerking met het ministerie van Binnenlandse Zaken, districten (Dzongkhag), sub-districten (Gewog), het bosbeheer en de burgers. Het proces ‘overdracht van land’ wordt geïnitieerd door de rechtbank van het Dzongkhag kantoor; registratie vindt plaats bij het Bureau Grondregistratie van de Topografische Dienst in de hoofdstad Thimphu. Er bestaat geen adequaat wettelijk kader voor het vestigen van hypotheken en voor eigendom van appartementen. Het onderzoek toont aan dat er bij het systeem in Bhutan geen directe contacten met klanten bestaan met betrekking tot de optimale toegang tot de gegevens. De communicatie is strikt gebaseerd op de ambtelijke hiërarchie. De automatisering van de grondregistratie is begonnen in 1991.

Het derde gedeelte van het onderzoek gaat over systeemmodellering met gebruik van objecttechnologie. Het modelleren van het beoogde PBGIS is gedaan met de Unified Modelling Language (UML) vanwege de mogelijkheden die geboden worden voor een stapsgewijze benadering alsmede voor hergebruik van bestaande systeemcomponenten. De 'subsystem'-, 'package'-, 'use case'-, 'activity'-, 'class'-, 'sequence'- en 'state'-diagrammen zijn de kernconcepten gedurende de analyse en het (her)-ontwerp van het PBGIS.

Vier subsystemen zijn onderkend binnen het PBGIS: ‘kadastrale metingen’, ‘grondregistratie’, ‘waardebepaling eigendom’ en ‘gegevensdistributie’. Deze subsystemen zijn gemodelleerd als onderdeel van organisatorische modellen.

Binnen deze subsystemen zijn de functies en/of de processen en de gegevens gemodelleerd. Statische modellen voor het subsysteem ‘kadastrale metingen’ zijn ontwikkeld. Refererend aan het Core Data Model (onder de auspiciën van de International Federation of Surveyors FIG) en als toevoeging aan objecten ‘onroerende zaak’, identificeert dit onderzoek aanvullende objectklassen in Nepal zoals betreffende administratieve eenheden, natuurlijke hulpbronnen en topografie. Het subsysteem ‘grondregistratie’ bestaat uit objecten betreffende rechten op grond alsmede personen. Rechten op grond worden gerepresenteerd als klassen in zichzelf, en niet altijd door associaties omdat de relatie tussen personen en grond sterk afhangt van de regelgeving omtrent het grondbezit in een land. Ten einde de dynamische aspecten te behandelen worden modellen gepresenteerd (in de vorm van use cases, activity en state diagrams) voor perceelssplitsing en informatiedistributie.

Het vierde gedeelte van dit onderzoek gaat over het maken van prototypen van organisaties om de mogelijkheid te hebben bedrijfsprocessen waarbij verschillende afdelingen betrokken zijn, te testen. Drie gevallen (namelijk het initieel structureren en laden van de database, de splitsing van percelen en de volledige overdrachten van eigendom) geven aan dat een goede verdeling van activiteiten, alsmede coördinatie en samenwerking van vitaal belang zijn voor de invoering van een PBGIS, omdat daarbij een of meerdere afdelingen betrokken zijn die hun middelen inzetten t.b.v. financiële als technische werkzaamheden. Analyse van de resultaten laat zien dat er nadruk gelegd moet worden op klantgerichtheid, producten, processen, taken en hun volgordelijkheid.
Uit het onderzoek blijkt dat de kwaliteitsfactoren van gegevensmodellen bij deze processen zijn: volledigheid, juistheid, flexibiliteit, integriteit, eenvoud, integratie, begrijpelijkheid en implementeerbaarheid. Deze factoren kunnen in beschouwing worden genomen in de systeemmodellen door de product- en proceskwaliteit te combineren gedurende de ontwikkelingsfase. Een continue kwaliteitsborgingsprocedure wordt aanbevolen voor de operationele fase.

Verschillende testen zijn uitgevoerd ten aanzien van de geometrische kwaliteit van de kadastrale gegevens op database-niveau. Testdatabases voor de buitenwijken van Kathmandu zijn gebouwd, gebruikmakend van ESRI ArcGIS software. De eerste test bestond uit het vergelijken van de nauwkeurigheid van oppervlaktes (groottes) en omtrekken van percelen welke afgeleid werden uit de oude kadastrale gegevens (gedigitaliseerd van de kadastrale kaart) met de ingewonnen grenzen in het veld met meetband en theodoliet. De resultaten laten zien dat naarmate de oppervlaktes of omtrekken groter zijn ook de fouten in de oppervlaktes of omtrekken groter zijn. In het testgebied is de gemiddelde grootte van een perceel 157 m2, gevonden fouten zijn ± 1.2 m2 in oppervlakte en ±0.2 m. in omtrek. Het tweede experiment betrof het testen van de kwaliteit van bestaande kadastrale gegevens ten opzichte van een digitale ortho-foto op foto schaal 1:10.000. De totale nauwkeurigheid is ± 1.8m in planimetrie afhankelijk van de kwaliteit van het digitaal terreinmodel, terrein type en begroeiing. De totale nauwkeurigheid is ± 3.0 m met IKONOS images voor zowel het panchromatische als het multispectrale bereik. De analyse toont aan dat de kwaliteit van de oude kadastrale kaarten kan worden verbeterd door middel van interactieve wijzigingsfuncties van de GIS software door integratie van kadastrale gegevens met ortho-foto's of IKONOS images.

Het laatste gedeelte van dit onderzoek gaat over richtlijnen voor de ontwikkeling van een PBGIS. Kritische Succes Factoren zijn vastgesteld op basis van doelstellingen en subdoelstellingen. De meest kritische factoren zijn organisatie en management gevolgd door technische en kwaliteitsaspecten en tenslotte institutionele, wettelijke en financiële aspecten. Er zijn veertien onderdelen die uiterste aandacht behoeven voor de ontwikkeling van het PBGIS. Deze worden hieronder opgesomd:

- Benoem een systeem ontwikkel team
- Ontleed het PBGIS in subsystemen
- Volg de systeem ontwikkel cyclus
- Gebruik standaard modelleringstalen voor analyse en ontwerp
- Ontwikkel een informatie architectuur
- Ontwikkel systeem modellen
- Ontwikkel voortdurend prototypes
- Gebruik commercieel beschikbare hard- en software
- Ontwikkel gegevens- en proces modellen als standaards
- Ontwikkel standaard gebruikers interfaces op basis van internet technologie
- Ontwikkel standaard procedures voor data conversie en integratie
- Gebruik grootschalige topografische gegevensbestanden of ortho-images als basis
- Volg een integraal kwaliteitsconcept

Tot slot wordt het gebruik van een leermodel (dat wil zeggen prototypen maken, voortgang boeken, en monitoren) gemotiveerd voor zowel de organisatie als voor de ontwikkeling van het PBGIS.

Curriculum Vitae

Arbind Man Tuladhar was born in Kathmandu (Nepal) on 20 July 1952. He attended both primary and secondary school in the same city. Then he obtained a first class BSc degree with distinctions in Mathematics and Statistics at Tribhuvan University in 1971. After that, he was fortunate enough to be admitted to the programme on surveying engineer at the Survey Training Institute, Survey of India, in Hyderabad (India). During this professional academic course, he gained extensive knowledge in the field of surveying and mapping. He successfully completed the course in 1973. After returning to Nepal, he worked at the Survey Department as a settlement officer and taught surveying and mapping subjects as a lecturer at the Institute of Engineering, Patan, Nepal. During these periods, he was highly motivated and eager to gain international experience. In early 1977, he was fortunate to go to the Republic of Yemen (formally Yemen Arab Republic) and work as a United Nations volunteer. During this seven-year period, he gained extensive practical experience as a land surveyor in the field of geodetic, topographical and cadastral surveys.

In August 1983, he came to ITC to follow the postgraduate course in Photogrammetry (P1). He successfully completed the course with distinction in 1984. Then he went on to follow the MSc programme in Photogrammetry (P2) at ITC. During the MSc study period, he carried out research work in the field of digital terrain modelling for GIS applications. This was the subject of his thesis, which he successfully defended in 1986, obtaining his MSc degree in Photogrammetry.

In April 1987, he joined ITC as a lecturer in photogrammetry in the Department of Geoinformatics. His teaching contribution covered many subjects in photogrammetry and GIS. With regard to ITC consulting activities, he was heavily involved with the modernisation programme of the Survey Training Institute at Hyderabad in India. After his return from India, he has since been working as assistant professor. He has been teaching digital photogrammetry, remote sensing, GIS, land administration, topographical and cadastral databases, spatial data modelling and information system development. He supervises final projects and MSc research works in photogrammetry, geoinformatics, GIS, cadastre and land registration, property valuation, databases, and spatial data infrastructure. During his career at ITC, he has been involved in many projects in India, Nepal, Argentina, Egypt, Lithuania, Namibia, Cyprus and Guatemala.

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